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LOT 32 / Ecodesign of Window Products
TASK 7 – Policy Options & Scenarios

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SUMMARY

This report presents the outcomes of the TASK 7 Policy Options & Scenario analysis of the "ENER Lot 32" Ecodesign Preparatory study, performed by VHK and ift Rosenheim, in collaboration with VITO.

Chapter 1 and 2 give a brief introduction to the study background (Chapter 1 - Preface) and overall methodology (Chapter 2 - Introduction).

Chapter 3 presents the policy analysis. It outlines the main barriers and opportunities for improving the environmental performance of windows, and sketches the regulatory framework that relates most directly to window environmental performance. Very relevant are the requirements set under the Construction Products Regulation that regulate how the performance of construction products, such as windows, should be established, and the Energy Performance of Buildings Directive, that requires Member States to set minimum energy requirements for building elements. It concludes that Energy Labelling offers the best approach to address the barriers and opportunities that have been identified, while respecting (and adding to) the existing legal framework.

Chapter 4 describes the elements that must be addressed in Energy Labelling of windows. The main aspect to regulate is the energy performance of windows, as the impacts of the window on related energy systems (heating and cooling) is the most significant form of resource consumption during use. The first part of the section describes how the energy performance of windows can be assessed using a simplified approach. Additional sections in Chapter 4 focus on the sensitivity of the method to establish the energy performance of windows in relation to changing climate conditions, thermal insulation of opaque elements of the building envelope, use of external shutters and orientation of the window. It shows that in particular the energy performance of the window in the cooling season is very sensitive to changes in these boundary conditions.

The second part of Chapter 4 presents the elements of a possible energy labelling of windows in the EU and discusses some of the main stakeholders comments in relation to these elements.

Chapter 5 presents the results of the scenario analysis, describing the impacts or effects of a possible market transformation. Important to note is that the scenarios are not based on empirical evidence. Some anecdotal evidence, with limited applicability, suggests that consumers pick up on window energy labelling information.

Chapter 6 presents the results of the impact analysis on industry and consumers in accordance with requirements set by MEErP 2011.

Chapter 7 presents the results of the sensitivity analysis. This analysis shows in how much the results (and conclusions drawn from the impact analysis) are affected by changes in main input parameters.

Chapter 8 presents the results of the overall study report of Task 1-7, conclusions drawn from all these reports and chapters, and presents recommendations to DG ENER who commissioned this study.

The Annexes present more detailed information as regards the sensitivity of the energy performance of windows during the heating season (Annex I), the energy performance of windows during the cooling season (Annex II), the background data used for the scenario analysis and also Task 3, 5 and 6 (Annex III), a short discussion on the difference between climate conditions and climate zones (Annex IV), a discussion on an EU map of climate conditions (Annex V) and the former (draft) proposal (Annex VI).

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LIST OF ABBREVIATIONS & ACRONYMS

AP	Acidification Potential
BAT	Best Available Technology
BNAT	Best Not yet Available Technology
BOM	Bill of Materials
CA	Concerted Action
C&D	Construction and demolition waste
CENELEC	European Committee for Electro technical Standardization
CEN	European Committee for Normalisation
CPD	Construction Products Directive
CPR	Construction Products Regulation
EN	European Norm
EOL	End Of Life
EOTA	European Organisation for Technical Assessment of construction products
EP	Eutrophication Potential
EPBD	Energy Performance of Buildings Directive
EPD	Environmental Product Declaration
EPS	Expanded Polystyrene
ETAG	European Technical Approval Guidelines
EU	European Union
EuP	Energy using Products
ErP	Energy related Products
FDES	Fiches de Déclaration Environnementale et Sanitaire (French EPD system)
GWP	Global Warming Potential
HM	Heavy Metals
IAQ	Indoor Air Quality
JRC	Joint Research Centre
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
MEErP	Methodology for Ecodesign of Energy related Products
MEEuP	Methodology for Ecodesign of Energy using Products
MEPS	Minimum Energy Performance Standard
MS	Member State
NEEAP	National Energy Efficiency Action Plan
NMVOC	Non Methane Volatile Organic Compound

NZEB	Nearly Zero Energy Building
ODP	Ozone Depletion Potential
ODS	Ozone Depleting Substance
OEF	Organisational Environmental Footprint
PEF	Product Environmental Footprint
PEFCRs	Product Environmental Footprint Category Rules
PM	Particulate Matter
POP	Persistent Organic Pollutants
POCP	Photochemical Oxidant Creation Potential
PRODCOM	PRODuction COMmunautaire
RES	Renewable Energy Sources
RoHS	Restriction of the use of certain Hazardous Substances
CI/SfB	Construction Index/Samarbetskommitten for Byggnadsfrago
SME	Small and Medium sized Enterprise
TC	Technical Committee
TR	Technical Report
VITO	Flemish Institute for Technological Research
VOC	Volatile Organic Compounds

LIST OF ITEMS OF WHICH PROPERTY RIGHTS CAN NOT BE TRANSFERRED TO THE UNION

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CHAPTER 1 PREFACE

This report has been prepared by Van Holsteijn en Kemna BV (VHK) and ift Rosenheim in collaboration with the Flemish Institute for Technological Research (VITO), under the Multiple Framework Contract related to preparatory studies and related technical assistance on specific product groups (ENER/C3/2012-418-Lot 1), and in response to the Terms of Reference included in the Contract for the "Ecodesign study with regard to Windows".

The subject of this report falls under the general context of sustainable industrial policy which aims to foster the development of products with less environmental impacts.

Directive 2009/125/EC ("Ecodesign Directive") is the cornerstone of this approach as it establishes a framework for the setting of Ecodesign requirements for energy-related products (ErPs) with the aim of ensuring the free movement of these products within the internal market. Directive 2009/125/EC targets ErPs as these account for a large portion of the consumption of energy and natural resources, and a number of other environmental impacts, in the Community, in particular during their use phase.

Directive 2010/30/EC on the energy labelling of ErPs is complementary to the Ecodesign Directive as it requires (a.o.) information on the impact by these products on the use of essential resources to be provided to consumers at the point of sale.

Any measure prepared under these directives must be preceded by a study or assessment ('preparatory study') that sets out to collect evidence and stakeholder input, explore policy options and describe the recommended policy mix (ecodesign and/or labelling and/or self-regulation measures).

The product groups considered as priorities for such studies have been listed in the Working Plan 2012-2014 (established according article 16(1) of the Ecodesign Directive) and this list includes "windows". Therefore a preparatory study has been requested by the Commission.

This preparatory study is to be executed according the Methodology for the Ecodesign of Energy-related Products (MEErP, 2011)[1] which identifies eight (1+7) tasks and shall allow stakeholder involvement. This report is the final report of Task 7 “Policy Options & Scenarios” of the study.

[1] http://www.meerp.eu/ VHK BV, Netherlands and COWI, Belgium: Methodology Study Ecodesign of Energy-related Products, MEErP Methodology Report, under specific contract SI2.581529, Technical Assistance for the update of the Methodology for the Ecodesign of Energy-using products (MEEuP), within the framework service contract TREN/R1/350-2008 Lot 3, Final Report: 28/11/2011

CHAPTER 2 INTRODUCTION

2.1. METHODOLOGY FOR ECODESIGN PREPARATORY STUDIES

This chapter introduces the objective of Task 7 of the full preparatory study. A full preparatory study follows the methodology for ecodesign of energy-related products established in 2011 (MEErP 2011) which itself is a succession of the former methodology dealing with energy-using products (MEEuP 2005) developed in 2005 to contribute to the creation of a methodology allowing evaluating whether and to which extent various energy-using products fulfil certain criteria according to Annex I and/or II of the Ecodesign Directive that make them eligible for implementing measures.

The full preparatory study is executed according to seven tasks, as described below:

Task 1 – Scope (definitions, standards and legislation);

Task 2 – Markets (volumes and prices);

Task 3 – Users (product demand side);

Task 4 – Technologies (product supply side, includes both BAT and BNAT);

Task 5 – Environment & Economics (Base case LCA & LCC);

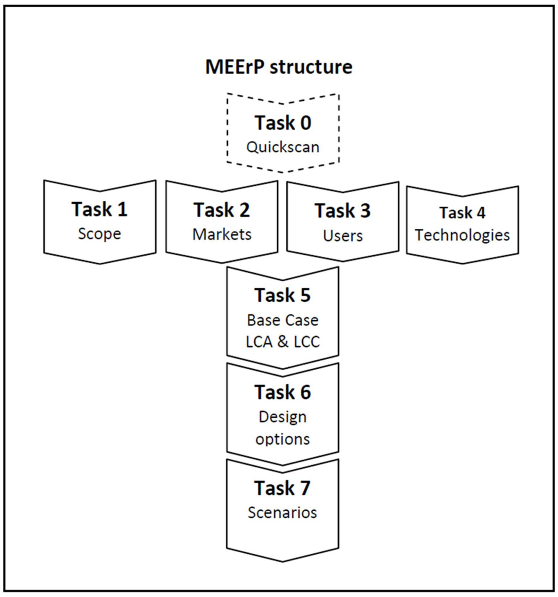
Task 6 – Design options;

Task 7 – Scenarios (Policy, scenario, impact and sensitivity analysis).

The MEErP structure makes a clear split between:

- Tasks 1 to 4 (product definitions, standards and legislation; economic and market analysis; consumer behaviour and local infrastructure; technical analysis) that have a clear focus on data retrieval and initial analysis;
- Tasks 5 (assessment of base case), 6 (improvement potential) and 7 (policy, scenario, impact and sensitivity analysis) with a clear focus on modelling.

Figure 1 MEErP structure



An optional Task 0 quick scan or first product screening has been introduced in the 2011 methodology for those product groups that are characterised by a large variety of products covered by a generic product group description. It was carried out for this study as well. The findings of this Task 0 are incorporated in the Task 1-4 reports.

Tasks 1 to 4 can be performed in parallel, whereas Task 5, 6 and 7 are sequential.

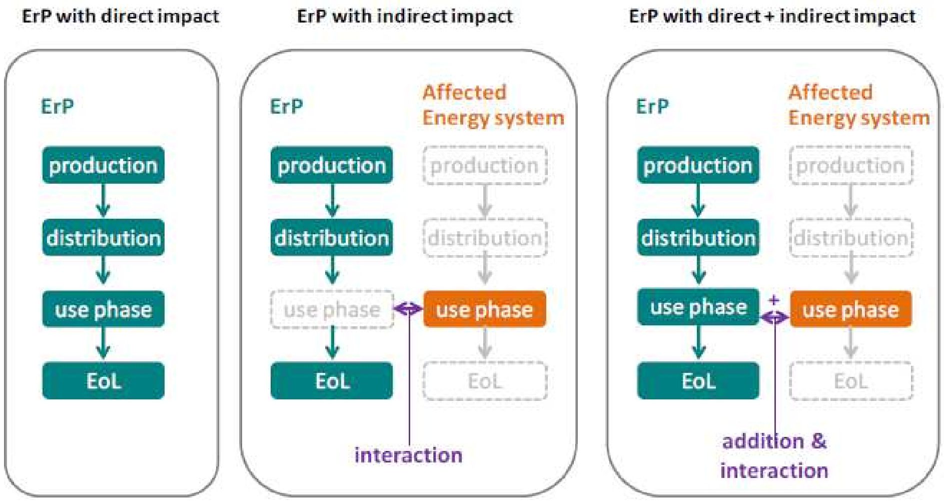
2.1.1. ENERGY RELATED PRODUCTS

The Directive 2009/125/EC defines an energy-related product as *"any good that has an impact on energy consumption during use which is placed on the market and/or put into service, and includes parts intended to be incorporated into energy-related products covered by this Directive, which are placed on the market and/or put into service as individual parts for end-users and of which the environmental performance can be assessed independently"*.

The impact on energy consumption during use of an energy-related product may take different forms and the MEErP methodology defined these as either direct and/or indirect impacts. The relevance of this lies in the analysis required and which should or should not include affected energy systems.

The MEErP introduced a grouping of energy related products into products with only direct impacts, only indirect impacts or both.

Figure 2 Three types of ErP (VHK, 2011)



Considering the above indicated grouping in MEErP of ErP products, windows are considered as an example of ErP with indirect impact.

2.2. MEERP – DETAILS OF WORK FOR TASK 7

The TASK description for TASK 7 according MEErP 2011 is described below.

Task 7. SCENARIOS

1. Policy analysis

1.1 Describe stakeholder consultation during preparatory study

1.2 Describe barriers (and opportunities) for improvements environmental impact; opportunities for Ecodesign measures (from Tasks 1-4)

1.3 Describe pro's and cons of (combinations of) Ecodesign measures and other policy instruments (e.g. self-regulation, energy label, EPBD); identify and describe overlaps with existing legislation

1.4 Select policy measures for further analysis, including timing and target levels, notably the options should:

a) Be based on the exact definition of the products, according to subtask 1.1 and modified/confirmed by the other tasks;
b) Provide ecodesign requirements, such as minimum (or maximum) requirements;

c) Be complemented, where appropriate, with (dynamic) labelling and benchmark categories linked to possible incentives, relating to public procurement or direct and indirect fiscal instruments. In case of energy labelling, labelling categories should be proposed;
d) Where appropriate, apply existing standards or propose needs/ generic requirements for harmonised standards to be developed;
e) Provide measurement requirements, including measurement standards and/or methods;
f) Consider possible self-regulation, such as voluntary agreement or sectorial benchmarks initiatives;
g) Provide requirements on installation of the product or on user information.]

2. Scenario analysis

2.1 Set up a stock model for the baseline (Business-as-Usual BaU); calculate for the period 1990-2030, preceded by an appropriate built-up period (product life), for the following parameters per year X (X=1990-2030):

a) annual sales in X (from Task 2, with actual and interpolated values), subdivided in new (incl. 1st time users) and replacement sales;
b) annual stock of product (from Task 2)= accumulative sales in X and preceding L-1 years (L=product life) minus products discarded in actual year (=sales in year X-L);
c) annual stock (number) or impact (e.g. in kWh) of the affected energy system (for indirect ErP);
d) annual net performance demand per unit (from Task 3), including growth rate if appropriate;
e) for significant impacts only: average unitary impact(s) (e.g. kWh energy and/or g emissions per performance unit, directly or indirectly) for products sold; this is the (set of) parameter(s) to be regulated;
f) total impact= stock units x performance demand per unit x unitary impact;

The MEERP 2011 requires reporting in a table showing 5 year intervals. However, as stated in MEERP Part 1, section 8.1 (p. 115) these are general guidelines and - depending on the product typology - there may be exceptions or even the necessity of a different approach. For windows this means that a 10-year interval is used for modelling.

Check the calculated total impact against values from this MEErP-report (when available) or other sources for consistency. Deviations of ± 15% are 'normal'; larger deviations require an explanation and possible adjustment of the stock model.

2.2 Calculate for the period 1990-2030 (with qualitative discussion of 2030-2050) for each of the options identified in 1.4 a scenario for total annual and accumulative impact of the policy mix, at the given timing and target level(s) (graphs and labels per impact type)

If no other data are available the following values may be assumed:

for the unitary impacts in the years of ('entry into force' minus 1-2 years) and 'implementation of (first) target' use interpolated values between baseline and (first) target unitary impact levels in periods after target implementation, the impact depends on the policy mix: In the time period after minimum requirements alone, the market is usually assumed to pick up the baseline trend after 1 year; when combined with other measures (e.g. labelling) the trend stays more positive than baseline for at least 5 years. Timely revision of labelling may prolong that period by ca. 3 years

3. Impact analysis industry and consumers

3.1 Introduce economic parameters in the stock model:

a) Introduce baseline product price (from previous tasks), in Net Present Value for a reference year (e.g. 2010), taking into account inflation rates as given in MEErP
b) Introduce unitary energy, water, consumable rates, annual repair and maintenance costs.
c) Introduce dynamic parameters: inflation rate, growth rate unitary prices (energy, water, etc.)
d) Simplify the relationship between a product's unitary impacts and product purchase price: determine a linear price elasticity from known anchor points (Base Case, LLCC, BAT) for price and unitary impact.
e) Determine the turnover rate per employment (from Task 2)
f) Determine the cost and margin built-up for the average product (%), with relative shares for OEMs, Manufacturer, Wholesale, Retail, VAT and other tax.

g) Introduce variables and mathematical relations in the stock model as appropriate (see also sensitivity analysis)

3.2 Calculate for the period 1990-2030 (with qualitative discussion of 2030-2050) for each of the options identified in 1.4 a scenario for total impact of the policy mix, at the given timing and target level(s) (graphs and labels per impact type)

a) EU-27 running costs including and excluding taxes (indicator of utility income and government income from energy/water/etc. VAT and other tax) in Euro2010, 1990-2030
b) EU-27 consumer expenditure, 1990-2030
c) EU-27 annual revenue industry, wholesale, retail, product VAT and other taxes (million Euro) in Euro2010, for reference years 2020 and 2030 (or 2050 instead of 2030 for construction products)
d) indicative share of SMEs, share in industry revenue; qualitative discussion of possible effect
e) employment (no. of jobs) industry, wholesale, retail/installers for reference years 2020 and 2030;

4. Sensitivity analysis of the main parameters.

Recalculate selected scenarios for variation in

a) higher and lower (50%) energy prices;
b) higher and lower (50%) elasticity between product price and unitary impact parameter;
c) new target levels or differences in timing as indicated by the Commission services;

And report on the in-/decrements (in tables)

5. Summary

5.1 Summarise the main policy recommendations per product

5.2 Summarise the main outcomes of the scenarios for Baseline, 2020 and 2030 (2050 for construction products)

5.3 Summarise the risk of possible negative impacts on health, safety, etc. in one +/- table

2.3. STAKEHOLDER CONSULTATION

Stakeholders to this study have been consulted on regularly basis. Consultation has been arranged and ensured by the following activities:

1. A study website (www.ecodesign-windows.eu) was set up to allow centralised dissemination of documents and the creation of an email-list through voluntary registration;
2. An email with an invitation to 'follow' the study by registering through the study website, was sent to over 400 different parties, which includes all major European building associations, representatives from CEN/CENELEC, representatives from Member States and members of the Ecodesign Consultation Forum and individual experts.
3. By December 2014 some 200 valid registrations were received.
4. Two public stakeholder meetings have been organised (on 17 March 2014 and on 31 October 2014) to discuss the TASK 1-4 and TASK 1-6 reports respectively. Stakeholders received documents some 4 weeks in advance in order to prepare. Minutes of each stakeholder meeting were posted on the study website, as well as presentations made during the meeting.
5. Feedback on study reports was received in writing, following publication of draft reports on the study website, and orally, during the stakeholder meetings. Compilations of comments received and the response by the authors have been pubslihed on the website.
6. The draft final version of the TASK 7 report was not presented to stakeholders in a stakeholder meeting (as commissioned by study client DG ENERGY), but written comments have been considered when preparing this final version of TASK 7 and the other Tasks.
7. Apart from the stakeholder meetings also some bilateral meetings were held upon request by stakeholders in which experts could more easily exchange ideas with the study writers.

CHAPTER 3 POLICY ANALYSIS

3.1. INTRODUCTION POLICY ANALYSIS

The policy analysis describes in section 3.2 'Problem analysis' the issue(s) that need/s to be addressed by possible policy measures, and the barriers and opportunities that exist for addressing this issue by measures.

The section 3.3 'Regulatory Framework' describes the available regulatory framework under which measures may be taken. Of course the focus lies with measures under the Ecodesign and Energy labelling Directive, but the relevance of other policy frameworks are described as well.

The section 3.4 (and section 4.1) 'Policy measures for further analysis' describes in more detail which measures may be taken (the possible effects of which are then presented in Chapter 4 Scenario Analysis).

The stakeholder consultation during this study is described in the previous Chapter 2 Introduction.

3.2. PROBLEM ANALYSIS

The problem analysis presents the *'issue to be addressed'* by EU legislation (see 2009/125/EC, Article 15.2.c.i), and opportunities for, and the barriers that prevent, the issue to be addressed properly by Community legislation.

3.2.1. THE ISSUE(S) TO BE ADDRESSED

Multiple studies and legal documents have concluded that the energy consumption of EU buildings is significant and that measures to reduce this energy consumption are required in order to minimise climate change and other environmental effects associated with energy consumption, to reduce dependency of the EU on imported energy and to reduce EU energy costs.

As regards energy the TASK 3 report shows that windows are on average responsible for 19% of EU heating residential energy demand[2] (assuming the boundary conditions are representative). The contribution of windows to the artificial cooling demand cannot be easily identified as ventilation (introducing warm outside air) and other internal (lighting, appliances) and external gains (black roofs) also play a role. However, the total artificial cooling demand is in general less than the net heat gain from windows during the cooling period (assuming the boundary conditions are representative) which means that not all 'excess heat' collected through windows is artificially cooled. Nevertheless, the improvement of the **energy performance** of windows placed on the market (installed in new buildings and as replacement for existing windows) can be a major contributor to the abovementioned goals.

→ **How to improve the environmental performance of windows installed in buildings?**

Improving window energy performance should be achieved by consideration of the whole context of the window, meaning not only its geographic location (which determines the climate conditions in which the windows functions), its orientation and inclination, but also the building characteristics (such as ventilation rates and presence and use of shutters[3] and other aspects that influence the utilisation factor) and

[2] Value relates to 'Residential sector, in year 2010' – outcome of stock model calculations February 2015. Data for other sectors and window types (roof windows) have not yet been validated.

[3] The term shutters is to be understood comprising all kinds of solar shading devices, including blinds (if used externally).

surroundings (because of possible obstacles to solar irradiance, etc.), in combination with knowledge on how the building is used (e.g. manual or automated control over shading devices, which set points for activation, etc.). Only if all these parameters are known and properly assessed, the optimum[4] window can be selected. If the window has adaptive elements that allow changing its characteristics depending on conditions, the use of these elemenrts should be optimised (requires automation or proper user behaviour).

New building development in principle allows the above assessment leading to selection of the optimum windows as many parameters are still variables. However, even in new builds there may be constraints of technical, economic, environmental, or other (including cognitive) nature that prohibits the selection and application of the optimum window.

In existing buildings window selection is much more constrained. Currently most window purchases (approximately 70% of sales and increasing) relate to replacement installations so the building and its context and use can be considered fixed (large renovation resembles 'new builds'). Although the building owner is ultimately responsible for the window selection, in most cases it is the installer who gives advice regarding window selection. A further complication is that most window selection, especially in the residential sector, is performed by window retailers that may not consider the "whole window context" (building, location, use, etc.).

Therefore, to achieve the goal of improving the energy performance of windows in new and existing buildings, not only the technical product has to be improved, but the whole chain of actors involved in the specification process has to be aware and should apply a selection process for optimum windows. This argument also applies to non-energy (resource efficiency) aspects as well.

As already indicated above, there are typical differences in the window specification process, depending on the sector (residential or non-residential) and final application (new buildings or existing buildings): The matrix below shows the typical differences.

Table 1 Main specifiers in residential/non-residential sectors for new and existing buildings

Application	Sector	
	Residential	**Non-residential**
Existing buildings, which covers repair, replacement and retrofit (typically small scae renovations)	windows are mainly specified by the installer, whereby the input of the owner (in case of rental buildings) or end-user (in case of owner-occupied buildings) is minor.	windows in the replacement market are mainly specified by architects and/or building construction specialists, employed or hired by the building developer.
New buildings (including large renovations as defined under EPBD)	Windows are mainly specified by building specialists (architects and/or advisors), employed or hired by the building developer who bears final responsibility of building design. The options for window selection are in most MS limited by a specified minimum performance (either directly, at component level, or indirectly, at building level) and in practice also limited to a certain maximum performance as the window specifier has to weigh investments for improved windows against investments in other building aspects (energy performance of other building elements or other effects of –improved- window performance[5]). Still, even architects or professional building advisors may lack the skills for optimal window selection.	

The window retailer may also be the supplier that places the product on the market[6]. The TASK 2 report shows that in the case of plastic-, metal- and certain wood-system windows, there usually is an OEM manufacturer who designs and supplies the framing and joining materials.

[4] "Optimum" is meant as the window best fulfilling the demands of the consumer as regards pricing, energy performance and other performance aspects (maintenance, sound insulation, etc.).

[5] Improving window energy performance ideally needs to be considered in a holistic manner, so that possible side effects of window selection (effect on ventilation or air infiltration, effects on condensation, cold draughts from facades, but also monetary effects, etc.) are properly taken into account. It could be that in certain contexts the application of the best performing window leads to higher costs and ultimately lower overall energy performance of the building, in case other, more cost-efficient, building improvements options cannot be financed because of higher spending on windows.

[6] Both 'retailer' and 'supplier' as defined in 2010/30/EU, the Energy Label Directive.

→ Non energy-aspects

The construction industry is a major consumer of resources (MEERP 2011, Part 2, Section 2.1, page 11, Materials) and also a major producer of waste (MEERP 2011, Part 2, Section 2.5, page 57, Waste). The Task 3 and 5 reports show that windows represent a major flow of PVC, aluminium and/or wood materials in the Union. Improving the resource efficiency of windows is therefore also an issue that may be addressed by Community legislation.

Resource efficiency covers prevention (reduction of material inputs) as well as improvement of reuse, recycling and/or recovery (by avoiding substances or material combinations that hinder proper end-of-life treatment). Resource efficiency also covers aspects such as presence or use of hazardous substances, the scarcity of materials (critical raw materials) and sourcing aspects (sustainable supply of materials). The analysis therefore should address possible ways to improve resource efficiency aspects.

The life cycle analysis in the TASK 5 report shows that most of the environmental impacts of windows are related to the indirect energy consumption of windows, which are mainly influenced by the energy related properties of windows such as the Uw-value and g-value.

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In addition to the above aspects related to environmental performance, other aspects also play a role in window selection such as daylighting potential, ventilation options, amenity (e.g. views, wellbeing), operating and maintenance, privacy, durability and security issues. All these have to be balanced with environmental performance to arrive at a true optimum solution. This balance may be different for each consumer.

The following section presents, as required according the structure set out in the MEERP, an analysis of barriers and opportunities for regulating the products in order to improve the environmental performance.

3.2.2. BARRIERS: MARKET AND/OR REGULATORY FAILURES

The main market and regulatory barriers, hampering a larger market penetration of energy efficient windows, were identified as follows:

→ Market failure

Lack of consumer information

Discussions with stakeholders learn that most consumers have some basic understanding of energy performance of windows, in the sense that windows with poor energy performance are known for problems like cold draughts and icing-on-the-inside during heating season.

But not many people are fully aware of the major improvements that have occurred in windows in the last decades: the use of IR coatings, thermal breakers in frames, solar control glazing, integrated solar shutters[7], triple glazing[8], reduced air leakage, improved spacers. The lack of awareness can partly be explained that advanced windows may look quite the same as conventional windows.

Also as regards the functioning of windows, not many people are aware that a properly specified and designed window can act as a heat gain instead of a heat loss factor, orientation and inclination permitting.

And even for climatic conditions that require cooling rather than heating, advanced windows may help to keep the heat out and the cold in, instead of losing it to the environment.

Adaptive elements, allowing the performance of the window to be better tuned towards the conditions, should be better used, and introduced.

[7] The term shutters is to be understood comprising all kinds of solar shading devices, including blinds (if used externally).

[8] And by combining window frames with double and triple glazing units, also quadruple and quintuple glazed windows can be produced.

As a result the general understanding of proper window selection of consumers is rather poor and this may even be worse when there is a split incentive and benefits of proper window selection are not borne by the same party that buys the window.

Split incentives

There is a split incentive between builders and building owners or landlords and tenants as regards the costs and efficiency of windows. The building-owners, i.e. the ones paying the energy bill, have an interest in energy-efficient windows. The builders are working on a strict budget. Likewise, in a situation between landlords, who would have to invest, and tenants, who pay the energy bill, very often there is a similar case of split incentive.

Other barriers hampering selection of 'optimum' windows may be:

High upfront costs and major disturbance

Window replacement is a costly affair and is associated with a major disturbance of activities in and close to the affected spaces (replacement of windows may require scaffolding outside the building, the space inside often cannot be used during removal of the old window and installation of the new window);

Other performance parameters

Window selection often not only takes into account the energy performance, but may also consider aspects like sound insulation, burglary resistance, privacy, resistance to fire, use as escape route, etc. the technical solutions for which may affect the energy performance.

Psychological barriers

Window performance (or "under"-performance) goes largely unnoticed. If the thermal resistance is too low, then often the heating (or cooling) system automatically adjusts to a higher setting. The only direct notion of window performance may be cold draughts or condensation on the inside, the rest is mainly experienced indirectly (through heating, and cooling, bills).

Lack of installer training and information

Some stakeholders have informed the study writers that many 'installers' (those who sell and install windows to customers) cannot properly advice customers as to which window would be the optimal selection for their application as they lack the necessary skills. Also poor installation of the window could affect its performance.

Reasons may be a general need to 'get the job done in as little time as possible', deficiencies in proper schooling, vocational training and information (e.g. books, standards, etc.), a lack of competition (installers do not compete at the level of window energy performance), no mandatory certification (no tangible commercial gain from training) and economics (training costs time and money, which is scarce especially with SMEs).

This issue is mainly prevalent in the replacement of windows in the residential sector because stakeholders believe that in the non-residential sector there is a higher involvement of professional building advisors (architects, building physics specialists, engineers, installers)

There are some 12 energy labelling schemes in the EU specifically set up for windows, which aim to address this lack of information. Participation in such schemes is however voluntarily (although Member States authorities can influence this by referring in their building requirements to such rating schemes, as is the case in the UK, for domestic refurbishment[9]).

Technical barriers, e.g. building limitations:

There may also be technical constraints or barriers to installing better performing windows: it may be that the building envelope (support structure) does not allow fitting windows with improved energy performance (e.g. bigger window sills needed);

Fitting windows with improved performance may (if not carefully examined) lead to problems with building physics (if the window is not the coldest surface anymore, condensation may occur elsewhere; a window with reduced air infiltration may reduce indoor air quality if not combined with appropriate ventilation measures);

Lack of consensus on methodology / parameters for energy performance assessment

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[9] This is for domestic refurbishment only. Compliance cannot be demonstrated for new build or non-domestic refurbishment..

The industries involved in establishing window energy performance largely agree on the method to assess performance: stakeholders agree with using EN ISO 13790 (to establish building heating/cooling needs) and ISO 18292... (to establish window performance properties). But as the actual performance of a window is also highly dependent on specific location, orientation/inclination, building characteristics and use parameters, there are a multitude of parameters ('boundary conditions') that need to be established in order to calculate the overall performance of a window in a certain context.

The industries involved have expressed different opinions on how such parameters should be identified or selected: To give an example, certain stakeholders prefer an approach where the performance of the windows is established without use of solar shutters as the actual use cannot be predicted at time of placing on the market, whereas others prefer it the other way around, as neglecting the presence of a incorporated shading device is not realistic either. Industry representatives showed different opinions as regards the method to be based on a room, or on a reference building, wall-insulation values, ventilation rates, control or use of shutters, etc. which makes it very difficult to achieve consensus on the window performance used for rating.

As regards resource efficiency, the application of windows in the building envelope requires windows to be weather-resistant, able to withstand wind loads and pressure differences, and sturdy enough to minimise risk of burglary, etc. All these (and other) requirements mean that windows are typically constructed and applied in a way that they are long-lasting and not easily removed from the building, nor separated into different material fractions. Such requirements do not facilitate recycling into separate fractions, but are required to ensure long product lives.

→ **Regulatory failure(s)**

Scattered and inconsistent policy measures

Windows are construction products and thus the assessment of their performance is covered in the EU under the CPR[10], which requires the product to carry the CE marking, as laid down in applicable harmonised standards. This means that in theory every window product has its main properties in clear display (the CPR requires affixing of CE marking on the product packaging or similar), also depending on the requirements of the particular country.

Where windows are sourced from so-called 'system houses' the availability of data to be used for CE marking is often not problematic. However, a significant share of windows is placed on the market in such a way (frame and glazing supplied separately, by different suppliers, for example quite common in The Netherlands) that the supplier is neither aware nor even capable, of providing this information. According information from stakeholders, only a few of such suppliers have administrative provisions that allow calculation of parameters required for CE marking.

The EPBD[11] required Member States to introduce minimum requirements for building 'elements'. Windows can be such elements, although different interpretations are possible (some MS have requirements for all fenestration elements combined, or the whole façade combined, or even only at building level).

The TASK 1 analysis shows that the minimum performance varies per member State or even per region ('zone') within MS, as the climatic conditions and the building characteristics differ per MS/region. In this, one can recognise the principles of subsidiarity and proportionality according which action taken at national, regional or local level rather than Community level prevails if proven to be more effective. When setting requirements the EPBD requires MS to follow the cost optimal methodology.

Although the need to differentiate minimum requirements per MS is therefore understood by most stakeholders, there is dissatisfaction among certain stakeholders as these national requirements in most cases only cover the window U_w value and ignore the g-value (and other relevant parameters). The TASK 4

[10] REGULATION (EU) No 305/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC

[11] DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings

and 6 report show that different combinations of U_w and g-values can be equally performing, so limiting requirements to only U_w values is considered inadequate by these stakeholders.

Additionally, local authorities may regulate the appearance of windows in (particularly) historical buildings. Options for window improvement in such buildings may be limited (but are not zero).

3.2.3. Opportunities

There are many technical options to improve the environmental performance of windows: The properties of glazing, coatings, spacers, cavities (and gases used within) and frames that determine / influence energy performance are continuously improved and products incorporating such improvements are made available continuously (see TASK 4).

Regarding resource efficiency, certain window frame materials have lesser impacts during production (e.g. through light weighting, or avoiding of hazardous substances) but the overall environmental impact is still dominated by its energy related characteristics (see TASK 5) .

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Although identification of the optimum window may be a highly complex activity, there is room to improve the information provided to consumers or other persons responsible for specification of the window and final purchase as regards the environmental performance of windows. This requires appropriate instruments and an information campaign.

There is an opportunity to introduce in the building community the aspect of window performance rating on the basis of an energy balance, and not just solely the consideration of the U_w of the window;

There is an opportunity to promote the use of adaptive windows, ie. windows that can 'change' their characteristics in order to achieve a better performance. This aspect should be included in the information campaign so that the adaptive element is used properly.

3.3. Regulatory Framework

The previous section presented barriers and opportunities for improving the environmental performance of windows placed on the EU market and installed in new and existing buildings.

This section describes the pro's and cons of (combinations of) Ecodesign measures and other policy instruments (e.g. self-regulation, energy label, EPBD) and the possible overlaps with existing legislation that may also aim to improve the environmental performance of windows.

The current legal framework for (possible) EU measures for windows:

1. Ecodesign Directive 2009/125/EC;
2. Energy labelling Directive 2010/31/EC;
3. Construction Products Regulation 305/2011;
4. Energy Performance of Buildings Directive 2010/30/EC, in combination with National Building Codes;
5. Energy Efficiency Directive 2012/27/EU;
6. European Timber Regulation 995/2010

Each regulatory framework allows a specific set of measures to be introduced. These are discussed below.

3.3.1. Ecodesign Directive 2009/125/EC

The Ecodesign Directive allows setting of specific ecodesign requirements and/or generic ecodesign requirements, provided certain criteria as regards the product group to be regulated and the possible requirements themselves are met, but prefers self-regulation over legislation.

→ **Self-regulation**

Under the Ecodesign Directive self-regulation is generally the preferred option. For the assessment of voluntary agreements or other self-regulation measures presented as alternatives to implementing measures, information on at least the following issues should be available: openness of participation, added value, representativeness, quantified and staged objectives, involvement of civil society, monitoring and reporting, cost-effectiveness of administering a self-regulatory initiative, sustainability and incentive compatibility.

Incentive compatibility refers to the statement in 2009/125/EC that *"self-regulatory initiatives are unlikely to deliver the expected results if other factors and incentives — market pressure, taxes, and legislation at national level — send contradictory signals to participants in the self-regulatory initiative. Policy consistency is essential in this regard and must be taken into consideration when assessing the effectiveness of the initiative"*[12].

In the case of windows, no single stakeholder has brought forward a willingness to subject the market to self-regulation.

As manufacturers of windows are split up into a limited number of 'system houses' supplying window frames and supporting documentation, a limited number of 'glazing' suppliers, and a vast number of often very small (micro-sized) companies that assemble / produce, sell and install windows openness of participation, representativeness and monitoring / reporting is expected to be problematic.

The study writers also did not find agreement among stakeholders as to the goal of a possible self-regulation (removing least efficient windows from the market or other generic requirements) nor agreement on how to express the performance of windows in a simple (easy to use and understand) metric or rating scheme.

There are exceptions with regard to resource efficiency: The aluminium and plastics (PVC) industry are voluntarily phasing out the use of hazardous substances. A major driver for these activities is the restriction of use of such compounds under REACH.

→ **Ecodesign requirements – eligibility criteria**

The study shows that the generic product group 'windows' (façade and roof windows) meets the eligibility criteria as it is significant from economic (Task 2 - Market) and environmental (Task 5 - Environmental impacts) perspective and provides room for improvement (Task 6 - Options and LCC) and therefore may –in principle- be subject to ecodesign requirements.

The specific measures (Regulations) under the Ecodesign Directive introduce minimum or threshold values for environmental parameters of the product, such as its energy performance or efficiency, the presence (or absence) of certain substances, emission values, etc. These parameters must be quantifiable and be able to be measured using reliable, reproducible and up-to-date measurement standards.

Whether the criteria for specific or generic ecodesign requirements will be met is set out in the following sections.

→ **Specific requirements (threshold values)**

As regards specific requirements Article 15, item 6 states that "*specific ecodesign requirements shall be introduced for selected environmental aspects which have a significant environmental impact*". Annex II of 2009-2010-EC presents the criteria related to the setting of specific ecodesign requirements, such as economic and technical feasibility and the least life cycle cost minimum as target for specific requirements (for energy and other resources consumed during use).

This study (TASK 3 and 5) has shown that energy consumption in the use phase (by heating/cooling systems of the building in which the window is installed) is a significant environmental aspect.

[12] Copied from 2009/125/EC, Annex VIII, point 9.

The impacts caused by presence of substances or (suboptimal) end-of-life treatment have not been proven to be significant, but as the industries themselves address these issues, they can be regarded to be 'an issue to be addressed'.

Specific requirements related to energy

The Ecodesign Directive requires specific measures relating to energy use, to be based on a life cycle costing method, for which the least life cycle cost point is the potential target value for measures.

The TASK 1 description of the EPBD shows that Member States are required to introduce requirements for 'building elements' based on a cost-optimal approach. This means that most, if not all MS, have introduced (or are working to introduce) requirements that will lead to application of windows at their least life cycle cost point. The envisaged specific energy performance requirements under Ecodesign at least life cycle cost target levels would thus not lead to further savings.

Secondly, the main purpose of the Ecodesign Directive is to harmonise (potential) environmental legislation applicable to products, to maintain a functioning internal market. The LCC analysis in Task 6 shows that, depending on which conditions apply, the target LCC point is not the same across the three climate conditions considered in the analysis. This means that it will be difficult to properly harmonise the market based on a single target is not the optimal solution across all possible climate conditions.

A third point is embedded in the principles of the Treaty relating to subsidiarity and proportionality. Requirements at Member State level may better take into account relevant (local) aspects like climate conditions, building properties etc. TASK 6 has shown that the LLCC point depends on specific conditions. It can be argued that minimum energy performance requirements should be better handled at national level, rather than EU level.

For these three reasons it is concluded that specific ecodesign measures (limit values or minimum requirements for energy performance of windows) should not be part of the further assessment of policy options.

This conclusion aligns with the analysis provided for another construction product: Thermal insulation.

Thermal insulation

Thermal insulation is a 'conditional' product group in the second Ecodesign Working Plan. Therefore an investigative preparatory study, comprising only Task 0, 1 and 7 (partly), was conducted, the findings of which became available in February 2014[13]. Since thermal insulation is, like windows, a typical construction product, the below text shows these findings as they may be relevant to windows as well.

The findings of the study showed that it would not be suitable to bring thermal insulation under ecodesign for the following main reasons :

1. At the product level it is impossible to define a specific energy savings performance target in the usage phase because this varies across the EU for the same product, due to different building and climate characteristics. A target is possible at the building envelope level, but this is already covered by the Energy Performance of Buildings Directive (EPBD).

2. Production phase impacts are comparatively low and a wide range of insulation options are required to meet diverse and constraining renovation requirements. Information is often well provided through voluntary Environmental Product Declarations (EPDs) which are seeing good uptake in member states; the Construction Products Regulation (CPR) already enforces information requirements and would be more suitable for making EPD information requirements mandatory than an ecodesign regulation.

3. End of Life, lifespan and disassembly aspects are small compared to the use phase savings. Information on these aspects is covered in EPDs and penetration would be sped up if these became mandatory.

4. Ecodesign could provide generic information on optimal installation techniques; however this alone is not enough to set up a regulation.

Following the study, the EC informed stakeholders at the Consultation Forum on 05.05.2014 that the product group will not be studied or regulated further under Ecodesign[14]

[13] VITO, "Exploratory study with regard to Ecodesign of thermal insulation in buildings (Lot 36): MEErP tasks 0, 1 and 7 (partly)," February 2014.

[14] European Commission Services, "Working Document on Thermal Insulation Products (Lot 36) – Results from exploratory study and suggested way forward," Brussels, April 2014.

Specific requirements related to non-energy aspects

As regards non-energy aspects, the environmental analysis in Task 5 did not show these to be very significant when looking from an individual product life cycle perspective. However, when looked at from a larger (societal, cross category) perspective, it is apparent that windows, as a construction product, are contributing to considerable amounts of resource consumption and waste at end-of-life.

Building construction & demolition waste

In order to minimise (or prevent) creation of building waste one needs to consider the regulations that apply to renovating and demolishing buildings and the treatment of waste that arises. The case for aluminium windows shows that high recovery rates can be achieved if economic incentives exist. Introduction of technical minimum requirements for windows are not expected to change / improve the economic incentives to recycle plastic or wooden windows. Proper treatment of building waste may be better achieved by another type of regulation (local?) specifically addressing building waste (how it is created and treated[15]).

Furthermore the Waste framework Directive 2008/98/EC (Article 11.2.c) requires that by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material defined in category 17 05 04 in the list of waste shall be increased to a minimum of 70 % by weight. It is therefore expected that member States will step up their national requirements related to building waste.

Furthermore, depending on the frame material used, there may be use of hazardous substances during the production phase (although manufacturers are addressing these issues already).

Therefore, the following paragraphs describe whether non-energy aspects should be considered for specific requirements. The structure follows the resource efficiency parameters identified in the 2013 JRC study[16].

RRR & Use of priority resources

The re-usability of windows is in general very low as their physical state often does not allow proper re-use. Life extension does occur by replacing glazing units and repair of hardware. Re-use sometimes occurs in very specific applications, but this is often not with the same principal use as fenestration element in the building envelope[17]. Re-use is not advocated either as it would slow down the penetration of windows with a better energy performance.

The recyclability rate is to be assessed by partitioning, following expert analysis, each component to one of four waste streams (parts for 1) selective treatment, 2) selective recycling, 3) difficult to process and 4) material separation)) and then apply the typical recycling percentage of that waste stream. The analysis in TASK 4 of end-of-life shows that generic recycling rates do not exist for windows, and may be very site specific (the EAA study on recycling of aluminium windows shows a high average percentage, but the study authors also came across projects with low recycling rates) or very dependent on organisational aspects (the PVC recycling program VinylPlus achieved a recycling rate of 14%). It is believed that these aspects (site conditions and organisational conditions are much more determining a possible recycling than design aspects of the window itself).

The recoverability rate is partly governed by presence of hazardous substances that could complicate energy recovery. The removal of lead and cadmium from PVC windows would make overall recovery of easier.

Recycled content

For plastic or metal windows the recycled content may be stated. Recycled content of commodity materials (e.g. aluminium) can be stated by suppliers. Certain manufacturers may claim substantially higher rates than commodity (aluminium recycled content of up to 87% are claimed[18]) but in order to achieve this, the sourcing of the secondary material need to be well organised. But as the demand in secondary (recycled) aluminium

[15] Example: Since 1 April 2014, the Netherlands have added glass to the streams of building waste that need to be separated and treated properly.

[16] (reference to add)

[17] See http://superuse-studios.com/index.php/category/re-build/

[18] Reynaers CS68 window has been awarded the Dutch Dubo keur, statinga 87.4% recycled content (http://www.nibe.org/nl/nieuws/DUBOkeurcertificatenReynaersAluminium)

exceeds its supply[19], increasing use of recycled aluminium in one product group, may result in reduced use of recycled aluminium in another group. Because its supply is finite, the balance between supply and demand is fundamentally unstable.

Durability / product life extension

The life cycle assessment in TASK 5 showed that the higher the energy performance of the window, the greater the relative contribution of the production phase in the total life cycle impact. An option to reduce the burden of the production phase is to increase the product life, by increasing its durability.

An assessment of this aspect has been included in the TASK 7 Scenario analysis and this showed that increasing lifetime may reduce material inputs, but also reduces (slows down) the penetration of windows with higher energy performance. When assessed on the basis of direct (energy performance) and indirect energy (material rucksack, according MEErP Ecoreport 2013) the balance is negative for increased product life.

Hazardous substances

As regards the use of hazardous substances, the TASK 4 analysis shows that for wooden windows the substances currently used are not considered to be problematic.

For aluminium windows there may be use of Cr6+ compounds during the production phase. During this treatment the Cr6+ is converted to Cr3 which is less hazardous. There are alternatives under development for some time, but their adoption is mainly triggered by the REACH legislation which will forbid the use of Cr6+ by Sept 2017 except if there is a specific request for authorisation submitted by March 2016 and accepted. At this stage it is unclear whether applications for authorization will be submitted for Al pre-treatment. In any case, it is most likely that the Cr6+ pre-treatment lines in EU will switch to alternatives treatments in the next 2-3 years.

For PVC windows the use of lead-based stabilisers declined by 81% in the EU-27 compared to 2007, progressing towards the target of completing their substitution by the end of 2015. The use of phthalates and other plasticisers is not relevant for rigid PVC (UPVC = Unplasticised PolyVinyl Chloride) products such as windows. Restricting through regulation the presence of lead in PVC windows would severely hamper the potential for recycling into new PVC windows, unless an exemption for recyclates to contain up to 1% lead is introduced as well. Cadmium has been used in semi-rigid and flexible foil for products such as roofing membranes and in rigid applications for outdoor use such as window profiles. In Europe, it has been replaced by barium/zinc stabilizers in foils. The EU Directive 91/338 still allowed the use of cadmium stabilisers in window profile and roofing membranes but the Voluntary Agreement of the PVC Industry signed in 2000 resulted in discontinuation of use of cadmium stabilizers by all its members as from 2001. Directive 91/338 was included in Annex XVII of the REACH chemical Regulation (Restrictions) when REACH entered into force. The provisions regarding cadmium were amended in 2011 by Regulation 494/2011, which extended the 0.01 % cadmium limit to all PVC articles, but contains a derogation for most rigid PVC construction products containing recovered PVC, where cadmium levels may be up to 0.1 % weight. This derogation will be reviewed by end 2017[20].

The study concludes that specific requirements regarding presence (or use) of harmful substances are not needed as most harmful substances have already been phased out, or subject to ongoing phase-out initiatives, most often triggered by the REACH Regulation.

Possible requirements relating to the origin of wood used for wooden windows are discussed in the section dealing with the EUTR (European Timber Regulation 995/2010).

Possible requirements relating to weight reduction have not been shown to be feasible (on the contrary, often the higher weight window –triple glazing- shows better overall environmental performance). The windows industry is researching the possibility of polymer window frames that are based on glass-fibre reinforced polymers which will reduce weight and may improve the frame fraction. Such windows have been mentioned in the TASK 4 report, but their current market significance is too low to consider them as baseline for minimum requirements.

[19] http://www.alueurope.eu/eu-policies/recycling/

[20] Source: http://www.pvc.org/en/p/cadmium-stabilisers

→ **Generic requirements (information only)**

Annex B of 2009/125/EC describes the form of possible **generic requirements** to be set under Ecodesign. These may be related to:

1. the supply of information (regarding the manufacturing process, the use of the product and information for (waste) treatment facilities)
2. and/or requirements for the manufacturer, involving an assessment of ecodesign activities employed by manufacturer (establishing an environmental profile, performing an environmental benchmarking exercise).

It is important to note that the generic requirements do not pose limit values on any specific parameters.

Table 2 below presents the options for generic requirements and a discussion of pro's and con's.

Table 2 Overview assessment appropriateness of generic requirements

<table>
<tr><th>Information in accordance with Annex I of 2009/125/EC</th><th>Opportunities / benefits</th><th>Barriers / drawbacks</th></tr>
<tr><td rowspan="2">1. Supply of information regarding the manufacturing process. This could be information regarding:
a. the sourcing of materials (e.g. for wood based windows information that certain criteria for sustainable management of timber have been met or not);
b. the presence of recycled materials in the final product;
c. the use or presence of (hazardous) substances in the final product.</td><td>This information would allow the window purchaser to take into account these environmental aspects when purchasing</td><td>If introduced as ecodesign requirement, the CE marking (and admittance to EU market) would depend on the availability and correctness of the information.</td></tr>
<tr><td colspan="2">The main criteria for a successful implementation of such information requirements are 1) its allowance under WTO, 2) what is the expected benefit. In case the requirements cannot be proven by product testing (if it cannot be determined in the final product) proof must be given by a "paper trail" of production processes involved. Requirements on production processes are not generally acceptable under WTO rules, and urgency must be proven. For 'wood-origin' the matter is (partially) addressed under the EUTR, for use of hazardous substances in the production phase the industry has developed several initiatives to regulate these, often triggered by the REACH regulation. It also means that reliable and undisputed measurement standards must be available.</td></tr>
<tr><td rowspan="2">2. Supply of information regarding the use of the product. This could be information regarding:
a. the energy performance (more elaborate than CE marking);
b. use, maintenance and repair;
c. the warranty and/or availability of spare parts</td><td>More elaborate information on energy properties (U value of frame and glazing separate, spacer properties, etc.) would allow consideration of these aspects in buildings according the passive-house standard.
Information on use, maintenance and repair can be considered standard practice when purchasing windows. For users of existing windows better information may be relevant (as to how to ventilate properly, use of shading, etc.).
Information on warranty and/or availability of spare parts may help to avoid premature disposal in case of failure before natural product life is reached.</td><td>As regards information for passive-house builds, the industry has developed a database to which manufacturers can voluntarily submit products and data. A mandatory requirement would lead to higher costs and efforts to be compliant (more tests basically) and would add administrative burden to a sector consisting of many small and micro sized enterprises.
The information on use, maintenance and repair can be considered to be normal practice. Information can only be provided at moment of purchase. Users of existing windows would not be reached.
Information on warranty and spare parts is standard practice.</td></tr>
<tr><td colspan="2">The criteria for a successful implementation of such information requirements are the expected benefit. For information regarding use and warranty, the expected benefit is small as it is current practice.
For information regarding more detailed window energy performance the benefit is considered to be limited as the market has shown that parties already respond to a call for such information (i.e. the passive house databank). A mandatory roll out, would require extra efforts for all parties concerned whereas the information would be used by a relatively small group of users (a near zero energy building can also be achieved without such specific information).</td></tr>
<tr><td>3. Supply of information for treatment facilities (end-of-life of the product). This could be information regarding:
d. the presence of (hazardous) substances in the (discarded) product..</td><td>For example, PVC windows could be equipped with a marking that shows whether hazardous substances are/are not present in the product. This way treatment facilities would in principle be able to separate the window frame waste stream into separate fractions.</td><td>It is expected that PVC windows will soon no longer contain lead. The benefit of this mandatory information is then questionable.</td></tr>
</table>

	The main criterion for a successful implementation of such information requirements is the expected benefit. It is expected the requirement will(soon) become obsolete as the respective substances are phased out. The criterion has not been met.	
4. Supply of information on ecodesign activities **e. establishment of an ecological profile by the manufacturer** **f. results of an environmental benchmarking exercise.**	If multiple suppliers would follow the same methodology and information sources for establishing and ecological profile, this would allow comparison on basis of ecological properties. DG ENV has started the 'PEF' project to establish product category rules for making environmental assessments, but 'windows' do not yet have such commonly agreed product category rules.	Many industries have already started with establishing EPD's (see Task 1). However, comparison may not always be possible if different methods are used. It would not be advisable to develop an approach that is again different to that developed for whole buildings. As regards the benchmarking, window suppliers should use the same method as the Commission to render a benchmarking exercise useful. The lack of a common agreed method makes this option unattractive.
	The main criterion for a successful implementation of such information requirements is the existence of a commonly agreed method for establishing the environmental profile. This criterion has not been met.	

As to information requirements relating to "detailed energy performance properties"

Certain stakeholders have stated that the generic window performance parameters (U_W, g-value, leakage, daylight transmittance and frame fraction, as specified by many manufacturers through CE marking and the related declaration of performance) are not sufficient for current 'passive house calculations'. For example: for such detailed calculations also the individual U-values of the transparent element (IGU) and the frame, and also the linear thermal transmittance Ψ are required to calculate the U-value of any size window. Certain manufacturers may have these parameters readily available, but most manufacturers (especially the small and micro-sized window retailers) do not assess performance of these window elements, but rather present information for the window as a whole, for standard sizes only. The harmonised product standard for windows EN 14351-1 allows several ways to calculate or assess the U value and other performance parameters, ranging from direct measurement of a standard window, to using tabulated values, to – and this is what is required for detailed energy performance properties – by assessing performance of individual elements and then calculating the overall performance.

The detailed thermal transmittance properties of the individual window components to consider for the detailed calculation of the thermal transmittance of a single window are (as identified by TC 89, Thermal performance of buildings and building components; collaborating with ISO/TC 163/SC 2, and taken from TC89 draft xls-table for EN ISO 10077-1: Thermal performance of windows, doors and shutters):

- Thermal transmittance of the frame U_f;
- Thermal transmittance of the glass U_g;
- Thermal transmittance of a panel U_p (if the window has integrated opaque panels);
- Linear thermal transmittance of the frame / glass junction Ψ_{fg};
- Linear thermal transmittance of the frame / panel junction Ψ_{fp};
- Linear thermal transmittance of the glazing bar (Georgian bar) Ψ_{gb};

For coupled windows and box windows further characteristics must be known to calculate the thermal transmittance of the window:

- Thermal transmittance of the outer and inner window of a box window
- Thermal resistance R_s of the air cavity of a box window or the coupled window

To consider the effect of a closed shutter on the thermal transmittance of a window the

- Thermal resistance of the cavity and the;
- Additional thermal resistance of shutter (incl. cavity) must be known.

Additionally at least the following detailed geometrical data of the window must be known

- Width and height of the window;
- Width of the frames;
- Width of the cavity (only for box windows and coupled windows);

Certain manufacturers provide such detailed performance information on voluntary basis as they have registered their window products in the 'passive house database' of compliant products[21].

It should be noted that the EN 13790 standard for determining building energy performance (heating and cooling demand) also does not require these detailed characteristics.

Chapter 7 presents a qualitative discussion of a possible measure[22]. A quantitative analysis is deemed not possible due to lack of knowledge on the actual use of such information and its impacts.

As to information requirements relating to production, use and end-of-life

[21] See: http://www.passiv.de/komponentendatenbank/en-EN

[22] A quantitative assessment is deemed unrealistic as there is no way of knowing / predicting the share of building developments that use this detailed information, and the (reduction in) energy consumption related to that.

Many manufacturers of window have started to issue EPDs (Environmental product Declarations) that present the life cycle impacts of the product. But although such life cycle information is reaching the market, it is not yet meeting the criteria that the methods are ”quantifiable and be able to be measured using reliable, reproducible and up-to-date measurement standards".

It should be noted that EPD’s (that is, the templates for the EPD’s) are prepared by working groups in the standardisation process without a specific mandate or format. In other words, there is less control over the process than in the case of Ecodesign information requirements, where the template for information to be specified by manufacturers is laid down in an Annex to the Regulation. At the moment the relevant CEN TC33 is planning to draft a new standard defining the basis for the product category rules for windows.

Regarding hazardous substances the standard EN 14351-1 states that "in so far as the state of the art permits, the manufacturer shall establish those materials in the product which are liable to emission or migration during normal intended use and for which emission or migration into the environment is potentially dangerous to hygiene, health or the environment. The manufacturer shall establish and make the appropriate declaration of content according to the legal requirements in the intended country of destination. NOTE An informative database of European and national provisions on dangerous substances is identified in Annex ZA[23]."

→ **Conclusions Ecodesign Directive**

Self-regulation is not considered a viable policy option and will not be further assessed as policy measure for further analysis.

As regards <u>specific requirements on window energy performance</u> the lack of potential savings, the lack of an appropriate target value for harmonisation and the existence of local requirements mean that specific requirements for a minimum energy performance will not be further assessed.

As regards <u>specific requirements on non-energy aspects</u>, the analysis shows that most aspects are already dealt with, or are being dealt with, most often triggered by the REACH Regulation. Therefore it is suggested to continue this path of the REACH Regulation dealing with hazardous substances, as the issue in most cases is not window-specific and is better treated horizontally. The measure will not be further assessed.

As regards <u>generic requirements (information requirements)</u> the discussion of information options shows that the Ecodesign Directive can be used to provide consumers with information regarding specific energy performance parameters. However, requiring more specific information of energy performance of window components (referred to as "detailed energy performance properties", related to glazing, frame, etc. separately) may also lead to higher implementation efforts and costs (more elaborate testing required, which will not automatically lead to a better performing product).

Furthermore, the legal framework set up by the CPR allows Member States to impose (minimum or information) requirements on building products. Where these requirements cover aspects that are not already covered by the standard EN 14351-1, and where these are not considered to compromise the objective of the EU Single Market, the standard may be revised so that the performance is assessed in a harmonised manner.

The above conclusions means that Ecodesign requirements will not be further assessed in section 3.4 'Policy measures for further analysis' and Chapter 4.

3.3.2. ENERGY LABELLING DIRECTIVE 2010/31/EC

The TASK 1 report identified twelve schemes in total in Europe used for energy efficiency (or performance) rating of windows. Admittedly, the UK, Danish and Finnish schemes are the oldest.

All schemes are not mandatory but voluntary. Only one of these schemes, the UK one is defined and referenced in the national building regulation. The majority of these existing voluntary energy labelling

[23] Correct reference: http://ec.europa.eu/enterprise/sectors/construction/cp-ds/index_en.htm

schemes in Europe are not only based on the heat losses (U-value, air tightness) but calculating the energy performance index of a window based on energy balance (including both solar gain and heat loss). For the communication to the “end customer” most labels are using the familiar seven efficiency classes from red to green and labelled A to G.

Comparing the existing schemes, there are different approaches for the evaluation of the energy performance index. All of the schemes are considering the heating situation. The cooling situation (with which is meant not only the use of air conditioners, but also the risk for overheating) is not considered by all schemes. Two schemes consider cooling as part of rating based on annual heating and cooling performance combined: UFME (France) and ANFAJ (Portugal). Cooling is also presented separately as 'summer comfort indicator' in the UFME and ANFAJE scheme. Only one is considering the benefits of sun shading devices (i.e. German ift Rosenheim), especially as far as the cooling situation is concerned.

Information on the actual effectiveness of an window rating scheme could not be retrieved, with the UK scheme as sole exception.

According information received from the BFRC the minimum performance required in UK builing regulations is WER class C. Currently, there were 682869 installations registered, of which 53% were compliant via the WER route. Of these WER registrations 3.61% were A+ rated, 66.69% were A rated, 6.17% wer B rated and 27.06% C rated. This clearly shows that the existing UK WER system is very successful in persuading consumers to purchase higher performing products than required as minimum by Building Regulations (WER = C) and is a successful marketing tool for upselling higher performing products.

The UK situation is however not representative for the rest of the EU: In the UK the introduction of the window rating scheme coincided with a lack of CE marking on products as the UK government did not implement the Construction Products Directive 89/106/EEC until 2011[24]. Therefore the window rating scheme was the only uniform way of comparing window performance. Furthermore, the scheme was incorporated into the English Building Code requirements such that a window with a WER Band C or higher is deemed to satisfy the [2013/current] energy requirements when replacing windows in homes or in buildings that are domestic in character. This is optional for the replacement of windows in domestic buildings and the requirement can also be satisfied by using products with the appropriate U_w value. Note that the WER route is not an option for satisfying the requirements of new build (domestic or non-domestic) or non-domestic replacement.

The label classes according to the UK WER scheme were referenced in the applicable Building Codes for the refurbishment of domestic and domestic in character buildings. These two circumstances made the label quite successful in the sense that many consumers are aware of the label and took the information into account when purchasing windows.

Under the Energy Labelling Directive the EU can introduce the mandatory provision of information at the point of sale, whereby the information relates to energy or other resource consumption during use.

Article 10, Delegated acts 1 states:

> *"The Commission shall lay down details relating to the label and the fiche by means of delegated acts in accordance with Articles 11 to 13, relating to each type of product in accordance with this Article.*
>
> *Where a product meets the criteria listed in paragraph 2, it shall be covered by a delegated act in accordance with paragraph 4.*
>
> *Provisions in delegated acts regarding information provided on the label and in the fiche on the consumption of energy and other essential resources during use shall enable end-users to make better informed purchasing decisions and shall enable market surveillance authorities to verify whether products comply with the information provided.*
>
> *Where a delegated act lays down provisions with respect to both energy efficiency and consumption of essential resources of a product, the design and content of the label shall emphasise the energy efficiency of the product."*

The criteria referred to in paragraph 1 above are the following (paragraph 2):

[24] This has changed as the new Construction products regulation 305/2011/EU is direct applicable in all Member States.

(a) according to most recently available figures and considering the quantities placed on the Union market, the products shall have a significant potential for saving energy and, where relevant, other essential resources;

(b) products with equivalent functionality available on the market shall have a wide disparity in the relevant performance levels;

(c) the Commission shall take into account relevant Union legislation and self-regulation, such as voluntary agreements, which are expected to achieve the policy objectives more quickly or at lesser expense than mandatory requirements.

These criteria correspond to eligibility criteria applied under the Ecodesign Directive, and the product group 'windows' is considered to be eligible, in particular for the parameter 'energy performance' of the window.

The delegated act must specify (paragraph 4):

a) *the exact definition of the type of products to be included;*
b) *the measurement standards and methods to be used in obtaining the information referred to in Article 1(1);*
c) *the details of the technical documentation required pursuant to Article 5;*
d) *the design and content of the label referred to in Article 4, which as far as possible shall have uniform design characteristics across product groups and shall in all cases be clearly visible and legible. The format of the label shall retain as a basis the classification using letters from A to G; the steps of the classification shall correspond to significant energy and cost savings from the end-user perspective.*
e) *the location where the label shall be fixed to the product displayed and the manner in which the label and/or information are to be provided in the case of offers for sale as covered by Article 7. Where appropriate, the delegated acts may provide for the label to be attached to the product or printed on the packaging, or for the details of the labelling requirements for printing in catalogues, for distance selling and Internet sales;*
f) *the content and, where appropriate, the format and other details concerning the fiche or further information specified in Article 4 and Article 5(c). The information on the label shall also be included on the fiche;*
g) *the specific content of the label for advertising, including, as appropriate, the energy class and other relevant performance level(s) of the given product in a legible and visible form;*
h) *the duration of label classification(s), where appropriate, in accordance with point (d);*
i) *the level of accuracy in the declarations on the label and fiches;*
j) *the date for the evaluation and possible revision of the delegated act, taking into account the speed of technological progress.*

These criteria can be met in a delegated act. As regards point (b) 'measurement standards' it should be noted that standards are present, but actual calculation of performance depends on assumptions regarding boundary conditions. This is further discussed in Chapter 6.

→ Conclusions Energy Labelling Directive

The conclusion is that Energy Labelling may be applied to window (label and fiche) but must be limited to information relevant for resource consumption in the use phase only. The label shall use the A-G scale.

However, the effectiveness of an European energy label for windows is difficult to predict as only one of the labelling schemes in the EU provided some information on its effectiveness to transform the market, and this example (the UK WER scheme) is not considered representative. It is assumed that the success of the Label in the UK is also because the label is addressed in the British regulation as one option to show compliance with the requirements for domestic refurbishment. Nonetheless, the label succeeded in convincing consumers to buy windows that perform better than required as minimum.

On the other side, doing nothing means that the current lack of comparable and comprehensive information on window energy performance will remain to exist. There are currently some 12 window label schemes active in Europe. It could very well be that this will be raised to the level that each MS has one or more label schemes in operation withing its borders.

Although the effects of the introduction of an EU window energy label are difficult to quantify, it is expected to be positive as it is considered an effective way (besides more stringent MS requirements on the replacement market as well) to improve window energy performance especially in small scale replacement situations in residential buildings.

The experience with labelling schemes in operation in the EU shows that, if properly aligned with other window related measures, the visibility and recognisability of the label can be significant. A prime example is the UK labelling scheme (BFRC) which has been recognised in the building regulations applicable to window replacement in the UK (see also TASK 1).

Therefore it is concluded that the product group windows fulfils the criteria for establishing an EU Energy Label as:

- windows have a significant potential for saving energy;
- windows show a wide disparity in the relevant performance levels;
- and labelling may support other Union legislation aimed at achieving similar policy objectives.

However, certain questions remain, such as how the label should be designed and how the calculation of performance should take place and what effects can be assigned to an EU energy label. These aspects are further discussed in Chapter 4 (proposed measure) and 5 (scenario and impact analysis).

As the Energy Labelling Directive requires suppliers to provide both a label and a fiche, this fiche may contain the "detailed energy performance properties" as developed under responsibility of TC 89, for more detailed window calculations as in PassiveHouse standards.

As the Energy Label does not involve CE marking this "detailed information" would not affect existing CE marking procedures (as requirements under Ecodesign Directive would). The provision of such additional 'detailed information" is assessed in Chapter 8 Conclusions.

There are some consumer research studies on the effectiveness of labels as applied in the EU. A study [25] from 2013 on the design of the new (recast) label found that:

- New labels are generally well liked/appreciated;
- Participants preferred the look of the new labels compared to the old;
- Reasonably high level of comprehension;
- Certain icons present significant difficulties:
  - This can in principle be addressed through targeted educational efforts such as in---store leaflets and sales staff training;
- Most consumers are able to use labels correctly rank efficiency of products a simple test of comprehension: But a significant minority had difficulty in doing this; evidence that this could be overcome through explanation;
  - suggests education/information at the point of sale needed;
- Proportion of consumers able to use the label drops in more complex consumer comprehension test;
- Most made the connection between the label and energy and efficiency, although significant proportion unaware. Did not greatly hinder how participants used/ understood label;
- Efficiency reasonably important parameter for participants;
- Majority of consumers strongly motivated by the information on the label;
- No significant difference in comprehension between the A-to-G label and the A+++- to-D labels;
- But evidence that higher efficiency classes in the A-to-G label are more motivating than in A+++-to-D label:
  - suggests subdivision of A class has weakened the market transformation impact of the label;
- Many consumers wrongly interpret an efficiency class as being present on the market if it is indicate on the label:
  - suggests this could weaken the market transformation effectiveness of the eligible classes;

[25] "The new energy label: assessing consumer comprehension and effectiveness as a market transformation tool" by Paul Waide and Rowan Watson of Navigant Consulting, Inc, with additional support from Millward Brown and SEVEn, with the assistance of SoWatt (France and Italy), Escan (Spain), KAPE (Poland), Öko-Institut (Germany), and EnEffect (Bulgaria), May 2013. (location: http://www.clasponline.org/en/Resources/Resources/PublicationLibrary/2013/Assessing-Consumer-Comprehension-of-the-EU-Energy-Label.aspx)

- Consumers respond to the division between the three green classes and the rest:
  - suggests this division important when devising efficiency thresholds;
- Most consumers unaware scheme is EU wide:
  - opportunity to promote the role of government in the scheme to enhance credibility.

The recommendations by this study are:

- Consider redrawing the A-to-G efficiency scale in preference to adding more plus signs;
- Maximise the impact of the demarcation between the green and yellow parts of the scale;
- Ensure all efficiency classes indicated on the label are still permitted for sale.
- Review problematic icons and 'Energ[y]';
- Consider increasing awareness of labelling as a government scheme as a way of enhancing trust;
- Strengthen label comprehension through measures to increase consumer understanding;
- Test efficacy of potential future design modifications with consumers before deciding on designs;
- Opportunity to examine reduced market transformation effectiveness of new label found in this study in ongoing and upcoming European Commission funded studies

Whether a proposal for an Energy label for windows will be largely understood and accepted by consumers can not be confirmed within the constraints of this study: For such information a well laid out consumer research study would be needed. On the other hand, many existing energy labels for windows use similar ways to inform consumers.

3.3.3. CPR - Construction Products Regulation 305/2011

Under the Construction Products Regulation 305/2011 (CPR) manufacturers shall declare the performance of their product when placed on the market. This is essentially comparable to a generic (information) ecodesign requirement. Furthermore the CPR allows establishing requirements relating to 'threshold levels' and 'classes of performance'. However, since the CPR is "reacting" to requirements set at EU or national level, the CPR is a "passive" instrument, compared to the "pro-active" approach for specific ecodesign requirements and energy labelling requirements.

Therefore the CPR may overlap with the Ecodesign Directive and Energy Labelling as possible requirements, but its reactive approach makes this very unlikely and its scope is limited to construction products. If the construction product is 'energy related' it could be within scope of the CPR, the Ecodesign Directive an Energy Labelling Directive as well.

The possible CPR measures are stated in the articles presented below:

Related to generic (information) requirements

- Article 3 *Basic requirements for construction works and essential characteristics of construction products*, item 3. "*For specific families of construction products covered by a harmonized standard, the Commission shall, where appropriate and in relation to their intended uses as defined in harmonized standards, determine by means of delegated acts in accordance with Article 60, those essential characteristics for which* ***the manufacturer shall declare the performance of the product*** *when it is placed on the market.*

Related to specific (limit value) requirements

- *Where appropriate, the Commission shall also determine, by means of delegated acts in accordance with Article 60, the* ***threshold levels*** *for the performance in relation to the essential characteristics to be declared.*"
- Article 27, item 3. When provided for in the relevant mandates, the European standardisation bodies shall establish in harmonised standards **threshold levels** in relation to essential characteristics and, when appropriate, for intended uses, to be fulfilled by construction products in Member States.

Related to Energy Labelling requirements

- Article 27, item 1. The Commission may adopt delegated acts in accordance with Article 60, to **establish classes of performance** in relation to the essential characteristics of construction products.

The CPR articles are much less clear as to what criteria need to be fulfilled before the Commission can propose to regulate certain parameters. The CPR mechanism is however entirely different to that of

Ecodesign, as the CPR works through mandates to standardisation bodies that develop standards that describe how the essential characteristics shall be determined . The declaration of performance has to be done according to the CPR. The authority of the CPR is in the hands of the Commission.

CPR and Ecodesign

In case there are Ecodesign specific requirements (*thresholds* under CPR terminology) for certain parameters (*essential characteristics* under CPR terminology) for which there are already minimum requirements / thresholds in harmonised standards cited in the OJEU under CPR, the ecodesign minimum requirements are directly applicable in Member States and prevail over the thresholds included in hENs, as *lex specialis* in the field of sustainable development and energy efficiency. As a consequence, the corresponding standards will need to be adapted accordingly (and the revised versions cited in the OJEU under the CPR when adapted).

As regards information requirements the CPR states in Article 8:

Article 8, General principles and use of CE marking, item 3: For any construction product covered by a harmonised standard, or for which a European Technical Assessment has been issued, the CE marking shall be the only marking which attests conformity of the construction product with the declared performance in relation to the essential characteristics, covered by that harmonised standard or by the European Technical Assessment.

The consequence is, that characteristics "declared" under CPR cannot be again declared under the Ecodesign Directive. This limitation will probably not extend to Energy labelling as energy labelling is not used to attest conformity.

The window performance parameters are as established by EN 14351-1, which gives values for the environmental parameters for facade windows, under CPR basic requirements #6, **<u>when required</u>**:

- Thermal transmittance: overall window U-value U_w in W/m2*K;
- Radiation properties:
    - solar energy transmittance, g-value (dimensionless)
    - light transmission.
- Class of the air permeability.

→ **Conclusions Construction products Regulation**

The conclusion is that the CPR in principle allows similar requirements as under Ecodesign, but that the legal procedure is distinctly different. The arguments to (not) introduce specific or generic requirements are the same as under the Ecodesign Directive.

The question whether generic requirements should be introduced, and under which regulatory framework (Ecodesign or CPR) depends on the level of freedom the Member States will allow for setting requirements. The benefit for establishing these requirements under the CPR is that the responsibility of the work remains at the hands of those who are dealing with it right now (which is CEN TC 33). The benefit for establishing these requirements under the Ecodesign Directive is that the Ecodesign Regulatory Committee has direct influence in the identification of the actual parameters to regulate.

A third possibility is to leave parameters unregulated and let the market sort it out: In case the demand from market actors for information of certain performance parameters increases, manufacturers will be naturally incentivised to supply the data, as is currently the case in the private and voluntary passive house data base of compliant products[26].

Similar to Ecodesign requirements a (possible) measure under the CPR will not be further assessed in section 4 and no quantitative analysis will be performed.

[26] http://www.passiv.de/komponentendatenbank/en-EN

3.3.4. EPBD - Energy Performance of Buildings Directive2010/31/EU

The Directive 2010/31/EU on the energy performance of buildings lays down requirements as regards (emphasis by author):

1. the common general framework for a methodology for calculating the integrated energy performance of buildings and building units;
2. the application of minimum requirements to the energy performance of new buildings and new building units;
3. the application of minimum requirements to the energy performance of:
    a. (i) existing buildings, building units and **building elements** in the context of major renovation;
    b. (ii) **building elements** that form part of the building envelope and that have a significant impact on the energy performance of the building envelope when they are retrofitted or replaced; and
    c. (iii) technical building systems whenever they are installed, replaced or upgraded;
4. national plans for increasing the number of nearly zero- energy buildings;
5. energy certification of buildings or building units;
6. regular inspection of heating and air-conditioning systems in buildings; and
7. independent control systems for energy performance certificates and inspection reports.

The requirements established for **building elements**[27] are of particular interest to this study as these may comprise requirements for windows (as an element of the building envelope).

In accordance with article 4 Member States shall take the necessary measures to ensure that minimum energy performance requirements are set for building elements that form parts of the building envelope and that have a significant impact on the energy performance of the building envelope when they are replaced or retrofitted, with a view to achieving cost-optimal levels.

Regarding existing buildings article 7 requires Member States to take the necessary measures to ensure that when a building element that forms part of the building envelope and has a significant impact on the energy performance of the building envelope, is retrofitted or replaced[28], the energy performance of the building element meets minimum energy performance requirements in so far as this is technically, functionally and economically feasible.

With regard to the methodology to apply for setting requirements, the positive influence of (a.o.) ***local solar exposure conditions*** shall, where relevant in the calculation, be taken into account (in accordance with Annex I, item 4(a)). This means that the requirements for building elements mentioned above should consider solar gains (thus for windows, should consider the g-value) whereas this is currently not the case in many Building Codes (as shown in Task 1, national requirements).

An expansion of scope of the EPBD to overall environmental performance (including non-energy aspects), could -in theory- allow setting stricter environmental performance requirements by MS than set under Ecodesign (if any) following the amendment by the EED (see Section 3.3.5). However, as long as the EPBD focuses on energy performance only, the setting of stricter resource efficiency requirements for products regulated under Ecodesign is not allowed.

The Energy Performance of Buildings Directive (EPBD, 2010/31/EU) suggests that product level legislation and system-level building regulations should be complementary. In recital 12 of the EPBD it says: *'When setting energy performance requirements for technical building systems, Member states should use, where available and appropriate, harmonised instruments, in particular testing and calculation methods and energy efficiency classes developed under measures implementing Directive 2009/125/EC on ecodesign requirements for energy-related products, and Directive 2010/30/EU on labelling, with a view to ensuring coherence with related initiatives and to minimise, to the extent possible, potential fragmentation of the market'*. Although a

[27] According Article 2(9) of 2010/31/EU 'building element' means a technical building system or an element of the building envelope. Element is not further specified.

[28] Note that 'retrofit' or 'replacement' are not defined in the EPBD, so it depends on the actual Building Code in the specific MS if and which requirements apply.

recital carries no legal requirement, the intention or desire of the Commission to remove inconsistent approaches is evident.

→ **Conclusions Energy Performance of Buildings Directive**

The conclusion is that the EPBD already incorporated all elements for a proper consideration of the energy performance of windows (not only the U value, but also considering local solar exposure conditions). How this is implemented in MS Building Codes is however left to the Member States. Judging by the requirements set by member States on windows, most are simply based on U values.

The EPBD as policy option will not be further assessed in the following section 4 as there is no quantitative analysis to be performed. However, the fact that many MS have requirements for windows based on U_W only, is important for the consideration of Energy labelling as possible option.

3.3.5. EED – ENERGY EFFICIENCY DIRECTIVE 2012/27/EU

In case products are covered by Ecodesign implementing measures, Member States cannot set stricter requirements to those product as that would hamper the internal market. But Article 27 of the Energy Efficiency Directive (EED) 2012/27/EU opened the door to allow Member States to set stricter requirements for building components in the context of building energy performance requirements under EPBD 2010/31/EU, as long as this does not result in unjustifiable barriers to trade.

- According EED Article 27, item 3(1) the following recital is added: *(35a) Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (*) requires Member States to set energy performance requirements for building elements that form part of the building envelope and system requirements in respect of the overall energy performance, the proper installation, and the appropriate dimensioning, adjustment and control of the technical building systems which are installed in existing buildings. It is consistent with the objectives of this Directive that these requirements may in certain circumstances limit the installation of energy-related products which comply with this (EED) Directive and its implementing measures, provided that such requirements do not constitute an unjustifiable market barrier*;
- According EED Article 27, item 3(2) the following sentence is added to the end of (Ecodesign) Article 6(1) on Free Movement: *'This shall be without prejudice to the energy performance requirements and system requirements set by Member States in accordance with Article 4(1) and Article 8 of Directive 2010/31/EU.'.*

This means that Member States may require a stricter product performance (under EPBD) than required under Ecodesign measures covering the same product.

According EED Article 4 *"Member States shall establish a long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private".*

A first version of the strategy shall be published by 30 April 2014 and updated every three years thereafter and submitted to the Commission as part of the National Energy Efficiency Action Plans.

The public sector is to lead by example by renovating 3% of buildings owned and occupied by the central governments starting from 01 January 2014 and by including energy efficiency considerations in public procurement – insofar as certain conditions are met (e.g. cost-effectiveness, economic feasibility) – so as to purchase energy efficient buildings, products and services.

→ **Conclusions Energy Efficiency Directive**

The EED does not allow for setting requirements or measures specifically to windows, although the EED requirements themselves are expected to stimulate the uptake of efficient windows (at least for the government owned buildings).

The (possible) measure will not be further assessed in the following section 4 as there is no quantitative analysis to be performed.

3.3.6. EUTR - Timber Regulation 995/2010

On 20 October 2010, the European Union adopted Regulation 995/2010[29], the EU Timber Regulation (EUTR) to prevent sales of illegal timber products in the EU.

The EUTR imposes three key requirements on EU Operators and Traders that "first place" forest products on the EU market:

1. The EUTR prohibits the import of illegally produced timber products to the EU market;
2. Timber products with a Forest Law Enforcement Governance and Trade (FLEGT) or CITES license will be accepted as legal. In the absence of these licenses Operators must use "due diligence" to verify the legal status of the timber products to minimise the risk of illegal wood entering the EU. Any such company failing to demonstrate due diligence, or found to have placed illegally harvested wood on the EU market, is subject to legal sanction.
3. Once timber products are placed on the EU market subsequent Traders must maintain records of their suppliers to ensure traceability back to the point of import.

The EUTR covers a wide range of timber and wood products, as listed in its annex using EU customs code labelling. Wooden windows are covered as the annex includes code 4418 *"Builders' joinery and carpentry of wood, including cellular wood panels, assembled flooring panels, shingles and shakes"* which covers sub-code 4418 10 *"Windows, French windows and their frames"*.

EU Member States are responsible for overseeing and applying the law.

From 3 March 2013, any Operator who imports timber products into the EU market must ensure that these products have been legally produced at first point of entry. 'Legally harvested' means harvested in accordance with the applicable legislation in the country of harvest. 'Applicable legislation' means the legislation in force in the country of harvest covering the following matters:

- rights to harvest timber within legally gazetted boundaries,
- payments for harvest rights and timber including duties related to timber harvesting,
- timber harvesting, including environmental and forest legislation including forest management and biodiversity conservation, where directly related to timber harvesting,
- third parties' legal rights concerning use and tenure that are affected by timber harvesting, and
- trade and customs, in so far as the forest sector is concerned.

→ **Conclusions European Timber Regulation**

The EUTR provides an existing legal framework for addressing concerns about the illegally traded wood products, including windows. Additional (under Ecodesign or CPR) requirements regarding legal sourcing of wooden window (products) will thus not add to the existing legal framework.

The EUTR as (possible) policy option for windows will not be further assessed in section 3.4.

[29] O.J. L 295/23, 12.11.2010, REGULATION (EU) No 995/2010 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 October 2010 laying down the obligations of operators who place timber and timber products on the market

3.3.7. WFD – Waste Framework Directive 2008/98/EC

The European Waste Framework Directive is driving the member states towards reducing, reusing and recycling of Construction & Demolition Waste (CDW). Under Article 11.2.b a target of 70% material recovery for construction and demolition waste is set.

In areas where landfills are restricted for different reasons, the rising price for dumping CDW on landfills creates an additional stimulus for recycling of non-ferrous materials until these processes will be cost-covering.

3.4. Policy measures for further analysis

The following policy options have been selected for further analysis:

- Energy labelling.

The measure will be elaborated in Chapter 4.

CHAPTER 4 POLICY MEASURE FOR FURTHER ANALYSIS

4.1. INTRODUCTION POLICY MEASURE FOR FURTHER ANALYSIS

The previous chapter has shown that an EU Energy Label scheme for façade and roof windows (for the residential sector) provides opportunities to address the following issues:

- to improve consumer understanding of window performance, and differences in performance of products. This requires an information campaign to introduce the label and to educate the audience about the main elements of the label.
- to introduce in the building community the aspect of window performance rating on the basis of an energy balance, and not just solely the consideration of the U_w of the window;
  - the EU label could give an incentive to Member States to base their building element requirements for windows on this EU approach by referring to a minimum required performance as established in accordance with the label. The technical fiche would provide this performance.
- to promote the use of adaptive windows, ie. windows that can 'change' their characteristics in order to achieve a better performance. This requires that the label considers the use of adaptive elements such as moveable shading devices. This aspect should be included in the information campaign so that the adaptive element is used properly.

This chapter describes the proposed measure (Energy Labelling of windows) in more detail. This chapter has been thoroughly revised/rewritten after its first publication in the draft TASK 7 report published on 24 February 2015. The revision followed after consideration of comments from Commission Services and stakeholders on the draft TASK 7 report.

The following two sections show how these comments have been considered in revised proposals for measures.

The first part of this section describes the basic method for establishing window performance. This part is mainly intended to show that a robust method can be developed and applied in a regulatory context for the performance rating of façade and roof windows. A large part is dedicated to describing the underlying methodology for assessing performance of façade and roof windows, as this method is the basis for the former and revised proposal.

The second part describes the window energy label proposal. This section includes various comments from main stakeholders received on the former (draft) proposal (see Annex VI for former, draft, proposal).

For the purpose of shortening references to the many windows types assessed in this chapter, the following designation shall be used throughout this and subsequent chapters and annexes.

Table 3 Descriptions of windows types assessed in this chapter

Window designation	U_W W/(m^2*K)		g	Description of typical facade window (for roof windows, see specific descriptions)	Shortened description	
	if facade window	if roof window	[-]		if facade window	if roof window
without shutters (or other window covering, shading devices)						
1a	5.8	6.6	0.85	single	Uw 5.8 / g 0.85	Uw 6.6 / g 0.85
2a	2.8	3.2	0.78	double IGU, standard	Uw 2.8 / g 0.78	Uw 3.2 / g 0.78
3a	1.7	2.1	0.65	double IGU, lowE, argon	Uw 1.7 / g 0.65	Uw 2.1 / g 0.65
4a	1.3	1.7	0.6	double IGU,lowE, argon, impr	Uw 1.3 / g 0.6	Uw 1.7 / g 0.6
5a	1	1.1	0.55	triple IGU, lowE, argon	Uw 1 / g 0.55	Uw 1.1 / g 0.55

Window designation	U_W W/(m^2*K)		g	Description of typical facade window (for roof windows, see specific descriptions)	Shortened description	
6a	0.8	0.9	0.6	triple IGU, lowE, argon, impr.	Uw 0.8 / g 0.6	Uw 0.9 / g 0.6
7a	1	1.1	0.58	coupled	Uw 1 / g 0.58	Uw 1.1 / g 0.58
8a	0.6	0.7	0.47	quadruple	Uw 0.6 / g 0.47	Uw 0.7 / g 0.47
9a	2.8	3.2	0.35	as 02, with solar control glazing	Uw 2.8 / g 0.35	Uw 3.2 / g 0.35
10a	1.3	1.7	0.35	as 04, with solar control glazing	Uw 1.3 / g 0.35	Uw 1.7 / g 0.35
11a	0.8	0.9	0.35	as 06, with solar control glazing	Uw 0.8 / g 0.35	Uw 0.9 / g 0.35
with shutter						
1b	5.8	6.6	0.85	single	Uw 5.8 / g 0.85 shading	Uw 6.6 / g 0.85 shading
2b	2.8	3.2	0.78	double IGU, standard	Uw 2.8 / g 0.78 shading	Uw 3.2 / g 0.78 shading
3b	1.7	2.1	0.65	double IGU, lowE, argon	Uw 1.7 / g 0.65 shading	Uw 2.1 / g 0.65 shading
4b	1.3	1.7	0.6	double IGU,lowE, argon, impr	Uw 1.3 / g 0.6 shading	Uw 1.7 / g 0.6 shading
5b	1	1.1	0.55	triple IGU, lowE, argon	Uw 1 / g 0.55 shading	Uw 1.1 / g 0.55 shading
6b	0.8	0.9	0.6	triple IGU, lowE, argon, impr.	Uw 0.8 / g 0.6 shading	Uw 0.9 / g 0.6 shading
7b	1	1.1	0.58	coupled	Uw 1 / g 0.58 shading	Uw 1.1 / g 0.58 shading
8b	0.6	0.7	0.47	quadruple	Uw 0.6 / g 0.47 shading	Uw 0.7 / g 0.47 shading
9b	2.8	3.2	0.35	as 02, with solar control glazing	Uw 2.8 / g 0.35 shading	Uw 3.2 / g 0.35 shading
10b	1.3	1.7	0.35	as 04, with solar control glazing	Uw 1.3 / g 0.35 shading	Uw 1.7 / g 0.35 shading
11b	0.8	0.9	0.35	as 06, with solar control glazing	Uw 0.8 / g 0.35 shading	Uw 0.9 / g 0.35 shading

4.2. BASIC METHOD FOR ESTABLISHING ENERGY PERFORMANCE OF WINDOWS

4.2.1. CALCULATION METHODS

The preferred method proposed to establish energy performance of windows is an **energy balance**. This refers to the notion that not only energy losses should be considered (related to the U_W value) but also energy gains from solar irradiance (related to the g value of the window).

Some stakeholders have argued that the performance of the window should be based on complex, sophisticated, dynamic modelling tools, based on hourly calculations of energy flows. However, for the purpose of labelling by suppliers (these are manufacturers or importers of windows) such calculations are considered too complicated as it requires analysis and modelling of vast amounts of data (outside and inside teperatures, solar irradiance levels, outher boundary conditions like ventilation rates, U value of opaque elements, etc.). Such calculations are simply not feasible for the 70 to 90 million window products placed on the market annually by several thousands of suppliers.

Also the 'adiabatic' method as applied in the Task 4 report is considered to be too complex for regulatory purposes.

The most preferred option are the use of simple energy balance equations which require as inputs only the window energy characteristics, established using harmonised standards also used for CE marking. The fixed parameters in these equations however, have been identified using complex dynamic hourly assessment models.

Such energy balance equations have been introduced in 2002 in the EWERS studies[30] (European Window Energy Rating Scheme) and are also described in the relevant standards ISO 18292 in conjunction with EN ISO 13790. Such energy balance equations are therefore considered to be acceptable as basis for window energy rating. They are also applied by the majority of the current existing window rating schemes operating

[30] Spiekman, M.E., van Dijk, H.A.L., 'Development of energy rating method. Part 2 – Discussion document', 13 January 2002, EWERS-document, and Spiekman, M.E., van Dijk, H.A.L., 'Development of energy rating method. Part 3 – Discussion document', 25 April 2002, EWERS- document

nationally (examples of schemes using energy balance equations: UK/BFRC, DK/Vindues, FI/Energia Ikkuna, FR/UFME).

→ Basic calculation methods

In general the method to calculate the label information considers the following points:

- The determination of the energy performance of windows is based on international standards, in particular EN ISO 13790[31] and ISO 18292[32];
- The energy label information addresses both the performance for heating and cooling. Even if there is no artificial cooling in the building, the energy performance indicator would be useful to assess a possible risk for overheating;
- The following main characteristics of a window are considered, in accordance with ISO 18292:
  - Heat losses of the window due to thermal transmittance;
  - Heat gains of the window due to solar radiation;
  - Heat losses of the window due to air infiltration;
- To avoid excessive additional burden for the manufacturers all necessary characteristics of the window shall be determined according to harmonised European standards;
- Small variations of the relevant boundary conditions should not lead to significant different ranking of different design options.

As a consequence of the above points the energy label for windows should be limited to applications (buildings) where the assumed boundary conditions are representative and vary only within certain limits. Residential buildings are fulfilling these requirements in general.

Non-residential buildings can differ significantly in the relevant parameters (e.g. ratio of the window area to floor area; internal loads, usage etc.). Variations in boundary conditions may have a significant impact on the energy performance of different design options / window types and thus on the ranking. To find the best design option for such buildings a holistic approach is preferred, considering all the relevant parameters of the building and its components.

As stated the calculation method to be applied to establish the energy performance of a window, must be simple and robust. The following paragraphs show how this simple and robust method, based on energy balance equations, has been derived from (and validated by) more detailed, elaborate calculations.

ISO 18292 identifies two basic types of method for calculating building energy use for space heating and cooling, which can be used for window performance assessment:

1. quasi-steady-state methods, calculating the heat balance over a sufficiently long time (typically one month or a whole season), which enables one to take dynamic effects into account by an empirically determined gain and/or loss utilization factor;
2. dynamic methods, calculating the heat balance with short times steps (typically one hour) taking into account the heat stored in, and released from, the mass of the building.

These two basic approaches can be put into practice in various ways. ISO 18292 describes three different calculation procedures:

1. a fully prescribed **monthly** quasi-steady-state calculation method (plus, as a special option, a **seasonal** method);
2. a fully prescribed **simple hourly** dynamic calculation method;
3. calculation procedures for **detailed** (e.g. hourly) dynamic simulation methods

The monthly (and seasonal) calculation gives correct results on an annual basis, but the results for individual months close to the beginning and the end of the heating and cooling season can have large relative errors. The monthly energy balance calculation method is a more elaborate implementation of what essentially is a seasonal energy balance calculation method.

[31] Energy performance of buildings — Calculation of energy use for space heating and cooling (ISO/TC 163/SC 2)

[32] Energy performance of fenestration systems for residential buildings — Calculation procedure (ISO/TC 163/SC 2)

The alternative method for simple hourly calculations has been added to facilitate the calculation using hourly user schedules (such as temperature set-points, ventilation modes, operation schedule of movable solar shading and/or hourly control options based on outdoor or indoor climatic conditions).

The procedures for the use of more detailed simulation methods ensure compatibility and consistency between the application of different types of method and must be done using specialised software.

For the purpose of establishing the energy performance of windows, the 'simple hourly method' is considered to have an acceptable balance between simplicity and accuracy. The equations to be used for the simple hourly dynamic calculation are presented in EN 13790, Section 7.2.2 and Annex C (some 13 equations in total).

The simple hourly calculation method defined in EN ISO 13790 is a simplification of a detailed dynamic simulation, with the following advantages:

- clearly specified, limited set of equations, enabling traceability of the calculation process;
- reduction of the input data as much as possible;
- unambiguous calculation procedures;
- with main advantage that the hourly time intervals enable direct input of hourly patterns.

EN ISO 13790 states, that the model has an adequate level of accuracy, especially for room-conditioned buildings where the thermal dynamic of the room behaviour is of high impact.

Inputs to the 'simple hourly dynamic calculation' are window characteristics and boundary conditions (and certain physical constants). The boundary conditions describe how the window interacts with its environment and describes properties of this environment. The calculation starts with selecting a climate condition that defines outdoor temperatures and solar irradiance and requires defining the space that is climatised (we used both the 'single room model' and the 'family house model'), the characteristics of this space (e.g. U value of opaque elements, thermal mass) and how the space 'responds' to changing conditions (such set points for activation of solar shading, night time ventilation rates). Characteristics and boundary conditions

The main window characteristics, described in the table below, are determined according to harmonized European standards and in accordance to ISO 18292. This information is in general available from the window manufacturer. Therefore there is limited to no additional burden as far as the determination of the relevant characteristics is concerned.

Table 4 Window characteristics required for calculation of energy performance of windows

Symbol	Characteristic	Unit	Source
U_W	Thermal transmittance of the window	W/(m²K)	CE Label for windows, Determination and declaration according to hEN 14351-1, Mandated characteristic
$U_{W,S}$	Thermal transmittance of the window with closed shutter	W/(m²K)	Determination according to EN ISO 10077-1 or EN ISO 12567-1 Note: hEN 14351-1 is currently amended regarding the determination of $U_{W,S}$
ΔR	Additional thermal resistance of a closed shutter	(m²K)/W	CE Label for shutters and external venetian blinds, Determination and declaration according to hEN 13659, Mandated characteristic
Q_{100}	reference air permeability at a test pressure of 100 Pa	m³/(h m²)	CE Label for windows, Determination and declaration of the relevant class according to hEN 14351-1, Mandated characteristic Class 1 : 50 m³/(h m²) Class 2 : 27 m³/(h m²) Class 3 : 9 m³/(h m²) Class 4 : 3 m³/(h m²)
g	Solar energy transmittance of the transparent part of the window	-	CE Label for windows, Determination and declaration according to hEN 14351-1, Mandated characteristic Note: hEN 14351-1 is currently amended regarding the determination of g_w

g_t	Solar energy transmittance of the transparent part of the window with shutter closed	-	CE Label for windows, Determination and declaration according to hEN 14351-1, Mandated characteristic Note: hEN 14351-1 is currently amended regarding the determination of $g_{w,t}$
F_F	Frame fraction of the window	-	Determination according to EN ISO 10077-1 Note: hEN 14351-1 is currently amended regarding the determination of F_F. It is expected that F_F will become a mandated characteristic in near future

The method also requires consideration of certain constants as described in the table below.

Table 5 Constants required for calculation of energy performance of windows

Symbol	Characteristic	Value	Unit	Source
Δp	Fixed pressure difference for the calculation of the infiltration	6	Pa	ISO 18292
ρc_p	the thermal capacitance of air	0,344	$Wh/(m^3K)$	ISO 18292

Since a possible energy label is primarily intended for the residential market the calculations were carried out for a fixed ratio of the window area A_W to the floor area A_{floor} of 20%. According to literature and other studies[33] this ratio can be seen as representative for residential buildings.

The other boundary conditions assumed for the calculations have been as follows:

Table 6 Level of thermal insulation of the investigated buildings

Climate		Mean U-value of the building envelope $\tilde{U}_{env}$ in W/m^2K
North	Single room	0,6
	Single family house "old"	0,6
	Single family house "renovated"	0,3
Central	Single room	0,8
	Single family house "old"	0,8
	Single family house "renovated"	0,4
South	Single room	1,0
	Single family house "old"	1,0
	Single family house "renovated"	0,6

Table 7 Boundary conditions and other parameters used for the calculation in the heating and cooling season

Parameter		*Source*
window-to-floor ratio	20%	[several sources use identical value]
Pressure Difference Δp	Δp=6 Pa	ISO 18292

[33] Proposal for Energy Rating Systemof windows in EU; DTU Civil Engineering-Report R-201 (UK); ISBN: 9788778772787

Temperature set point for heating	$T_{i,set}$ = 20°C	Table G.12 EN 13790
Temperature set point for cooling	$T_{i,set}$ = 26°C	Table G.12 EN 13790
Heat Capacity	heavy C^*_m = 260 000J/m^{2}K (A_{floor})	EN ISO 13790
Ventilation rate	n=0.5 h^{-1}	DIN 4108-2 See also Table G.12 EN 13790
Ventilation rate assuming ventilative cooling	n=2.0 h^{-1} for Ti>23°C and Ti>Te	DIN 4108-2
Internal heat sources (related to floor area)	Q_i =5 W/m^2	DIN 4108-2 , see also Table G.8 EN 13790
Usage	24 h/7 days a week	
Set point for activation of the sun shading during heating period	Scenario 1: The shutter was closed from sunset to sun rise Scenario 2: The shutter was closed from 22:00 to 6:00	[no reference]
Set point for activation of the sun shading during cooling period	I_{sol} > 300 W/m^2 and T_e > 15°C	EN ISO 13790

The relevant standard for the calculation of energy use for space heating and cooling EN ISO 13790 states in its Annex G:

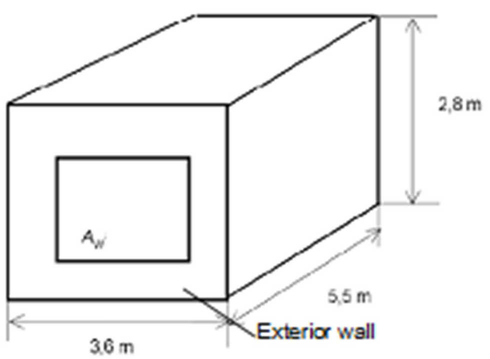
"Unless otherwise specified at national level, the solar shading shall be taken as being switched on if the intensity of the solar radiation on the surface at the given hour exceeds 300 W/m^2 and switched off if the hourly value is below this value."

Therefore the set point for the activation of the solar shading was defined at a level of I_{sol} = 300 W/m^2. Note: The solar shading was activated only if the external temperature T_e was higher than 15°C.

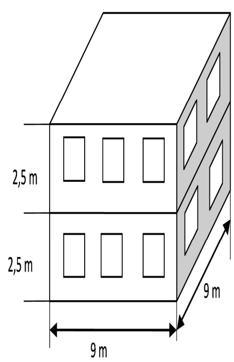
The ABC/XYZ approach can be applied to either a single room model, or a single family model. Each has its own advantages and disadvantages as presented in Table 8.

Figure 3 Single room model and single family house model

Single room model according to EN 13791; V = 55,4 m³; Afloor = 19,8 m²



Simplified single family house; V = 405 m³; Afloor = 2x81 m²=162 m²



Adiabatic vs. ABC/XYZ

The simple hourly dynamic calculation can either be performed on the basis of the 'adiabatic' method (as applied in Task 4, for the identification of the best available technology) or following an approach that allows identification of so-called 'ABC/XYZ' values.

The adiabatic approach has as downside that it requires extensive calculations to establish the window performance. Such calculations are not feasible in the regulatory context, as they must rely on software implemented calculation rules. It would be practically impossible to write down these rules in a regulatory document.

The ABC/XYZ approach is much better suited for regulatory purposes. This approach also relies on extensive calculations, but only as preparation. Once these calcualtions are finalised, averaged ABC and XYZ values can be defined from the calculated results and these averaged values can easily be implemented in regulatory documents. In fact, many other energy labelling schemes in Europe have applied this method.

Single room model vs. Single family house

As explained also in the Annex the calculations for the single family house are based on the approach of a "one-zone" model. In a one-zone model it is assumed, that there is only one representative air temperature; meaning that the temperature in different rooms is the same. Furthermore the "one-zone" model approach assumes that the solar gains achieved through a window will serve as an energy input for the complete building and not only for the room where the window is installed. The solar gains are distributed evenly; they are smoothed over the complete building. Therefore the so called utilization factor is the same for all windows.

The calculations of the single room model are based per definition (only one room) on the one zone model approach.

While a one-zone **building** model (as in the single family house) can be used for the calculation of an averaged energy performance index for cooling it might be misleading in the identification of thermal comfort in specific rooms. Even if there is minor energy need for cooling in a dwelling (calculated as a one zone building) there might be an increased energy need for cooling in a specific room. Therefore there could be a significant risk of overheating if no measures would be applied.

But if there is a (critical) room in a building that has a certain risk of overheating (also meaning less comfort) the primary energy related characteristic of the window that is able to influence the risk of overheating is the g-value of the window.

The following tables presents the (dis)advantages of the adiabatic versus the ABC approach, and the single room versus the family house approach.

Table 8 Advantages and disadvantages of adiabatic / ABC and single room / family house

Assumed building	advantage / disadvantage	Method to determine the energy associated to the windows		Remarks
		Dynamic hourly calculation **"Adiabatic" apporach**	**Seasonal method (also in principle based on dynamic hourly calculation)** **"ABC/XYZ factors"**	
		The "adiabatic approach" is more "precise" than ABC, but can not be used for regulatory purposes, because a software tool is necessary to calculate the energy performance of a specific window.	To derive the ABC and XYZ values also hourly calculations have to be performed. Identification of ABC/XYZ follows procedures as described in Annex I and II Once these ABC/XYZ values are defined, the calculation of the energy performance of a window is based on simple equations and allows simple integration into regulatory text.	
Single room	advantage	The single room (here in combination with the adiabatic approach) has the advantage that façade and roof window effects can easily be separated (apply the solar radiation data for the relevant inclination for roof window). Also the effects of a different orientation of facade or roof window can be assessed.	The single room (here in combination with the ABC/XYZ approach) has the advantage that façade and roof window effects can easily be separated (apply the solar radiation data for the relevant inclination for roof window). Also the effects of a different orientation of facade or roof window can be assessed.	The single room approach may be more representative of apartment buildings as the exterior envelope is reduced. It may be more representative for a cooling situation as usually only a limited numbers of spaces require cooling.
	disadvantage	The heat loss in the single room is minimal as other walls are adiabatic. Therefore the utilisation factor for solar gains in winter is low (compared to single family house). Summer solar gains lead much faster to overheating.	The heat loss in the single room is minimal as other walls are adiabatic. Therefore the utilisation factor for solar gains in winter is low (compared to single family house). Summer solar gains lead much faster to overheating.	
Single Family house **(single zone approach)**	advantage	The single family house in combination with the adiabatic approach has a more realistic calculation of heat losses of the building and therefore a higher and more realistic utilisation factor for solar gains (compared to single room model).	The combination of the single family house and the ABC approach allows the effects of window orientation to be assessed – this does assume that utilisation rate is same for all windows and only radiation per window is different. The combination of the single family house and the ABC approach can be used to assess effects for roof and façade windows separately (same utilisation rate applied to specific window, difference related to solar irradiance only).	The family house may be more representative for window replacement in a single family dwelling setting. As a single zone is defined solar gains of a specific window are distributed over the whole house which may lead to under- or overestimating the cooling needs .
	disadvantage	As this model assumes one representative air temperature for the whole zone (total house), the risk of possible **overheating** may be underestimated when compared to a situation that surplus heat is not evenly distributed over the complete dwelling. Also it is **not possible** to differentiate effects per orientation or per inclination. The single zone means heat gains are distributed over whole zone.	The combination of the single family house and the ABC approach assumes one representative air temperature for the whole zone (total house), the risk of possible **overheating** may be underestimated when compared to a situation that surplus heat is not evenly distributed over the complete dwelling.	

Considering the above presented advantages and disadvantages it is recommend to propose the performance rating on values established using the ABC/XYZ approach: This approach is simpler (once the ABC values etc. have been established) and fits better in a regulatory context.

As regards the assumed building used to establish ABC or XYZ values, both approaches (single room and family house) are a possibility: The single room approach offers advantages for the assessment of the cooling performance (less chance of underestimating). The family house offers a more realistic aproach for the heating performance as the overall surface for heat losses is larger and the utilisation factor is higher.

Note: Using the hourly method, each window type has its own specific set of ABC/XYZ values. This means that the ABC/XYZ values as identified using the hourly calculations cannot be DIRECTLY used for window rating, as each window type would have its own set ABC/XYZ parameters. One would need as much calculation tables and values as there are window types. This approach is not feasible as not each permutation of U value, g value or other variant in boundary condition is known to the legislator.

Instead the following sections shows how window label rating could be based on calculation of window performance using **average** ABC/XYZ values.

4.2.2. ENERGY PERFORMANCE INDEX FOR HEATING

→ **Simplified approach for heating**

The window energy performance index for heating $P_{E,H,W}$ can be determined according to the following energy balance equation.

Equation 1

$$P_{E,H,W} = A \cdot (U_{W,eff} + H_{ve,w}) - B \cdot g_W$$

The first term 'A' characterises the heat losses due to thermal transmittance and infiltration. The second term 'B' characterises the heat gains due to solar radiation. If the second term is larger than the first the energy performance index becomes negative. This is the case if the solar energy gains of a window are higher than the energy losses. In that condition the window is a net energy gaining building element. The energy gain can be used to compensate energy losses of other building elements e.g. wall, roof. The most energy efficient window has the lowest (or even a negative) performance.

This equation (and others that follow below) is constructed from various equations presented in EN 13790:2007 (e.g. paragraph 7.2.1.1, equation 3, describing energy needs for heating) and ISO 18298 (e.g. paragraph 6.2, equation 8, describing heating energy needs, and paragraph 6.4.2, equation 15, describing the overall solar heat gain). It is also described in the EWERS documents[34].

The effective thermal transmittance of the window $U_{W,eff}$ is calculated according to:

Equation 2

$$U_{W,eff} = (1 - C) \cdot U_W + C \cdot U_{W,S}$$

and $U_{W,s}$ is calculated according to:

[34] Spiekman, M.E., van Dijk, H.A.L., ‘Development of energy rating method. Part 2 – Discussion document’, 13 January 2002, EWERS-document, and Spiekman, M.E., van Dijk, H.A.L., ‘Development of energy rating method. Part 3 – Discussion document’, 25 April 2002, EWERS- document

Equation 3

$$U_{W,S} = \left(1/U_W + \Delta R\right)^{-1}$$

The equation takes into account the reduction of the thermal transmittance of the window with a closed shutter (factor ΔR).

The transmittance caused by infiltration $H_{ve,w}$ is calculated according to

Equation 4

$$H_{ve,w} = \left(\frac{\Delta p}{100Pa}\right)^{2/3} \rho \cdot c_p \cdot Q_{100}$$

The solar energy transmittance of the window g_W is calculated according to

Equation 5

$$g_W = g \cdot (1 - F_F)$$

Other parameters are as defined in the Table 7 for boundary conditions.

It must be noted, that the U-value of the roof window is also a function of the inclination. As described in TASK 4 the increase of the U-value should be considered when calculating the energy performance index for heating for roof windows. The CE mark for roof windows currently states only the U-value for vertical installation. Therefore a simple correction of the declared U-value to a design value is proposed.

Equation 6

$$U_{W,des} = U_W + \Delta U_W = U_W + F_F \cdot \Delta U_g$$

The ΔU_g value can be calculated according to EN 673 as the difference of the U_g value for vertical installation and the U_g value for an inclination of 40°.

Table 9 and Table 10 are showing calculated ΔU_g values as a function of different IGU constructions assuming:

- a representative gas filling rate of 90% for Ar (Argon) and Kr (Krypton);
- one low e coating in the cavity of a double IGU and two low e coatings in the cavites of a triple IGU (one coating in each cavity);
- that the cavity width of the first and second cavity of a triple IGUs is equal.

Table 9 ΔU_g in W/(m²K) for double IGUs for an inclination of 40°

	Air filling				Argon filling			Krypton filling	
Cavity width in mm	Air filling ε_n = 0.89	Air filling ε_n = 0.02	Air filling ε_n = 0.05	Air filling ε_n = 0.10	Ar filling ε_n = 0.02	Ar filling ε_n = 0.05	Ar filling ε_n = 0.10	Kr filling ε_n = 0.02	Kr filling ε_n = 0.05
8								0.34	0.33
10	0.34	0.19	0.19	0.21	0.19	0.20	0.21	0.47	0.45
12	0.43	0.38	0.38	0.37	0.35	0.35	0.35	0.41	0.42
14	0.50	0.51	0.52	0.50	0.47	0.46	0.46	0.38	0.40
16	0.54	0.60	0.58	0.58	0.48	0.47	0.46		
18	0.53	0.57	0.56	0.55	0.46	0.45	0.44		

Table 10 ΔU_g in W/(m²K) for triple IGUs for an inclination of 40°

Cavity width in mm	Air filling ε_n = 0.02	Air filling ε_n = 0.05	Air filling ε_n = 0.10	Ar filling ε_n = 0.02	Ar filling ε_n = 0.05	Ar filling ε_n = 0.10	Kr filling ε_n = 0.02	Kr filling ε_n = 0.05
2 x 8	0.05	0.05	0.06	0.03	0.03	0.04	0.05	0.06
2 x 10	0.03	0.04	0.04	0.02	0.02	0.03	0.14	0.16
2 x 12	0.04	0.04	0.05	0.06	0.06	0.06	0.22	0.22
2 x 14	0.14	0.13	0.14	0.13	0.13	0.12	0.21	0.22
2 x 16	0.22	0.20	0.20	0.19	0.19	0.18		
2 x 18	0.27	0.27	0.26	0.24	0.23	0.22		
2 x 20	0.30	0.30	0.29					

The ΔUg value for a single pane can be calculated to ΔUg = 1.2 W/(m²K)

Analysing the calculated data it can be seen, that there is only minor influence of the emissivity of the low e coating on the ΔUg value. Therefore it is proposed to use a representative emissivity of ε_n = 0,05 for drafting tabulated values of ΔUg. Such tabulated values could be used as an alternative to the detailed calculation according to EN 673.

The parameters ABC are defined as follows.

Table 11 Parameters required for calculation of HEATING energy performance

Symbol	Description	Unit	Source
A	Heating degree hours	kKh	Derived from hourly calculation
B	"Useable" solar radiation	kWh/m²	Derived from hourly calculation
C	dimensionless fraction of accumulated temperature difference for period with shutter closed	-	Derived from hourly calculation

The parameters A, B and C were calculated for three climate conditions using the single family house model and with consideration of:

- different design options of the window (11 basecases),
- different insulation levels of the opaque building envelop (U_{env}),
- without and with use of external shutters (Δ R) and solar shading (F_C);
- different climate conditions North/Central/South (which determine temperature difference indoor and outdoor, and solar irradiance);
- for both façade and roof windows.

Additionally also calculations using the single room model were performed.

The factor A (heating degree hours) was calculated by hourly accumulation of the difference between the internal set point temperature $T_{i,set}$ (20°C) and the external temperature T_e.

To evaluate the factor B (usable solar radiation) the solar heat input was calculated for all days with a heating need. Therefore two separate steps were necessary. First, the thermal heat demand of the building was modelled with the actual characteristics of the window. Then a second calculation was done assuming the g value of the window to be zero. The difference between the two calculations is the usable heat gain. The ratio between the useable total heat gain per day and the total solar input per day defines the utilization factor for that day. B was then calculated by multiplying the daily accumulation of solar radiation on the window with the daily utilization factor. The accumulation of all these daily values leads to the factor B.

Stakeholders asked to calculate also B factors for different orientations to consider also the orientation in the Life Cycle Cost analyses. For the single family house this was done by assuming that the daily utilization factor is the same for every orientation. Multiplying this daily utilization factor with the daily accumulation of solar radiation on the window for the individual orientation and accumulation all these daily values lead to the factor B as a function of the orientation. The same approach was used to calculate the B values for roof windows with different inclinations and orientations.

For the single room model, the B value can be determined more directly as the inclination and orientation of the façade (or roof) can relatively easily be adjusted.

The factor C was calculated as the dimensionless fraction of accumulated temperature difference for the hours with shutter closed.

All calculated results for the heating performance are given in Annex I.

→ Results heating performance of façade windows

The ABC values for the energy balance equation for heating, as an average of the two investigated single family houses (different level of insulation) are as shown in the below tables.

The values for the North and Central conditions are the average of specific values for window type 3 to 8, shading and without shading combined. The values for the South conditions are the average of specific values window type 2-4, 9 and 10 'with shading' and 'without shading' combined as these are believed to be the most representative for such conditions.

Table 12 Average ABC parameters for façade windows (specific to U_{env}), single family house

	A			B			C	
	Single family house old	Single family house renovated / new	Single family house **average of old/new**	Single family house old	Single family house renovated	Single family house **average of old/renovated**	Scenario 1 sunset to sunrise	Scenario 2 22:00 to 06:00
North	108	99	**103**	303	231	**267**	0,66	0,36
Central	71	63	**67**	271	204	**238**	0,65	0,38
South	26	20	**23**	283	229	**256**	0,65	0,40

The values for B are assuming a uniform distribution of the façade windows with respect to the orientation. To consider a non-uniform distribution the next table is showing the individual values for B as a function of the orientation.

Parameter C is not dependent on orientation as C represents shutter activation according a time schedule.

Table 13 Parameter B for façade windows as a function of different orientations

	B														
	Uniform			Orientation North			Orientation East			Orientation South			Orientation West		
	old	renovated	**Average**	old	renovated	**Average**	old	renovated	**Average**	old	renovated	**Average**	old	renovated	**Average**
Climate North	303	231	267	145	107	**126**	289	213	**251**	479	386	**432**	297	221	**259**
Climate Central	271	204	238	143	110	**127**	251	181	**216**	418	326	**372**	272	199	**236**

Climate south	283	229	256	115	92	**103**	265	209	**237**	485	401	**443**	269	215	**242**

Values for the single room model are shown in Annex I.

Analysing the results of the calculations the following can be concluded:

Heating degree hours (Parameter A)

The calculations show that the Parameter A (Degree hours for heating) is quite high for all window types considered, meaning that the U value influences the overall performance index to a high degree. Parameter A is mainly influenced by the climate conditions (North, Central, South), and affected by the assumed average U value of the (opaque) envelope (see difference 'single family house old' and 'renovated'), but to a lesser degree.

Solar radiation (Parameter B)

Parameter B is also very important to the calculation of the overall energy performance, but is less influenced by the climate condition when calculated using the boundary conditions assumed (currently the boundary conditions assume different levels of U_{env} per climate condition. If we use the same average U_{env} over all conditions then B will reduce in South condition as the length of the heating period decreases as a better insulation level is assumed).

Usage of solar shading devices (Parameter C)

Parameter C is determined by the assumed use of the solar shading device. We have calculated the parameter for two scenarios: One where the shutters are closed from sunset till dawn, and second, where the shutters are closed from 22 pm till 6 am.

Using the above defined ABC parameters the energy performance index for heating can be calculated (for windows with solar shading C is set at 0.66-0.65, sunset-dawn).

The table below shows the calculated heating performance of windows using the averaged A, B and C values as defined above, with the B value as a function of orientation (A value is based on uniform A value and then corrected according single room values for each orientation). As this is for heating, the values do not assume ventilative cooling to take place.

Table 14 Heating Performance for façade windows based on the B values as a function of different orientations

FACADE WINDOWS, heating	North					Central					South				
	uni	N	E	S	W	uni	N	E	S	W	uni	N	E	S	W
A	103	103	103	103	103	67	67	67	67	67	23	23	23	23	23
B	267	126	251	432	259	238	127	216	372	236	256	103	237	443	242
C	0.66	0.66	0.66	0.66	0.66	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
without shutter	$P_{E,H,W}$	$P_{E,H,W}$	$P_{E,H,W}$	$P_{E,H,W}$	$P_{E,H,W}$	$P_{E,H,W}$	$P_{E,H,W}$	$P_{E,H,W}$	$P_{E,H,W}$	$P_{E,H,W}$	$P_{E,H,W}$	$P_{E,H,W}$	$P_{E,H,W}$	$P_{E,H,W}$	$P_{E,H,W}$
Uw 5.8 / g 0.85	588	671	597	489	592	340	406	353	260	341	14	105	26	-97	23
Uw 2.8 / g 0.78	193	270	201	102	197	88	149	100	15	89	-64	19	-54	-166	-57
Uw 1.7 / g 0.65	71	135	78	-5	74	16	66	26	-45	16	-74	-4	-65	-159	-67
Uw 1.3 / g 0.6	39	98	45	-31	42	-3	44	6	-59	-2	-74	-10	-66	-152	-68
Uw 1 / g 0.55	17	71	23	-47	20	-14	28	-6	-66	-14	-72	-13	-65	-144	-66
Uw 0.8 / g 0.6	-13	46	-6	-82	-10	-36	10	-27	-92	-35	-85	-21	-77	-164	-80
Uw 1 / g 0.58	11	69	18	-56	15	-19	26	-11	-74	-19	-77	-15	-70	-153	-72
Uw 0.6 / g 0.47	-9	37	-4	-64	-7	-28	9	-21	-72	-27	-67	-16	-60	-128	-62
Uw 2.8 / g 0.35	273	307	277	233	275	160	187	165	127	160	13	50	17	-33	16
Uw 1.3 / g 0.35	85	120	89	45	87	39	66	44	6	39	-29	8	-24	-75	-26
Uw 0.8 / g 0.35	34	68	38	-7	36	6	33	11	-27	6	-41	-3	-36	-86	-37
with shutter															
Uw 5.8 / g 0.85 shading	391	475	401	293	396	215	281	228	135	216	-29	62	-18	-140	-21
Uw 2.8 / g 0.78 shading	131	208	140	41	135	49	110	61	-24	50	-78	6	-67	-180	-70
Uw 1.7 / g 0.65 shading	45	109	52	-31	48	-1	50	9	-62	0	-79	-10	-71	-164	-73
Uw 1.3 / g 0.6 shading	22	82	29	-47	26	-13	34	-4	-69	-12	-77	-13	-69	-156	-72
Uw 1 / g 0.55 shading	7	61	13	-57	10	-21	22	-12	-72	-20	-74	-15	-67	-146	-69
Uw 0.8 / g 0.6 shading	-20	40	-13	-89	-16	-40	6	-31	-97	-39	-87	-23	-79	-165	-81
Uw 1 / g 0.58 shading	1	59	8	-66	5	-26	19	-17	-80	-25	-79	-17	-72	-155	-74
Uw 0.6 / g 0.47 shading	-13	33	-8	-68	-11	-30	6	-23	-74	-30	-68	-17	-61	-129	-63
Uw 2.8 / g 0.35 shading	211	246	215	171	213	121	148	126	88	121	-1	37	4	-47	3
Uw 1.3 / g 0.35 shading	69	104	73	29	71	29	56	34	-4	29	-33	5	-28	-78	-29
Uw 0.8 / g 0.35 shading	27	62	31	-13	29	2	29	7	-31	2	-42	-5	-37	-88	-39

Table 15 Comparing heating performance based on average ABC values with window-specific ABC values for façade windows

FACADE WINDOWS, heating	North, U_{env}=0.6						North, U_{env}=0.3						Central U_{env}=0.8						Central U_{env}=0.4						South U_{env}=1.0						South U_{env}=0.6					
	A	B/uni	C/sun		ranked		A	B/uni	C/sun		ranked		A	B/uni	C/sun		ranked		A	B/uni	C/sun		ranked		A	B/uni	C/sun		ranked		A	B/uni	C/sun		ranked	
				$P_{E,H,W}$	avg	spec.				$P_{E,H,W}$	avg	spec.				$P_{E,H,W}$	avg	spec.				$P_{E,H,W}$	avg	spec.				$P_{E,H,W}$	avg	spec.				$P_{E,H,W}$	avg	spec.
1a	112	325	0	616	11	11	109	307	0	605	11	11	74	293	0	360	11	11	71	273	0	350	11	11	27	283	0	27	11	11	24	265	0	16	11	11
2a	108	299	0	190	9	9	102	250	0	197	9	9	71	270	0	85	9	9	65	224	0	91	9	9	24	264	0	-66	7	7	18	202	0	-51	7	7
3a	108	303	0	63	7	7	100	233	0	80	7	7	71	268	0	10	7	7	63	207	0	23	7	7	24	261	0	-74	4	5	17	194	0	-57	4	3
4a	108	303	0	30	6	6	99	235	0	46	6	6	71	271	0	-10	5	5	63	206	0	5	5	6	24	265	0	-76	3	3	17	188	0	-54	3	4
5a	108	305	0	8	4	4	99	235	0	24	4	4	71	273	0	-23	4	4	63	207	0	-7	4	4	24	268	0	-75	5	4	17	190	0	-53	5	5
6a	107	294	0	-21	1	1	97	219	0	1	1	2	70	262	0	-43	1	1	61	190	0	-21	1	1	23	253	0	-84	1	1	15	177	0	-60	1	1
7a	108	298	0	4	3	3	98	228	0	21	3	3	70	271	0	-29	3	3	62	203	0	-11	3	3	24	266	0	-80	2	2	16	189	0	-58	2	2
8a	109	312	0	-20	2	2	100	237	0	-2	2	1	71	281	0	-39	2	2	63	210	0	-21	2	2	25	283	0	-74	6	6	18	201	0	-52	6	6
9a	114	362	0	285	10	10	110	325	0	281	10	10	75	326	0	166	10	10	72	295	0	163	10	10	30	320	0	20	10	10	26	302	0	11	10	10
10a	112	333	0	82	8	8	106	303	0	80	8	8	74	311	0	32	8	8	68	261	0	35	8	8	28	307	0	-34	9	9	23	261	0	-30	9	9
11a	111	329	0	26	5	5	105	275	0	33	5	5	73	305	0	-5	6	6	67	245	0	4	6	5	28	305	0	-48	8	8	22	244	0	-39	8	8
1b	112	325	0.64	409	11	11	109	307	0.64	404	11	11	74	293	0.64	224	11	11	71	273	0.64	220	11	11	27	283	0.65	-24	10	10	24	265	0.65	-29	10	10
2b	108	299	0.65	127	9	9	102	250	0.66	137	9	9	71	270	0.64	44	9	9	65	224	0.65	52	9	9	24	264	0.65	-80	4	5	18	202	0.64	-62	4	1
3b	108	303	0.65	36	7	7	100	233	0.66	55	7	7	71	268	0.64	-7	6	7	63	207	0.65	7	6	7	24	261	0.65	-80	3	3	17	194	0.64	-61	3	3
4b	108	303	0.65	14	5	5	99	235	0.66	30	5	6	71	271	0.64	-21	5	5	63	206	0.65	-4	5	5	24	265	0.65	-80	5	4	17	188	0.64	-57	5	5
5b	108	305	0.65	-3	4	4	99	235	0.66	15	4	4	71	273	0.64	-29	4	4	63	207	0.65	-13	4	4	24	268	0.65	-78	6	6	17	190	0.64	-55	6	6
6b	107	294	0.65	-28	1	1	97	219	0.66	-5	1	2	70	262	0.64	-47	1	1	61	190	0.65	-25	1	1	23	253	0.65	-86	1	1	15	177	0.64	-61	1	2
7b	108	298	0.65	-6	3	3	98	228	0.66	12	3	3	70	271	0.64	-35	3	3	62	203	0.65	-16	3	3	24	266	0.65	-82	2	2	16	189	0.64	-60	2	4
8b	109	312	0.65	-24	2	2	100	237	0.66	-6	2	1	71	281	0.64	-41	2	2	63	210	0.65	-24	2	2	25	283	0.65	-75	7	7	18	201	0.64	-53	7	7
9b	114	362	0.64	219	10	10	110	325	0.64	217	10	10	75	326	0.64	122	10	10	72	295	0.64	122	10	10	30	320	0.65	2	11	11	26	302	0.64	-4	11	11
10b	112	333	0.64	65	8	8	106	303	0.65	64	8	8	74	311	0.64	21	8	8	68	261	0.64	25	8	8	28	307	0.65	-39	9	9	23	261	0.64	-34	9	9
11b	111	329	0.64	19	6	6	105	275	0.65	27	6	5	73	305	0.64	-9	7	6	67	245	0.64	0	7	6	28	305	0.65	-50	8	8	22	244	0.64	-40	8	8

The Table 15 shows a comparison of the heating performance calculated using the averaged ABC values (possibly to be used for EU labelling) with the calculated heating performance using the window-type specific ABC parameters. It shows that in the majority of cases the ranking of the top 3 windows is identical, and where a difference occurs (grey highlighted cells), the difference is usually very small (and within class borders as one will see later on). The comparison is made for windows with uniform orientation only (parameter B for 'uni' or uniform orientation), but gives sufficient confidence in the method.Results heating performance of roof windows.

→ **Results heating performance of roof windows**

Roof windows are not installed in a vertical position but with a certain inclination. Due to the inclination the solar irradiance on the roof window will increase. To consider this the table below shows the B values for roof windows assuming a representative inclination of 40°. B-values for inclinations of zero degree, 20º and 60º are also stated in Annex I.

Table 16 Parameter B for roof windows as a function of different orientations for an inclination of 40°

	B														
	Average orientation			Orientation North			Orientation East			Orientation South			Orientation West		
	old	new	**avg.**	old	new	**avg.**	old	new	**avg.**	old	new	**avg.**	old	new	**avg.**
North	386	286	336	212	151	**182**	384	279	**331**	560	429	**495**	388	284	**336**
Central	372	235	304	219	140	**180**	363	226	**295**	523	335	**429**	382	240	**311**
south	379	301	340	170	128	**149**	378	299	**339**	587	474	**531**	382	303	**343**

We assume, that the length of the heating period is not (significantly) affected if roof windows are installed in a building or not. With this assumption value A is the same for façade windows and roof windows. Parameter C is also the same as for façade windows as it depends on time schedules. The ABC values for the uniform orientation thus become as shown below.

Table 17 Specific ABC parameters for roof windows (specific to U_{env}), single family house

	A			B			C	
	Single family house old	Single family house renovated / new	Single family house **average of old/new**	Single family house old	Single family house renovated	Single family house **average of old/renovated**	Scenario 1 sunset to sunrise	Scenario 2 22:00 to 06:00
North	108	99	**103**	386	286	336	0,66	0,36
Central	71	63	**67**	372	235	304	0,65	0,38
South	26	20	**23**	379	301	340	0,65	0,40

In comparison to façade windows (see Table 12) roof windows (with an average inclination of 40°) are having an approximately 26% to 33% higher B factor. Annex I shows the detailed results of the calculations for the determination of the B values for roof windows (window type specific values, A and C are as established for roof windows).

Table 19 below shows the heating performance $P_{E,H,W}$ for roof windows. Note that the U values have been increased in accordance Table 18 to reflect the increase of thermal transmittance when installed at an inclination of 40º.

Table 20 compares the heating performance of roof windows using the window-specific ABC values with the averaged ABC values.

Note that U_W values have been corrected to reflect inclined installation of 40 ºin accordance with Table 9 and Table 10, resulting in values as shown below.

Table 18 U_{window} in $W/(m^2K)$ for an inclination of 40°

No.	$U_{window\ (vertical)}$	g_{gl}	Frame fraction	Air tight Class	ΔUg	$U_{window\ (40°)}$
1 a/b	5.8	0.85	30%	2	1.2	6.6
2 a/b	2.8	0.78	30%	3	0.50	3.2
3 a/b	1.7	0.65	30%	4	0.50	2.1
4 a/b	1.3	0.60	30%	4	0.50	1.7
5 a/b	1.0	0.55	30%	4	0.20	1.1
6 a/b	0.8	0.60	30%	4	0.20	0.9
7 a/b	1.0	0.58	30%	4	0.20	1.1
8 a/b	0.6	0.47	30%	4	0.10	0.7
9 a/b	2.8	0.35	30%	3	0.50	3.2
10 a/b	1.3	0.35	30%	4	0.50	1.7
11 a/b	0.8	0.35	30%	4	0.20	0.9

Table 19 Heating Performance for roof windows based on the B values as a function of different orientations (A and C as for façade windows)

ROOF WINDOWS, heating						North					Central					South				
						uni	N	E	S	W	uni	N	E	S	W	uni	N	E	S	W
A						103					67					23				
B						336	182	332	495	336	304	180	295	429	311	340	149	339	531	343
C						0.66	0.66	0.66	0.66	0.66	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
without shutter	Uw	g	ΔR	Q100	Ff															
1a	6.6	0.85	0.17	27.0	0.3	629	721	632	535	629	354	428	359	279	350	-17	96	-16	-131	-19
2a	3.2	0.78	0.17	9.0	0.3	196	281	199	110	196	79	147	84	11	75	-101	3	-100	-205	-102
3a	2.1	0.65	0.17	3.0	0.3	80	151	83	8	80	12	69	16	-45	9	-103	-16	-102	-189	-104
4a	1.7	0.6	0.17	3.0	0.3	51	116	53	-16	51	-4	48	0	-56	-7	-100	-20	-99	-180	-101
5a	1.1	0.55	0.17	3.0	0.3	1	60	2	-60	1	-33	15	-30	-81	-36	-102	-28	-101	-175	-103
6a	0.9	0.6	0.17	3.0	0.3	-32	33	-30	-98	-32	-57	-5	-53	-110	-60	-118	-38	-118	-198	-119
7a	1.1	0.58	0.17	3.0	0.3	-6	56	-5	-71	-6	-39	11	-36	-90	-42	-109	-31	-108	-186	-110
8a	0.7	0.47	0.17	3.0	0.3	-22	29	-20	-74	-22	-43	-2	-40	-84	-45	-92	-29	-92	-155	-93
9a	3.2	0.35	0.17	9.0	0.3	297	335	298	259	297	170	201	173	140	169	1	48	2	-45	1
10a	1.7	0.35	0.17	3.0	0.3	110	148	111	71	110	49	80	52	19	48	-40	6	-40	-87	-41
11a	0.9	0.35	0.17	3.0	0.3	27	65	28	-12	27	-4	27	-2	-35	-6	-59	-12	-59	-106	-60
with shutter	Uw	g	ΔR	Q100	Ff															
1b	6.6	0.85	0.17	27.0	0.3	391	483	394	297	391	203	277	208	128	198	-70	44	-69	-183	-71
2b	3.2	0.78	0.17	9.0	0.3	119	204	122	33	119	30	98	35	-38	26	-118	-13	-117	-222	-119
3b	2.1	0.65	0.17	3.0	0.3	43	113	45	-29	43	-12	45	-7	-69	-15	-111	-24	-110	-198	-112
4b	1.7	0.6	0.17	3.0	0.3	25	90	27	-42	25	-20	32	-16	-73	-23	-106	-25	-105	-186	-107
5b	1.1	0.55	0.17	3.0	0.3	-11	48	-9	-72	-11	-41	7	-37	-89	-43	-104	-31	-104	-178	-105
6b	0.9	0.6	0.17	3.0	0.3	-40	25	-38	-106	-40	-62	-10	-58	-115	-65	-120	-40	-120	-200	-121
7b	1.1	0.58	0.17	3.0	0.3	-18	45	-16	-83	-18	-47	3	-43	-98	-50	-112	-34	-111	-189	-113
8b	0.7	0.47	0.17	3.0	0.3	-27	24	-25	-79	-27	-46	-5	-43	-87	-48	-93	-30	-93	-156	-94
9b	3.2	0.35	0.17	9.0	0.3	220	258	222	182	220	122	152	124	91	120	-15	31	-15	-62	-16
10b	1.7	0.35	0.17	3.0	0.3	84	122	85	45	84	33	63	35	2	31	-46	1	-46	-93	-47
11b	0.9	0.35	0.17	3.0	0.3	19	57	20	-20	19	-9	21	-7	-40	-11	-61	-14	-60	-107	-61

Table 20 Comparing heating performance based on average ABC values with window-specific ABC values for roof windows

	North, U_{env}=0.6, 40º						North, U_{env}=0.3, 40º						Central U_{env}=0.8, 40º						Central U_{env}=0.4, 40º						South U_{env}=1.0, 40º						South U_{env}=0.6, 40º					
	A	B/uni	C/sun	$P_{E,H,W}$	ranked avg	spec.	A	B/uni	C/sun	$P_{E,H,W}$	ranked avg	spec.	A	B/uni	C/sun	$P_{E,H,W}$	ranked avg	spec.	A	B/uni	C/sun	$P_{E,H,W}$	ranked avg	spec.	A	B/uni	C/sun	$P_{E,H,W}$	ranked avg	spec.	A	B/uni	C/sun	$P_{E,H,W}$	ranked avg	spec.
1a	112	424	0	646	11	11	109	396	0	639	11	11	74	413	0	348	11	11	71	376	0	346	11	11	27	382	0	-11	10	10	24	353	0	-17	10	10
2a	108	383	0	188	9	9	102	310	0	206	9	9	71	372	0	58	9	9	65	303	0	73	9	9	24	350	0	-103	5	5	18	265	0	-79	5	2
3a	108	387	0	68	7	7	100	288	0	95	7	7	71	368	0	-7	7	7	63	279	0	15	7	7	24	347	0	-104	3	4	17	249	0	-75	3	4
4a	108	387	0	38	6	6	99	291	0	62	6	6	71	372	0	-24	6	6	63	277	0	1	6	6	24	351	0	-103	6	6	17	242	0	-70	6	7
5a	108	390	0	-14	4	4	99	290	0	13	4	4	71	375	0	-55	4	4	63	279	0	-28	4	4	24	356	0	-107	4	3	17	245	0	-73	4	5
6a	107	374	0	-44	1	1	97	269	0	-10	1	2	70	359	0	-77	1	1	61	256	0	-43	1	1	23	335	0	-116	1	1	15	227	0	-79	1	1
7a	108	379	0	-18	3	3	98	281	0	9	3	3	70	372	0	-63	3	3	62	273	0	-33	3	3	24	353	0	-113	2	2	16	243	0	-79	2	3
8a	109	400	0	-38	2	2	100	294	0	-11	2	1	71	386	0	-66	2	2	63	283	0	-39	2	2	25	377	0	-103	7	7	18	260	0	-70	7	6
9a	114	474	0	303	10	10	110	419	0	302	10	10	75	460	0	163	10	10	72	408	0	165	10	10	30	435	0	4	11	11	26	404	0	-3	11	11
10a	112	430	0	103	8	8	106	385	0	103	8	8	74	435	0	31	8	8	68	356	0	39	8	8	28	413	0	-49	9	9	23	344	0	-42	9	9
11a	111	424	0	14	5	5	105	343	0	27	5	5	73	424	0	-27	5	5	67	333	0	-11	5	5	28	409	0	-71	8	8	22	321	0	-55	8	8
1b	112	424	0.64	396	11	11	109	396	0.64	395	11	11	74	413	0.64	183	11	11	71	376	0.64	187	11	11	27	382	0.65	-72	8	9	24	353	0.65	-72	8	7
2b	108	383	0.65	109	9	9	102	310	0.66	130	9	9	71	372	0.64	7	8	8	65	303	0.65	26	8	9	24	350	0.65	-121	2	1	18	265	0.64	-92	2	1
3b	108	387	0.65	29	7	7	100	288	0.66	58	7	7	71	368	0.64	-32	6	6	63	279	0.65	-7	6	7	24	347	0.65	-112	4	4	17	249	0.64	-81	4	2
4b	108	387	0.65	11	6	6	99	291	0.66	37	6	6	71	372	0.64	-42	5	5	63	277	0.65	-15	5	6	24	351	0.65	-109	5	6	17	242	0.64	-74	5	6
5b	108	390	0.65	-26	4	4	99	290	0.66	2	4	4	71	375	0.64	-63	4	4	63	279	0.65	-35	4	4	24	356	0.65	-110	6	5	17	245	0.64	-75	6	5
6b	107	374	0.65	-52	1	1	97	269	0.66	-18	1	1	70	359	0.64	-82	1	1	61	256	0.65	-48	1	1	23	335	0.65	-118	1	2	15	227	0.64	-81	1	3
7b	108	379	0.65	-30	3	3	98	281	0.66	-2	3	3	70	372	0.64	-71	2	2	62	273	0.65	-40	2	3	24	353	0.65	-116	3	3	16	243	0.64	-80	3	4
8b	109	400	0.65	-43	2	2	100	294	0.66	-16	2	2	71	386	0.64	-69	3	3	63	283	0.65	-42	3	2	25	377	0.65	-104	7	7	18	260	0.64	-71	7	8
9b	114	474	0.64	221	10	10	110	419	0.64	222	10	10	75	460	0.64	109	10	10	72	408	0.64	113	10	10	30	435	0.65	-18	11	11	26	404	0.64	-22	11	11
10b	112	430	0.64	75	8	8	106	385	0.65	76	8	8	74	435	0.64	13	9	9	68	356	0.64	23	9	8	28	413	0.65	-56	10	10	23	344	0.64	-47	10	10
11b	111	424	0.64	5	5	5	105	343	0.65	19	5	5	73	424	0.64	-32	7	7	67	333	0.64	-16	7	5	28	409	0.65	-73	9	8	22	321	0.64	-57	9	9

The comparison shows that in most cases the ranking is similar, or that the differences are relatively small.

→ **General remarks on heating performance**

When looking at the results ofTable 14 and Table 19 it shows that the method using averaged ABC values does not introduce many changes in relative ranking of options when compared to a heating performance using window-specific ABC values, both when assessed with shading devices (shutters) or without.

Therefore the authors propose that a rating for heating performance can be based on the heating energy performance of the window as calculated using averaged ABC values (similar to many other window rating schemes).

For the consideration of shading devices consensus has to be achieved on a value for parameter C, which can be zero (no shading considered), maximum 0.66 (for shading used optimally, from sunset to sunrise) or somewhere in between (consensus value).

4.2.3. ENERGY PERFORMANCE INDEX FOR COOLING

→ **Simplified approach for cooling**

The window energy performance index for cooling $P_{E,C,W}$ can be determined according to the following energy balance equation. The cooling performance represents the amount of excess heat that is present in the space considered. Therefore the lower the value the better.

Equation 7

$$P_{E,C,W} = -X \cdot (U_W + H_{ve,w}) + Y \cdot g_{W,eff}$$

where:

'X' characterises heat losses due to thermal transmittance and infiltration;

'Y' characterises the heat gains due to solar radiation. A lower $g_{W,eff}$ thus contributes to a lower calculated value or a better cooling performance (lower value = more energy efficient).

$H_{ve,w}$ and $g_{W,eff}$ as indicated below:

Equation 8

$$H_{ve,w} = \left(\frac{\Delta p}{100Pa} \right)^{2/3} \rho \cdot c_p \cdot Q_{100}$$

Equation 9

$$g_{W,eff} = (1 - F_F) \cdot [(1 - Z) \cdot g + Z \cdot g_t]$$

Terms are as described for heating or in the generic approach. The parameters X,Y and Z are as follows:

Table 21 Parameters required for calculation of COOLING energy performance

Symbol	Description	Unit	Source
X	Cooling degree hours	kKh	Derived from hourly calculation
Y	Solar radiation that leads to overheating	kWh/m^2	Derived from hourly calculation
Z	dimensionless weighted fraction for period with shutter closed	-	Derived from hourly calculation

The parameters X,Y and Z were calculated for three climate conditions, using the single family house model, and with consideration of:

- different design options of the window (11 basecases),
- different insulation levels of the opaque building envelop (U_{env}),
- different scenarios of ventilation (with and without ventilative cooling),
- without and with use of external shutters ($g_{W,eff}$);
- different climate conditions North/Central/South (which determine temperature difference indoor and outdoor, and solar irradiance);
- for both façade and roof windows.

Additionally also calculations using the single room model were performed.

The factors X, Y for the energy balance for cooling were calculated with the same approaches as the factors A and B for heating.

The factor Z is calculated as the dimensionless fraction of accumulated solar radiation for the hours with solar shading closed for the days where there was a need for cooling.

All calculated results are given in Annex II.

→ Results cooling performance of façade windows

The XYZ values for the energy balance equation for heating, as an average of the two investigated single family houses (different level of insulation) are as shown in the below tables. Values for the single room model are shown in Annex I.

The table on the next page shows values for both the condition with standard ventilation ($h=0.5^{-1}$) and with ventilative cooling assumed ($h=2.0$, if $T_e > 23ºC$ and $T_i > T_e$).

Table 22 Specific XYZ parameters for façade windows (specific to U_{env}), single family house

		ventil.cooling?	North	Central	South
X	Single family house old	no	1	1	-3
		yes	0	0	-5
	Single family house renovated	no	5	4	-2
		yes	0	0	-4
	Single family house **average of old/renovated**	no	**3**	**3**	**-2**
		yes	**0**	**0**	**-4**
Y	Single family house old	no	34	**60**	305
		yes	9	**28**	263
	Single family house renovated	no	95	135	367
		yes	15	42	295
	Single family house **average of old/renovated**	no	**65**	**98**	**336**
		yes	**12**	**35**	**279**
Z	Single family house old	no	**0.6**	**0.5**	**0.66**
		yes	**0.69**	**0.53**	**0.66**
	Single family house renovated	no	**0.53**	**0.46**	**0.65**
		yes	**0.66**	**0.52**	**0.66**
	Single family house **average of old/renovated**	no	**0.56**	**0.47**	**0.66**
		yes	**0.68**	**0.53**	**0.66**

The values for Y and Z are assuming an uniform distribution of the façade windows with respect to the orientation. To consider a non-uniform distribution the next table is showing the individual values for Y and Z as a function of the orientation. Parameter Z relates to shutter activation according solar irradiance levels and temperature differences and is also orientation dependent.

Parameter X is also dependent on orientation as it is related to the length of the cooling season, but the values and the actual differences per orientation are that small compared to values for Y, that the orientation aspect of parameter X can be ignored (values shown in Annex II are for 'single room model' only).

Table 23 Parameter Y&Z for façade windows for different orientations, single family house

Climate condition	U envelope	Ventilative cooling		Uniform	N	E	S	W
North	0.6	no	**Y**	34	19	41	39	38
			Z	0.60	0.03	0.62	0.75	0.71
		yes	**Y**	9	5	11	11	11
			Z	0.69	0.05	0.78	0.79	0.79
	0.3	no	**Y**	95	54	114	108	104
			Z	0.53	0.02	0.48	0.70	0.67
		yes	**Y**	15	8	18	18	17
			Z	0.66	0.04	0.74	0.78	0.75
Central	0.8	no	**Y**	60	40	72	62	65
			Z	0.50	0.00	0.58	0.62	0.60
		yes	**Y**	28	20	34	29	31
			Z	0.53	0.00	0.62	0.64	0.64
	0.4	no	**Y**	135	88	163	142	148
			Z	0.46	0.00	0.50	0.57	0.58
		yes	**Y**	42	29	49	43	46
			Z	0.52	0.00	0.60	0.65	0.63
South	1.0	no	**Y**	305	165	373	308	375
			Z	0.66	0.00	0.77	0.73	0.77
		yes	**Y**	263	142	325	259	325
			Z	0.66	0.00	0.77	0.72	0.77
	0.6	no	**Y**	367	197	446	378	448
			Z	0.65	0.00	0.75	0.73	0.76
		yes	**Y**	295	160	363	294	364
			Z	0.66	0.00	0.77	0.73	0.77

Analysing the results of the calculations the following can be concluded:

Cooling degree hours (Parameter X)

The calculations show that the Parameter X (Degree hours for cooling) is very low for all investigated cases.

For the Climate North, X is in between 0 kKh and 9 kKh, for the Climate Central in between 0 kKh and 6 kKh and for the Climate South between 0 kKh and -5 kKh. Therefore the influence of the U value of the window has almost no influence on the Energy performance index for cooling.

Analysing the calculated data in more detail it can be seen, that the Parameter X depends not only on the climatic conditions and the chosen boundary conditions (e.g. U value of the opaque envelope, possibility for ventilative cooling) but also on the characteristics of the window itself. This effect is higher for the Climate North than Climate Central than Climate South. The reason for that is, that the cooling amount in the Climate North is only caused by the solar gains of the window. In the Climate South the cooling load is not only caused by the solar gains of the window but also caused by other effects e.g. the necessary ventilation of the building. Therefore the length of the cooling period (for fixed other boundary conditions) is influenced significantly by the characteristics of the window in the Climate North and also in the Climate Central. In Climate South the influence of the window characteristics on the length of the cooling period is not so strong.

Solar radiation (Parameter Y)

Beside climatic conditions and the orientation the parameter Y (Solar radiation that leads to overheating) is effected by the characteristics of the building (e.g. level of thermal insulation), by the possibility of ventilative cooling and also by the characteristics of the window itself.

Level of insulation

The calculations show, that the level of insulation has a significant effect on the Parameter Y and therefore on the Energy performance index for cooling. As an example, Table 24 shows the calculated Parameter Y for two different levels of insulation of the building envelope (single family house) for the Central climate and not considering ventilative cooling. The improvement of the insulation level of the building envelope from 0.8 W/m^2K to 0.4 W/m^2K approx. doubles the Parameter Y.

Table 24 Parameter Y for two levels of insulation of the Single family house, Climate Central, no ventilative cooling

						U_{env}=0,8 W/(m²K)					U_{env}=0,4 W/(m²K)				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	Y (uniform distr.)	Y North	Y East	Y South	Y West	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	51	33	62	54	57	79	50	95	83	87
2a	2,8	0,78	30%	1,0	3	76	48	92	80	84	134	86	162	140	147
3a	1,7	0,65	30%	1,0	4	79	51	95	83	87	153	98	185	160	168
4a	1,3	0,60	30%	1,0	4	78	50	94	82	86	158	102	190	165	173
5a	1,0	0,55	30%	1,0	4	76	49	91	80	84	159	103	192	167	175
6a	0,8	0,60	30%	1,0	4	86	55	104	90	94	176	114	212	184	193
7a	1,0	0,58	30%	1,0	4	80	51	97	84	88	165	106	199	173	181
8a	0,6	0,47	30%	1,0	4	71	46	84	74	78	159	103	192	167	175
9a	2,8	0,35	30%	1,0	3	36	25	43	38	40	68	45	80	71	74
10a	1,3	0,35	30%	1,0	4	48	33	56	50	52	108	70	130	114	119
11a	0,8	0,35	30%	1,0	4	53	36	62	55	58	125	81	151	132	137
1b	5,8	0,85	30%	0,1	2	27	20	32	27	29	39	28	47	40	43
2b	2,8	0,78	30%	0,1	3	38	27	45	39	41	78	53	93	82	85
3b	1,7	0,65	30%	0,1	4	41	29	48	42	44	98	65	117	103	107
4b	1,3	0,60	30%	0,1	4	41	30	48	42	44	104	69	124	109	114
5b	1,0	0,55	30%	0,1	4	40	29	48	41	43	107	71	128	113	117
6b	0,8	0,60	30%	0,1	4	45	32	54	46	49	123	81	147	129	135
7b	1,0	0,58	30%	0,1	4	42	30	50	43	45	112	74	134	118	122
8b	0,6	0,47	30%	0,1	4	39	29	46	40	41	110	73	131	116	120
9b	2,8	0,35	30%	0,1	3	24	18	28	24	25	40	30	47	41	43
10b	1,3	0,35	30%	0,1	4	29	23	34	29	31	69	47	82	72	74
11b	0,8	0,35	30%	0,1	4	32	24	37	32	34	83	56	98	87	90
			Average windows 3a-8a;3b-8b			60	40	72	62	65	135	88	163	142	148

Ventilative cooling

The effect on the parameter Y whether ventilative cooling is considered or not is shown in the following Table 25 and Table 26 as an example. Assuming ventilative cooling leads to a significant decrease of the parameter Y and as a consequence of the energy demand for artificial cooling.

For the Climate North (see Table 25) the parameter Y is decreasing dramatically when ventilative cooling is considered. Also for the Climate South Y is decreasing. But is has to be noted, that the relative decrease for South is much lower than for the climate North. This effect is in general logical. Ventilative cooling is more effective when the temperature difference between the external temperature and the set point temperature for cooling (26°C) is higher and the time with that temperature difference is longer.

Table 25 Parameter Y , Single family house, U_{env}=0,4 W/m²K, Climate North,

						withouth ventilative cooling					with ventilative cooling				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	Y (uniform distr.)	Y North	Y East	Y South	Y West	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	44	24	53	51	49	19	10	22	22	21
2a	2,8	0,78	30%	1,0	3	100	56	120	114	110	29	16	35	33	33
3a	1,7	0,65	30%	1,0	4	120	68	143	137	132	27	15	33	31	31
4a	1,3	0,60	30%	1,0	4	125	71	149	143	137	26	14	31	30	29
5a	1,0	0,55	30%	1,0	4	127	72	151	145	139	24	13	28	27	27
6a	0,8	0,60	30%	1,0	4	147	84	175	168	161	29	16	34	33	32
7a	1,0	0,58	30%	1,0	4	134	76	159	152	146	26	14	31	30	29
8a	0,6	0,47	30%	1,0	4	126	71	150	143	137	20	11	23	23	22
9a	2,8	0,35	30%	1,0	3	30	17	36	35	33	7	4	8	8	8
10a	1,3	0,35	30%	1,0	4	66	37	79	75	72	10	5	12	11	11
11a	0,8	0,35	30%	1,0	4	83	47	100	95	92	11	6	13	13	12
1b	5,8	0,85	30%	0,1	2	9	5	11	10	10	4	2	5	5	5
2b	2,8	0,78	30%	0,1	3	32	18	39	37	35	6	3	7	7	7
3b	1,7	0,65	30%	0,1	4	50	28	59	56	54	6	3	7	7	7
4b	1,3	0,60	30%	0,1	4	55	32	66	63	61	6	3	7	6	6
5b	1,0	0,55	30%	0,1	4	58	33	70	66	64	5	3	6	6	6
6b	0,8	0,60	30%	0,1	4	75	43	91	85	82	6	3	7	7	7
7b	1,0	0,58	30%	0,1	4	63	36	76	71	69	6	3	7	7	6
8b	0,6	0,47	30%	0,1	4	61	35	73	70	67	5	3	6	6	6
9b	2,8	0,35	30%	0,1	3	10	5	12	11	11	2	1	2	2	2
10b	1,3	0,35	30%	0,1	4	24	14	29	27	25	3	1	3	3	3
11b	0,8	0,35	30%	0,1	4	34	19	41	39	36	3	2	4	3	3
Average windows 3a-8a;3b-8b						95	54	114	108	104	15	8	18	18	17

Table 26 Parameter Y , Single family house, U_{env}=1,0 W/m²K Climate South,

						withouth ventilative cooling					with ventilative cooling				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	Y (uniform distr.)	Y North	Y East	Y South	Y West	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	296	159	362	300	364	267	144	329	267	330
2a	2,8	0,78	30%	1,0	3	335	180	407	343	410	291	157	356	291	358
3a	1,7	0,65	30%	1,0	4	343	184	416	352	419	291	157	358	291	359
4a	1,3	0,60	30%	1,0	4	344	185	418	353	421	291	157	358	290	359
5a	1,0	0,55	30%	1,0	4	344	185	418	352	421	289	156	356	288	356
6a	0,8	0,60	30%	1,0	4	353	189	428	363	431	296	160	364	296	365
7a	1,0	0,58	30%	1,0	4	347	186	422	356	424	292	158	359	291	360
8a	0,6	0,47	30%	1,0	4	341	184	415	348	418	285	154	351	283	351
9a	2,8	0,35	30%	1,0	3	289	156	355	289	355	253	137	313	248	313
10a	1,3	0,35	30%	1,0	4	313	169	384	316	385	265	144	328	261	328
11a	0,8	0,35	30%	1,0	4	322	174	393	325	394	269	146	333	266	333
1b	5,8	0,85	30%	0,1	2	254	138	314	252	314	233	126	289	227	289
2b	2,8	0,78	30%	0,1	3	286	155	351	286	352	250	136	310	245	310
3b	1,7	0,65	30%	0,1	4	296	160	363	297	364	254	138	314	248	314
4b	1,3	0,60	30%	0,1	4	299	161	366	300	367	254	138	315	248	315
5b	1,0	0,55	30%	0,1	4	300	162	368	301	368	254	138	315	248	315
6b	0,8	0,60	30%	0,1	4	306	165	375	308	376	258	140	320	252	320
7b	1,0	0,58	30%	0,1	4	302	163	370	303	371	256	139	317	250	317
8b	0,6	0,47	30%	0,1	4	301	162	369	302	369	253	138	315	247	315
9b	2,8	0,35	30%	0,1	3	263	142	325	260	325	234	127	292	227	292
10b	1,3	0,35	30%	0,1	4	283	153	348	282	348	244	132	303	236	303
11b	0,8	0,35	30%	0,1	4	290	156	356	290	356	247	134	307	240	307
Average windows 2a-4a,9a,10a; 2b-4b,9b,10b						305	165	373	308	375	263	142	325	259	325

Characteristics of the window

When discussing the results for the degree hours for cooling it was already noted, that the length of the cooling period is affected by the properties of the window itself. This is of course also the same for the parameter Y. Analysing the calculated Parameter Y it is can be seen, that Y depends on the characteristics of the window itself. This dependency is much higher in the Climate North and in the Climate Central than in the Climate South. The reason for that is the same as already stated for the degree hours. In Climate North the cooling load is caused by the solar gains only. In Climate South, as the other extreme, the need for artificial cooling is not only caused by the solar gains through the window but e.g. also by the ventilation of the building. As an example the values given in Table 25 and Table 26 can be used to show this effect. Comparing the different Y values for the window with an U value of 1.3 shows that Y is decreasing the lower the (effective) g value is (window No. 4 and 10).

The consequence of this effect is, that defining an average Y value for a fixed set of boundary conditions would lead to underestimation or overestimation of the Energy performance index for different design options.

Example: In Table 25 average values of Y are calculated by averaging the same design options (Window 3 to 8) as for the ABC values for heating. Calculating the average for these design options with an without sun shading leads to an average Y value of 95 kWh/m^2 (for a uniform distribution of the windows, assuming no ventilative cooling => first yellow column of Table 25). Comparing the average Y-value with the "real" Y values for the design option shows that effect. The window with Uw=1,3 and g = 0,60 has a "real" Y value of 125 (=> underestimation), the window with the same Uw value but with a solar control glass would have a "real" Y value of 66 (overestimation). The effect would be the same if different approaches for averaging would be used (e.g. only the windows 3-8 without sun shading or only the windows with sun shading).

Usage of solar shading devices (Parameter Z)

The factor Z is the dimensionless fraction of accumulated solar radiation for the hours with solar shading closed for the days where there was a need for cooling.

The relevant standard for the calculation of energy use for space heating and cooling EN ISO 13790 states in its Annex G:

"Unless otherwise specified at national level, the solar shading shall be taken as being switched on if the intensity of the solar radiation on the surface at the given hour exceeds 300 W/m^2 and switched off if the hourly value is below this value."

Therefore the set point for the activation of the solar shading was defined at a level of I_{sol} = 300 W/m^2.

The factor Z therefore is

Equation 10

$$Z = \sum_{cooling\ \ days} I_{sol>300W} \Big/ \sum_{cooling\ \ days} I_{sol}$$

Note: The solar shading was activated only if the external temperature T_e was higher than 15°C.

Table 27 is showing the averaged values for the Parameter Z for façade windows (Table 31 applies to roof windows). The values were derived based on the calculation for the single family house as an average. The 'average' Z factor (Z uniform distribution) is calculated not only as the average of the four orientations but also weighted for the solar irradiance per orientation (Y factor).

Table 27 Averaged Parameter Z as a function of the Climate and the orientation, façade windows

	Usage sun protection				
Climate	Z (uniform distr.)	Z North	Z East	Z South	Z West
North	0,62	0,03	0,65	0,76	0,73
Central	0,50	0,00	0,57	0,62	0,61
South	0,65	0,00	0,77	0,73	0,77

The table below shows the calculated cooling performance of windows using the averaged X, Y and Z values as defined above, with the Y value as a function of orientation.

Table 28 Cooling Performance for façade windows based on the Y values as a function of different orientations, assuming no ventilative cooling

								NO VENTILATIVE COOLING															WITH VENTILATIVE COOLING														
								North					Central					South					North					Central					South				
FACADE WINDOWS, cooling								uni	N	E	S	W	uni	N	E	S	W	uni	N	E	S	W	uni	N	E	S	W	uni	N	E	S	W	uni	N	E	S	W
X							X	3.0	3.0	3.0	3.0	3.0	2.4	2.4	2.4	2.4	2.4	-2.8	-2.8	-2.8	-2.8	-2.8	0.2	0.2	0.2	0.2	0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-4.5	-4.5	-4.5	-4.5	-4.5
Y							Y	64.7	36.7	77.5	73.6	70.9	97.5	64.2	117.1	102.1	106.7	336.1	180.8	409.4	343.0	411.4	12.4	6.7	14.7	14.2	13.9	35.2	24.3	41.6	36.4	38.6	279.0	151.0	344.1	276.2	344.7
Z							Z	0.56	0.03	0.55	0.72	0.69	0.48	0.00	0.54	0.60	0.59	0.65	0.00	0.76	0.73	0.77	0.67	0.04	0.76	0.79	0.77	0.53	0.00	0.61	0.64	0.64	0.66	0.00	0.77	0.72	0.77
	Uw	g	ΔR	Q100	Ff	gt	$g_{w,eff}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$	$P_{E,C,W}$
1a	5.8	0.85	0.17	27.0	0.3	0.85	0.60	17	19	14	17	19	41	47	35	47	36	220	130	264	223	264	6	3	7	7	7	21	15	25	22	23	199	123	237	197	238
2a	2.8	0.78	0.17	9.0	0.3	0.78	0.55	26	19	28	28	28	46	39	48	49	46	193	109	233	196	233	6	3	7	7	7	19	13	23	20	21	167	97	203	166	203
3a	1.7	0.65	0.17	3.0	0.3	0.65	0.46	24	16	27	27	26	40	31	44	43	41	158	88	191	161	192	5	3	6	6	6	16	11	19	17	18	135	77	165	134	165
4a	1.3	0.6	0.17	3.0	0.3	0.60	0.42	23	15	26	25	25	38	29	42	40	39	145	80	176	148	177	5	3	6	6	6	15	10	18	15	16	124	70	151	123	151
5a	1	0.55	0.17	3.0	0.3	0.55	0.39	21	14	25	24	24	35	26	39	37	37	133	73	161	135	161	5	2	5	5	5	14	9	16	14	15	113	63	138	112	138
6a	0.8	0.6	0.17	3.0	0.3	0.60	0.42	24	15	28	27	27	39	28	45	41	41	144	79	175	147	175	5	3	6	6	6	15	10	18	15	16	122	68	149	120	149
7a	1	0.58	0.17	3.0	0.3	0.58	0.41	23	14	26	26	25	37	27	42	39	39	140	77	169	142	170	5	2	6	6	5	14	10	17	15	16	119	67	145	117	145
8a	0.6	0.47	0.17	3.0	0.3	0.47	0.33	19	12	22	21	21	30	22	35	32	32	113	62	137	115	137	4	2	5	5	4	12	8	14	12	13	95	53	117	94	117
9a	2.8	0.35	0.17	9.0	0.3	0.35	0.25	6	8	4	6	7	16	20	13	19	14	91	55	109	92	110	2	1	3	3	3	9	6	10	9	10	83	52	99	82	99
10a	1.3	0.35	0.17	3.0	0.3	0.35	0.25	12	8	12	13	13	20	17	22	22	21	86	49	104	88	105	3	1	3	3	3	9	6	10	9	10	75	44	91	74	91
11a	0.8	0.35	0.17	3.0	0.3	0.35	0.25	13	9	15	14	14	22	17	24	23	22	85	47	103	86	103	3	1	3	3	3	9	6	10	9	10	73	41	89	72	89
	Uw	g	ΔR	Q100	Ff	gt	$g_{w,eff}$																														
1b	5.8	0.85	0.17	27.0	0.3	0.15	0.29	-1	9	-8	-4	-1	14	29	2	19	6	127	80	150	128	150	2	0	2	2	2	9	6	10	9	9	98	68	113	97	113
2b	2.8	0.78	0.17	9.0	0.3	0.15	0.27	9	10	8	10	10	21	23	19	24	19	109	64	131	110	131	2	1	3	2	2	8	5	9	8	8	75	47	89	74	89
3b	1.7	0.65	0.17	3.0	0.3	0.15	0.24	11	9	12	12	12	21	19	21	23	20	92	52	111	93	111	2	1	2	2	2	6	4	8	7	7	58	35	70	58	70
4b	1.3	0.6	0.17	3.0	0.3	0.15	0.22	11	8	12	12	12	20	17	21	22	20	85	48	103	87	104	2	1	2	2	2	6	4	7	6	6	53	32	63	52	63
5b	1	0.55	0.17	3.0	0.3	0.15	0.21	11	8	12	12	12	19	16	21	21	20	80	45	96	81	96	2	1	2	2	2	5	4	6	6	6	47	28	57	47	57
6b	0.8	0.6	0.17	3.0	0.3	0.15	0.22	13	9	14	14	14	21	17	24	23	22	84	47	102	86	102	2	1	2	2	2	6	4	7	6	6	50	29	61	50	61
7b	1	0.58	0.17	3.0	0.3	0.15	0.22	12	8	13	13	13	20	17	22	22	21	83	46	100	84	100	2	1	2	2	2	6	4	7	6	6	50	29	60	49	60
8b	0.6	0.47	0.17	3.0	0.3	0.15	0.19	11	7	12	12	12	18	14	20	19	19	70	39	85	71	85	1	1	2	2	2	5	3	5	5	5	39	23	48	39	48
9b	2.8	0.35	0.17	9.0	0.3	0.15	0.16	1	5	-2	0	1	8	14	4	11	5	65	40	77	65	77	1	0	1	1	1	4	3	4	4	4	42	29	48	41	48
10b	1.3	0.35	0.17	3.0	0.3	0.15	0.16	6	6	6	7	7	13	12	12	14	12	60	35	72	61	72	1	0	1	1	1	3	2	4	4	4	33	21	40	33	40
11b	0.8	0.35	0.17	3.0	0.3	0.15	0.16	8	6	9	9	9	14	12	15	15	14	58	33	71	59	71	1	0	1	1	1	3	2	4	4	4	31	19	37	31	38

Table 29 Comparing cooling performance based on average XYZ values with window-specific XYZ values for façade windows – no ventilative cooling

VENTILATIVE COOLING: no

	North, U_{env}=0.6						North, U_{env}=0.3						Central U_{env}=0.8					
	X	Y/uni	Z	$P_{E,C,W}$	ranked avg	ranked specific	X	Y/uni	Z	$P_{E,C,W}$	ranked avg	ranked specific	X	Y/uni	Z	$P_{E,C,W}$	ranked avg	ranked specific
without shading																		
1a	0.9	27	0	10	4	4	2	44	0	13	4	3	0	51	0	27	10	5
2a	2.3	52	0	21	11	10	6	100	0	36	11	5	1	76	0	37	11	11
3a	2.5	55	0	20	9	9	7	120	0	42	9	8	2	79	0	33	9	9
4a	2.3	55	0	20	8	7	7	125	0	42	8	9	1	78	0	31	7	7
5a	2.1	52	0	18	6	6	7	127	0	41	6	7	1	76	0	28	5	6
6a	2.9	64	0	24	10	11	9	147	0	53	10	11	2	86	0	34	8	10
7a	2.4	57	0	20	7	8	8	134	0	46	7	10	2	80	0	31	6	8
8a	1.6	47	0	14	5	5	7	126	0	36	5	6	1	71	0	23	4	4
9a	0.2	11	0	2	1	1	1	30	0	5	1	1	0	36	0	9	1	1
10a	0.5	22	0	5	2	2	2	66	0	13	2	2	0	48	0	11	2	2
11a	0.7	27	0	6	3	3	3	83	0	17	3	4	0	53	0	13	3	3
with shading																		
1b	0.0	6	0.65	2	1	4	0	9	0.61	2	1	2	0	27	0.51	10	4	6
2b	0.2	11	0.6	2	5	6	1	32	0.55	6	5	5	0	38	0.49	12	10	11
3b	0.2	13	0.6	3	7	9	2	50	0.53	11	7	6	0	41	0.5	11	9	9
4b	0.2	13	0.6	3	9	8	2	55	0.53	11	9	8	0	41	0.51	10	7	7
5b	0.2	13	0.6	3	8	7	2	58	0.53	12	8	9	0	40	0.51	9	6	5
6b	0.3	16	0.59	3	11	11	3	75	0.52	16	11	11	0	45	0.49	12	11	10
7b	0.2	14	0.6	3	10	10	2	63	0.53	13	10	10	0	42	0.51	10	8	8
8b	0.2	12	0.61	2	6	5	2	61	0.54	11	6	7	0	39	0.51	8	5	4
9b	0.0	4	0.69	1	2	1	0	10	0.64	1	2	1	0	24	0.49	4	1	1
10b	0.0	7	0.67	1	3	2	0	24	0.59	3	3	3	0	29	0.5	5	2	2
11b	0.1	9	0.66	1	4	3	1	34	0.59	5	4	4	0	32	0.5	6	3	3

	Central U_{env}=0.4						South U_{env}=1.0						South U_{env}=0.6					
	X	Y/uni	Z	$P_{E,C,W}$	ranked avg	ranked specific	X	Y/uni	Z	$P_{E,C,W}$	ranked avg	ranked specific	X	Y/uni	Z	$P_{E,C,W}$	ranked avg	ranked specific
without shading																		
1a	1	79	0	38	10	4	-3	296	0	200	11	11	-2	338	0	218	11	11
2a	4	134	0	59	11	8	-2	335	0	190	10	10	0	395	0	216	10	10
3a	5	153	0	60	9	9	-2	343	0	160	9	9	0	411	0	187	9	9
4a	5	158	0	59	7	7	-2	344	0	148	8	7	0	415	0	174	8	7
5a	5	159	0	55	5	6	-2	344	0	135	5	5	0	417	0	161	5	5
6a	7	176	0	68	8	11	-2	353	0	150	7	8	1	429	0	179	7	8
7a	6	165	0	61	6	10	-2	347	0	144	6	6	0	421	0	170	6	6
8a	5	159	0	49	4	5	-3	341	0	114	4	4	0	417	0	137	4	4
9a	1	68	0	15	1	1	-4	289	0	84	3	3	-3	344	0	94	3	1
10a	2	108	0	24	2	2	-4	313	0	82	2	1	-2	383	0	97	2	2
11a	3	125	0	28	3	3	-3	322	0	82	1	2	-2	396	0	99	1	3
with shading																		
1b	0	39	0.49	13	4	3	-5	254	0.66	101	11	11	-4	288	0.65	110	11	11
2b	1	78	0.46	22	10	5	-4	286	0.66	86	10	10	-3	340	0.65	99	10	10
3b	2	98	0.46	25	9	8	-4	296	0.66	74	9	9	-3	361	0.65	87	9	9
4b	2	104	0.46	26	7	9	-4	299	0.66	69	8	8	-3	367	0.65	83	8	7
5b	2	107	0.46	25	6	7	-4	300	0.66	65	5	5	-3	371	0.65	78	5	5
6b	3	123	0.46	31	11	11	-4	306	0.66	69	7	7	-2	380	0.65	84	7	8
7b	2	112	0.46	27	8	10	-4	302	0.66	67	6	6	-3	373	0.65	81	6	6
8b	2	110	0.46	23	5	6	-4	301	0.66	57	4	4	-3	375	0.65	71	4	4
9b	0	40	0.51	7	1	1	-4	263	0.65	55	3	3	-4	309	0.65	61	3	3
10b	1	69	0.49	11	2	2	-4	283	0.65	50	2	2	-4	346	0.66	58	2	1
11b	1	83	0.47	14	3	4	-4	290	0.65	49	1	1	-3	358	0.65	58	1	2

Table 30 Comparing cooling performance based on average XYZ values with window-specific XYZ values for façade windows – with ventilative cooling

VENTILATIVE COOLING: YES																																				
	North, U_{env}=0.6						North, U_{env}=0.3						Central U_{env}=0.8						Central U_{env}=0.4						South U_{env}=1.0						South U_{env}=0.6					
	X	Y/uni	Z				X	Y/uni	Z				X	Y/uni	Z				X	Y/uni	Z				X	Y/uni	Z				X	Y/uni	Z			
					ranked						ranked						ranked						ranked						ranked						ranked	
without shading				$P_{E,C,W}$	avg	specific				$P_{E,C,W}$	avg	specific				$P_{E,C,W}$	avg	specific				$P_{E,C,W}$	avg	specific				$P_{E,C,W}$	avg	specific				$P_{E,C,W}$	avg	specific
1a	0.2	14	0	7	10	9	0	19	0	8	10	5	-0.2	36	0	23	11	10	0	46	0	27	11	10	-4	267	0	191	11	11	-4	296	0	206	11	11
2a	0.3	19	0	9	11	11	1	29	0	13	11	11	0.0	42	0	23	10	11	0	61	0	32	10	11	-4	291	0	172	10	10	-4	328	0	191	10	10
3a	0.3	17	0	7	9	10	1	27	0	11	9	9	-0.1	39	0	18	9	9	0	59	0	26	9	9	-4	291	0	140	9	9	-4	332	0	158	9	9
4a	0.2	15	0	6	7	7	1	26	0	10	7	8	-0.1	38	0	16	8	7	0	57	0	24	8	7	-4	291	0	128	8	8	-4	332	0	145	8	7
5a	0.2	14	0	5	5	5	0	24	0	9	5	6	-0.2	36	0	14	5	5	0	54	0	21	5	5	-4	289	0	116	5	5	-4	331	0	132	5	5
6a	0.3	17	0	7	8	8	1	29	0	12	8	10	-0.1	40	0	17	7	8	0	61	0	25	7	8	-4	296	0	128	7	7	-4	340	0	146	7	8
7a	0.2	15	0	6	6	6	1	26	0	10	6	7	-0.1	37	0	15	6	6	0	57	0	23	6	6	-4	292	0	124	6	6	-4	334	0	140	6	6
8a	0.1	12	0	4	4	4	0	20	0	6	4	4	-0.2	32	0	11	4	4	0	49	0	16	4	4	-5	285	0	97	4	4	-4	327	0	111	4	4
9a	0.0	5	0	1	1	1	0	7	0	2	1	1	-0.2	20	0	6	3	1	0	28	0	8	3	1	-5	253	0	78	3	3	-5	282	0	84	3	3
10a	0.0	6	0	1	2	2	0	10	0	2	2	2	-0.2	23	0	6	2	2	0	33	0	8	2	2	-5	265	0	72	2	2	-5	300	0	80	2	2
11a	0.0	7	0	2	3	3	0	11	0	3	3	3	-0.2	24	0	6	1	3	0	36	0	9	1	3	-5	269	0	70	1	1	-5	307	0	80	1	1
with shading																																				
1b	0.0	3	0.7	0.8	4	6	0	4	0.67	1.1	4	6	0	19	0.54	8	11	11	0	24	0.52	10	11	10	-5	233	0.65	100	11	11	-5	254	0.66	104	11	11
2b	0.0	4	0.67	1.0	11	11	0	6	0.64	1.6	11	11	0	22	0.54	7	10	10	0	29	0.51	10	10	11	-5	250	0.65	81	10	10	-5	279	0.66	87	10	10
3b	0.0	4	0.69	0.9	9	10	0	6	0.65	1.4	9	10	0	21	0.53	6	9	9	0	28	0.52	8	9	9	-5	254	0.65	67	9	9	-5	285	0.66	73	9	9
4b	0.0	4	0.69	0.8	8	8	0	6	0.65	1.3	8	8	0	20	0.53	5	8	7	0	28	0.52	7	8	7	-5	254	0.65	62	8	8	-5	286	0.65	68	8	8
5b	0.0	3	0.7	0.6	6	5	0	5	0.67	1.0	6	5	0	20	0.53	5	5	5	0	27	0.53	7	5	5	-5	254	0.65	57	5	5	-5	287	0.65	64	5	5
6b	0.0	4	0.68	0.8	10	9	0	6	0.65	1.3	10	8	0	21	0.53	5	7	8	0	29	0.52	8	7	8	-5	258	0.65	60	7	7	-5	292	0.66	66	7	7
7b	0.0	4	0.69	0.8	7	7	0	6	0.66	1.2	7	7	0	20	0.53	5	6	6	0	28	0.52	7	6	6	-5	256	0.65	59	6	6	-5	289	0.65	66	6	6
8b	0.0	3	0.7	0.5	5	4	0	5	0.68	0.9	5	4	0	19	0.51	4	4	4	0	25	0.54	5	4	4	-5	253	0.66	49	3	3	-5	286	0.65	56	3	4
9b	0.0	1	0.73	0.1	1	1	0	2	0.7	0.3	1	1	0	15	0.5	3	3	2	0	18	0.51	3	3	1	-5	234	0.66	52	4	4	-5	257	0.66	55	4	3
10b	0.0	1	0.7	0.1	2	2	0	3	0.71	0.4	2	2	0	16	0.51	3	2	1	0	21	0.5	4	2	2	-5	244	0.66	44	2	2	-5	270	0.66	48	2	2
11b	0.0	2	0.7	0.3	3	3	0	3	0.7	0.4	3	3	0	17	0.51	3	1	3	0	22	0.5	4	1	3	-5	247	0.66	42	1	1	-5	275	0.65	47	1	1

The Table 29 and Table 30 show that in the ranking of cooling performance based on averaged ABC values is not always consistent with the ranking based on using specific ABC values, especially for the North and Central climate conditions. As stated before the value Y is partly a function of the characteristics of the window itself. This dependency is much higher in the Climate North and in the Climate Central than in the Climate South. Averaged Y values will therefore show a larger deviation from specific values. The reason for that is the same as already stated for the degree hours. In Climate North the cooling load is caused by the solar gains only. In Climate South, as the other extreme, the need for artificial cooling is not only caused by the solar gains through the window but e.g. also by the ventilation of the building (introducing warmer air leads to a cooling requirement independent of the window characteristics).

→ **Results cooling performance of roof windows**

Roof windows are not installed in a vertical position but with a certain inclination. Due to the inclination the solar irradiance on the roof window will increase. To consider this the table below shows the XYZ values for roof windows assuming a representative inclination of 40°.

The table shows both Y and Z values for a uniform and orientation-specific distribution of roof windows.

Table 31 Parameter Y & Z for roof windows as a function of different orientations, single family house

Climate condition	U env	Ventilative cooling	X	Y Z per orientation	Uniform	N	E	S	W
North	0.6	no	1	Y	50	33	54	61	50
				Z	0.73	0.26	0.75	0.87	0.83
		yes	0	Y	13	9	14	17	14
				Z	0.80	0.34	0.87	0.91	0.87
	0.3	no	5	Y	138	94	150	168	140
				Z	0.66	0.21	0.65	0.82	0.80
		yes	0	Y	22	15	24	27	23
				Z	0.78	0.31	0.84	0.90	0.85
Central	0.8	no	1	Y	96	78	103	108	96
				Z	0.76	0.58	0.77	0.83	0.80
		yes	0	Y	46	38	49	51	46
				Z	0.76	0.57	0.79	0.83	0.81
	0.4	no	4	Y	220	177	235	248	219
				Z	0.73	0.56	0.73	0.81	0.79
		yes	0	Y	68	56	72	75	68
				Z	0.77	0.58	0.78	0.84	0.81
South	1.0	no	-3	Y	562	452	580	636	581
				Z	0.89	0.80	0.91	0.92	0.91
		yes	-5	Y	489	398	505	548	506
				Z	0.90	0.81	0.91	0.92	0.92
	0.6	no	-2	Y	671	533	692	766	694
				Z	0.89	0.79	0.91	0.92	0.91
		yes	-4	Y	547	443	565	616	566

	Z	0.89	0.81	0.91	0.92	0.92

Table 32 Averaged Parameter Z as a function of the Climate and the orientation, roof windows 40° inclination, average of with/without ventilative cooling

	Usage sun protection				
Climate	Z (uniform distr.)	Z North	Z East	Z South	Z West
North	0,74	0,28	0,78	0,88	0,84
Central	0,75	0,57	0,75	0,82	0,80
South	0,89	0,80	0,91	0,92	0,91

Note that, similar to establishing the heating performance of roof windows, a correction may be applied to the U_W values for inclined installation in order to calculate the cooling performance $P_{E,C,W}$ for roof windows.

Table 33 U_{window} in $W/(m^2K)$ for an inclination of 40°

No.	$U_{window\ (vertical)}$	g_{gl}	Frame fraction	Air tight Class	ΔUg	$U_{window\ (40°)}$
1 a/b	5.8	0.85	30%	2	1.2	6.6
2 a/b	2.8	0.78	30%	3	0.50	3.2
3 a/b	1.7	0.65	30%	4	0.50	2.1
4 a/b	1.3	0.60	30%	4	0.50	1.7
5 a/b	1.0	0.55	30%	4	0.20	1.1
6 a/b	0.8	0.60	30%	4	0.20	0.9
7 a/b	1.0	0.58	30%	4	0.20	1.1
8 a/b	0.6	0.47	30%	4	0.10	0.7
9 a/b	2.8	0.35	30%	3	0.50	3.2
10 a/b	1.3	0.35	30%	4	0.50	1.7
11 a/b	0.8	0.35	30%	4	0.20	0.9

→ **General remarks on cooling performance**

Regarding the energy performance index for cooling the following remarks should be made:

1. Dealing with the issue of cooling is **much more complex** than the issue of heating.
2. The value of the parameter X (cooling degree hours) is very low. Therefore the U-value of the window has almost no influence on the Energy performance index for cooling. The Energy performance index for cooling depends almost entirely on the solar energy transmittance of the window (all other conditions kept equal).
3. The value of the parameter Y (Solar radiation leading to cooling amount) depends significantly on the boundary conditions of the building e.g. the insulation level of the building envelope but also on the option to consider ventilative cooling etc.. Furthermore the Parameter Y depends on the characteristic of the window itself.
4. If a representative Parameter Y could be defined / chosen, the energy performance index for cooling is almost entirely determined by the g-value of the window and the presence of solar shading system.

4.2.4. OVERVIEW OF ABC AND XYZ VALUES ESTABLISHED IN THE STUDY

The following page shows all ABC and XYZ values developed for the purpose of window energy performance assessments (within the boundary conditions as discussed).

Table 34 All ABC and XYZ values for (residential) façade windows

	Method	Climate conditions	Uenv	A-uni	A-N	A-E	A-S	A-W	B-uni	B-N	B-E	B-S	B-W	C-set/rise	C-22/6	Ventilative cooling	X-uni	X-N	X-E	X-S	X-W	Y-uni	Y-N	Y-E	Y-S	Y-W	Z-uni	Z-N	Z-E	Z-S	Z-W
FACADE WINDOWS	single room	North	0.6	89	101	90	76	90	161	109	152	230	153	0.68	0.35	vent cool	0.5	0.06	0.7	0.6	0.5	23	5	30	30	26	0.7	0.0	0.7	0.8	0.8
	single room	Central	0.8	53	62	54	41	53	133	99	118	192	124	0.65	0.36	vent cool	0.2	-0.1	0.5	0.2	0.4	57	29	75	59	63	0.6	0.0	0.6	0.7	0.6
	single room	South	1	11	19	11	4	11	97	80	112	90	104	0.64	0.45	vent cool	-4.1	-4.6	-4.0	-3.8	-3.9	341	175	418	352	420	0.7	0.0	0.8	0.8	0.8
	family house	North	0.6	108					303	145	289	479	297	0.65	0.36	no	1.3					34	19	41	39	38	0.6	0.03	0.6	0.7	0.7
	family house	North	0.3	99					231	107	213	386	221	0.66	0.35	no	4.7					95	54	114	108	104	0.5	0.02	0.5	0.7	0.7
	family house	North	0.45	103					267	126	251	432	259	0.65	0.35	no	3.0					65	37	77	74	71	0.6	0.03	0.5	0.7	0.7
	family house															vent cool	0.1					9	5	11	11	11	0.7	0.05	0.8	0.8	0.8
	family house															vent cool	0.3					15	8	18	18	17	0.7	0.04	0.7	0.8	0.7
	family house															vent cool	0.2					12	7	15	14	14	0.7	0.04	0.8	0.8	0.8
	family house	Central	0.8	71					271	143	251	418	272	0.64	0.38	no	0.8					60	40	72	62	65	0.5	0.0	0.6	0.6	0.6
	family house	Central	0.4	63					204	110	181	326	199	0.65	0.37	no	3.9					135	88	163	142	148	0.5	0.0	0.5	0.6	0.6
	family house	Central	0.6	67					238	127	216	372	236	0.65	0.38	no	2.4					98	64	117	102	107	0.5	0.0	0.5	0.6	0.6
	family house															vent cool	-0.1					28	20	34	29	31	0.5	0.0	0.6	0.6	0.6
	family house															vent cool	0.0					42	29	49	43	46	0.5	0.0	0.6	0.6	0.6
	family house															vent cool	-0.1					35	24	42	36	39	0.5	0.0	0.6	0.6	0.6
	family house	South	1	26					283	115	265	485	269	0.65	0.40	no	-3.5					305	165	373	308	375	0.7	0.0	0.8	0.7	0.8
	family house	South	0.6	20					229	92	209	401	215	0.65	0.39	no	-2.1					367	197	446	378	448	0.7	0.0	0.8	0.7	0.8
	family house	South	0.8	23					256	103	237	443	242	0.65	0.40	no	-2.8					336	181	409	343	411	0.7	0.0	0.8	0.7	0.8
	family house															vent cool	-4.6					263	142	325	259	325	0.7	0.0	0.8	0.7	0.8
	family house															vent cool	-4.4					295	160	363	294	364	0.7	0.0	0.8	0.7	0.8
	family house															vent cool	-4.5					279	151	344	276	345	0.7	0.0	0.8	0.7	0.8

Table 35 All ABC and XYZ values for (residential) roof windows

	Method	Climate conditions	Uenv	A-uni	A-N	A-E	A-S	A-W	B-uni	B-N	B-E	B-S	B-W	C-set/rise	C-22/6	Ventilative cooling	X-uni	X-N	X-E	X-S	X-W	Y-uni	Y-N	Y-E	Y-S	Y-W	Z-uni	Z-N	Z-E	Z-S	Z-W
ROOF WINDOWS	single room	North	0.6	86	98	85	76	86	156	121	148	197	158	0.64	0.35	vent cool	1.3	0.56	1.49	1.80	1.22	56.2	24	63	84	54	0.75	0.33	0.69	0.81	0.85
	single room	Central	0.8	49	58	50	39	49	150	105	151	189	155	0.64	0.36	vent cool	1.2	0.6	1.3	1.7	1.3	127	88	141	158	123	0.75	0.59	0.73	0.81	0.81
	single room	South	1	9	18	8	3	7	90	79	104	78	99	0.63	0.38	vent cool	-3.0	-3.8	-3.1	-2.2	-3.0	659	512	678	770	678	0.88	0.81	0.89	0.89	0.91
	family house	North	0.6	108					386	212	384	560	388	0.65	0.36	no	1.3					50	33	54	61	50	0.73	0.26	0.75	0.87	0.83
	family house	North	0.3	99					286	151	279	429	284	0.66	0.35	no	4.7					138	94	150	168	140	0.66	0.21	0.65	0.82	0.80
	family house	North	0.45	103					336	182	332	495	336	0.65	0.35	no	3.0					94	64	102	114	95	0.70	0.24	0.70	0.85	0.82
	family house															vent cool	0.1					13	9	14	17	14	0.80	0.34	0.87	0.91	0.87
	family house															vent cool	0.3					22	15	24	27	23	0.78	0.31	0.84	0.90	0.85
	family house															vent cool	0.2					18	12	19	22	18	0.79	0.32	0.85	0.91	0.86
	family house	Central	0.8	71					372	219	363	523	382	0.64	0.38	no	0.8					96	78	103	108	96	0.8	0.6	0.8	0.8	0.8
	family house	Central	0.4	63					235	140	226	335	240	0.65	0.37	no	3.9					220	177	235	248	219	0.7	0.6	0.7	0.8	0.8
	family house	Central	0.6	67					304	180	295	429	311	0.65	0.38	no	2.4					158	127	169	178	157	0.7	0.6	0.8	0.8	0.8
	family house															vent cool	-0.1					46	38	49	51	46	0.8	0.6	0.8	0.8	0.8
	family house															vent cool	0.0					68	56	72	75	68	0.8	0.6	0.8	0.8	0.8
	family house															vent cool	-0.1					57	47	60	63	57	0.8	0.6	0.8	0.8	0.8
	family house	South	1	26					379	170	378	587	382	0.65	0.40	no	-3.5					562	452	580	636	581	0.9	0.8	0.9	0.9	0.9
	family house	South	0.6	20					301	128	299	474	303	0.65	0.39	no	-2.1					671	533	692	766	694	0.9	0.8	0.9	0.9	0.9
	family house	South	0.8	23					340	149	339	531	343	0.65	0.40	no	-2.8					617	492	636	701	638	0.9	0.8	0.9	0.9	0.9
	family house															vent cool	-4.6					489	398	505	548	506	0.9	0.8	0.9	0.9	0.9
	family house															vent cool	-4.4					547	443	565	616	566	0.9	0.8	0.9	0.9	0.9
	family house															vent cool	-4.5					518	421	535	582	536	0.9	0.8	0.9	0.9	0.9

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4.2.5. USE OF DAYLIGHT

During the stakeholder meetings it was mentioned by some stakeholders, that the impact of the design of the window on the energy use for artificial lighting should be considered. Therefore the consultants searched for a simplified method to tackle this issue. The convenors of the relevant European working groups involved in the standardization process were asked, but stated that at the moment no simplified approach is available to consider the energy demand for artificial lighting in the simple energy balance equation for windows.

It must also be expected, that the energy demand for artificial lighting influenced by different design options of a window is not significant in the residential sector. Additionally it is likely, that the energy demand for artificial lighting will decrease dramatically in the near future due to the implementation of the ecodesign regulation for household lamps (COMMISSION REGULATION (EC) No 244/2009).

Nevertheless ISO 18292 addresses the issue of daylight provision with windows by defining a daylight potential factor:

"The daylight potential of a fenestration system indicates its potential to supply a building with daylight and depends on the visible transmittance, the glazing to fenestration system area ratio and on the view factor from the glazing to the sky and the ground. The latter parameter is used to determine the effect of different fenestration system slope angles."

According to ISO 18292, the daylight potential of the fenestration system as a building component is treated as independent of parameters such as the fenestration system height over floor, building overhangs and of the interior of the building. These all affect the daylight performance in practical situations.

The daylight potential is calculated by the following formula:

Equation 11

$$\tau_{DP} = \tau_v (F_{g-s} + r \cdot F_{g-g}) \cdot (1 - F_F)$$

Where

τ_v is the light transmittance of the glazing (determined according to EN 410)

F_{g-s} is the view factor form the glazing to the sky

F_{g-s} is the view factor form the glazing to the ground

r is the albedo of the ground (r=0,2 is normally used)

F_F is the frame fraction of the window

All of these characteristics are without dimension. The relationship between the view factors and the installation angle of the window are given below

Equation 12

$$F_{g-s} = (1 + \cos\gamma)/2$$

Equation 13

$$F_{g-g} = (1 - \cos\gamma)/2$$

Where

γ is the angle between the glazing plane and the horizontal, where γ = 0°

With an albedo r=0,2 the daylight potential for facade windows (vertical installation) therefore transforms to

Equation 14

$$\tau_{DP,facade} = 0.6 \cdot \tau_v \cdot (1 - F_F)$$

Assuming a representative inclination for roof windows of 40° the daylight potential factor for roof windows is

Equation 15

$$\tau_{DP,roof} = 0.93 \cdot \tau_v \cdot (1 - F_F)$$

If the window comprises a movable shading device that shades solar radiation (e.g. venetian blind, shutter), values for the complete dynamic range (fully open and fully closed) shall be given. The daylight potential of a window in combination with a shading device therefore is:

Equation 16

$$\tau_{DP,t} = \tau_{v,t}(F_{g-s} + r \cdot F_{g-g}) \cdot (1 - F_F)$$

Where

τ_v is the total light transmittance of the glazing in combination with the solar protection device (determined according to EN 13363-1 or EN 13363-2)

This approach could be used to give additional information about the daylight in an Energy label However, it is not known as to whether consumers understand such a number in the range between 0 and 1. Therefore it might be better to transform the figure in something better understandable.

4.3. Revised proposed Energy Labelling

This section presents the options we identified for energy labelling of façade and roof windows. As certain options have advantages and disadvantages over others, we can only recommend a selection of possible labels. It is up to the Commission to select, in consultation with relevant stakeholders, the final designs to develop further in a policy process. The authors emphasise that the actual decision of the window label design is a political one, and not a technical one.

The section is structured around the main elements of window energy labelling:

1. definition of the scope;
2. establishing measurement and calculation methods;
3. establishing a classification, which is assigning a performance class (here: A-G) to the performance established for the product.
4. presenting the design of the label, which lays down how the performance class, and possibly other information, is presented on the label.
5. presenting the technical fiche and a possible installer label.

4.3.1. Scope

We recommend that the energy label for windows is tuned towards use in the residential replacement market, as in this sector the need for product performance information is the highest. In other markets (new builds, non-residential) the need for such information is less, as the chances that specialists will be involved in the specification of new / replacement windows is much higher.

The scope should be set in line with the scope of products to be assessed as 'windows' under EN 14351-1. This means that shading devices, when they are part of the window, are included in the scope, regardless whether they are positioned on the interior, exterior side or incorporated within glass panes.

We do not recommend limiting the scope in a regulatory document, to 'windows for the residential sector' only, as this could create an additional burden for suppliers to single out windows for residential applications (depends on status of consumer) and would be difficult to enforce anyway. The consequence may be that certain non-residential consumers, performing a small scale renovation, could be confronted with a label not specifically designed for their typical use. This is not considered a problem as the supplier can and should be able to explain the label is intended for residential applications mainly. The supplier could also give further advice on how to properly select windows, with or without use of the information given by the label.

Therefore, the scope of the label should apply to windows, these being façade windows, roof windows and window doors, defined as:

> ***Window*** *means a building component for closing an opening in a wall or pitched roof that will admit light and may provide ventilation and incorporates at least:*
>
> - *frame;*
> - *transparent filling element, made out of glass;*
>
> *and may incorporate (optionally):*
>
> - *opaque filling element;*
> - *internal, integrated or external shutter / sun shading device.*
>
> ***Facade window*** *means a window intended for installation in wall or the like which has an angle to the vertical of (tbd*[35]*) degrees.*
>
> ***Roof window*** *means a window intended for installation in a roof or the like which is inclined at an angle to the vertical of (tbd) degrees. Roof windows have the same characteristics as façade windows installed in walls with regard to function, cleaning, maintenance and durability*

[35] 'tbd'= to be decided. The distinction between façade and roof windows may be based on the maximum allowable angle of installation. This will need to be defined in follow up activities

> ***Window door** means a façade window intended for passage of humans, but not an external or internal pedestrian doorset.*

Additional definitions for 'frame', 'transparent filling element', 'opaque filling elements', and 'internal, integrated or external shutter / sun shading device' may need to be developed.

As regards 'shutters / shading devices' we note that the device must be moveable (allow a variation in gt).

We note that the relative position and type of the shading device is not limited. As long as the additional thermal resistance and the gt can be established, the device can be considered in the rating, regardless whether it is internal, external or integrated within panes. This also applies to switchable glazing: if the gt can be established according acceptable conventions, then this can be considered in the same way as shading devices are considered.

Of course a window with a possible shading device should allowing placing on the market in accordance with EU guidelines. Current interpretation is that the actual number of boxes supplied is not relevant as long as they're one administrative unit, with one supplier responsible for placing on the market. The configuration of a window supplied by manufacturer A and a shading device supplied by manufacturer B would not constitute a single placing on the market as envisaged according the Energy Labelling Directive.

Windows, or products that meet the definition of windows, that meet one or more of the following descriptions shall be excluded from the label scope:

- roof lights (definition to be based on EN 1873 and prEN 14963);
- curtain walling (definition to be based on EN 13830)[36];
- windows subject to regulations on smoke leakage and resistance to fire (definition to be based on prEN 16034);
- windows for escape routes.

The proposed exclusion of windows subject to regulations on smoke leakage and resistance to fire and windows for escape routes is in accordance with the current version of EN 14351-1. The consultants were informed that there is a CEN/TC 33 Decision[37] to change the title of EN 14351-1 "Windows and doors – Product standard, performance characteristics – Part 1: Windows and external pedestrian doorsets without resistance to fire and/or smoke leakage characteristics" into "Windows and doors – Product standard, performance characteristics – Part 1: Windows and external pedestrian doorsets". The scope will be revised accordingly. Therefore it is expected, that in the near future (next year) the energy related and other (e.g. acoustic) performance characteristics of windows subject to regulations on smoke leakage and resistance to fire and of windows for escape routes will be determined according to EN 14351-1. Depending on the time scale of a possible introduction of a European Energy Label, there is the possibility to include also these window products.

Windows that offer a certain performance sound insulation and/or burglary resistance are covered by EN 14351-1 and could therefore be included in the scope of the labelling regulation. Such windows (with improved sound insulation or burglary resistance) could have higher U-values and different g-values than “standard windows”, so the presence of such properties can affect the overall energy performance of such windows. This can be explained by the window supplier and applies evenly to all windows with such specialty properties (one should only compare a window with certain sound insulating properties to another window with sound insulating properties, and not to a window without such sound insulating properties).

The above also means that doors (doorsets) are excluded from the label. To be exact the following door products shall be excluded:

- external pedestrian doorsets according to prEN 14351-1;
- internal pedestrian doorsets according to prEN 14351-2;
- pedestrian doorsets subject to regulations on smoke leakage and resistance to fire according to prEN 16034;

[36] In case part of the curtain wall is an element that can be opened, then this element covered by EN 14351-1

[37] CEN/TC 33 Decision 1065 (Vienna-01/2015)-WG1-change of the title of EN 14351-1

- industrial, commercial and garage doors and gates according to EN 13241-1;
- revolving doorsets;

The advantage to align the scope with windows as covered by EN 14351-1 is that if measures are proposed for windows (e.g. energy labelling) it would be clear which products are addressed as there will be full alignment with windows that have to carry a CE mark according to EN 14351-1.

The scope should also exclude windows as used in means of transport (windows for cars, buses, trains, ships, aeroplanes, etc.) as 'means of transport' is outside the scope of Directives 125/2009 (Ecodesign) and 30/2010 (Energy labelling).

4.3.2. MEASUREMENT AND CALCULATION METHOD

→ Measurement method

The measurement of the main parameters (Uw, g-value, leakage, etc.) for establishing either the heating and/or the cooling performance shall take into account the following considerations:

1. the Uw value, g-value, air leakage, gt (g value of window with shutter closed), frame fraction F_F shall be established in accordance with hEN 14351-1. The study writers recommend that **these parameters are determined for the two standard sizes defined in hEN 14351-1**. Taking the outer dimensions also means that the frame fraction F_F will affect the performance of the window (lower frame fraction means more transparent area and more losses and gains determined by glazing properties) which gives an incentive to develop windows with lower frame fractions (although the performance remains integral, for the complete window);
2. the **Uw value of roof windows** should be established for an inclined application of the roof window (this study recommends an inclination of 40º). This is considered reasonable as the B parameter (solar irradiance value) established for roof windows also assumes an inclined application. Combining this with U_w values for roof windows established at 90º inclination (current practice) should be avoided.
3. The Class of the airtightness of the window shall be established in accordance with hEN 14351-1. To calculate the heating performance of the window the volume flows Q100 are linked to the particular class:

   Class 1: 50 $m^3/(h^* m^2)$

   Class 2: 27 $m^3/(h^* m^2)$

   Class 3: 9 $m^3/(h^* m^2)$

   Class 4: 3 $m^3/(h^* m^2)$

   If Class 0 (not tested) or npd (no performance determined) is declared, the volume flow shall be taken as 50 $m^3/(h\ m^2)$;
4. The solar factor for the combination of glazing and solar protection device g_t (value that determines the $g_{W,eff}$) shall be established in accordance with hEN 14351-1;
5. The additional thermal resistance of a closed shutter (ΔR, in (m2K)/W) shall be determined according to hEN 13659.

→ Calculation method

Depending on the type of information requested for the label, certain performances need to be calculated.

The equations for the calculation method are shown in section 4.2 .

In TASK 3, 5 and 6, the ABC and XYZ values were 'corrected' to better represent the average window and shutter use. For the assessment of the window performance for the purpose of labelling we propose to simplify the use of the ABC, and XYZ values and not apply such corrections.

4.3.3. CLASSIFICATION AND LABEL DESIGN

The former draft proposal for a possible energy labelling of windows invoked numerous comments from stakeholders. The compilation of comments received is available from the study website. This section will not address all these comments in detail but will focus on some of the main issues that have been raised by stakeholders, these being:

1. The window label (rating, classification) should be specific to Member States conditions, not to generic "EU" conditions;
2. The cooling performance should be based on an energy balance equation (in kWh/m^2 , using XYZ), taking into consideration climate conditions, and not just the climate independent $g_{W,eff}$;
3. The heating and cooling performance should be combined into a single annual value;
4. The classification should be the same across the whole EU and not different per climate condition;
5. The label should show a map of climate conditions considered in the rating/classification;
6. A fourth climate condition should be added;
7. The use of an incorporated solar shading device should not be considered in the rating;
8. The label design should also show the main (energy) characteristics of the window such as: U_W, g, air leakage, daylight potential, acoustic performance.

These comments have helped us to shape our final recommended window energy label scheme. In order to show how these comments have been taken into consideration, we addressed these in the following paragraphs.

→ EU or MS window energy label?

Stakeholder ANFAJE, EBC, FAEC, CAB, BritGlass and BFRC argued in favour of a country (Member State) specific window rating scheme[38]. If indeed the window rating (the method and values used to calculate performance) and classification (the class borders assigning a performance value to a certain energy class) are specific to MS then we believe such a label cannot be introduced through a delegated act (Regulation) under the Energy Labelling Directive 2010/30/EU, as the delegated act assumes that the label design, including rating and classification, is harmonised across the EU and not different per MS.

If the EU Energy label Directive does not provide the right context for a MS specific label, what context would be right? There are a number of alternatives that may allow a MS specific approach to window labelling:

1. Continue the present situation with schemes initiated per MS;
2. Introduce window labelling as part of the EPBD package;
3. Introduce window labelling under the CPR.

Continue the present situation?

The present situation, where various window labelling schemes are initiated and in operation (with varying success) by private organisations in various countries, results in a form of country-specific window energy rating. The downside is that this results in a scattered market that complicates cross-border trade. Currently there are some 12 labelling schemes in operation, or initiated, in 11 countries (including Switzerland). In Italy there are two competing schemes.

It has to be highlighted that in general the current existing schemes in the MS were not introduced by the MS itself as a legal act but are operated by private institutions. One exception is the labelling scheme in the U.K.. Although the U.K. scheme itself is not mandatory but voluntary, it can be used to show compliance with the requirements in the national building regulation. Five of these schemes present a heating performance only, four present heating and cooling separately and two present a combined annual (heating + cooling) performance (plus possibly some additional cooling or heating comfort indicators)[39].

[38] The mentioning of stakeholders only means a support based on principle. In most cases this support is conditional (depends on other factors besides discussed in this paragraph).

[39] No information was available on the scheme operational in Slovenia

Organisations in other countries could consider introducing a country-specific labelling scheme based on principles laid down in this study or other schemes, but specific for their climate conditions. This approach could result in possibly more than 28 different rules for rating and classification[40] of windows (Italy has two label schemes in operation/initiated).

Window labelling under the EPBD?

Another possibility for MS specific window energy rating could be a requirement under the EPBD (recast needed) to introduce such schemes, similar to the requirement to develop a label for buildings. Although the EPBD could harmonise the methodology to be used for developing rating schemes in broad terms, it cannot enforce the exact same equations and values upon MS (the EPBD is a Directive and needs to be implemented in MS legislation) and therefore this approach would most likely result in a scattered approach of window energy performance across the EU, much similar to the current situation (where in various MS different labelling schemes are operational, each with different rating and classification methods).

Window labelling under the CPR?

A third possibility is to use the Construction Products Regulation to mandate the relevant TC to develop a performance rating and label design to be included in (to be) harmonised product standards. This would probably avoid the scattered result described above, but would face similar issues as this study and tough choices will need to be made as well. For this reason the benefit, when compared to developing an EU label under 2010/30/EU, is unclear.

Concluding

As this study deals with the feasibility of establishing an EU Energy label for Windows, we will not further develop the above described approaches, as this is outside the scope of this study. It is the responsibility of the Commission to further develop such approaches when required.

→ **Solar shading device should be ignored**

Stakeholder SEA, Profine, Finstral, GfE, BritGlass, ANEC and BFRC[41] proposed to ignore shading devices that are incorporated into the window (as placed on the market). In contrast at least EAA and ESSO are asking to consider the effect of shutter and shading devices in the energy performance index. Other stakeholders have refrained from commenting.

Certain opponents to inclusion of shading devices argue that solar shading devices are not used in the country they are situated in. We note that as the EU label is for the whole of the EU, including Southern States where use of solar shading is very abundant, this cannot be a reason to ignore shading devices. Furthermore, TASK 2 sales data shows there is a market for shading devices in the countries mentioned by the stakeholders, although sales are indeed smaller.

Stakeholders have argued that there is not enough knowledge on how shutters are actually used by persons, and this should be a reason to ignore these devices. We do not agree as consideration of the adaptable nature of such windows that allow changing their characteristics, provide an opportunity to make buildings in the EU respond better to changing conditions. We acknowledge that this needs to go together with an information campaign on proper use of shading devices.

Most building energy efficiency experts have stated that Europe's buildings need to become smarter, able to respond to changing conditions, and have promoted the concept of 'adaptable facades'. The consideration of windows that can adapt its characteristics, for instance through moveable shading devices, fits this goal, as shading devices allow the user (manually or through automated systems) to control the amount of incoming solar gains (and also glare, privacy, etc.). An adaptable window should not be limited to use of shutters and

[40] Certain window labelling schemes are initatied by private parties and do not necessarily reflect the preferred approach according Member State authorities.

[41] The mentioning of stakeholders only means a support based on principle. In most cases this support is conditional (depends on other factors besides discussed in this paragraph).

solar shading devices. Also switchable glazings that allow to change the characteristic of the window to take into account different boundary conditions, should be considered appropriately.

The number of studies dealing with the actual use of shading devices are indeed very limited. So far the study team has identified three possibly relevant studies.

The first is a US study on the use of internal window covering[42] .Below are some excerpts from the Executive Summary:

> *Initial analyses by the U.S. Department of Energy and the window covering industry suggested that window coverings—blinds, shades, curtains, and awnings— could save significant energy at low cost.*
>
> *Solar heat gain appears to play a role in window covering choice and operation, leading to notable differences among climate regions. There is a 20 percentage point difference between the Southern and Northern climate zones in the share of coverings that are closed in the summer.*
>
> *People rarely move their window coverings. Approximately half of coverings are closed at all times. Between 75% and 84% of coverings remain in the same position throughout the day, depending on the season (summer or winter) and time of week (weekday or weekend). Moreover, between 56% and 71% of households do not adjust any of the covering in their house on a daily basis, depending on the season and time of week.*

The study conveys a 'mixed message': window covering may help achieving energy savings, but most people do not regularly adjust the covering to achieve the best effect in given conditions. Of course, covering is used for many reasons, such as privacy (for instance covering in many bathrooms or bedrooms)., which may result in not adjusting the covering according optimal energy saving strategies.

Apart from this, the study exhibits a wealth of information on how people, in various climatic conditions, use their window covering.

The second study is a Swiss study regarding the use of moveable shading devices in offices [43]. Below are some excerpts from the Executive Summary:

> *This project focused on the effective use of movable shading devices in offices, and on the impact on the indoor day lighting.*
>
> *The key finding is that sunscreens are adjusted infrequently (less than 2 movements blinds / week) regardless of the orientation or season. The consequence of this misuse is that the contribution of natural light is far from being optimised.*
>
> *The main conclusion of this study is that the implementation of automatic blinds can significantly increase the number of hours artificial lighting is not required while preserving the visual comfort and freedom of choice of users.*

Again, this study shows that shading devices are not used properly by humans, but it also shows that humans are much more tolerant to changing environmental conditions (read" lighting levels) as some office workers are satisfied with light levels far below or above recommended.

The third and most interesting study, as it deals directly with the subject at hand, is a consumer research study of use of moveable shading devices by IPSOS France, commissioned by SOMFY in 2009[44]. In this study over 1500 persons were interviewed regarding their use of moveable shading devices. The group is a fair representation of an average (French) consumer.

The below statements summarise some of the main conclusions of this consumer research study:

1. In winter, 70% of dwellings have their shutters closed daily;
2. In summer, 57% of dwellings have their shuttersclosed daily;
3. The shutter type (control type also) impacts the closure frequency :
4. In summer as in winter, motorized shutters are closed more than 15% compared to manual shutters;

[42] "Residential Windows and Window Coverings: A detailed view of the installed base and user behavious", by D7R International Ltd. for US DOE, September 2013.

[43] B. Paule, J. Boutillier, S. Pantet, "Performance Globale en Eclarirage – Global Lighting performance" Swiss federal office for energy / Estia SA, Lausanne, January 2015 (executive summary).

[44] Presentations of this study have been made available by R. Beuhorry, SOMFY.

5. the main reasons to activate the shutters is for energy related reasons (in winter: keep warm, in summer: keep cool);
6. as regards automated shading devices, no conclusions could be reached as there were too few in the analysis and respondents didn't know which control type was installed.

The tables below show more detailed information.

Table 36 Share of respondents having their shutters closed, by type of shutter and season

Type of shutter	Winter	Summer
Motorised shutter	82%	70%
Manual shutter	68%	55%
Manual rolling shutter	72%	59%
Other manual shutter	67%	53%

Table 37 Main reasons stated for activation of the shutter (mentioned as 1st, 2nd or 3rd)

Winter		← time of year →	Summer	
mentioned as 2nd, 3rd reason	mentioned as 1st reason	Reason ↓	mentioned as 1st reason	mentioned as 2nd, 3rd reason
72%	38%	to insulate in winter / to keep cool in summer	28%	71%
65%	28%	to improve sleep	33%	67%
53%	18%	for safety	20%	45%
53%	13%	for privacy	9%	41%

This study shows that the average user (at least in France) is very much aware of the benefits of shutter activation in BOTH summer AND winter. It also shows that more than 50% of respondents activate their shutter (higher shares applying to motorised shutters, offering more comfort in control).

ROMAZO, the Dutch window covering association, published two separate studies, performed by TNO Netherlands, that showed that moveable shading devices can save significant amounts of cooling energy[45], and also significant amounts of heating energy [46] when properly applied.

We conclude that although people may be relatively inactive and tolerant, one of the main reasons humans do control/activate shading devices is to achieve better thermal comfort (source: IPSOS/SOMFY).

We conclude that moveable shading devices, and other technologies that allow the window to adapt to changing conditions, e.g. switchable glazing, when equipped with the right characteristics and used properly, can save energy compared to windows that do not change characteristics (remain static) in changing conditions (source: Swiss study, TNO studies).

We therefore recommend the following regarding the consideration of shutters/shading in a window energy rating scheme applicable to windows:

1. The current proposed product scope for policy measures (e.g. labelling) is linked to the European harmonized product standard for windows hEN 14351-1. The advantage of that product definition is that any window with a CE-mark will also carry an energy label. This definition is accepted by nearly all stakeholders. As EN 14351-1 applies to windows with or without incorporated shutters and/or shutterboxes and/or blinds excluding windows with incorporated shutters/blinds would not be in line with EN 14351-1.

[45] "Buitenzonwering en energiebesparing op verwarmen en koelen", TNO report 2008-D-R0716-B-S, 2008

[46] "Besparingen op verwarmingsenergie door thermische isolatie van zonweringen", TNO report 2015 R 10396, March 2015.

2. It may also be helpful in the discussion to not use only the terms "shutters, blinds" but the term "adaptive windows". The general approach of the consultants is to create a method for the evaluation for the energy performance of adaptive windows. Currently adaptive windows are mainly windows with moveable shutters/blinds. But also the glazing industry is spending a lot of effort in the development of adaptive (or smart) glazings allowing the control and adjustment of the solar gains of a window (similar to moveable blinds). The further development of adaptive windows is one of the major issues in window development. All running EU funded R&D projects are addressing the development of adaptive windows as a major task. Therefore the consultants think that a European Energy label should not only be for static window properties but should allow to consider switchable technologies ie. adaptive windows.
3. Especially as far as the reduction of cooling energy is concerned shading devices play an import role. We understand that an Energy label should be independent from technology. Therefore it is hard to understand why one technology that can be incorporated in a window- solar control glass- should be considered but a different technology that can also be incorporated should be excluded.

The information presented in this report allows the development of both a proposal that does not consider adaptive windows, as well as a proposal that does consider the possible use of switchable devices in adaptive windows, or a combination of both, in a label design.

→ **Label includes map of climate conditions**

Stakeholders DEA, SEA, CAB, GfE and ECOS[47] have proposed to include a map showing the EU climate conditions graphically if the window rating label shows performance for these climate conditions, similar to energy labels developed for space heaters and room air conditioners.

Such maps do not convey information on the actual performance of products, but convey information **on the conditions used to establish the performance. It should be used in combination with the performances stated on the label (using A-G), so that the consumer is guided towards the more representative A-G rating for his/her situation.**

The heating map as used in Regulation 811/2013 relates to areas with a design temperature as referenced in many European building regulations ie. it is based on the lowest temperature in usually three consecutive days in the last 20 years, i.e. when there is no thermal store of the house left from previously warmer periods. For 'Colder' this design temperature is -22ºC, for 'Average' this is -10ºC and for 'Warmer' this is +2ºC. Performance of space heaters that are affected by climatic conditions (heat pumps mainly) are then established using a bin load profile connected to these design temperatures (-22ºC, -10º and +2ºC, as in table 12 of Annex VII of Regulation 811/2013).

The map used for water heaters is based on solar irradiance levels for 'Colder', 'Average' and 'Warmer' conditions (as in table 5 of Annex VII of Regulation 812-2013). Roughly speaking the irradiance levels correspond to levels established for Helsinki, Strasbourg and Athens.

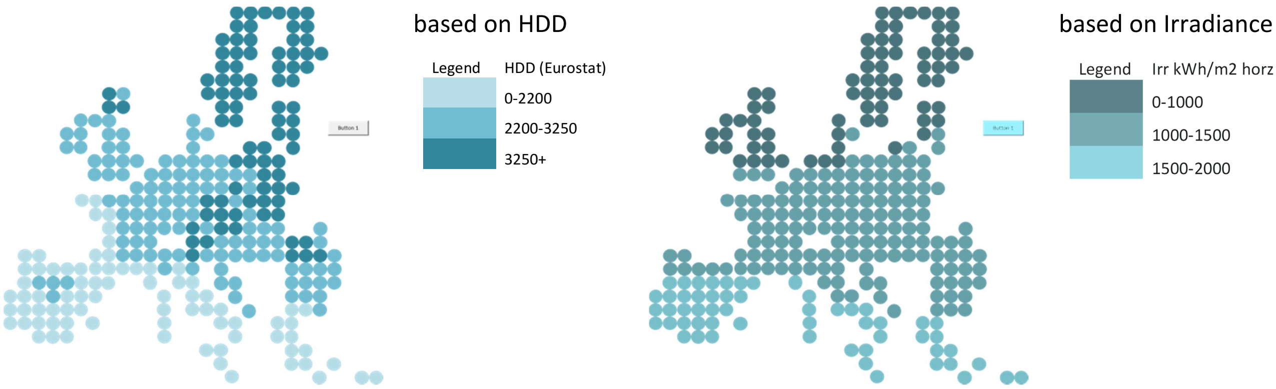
Figure 4 Existing EU map for space heating (left) and water heating (right)

[47] The mentioning of stakeholders only means a support based on principle. In most cases this support is conditional (depends on other factors besides discussed in this paragraph).

So for space heaters and water heaters the colours on the map shown on the label relate to separate conditions for assessment of the performance of the product. For windows we would refer to these as boundary conditions.

Several options for an EU map to be shown n an EU Energy Label are possible, depending on where class boundaries are drawn. The below examples show maps drawn on the basis of heating degree days (for heating performance) and solar irradiance levels (for cooling performance). These 'zones' are aligned with the climate conditions that have been used to assess performance. See also Annex V for more information on how these maps have been established.

Figure 5 Options for an EU map for heating performance (left) and cooling performance (right), source VHK, 2015



The 'heating map' is based on HDD as presented by Eurostat for NUTS2 regions (see Annex V), the 'cooling map' is based on solar irradiance on a horizontal plane as resented by SolarGIS (see Annex V).

A map for the combined performance (heating + cooling) could not be drawn as no method exists to present HDD and irradiance <u>on a single scale</u>.

By including the window characteristics an overall performance can be calculated, but this introduces even more variables (the window characteristics U_W, g values etc.) so that eventually each window assessed could result in it's own unique 'EU map'. This can not be established in the current regulatory framework for Energy Labelling according 2010/30/EU.

A software tool, possibly accessible through internet, could be useful in establishing such unique EU maps, but should be certified for such use. The algorithm should be fully in line with the regulatory method and the regulatory text may need to describe this algorithm or it's basics.

→ **A fourth climate condition should be added**

GfE proposed to show performances based on "three or four climate conditions". The fourth condition would be created by adding another 'zone', or better: splitting up the 'Central' (= Strasbourg) into an 'Oceanic'(=Paris) and 'Continental' (= Vienna) zone. We have assessed the possible benefits of this approach as follows.

Figure 6 EU map, as presented by GfE, for a fourth condition (map for illustration only)

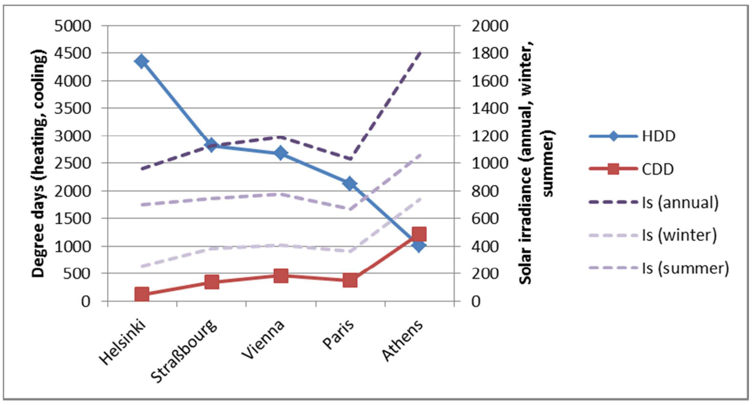
An analysis of heating degree days and cooling degree days and irradiance shows that the added benefit for these locations is relatively small:

- The HDD in Strasbourg are slightly higher than Paris or Vienna, but for CDD Strasbourg is quite identical to Paris, and for annual irradiance Strasbourg is in between Paris and Vienna.

Table 38 Adding Paris and Vienna as climate condition

Unit	Helsinki	Stras- bourg	Vienna	Paris	Athens	Climate aspect
Heating degree days, HDD in kKh	4344	2813	2671	2129	1010	Base Temperature 18°C (Meteonorm)
Cooling degree days, CDD in kKh	119	343	462	374	1226	Base Temperature 18°C (Meteonorm)
Irradiance (annual), Is in kWh/m^2	959	1126	1189	1028	1796	Annual global radiation (Meteonorm)
Irradiance Is (summer), Is in kWh/m^2	703	745	779	665	1055	Global radiation May to September (own calculation, based on Meteonorm)
Irradiance (winter), Is in kWh/m^2	256	381	410	363	741	Global radiation October to April (own calculation, Meteonorm)

Figure 7 Adding Paris and Vienna as climate condition



We conclude that the added benefit for considering Paris and Vienna is limited, and that Strasbourg is sufficiently representative for climates in Paris and Vienna.

Nonetheless, the presentation of an EU map, linked to climate conditions used to establish the performance is incorporated in our options for a revised proposal for energy labelling of windows in the EU (see section above).

→ Label should show also other (energy) characteristics of window

Many stakeholders[48] have opted for inclusion in the POS (point-of-sale) label some or many other performance characteristics of windows, such as the U_W, g, air leakage, daylight potential, acoustic performance.

Our initial draft designs did not consider this extra information as we expect the average consumer not to take this information into consideration when shopping for windows.

Nonetheless, the call by many stakeholders, and the fact that many other, existing window rating schemes also present such information, has lead us to reconsider this in our revised label designs.

Of course the information would also be shown in the technical fiche.

Some stakeholders have argued against the inclusion of such information as it would duplicate information already required for CE marking.

This is not necessarily true as the CE marking information may differ per MS as requirements per MS may differ. We agree that a large majority of window suppliers (possibly more than 95%) have the main energy characteristics readily available so inclusion of this information in the window label would indeed be duplicating, but the additional effort would be minimal.

Stakeholders have also pointed out that it is allowed to declare performance (and thus information to be shown on the CE label) for a group of products (as long as the individual performance is not less than what is stated for the group). If this same information is used for window labelling, then it may be that the actual performance is better than claimed. In order to preserve market attractiveness, these suppliers would need to establish the performance of all individual products.

One stakeholder (DEA) proposed to also show the exact rating values on the label (ie. performance in kWh/m^2). We did not support this as the actual rating information (in its current form of kWh/m^2) is of little use as the calculation is based on fixed and generic boundary conditions. The exact value has little meaning for the consumer, other than to compare it with other windows that have been rated on the same basis.

We have opted to include this 'exact rating' information in the technical fiche as it may help to discern the better performing window within the same class and could be used for more detailed quotations by suppliers.

→ Principle designs of an energy label for windows

The previous section 4.2 identified ABC and XYZ values for 3 climate conditions, and various boundary conditions. The energy label for windows should however only present a selection of these possible performances. The selection process can be imagined as a decision tree.

The first decision is to present heating and cooling performance separately or combined into a single value. The heating performance is preferably established using the ABC approach, but the cooling performance may be established by either the $g_{W,eff}$ or an XYZ approach. For a combined value only the ABC+XYZ approach is possible.

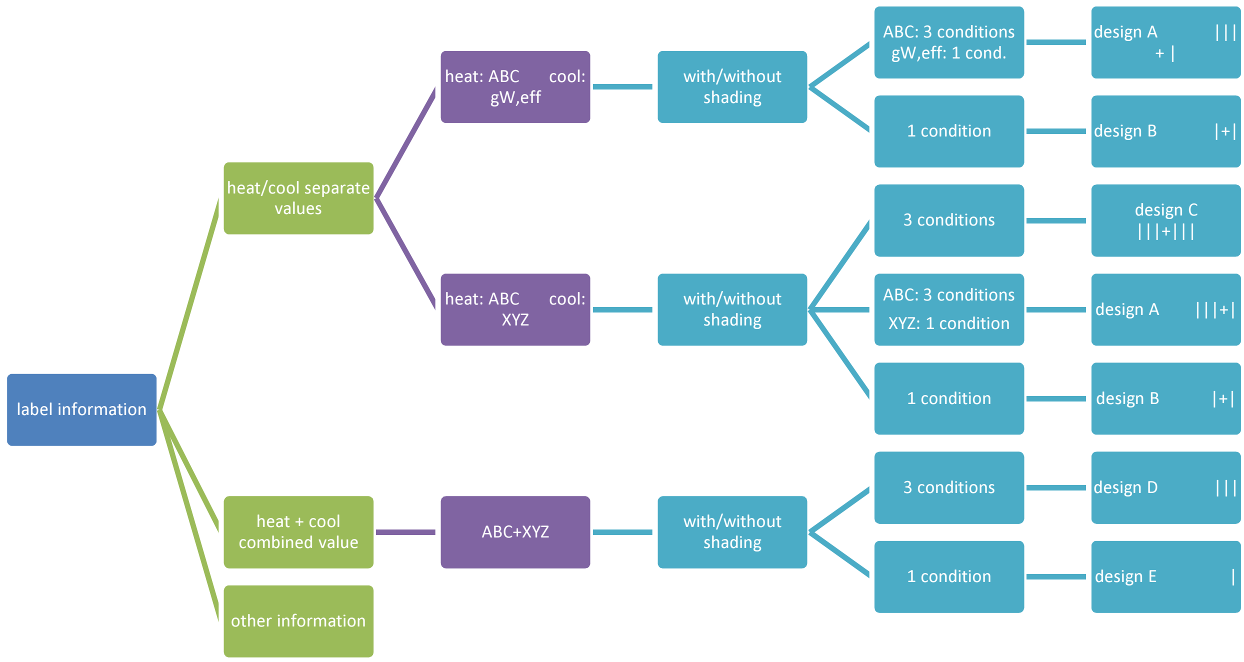
Then a decision has to be made to base the performance on the consideration of 'adaptive' windows (possible moveable shading devices or switchable glazing), or not, or to present both.

A decision needs to be made whether the performances are presented for one climate condition (per heating, cooling or combined performance) or for multiple conditions (the information in the report allows three conditions). Following this decision tree it is apparent that some 5 different basic label designs are possible.

(if performance with shading is presented separately the number of performances shown will be doubled).

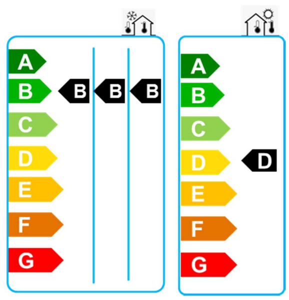
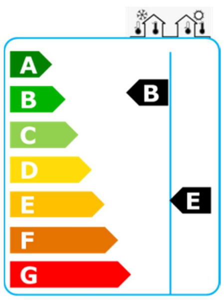
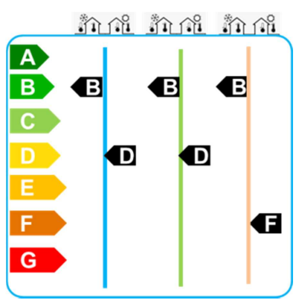
[48] The mentioning of stakeholders only means a support based on principle. In most cases this support is conditional (depends on other factors besides discussed in this paragraph).

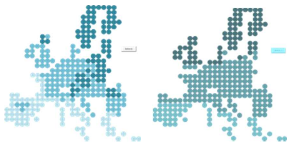
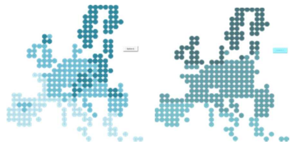
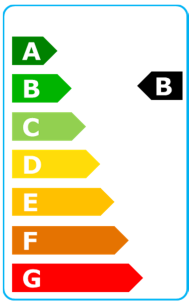
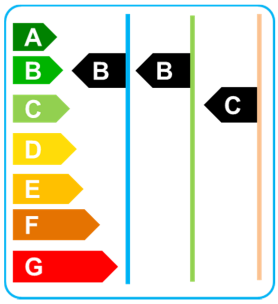
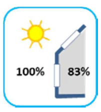
Figure 8 Decision tree for basic label design



More explicitly, the labels could contain the following information elements.

Table 39 Possible label information elements

Label information	3 conditions for heating performance, 1 for cooling	1 condition for each performance	3 conditions for each performance
Heating & cooling shown separate (the *winter / summer house symbol* may be replaced by another symbol indicating heating vs. cooling)	**design A** 	**design B** 	**design C** 
in case the 'house with thermometer' symbols are not clear, alternative symbols can be used (as in 626/2012/EU)	for heating 		for cooling 
If the main performance is 'without shading' then an additional performance with shading could be added	A A A A	A C	A B A B A C

Possible EU map	heating cooling 	(map not useful)	heating cooling 
Heating and cooling combined in a single annual value		**design E** 	**design D** 
If the main performance is 'without shading' then an additional performance with shading could be added		A B C D E F G ..or.. A	A A A
Possible EU map		(map not useful)	a map combining the heating and cooling conditions into a single metric could not be established
Other performance characteristics **NOTE! The symbols may be changed when a proposal is developed further**	 	A symbol can be added to show shading is present and what type (different symbols for exterior, integrated, interior). For adaptive glazing the same symbol as for integrated shading (into IGU) could be used (symbol not shown).	
	U_W = 1.3	U_W in W/(m^{2}K)	
	g = 0.60	g_W value $g_{W,t}$ value, if shading is present	
		acoustic performance	
		daylight potential	

Other information	**QR code (QR=Quick Response)** This was mentioned in the Energy Labelling Evaluation study as possible information element to add[49]. It would allow a consumer (or market surveillance authorities) easier access to more information (technical fiche, information in a national language, etc.). A current example is its use on the US fueleconomy label[50]. Alternatives exists such as the *'ecoGator'* app that works on visual recognition of the Energy Label label itself, without QR code[51].

The following sections describe in more detail the options for presenting information regarding the heating performance, cooling performance or combined performance.

4.3.4. Heating performance

In case the label presents heating and cooling performance separately we see no urgent need to have the underlying data (ABC, XYZ) to be based on the same method. Either the single room or single family house based data could be used. We recommend for heating to base this on the single family house as this assumes more realistic heat loss characteristics.

→ **Heating performance – triple classification**

The proposed ABC values are based on the single family house method, and are the average of low and high U envelope values.

Table 40 ABC values for façade window, based on family house

	A	B	C sunset to sunrise	C 22:00 to 06:00
North	103	267	0,66	0.35
Central	67	238	0,65	0,38
South	23	256	0,65	0,40

Table 41 ABC values for roof window, based on family house

	A	B	C sunset to sunrise	C 22:00 to 06:00
North	103	336	0,66	0,**35**
Central	67	304	0,65	0,**38**
South	23	340	0,65	0,**40**

The performance calculated on the basis of these values is for facade windows as follows (with C based on sunset to sunrise). Note that the U_w for roof windows is corrected to values estimated to be typical for inclined (40º) installation.

[49] E.Molenbroek, et al, Final technical report - Evaluation of the Energy Labelling Directive and specific aspects of the Ecodesign Directive ENER/C3/2012-523, Ecofys, 2014.

[50] http://www.fueleconomy.gov/feg/label/video.shtml

[51] http://www.myeconavigator.eu/mobile-app/innovative-scanning-function/, coordination by Austrian Energy Agency, as part of the 'Efficiency 2.1' program

Table 42 Heating performances $P_{E,H,W}$, family house, façade and roof windows

FACADE WINDOWS				ROOF WINDOWS			
without shutter	North	Central	South	without shutter	North	Central	South
Uw 5.8 / g 0.85	588	340	14	Uw 6.6 / g 0.85	629	354	-17
Uw 2.8 / g 0.78	193	88	-64	Uw 3.2 / g 0.78	196	79	-101
Uw 1.7 / g 0.65	71	16	-74	Uw 2.1 / g 0.65	80	12	-103
Uw 1.3 / g 0.6	39	-3	-74	Uw 1.7 / g 0.6	51	-4	-100
Uw 1 / g 0.55	17	-14	-72	Uw 1.1 / g 0.55	1	-33	-102
Uw 0.8 / g 0.6	-13	-36	-85	Uw 0.9 / g 0.6	-32	-57	-118
Uw 1 / g 0.58	11	-19	-77	Uw 1.1 / g 0.58	-6	-39	-109
Uw 0.6 / g 0.47	-9	-28	-67	Uw 0.7 / g 0.47	-22	-43	-92
Uw 2.8 / g 0.35	273	160	13	Uw 3.2 / g 0.35	297	170	1
Uw 1.3 / g 0.35	85	39	-29	Uw 1.7 / g 0.35	110	49	-40
Uw 0.8 / g 0.35	34	6	-41	Uw 0.9 / g 0.35	27	-4	-59
with shutter				with shutter			
Uw 5.8 / g 0.85 shading	391	215	-29	Uw 6.6 / g 0.85 shading	391	203	-70
Uw 2.8 / g 0.78 shading	131	49	-78	Uw 3.2 / g 0.78 shading	119	30	-118
Uw 1.7 / g 0.65 shading	45	-1	-79	Uw 2.1 / g 0.65 shading	43	-12	-111
Uw 1.3 / g 0.6 shading	22	-13	-77	Uw 1.7 / g 0.6 shading	25	-20	-106
Uw 1 / g 0.55 shading	7	-21	-74	Uw 1.1 / g 0.55 shading	-11	-41	-104
Uw 0.8 / g 0.6 shading	-20	-40	-87	Uw 0.9 / g 0.6 shading	-40	-62	-120
Uw 1 / g 0.58 shading	1	-26	-79	Uw 1.1 / g 0.58 shading	-18	-47	-112
Uw 0.6 / g 0.47 shading	-13	-30	-68	Uw 0.7 / g 0.47 shading	-27	-46	-93
Uw 2.8 / g 0.35 shading	211	121	-1	Uw 3.2 / g 0.35 shading	220	122	-15
Uw 1.3 / g 0.35 shading	69	29	-33	Uw 1.7 / g 0.35 shading	84	33	-46
Uw 0.8 / g 0.35 shading	27	2	-42	Uw 0.9 / g 0.35 shading	19	-9	-61

A classification according the following table may be applied.

Table 43 Heating class boundaries, family house, triple classification

	FACADE (.. < kWh/m2)			ROOF (.. < kWh/m2)		
Class	North	Central	South	North	Central	South
A	0	-10	-70	-5	-20	-100
B	25	-5	-65	5	-10	-50
C	50	5	-40	20	5	-25
D	75	25	-10	40	25	-12
E	100	50	0	65	50	-6
F	125	100	10	115	100	0
G						

The energy performance class of the windows are as follows.

Table 44 Heating energy classes, family house, triple classification

FACADE WINDOWS	North	Central	South	ROOF WINDOWS	North	Central	South
Uw 5.8 / g 0.85	G	G	G	Uw 6.6 / g 0.85	G	G	D
Uw 2.8 / g 0.78	G	F	C	Uw 3.2 / g 0.78	G	F	A
Uw 1.7 / g 0.65	F	D	A	Uw 2.1 / g 0.65	F	D	A
Uw 1.3 / g 0.6	D	C	A	Uw 1.7 / g 0.6	E	C	B
Uw 1 / g 0.55	C	A	A	Uw 1.1 / g 0.55	B	A	A
Uw 0.8 / g 0.6	A	A	A	Uw 0.9 / g 0.6	A	A	A
Uw 1 / g 0.58	C	A	A	Uw 1.1 / g 0.58	A	A	A
Uw 0.6 / g 0.47	A	A	B	Uw 0.7 / g 0.47	A	A	B
Uw 2.8 / g 0.35	G	G	G	Uw 3.2 / g 0.35	G	G	E
Uw 1.3 / g 0.35	F	E	D	Uw 1.7 / g 0.35	F	E	C
Uw 0.8 / g 0.35	D	D	C	Uw 0.9 / g 0.35	D	C	B
Uw 5.8 / g 0.85 shading	G	G	D	Uw 6.6 / g 0.85 shading	G	G	B
Uw 2.8 / g 0.78 shading	G	E	A	Uw 3.2 / g 0.78 shading	G	E	A
Uw 1.7 / g 0.65 shading	E	C	A	Uw 2.1 / g 0.65 shading	E	B	A
Uw 1.3 / g 0.6 shading	D	A	A	Uw 1.7 / g 0.6 shading	D	A	A
Uw 1 / g 0.55 shading	C	A	A	Uw 1.1 / g 0.55 shading	A	A	A
Uw 0.8 / g 0.6 shading	A	A	A	Uw 0.9 / g 0.6 shading	A	A	A
Uw 1 / g 0.58 shading	B	A	A	Uw 1.1 / g 0.58 shading	A	A	A
Uw 0.6 / g 0.47 shading	A	A	B	Uw 0.7 / g 0.47 shading	A	A	B
Uw 2.8 / g 0.35 shading	G	G	E	Uw 3.2 / g 0.35 shading	G	G	D
Uw 1.3 / g 0.35 shading	F	E	D	Uw 1.7 / g 0.35 shading	F	E	C
Uw 0.8 / g 0.35 shading	D	C	C	Uw 0.9 / g 0.35 shading	C	C	B

→ Heating performance – single classification

Stakeholders like EAA and CAB[52] have proposed to use only one single classification for the classes in the three climatic conditions instead of using specific classifications for every climatic condition.

The proposed ABC values are the same as for the classification of three conditions, so the performances are different for each climate condition.

Table 45 ABC values for façade window, based on family house

	A	B	C sunset to sunrise	C 22:00 to 06:00
North	103	267	0,66	0.35
Central	67	238	0,65	0,38
South	23	256	0,65	0,40

[52] The mentioning of stakeholders only means a support based on principle. In most cases this support is conditional (depends on other factors besides discussed in this paragraph).

Table 46 ABC values for roof window, based on family house

	A	B	C sunset to sunrise	C 22:00 to 06:00
North	103	336	0,66	0,**35**
Central	67	304	0,65	0,**38**
South	23	340	0,65	0,**40**

The performance calculated on the basis of these values is for facade and roof windows as follows (with C based on sunset to sunrise). Note that the U_w for roof windows is corrected to values estimated to be typical for inclined (40º) installation.

Table 47: Heating performances $P_{E,H,W}$, family house

FACADE WINDOWS				ROOF WINDOWS			
without shutter	North	Central	South	without shutter	North	Central	South
Uw 5.8 / g 0.85	588	340	14	Uw 6.6 / g 0.85	629	354	-17
Uw 2.8 / g 0.78	193	88	-64	Uw 3.2 / g 0.78	196	79	-101
Uw 1.7 / g 0.65	71	16	-74	Uw 2.1 / g 0.65	80	12	-103
Uw 1.3 / g 0.6	39	-3	-74	Uw 1.7 / g 0.6	51	-4	-100
Uw 1 / g 0.55	17	-14	-72	Uw 1.1 / g 0.55	1	-33	-102
Uw 0.8 / g 0.6	-13	-36	-85	Uw 0.9 / g 0.6	-32	-57	-118
Uw 1 / g 0.58	11	-19	-77	Uw 1.1 / g 0.58	-6	-39	-109
Uw 0.6 / g 0.47	-9	-28	-67	Uw 0.7 / g 0.47	-22	-43	-92
Uw 2.8 / g 0.35	273	160	13	Uw 3.2 / g 0.35	297	170	1
Uw 1.3 / g 0.35	85	39	-29	Uw 1.7 / g 0.35	110	49	-40
Uw 0.8 / g 0.35	34	6	-41	Uw 0.9 / g 0.35	27	-4	-59
with shutter				with shutter			
Uw 5.8 / g 0.85 shading	391	215	-29	Uw 6.6 / g 0.85 shading	391	203	-70
Uw 2.8 / g 0.78 shading	131	49	-78	Uw 3.2 / g 0.78 shading	119	30	-118
Uw 1.7 / g 0.65 shading	45	-1	-79	Uw 2.1 / g 0.65 shading	43	-12	-111
Uw 1.3 / g 0.6 shading	22	-13	-77	Uw 1.7 / g 0.6 shading	25	-20	-106
Uw 1 / g 0.55 shading	7	-21	-74	Uw 1.1 / g 0.55 shading	-11	-41	-104
Uw 0.8 / g 0.6 shading	-20	-40	-87	Uw 0.9 / g 0.6 shading	-40	-62	-120
Uw 1 / g 0.58 shading	1	-26	-79	Uw 1.1 / g 0.58 shading	-18	-47	-112
Uw 0.6 / g 0.47 shading	-13	-30	-68	Uw 0.7 / g 0.47 shading	-27	-46	-93
Uw 2.8 / g 0.35 shading	211	121	-1	Uw 3.2 / g 0.35 shading	220	122	-15
Uw 1.3 / g 0.35 shading	69	29	-33	Uw 1.7 / g 0.35 shading	84	33	-46
Uw 0.8 / g 0.35 shading	27	2	-42	Uw 0.9 / g 0.35 shading	19	-9	-61

The classification is in this case limited to a single column, as all performances for the three climate conditions are assessed according the same class boundaries.

EAA proposed to use the definition for the Northern Climate to evaluate the individual class for all three climatic conditions. The definition of the classes for heating and the results would be as shown in the table below.

For roof windows the same class boundaries could apply. The resulting heating class boundaries for façade and roof windows are:

Table 48 Heating class boundaries, single classification, façade and roof windows

Class	FACADE (.. < kWh/m2)	ROOF (.. < kWh/m2)
A	-5	-5
B	5	5
C	20	20
D	40	40
E	65	65
F	115	115
G		

The heating performance energy label class of the windows according the above defined boundaries is as follows.

Table 49 Heating energy classes, single classification

Facade windows	North	Central	South	Roof windows	North	Central	South
Uw 5.8 / g 0.85	G	G	C	Uw 6.6 / g 0.85	G	G	A
Uw 2.8 / g 0.78	G	F	A	Uw 3.2 / g 0.78	G	F	A
Uw 1.7 / g 0.65	F	C	A	Uw 2.1 / g 0.65	F	C	A
Uw 1.3 / g 0.6	D	B	A	Uw 1.7 / g 0.6	E	B	A
Uw 1 / g 0.55	C	A	A	Uw 1.1 / g 0.55	B	A	A
Uw 0.8 / g 0.6	A	A	A	Uw 0.9 / g 0.6	A	A	A
Uw 1 / g 0.58	C	A	A	Uw 1.1 / g 0.58	A	A	A
Uw 0.6 / g 0.47	A	A	A	Uw 0.7 / g 0.47	A	A	A
Uw 2.8 / g 0.35	G	G	C	Uw 3.2 / g 0.35	G	G	B
Uw 1.3 / g 0.35	F	D	A	Uw 1.7 / g 0.35	F	E	A
Uw 0.8 / g 0.35	D	C	A	Uw 0.9 / g 0.35	D	B	A
Uw 5.8 / g 0.85 shading	G	G	A	Uw 6.6 / g 0.85 shading	G	G	A
Uw 2.8 / g 0.78 shading	G	D	A	Uw 3.2 / g 0.78 shading	G	D	A
Uw 1.7 / g 0.65 shading	D	B	A	Uw 2.1 / g 0.65 shading	E	A	A
Uw 1.3 / g 0.6 shading	D	A	A	Uw 1.7 / g 0.6 shading	D	A	A
Uw 1 / g 0.55 shading	C	A	A	Uw 1.1 / g 0.55 shading	A	A	A
Uw 0.8 / g 0.6 shading	A	A	A	Uw 0.9 / g 0.6 shading	A	A	A
Uw 1 / g 0.58 shading	B	A	A	Uw 1.1 / g 0.58 shading	A	A	A
Uw 0.6 / g 0.47 shading	A	A	A	Uw 0.7 / g 0.47 shading	A	A	A
Uw 2.8 / g 0.35 shading	G	G	B	Uw 3.2 / g 0.35 shading	G	G	A
Uw 1.3 / g 0.35 shading	F	D	A	Uw 1.7 / g 0.35 shading	F	D	A
Uw 0.8 / g 0.35 shading	D	B	A	Uw 0.9 / g 0.35 shading	C	A	A

It can be noticed that windows rated for the North condition show diverging performances, as to be expected. For the condition Central the range of window classes is already smaller; certain windows show an increase of class. The most significant impact can be seen for the climate South. The worst classification for heating will start with the class C for a single glazed façade window. Almost all other design options investigated will become class A. It shows that with a single classification for different climate conditions, it is more difficult to achieve a ranking of products that suits all climate conditions optimally.

This rating would not help consumers in Southern conditions looking for windows with better than average heating performance to reduce heating costs as differences in heating performance of windows beyond single glazing are all assigned the same class.

4.3.5. COOLING PERFORMANCE

In the draft TASK 7 report a cooling performance on the basis of the effective g value of the window: $g_{W,eff}$ was proposed.

This is a simple, robust and effective way to communicate to consumers the effectiveness of the window to reduce solar gains and ovoid possible risk of overheating, as the $g_{W,eff}$ is the single most determining parameter.

$g_{W,eff}$ Is established as (see also section 4.2.3):

Equation 17

$$g_{W,eff} = (1 - F_F) \cdot [(1 - Z) \cdot g + Z \cdot g_t]$$

The consequence of the above is that the cooling performance (when based on $g_{W,eff}$) is not climate condition dependent as the parameter X and Y are not used.

The Z value can be based on a single climate or the average of the three conditions considered: Parameter Z can be representative for a warm (Southern) climate condition, Z=0.7, or the Z can be a weighted average of the three climate dependent parameters Z, whereby North represents 8%, Central 61% and South 31%. The average Z parameter is then 0.56.

The following classification of $g_{W,eff}$ for Z = average is proposed.

Table 50 Example classification of cooling performance (proposal)

Class	Class boundaries (-)	class difference	Example windows
A	$g_{W,eff} \leq 0.10$		Windows with IGU with reduced g-value (e.g.solar control) and/or external solar shading device)
B	$0.10 < g_{W,eff} \leq 0.13$	0.03	Windows with IGU with reduced g-value (e.g.solar control) and/or external solar shading device)
C	$0.13 < g_{W,eff} \leq 0.19$	0.06	Windows with IGU with reduced g-value (e.g.solar control) and/or external solar shading device)
D	$0.19 < g_{W,eff} \leq 0.28$	0.09	Windows with IGU with reduced g-value (e.g.solar control) g > 0.27 or with external shading device
E	$0.28 < g_{W,eff} \leq 0.40$	0.12	Windows with IGU with reduced g-value (e.g.solar control) g > 0.40 or with internal shading device
F	$0.40 < g_{W,eff} \leq 0.55$	0.15	Windows with double IGU with high g-value g > 0.58
G	$0.55 < g_{W,eff}$		Windows with double IGU without low e and single glass g > 0.78

The rest of this sections deals with cooling performance expressed as $P_{E,C,W}$ in kWh/m^2.

→ **Cooling performance based on energy balance**

Stakeholder DEA, CAB, GfE, EAA and BFRC prefer a cooling performance to be based on the energy balance equations, using XYZ values, instead of the climate independent $g_{W,eff}$[53]. This is necessary:

a) to classify the different design options under different climatic conditions on one definition of the classes (see also the section *"The classification should be the same across the whole EU and change per climate condition"*) or;
b) calculate the annual energy performance of different design options (see also the section "The heating and cooling performance should be combined into a single annual value")).

The paragraphs below present a cooling performance based on energy balance equations for given XYZ values and expressed as kWh/m^2 as an option for consideration by the Commission.

Consensus needs to be established as regards parameter Z considering the use of shading devices (should they be considered in the rating, and if so what factor Z should be assigned) and the use of ventilative cooling.

We recommend that when XYZ values are used to establish a cooling performance these are based on the assumption that ventilative cooling takes place as this is considered standard practice (if it's hot inside, and cooler outside, the first thing one does is opening the windows). Stakeholders interested in XYZ values that do not assume ventilative cooling to take place can identify these in section 4.2.4 and/or Annex II.

We recommend that when a performance is established for an 'adaptive' window, such as windows equipped with moveable shading devices, this performance is considering a proper use of these devices. Stakeholders interested in the performance assuming a less than optimal use of shading devices can modify the C or Z values at will (if set at zero, the shading device is not considered).

As already stated in 4.2.3 the values given in Table 22 to Table 27 are averaging the impact of the window characteristic on the XYZ values. As a consequence using average XYZ values will lead to underestimation or overestimation of the cooling energy performance index for different design options. This cannot be avoided as using window specific XYZ values are not an option.

The ABC and XYZ values proposed for a possible rating of windows are presented below. Both values established using the single room and family house method are presented as, depending on the specific performance to be rated, it may be preferred to use either the one or the other. In order to be complete values for both methods are shown below.

In case the label presents heating and cooling performance separately we see no urgent need to have the underlying data (ABC, XYZ) to be based on the same method. Either the single room or single family house based data could be used for establishing the cooling performance. We recommend for cooling to base this on the single room as this will less likely result in underestimating the cooling performance.

The values are averaged for higher and lower Uenv.

Two options for rating/classification have been assessed:

1. The first option describes establishing the performance for three climate conditions and then applying a classification, specifically adjusted to (performances under) these three conditions;
2. The second option describes establishing the performance for three climate conditions and then applying a single classification. This option has been requested by stakeholder EAA.

→ **Cooling performance – triple classification**

The proposed XYZ values are based on the single family house method, and are the average of low and high U envelope values.

[53] The mentioning of stakeholders only means a support based on principle. In most cases this support is conditional (depends on other factors besides discussed in this paragraph).

Table 51 XYZ values for cooling performance of facade window, based on single room approach, average Uenv, with ventilative cooling

	X	Y	Z
North	0.5	23	0.71
Central	0.2	57	0.57
South	-4.1	341	0.68

Table 52 XYZ values for cooling performance of roof window, based on single room approach, average Uenv, with ventilative cooling

	X	Y	Z
North	1.3	56	0,75
Central	1.2	127	0,75
South	-3.0	659	0,88

The performance calculated on the basis of these values is for facade windows as follows (with C based on sunset to sunrise). Note that the U_w for roof windows is corrected to values estimated to be typical for inclined (40º) installation.

Table 53 Cooling performances $P_{E,C,W}$, single room

FACADE WINDOWS				ROOF WINDOWS			
	North	Central	South		North	Central	South
Uw 5.8 / g 0.85	10	32	232	Uw 6.6 / g 0.85	23	66	417
Uw 2.8 / g 0.78	11	30	200	Uw 3.2 / g 0.78	26	65	371
Uw 1.7 / g 0.65	10	25	163	Uw 2.1 / g 0.65	23	55	307
Uw 1.3 / g 0.6	9	23	149	Uw 1.7 / g 0.6	21	51	283
Uw 1 / g 0.55	8	22	136	Uw 1.1 / g 0.55	20	47	258
Uw 0.8 / g 0.6	9	24	147	Uw 0.9 / g 0.6	22	52	280
Uw 1 / g 0.58	9	23	143	Uw 1.1 / g 0.58	21	50	272
Uw 0.6 / g 0.47	7	18	115	Uw 0.7 / g 0.47	17	41	220
Uw 2.8 / g 0.35	4	13	97	Uw 3.2 / g 0.35	9	27	173
Uw 1.3 / g 0.35	5	14	90	Uw 1.7 / g 0.35	11	29	167
Uw 0.8 / g 0.35	5	14	88	Uw 0.9 / g 0.35	12	30	165
Uw 5.8 / g 0.85 shading	2	12	113	Uw 6.6 / g 0.85 shading	3	19	175
Uw 2.8 / g 0.78 shading	4	12	92	Uw 3.2 / g 0.78 shading	7	23	153
Uw 1.7 / g 0.65 shading	4	11	78	Uw 2.1 / g 0.65 shading	8	22	134
Uw 1.3 / g 0.6 shading	4	11	73	Uw 1.7 / g 0.6 shading	8	21	127
Uw 1 / g 0.55 shading	4	10	68	Uw 1.1 / g 0.55 shading	8	21	119
Uw 0.8 / g 0.6 shading	4	11	71	Uw 0.9 / g 0.6 shading	9	22	125
Uw 1 / g 0.58 shading	4	11	70	Uw 1.1 / g 0.58 shading	9	21	123
Uw 0.6 / g 0.47 shading	4	9	61	Uw 0.7 / g 0.47 shading	8	19	109

Uw 2.8 / g 0.35 shading	2	7	63	Uw 3.2 / g 0.35 shading	3	13	104
Uw 1.3 / g 0.35 shading	3	8	55	Uw 1.7 / g 0.35 shading	6	16	98
Uw 0.8 / g 0.35 shading	3	8	53	Uw 0.9 / g 0.35 shading	7	17	96

A classification according the following table may be applied.

Table 54 Cooling class boundaries, single room, triple classification

	FACADE (.. < kWh/m2)			ROOF (.. < kWh/m2)		
Class	North	Central	South	North	Central	South
A	3	10	70	8	30	160
B	5	15	100	12	36	200
C	7	20	130	16	42	240
D	9	25	160	20	48	280
E	11	30	190	24	54	320
F	13	35	220	30	60	360
G						

The energy performance classes of the windows are as follows.

Table 55 Cooling energy classes, single room, triple classification

FACADE WINDOWS				ROOF WINDOWS			
	North	Central	South		North	Central	South
Uw 5.8 / g 0.85	E	F	G	**Uw 6.6 / g 0.85**	E	G	G
Uw 2.8 / g 0.78	E	F	F	**Uw 3.2 / g 0.78**	F	G	G
Uw 1.7 / g 0.65	E	E	E	**Uw 2.1 / g 0.65**	E	F	E
Uw 1.3 / g 0.6	D	D	D	**Uw 1.7 / g 0.6**	E	E	E
Uw 1 / g 0.55	D	D	D	**Uw 1.1 / g 0.55**	E	D	D
Uw 0.8 / g 0.6	E	D	D	**Uw 0.9 / g 0.6**	E	E	E
Uw 1 / g 0.58	D	D	D	**Uw 1.1 / g 0.58**	E	E	D
Uw 0.6 / g 0.47	D	C	C	**Uw 0.7 / g 0.47**	D	C	C
Uw 2.8 / g 0.35	B	B	B	**Uw 3.2 / g 0.35**	B	A	B
Uw 1.3 / g 0.35	B	B	B	**Uw 1.7 / g 0.35**	B	A	B
Uw 0.8 / g 0.35	C	B	B	**Uw 0.9 / g 0.35**	C	A	B
Uw 5.8 / g 0.85 shading	A	B	C	**Uw 6.6 / g 0.85 shading**	A	A	A
Uw 2.8 / g 0.78 shading	B	B	B	**Uw 3.2 / g 0.78 shading**	A	A	A
Uw 1.7 / g 0.65 shading	B	B	B	**Uw 2.1 / g 0.65 shading**	A	A	A
Uw 1.3 / g 0.6 shading	B	B	B	**Uw 1.7 / g 0.6 shading**	A	A	A
Uw 1 / g 0.55 shading	B	B	A	**Uw 1.1 / g 0.55 shading**	A	A	A
Uw 0.8 / g 0.6 shading	B	B	B	**Uw 0.9 / g 0.6 shading**	A	A	A
Uw 1 / g 0.58 shading	B	B	A	**Uw 1.1 / g 0.58 shading**	A	A	A
Uw 0.6 / g 0.47 shading	B	A	A	**Uw 0.7 / g 0.47 shading**	A	A	A
Uw 2.8 / g 0.35 shading	A	A	A	**Uw 3.2 / g 0.35 shading**	A	A	A
Uw 1.3 / g 0.35 shading	A	A	A	**Uw 1.7 / g 0.35 shading**	A	A	A
Uw 0.8 / g 0.35 shading	A	A	A	**Uw 0.9 / g 0.35 shading**	A	A	A

→ **Cooling performance – single classification**

Same as for the heating, EAA proposed to use a single (climate independent) definition for the cooling classes but not based only on the $g_{W,eff}$ value only, but on an energy balance equation multiplying the $g_{W,eff}$ with an Y-value representative for the Climate South.

The proposed XYZ values are the same as for the classification of three conditions, so the performances are different for each climate condition.

Table 56 XYZ values for cooling performance of facade window, based on single room approach, average Uenv, with ventilative cooling

	X	Y	Z
North	0.5	23	0.71
Central	0.2	57	0.57
South	-4.1	341	0.68

Table 57 XYZ values for cooling performance of roof window, based on single room approach, average Uenv, with ventilative cooling

	X	Y	Z
North	1.3	56	0,75
Central	1.2	127	0,75
South	-3.0	659	0,88

The performance calculated on the basis of these values is for facade windows as follows (with C based on sunset to sunrise). Note that the U_w for roof windows is corrected to values estimated to be typical for inclined (40º) installation.

Table 58 Cooling performances $P_{E,C,W}$, single room

FACADE WINDOWS				ROOF WINDOWS			
	North	Central	South		North	Central	South
Uw 5.8 / g 0.85	10	32	232	**Uw 6.6 / g 0.85**	23	66	417
Uw 2.8 / g 0.78	11	30	200	**Uw 3.2 / g 0.78**	26	65	371
Uw 1.7 / g 0.65	10	25	163	**Uw 2.1 / g 0.65**	23	55	307
Uw 1.3 / g 0.6	9	23	149	**Uw 1.7 / g 0.6**	21	51	283
Uw 1 / g 0.55	8	22	136	**Uw 1.1 / g 0.55**	20	47	258
Uw 0.8 / g 0.6	9	24	147	**Uw 0.9 / g 0.6**	22	52	280
Uw 1 / g 0.58	9	23	143	**Uw 1.1 / g 0.58**	21	50	272
Uw 0.6 / g 0.47	7	18	115	**Uw 0.7 / g 0.47**	17	41	220
Uw 2.8 / g 0.35	4	13	97	**Uw 3.2 / g 0.35**	9	27	173
Uw 1.3 / g 0.35	5	14	90	**Uw 1.7 / g 0.35**	11	29	167
Uw 0.8 / g 0.35	5	14	88	**Uw 0.9 / g 0.35**	12	30	165
Uw 5.8 / g 0.85 shading	2	12	113	**Uw 6.6 / g 0.85 shading**	3	19	175
Uw 2.8 / g 0.78 shading	4	12	92	**Uw 3.2 / g 0.78 shading**	7	23	153

FACADE WINDOWS				ROOF WINDOWS			
Uw 1.7 / g 0.65 shading	4	11	78	**Uw 2.1 / g 0.65 shading**	8	22	134
Uw 1.3 / g 0.6 shading	4	11	73	**Uw 1.7 / g 0.6 shading**	8	21	127
Uw 1 / g 0.55 shading	4	10	68	**Uw 1.1 / g 0.55 shading**	8	21	119
Uw 0.8 / g 0.6 shading	4	11	71	**Uw 0.9 / g 0.6 shading**	9	22	125
Uw 1 / g 0.58 shading	4	11	70	**Uw 1.1 / g 0.58 shading**	9	21	123
Uw 0.6 / g 0.47 shading	4	9	61	**Uw 0.7 / g 0.47 shading**	8	19	109
Uw 2.8 / g 0.35 shading	2	7	63	**Uw 3.2 / g 0.35 shading**	3	13	104
Uw 1.3 / g 0.35 shading	3	8	55	**Uw 1.7 / g 0.35 shading**	6	16	98
Uw 0.8 / g 0.35 shading	3	8	53	**Uw 0.9 / g 0.35 shading**	7	17	96

The classification is in this case limited to a single column, as all performances for the three climate conditions are assessed according the same class boundaries.

For façade windows the best performance is 4 kWh^2, and the worst 232 kWh/m^2. Dividing this range in 6 steps gives increments of around 38 kWh.

For roof windows the best performance is 9 kWh^2, and the worst 417 kWh/m^2. Dividing this range in 6 steps gives increments of around 68 kWh.

Table 59 Cooling class boundaries, single room, single classification

	FACADE (.. < kWh/m2)	ROOF (.. < kWh/m2)
Class		
A	10	10
B	50	80
C	90	150
D	130	220
E	170	290
F	210	360
G		

The cooling performance class of the windows is as follows.

Table 60 Cooling energy classes, single room, single classification

Facade windows				Roof windows			
	North	Central	South		North	Central	South
Uw 5.8 / g 0.85	B	B	G	Uw 6.6 / g 0.85	B	C	G
Uw 2.8 / g 0.78	B	B	F	Uw 3.2 / g 0.78	B	C	G
Uw 1.7 / g 0.65	A	B	D	Uw 2.1 / g 0.65	B	C	G
Uw 1.3 / g 0.6	A	B	D	Uw 1.7 / g 0.6	B	C	G
Uw 1 / g 0.55	A	B	D	Uw 1.1 / g 0.55	B	B	G
Uw 0.8 / g 0.6	A	B	D	Uw 0.9 / g 0.6	B	C	G
Uw 1 / g 0.58	A	B	D	Uw 1.1 / g 0.58	B	C	G
Uw 0.6 / g 0.47	A	B	D	Uw 0.7 / g 0.47	B	B	G
Uw 2.8 / g 0.35	A	B	D	Uw 3.2 / g 0.35	A	B	F
Uw 1.3 / g 0.35	A	B	C	Uw 1.7 / g 0.35	B	B	D
Uw 0.8 / g 0.35	A	B	C	Uw 0.9 / g 0.35	B	B	D
Uw 5.8 / g 0.85 shading	A	B	D	Uw 6.6 / g 0.85 shading	A	B	D

Uw 2.8 / g 0.78 shading	A	B	D	Uw 3.2 / g 0.78 shading	A	B	D
Uw 1.7 / g 0.65 shading	A	B	C	Uw 2.1 / g 0.65 shading	A	B	D
Uw 1.3 / g 0.6 shading	A	B	C	Uw 1.7 / g 0.6 shading	A	B	D
Uw 1 / g 0.55 shading	A	B	C	Uw 1.1 / g 0.55 shading	A	B	C
Uw 0.8 / g 0.6 shading	A	B	C	Uw 0.9 / g 0.6 shading	A	B	D
Uw 1 / g 0.58 shading	A	B	C	Uw 1.1 / g 0.58 shading	A	B	D
Uw 0.6 / g 0.47 shading	A	A	C	Uw 0.7 / g 0.47 shading	A	B	C
Uw 2.8 / g 0.35 shading	A	A	C	Uw 3.2 / g 0.35 shading	A	A	C
Uw 1.3 / g 0.35 shading	A	A	C	Uw 1.7 / g 0.35 shading	A	A	C
Uw 0.8 / g 0.35 shading	A	A	C	Uw 0.9 / g 0.35 shading	A	A	C

EAA suggested to apply a different classification:

Table 61 Cooling performance energy label class boundaries and results, based on the proposal by EAA

Energy Class / cooling	Class boundaries (-)
A	$P_{E,C,W} \leq 30$
B	$30 < P_{E,C,W} \leq 40$
C	$40 < P_{E,C,W} \leq 60$
D	$60 < P_{E,C,W} \leq 90$
E	$90 < P_{E,C,W} \leq 125$
F	$125 < P_{E,C,W} \leq 170$
G	$170 < P_{E,C,W}$

cooling / single room	North	Central	South	cooling / family house	North	Central	South
Uw 5.8 / g 0.85	A	B	G	Uw 5.8 / g 0.85	A	A	G
Uw 2.8 / g 0.78	A	B	G	Uw 2.8 / g 0.78	A	A	F
Uw 1.7 / g 0.65	A	A	F	Uw 1.7 / g 0.65	A	A	F
Uw 1.3 / g 0.6	A	A	F	Uw 1.3 / g 0.6	A	A	D
Uw 1 / g 0.55	A	A	F	Uw 1 / g 0.55	A	A	D
Uw 0.8 / g 0.6	A	A	F	Uw 0.8 / g 0.6	A	A	D
Uw 1 / g 0.58	A	A	F	Uw 1 / g 0.58	A	A	D
Uw 0.6 / g 0.47	A	A	D	Uw 0.6 / g 0.47	A	A	D
Uw 2.8 / g 0.35	A	A	D	Uw 2.8 / g 0.35	A	A	D
Uw 1.3 / g 0.35	A	A	D	Uw 1.3 / g 0.35	A	A	D
Uw 0.8 / g 0.35	A	A	D	Uw 0.8 / g 0.35	A	A	D
Uw 5.8 / g 0.85 shading	A	A	D	Uw 5.8 / g 0.85 shading	A	A	D
Uw 2.8 / g 0.78 shading	A	A	D	Uw 2.8 / g 0.78 shading	A	A	D
Uw 1.7 / g 0.65 shading	A	A	D	Uw 1.7 / g 0.65 shading	A	A	C
Uw 1.3 / g 0.6 shading	A	A	D	Uw 1.3 / g 0.6 shading	A	A	C
Uw 1 / g 0.55 shading	A	A	D	Uw 1 / g 0.55 shading	A	A	C
Uw 0.8 / g 0.6 shading	A	A	D	Uw 0.8 / g 0.6 shading	A	A	C
Uw 1 / g 0.58 shading	A	A	D	Uw 1 / g 0.58 shading	A	A	C
Uw 0.6 / g 0.47 shading	A	A	D	Uw 0.6 / g 0.47 shading	A	A	B
Uw 2.8 / g 0.35 shading	A	A	D	Uw 2.8 / g 0.35 shading	A	A	C
Uw 1.3 / g 0.35 shading	A	A	C	Uw 1.3 / g 0.35 shading	A	A	B
Uw 0.8 / g 0.35 shading	A	A	C	Uw 0.8 / g 0.35 shading	A	A	B

These values may have however not be based on performances using the same XYZ values (EAA's data may be based outdated values). The consequences of following this approach, regardless of the exact class boundaries, are fairly similar to other single classification boundaries: For a climate dependent cooling performance with a single classification for class boundaries many window types achieve an A-class rating in the central and northern conditions and only in the southern conditions differences between windows emerge.

This rating would not help people in buildings in Northern or Central conditions in selecting windows for spaces prone to overheating due to solar gains.

4.3.6. COMBINED PERFORMANCE (HEATING + COOLING)

→ **Heating and cooling performance combined into a single annual value**

Stakeholders like GfE[54] have proposed not to use a separate energy performance indexes for heating and cooling but base the ranking on a calculated annual energy performance $P_{E,A,W}$ which combines both performances into a single value.

The principle is shown in the below equation.

Equation 18

$$P_{E,A,W} = P_{E,H,W} + P_{E,C,W}$$

Using the definitions for $P_{E,H,W}$. and $P_{E,C,W}$ according to the equations in Chapter 4.3 the annual energy performance index $P_{E,A,W}$ becomes

Equation 19

$$P_{E,A,W} = A \cdot (U_{W,eff} + H_{ve,w}) - B \cdot g_W - X \cdot (U_W + H_{ve,w}) + Y \cdot g_{W,eff}$$

If no shading device/shutter is to be considered the annual energy performance index $P_{E,A,W}$ can be simplified:

Equation 20

$$P_{E,A,W} = (A - X) \cdot (U_{W,eff} + H_{ve,w}) + (Y - B) \cdot g_W$$

The rest of this section is based on the simpel summation of $_{PE,H,W}$ and $_{PE,C,W}$ to show the performance and ranking when equipped with a shading device.

A very relevant aspect of the approach based on the combined performance is that it assumes the cooling performance is just as important to the final consumer as the heating performance, regardless of actual conditions, including outdoor climate.

The combination of performances has the consequence that windows with a worse heating performance and better cooling performance (windows with a lower g value) achieve the same or similar rating as windows with a better heating performance and worse cooling performance (windows with a higher g value) although the actual application may prefer one or the other (not both equally).

One can expect that consumers in heating dominated countries are, in general, less concerned with the cooling performance of a window. In case such consumers are confronted with a single combined value they cannot properly assess the performance of the window. The same is true for consumers who are primarily interested in reducing heat gains through windows and are interested in cooling performance mainly.

[54] The mentioning of stakeholders only means a support based on principle. In most cases this support is conditional (depends on other factors besides discussed in this paragraph).

Combining heating and cooling performances into a single annual combined value has the following consequences:

- By adding heating and cooling performance information is lost which could have been used by consumers: A 'good' window may achieve a good rating because of its good cooling performance (possibly through a lower g value) and another window may achieve a similar good performance by having a good heating performance (lower U value and/or higher g). But the optimum application of such windows with similar performances is quite different. Separate heating and cooling performances allow the consumer to select windows that fit his/her needs.
- On average some 10% of EU dwellings have artificial cooling (year 2005), possibly increasing to 24% in year 2030[55]. A window energy rating based on simply adding cooling to heating performance would thus 'misguide' between 90% to 76% (year 2005-2030) of EU consumers as these have no artificial cooling energy system to be affected. In North and Central Europe the share of people without cooling systems is even higher: For 2005 some 30% of the dwellings in countries with HDD below 1500 (typical South climate condition) have artificial cooling, some 10% of dwellings in countries with HDD between 1500 and 3250 (Central climate conditions) have artificial cooling and some 2% of dwellings in country with HDD above 3250 (North climate condition) have artificial cooling. A combined annual value is not required for consumers in South Europe, with a higher share of RAC use, to consider the cooling performance.

Table 62 Share of dwellings with air conditioners

	HDD	airconditioners ('000)		dwelling stock ('000)		share of dwellings with RAC	
		2005	**2030**	**2010**	**2030**	**2010**	**2030**
Austria	3301	120	540	3563	4568	3%	12%
Belgium	2696	193	864	4523	5799	4%	15%
Bulgaria	2403	482	1,439	3082	3951	16%	36%
Cyprus	600	201	375	299	384	67%	98%
Czech	3327	50	65	3998	5125	1%	1%
Germany	3063	444	946	39210	50269	1%	2%
Denmark	3235	99	444	2671	3424	4%	13%
Estonia	4302	26	115	653	837	4%	14%
Greece	1449	2,144	4,002	3847	4932	56%	81%
Spain	1686	4,715	13,609	16741	21463	28%	63%
Finland	5596	84	489	2449	3140	3%	16%
France	2340	1,150	5,135	27039	34664	4%	15%
Croatia	2316	267	797	1477	1894	18%	42%
Hungary	2594	38	64	4028	5164	1%	1%
Ireland	2841	67	387	1649	2115	4%	18%
Italy	1829	5,960	19,201	26944	34543	22%	56%
Lithuania	3931	63	280	1537	1970	4%	14%
Luxembourg	2967	9	41	188	241	5%	17%
Latvia	4161	44	197	999	1281	4%	15%
Malta	499	25	75	142	182	18%	41%

[55] P.Riviere, Ecodesign preparatory study Lot 10 Room Air conditioners, Task 4, Table 2-11 and 2-12, Armines, France.

	HDD	airconditioners ('000)		dwelling stock ('000)		share of dwellings with RAC		
Netherlands	2727	302	1,350	6987	8957	4%	15%	
Poland	3439	67	101	13422	17208	0%	1%	
Portugal	1166	75	193	3794	4864	2%	4%	
Romania	2773	1,353	4,036	7351	9424	18%	43%	
Sweden	5291	144	839	4171	5347	3%	16%	
Slovenia	2774	125	374	764	980	16%	38%	
Slovakia	3160	338	1,009	1729	2217	20%	46%	
UK	2990	1,016	5,821	22539	28896	5%	20%	
total		19,602	62,788	205797	263839	10%	24%	
By climate condition		airconditioners ('000)		dwelling stock ('000)		**2005**	**2030**	**2020**
HDD < 1500	**South**	2,445	4,645	8,082		**30%**	**57%**	**46.6%**
1500 < HDD < 3235	**Central**	16459	55073	164252		**10%**	**34%**	**24.1%**
HDD > 3235	**North**	698	3,070	33,462		**2%**	**9%**	**6.3%**

Values for 2020 are interpolated. HDD 3235 is selected as Denmark is then included in the Northern climate condition. Dwelling stock growth assumed is 1.0125%/yr.

– To address this difference in dwellings with and without cooling to be addressed by a single value, the least error is introduced by correcting the cooling performance by a value that signifies the share of dwellings with artificial cooling. Interpolating the 2005 and 2030 data (see Table 62 Share of dwellings with air conditioners) this results in a correction factor of 47% for South, 24% for Central and 6% for North.

Where ABC and XYZ values are used for calculating the heating and cooling performance with the ultimate goal to combine these into a single, annual value, we recommend to use ABC/XYZ values as established using the same method: So either use values based on the single room method or the single family house method, for both heating and cooling. The assessment below is based on using values based on the single family house, for both heating and cooling.

Please note that other selections for (or averaging of) ABC or XYZ values is/are still possible as various values (based on boundary conditions assuming higher or lower U_{env} values, with ventilative cooling or not, etc.) are presented in the Annex I and II.

→ Combined performances – triple classification

In this assessment the heating and cooling performances will be combined into a single value. For this reason it is preferred that the ABC ad XYZ values that apply share a common basis. We have used the single family house as basis. This means that the cooling performances are lower than established using values based on the single room method.

Table 63 ABC values for façade window, based on family house

	A	B	C sunset to sunrise	C 22:00 to 06:00
North	103	267	0,66	0.35
Central	67	238	0,65	0,38
South	23	256	0,65	0,40

Table 64 ABC values for roof window, based on family house

	A	B	C sunset to sunrise	C 22:00 to 06:00
North	103	336	0,66	**0,35**
Central	67	304	0,65	**0,38**
South	23	340	0,65	**0,40**

Table 65 XYZ values for cooling performance of facade window, based on family house approach, average Uenv, with ventilative cooling

	X	Y	Z
North	0.2	12	0.67
Central	-0.1	35	0.53
South	-4.5	279	0.66

Table 66 XYZ values for cooling performance of roof window, based on family house approach, average Uenv, with ventilative cooling

	X	Y	Z
North	0.2	18	0,79
Central	-0.1	57	0,76
South	-4.5	518	0,89

Having identified the ABC and XYZ values the performance of the (facade or roof) window can be calculated.

Table 67 Combined performances $P_{E,H,W} + P_{E,C,W}$, façade window, family house approach

FACADE WINDOWS	HEATING			COOLING			COMBINED			COMBINED & corrected for RAC share		
	North	Central	South	North	Central	South	North	Central	South	North	Central	South
(correction $P_{E,C,W}$)										6%	24%	47%
Uw 5.8 / g 0.85	588	340	14	6	21	199	594	361	213	588	341	26
Uw 2.8 / g 0.78	193	88	-64	6	19	167	199	108	103	193	90	-54
Uw 1.7 / g 0.65	71	16	-74	5	16	135	76	32	62	71	17	-65
Uw 1.3 / g 0.6	39	-3	-74	5	15	124	43	12	50	39	-2	-66
Uw 1 / g 0.55	17	-14	-72	5	14	113	21	-1	41	17	-13	-65
Uw 0.8 / g 0.6	-13	-36	-85	5	15	122	-8	-21	36	-13	-35	-78
Uw 1 / g 0.58	11	-19	-77	5	14	119	16	-5	41	12	-18	-70
Uw 0.6 / g 0.47	-9	-28	-67	4	12	95	-6	-16	28	-9	-27	-61
Uw 2.8 / g 0.35	273	160	13	2	9	83	275	169	96	273	161	18
Uw 1.3 / g 0.35	85	39	-29	3	9	75	88	48	46	85	39	-25
Uw 0.8 / g 0.35	34	6	-41	3	9	73	36	14	32	34	6	-36
Uw 5.8 / g 0.85 shading	391	215	-29	2	9	98	393	224	69	391	217	17
Uw 2.8 / g 0.78 shading	131	49	-78	2	8	75	133	57	-3	131	51	-43

Uw 1.7 / g 0.65 shading	45	-1	-79	2	6	58	46	6	-21	45	1	-52
Uw 1.3 / g 0.6 shading	22	-13	-77	2	6	53	24	-7	-25	23	-11	-53
Uw 1 / g 0.55 shading	7	-21	-74	2	5	47	9	-15	-27	7	-19	-52
Uw 0.8 / g 0.6 shading	-20	-40	-87	2	6	50	-18	-34	-36	-20	-39	-63
Uw 1 / g 0.58 shading	1	-26	-79	2	6	50	3	-20	-30	1	-24	-56
Uw 0.6 / g 0.47 shading	-13	-30	-68	1	5	39	-12	-25	-28	-13	-29	-49
Uw 2.8 / g 0.35 shading	211	121	-1	1	4	42	212	124	41	211	122	19
Uw 1.3 / g 0.35 shading	69	29	-33	1	3	33	70	32	1	69	30	-17
Uw 0.8 / g 0.35 shading	27	2	-42	1	3	31	28	5	-11	27	2	-27

Table 68 Combined performances $P_{E,H,W} + P_{E,C,W}$, roof window, family house approach

ROOF WINDOWS	**HEATING**			**COOLING**			**COMBINED**			**COMBINED & corrected for RAC share**		
	North	Central	South	North	Central	South	North	Central	South	North	Central	South
(correction $P_{E,C,W}$)										6%	24%	47%
Uw 6.6 / g 0.85	629	354	-17	9	34	345	638	388	327	630	356	3
Uw 3.2 / g 0.78	196	79	-101	9	31	300	205	110	199	197	81	-83
Uw 2.1 / g 0.65	80	12	-103	8	26	246	88	38	143	81	14	-88
Uw 1.7 / g 0.6	51	-4	-100	7	24	226	58	20	126	51	-2	-86
Uw 1.1 / g 0.55	1	-33	-102	7	22	205	7	-11	103	1	-32	-90
Uw 0.9 / g 0.6	-32	-57	-118	7	24	222	-24	-33	104	-31	-56	-105
Uw 1.1 / g 0.58	-6	-39	-109	7	23	216	1	-16	107	-6	-38	-96
Uw 0.7 / g 0.47	-22	-43	-92	6	19	174	-16	-24	82	-22	-42	-82
Uw 3.2 / g 0.35	297	170	1	4	14	144	301	185	145	298	171	10
Uw 1.7 / g 0.35	110	49	-40	4	14	135	114	63	95	110	50	-32
Uw 0.9 / g 0.35	27	-4	-59	4	14	132	31	10	73	27	-3	-51
Uw 6.6 / g 0.85 shading	391	203	-70	2	10	126	393	213	57	391	203	-62
Uw 3.2 / g 0.78 shading	119	30	-118	2	9	99	122	39	-19	119	31	-112
Uw 2.1 / g 0.65 shading	43	-12	-111	2	8	79	45	-4	-32	43	-11	-106
Uw 1.7 / g 0.6 shading	25	-20	-106	2	7	72	27	-13	-34	25	-20	-101
Uw 1.1 / g 0.55 shading	-11	-41	-104	2	6	64	-9	-34	-41	-11	-40	-101
Uw 0.9 / g 0.6 shading	-40	-62	-120	2	7	68	-38	-55	-52	-40	-62	-116
Uw 1.1 / g 0.58 shading	-18	-47	-112	2	7	67	-16	-40	-45	-18	-46	-108
Uw 0.7 / g 0.47 shading	-27	-46	-93	2	5	54	-25	-40	-40	-27	-46	-90
Uw 3.2 / g 0.35 shading	220	122	-15	1	4	54	221	126	38	221	122	-12
Uw 1.7 / g 0.35 shading	84	33	-46	1	4	45	85	37	-1	84	33	-43
Uw 0.9 / g 0.35 shading	19	-9	-61	1	4	42	20	-5	-19	19	-9	-58

Note that the U_w for roof windows is corrected to values estimated to be typical for inclined (40º) installation.

A classification according the following table may be applied.

Table 69 Combined performance class boundaries, triple classification (RAC corrected)

	FACADE (.. < kWh/m2)			ROOF (.. < kWh/m2)		
Class	North	Central	South	North	Central	South
A	0	-5	-15	-5	-20	-80
B	25	10	-10	5	-10	-50
C	50	30	0	20	5	-20
D	75	60	10	40	25	0
E	100	100	20	65	50	20
F	125	150	40	115	100	50
G						

The energy performance classes of the windows are as follows.

Table 70 Combined performance energy classes, triple classification, family house (RAC corrected)

Facade windows				Roof windows			
	North	Central	South		North	Central	South
Uw 5.8 / g 0.85	G	G	G	Uw 6.6 / g 0.85	G	G	E
Uw 2.8 / g 0.78	G	E	E	Uw 3.2 / g 0.78	G	F	A
Uw 1.7 / g 0.65	D	C	B	Uw 2.1 / g 0.65	F	D	A
Uw 1.3 / g 0.6	C	B	A	Uw 1.7 / g 0.6	E	C	A
Uw 1 / g 0.55	B	A	A	Uw 1.1 / g 0.55	B	A	A
Uw 0.8 / g 0.6	A	A	A	Uw 0.9 / g 0.6	A	A	A
Uw 1 / g 0.58	B	A	A	Uw 1.1 / g 0.58	A	A	A
Uw 0.6 / g 0.47	A	A	A	Uw 0.7 / g 0.47	A	A	A
Uw 2.8 / g 0.35	G	G	G	Uw 3.2 / g 0.35	G	G	E
Uw 1.3 / g 0.35	E	D	D	Uw 1.7 / g 0.35	F	F	C
Uw 0.8 / g 0.35	C	B	C	Uw 0.9 / g 0.35	D	C	B
Uw 5.8 / g 0.85 shading	G	G	E	Uw 6.6 / g 0.85 shading	G	G	B
Uw 2.8 / g 0.78 shading	G	D	A	Uw 3.2 / g 0.78 shading	G	E	A
Uw 1.7 / g 0.65 shading	C	B	A	Uw 2.1 / g 0.65 shading	E	B	A
Uw 1.3 / g 0.6 shading	B	A	A	Uw 1.7 / g 0.6 shading	D	B	A
Uw 1 / g 0.55 shading	B	A	A	Uw 1.1 / g 0.55 shading	A	A	A
Uw 0.8 / g 0.6 shading	A	A	A	Uw 0.9 / g 0.6 shading	A	A	A
Uw 1 / g 0.58 shading	B	A	A	Uw 1.1 / g 0.58 shading	A	A	A
Uw 0.6 / g 0.47 shading	A	A	A	Uw 0.7 / g 0.47 shading	A	A	A
Uw 2.8 / g 0.35 shading	G	F	E	Uw 3.2 / g 0.35 shading	G	G	D
Uw 1.3 / g 0.35 shading	D	C	A	Uw 1.7 / g 0.35 shading	F	E	C
Uw 0.8 / g 0.35 shading	C	B	A	Uw 0.9 / g 0.35 shading	C	C	B

→ **Combined performance – single classification**

In this assessment the heating and cooling performances will be combined into a single value and one single classification is applied to performances regardless of climate condition.

Table 71 ABC values for façade window, based on family house

	A	B	C	C

			sunset to sunrise	22:00 to 06:00
North	103	267	0,66	0.35
Central	67	238	0,65	0,38
South	23	256	0,65	0,40

Table 72 ABC values for roof window, based on family house

	A	B	C sunset to sunrise	C 22:00 to 06:00
North	103	336	0,66	0,35
Central	67	304	0,65	0,38
South	23	340	0,65	0,40

Table 73 XYZ values for cooling performance of facade window, based on family house approach, average Uenv, with ventilative cooling

	X	Y	Z
North	0.2	12	0.67
Central	-0.1	35	0.53
South	-4.5	279	0.66

Table 74 XYZ values for cooling performance of roof window, based on family house approach, average Uenv, with ventilative cooling

	X	Y	Z
North	0.2	18	0,79
Central	-0.1	57	0,76
South	-4.5	518	0,89

The calculated performance is corrected for share of RAC in dwellings.

Table 75 Combined performance $P_{E,H,W} + P_{E,C,W}$ of facade windows

FACADE WINDOWS	HEATING			COOLING			COMBINED			COMBINED & corrected		
	North	Central	South	North	Central	South	North	Central	South	North	Central	South
(correction $P_{E,C,W}$)										6%	24%	47%
Uw 5.8 / g 0.85	588	340	14	6	21	199	594	361	213	588	341	26
Uw 2.8 / g 0.78	193	88	-64	6	19	167	199	108	103	193	90	-54
Uw 1.7 / g 0.65	71	16	-74	5	16	135	76	32	62	71	17	-65
Uw 1.3 / g 0.6	39	-3	-74	5	15	124	43	12	50	39	-2	-66
Uw 1 / g 0.55	17	-14	-72	5	14	113	21	-1	41	17	-13	-65
Uw 0.8 / g 0.6	-13	-36	-85	5	15	122	-8	-21	36	-13	-35	-78
Uw 1 / g 0.58	11	-19	-77	5	14	119	16	-5	41	12	-18	-70
Uw 0.6 / g 0.47	-9	-28	-67	4	12	95	-6	-16	28	-9	-27	-61
Uw 2.8 / g 0.35	273	160	13	2	9	83	275	169	96	273	161	18
Uw 1.3 / g 0.35	85	39	-29	3	9	75	88	48	46	85	39	-25

FACADE WINDOWS	HEATING			COOLING			COMBINED			COMBINED & corrected		
Uw 0.8 / g 0.35	34	6	-41	3	9	73	36	14	32	34	6	-36
Uw 5.8 / g 0.85 shading	391	215	-29	2	9	98	393	224	69	391	217	17
Uw 2.8 / g 0.78 shading	131	49	-78	2	8	75	133	57	-3	131	51	-43
Uw 1.7 / g 0.65 shading	45	-1	-79	2	6	58	46	6	-21	45	1	-52
Uw 1.3 / g 0.6 shading	22	-13	-77	2	6	53	24	-7	-25	23	-11	-53
Uw 1 / g 0.55 shading	7	-21	-74	2	5	47	9	-15	-27	7	-19	-52
Uw 0.8 / g 0.6 shading	-20	-40	-87	2	6	50	-18	-34	-36	-20	-39	-63
Uw 1 / g 0.58 shading	1	-26	-79	2	6	50	3	-20	-30	1	-24	-56
Uw 0.6 / g 0.47 shading	-13	-30	-68	1	5	39	-12	-25	-28	-13	-29	-49
Uw 2.8 / g 0.35 shading	211	121	-1	1	4	42	212	124	41	211	122	19
Uw 1.3 / g 0.35 shading	69	29	-33	1	3	33	70	32	1	69	30	-17
Uw 0.8 / g 0.35 shading	27	2	-42	1	3	31	28	5	-11	27	2	-27

Table 76 Combined performance $P_{E,H,W} + P_{E,C,W}$ of roof windows

ROOF WINDOWS	HEATING			COOLING			COMBINED			COMBINED & corrected		
	North	Central	South	North	Central	South	North	Central	South	North	Central	South
(correction $P_{E,C,W}$)										6%	24%	47%
Uw 5.8 / g 0.85	629	354	-17	9	34	345	638	388	327	630	356	3
Uw 2.8 / g 0.78	196	79	-101	9	31	300	205	110	199	197	81	-83
Uw 1.7 / g 0.65	80	12	-103	8	26	246	88	38	143	81	14	-88
Uw 1.3 / g 0.6	51	-4	-100	7	24	226	58	20	126	51	-2	-86
Uw 1 / g 0.55	1	-33	-102	7	22	205	7	-11	103	1	-32	-90
Uw 0.8 / g 0.6	-32	-57	-118	7	24	222	-24	-33	104	-31	-56	-105
Uw 1 / g 0.58	-6	-39	-109	7	23	216	1	-16	107	-6	-38	-96
Uw 0.6 / g 0.47	-22	-43	-92	6	19	174	-16	-24	82	-22	-42	-82
Uw 2.8 / g 0.35	297	170	1	4	14	144	301	185	145	298	171	10
Uw 1.3 / g 0.35	110	49	-40	4	14	135	114	63	95	110	50	-32
Uw 0.8 / g 0.35	27	-4	-59	4	14	132	31	10	73	27	-3	-51
Uw 5.8 / g 0.85 shading	391	203	-70	2	10	126	393	213	57	391	203	-62
Uw 2.8 / g 0.78 shading	119	30	-118	2	9	99	122	39	-19	119	31	-112
Uw 1.7 / g 0.65 shading	43	-12	-111	2	8	79	45	-4	-32	43	-11	-106
Uw 1.3 / g 0.6 shading	25	-20	-106	2	7	72	27	-13	-34	25	-20	-101
Uw 1 / g 0.55 shading	-11	-41	-104	2	6	64	-9	-34	-41	-11	-40	-101
Uw 0.8 / g 0.6 shading	-40	-62	-120	2	7	68	-38	-55	-52	-40	-62	-116
Uw 1 / g 0.58 shading	-18	-47	-112	2	7	67	-16	-40	-45	-18	-46	-108
Uw 0.6 / g 0.47 shading	-27	-46	-93	2	5	54	-25	-40	-40	-27	-46	-90
Uw 2.8 / g 0.35 shading	220	122	-15	1	4	54	221	126	38	221	122	-12
Uw 1.3 / g 0.35 shading	84	33	-46	1	4	45	85	37	-1	84	33	-43

ROOF WINDOWS	HEATING			COOLING			COMBINED			COMBINED & corrected		
Uw 0.8 / g 0.35 shading	19	-9	-61	1	4	42	20	-5	-19	19	-9	-58

A classification according the following table may be applied.

Table 77 Combined performance class boundaries, single classification (RAC corrected)

	FACADE (.. < kWh/m2)	ROOF (.. < kWh/m2)
Class		
A	**-5**	**0**
B	**0**	**25**
C	**25**	**50**
D	**50**	**100**
E	**75**	**150**
F	**100**	**200**
G		

The combined performance class of the window is as follows.

Table 78 Combined performance energy classes, single classification (RAC corrected)

Facade windows	North	Central	South	Roof windows	North	Central	South
Uw 5.8 / g 0.85	G	G	G	Uw 6.6 / g 0.85	G	G	B
Uw 2.8 / g 0.78	G	F	C	Uw 3.2 / g 0.78	F	D	A
Uw 1.7 / g 0.65	E	C	A	Uw 2.1 / g 0.65	D	B	A
Uw 1.3 / g 0.6	D	C	A	Uw 1.7 / g 0.6	D	A	A
Uw 1 / g 0.55	C	A	A	Uw 1.1 / g 0.55	B	A	A
Uw 0.8 / g 0.6	A	A	A	Uw 0.9 / g 0.6	A	A	A
Uw 1 / g 0.58	C	A	A	Uw 1.1 / g 0.58	A	A	A
Uw 0.6 / g 0.47	A	A	A	Uw 0.7 / g 0.47	A	A	A
Uw 2.8 / g 0.35	G	G	E	Uw 3.2 / g 0.35	G	F	B
Uw 1.3 / g 0.35	F	D	C	Uw 1.7 / g 0.35	E	D	A
Uw 0.8 / g 0.35	D	C	A	Uw 0.9 / g 0.35	C	A	A
Uw 5.8 / g 0.85 shading	G	G	C	Uw 6.6 / g 0.85 shading	G	G	A
Uw 2.8 / g 0.78 shading	G	E	A	Uw 3.2 / g 0.78 shading	E	C	A
Uw 1.7 / g 0.65 shading	D	C	A	Uw 2.1 / g 0.65 shading	C	A	A
Uw 1.3 / g 0.6 shading	C	A	A	Uw 1.7 / g 0.6 shading	C	A	A
Uw 1 / g 0.55 shading	C	A	A	Uw 1.1 / g 0.55 shading	A	A	A
Uw 0.8 / g 0.6 shading	A	A	A	Uw 0.9 / g 0.6 shading	A	A	A
Uw 1 / g 0.58 shading	C	A	A	Uw 1.1 / g 0.58 shading	A	A	A
Uw 0.6 / g 0.47 shading	A	A	A	Uw 0.7 / g 0.47 shading	A	A	A
Uw 2.8 / g 0.35 shading	G	G	C	Uw 3.2 / g 0.35 shading	G	E	A
Uw 1.3 / g 0.35 shading	E	D	A	Uw 1.7 / g 0.35 shading	D	C	A
Uw 0.8 / g 0.35 shading	D	C	A	Uw 0.9 / g 0.35 shading	B	A	A

The need for a summer comfort indicator

The combination of an annual combined value AND a cooling performance indicator (*summer comfort indicator* as it is called in the French UFME scheme) is proposed with the argument that "people may be interested how good the window is in avoiding overheating". Although we agree that consumers may be interested in this, we see no need to have this combined with an annual value, as a separate cooling performance serves the same purpose.

Additionally, one can argue that since even more consumers are also interested in "how good the window keeps heat in", a *winter comfort indicator* should be included. Following this, if both cooling and heating indicators are required (according the rationale explained before) then the logical solution is to show the separate heating and cooling performances. The summer comfort indicator is currently only present in window label schemes tuned towards warmer climates (in France, Portugal, Spain).

4.3.7. Other elements of the window energy label

→ Technical Fiche

In addition to the information presented on the POS[56] label, delegated acts shall, where appropriate, specify the way in which the label or the fiche or the information specified on the label or in the fiche shall be displayed or provided to the potential end-user. 'Fiche' means a standard table of information relating to a product.

This technical data should be aligned with the harmonised standard for windows EN 14351-1 which states the parameters and methods for which performance can be declared under the CPR.

The table below presents a concept for the fiche, showing which performance parameters should be included. The actual content will depend on the rating and classification method applied in the final design of the label (e.g. not a separate heating and cooling performance, but a combined one).

Depending on which label design is selected the appropriate ABC/Z values need to be stated. In order to allow a more differentiated advice to consumers, the technical fiche contains ABC/Z values specific per orientation.

Table 79 Proposed technical fiche facade windows)

Fiche information roof windows	value (+ unit)								
ABC for heating performance calculation Roof windows	A (kKh)	B (kWh/m²)				C (-)			
		uniform	North	East/West	South				
Depending in which label design is selected, the appropriate ABC values can be entered	xx	xx	xx	xx	xx	xx			
Heating energy performance	Energy performance (kWh/m2*yr)				Label rating				
	.. kWh (m2*yr)				A-G rating				
XYZ for cooling performance calculation Roof windows	X (kKh)	Y (kWh/m²)				Z (-)			
		uni	N	E/W	S	uni	N	E/W	S
Depending in which label design is selected, the appropriate XYZ values can be entered	xx	xx	xx	xx	xx	xx	xx	xx	xx
Cooling energy performance	Energy performance (kWh/m2*yr) or …Effective g-value $g_{w,eff}$ (-)				Label rating				
	.. kWh (m2*yr) {[-]				A-G rating				
Thermal transmittance of window,	(W/m²*K)								

[56] POS = Point-of-sale

without shading activated (U_w)	
Thermal transmittance of window, with shading activated (if applicable) (U_{ws})	(W/m^2*K)
Total solar energy transmittance, without shading activated (g)	(-)
Total solar energy transmittance, with shading activated (g_t)	(-)
Daylight potential factor, without shading activated (τ_v)	(-)
Daylight potential factor, with shading activated ($\tau_{v,t}$)	(-)
Air leakage (class)	(class 1, 2, 3 or 4)
Frame fraction (F_F)	(-)

For roof windows the B values and the Z values are different to façade windows, which is the reason these require a specific technical fiche.

Table 80 Proposed technical fiche roof windows)

Fiche information roof windows	**value (+ unit)**								
ABC for heating performance calculation Roof windows	A (kKh)	B (kWh/m^2)				C (-)			
		uniform	North	East/West	South				
Depending in which label design is selected, the appropriate ABC values can be entered	xx	xx	xx	xx	xx	xx			
Heating energy performance	Energy performance (kWh/m2*yr)					Label rating			
	.. kWh (m2*yr)					A-G rating			
XYZ for cooling performance calculation Roof windows	X (kKh)	Y (kWh/m^2)				Z (-)			
		uni	N	E/W	S	uni	N	E/W	S
Depending in which label design is selected, the appropriate XYZ values can be entered	xx	xx	xx	xx	xx	xx	xx	xx	xx
Cooling energy performance	Energy performance (kWh/m2*yr) or ...Effective g-value $g_{W,eff}$ (-)					Label rating			
	.. kWh (m2*yr) {[-]					A-G rating			
Thermal transmittance of window, without shading activated (U_w)	(W/m^2*K)								
Thermal transmittance of window, with shading activated (if applicable) (U_{ws})	(W/m^2*K)								
Total solar energy transmittance, without shading activated (g)	(-)								
Total solar energy transmittance, with shading activated (g_t)	(-)								
Daylight potential factor, without shading activated (τ_v)	(-)								
Daylight potential factor, with shading activated ($\tau_{v,t}$)	(-)								

Air leakage (class)	(class 1, 2, 3 or 4)
Frame fraction (F_F)	(-)

→ Installer label

In section 4.4.5 the possibility of a package label is discussed (package labels have been introduced under Regulation 811/2013 to allow dealers of packages of space heater, temperature control and solar devices to calculate and show the seasonal space heating energy efficiency class for that package).

For windows the purpose would be to provide better advice to consumers as the performance of a window is orientation-specific. The package label for windows would allow installers to calculate for each window in the package (of which they know the intended orientation) the heating performance and cooling performance. This would enable consumers to be better informed of the actual performance of the window in its intended application.

For the purpose of the package label, the installer has to combine the information from the technical fiche (window characteristics and orientation specific ABC & Z values), calculate the performance for each window in the package and possible alternative options and inform the consumer of this performance.

For the overall performance it is possible to combine (sum) the performance of the window(s) (this can be for either heating and colling separate of for the combined performance). The objective remains the same as for individual windows: to achieve the lowest overall values (expressed in kWh/m2*yr). The installer could even calculate an averaged value for the total package, by weighing the respective contributions per window for their size.

For the cooling performance the performances of the windows should not be averaged, as it is important to maintain the orientation-specific performance (performance is expressed dimensionless).

The package fiche would allow the installer, through a relatively simple calculation procedure, to better take into account the effect of window orientation, by taking the performance per orientation and calculating a weighing factor per orientation based on window area per orientation (for heating performance). This allows a more adequate overall performance of windows to be shown to the consumer (and thus also the effects of changing performance of a window in a certain orientation).

Window number	Size	Orientation	Energy balance (kWh/m^2)			(possibly add calculation for with, or without. use of shading
			heating	cooling	(or combined)	
1	1.5	North	7	10		
2	1.5	South	-30	50		
3	0.6	North	20	5		
4	2.5	South	-80	100		
etc.						
Overall project performance			-36	55	etc.	etc.

We do not recommend an A-G ranking as the results are sensitive to size and orientation. It should be made clear whether and which results assume use of shading (if applicable).

CHAPTER 5 SCENARIO ANALYSIS

5.1. INTRODUCTION SCENARIO ANALYSIS

The MEERP 2011 methodology requires consideration of the following aspects in this subtask:

Set up a stock model for the baseline (Business-as-Usual BaU); calculate for the period 1990-2030, preceded by an appropriate built-up period (product life), for the following parameters per year X (X=1990-2030):

a) annual **sales** in X (from Task 2, with actual and interpolated values), subdivided in new (incl. 1st time users) and replacement sales;
b) annual stock of product (from Task 2)= accumulative sales in X and preceding L-1 years (L=product life) minus products discarded in actual year (=sales in year X-L);
c) annual stock (number) or impact (e.g. in kWh) of the affected energy system (for indirect ErP);
d) annual net performance demand per unit (from Task 3), including growth rate if appropriate;
e) for significant impacts only: average unitary impact(s) (e.g. kWh energy and/or g emissions per performance unit, directly or indirectly) for products sold; this is the (set of) parameter(s) to be regulated;
f) total impact= stock units x performance demand per unit x unitary impact;

Check the calculated total impact against values from this MEErP-report (when available) or other sources for consistency. Deviations of ± 15% are 'normal'; larger deviations require an explanation and possible adjustment of the stock model.

Calculate for the period 1990-2030 (with qualitative discussion of 2030-2050) for each of the options identified in the scenario for total annual and accumulative impact of the policy mix, at the given timing and target level(s) (graphs and labels per impact type)

If no other data are available the following values may be assumed:

for the unitary impacts in the years of ('entry into force' minus 1-2 years) and 'implementation of (first) target' use interpolated values between baseline and (first) target unitary impact levels in periods after target implementation, the impact depends on the policy mix: In the time period after minimum requirements alone, the market is usually assumed to pick up the baseline trend after 1 year; when combined with other measures (e.g. labelling) the trend stays more positive than baseline for at least 5 years. Timely revision of labelling may prolong that period by ca. 3 years

This report will not follow the MEERP 2011 methodology exactly for the following reasons:

- The MEERP 2011 requires reporting in a table showing 5 year intervals. However, as stated in MEERP Part 1, section 8.1 (p. 115) these are <u>general</u> guidelines and - depending on the product typology - there may be <u>exceptions</u> or even the necessity of a different approach. For windows this means that a 10-year interval is used for modelling as the 5 year interval requires inputs at a (time)resolution that is not available (see below).
- This also has a 'knock-on' effect on the calculation of impacts just before the first implementation date, where MEERP 2011 recommends interpolating values between baseline and performance in first year of target settings. There are two main reasons why the windows model is different:
- First, the data that supports the model is not available at one-year intervals. In most cases the underlying data is available for time intervals of more than 10 years which means the 10 year interval is already an increase in 'resolution'. Adding more resolution (5 year interval) would not improve the reliability of model outcomes.
- Second, as stated before the scenario analysis will not include a scenario for specific ecodesign requirements. All variants are for energy labelling only. Therefore the description in MEERP on how to model the combined ecodesign and labelling requirements does not apply. And even for the labelling there is very little data available that can be used to model possible effects. Therefore the

scenario analysis is a description of possible futures (ex ante), rather than a projection or extrapolation of ex post data.

5.1.1. Policy mix considered

The policy mix considered is the introduction of an EU Energy Label for windows. It should be understood that the results of the scenario analysis are at best an indication of a possible outcome of policy measures.

The analysis is a scenario analysis ("what if" analysis) based on a stock model for the baseline (Business-as-Usual BAU), calculated for the period 1990-2050, preceded by an appropriate built-up period, for the following parameter: energy performance of the window (expressed as energy balance in kWh/m^2*year), for both heating and cooling.

5.2. Baseline / Business-as-usual

5.2.1. Description

The baseline scenario, to which savings will be referenced, is a so-called 'business-as-usual' scenario which means that existing and planned measures are executed, and no new measures will be introduced. This option functions as baseline or reference for potential savings from other scenarios.

The 'Business-as-usual' scenario is intended to describe a possible future assuming that ongoing trends and policies/measures will continue to apply. No drastic change in policies is assumed for this scenario.

This means that the EPBD, the EED and other building energy related policies, also at individual Member State level, are assumed to apply and are expected to influence the market of windows.

In the baseline scenario it is assumed that the EPBD and CPR continue to push (minimum requirements for windows in accordance with EPBD, pushes the market towards the cost optimum point) and pull (CE marking under CPR provides information on performance[57]) the market towards better performing windows.

The calculation model calculates outcomes at level of Member State and EU28 and requires inputs for the following main aspects:

1) floor area and building age, by sector, and country:
    a) residential, with subsector:
        i) single family;
        ii) multi family
    b) non-residential, with subsector:
        i) offices;
        ii) education;
        iii) health;
        iv) gastronomic;
        v) trade;
        vi) sports;
        vii) other;
    c) roof windows;
2) indirect energy system function:
    a) heating and/or
    b) cooling demand;
3) window product life;
4) share of stock that remains 'original';
5) new builds rate and demolishment rate;

[57] Certain stakeholders do not agree that the CE marking information pulls the market as it is not consumer friendly. The information could however resemble that of the US NFRC (see TASK 1).

6) 'window-to-floor ratio 20% (variable for residential only, fixed for other sectors);
7) insulated glazing unit (IGU) replacement rate;

The energy calculations in the model are based on a complete window replacement. The replacement of the glazing unit is introduced in the model in the calculation of overall costs, but is not assumed to result in a change of original window performance as this would make the model too complicated, as it would require the simultaneous modelling of window and glazing replacement scenario's, that result in varying window performances over their life, and are regulated according different product lives for replacement (windows versus IGU life). Replacement of the IGU (and thus introducing costs) is assumed once for windows if the product life is 40 years or more.

In case of window replacement it is assumed that the new window has the characteristics of the average new window placed on the market. It is not assumed that consumers replace windows by exactly the same, possibly outdated, type. It is also not assumed that consumer upgrade their windows whilst they are still in service, for instance by adding 'storm windows' (additional glazing, often plastic, with simple frames, attached to the interior or exterior) to combat cold draughts. This behaviour may occur in real life but could not be replicated in the model.

The volume of windows placed on the market is driven by a replacement demand, calculated on the basis of building floor area and window-to-floor ratio, and by age of building, and by a new build demand, driven by the rate of new builds. Relevant data are presented in Annex III.

Driving the performance of products are the characteristics of new windows entering the market (either in new buildings, or as replacement of existing windows). The assumptions regarding the historic market (that determines the characteristics of the stock) and the future market are important input values as they define how fast the market transforms (together with other aspects such as product life, new build rate, share windows remaining original, etc.).

Almost no data was received from stakeholders that allowed describing the window market on the basis of window energy characteristics. Therefore the sales have been assumed so that certain alignment with existing stock data was achieved (see also Task 2). This means that market trends up to 2020 are not based on direct sales data but 'tuned' to arrive at plausible outcomes.

The only stakeholder that provided some feedback as regards the possible market trends was Glass for Europe and the baseline in this final report has been corrected (with respect to the draft report of 24 February 2015) in line with their recommendations as much as possible (as data is not presented at the required level of detail some smaller deviations may occur) up to year 2030.

Table 81 Glazing trends according Glass for Europe

	U_W	g	IGU	2010	2020	2030
1.	5.8	0.85	single	4%	3%	2%
2.	2.8	0.78	double	31%	19%	11%
3.	1.7	0.65	double	23%	28%	25%
4.	1.3	0.6	double	32%	32%	33%
5.	1	0.55	triple	6%	9%	9%
6.	0.8	0.6	triple	1%	1%	6%
7.	1	0.58	coupled	1%	1%	1%
8.	0.6	0.47	quadruple	0%	0%	1%
9.	2.8	0.35	double	2%	5%	7%
10.	1.3	0.35	double	0%	2%	5%
11.	0.8	0.35	triple	0%	0%	0%

In their comments Glass for Europe states that market trends beyond 2020 are hypothetical by definition. Projections for 2040 and 2050 have been labelled as 'illusory'. Nonetheless, the supply of data for these years is required according the methodology to which this study is bound, illusory or not.

Therefore, the numbers provided for beyond 2030 are our own projections, not supported by any scientific study or independent market analysis and should be treated with appropriate caution.

Glass for Europe also pointed out a study by the UK National Energy Foundation[58] which could be used as basis for UK data specifically.

On the basis of this study one could conclude that in year 2006 about half of the UK domestic building stock had a form of single glazing the other half a form of double glazing[59] (all age bands, from before 1900 until 2006, combined).

On page 37 of the NEF study three scenarios have been described. The table below shows how these scenario's result in shares of glazing in stock.

Table 82 NEF study: UK stock of windows by type according 3 scenario's

BAU 2006			BAU 2050		ENHANCED 2050		TECHNICAL POTENTIAL 2050	
(% of segment)	share frame type	(% of total)	(% of segment)	(% of total)	(% of segment)	(% of total)	(% of segment)	(% of total)
single glazing 49%	wood / metal 60%	30%	25% remains same, 25% upgraded to double glazing 50% upgraded to double glazing with low-E	single: 7.5% double: 7.5% double/lowE: 15%	25% remains same 50% conservation glass (U 1.1) 25% triple / lowE	single: 12.5% double/lowE or conservation glass: 25% triple / lowE: 12.5%	100% upgraded to triple / lowE	triple/ lowE: 100%
	PVC 40%	20%	100% upgraded to low-E	double/lowE: 20%				
double glazing 51%	(not relevant for 2050 scenario's)	50%	50% remains same 50% upgraded to double glazing low-E	double: 25% double / lowE: 25%	50% remains same[60] 50% upgraded to triple glazing / low-E	double*: 25% triple / lowE: 25% (*: see footnote)	100% upgraded to triple / lowE	
Summary								
Window+glazing type	indicative U value (of window)	**BAU 2006**		**BAU 2050**		**ENHANCED 2050** (*: see footnote)		**TECHNICAL POTENTIAL 2050**
single	5.8	49%		7.5%		12.5%		
double	2.8	51%		32.5%		(assumed zero*)		
double lowE+conservation glass	1.3			60%		25% + 25%*		
triple lowE	1.0					37.5%		100%
average Uw of stock window		approx. 4.3		approx. 2.1		approx. 1.75		approx. 1.0

An attempt has been made to reproduce the stock forecast by NEF while respecting the overall glazing trends identified by GfE. Particularly for single and simple double glazing this proved daunting as an attempt to increase single and simple double glazing sales in UK (to reproduce NEF estimates) would conflict with GfE estimates for overall EU single and simple double glazing sales (the UK represents some 10% of window sales shares, so is significant in overall EU sales and stock). The table below shows the resulting UK sales and stock as assumed in the baseline / business-as-usual. Sales shares for other MS are stated in Annex III.

Table 83 NEF study: UK stock of windows by type according 3 scenario's

UK windows	SALES							STOCK						
	1990	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Uw 5.8 / g 0.85	47%	25%	10%	5%	5%	5%	5%	68%	52%	37%	24%	12%	8%	7%

[58] "Glazing in buildings – reducing energy us", NEF Glazing Supply Chain Group., Operational energy reduction potential driven by energy efficienct glazing uptake in the UK existing building stock. March 2015

[59] This was extracted from Figure 4 of abovementioned NEF report. The summed totals of the figure per type of glazing exceed 100% as one dwelling may have multiple types of glazing. When indexed to 100, the share of glazing types appears to be 49% for single glazing and 51% double glazing. Small deviations may be possible as it is an interpration of a graph and underlying data was not available.

[60] We assume that also these windows are upgraded to double glazing + lowE as otherwise the resulting average stock window would not be better than that according BAU scenario. This is not as such explained in the NEF study.

Uw 2.8 / g 0.78	48%	55%	35%	30%	23%	17%	10%	30%	42%	44%	41%	34%	26%	20%
Uw 1.7 / g 0.65	5%	20%	35%	38%	37%	36%	35%	2%	7%	15%	24%	32%	35%	35%
Uw 1.3 / g 0.6	0%	0%	20%	25%	31%	36%	42%	0%	0%	5%	11%	20%	28%	32%
Uw 1 / g 0.55	0%	0%	0%	2%	3%	3%	4%	0%	0%	0%	1%	1%	2%	3%
Uw 0.8 / g 0.6	0%	0%	0%	0%	1%	3%	4%	0%	0%	0%	0%	0%	1%	2%
Uw 1 / g 0.58	0%	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Uw 0.6 / g 0.47	0%	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Uw 2.8 / g 0.35	0%	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Uw 1.3 / g 0.35	0%	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Uw 0.8 / g 0.35	0%	0%	0%	0%	0%	0%	0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
avg Uw	4.2	3.3	2.4	2.1	2.0	1.9	1.8	4.8	4.3	3.7	3.1	2.5	2.2	2.0

Table 84 Comparing GfE estimates and sales shares as applied in BAU 2010-2030, for EU28

Window type	GfE 2010	model 2010	GfE 2020	model 2020	GfE 2030	model 2030
Uw 5.8 / g 0.85	4%	4.7%	3%	2.5%	2%	1.9%
Uw 2.8 / g 0.78	31%	30%	19%	16%	11%	13%
Uw 1.7 / g 0.65	23%	32%	28%	33%	25%	29%
Uw 1.3 / g 0.6	32%	27%	32%	30%	33%	33%
Uw 1 / g 0.55	6%	5%	9%	10%	9%	8%
Uw 0.8 / g 0.6	1%	0.0%	1%	0.3%	6%	5.1%
Uw 1 / g 0.58	1%	0.6%	1%	1.0%	1%	1.0%
Uw 0.6 / g 0.47	0%	0.0%	0%	0.0%	1%	0.6%
Uw 2.8 / g 0.35	2%	3.1%	5%	5.1%	7%	6.8%
Uw 1.3 / g 0.35	0%	0.0%	2%	1.0%	5%	2.1%
Uw 0.8 / g 0.35	0%	0.0%	0%	0.0%	0%	0.0%
average U_W of window sold	2.0	2.1	1.9	1.8	1.7	1.7

The following settings have been applied in the model to calculate the impacts per sector.

Member State / Zone	EU28	
Sector	**select: residential / non-residential / roof windows**	
Subsector	**select: all res / all non-res/ all roof windows**	
SETTINGS	**≤ 2010**	**≥ 2020**
Average window life (years)	40	40
share 'original state'	5%	5%
Building demolishment rate (%/yr)	1.00%	1.00%
New build rate (%/yr)	-0.25%	-0.25%
price decrease	0.0%	1.0%
WINDOW-to-FLOOR ratio (%)	20%	
Average glazing replacement (years)	30	30

SCENARIO / SENS.	BAU		
purchase price - sensitivity	1	discount rate	4%
energy costs - sensitivity	1	escalation rate	4%
shutters/shading devices - sensitivity	estimated		
orientation - sensitivity	uniform	vent/cooling - sensitivity	**vent cool**
		Uenv - sensitivity	**avg**

The heating and cooling demand affected by windows is aligned with the study "Average EU building heat load for HVAC equipment", which is also aligned with the "Ecodesign Impact Accounting Study", in particular where the cooling demand is concerned. A slight curved growth is assumed for the heating demand and a significant growth for the cooling demand (in line with the sources stated).

The heating and cooling demand were allocated to the sectors, on the basis of the share of windows involved, the specific heat/cool demand of spaces and also corrected for the country specific relative heating and cooling demand. The heating and cooling demand is shown in Annex III.

5.2.2. Residential sector

The table below presents the annual sales, stock and impacts / related energy consumption (accordance with MEERP 2011 requirements) for the BAU scenario / residential sector.

Table 85 BAU Scenario / residential

OUTPUT Residential		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	68	44	48	47	45	44	43
Demolished	'10^6 m2/yr	-12	-15	-19	-24	-34	-36	-41
Sales replacements	'10^6 m2/yr	87	94	102	107	110	112	113
Total stock	'10^9 m2/yr	3.5	3.8	4.1	4.3	4.4	4.5	4.5
Heating energy	TWh_fuel	1308	985	642	335	153	83.8	58.9
Cooling energy	TWh_fuel	3	8	21	23	28	29.1	30.1
Final energy windows	**TWh_fuel/yr**	**1311**	**993**	**663**	**358**	**181**	**113**	**89**
	PJ_prim	**4719**	**3576**	**2387**	**1287**	**651**	**407**	**320**
GHG Emissions	Mt CO2 eq./yr	261	191	122	65	32	20	15
Mat. in	kt	3190	2988	3480	3678	3790	3883	3937
Mat. out	kt	-1948	-2295	-2660	-3064	-3459	-3607	-3761
Indirect energy	TWh_fuel	24	26	30.0	27.0	20.8	15.8	13.3
New+replace costs	billion EUR (10^9)	48	38	37	29	23	19	15
Glazing repl./maint. costs	billion EUR (10^9)	32	28	27	24	21	19	18
Energy costs	billion EUR (10^9)	86	66	46	26	15	11	9
Overall costs	billion EUR (10^9)	166	132	110	79	60	49	42
Employees	'000			280	280	279	283	290
Avg. heating perf. new	kWh/m2*yr	114	77	30	18	15	11	8
Avg. cooling perf. new	kWh/m2*yr	67	63	57	53	52	50	48
Stock cool.perf.	TWh_cool	246	256	261	255	247	239	232
Share window heat loss of heat demand	%	37%	31%	24%	15%	10%	7%	6%

5.2.3. NON-RESIDENTIAL SECTOR

The table below presents the annual sales, stock and impacts / related energy consumption (accordance with MEERP 2011 requirements) for the BAU scenario / non-residential sector.

Table 86 BAU Scenario / non-residential

OUTPUT Non-residential		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	14	15	19	18	18	17	17
Demolished	'10^6 m2/yr	-5	-5	-5	-6	-8	-10	-12
Sales replacements	'10^6 m2/yr	21	24	27	30	32	34	35
Total stock	'10^9 m2/yr	0.8	0.9	1.1	1.2	1.3	1.4	1.4
Heating energy	TWh_fuel	130	108	80	50	30	21.2	17.1
Cooling energy	TWh_fuel	48	68	62	49	42	37.6	33.9
Final energy windows	**TWh_fuel/yr**	**178**	**175**	**142**	**99**	**72**	**59**	**51**
	PJ_prim	**642**	**631**	**511**	**355**	**258**	**212**	**184**
GHG Emissions	Mt CO2 eq./yr	37	36	28	19	14	11	9
Mat. in	kt	720	837	1059	1149	1220	1278	1318
Mat. out	kt	-505	-597	-713	-842	-967	-1073	-1171
Indirect energy	TWh_fuel	5	7	9.5	9.0	7.6	6.1	5.2
New+replace purchase costs	billion EUR (10^9)	11	11	11	9	7	6	5
Glazing replace./maintenance costs	billion EUR (10^9)	8	7	7	6	6	6	5
Energy costs	billion EUR (10^9)	10	11	9	7	5	5	4
Overall costs	billion EUR (10^9)	29	29	28	22	19	16	14
Employees	'000			146	134	127	123	122
Avg. heating perf. new	kWh/m2*yr	51	39	23	18	16	14	12
Avg. cooling perf. new	kWh/m2*yr	75	71	65	60	58	56	54
Stock cool.perf.	TWh_cool	65	71	77	79	82	82	82
Share window heat loss of heat demand	%	5%	5%	4%	3%	3%	2%	3%

5.2.4. ROOF WINDOWS

The table below presents the annual sales, stock and impacts / related energy consumption (accordance with MEERP 2011 requirements) for the BAU scenario / roof window sector.

Table 87 BAU Scenario / roof windows

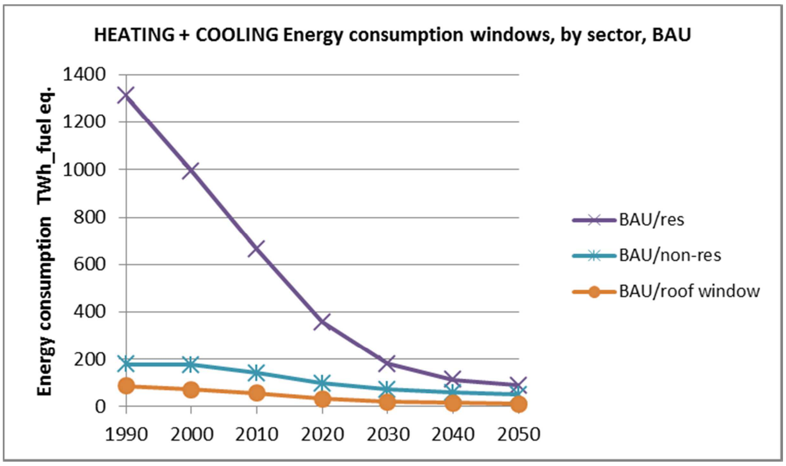
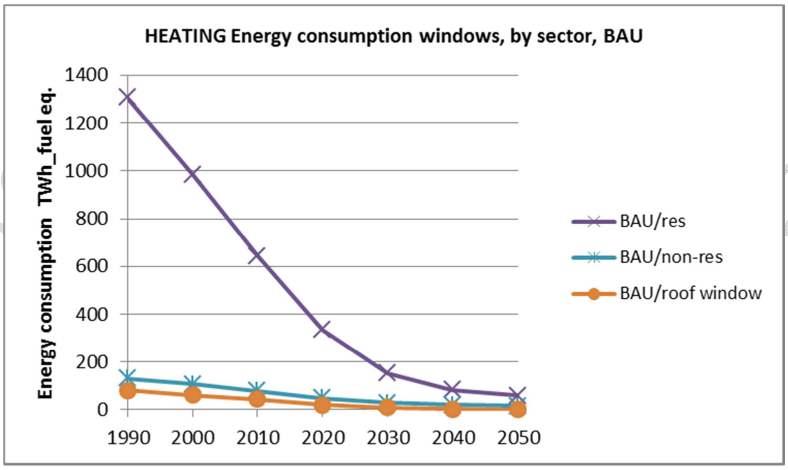
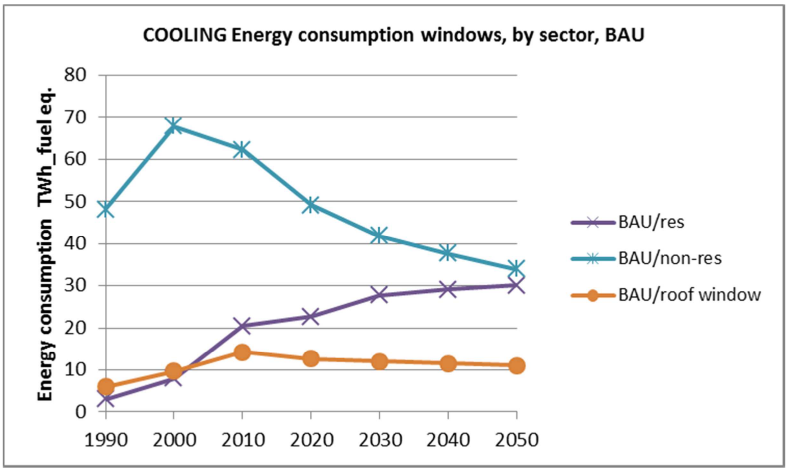
OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	5	4	5	5	5	5	4
Demolished	'10^6 m2/yr	-1	-1	-2	-2	-3	-3	-4
Sales replacements	'10^6 m2/yr	7	8	8	9	10	10	10
Total stock	'10^9 m2/yr	0.3	0.3	0.3	0.4	0.4	0.4	0.4
Heating energy	TWh_fuel	97	75	54	30	15	9.2	6.6
Cooling energy	TWh_fuel	6	10	14	13	12	11.6	11.0
Final energy windows	**TWh_fuel/yr**	103	85	68	42	27	21	18
	PJ_prim	369	307	246	152	99	75	63
GHG Emissions	Mt CO2 eq./yr	21	17	13.0	8.0	5.2	3.9	3.1
Mat. in	kt	400	403	461	491	504	513	516
Mat. out	kt	-238	-284	-328	-377	-427	-457	-487
Indirect energy	TWh_fuel	2	2	2.3	2.2	2.0	1.8	1.6
New+replace purchase costs	billion EUR (10^9)	6	5	5.7	5.4	4.7	4.0	3.5
Glazing replace./maintenance costs	billion EUR (10^9)	3	2	2.2	2.0	1.8	1.7	1.6
Energy costs	billion EUR (10^9)	7	7	6.1	4.2	3.2	2.7	2.4
Overall costs	billion EUR (10^9)	16	14	14.0	11.7	9.7	8.4	7.5
Employees	'000			113	97	85	76	70
Avg. heating perf. new	kWh/m2*yr	105	83	48	18	18	18	18
Avg. cooling perf. new	kWh/m2*yr	146	141	124	110	110	110	110
Stock cool.perf.	TWh_cool	41	45	47	47	47	46	46
Share window heat loss of heat demand	%	26%	22%	19%	12%	9%	7%	6%

The product life assumed is 40 years (one glazing replacement assumed), the market shares of roof window types are as shown in Table 199 (for EU28 only).

5.2.5. BAU Scenario energy for heating, cooling and combined

This section shows the energy consumption attributed to windows in the various sectors in graphs.

Table 88 Graphs of BAU energy for heating, cooling, and combined

BAU




5.3. Scenario's

5.3.1. Description

For the period 2020-2050 three scenarios have been defined to calculate the impact of a possible policy mix, at given timing and target level(s).

The scenario's model possible effects of the introduction of a window energy label (energy performance rating scheme). It does not model the effect of different label formats as the actual impacts of different formats are difficult to express quantitatively.

Instead the scenarios refer to a possible market response to the introduction of labels, ranging from modest to extreme.

Scenario's for façade and roof windows are different as for roof windows the number of available window types is smaller (4 base cases identified), and we wanted to asses a scenario with improved solar control glazing as well.

The scenarios for the façade windows are based on the following assumptions:

1. The first "Modest" scenario assumes an average window performance in-between "BAU" and scenario "Advanced";
2. The second scenario "Advanced" assumes that some 50% of sales is the most efficient window available.;
3. the third scenario "extreme" models the effects of consumers purchasing the best performing window available in their territory. This means that for northern MS the average window purchased has a very low U-value (indicative between 0.8 and 0.6) and high g-values, whereas for southern MS the average window purchased has higher U-values and higher g-values.

Table 89 Residential facade window, EU28 sales share by base case

	BAU				Modest		Advanced		Extreme	
	1990	2010	2030	2050	2030	2050	2030	2050	2030	2050
01_single	38%	5%	2%	1%	0%	0%	0%	0%	0%	0%
02_double IGU, standard	35%	30%	13%	5%	7%	4%	2%	0%	1%	0%
03_double IGU, lowE, argon	26%	32%	29%	20%	27%	13%	18%	9%	5%	0%
04_double IGU,lowE, argon, impr	0%	27%	33%	38%	35%	37%	38%	33%	20%	19%
05_triple IGU, lowE, argon	1%	5%	8%	5%	10%	5%	13%	7%	24%	4%
06_triple IGU, lowE, argon, impr.	0%	0%	5%	14%	9%	23%	18%	33%	35%	58%
07_coupled	0%	1%	1%	1%	2%	1%	2%	1%	2%	1%
08_quadruple	0%	0%	1%	2%	1%	2%	2%	3%	3%	4%
09_as 02, solar	0%	3%	7%	10%	6%	7%	4%	2%	0%	0%
10_as 04, solar	0%	0%	2%	4%	3%	8%	4%	11%	9%	13%
11_as 06, solar	0%	0%	0%	0%	0%	0%	0%	1%	1%	2%
average U_w of window sold	3.63	2.12	1.73	1.52	1.52	1.36	1.31	1.17	1.06	0.96

The above identified sales (plus those preceding 1990) result in a stock of windows as shown below.

Table 90 Residential facade window, EU28 stock share by base case

STOCK	1990	2000	2010	2020	2030	2040	2050
01_single	56%	42%	30%	16%	8%	4%	3%

02_double IGU, standard	30%	34%	33%	27%	22%	16%	11%
03_double IGU, lowE, argon	14%	21%	27%	31%	31%	29%	26%
04_double IGU,lowE, argon, impr	0%	2%	8%	18%	25%	31%	33%
05_triple IGU, lowE, argon	0%	1%	2%	5%	7%	8%	7%
06_triple IGU, lowE, argon, impr.	0%	0%	0%	0%	1%	4%	7%
07_coupled	0.0%	0.0%	0.2%	0.5%	0.7%	0.9%	0.9%
08_quadruple	0.0%	0.0%	0.0%	0.0%	0.2%	0.5%	0.9%
09_as 02, solar	0.0%	0.3%	1.0%	2.7%	4.2%	5.8%	7.3%
10_as 04, solar	0.0%	0.0%	0.0%	0.3%	0.8%	1.6%	2.5%
11_as 06, solar	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
avg.Uw	4.3	3.8	3.2	2.6	2.2	1.9	1.8

It shows that according this model almost 2/3 of windows in the EU in 2010 are still single glazing or simple double glazing (no low E coating). This is a smaller value than currently advocated by GfE (according GfE some 84% of EU dwelling still have outdated windows). The difference is partly caused by incompatibility of trying to match GfE sales data for 2010-2030 with inputs to the model. Other reasons may be a higher product life than assumed or, quite possibly, a higher rate of windows remaining in original (or at least, in outdated) state.

The single most important reason is however the make up of the stock. In 2010 some 60% of the building stock is of before 1980, but also older buildings will have been renovated with 'modern' glass. Hard coatings entered the markets around 1985 (slightly less in some parts of the EU and slightly later for some others). Soft coatings appeared on markets about 10 years later, at around 1995. If we tune the model to calculate the windows stock assuming a window product life of 50 years and 100% remaining original, we would still end up with maximum 80% single and simple double glazing in 2010.

Table 91 Theoretical make up of stock, if all windows before 2020 remained original and have an average life of 50 years

STOCK window type	1990	2000	2010
01_single	70%	64%	56%
02_double IGU, standard	20%	22%	24%
03_double IGU, lowE, argon	9%	12%	15%
04_double IGU,lowE, argon, impr	0%	1%	4%
05_triple IGU, lowE, argon	0%	0%	1%
06_triple IGU, lowE, argon, impr.	0%	0%	0%
07_coupled	0.0%	0.0%	0.1%
08_quadruple	0.0%	0.0%	0.0%
09_as 02, solar	0.0%	0.1%	0.5%
10_as 04, solar	0.0%	0.0%	0.0%
11_as 06, solar	0.0%	0.0%	0.0%
avg.Uw	4.8	4.6	4.2

The scenario's for the roof windows are:

1. The first "Modest" scenario assumes an improvement in window performance between "BAU" and scenario "Advanced";

2. The second scenario "Advanced" assumes that the majority of sales are the most efficient window available;
3. For roof windows the third scenario "Extreme" models the effects of increased sales of windows with lower g values. The overall Uw was kept constant (sales shifting from U_W 1.3, g 0.6 to U_W 1.3, g 0.35).

Table 92 Roof window, sales and stock share by base case

SALES window type	BAU				Modest		Advanced		Extreme	
	1990	**2010**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**
roof_01	20%	5%	0%	0%	0%	0%	0%	0%	0%	0%
roof_02	80%	35%	0%	0%	0%	0%	0%	0%	0%	0%
roof_03		60%	100%	100%	83%	50%	83%	50%	83%	50%
roof_04			0%	0%	17%	50%	0%	0%	0%	0%
roof_05			0%		0%	0%	17%	50%	0%	0%
roof_06		0%	0%	0%	0%	0%	0%	0%	17%	50%

STOCK window type	1990	2000	2010	2020	2030	2040	2050
roof_01	43.9%	28%	19%	9%	5%	2%	1%
roof_02	56.1%	69%	63%	40%	23%	8%	1%
roof_03	0.0%	3%	18%	51%	72%	89%	98%
roof_04	0.0%	0%	0%	0%	0%	0%	0%
roof_05	0.0%	0%	0%	0%	0%	0%	0%
roof_06	0.0%	0%	0%	0%	0%	0%	0%
avg. U value	4.7	4.1	3.6	2.7	2.3	1.9	1.8

No stakeholder was able or willing to comment on sales of roof windows, nor on the projections for façade windows.

Therefore, the numbers provided are our own projections, not supported by any scientific study or independent market analysis and should be treated with appropriate caution.

These scenario's assume that consumers recognise the window energy label and change their purchasing behaviour in such a way that windows with a better performance are sold more often. The UK WER scheme provides an example that indeed consumers are willing to purchase windows that are "better than required by building regulations". Of course the extent of this behaviours is not known beforehand. Therefore the scenarios have been defined to present a range in possible outcomes.

Sales and stock of windows are identical as in the baseline (BAU) scenario. Only the properties of the average window sold in the market are subject to change.

Also the overall heating /cooling demand of the buildings, excluding the effect of the windows, is kept identical to that of the baseline (BAU), so that savings are not caused by changes in the heating or ventilation system or the thermal properties of other building envelope elements (walls, roofs, etc.). This way, the savings calculated are only attributable to changes in window properties. Furthermore, by referencing the savings to the business-as-usual

The introduction of information requirements are not quantified and only discussed qualitatively.

5.3.2. SCENARIO RESULTS

The model has calculated the following outcomes for the residential, non-residential and roof window sector. The tables show first the main outcomes and then the absolute and relative change compared to BAU.

Table 93 Residential Scenario A - Modest

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	68	44	48	47	45	44	43
Demolished	'10^6 m2/yr	-12	-15	-19	-24	-34	-36	-41
Sales replacements	'10^6 m2/yr	87	94	102	107	110	112	113
Total stock	'10^9 m2/yr	3.5	3.8	4.1	4.3	4.4	4.5	4.5
Heating energy	TWh_fuel	1308	985	642	313	127	54.4	26.9
Cooling energy	TWh_fuel	3	8	21	23	27	27.1	26.9
Final energy windows	**TWh_fuel/yr**	**1311**	**993**	**663**	**336**	**154**	**81**	**54**
	PJ_prim	**4719**	**3576**	**2387**	**1208**	**553**	**293**	**194**
GHG Emissions	Mt CO2 eq./yr	261	191	122.1	60.9	27.6	14.8	10.0
Mat. in	kt	3190	2988	3480	3778	3909	4020	4091
Mat. out	kt	-1948	-2295	-2660	-3094	-3518	-3695	-3883
Indirect energy	TWh_fuel	24	26	30.0	27.8	21.6	16.6	13.9
New+replace purchase costs	billion EUR (10^9)	48	38	37.3	30.1	24.1	19.5	15.7
Glazing replace./maintenance costs	billion EUR (10^9)	32	28	26.8	23.9	21.3	19.3	17.8
Energy costs	billion EUR (10^9)	86	66	45.7	24.6	13.3	8.8	7.2
Overall costs	billion EUR (10^9)	166	132	109.8	78.6	58.8	47.5	40.6
Employees	'000			280	280	279	283	292
Avg. heating perf. new	kWh/m2*yr	114	77	30	7	5	2	-1
Avg. cooling perf. new	kWh/m2*yr	67	63	57	51	50	49	48
Stock cool.perf.	TWh_cool	246	256	261	252	242	233	225
Share window heat loss of heat demand	%	37%	31%	24%	14%	8%	4%	3%
				2015:	19%			
ABS.CHANGE		**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Sales new build	'10^6 m2/yr	0	0	0	0	0	0	0
Demolished	'10^6 m2/yr	0	0	0	0	0	0	0
Sales replacements	'10^6 m2/yr	0	0	0	0	0	0	0
Total stock	'10^9 m2/yr	0	0	0.0	0.0	0.0	0.0	0.0
Heating energy	TWh_fuel	0	0	0	-22	-26	-29	-32.0
Cooling energy	TWh_fuel	0	0	0	0	-1	-2	-3.2
Final energy windows	**TWh_fuel/yr**	**0**	**0**	**0.0**	**-21.9**	**-27.1**	**-31.5**	**-35.1**
	PJ_prim	**0**	**0**	**0**	**-79**	**-98**	**-113**	**-126**
GHG Emissions	Mt CO2 eq./yr	0	0	0	-4	-4	-5	-5
Mat. in	kt	0	0	0	100.3	118.9	137.1	154.0
Mat. out	kt	0	0	0	-30.0	-59.5	-88.2	-122.1
Indirect energy	TWh_fuel	0	0	0	0.8	0.8	0.7	0.7
New+replace purchase costs	billion EUR (10^9)	0	0	0	1	1	1	1
Glazing replace./maintenance costs	billion EUR (10^9)	0	0	0	0	0	0	0
Energy costs	billion EUR (10^9)	0	0	0	-1	-2	-2	-2
Overall costs	billion EUR (10^9)	0	0	0	0	-1	-1	-1
Employees	'000			0	0	0	0	1
Avg. heating perf. new	kWh/m2*yr	0	0	0	-11	-10	-9	-8
Avg. cooling perf. new	kWh/m2*yr	0	0	0	-2	-2	-1	-1
Stock cool.perf.	TWh_cool	0	0	0	-3	-5	-6	-6
Share window heat loss of heat demand	%	0%	0%	0%	-1%	-2%	-2%	-3%
REL.CHANGE		**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	-7%	-17%	-35%	-54%
Cooling energy	TWh_fuel	0%	0%	0%	0%	-4%	-7%	-11%
Final energy windows	**TWh_fuel/yr**	**0%**	**0%**	**0%**	**-6%**	**-15%**	**-28%**	**-39%**
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	-6%	-14%	-25%	-33%
Mat. in	kt	0%	0%	0%	3%	3%	4%	4%
Mat. out	kt	0%	0%	0%	1%	2%	2%	3%
Indirect energy	TWh_fuel	0%	0%	0%	3%	4%	5%	5%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	3%	4%	5%	5%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	1%
Energy costs	billion EUR (10^9)	0%	0%	0%	-6%	-11%	-18%	-23%
Overall costs	billion EUR (10^9)	0%	0%	0%	-1%	-1%	-2%	-3%
Employees	'000			0%	0%	0%	0%	1%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	-60%	-68%	-82%	-107%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	-4%	-3%	-2%	-2%
Stock cool.perf.	TWh_cool	0%	0%	0%	-1%	-2%	-2%	-3%
Share window heat loss of heat demand	%	0%	0%	0%	-7%	-17%	-35%	-54%

Table 94 Residential Scenario B- Advanced

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	68	44	48	47	45	44	43
Demolished	'10^6 m2/yr	-12	-15	-19	-24	-34	-36	-41
Sales replacements	'10^6 m2/yr	87	94	102	107	110	112	113
Total stock	'10^9 m2/yr	3.5	3.8	4.1	4.3	4.4	4.5	4.5
Heating energy	TWh_fuel	1308	985	642	293	103	25.9	-5.4
Cooling energy	TWh_fuel	3	8	21	23	27	26.8	26.5
Final energy windows	**TWh_fuel/yr**	**1311**	**993**	**663**	**316**	**129**	**53**	**21**
	PJ_prim	**4719**	**3576**	**2387**	**1138**	**465**	**190**	**76**
GHG Emissions	Mt CO2 eq./yr	261	191	122.1	57.4	23.4	10.1	5.0
Mat. in	kt	261	191	122.1	57.4	23.4	10.1	5.0
Mat. out	kt	3190	2988	3480	3991	4123	4234	4304
Indirect energy	TWh_fuel	-1948	-2295	-2660	-3158	-3635	-3855	-4089
New+replace purchase costs	billion EUR (10^9)	48	38	37.3	32.1	25.8	20.8	16.7
Glazing replace./maintenance costs	billion EUR (10^9)	32	28	26.8	23.9	21.3	19.3	17.9
Energy costs	billion EUR (10^9)	86	66	45.7	23.3	11.7	6.9	5.1
Overall costs	billion EUR (10^9)	166	132	109.8	79.3	58.8	47.0	39.7
Employees	'000			280	280	279	283	293
Avg. heating perf. new	kWh/m2*yr	114	77	30	-3	-5	-8	-10
Avg. cooling perf. new	kWh/m2*yr	67	63	57	49	48	48	47
Stock cool.perf.	TWh_cool	246	256	261	249	238	228	219
Share window heat loss of heat demand	%	37%	31%	24%	13%	6%	2%	-1%
				2015:	18%			
ABS.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0	0	0	0	0	0	0
Demolished	'10^6 m2/yr	0	0	0	0	0	0	0
Sales replacements	'10^6 m2/yr	0	0	0	0	0	0	0
Total stock	'10^9 m2/yr	0	0	0.0	0.0	0.0	0.0	0.0
Heating energy	TWh_fuel	0	0	0	-42	-50	-58	-64.3
Cooling energy	TWh_fuel	0	0	0	0	-1	-2	-3.6
Final energy windows	**TWh_fuel/yr**	**0**	**0**	**0.0**	**-41.6**	**-51.6**	**-60.3**	**-67.9**
	PJ_prim	**0**	**0**	**0**	**-150**	**-186**	**-217**	**-244**
GHG Emissions	Mt CO2 eq./yr	0	0	0	-7	-9	-10	-10
Mat. in	kt	0	0	0	313.4	333.1	351.3	366.1
Mat. out	kt	0	0	0	-93.9	-176.3	-248.3	-327.4
Indirect energy	TWh_fuel	0	0	0	2.5	2.2	1.7	1.3
New+replace purchase costs	billion EUR (10^9)	0	0	0	3	3	2	2
Glazing replace./maintenance costs	billion EUR (10^9)	0	0	0	0	0	0	0
Energy costs	billion EUR (10^9)	0	0	0	-3	-3	-4	-4
Overall costs	billion EUR (10^9)	0	0	0	0	-1	-2	-2
Employees	'000			0	0	0	0	3
Avg. heating perf. new	kWh/m2*yr	0	0	0	-21	-20	-19	-18
Avg. cooling perf. new	kWh/m2*yr	0	0	0	-4	-3	-2	-2
Stock cool.perf.	TWh_cool	0	0	0	-6	-9	-11	-12
Share window heat loss of heat demand	%	0%	0%	0%	-2%	-3%	-5%	-6%
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	-12%	-33%	-69%	-109%
Cooling energy	TWh_fuel	0%	0%	0%	0%	-4%	-8%	-12%
Final energy windows	**TWh_fuel/yr**	**0%**	**0%**	**0%**	**-12%**	**-29%**	**-53%**	**-76%**
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	-11%	-27%	-49%	-67%
Mat. in	kt	0%	0%	0%	9%	9%	9%	9%
Mat. out	kt	0%	0%	0%	3%	5%	7%	9%
Indirect energy	TWh_fuel	0%	0%	0%	9%	10%	11%	10%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	10%	11%	12%	12%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	1%
Energy costs	billion EUR (10^9)	0%	0%	0%	-10%	-22%	-35%	-45%
Overall costs	billion EUR (10^9)	0%	0%	0%	0%	-1%	-3%	-5%
Employees	'000			0%	0%	0%	0%	1%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	-114%	-135%	-168%	-231%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	-7%	-6%	-5%	-4%
Stock cool.perf.	TWh_cool	0%	0%	0%	-2%	-4%	-5%	-5%
Share window heat loss of heat demand	%	0%	0%	0%	-12%	-33%	-69%	-109%

Table 95 Residential Scenario C – Extreme

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	68	44	48	47	45	44	43
Demolished	'10^6 m2/yr	-12	-15	-19	-24	-34	-36	-41
Sales replacements	'10^6 m2/yr	87	94	102	107	110	112	113
Total stock	'10^9 m2/yr	3.5	3.8	4.1	4.3	4.4	4.5	4.5
Heating energy	TWh_fuel	1308	985	642	272	76	-4.7	-39.6
Cooling energy	TWh_fuel	3	8	21	23	26	26.5	26.0
Final energy windows	**TWh_fuel/yr**	**1311**	**993**	**663**	**294**	**103**	**22**	**-14**
	PJ_prim	**4719**	**3576**	**2387**	**1060**	**370**	**78**	**-49**
GHG Emissions	Mt CO2 eq./yr	261	191	122.1	53.5	18.9	5.1	-0.3
Mat. in	kt	3190	2988	3480	4475	4567	4636	4659
Mat. out	kt	-1948	-2295	-2660	-3303	-3890	-4189	-4496
Indirect energy	TWh_fuel	24	26	30.0	33.2	25.7	19.3	15.3
New+replace purchase costs	billion EUR (10^9)	48	38	37.3	35.6	28.7	23.2	18.8
Glazing replace./maintenance costs	billion EUR (10^9)	32	28	26.8	23.9	21.3	19.3	18.0
Energy costs	billion EUR (10^9)	86	66	45.7	21.9	10.0	4.9	2.8
Overall costs	billion EUR (10^9)	166	132	109.8	81.4	60.0	47.4	39.6
Employees	'000			280	280	279	283	295
Avg. heating perf. new	kWh/m2*yr	114	77	30	-13	-16	-18	-20
Avg. cooling perf. new	kWh/m2*yr	67	63	57	47	47	46	46
Stock cool.perf.	TWh_cool	246	256	261	246	232	222	212
Share window heat loss of heat demand	%	37%	31%	24%	12%	5%	0%	-4%
				2015:	18%			
ABS.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0	0	0	0	0	0	0
Demolished	'10^6 m2/yr	0	0	0	0	0	0	0
Sales replacements	'10^6 m2/yr	0	0	0	0	0	0	0
Total stock	'10^9 m2/yr	0	0	0.0	0.0	0.0	0.0	0.0
Heating energy	TWh_fuel	0	0	0	-63	-77	-89	-98.5
Cooling energy	TWh_fuel	0	0	0	0	-1	-3	-4.1
Final energy windows	**TWh_fuel/yr**	**0**	**0**	**0.0**	**-63.2**	**-78.1**	**-91.2**	**-102.6**
	PJ_prim	**0**	**0**	**0**	**-227**	**-281**	**-328**	**-369**
GHG Emissions	Mt CO2 eq./yr	0	0	0	-11	-13	-15	-15
Mat. in	kt	0	0	0	796.9	777.5	753.4	721.9
Mat. out	kt	0	0	0	-238.5	-430.7	-581.8	-734.4
Indirect energy	TWh_fuel	0	0	0	6.2	4.9	3.5	2.1
New+replace purchase costs	billion EUR (10^9)	0	0	0	7	6	5	4
Glazing replace./maintenance costs	billion EUR (10^9)	0	0	0	0	0	0	0
Energy costs	billion EUR (10^9)	0	0	0	-4	-5	-6	-6
Overall costs	billion EUR (10^9)	0	0	0	2	0	-1	-2
Employees	'000			0	0	0	0	5
Avg. heating perf. new	kWh/m2*yr	0	0	0	-32	-31	-29	-28
Avg. cooling perf. new	kWh/m2*yr	0	0	0	-6	-5	-4	-3
Stock cool.perf.	TWh_cool	0	0	0	-9	-14	-17	-19
Share window heat loss of heat demand	%	0%	0%	0%	-3%	-5%	-7%	-10%
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	-19%	-50%	-106%	-167%
Cooling energy	TWh_fuel	0%	0%	0%	0%	-5%	-9%	-14%
Final energy windows	**TWh_fuel/yr**	**0%**	**0%**	**0%**	**-18%**	**-43%**	**-81%**	**-115%**
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	-17%	-41%	-74%	-102%
Mat. in	kt	0%	0%	0%	22%	21%	19%	18%
Mat. out	kt	0%	0%	0%	8%	12%	16%	20%
Indirect energy	TWh_fuel	0%	0%	0%	23%	24%	22%	16%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	23%	24%	25%	26%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	2%
Energy costs	billion EUR (10^9)	0%	0%	0%	-16%	-34%	-54%	-70%
Overall costs	billion EUR (10^9)	0%	0%	0%	3%	1%	-2%	-5%
Employees	'000			0%	0%	0%	0%	2%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	-173%	-206%	-258%	-358%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	-12%	-10%	-8%	-5%
Stock cool.perf.	TWh_cool	0%	0%	0%	-4%	-6%	-7%	-8%
Share window heat loss of heat demand	%	0%	0%	0%	-19%	-50%	-106%	-167%

Table 96 Non-residential Scenario A – Modest

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	14	15	19	18	18	17	17
Demolished	'10^6 m2/yr	-5	-5	-5	-6	-8	-10	-12
Sales replacements	'10^6 m2/yr	21	24	27	30	32	34	35
Total stock	'10^9 m2/yr	1	1	1	1	1	1	1
Heating energy	TWh_fuel	130	108	80	47	27	18	13
Cooling energy	TWh_fuel	48	68	62	48	41	37	34
Final energy windows	TWh_fuel/yr	178	175	142	95	68	55	47
	PJ_prim	642	631	511	344	245	197	168
GHG Emissions	Mt CO2 eq./yr	37.0	35.8	27.9	18.8	13.2	10.3	8.4
Mat. in	kt	720	837	1059	1181	1259	1323	1369
Mat. out	kt	-505	-597	-713	-851	-984	-1099	-1210
Indirect energy	TWh_fuel	5	7	9.5	9.2	7.9	6.3	5.4
New+replace purchase costs	billion EUR (10^9)	10.9	10.5	11.4	9.4	7.8	6.4	5.3
Glazing replace./maintenance costs	billion EUR (10^9)	8.2	7.3	7.0	6.4	6.0	5.6	5.4
Energy costs	billion EUR (10^9)	9.6	10.8	9.2	6.6	5.1	4.3	3.8
Overall costs	billion EUR (10^9)	28.7	28.6	27.6	22.4	18.9	16.4	14.4
Employees	'000	0	0	146	134	127	123	122
Avg. heating perf. new	kWh/m2*yr	51	39	23	13	12	10	9
Avg. cooling perf. new	kWh/m2*yr	75	71	65	58	56	55	53
Stock cool.perf.	TWh_cool	65	71	77	78	80	80	79
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
				2015:	4%			
ABS.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0	0	0	0	0	0	0
Demolished	'10^6 m2/yr	0	0	0	0	0	0	0
Sales replacements	'10^6 m2/yr	0	0	0	0	0	0	0
Total stock	'10^9 m2/yr	0	0	0	0	0	0	0
Heating energy	TWh_fuel	0	0	0	-3	-3	-3	-4
Cooling energy	TWh_fuel	0	0	0	-1	-1	-1	0
Final energy windows	TWh_fuel/yr	0	0	0	-3	-4	-4	-4
	PJ_prim	0	0	0	-12	-13	-14	-15
GHG Emissions	Mt CO2 eq./yr	0	0	0	-1	-1	-1	-1
Mat. in	kt	0	0	0	31.4	38.3	45.1	51.5
Mat. out	kt	0	0	0	-9.0	-16.8	-26.4	-38.3
Indirect energy	TWh_fuel	0	0	0	0.2	0.3	0.3	0.2
New+replace purchase costs	billion EUR (10^9)	0	0	0	0	0	0	0
Glazing replace./maintenance costs	billion EUR (10^9)	0	0	0	0	0	0	0
Energy costs	billion EUR (10^9)	0	0	0	0	0	0	0
Overall costs	billion EUR (10^9)	0	0	0	0	0	0	0
Employees	'000	0	0	0	0	0	0	0
Avg. heating perf. new	kWh/m2*yr	0	0	0	-4	-4	-3	-3
Avg. cooling perf. new	kWh/m2*yr	0	0	0	-2	-2	-1	-1
Stock cool.perf.	TWh_cool	0	0	0	-1	-2	-2	-2
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	-5%	-10%	-16%	-22%
Cooling energy	TWh_fuel	0%	0%	0%	-1%	-1%	-1%	-1%
Final energy windows	TWh_fuel/yr	0%	0%	0%	-3%	-5%	-7%	-8%
	PJ_prim	0%	0%	0%	0%	0%	0%	0%
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	-3%	-5%	-7%	-8%
Mat. in	kt	0%	0%	0%	3%	3%	4%	4%
Mat. out	kt	0%	0%	0%	1%	2%	2%	3%
Indirect energy	TWh_fuel	0%	0%	0%	3%	3%	4%	5%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	3%	4%	5%	5%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	1%
Energy costs	billion EUR (10^9)	0%	0%	0%	-2%	-4%	-5%	-6%
Overall costs	billion EUR (10^9)	0%	0%	0%	1%	1%	0%	0%
Employees	'000	0%	0%	0%	0%	0%	0%	0%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	-24%	-25%	-25%	-26%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	-4%	-3%	-2%	-2%
Stock cool.perf.	TWh_cool	0%	0%	0%	-1%	-2%	-2%	-3%
Share window heat loss of heat demand	%	0%	0%	0%	-5%	-10%	-16%	-22%

Table 97 Non-residential Scenario B- Advanced

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	14	15	19	18	18	17	17
Demolished	'10^6 m2/yr	-5	-5	-5	-6	-8	-10	-12
Sales replacements	'10^6 m2/yr	21	24	27	30	32	34	35
Total stock	'10^9 m2/yr	1	1	1	1	1	1	1
Heating energy	TWh_fuel	130	108	80	44	24	14	9
Cooling energy	TWh_fuel	48	68	62	48	40	36	32
Final energy windows	TWh_fuel/yr	178	175	142	92	64	50	41
	PJ_prim	642	631	511	333	231	181	149
GHG Emissions	Mt CO2 eq./yr	37.0	35.8	27.9	18.3	12.5	9.6	7.6
Mat. in	kt	720	837	1059	1247	1328	1394	1441
Mat. out	kt	-505	-597	-713	-870	-1017	-1147	-1274
Indirect energy	TWh_fuel	5	7	9.5	9.7	8.3	6.7	5.6
New+replace purchase costs	billion EUR (10^9)	10.9	10.5	11.4	10.0	8.3	6.8	5.6
Glazing replace./maintenance costs	billion EUR (10^9)	8.2	7.3	7.0	6.4	6.0	5.6	5.4
Energy costs	billion EUR (10^9)	9.6	10.8	9.2	6.4	4.9	4.1	3.6
Overall costs	billion EUR (10^9)	28.7	28.6	27.6	22.9	19.2	16.6	14.6
Employees	'000	0	0	146	134	127	123	123
Avg. heating perf. new	kWh/m2*yr	51	39	23	9	8	7	5
Avg. cooling perf. new	kWh/m2*yr	75	71	65	56	55	54	53
Stock cool.perf.	TWh_cool	65	71	77	77	79	79	78
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
				2015:	4%			
ABS.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0	0	0	0	0	0	0
Demolished	'10^6 m2/yr	0	0	0	0	0	0	0
Sales replacements	'10^6 m2/yr	0	0	0	0	0	0	0
Total stock	'10^9 m2/yr	0	0	0	0	0	0	0
Heating energy	TWh_fuel	0	0	0	-5	-6	-7	-8
Cooling energy	TWh_fuel	0	0	0	-1	-1	-2	-2
Final energy windows	TWh_fuel/yr	0	0	0	-6	-7	-9	-10
	PJ_prim	0	0	0	-22	-27	-31	-34
GHG Emissions	Mt CO2 eq./yr	0	0	0	-1	-1	-1	-2
Mat. in	kt	0	0	0	97.9	107.3	115.7	122.6
Mat. out	kt	0	0	0	-28.0	-49.8	-74.2	-102.4
Indirect energy	TWh_fuel	0	0	0	0.8	0.7	0.6	0.5
New+replace purchase costs	billion EUR (10^9)	0	0	0	1	1	1	1
Glazing replace./maintenance costs	billion EUR (10^9)	0	0	0	0	0	0	0
Energy costs	billion EUR (10^9)	0	0	0	0	0	0	0
Overall costs	billion EUR (10^9)	0	0	0	1	0	0	0
Employees	'000	0	0	0	0	0	0	1
Avg. heating perf. new	kWh/m2*yr	0	0	0	-8	-8	-7	-7
Avg. cooling perf. new	kWh/m2*yr	0	0	0	-4	-3	-3	-2
Stock cool.perf.	TWh_cool	0	0	0	-2	-3	-4	-4
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	-10%	-20%	-33%	-46%
Cooling energy	TWh_fuel	0%	0%	0%	-2%	-3%	-4%	-5%
Final energy windows	TWh_fuel/yr	0%	0%	0%	-6%	-10%	-15%	-19%
	PJ_prim	0%	0%	0%	0%	0%	0%	0%
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	-6%	-10%	-13%	-17%
Mat. in	kt	0%	0%	0%	9%	9%	9%	9%
Mat. out	kt	0%	0%	0%	3%	5%	7%	9%
Indirect energy	TWh_fuel	0%	0%	0%	9%	10%	10%	9%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	10%	11%	12%	12%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	1%
Energy costs	billion EUR (10^9)	0%	0%	0%	-5%	-7%	-9%	-11%
Overall costs	billion EUR (10^9)	0%	0%	0%	3%	2%	2%	2%
Employees	'000	0%	0%	0%	0%	0%	0%	1%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	-47%	-50%	-53%	-57%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	-7%	-6%	-4%	-3%
Stock cool.perf.	TWh_cool	0%	0%	0%	-2%	-4%	-4%	-5%
Share window heat loss of heat demand	%	0%	0%	0%	-10%	-20%	-33%	-46%

Table 98 Non-residential Scenario C - Extreme

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	14	15	19	18	18	17	17
Demolished	'10^6 m2/yr	-5	-5	-5	-6	-8	-10	-12
Sales replacements	'10^6 m2/yr	21	24	27	30	32	34	35
Total stock	'10^9 m2/yr	1	1	1	1	1	1	1
Heating energy	TWh_fuel	130	108	80	41	20	10	5
Cooling energy	TWh_fuel	48	68	62	47	39	35	31
Final energy windows	TWh_fuel/yr	178	175	142	89	60	45	35
	PJ_prim	642	631	511	319	214	161	127
GHG Emissions	Mt CO2 eq./yr	37.0	35.8	27.9	17.6	11.7	8.7	6.7
Mat. in	kt	720	837	1059	1398	1471	1526	1560
Mat. out	kt	-505	-597	-713	-914	-1089	-1246	-1401
Indirect energy	TWh_fuel	5	7	9.5	10.9	9.3	7.3	6.0
New+replace purchase costs	billion EUR (10^9)	10.9	10.5	11.4	11.1	9.2	7.6	6.3
Glazing replace./maintenance costs	billion EUR (10^9)	8.2	7.3	7.0	6.4	6.0	5.6	5.5
Energy costs	billion EUR (10^9)	9.6	10.8	9.2	6.2	4.7	3.9	3.3
Overall costs	billion EUR (10^9)	28.7	28.6	27.6	23.8	19.9	17.2	15.1
Employees	'000	0	0	146	134	127	123	124
Avg. heating perf. new	kWh/m2*yr	51	39	23	4	3	2	1
Avg. cooling perf. new	kWh/m2*yr	75	71	65	53	53	52	52
Stock cool.perf.	TWh_cool	65	71	77	76	77	76	75
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
				2015:	4%			
ABS.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0	0	0	0	0	0	0
Demolished	'10^6 m2/yr	0	0	0	0	0	0	0
Sales replacements	'10^6 m2/yr	0	0	0	0	0	0	0
Total stock	'10^9 m2/yr	0	0	0	0	0	0	0
Heating energy	TWh_fuel	0	0	0	-8	-10	-11	-12
Cooling energy	TWh_fuel	0	0	0	-2	-3	-3	-3
Final energy windows	TWh_fuel/yr	0	0	0	-10	-12	-14	-16
	PJ_prim	0	0	0	-36	-44	-51	-56
GHG Emissions	Mt CO2 eq./yr	0	0	0	-2	-2	-2	-2
Mat. in	kt	0	0	0	249.0	250.3	248.0	241.6
Mat. out	kt	0	0	0	-71.1	-121.8	-173.7	-229.2
Indirect energy	TWh_fuel	0	0	0	1.9	1.7	1.2	0.8
New+replace purchase costs	billion EUR (10^9)	0	0	0	2	2	2	1
Glazing replace./maintenance costs	billion EUR (10^9)	0	0	0	0	0	0	0
Energy costs	billion EUR (10^9)	0	0	0	0	-1	-1	-1
Overall costs	billion EUR (10^9)	0	0	0	2	1	1	1
Employees	'000	0	0	0	0	0	0	2
Avg. heating perf. new	kWh/m2*yr	0	0	0	-13	-12	-12	-11
Avg. cooling perf. new	kWh/m2*yr	0	0	0	-7	-5	-4	-2
Stock cool.perf.	TWh_cool	0	0	0	-3	-5	-6	-6
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	-16%	-32%	-52%	-73%
Cooling energy	TWh_fuel	0%	0%	0%	-4%	-6%	-8%	-9%
Final energy windows	TWh_fuel/yr	0%	0%	0%	-10%	-17%	-24%	-31%
	PJ_prim	0%	0%	0%	0%	0%	0%	0%
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	-10%	-15%	-21%	-27%
Mat. in	kt	0%	0%	0%	22%	21%	19%	18%
Mat. out	kt	0%	0%	0%	8%	13%	16%	20%
Indirect energy	TWh_fuel	0%	0%	0%	22%	22%	20%	15%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	23%	24%	25%	26%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	2%
Energy costs	billion EUR (10^9)	0%	0%	0%	-7%	-11%	-15%	-18%
Overall costs	billion EUR (10^9)	0%	0%	0%	7%	6%	5%	5%
Employees	'000	0%	0%	0%	0%	0%	0%	1%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	-76%	-79%	-83%	-89%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	-11%	-9%	-7%	-4%
Stock cool.perf.	TWh_cool	0%	0%	0%	-4%	-6%	-7%	-8%
Share window heat loss of heat demand	%	0%	0%	0%	-16%	-32%	-52%	-73%

Table 99 Roof window Scenario A – Modest

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	5	4	5	5	5	5	4
Demolished	'10^6 m2/yr	-1	-1	-2	-2	-3	-3	-4
Sales replacements	'10^6 m2/yr	7	8	8	9	10	10	10
Total stock	'10^9 m2/yr	0.3	0.3	0.3	0.4	0.4	0.4	0.4
Heating energy	TWh_fuel	97	75	54	30	15	8.6	5.5
Cooling energy	TWh_fuel	6	10	14	13	12	11.1	10.3
Final energy windows	TWh_fuel/yr	103	85	68	42	27	20	16
	PJ_prim	369	307	246	152	97	71	57
GHG Emissions	Mt CO2 eq./yr	21	17	13.0	8.0	5.1	3.8	3.0
Mat. in	kt	400	403	461	491	536	577	612
Mat. out	kt	-238	-284	-328	-377	-435	-478	-532
Indirect energy IN	TWh_fuel	2	2	2.3	2.2	2.2	2.2	2.2
New+replace purchase costs	billion EUR (10^9)	6	5	5.7	5.4	5.1	4.7	4.3
Glazing replace./maintenance costs	billion EUR (10^9)	3	2	2.2	2.0	1.8	1.7	1.6
Energy costs	billion EUR (10^9)	7	7	6.1	4.2	3.2	2.6	2.3
Overall costs	billion EUR (10^9)	16	14	14.0	11.7	10.0	9.0	8.2
Employees	'000			113	97	85	76	70
Avg. heating perf. new	kWh/m2*yr	105	83	48	18	15	13	11
Avg. cooling perf. new	kWh/m2*yr	146	141	124	110	107	104	101
Stock cool.perf.	TWh_cool	41	45	47	47	46	45	44
Share window heat loss of heat demand	%	26%	22%	19%	12%	9%	6%	5%
				2015:	15%			
ABS.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Demolished	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sales replacements	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total stock	'10^9 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heating energy	TWh_fuel	0.0	0.0	0.0	0.0	-0.2	-0.6	-1.1
Cooling energy	TWh_fuel	0.0	0.0	0.0	0.0	-0.3	-0.5	-0.7
Final energy windows	TWh_fuel/yr	0.0	0.0	0.0	0.0	-0.5	-1.1	-1.8
	PJ_prim	0.0	0.0	0.0	0.0	-1.8	-4.0	-6.5
GHG Emissions	Mt CO2 eq./yr	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2
Mat. in	kt	0.0	0.0	0.0	0.0	31.4	64.0	96.5
Mat. out	kt	0.0	0.0	0.0	0.0	-7.2	-21.5	-44.2
Indirect energy IN	TWh_fuel	0.0	0.0	0.0	0.0	0.2	0.4	0.6
New+replace purchase costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.4	0.6	0.8
Glazing replace./maintenance costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Overall costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.4	0.6	0.8
Employees	'000			0.0	0.0	0.0	0.0	0.0
Avg. heating perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	-2.4	-4.8	-7.2
Avg. cooling perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	-3.1	-6.1	-9.2
Stock cool.perf.	TWh_cool	0.0	0.0	0.0	0.0	-0.3	-0.9	-1.8
Share window heat loss of heat demand	%	0%	0%	0%	0%	0%	0%	-1%
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	0%	-2%	-6%	-16%
Cooling energy	TWh_fuel	0%	0%	0%	0%	-2%	-4%	-7%
Final energy windows	TWh_fuel/yr	0%	0%	0%	0%	-2%	-5%	-10%
	PJ_prim							
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	0%	-1%	-3%	-5%
Mat. in	kt	0%	0%	0%	0%	6%	12%	19%
Mat. out	kt	0%	0%	0%	0%	2%	5%	9%
Indirect energy IN	TWh_fuel	0%	0%	0%	0%	12%	23%	35%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	0%	8%	16%	24%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	0%
Energy costs	billion EUR (10^9)	0%	0%	0%	0%	0%	-1%	-3%
Overall costs	billion EUR (10^9)	0%	0%	0%	0%	4%	7%	10%
Employees	'000			0%	0%	0%	0%	0%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	0%	-13%	-27%	-40%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	0%	-3%	-6%	-8%
Stock cool.perf.	TWh_cool	0%	0%	0%	0%	-1%	-2%	-4%
Share window heat loss of heat demand	%	0%	0%	0%	0%	-2%	-6%	-16%

Table 100 Roof window Scenario B- Advanced

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	5	4	5	5	5	5	4
Demolished	'10^6 m2/yr	-1	-1	-2	-2	-3	-3	-4
Sales replacements	'10^6 m2/yr	7	8	8	9	10	10	10
Total stock	'10^9 m2/yr	0.3	0.3	0.3	0.4	0.4	0.4	0.4
Heating energy	TWh_fuel	97	75	54	30	15	8.3	4.9
Cooling energy	TWh_fuel	6	10	14	13	12	11.1	10.3
Final energy windows	TWh_fuel/yr	103	85	68	42	27	19	15
	PJ_prim	369	307	246	152	96	70	55
GHG Emissions	Mt CO2 eq./yr	21	17	13.0	8.0	5.1	3.7	2.9
Mat. in	kt	400	403	461	491	536	577	612
Mat. out	kt	-238	-284	-328	-377	-435	-478	-532
Indirect energy IN	TWh_fuel	2	2	2.3	2.2	2.2	2.2	2.2
New+replace purchase costs	billion EUR (10^9)	6	5	5.7	5.4	5.4	5.3	5.1
Glazing replace./maintenance costs	billion EUR (10^9)	3	2	2.2	2.0	1.8	1.7	1.6
Energy costs	billion EUR (10^9)	7	7	6.1	4.2	3.1	2.6	2.3
Overall costs	billion EUR (10^9)	16	14	14.0	11.7	10.4	9.6	8.9
Employees	'000			113	97	85	76	70
Avg. heating perf. new	kWh/m2*yr	105	83	48	18	14	10	7
Avg. cooling perf. new	kWh/m2*yr	146	141	124	110	107	104	101
Stock cool.perf.	TWh_cool	41	45	47	47	46	45	44
Share window heat loss of heat demand	%	26%	22%	19%	12%	9%	6%	5%
		5	4	5	5	5	5	4
ABS.CHANGE		**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Sales new build	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Demolished	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sales replacements	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total stock	'10^9 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heating energy	TWh_fuel	0.0	0.0	0.0	0.0	-0.4	-0.9	-1.7
Cooling energy	TWh_fuel	0.0	0.0	0.0	0.0	-0.3	-0.5	-0.7
Final energy windows	TWh_fuel/yr	0.0	0.0	0.0	0.0	-0.6	-1.4	-2.4
	PJ_prim	0.0	0.0	0.0	0.0	-2.3	-5.2	-8.6
GHG Emissions	Mt CO2 eq./yr	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.3
Mat. in	kt	0.0	0.0	0.0	0.0	31.4	64.0	96.5
Mat. out	kt	0.0	0.0	0.0	0.0	-7.2	-21.5	-44.2
Indirect energy IN	TWh_fuel	0.0	0.0	0.0	0.0	0.2	0.4	0.6
New+replace purchase costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.7	1.2	1.6
Glazing replace./maintenance costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
Overall costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.7	1.2	1.5
Employees	'000			0.0	0.0	0.0	0.0	0.0
Avg. heating perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	-3.7	-7.4	-11.1
Avg. cooling perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	-3.1	-6.1	-9.2
Stock cool.perf.	TWh_cool	0.0	0.0	0.0	0.0	-0.3	-0.9	-1.8
Share window heat loss of heat demand	%	0%	0%	0%	0%	0%	-1%	-2%
REL.CHANGE		**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	0%	-2%	-10%	-25%
Cooling energy	TWh_fuel	0%	0%	0%	0%	-2%	-4%	-7%
Final energy windows	TWh_fuel/yr	0%	0%	0%	0%	-2%	-7%	-14%
	PJ_prim							
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	0%	-1%	-4%	-8%
Mat. in	kt	0%	0%	0%	0%	6%	12%	19%
Mat. out	kt	0%	0%	0%	0%	2%	5%	9%
Indirect energy IN	TWh_fuel	0%	0%	0%	0%	12%	23%	35%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	0%	15%	30%	45%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	0%
Energy costs	billion EUR (10^9)	0%	0%	0%	0%	-1%	-2%	-4%
Overall costs	billion EUR (10^9)	0%	0%	0%	0%	7%	14%	20%
Employees	'000			0%	0%	0%	0%	0%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	0%	-21%	-41%	-62%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	0%	-3%	-6%	-8%
Stock cool.perf.	TWh_cool	0%	0%	0%	0%	-1%	-2%	-4%
Share window heat loss of heat demand	%	0%	0%	0%	0%	-2%	-10%	-25%

Table 101 Roof window Scenario C – Extreme

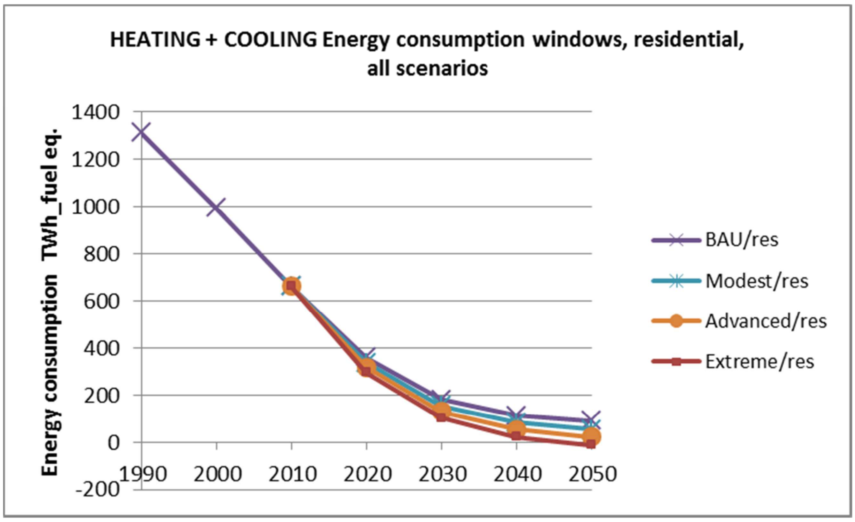
OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	5	4	5	5	5	5	4
Demolished	'10^6 m2/yr	-1	-1	-2	-2	-3	-3	-4
Sales replacements	'10^6 m2/yr	7	8	8	9	10	10	10
Total stock	'10^9 m2/yr	0.3	0.3	0.3	0.4	0.4	0.4	0.4
Heating energy	TWh_fuel	97	75	54	30	16	10.2	8.3
Cooling energy	TWh_fuel	6	10	14	13	12	10.6	9.7
Final energy windows	TWh_fuel/yr	103	85	68	42	27	21	18
	PJ_prim	369	307	246	152	98	75	65
GHG Emissions	Mt CO2 eq./yr	21	17	13.0	8.0	5.2	4.0	3.4
Mat. in	kt	400	403	461	491	504	513	516
Mat. out	kt	-238	-284	-328	-377	-427	-457	-487
Indirect energy IN	TWh_fuel	2	2	2.3	2.2	2.0	1.8	1.6
New+replace purchase costs	billion EUR (10^9)	6	5	5.7	5.4	4.8	4.3	3.8
Glazing replace./maintenance costs	billion EUR (10^9)	3	2	2.2	2.0	1.8	1.7	1.6
Energy costs	billion EUR (10^9)	7	7	6.1	4.2	3.2	2.8	2.5
Overall costs	billion EUR (10^9)	16	14	14.0	11.7	9.9	8.7	7.9
Employees	'000			113	97	85	76	70
Avg. heating perf. new	kWh/m2*yr	105	83	48	18	22	26	29
Avg. cooling perf. new	kWh/m2*yr	146	141	124	110	102	95	87
Stock cool.perf.	TWh_cool	41	45	47	47	46	44	41
Share window heat loss of heat demand	%	26%	22%	19%	12%	9%	8%	8%
		5	4	5	5	5	5	4
ABS.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Demolished	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sales replacements	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total stock	'10^9 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heating energy	TWh_fuel	0.0	0.0	0.0	0.0	0.4	1.0	1.7
Cooling energy	TWh_fuel	0.0	0.0	0.0	0.0	-0.5	-1.0	-1.4
Final energy windows	TWh_fuel/yr	0.0	0.0	0.0	0.0	-0.1	0.0	0.3
	PJ_prim	0.0	0.0	0.0	0.0	-0.4	0.0	1.2
GHG Emissions	Mt CO2 eq./yr	0.0	0.0	0.0	0.0	0.1	0.2	0.3
Mat. in	kt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mat. out	kt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect energy IN	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New+replace purchase costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.2	0.3	0.4
Glazing replace./maintenance costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Overall costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.2	0.3	0.5
Employees	'000			0.0	0.0	0.0	0.0	0.0
Avg. heating perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	3.9	7.7	11.6
Avg. cooling perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	-7.6	-15.3	-22.9
Stock cool.perf.	TWh_cool	0.0	0.0	0.0	0.0	-0.8	-2.3	-4.5
Share window heat loss of heat demand	%	0%	0%	0%	0%	0%	1%	2%
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	0%	3%	10%	26%
Cooling energy	TWh_fuel	0%	0%	0%	0%	-4%	-8%	-13%
Final energy windows	TWh_fuel/yr	0%	0%	0%	0%	0%	0%	2%
	PJ_prim							
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	0%	1%	4%	8%
Mat. in	kt	0%	0%	0%	0%	0%	0%	0%
Mat. out	kt	0%	0%	0%	0%	0%	0%	0%
Indirect energy IN	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	0%	3%	7%	10%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	0%
Energy costs	billion EUR (10^9)	0%	0%	0%	0%	1%	2%	5%
Overall costs	billion EUR (10^9)	0%	0%	0%	0%	2%	4%	6%
Employees	'000			0%	0%	0%	0%	0%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	0%	22%	43%	65%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	0%	-7%	-14%	-21%
Stock cool.perf.	TWh_cool	0%	0%	0%	0%	-2%	-5%	-10%
Share window heat loss of heat demand	%	0%	0%	0%	0%	3%	10%	26%

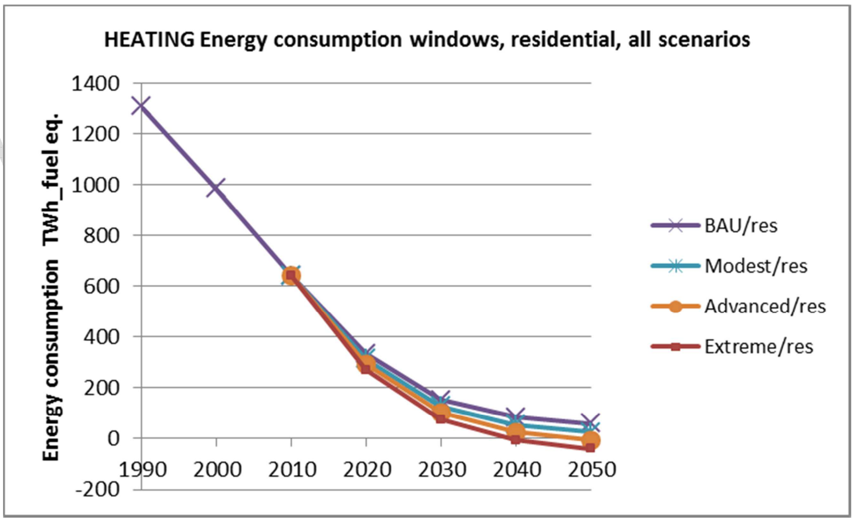
5.3.3. Scenario results / graphs

This section shows the energy consumption attributed to windows in the various sectors in graphs.

Table 102 Graphs of RESIDENTIAL energy for heating, cooling, and combined

RESIDENTIAL energy





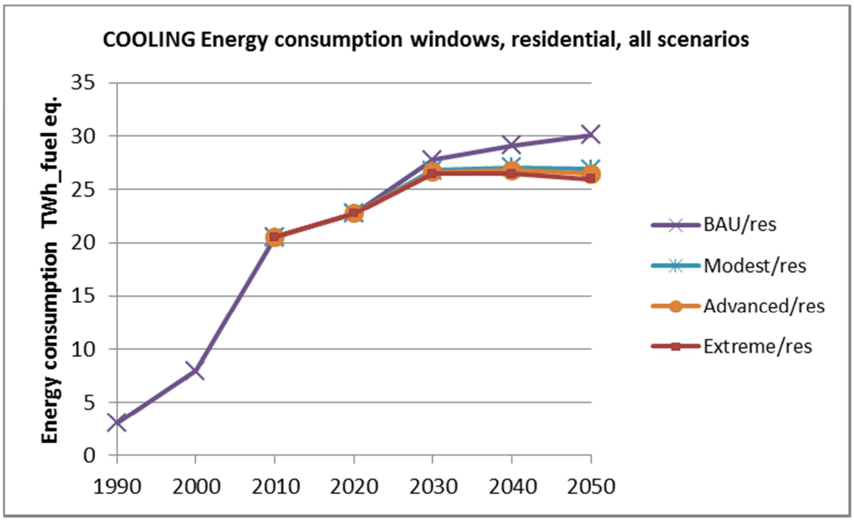
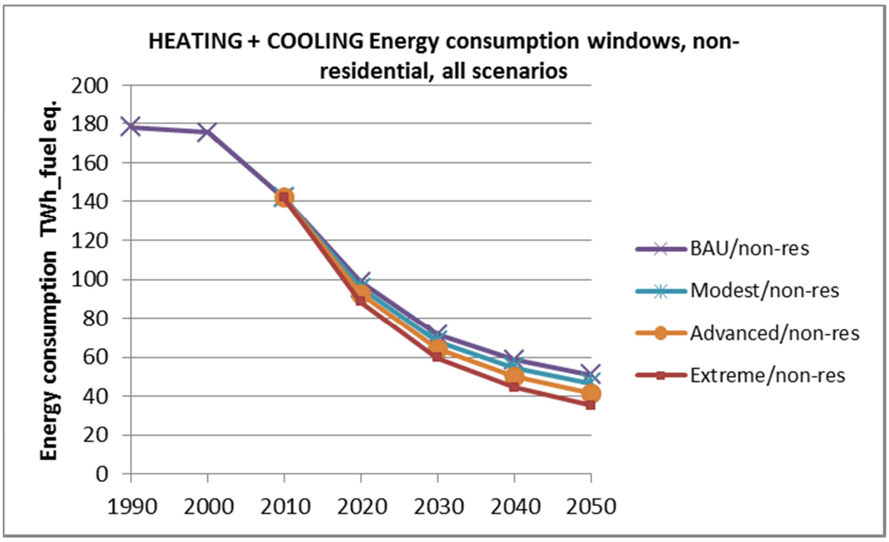
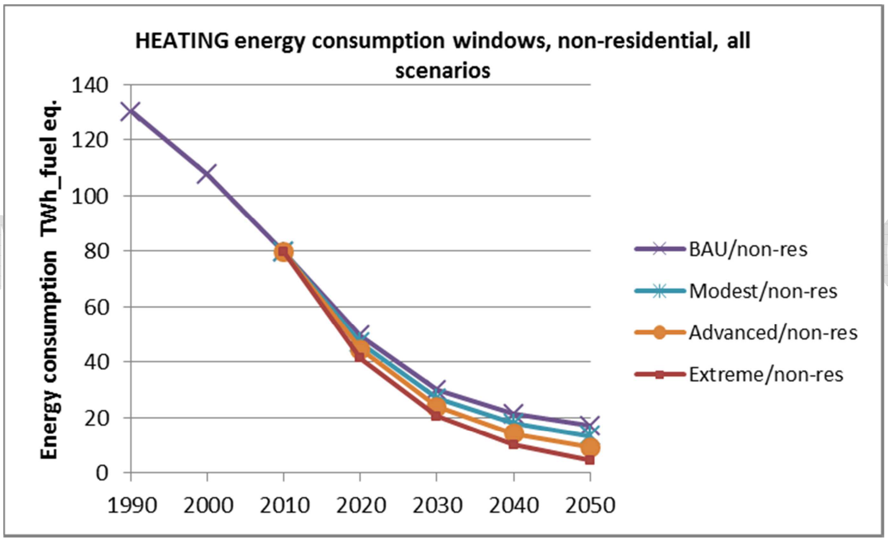


Table 103 Graphs of NON-RESIDENTIAL energy for heating, cooling, and combined

NON-RESIDENTIAL energy





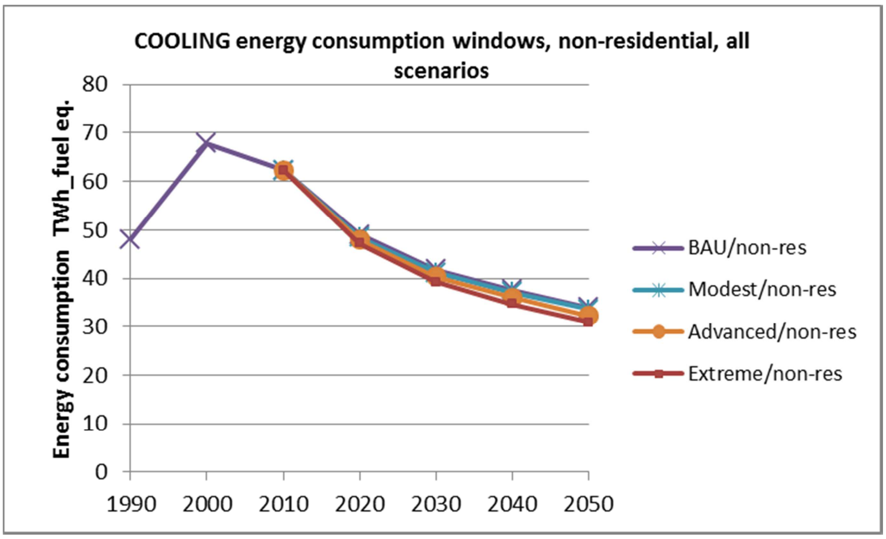
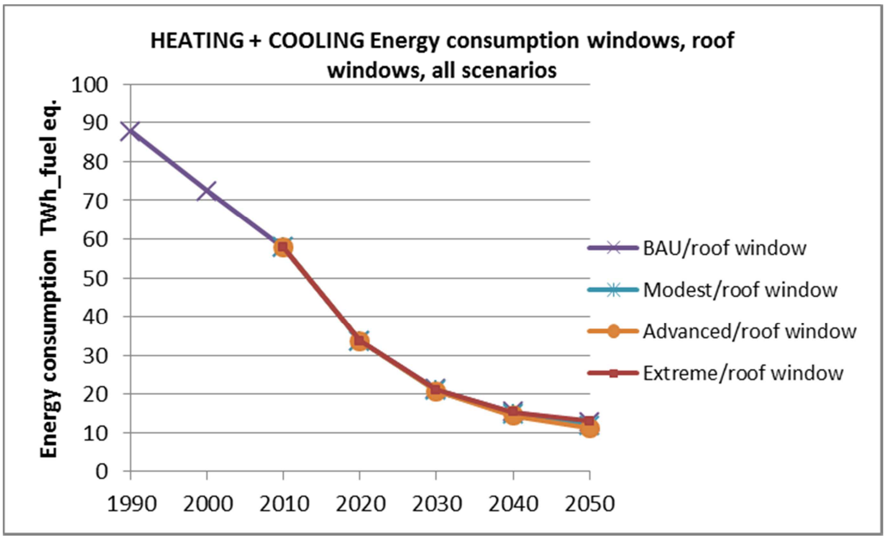
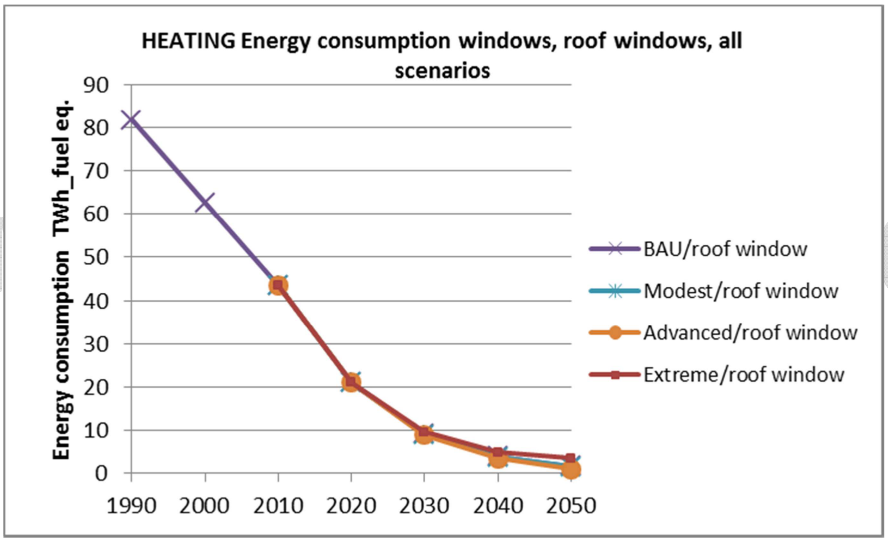
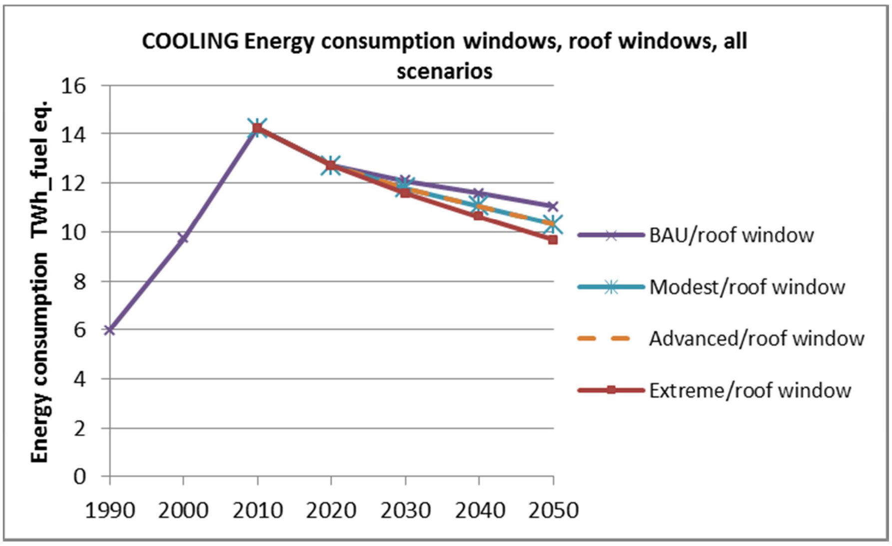


Table 104 Graphs of ROOF WINDOWS energy for heating, cooling, and combined

ROOF WINDOWS energy







5.3.4. DURABILITY / EXTENSION OF PRODUCT LIFE

The possible impact of improved durability or extension of the product life of windows has been assessed using the calculation model for residential windows.

The results (see table next page) show that an increase of an average window product life of 40 yrs. to 50 yrs. results in a net environmental loss. As can be expected, the annual material input is indeed reduced (some 192 kton saved, equivalent to some 6 TWh fuel) but at the same time the overall window energy performance is reduced as well (final energy more than 10 TWh higher), which leads to a loss of possible savings when compared to a scenario assuming a product life of 40 yrs.: the savings in material consumption do not outweigh the loss of savings caused by slower replacement of old windows by better performing windows.

If the window product life is REDUCED from 40 yrs. to 30 yrs., the model calculates a higher throughput of materials (332 kton more material input per year, comparable to 10 TWh of fuel), but also energy savings of 9 TWh/yr.

For other sectors, similar conclusions can be expected.

Note

The assessment was performed for residential (façade) windows only, for the EU28 level. Other model settings as for BAU. The material input per window is not assumed to change because of the increased life time. The material input per window does change as a result of the increase in average energy performance (relatively more triple pane glazing).

Table 105 Residential windows – extension of product life

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	67.8	44.1	47.7	46.5	45.4	44.3	43.2
Demolished	'10^6 m2/yr	-11.8	-15.4	-18.8	-17.0	-28.0	-36.9	-36.8
Sales replacements	'10^6 m2/yr	87.2	94.3	101.6	87.2	90.6	92.1	93.4
Total stock	'10^9 m2/yr	3.5	3.8	4.1	4.4	4.5	4.6	4.7
Heating energy	TWh_fuel	1307.7	985.2	642.5	441.0	223.4	123.3	69.2
Cooling energy	TWh_fuel	3.0	8.0	20.5	22.7	27.7	29.1	30.1
Final energy windows	TWh_fuel/yr	1310.7	993.2	663.0	463.8	251.2	152.5	99.2
	PJ_prim	4718.6	3575.5	2386.7	1669.6	904.2	548.9	357.2
GHG Emissions	Mt CO2 eq./yr	261.2	191.0	122.1	83.9	44.1	26.2	16.5
Mat. in	kt	1455.6	1284.4	1410.7	1277.8	1315.6	1334.3	1351.2
Mat. out	kt	-1005.9	-1150.4	-1316.5	-1155.1	-1303.3	-1381.8	-1348.5
Indirect energy IN	TWh_fuel	48.1	41.0	43.2	39.0	40.0	40.5	40.8
New+replace purchase costs	billion EUR (10^9)	48.4	37.6	37.3	25.3	20.3	16.2	13.0
Glazing replace./maintenance costs	billion EUR (10^9)	31.7	28.4	26.8	24.2	21.8	19.6	17.8
Energy costs	billion EUR (10^9)	86.1	65.9	45.7	32.9	19.6	13.3	9.9
Overall costs	billion EUR (10^9)	166.2	131.9	109.8	82.4	61.6	49.1	40.7
Employees	'000	0	0	280	282	283	287	291
Avg. heating perf. new	kWh/m2*yr	114	77	30	18	15	11	8
Avg. cooling perf. new	kWh/m2*yr	67	63	57	53	52	50	48
Stock cool.perf.	TWh_cool	246	256	261	269	263	253	244
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
				2015:	22%			
ABS.CHANGE		**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Sales new build	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Demolished	'10^6 m2/yr	0.0	0.0	0.0	6.6	5.7	-0.9	4.3
Sales replacements	'10^6 m2/yr	0.0	0.0	0.0	-20.1	-19.6	-20.2	-19.4
Total stock	'10^9 m2/yr	0.0	0.0	0.0	0.1	0.1	0.1	0.2
Heating energy	TWh_fuel	0.0	0.0	0.0	106.2	70.4	39.5	10.3
Cooling energy	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Final energy windows	TWh_fuel/yr	0.0	0.0	0.0	106.2	70.4	39.5	10.3
	PJ_prim	0.0	0.0	0.0	382.3	253.3	142.2	36.9
GHG Emissions	Mt CO2 eq./yr	0.0	0.0	0.0	19.0	12.1	6.5	1.6
Mat. in	kt	0.0	0.0	0.0	-192.5	-189.3	-197.3	-191.9
Mat. out	kt	0.0	0.0	0.0	262.6	215.7	133.1	190.8
Indirect energy IN	TWh_fuel	0.0	0.0	0.0	-5.9	-5.8	-6.0	-5.8
New+replace purchase costs	billion EUR (10^9)	0.0	0.0	0.0	-3.8	-2.9	-2.4	-1.9
Glazing replace./maintenance costs	billion EUR (10^9)	0.0	0.0	0.0	0.3	0.4	0.3	0.1
Energy costs	billion EUR (10^9)	0.0	0.0	0.0	6.9	4.6	2.6	0.7
Overall costs	billion EUR (10^9)	0.0	0.0	0.0	3.4	2.1	0.5	-1.1
Employees	'000	0.0	0.0	0.0	2.2	4.2	3.9	1.2
Avg. heating perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. cooling perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stock cool.perf.	TWh_cool	0.0	0.0	0.0	13.7	16.7	13.9	12.1
Share window heat loss of heat demand	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	-28%	-17%	2%	-10%
Sales replacements	'10^6 m2/yr	0%	0%	0%	-19%	-18%	-18%	-17%
Total stock	'10^9 m2/yr	0%	0%	0%	2%	3%	3%	4%
Heating energy	TWh_fuel	0%	0%	0%	32%	46%	47%	17%
Cooling energy	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
Final energy windows	TWh_fuel/yr	0%	0%	0%	30%	39%	35%	12%
	PJ_prim	0%	0%	0%	0%	0%	0%	0%
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	29%	38%	33%	11%
Mat. in	kt	0%	0%	0%	-13%	-13%	-13%	-12%
Mat. out	kt	0%	0%	0%	-19%	-14%	-9%	-12%
Indirect energy IN	TWh_fuel	0%	0%	0%	-13%	-13%	-13%	-12%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	-13%	-13%	-13%	-12%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	1%	2%	2%	1%
Energy costs	billion EUR (10^9)	0%	0%	0%	27%	31%	24%	7%
Overall costs	billion EUR (10^9)	0%	0%	0%	4%	4%	1%	-3%
Employees	'000	0%	0%	0%	1%	1%	1%	0%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Stock cool.perf.	TWh_cool	0%	0%	0%	5%	7%	6%	5%
Share window heat loss of heat demand	%	0%	0%	0%	32%	46%	47%	17%

5.4. COMPARISON TO 2ND ECODESIGN WORKING PLAN BACKGROUND STUDY

The savings for the residential sector in 2050 according scenario C "Extreme" are calculated to be some 103 TWh_fuel, which is 369 PJ. The savings in the non-residential sector are some 16 TWh or 56 PJ. Together this is some 425 PJ of savings in 2050. In 2030 the savings are approximately 325 PJ.

The savings identified in the background study for the second Working Plan[61] ('WP2') for the residential sector were some 177 PJ in 2020, 334 PJ in 2025 and 473 PJ in 2030. This does not differ very much from the above calculated savings of 227 to 328 PJ in the Extreme scenario for 2030 and 2050 for the residential sector, given the fact that the Lot 32 calculation model is much more elaborate and based on different background data.

The values for residential+non-residential are diverging much more, and this can be explained by the assumption in the WP2 study that the non-residential market would represent some 2/3 of the residential market, whereas the Lot 32 calculations (this study) show that the non-residential market represents some 13% of overall savings.

Table 106 Comparing scenario C savings to Second Ecodesign Work plan study NOTE: Heating only!

Savings (in PJ_fuel) for heating only	2020	2025	2030	2040	2050
Lot 32 study / residential	227	(n.a.)	277	319	355
Lot 32 study / residential + non-residential	257	(n.a.)	311	359	400
Background study Ecodesign WP2 / residential	177	334	473	(n.a.)	(n.a.)
Background study Ecodesign WP2 / residential + non-residential	294	555	785	(n.a.)	(n.a.)
difference residential only (Lot 32 compared to WP2)	28%		-41%		
difference residential + non-residential	-13%		-60%		

The differences may be also explained by a much higher building stock renewal rate assumed in the WP2 study (4% against approximately 1% in the current study) and a much shorter product life (25 years against 40 years assumed in the current study), which slows down replacement of old windows by newer ones.

The assumption that the non-residential sector windows energy demand represent 2/3 of the residential sector could not be confirmed in the Lot 32 study: Lot 32 calculated a window-to-floor ratio of 9% for the non-residential sector as a whole, the window related energy demand is much lower than shown in WP2. For the residential sector, the difference in savings for heating only, between the WP2 study of December 2011 and the Lot 32 study of June 2015 can satisfactorily be explained by:

1. first and foremost, the shorter product life assumed in WP2 (25 years versus 40 years in Lot 32 reference calculations). If Lot 32 would calculate with a product life between 20 and 30 years the savings (for 2030) would be in the range of 329 to 448 PJ of fuel (heating and cooling);
2. the smaller saving potential calculated in Lot 32: In WP2 a saving potential of 10% was assumed, whereas in Lot 32, the savings of scenario C are closer to 5% of the demand (2050 savings compared to 2010 demand).

The Lot 32 calculated savings should be regarded as an update of the WP2 savings as they are based on a much more detailed and complex modelling and calculation of savings.

[61] M. van Elburg et al, "Study on Amended Working Plan under the Ecodesign Directive", final report Task 3, 16 December 2011

CHAPTER 6 IMPACT ANALYSIS INDUSTRY & CONSUMERS

6.1. Introduction Impact Analysis Industry & Consumers

This chapter covers the economic impacts of the possible scenarios for industry and consumers.

The MEERP methodology asks for a description of the following aspects (non-relevant aspects omitted):

a) baseline product price, in Net Present Value for a reference year (e.g. 2010), taking into account inflation rates as given in MEErP
b) unitary energy, annual repair and maintenance costs.
c) inflation rate, growth rate unitary prices (energy, etc.)
d) relationship between a product's unitary impacts and product purchase price
e) the turnover rate per employee
f) cost and margin built-up for the average product (%)

The above variables and are introduced in the stock model using mathematical relations .

6.2. Cost price

→ Product price

The product price (street price) is based upon the data presented in Task 2.

Table 107 Purchase prices per window type and split-up

EU28	Uw (W/m2*K)	g (-)	Street price, incl. inst.+VAT
01_single	5.8	0.85	154
02_double IGU, standard	2.8	0.78	234
03_double IGU, lowE, argon	1.7	0.65	255
04_double IGU,lowE, argon, impr	1.3	0.60	256
05_triple IGU, lowE, argon	1.0	0.55	298
06_triple IGU, lowE, argon, impr.	0.8	0.60	403
07_coupled	1.0	0.58	370
08_quadruple	0.6	0.47	510
09_as 02, solar	2.8	0.35	288
10_as 04, solar	1.3	0.35	299
11_as 06, solar	0.8	0.35	456
roof_03	1.7	0.6	480
roof_04	1.1	0.5	708
roof_05	0.9	0.5	913
roof_06	1.7	0.35	578

The price elasticity is not determined in accordance with MEERP 2011 (which asks for a linear relationship). The available data comprises all available window types and therefore the average price can be calculated on the basis of the window sales.

6.3. Maintenance costs

The maintenance costs consist of two items: the glazing replacement costs, which vary depending the window type (triple glazing more expensive than single glazing) and the fixed annual costs for cleaning and painting (whichever applies, depending on frame material).

Table 108 Window maintenance costs and employees (BAU)

Maintenance/repair costs		Residential (façade)					Roof window				
		2010	**2020**	**2030**	**2040**	**2050**	**2010**	**2020**	**2030**	**2040**	**2050**
Window purchase costs for EU28/residential/all res	billion EUR (PWF corrected)	37	29	23	19	15	5.7	5.4	4.7	4.0	3.5
of which installation	billion EUR (PWF corrected)	7	6	5	4	4	2.1	1.8	1.5	1.3	1.2
Total repair/maintenance costs	billion EUR (PWF corrected)	27	24	21	19	18	2.2	2.0	1.8	1.7	1.6
of which glazing repair	(% of total maintenance)	24%	27%	30%	33%	37%	22%	25%	27%	30%	35%
of which labour (billion EUR, PWF corrected)	(estimated share labour in total maintenance costs: 67%)	30	34	37	40	42	1.5	1.3	1.2	1.1	1.0
glazing replacement costs	EUR/m2 window over window life (PWF corrected)	66	56	51	47	45	0.5	0.5	0.5	0.5	0.5
number of employees in manufacturing	thousand employees	253	194	152	119	94	30	31	26	23	20
number of employees in repair maintenance	thousand employees	181	199	212	226	241	15	17	18	20	21

The number of employees in manufacturing (for NEW windows) and repair / maintenance (for existing windows) are expected to overlap to a large degree.

A further split-up of employees per sector (split manufacturing into production, retail and installation) is not possible due to lack of data.

6.4. Energy costs

Energy costs are on average 0.07 EUR/kWh_primary in the EU28 for heating systems. The total annual energy costs is therefore some 22 billion EUR in 2010, decreasing to some 2 billion EUR in 2050.

The discounted values are identical in case the discount rate (d=4%) equals the escalation rate (e=4%). Only if the escalation rate exceeds the discount rate, a relative increase of discounted energy costs can be calculated. the table below shows this for d=4% and e=6%.

Table 109 Energy costs (BAU)

		Residential (façade) window					Roof window				
		2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Heating costs	billion EUR (PWF	42	22	10	5	4	3.5	1.9	1.0	0.6	0.4

	corrected)										
Cooling costs	billion EUR (PWF corrected)	3.7	4.1	5.0	5.2	5.4	2.6	2.3	2.2	2.1	2.0
PWF (discount 4%, escalation 4%)			1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0

→ Turnover per employee

The turnover per employee in the window manufacturing sector varies across the EU and is allegedly approximately 110 000 EUR in Germany and 76 000 in Poland (source: comments provided by Eurowindoor) with the EU28 at average 98 645 EUR. The values for the EU28 are based on values for Member States after correcting on the basis of the labour costs.

Table 110 Turnover per employee

Member State	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU 28
turnover per employee ('000 EUR)	110	119	70	90	80	110	120	79	84	96	110	114	79	75	107	104	73	116	73	83	113	76	82	72	123	86	77	96	99
Labour cost index	1.0	1.2	0.1	0.5	0.3	1.0	1.2	0.3	0.4	0.7	1.0	1.1	0.3	0.2	0.9	0.9	0.2	1.1	0.2	0.4	1.1	0.2	0.4	0.1	1.3	0.5	0.3	0.7	0.7

→ Rates

The calculation assume the following rates (unless indicated otherwise):

- the discount rate (interest-inflation) is a default provided by the Commission and is set at 4%;
- the escalation rate is the real (inflation corrected) running cost price increase. The MEERP 2011 suggest an escalation rate of also 4%;
- the present worth factor (PWF) recalculates future returns to the present, taking into account the discount and escalation rates.

In case the escalation rate is same as the discount rate, then the PWF is the same as the product life. In the sensitivity analysis the difference of outcomes at different rates are calculated.

The total combined costs of purchase, maintenance and energy are calculated to be close to 93-100 billion EUR. The share of especially energy reduces quite drastically, as purchase and maintenance / repair in particular are increasing.

Table 111 Total costs (PWF corrected)

		Residential (façade) window							Roof window						
		1990	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Total costs	**10^9 EUR**	166	132	110	79	60	49	42	16.8	16.0	14.0	14.0	11.7	9.7	8.4
manufact. + instal.	%	29%	29%	34%	37%	39%	38%	36%	38%	38%	36%	41%	47%	48%	48%
maint. / rep.	%	19%	22%	24%	30%	36%	40%	42%	16%	16%	16%	16%	17%	19%	20%
energy	%	52%	50%	42%	33%	25%	22%	22%	46%	46%	48%	44%	36%	33%	32%
o/w heating	%	51%	49%	38%	28%	17%	11%	9%	42%	40%	35%	25%	17%	10%	7%
o/w cooling	%	0%	1%	3%	5%	8%	11%	13%	3%	7%	12%	18%	20%	22%	25%

CHAPTER 7 SENSITIVITY ANALYSIS OF MAIN PARAMETERS

7.1. INTRODUCTION SENSITIVITY ANALYSIS OF THE MAIN PARAMETERS

This chapter presents the outcome of a sensitivity analysis for variations in the main parameters. According the MEERP 2011 methodology, the following parameters should be subject to sensitivity analysis,

a. higher and lower (50%) energy prices;

b. higher and lower (50%) elasticity between product price and unitary impact parameter;

c. new target levels or differences in timing as indicated by the Commission services;

d. life cycle costs covering the relevant factors and, where appropriate external environmental costs (societal LCC) :

> Extend the calculation of the base-case Life Cycle Costs for the end-user with the societal costs for emissions indicated in Chapter 5, using the outcome of Task 5.2 (emissions in mass per product over product life) and the monetary values per emission (in €/unit of mass) in this Chapter 7 and report on the in-/decrements (in tables)

In addition the following aspects have been assessed:

1. the sensitivity as regards the share of windows not replaced at 'new build level' is assessed;
2. the sensitivity as regards the stock renewal rate which is modelled on A) the basis of a shorter product life and B) the increase of the demolishment rate with increased New Build rate.

The above parameters have been assessed on the level of the EU 28 impacts (energy and costs) but for the residential sector only.

7.2. Sensitivity for changing energy prices

The methodology requires to consider a higher and lower (50%) elasticity between product price and unitary impact parameter. This is modelled by applying a mark-up to the purchase costs of 0.5 (-50%) and 1.5 (+50%).

Table 112 Energy prices at 50%

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	67.8	44.1	47.7	46.5	45.4	44.3	43.2
Demolished	'10^6 m2/yr	-11.8	-15.4	-18.8	-23.6	-33.7	-36.1	-41.2
Sales replacements	'10^6 m2/yr	87.2	94.3	101.6	107.3	110.2	112.3	112.8
Total stock	'10^9 m2/yr	3.5	3.8	4.1	4.3	4.4	4.5	4.5
Heating energy	TWh_fuel	1307.7	985.2	642.5	334.8	153.0	83.8	58.9
Cooling energy	TWh_fuel	3.0	8.0	20.5	22.7	27.7	29.1	30.1
Final energy windows	**TWh_fuel/yr**	1310.7	993.2	663.0	357.6	180.8	113.0	89.0
	PJ_prim	4718.6	3575.5	2386.7	1287.3	650.8	406.7	320.3
GHG Emissions	Mt CO2 eq./yr	261.2	191.0	122.1	64.9	32.1	19.7	14.9
Mat. in	kt	1455.6	1284.4	1410.7	1470.3	1505.0	1531.6	1543.1
Mat. out	kt	-1005.9	-1150.4	-1316.5	-1417.7	-1519.0	-1514.8	-1539.2
Indirect energy IN	TWh_fuel	48.1	41.0	43.2	44.9	45.8	46.4	46.6
New+replace purchase costs	billion EUR (10^9)	48.4	37.6	37.3	29.1	23.2	18.6	14.9
Glazing replace./maintenance costs	billion EUR (10^9)	31.7	28.4	26.8	23.9	21.3	19.3	17.7
Energy costs	billion EUR (10^9)	43.0	32.9	22.9	13.0	7.5	5.4	4.6
Overall costs	billion EUR (10^9)	123.1	98.9	86.9	66.0	52.0	43.2	37.2
Employees	'000	0	0	280	280	279	283	290
Avg. heating perf. new	kWh/m2*yr	114	77	30	18	15	11	8
Avg. cooling perf. new	kWh/m2*yr	67	63	57	53	52	50	48
Stock cool.perf.	TWh_cool	246	256	261	255	247	239	232
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
				2015:	19%			
ABS.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Demolished	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sales replacements	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total stock	'10^9 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heating energy	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooling energy	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Final energy windows	**TWh_fuel/yr**	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	PJ_prim	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GHG Emissions	Mt CO2 eq./yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mat. in	kt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mat. out	kt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect energy IN	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New+replace purchase costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glazing replace./maintenance costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy costs	billion EUR (10^9)	-43.0	-32.9	-22.9	-13.0	-7.5	-5.4	-4.6
Overall costs	billion EUR (10^9)	-43.0	-32.9	-22.9	-13.0	-7.5	-5.4	-4.6
Employees	'000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. heating perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. cooling perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stock cool.perf.	TWh_cool	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Share window heat loss of heat demand	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
Cooling energy	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
Final energy windows	**TWh_fuel/yr**	0%	0%	0%	0%	0%	0%	0%
		0%	0%	0%	0%	0%	0%	0%
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	0%	0%	0%	0%
Mat. in	kt	0%	0%	0%	0%	0%	0%	0%
Mat. out	kt	0%	0%	0%	0%	0%	0%	0%
Indirect energy IN	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	0%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	0%
Energy costs	billion EUR (10^9)	-50%	-50%	-50%	-50%	-50%	-50%	-50%
Overall costs	billion EUR (10^9)	-26%	-25%	-21%	-16%	-13%	-11%	-11%

Employees	'000	0%	0%	0%	0%	0%	0%	0%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Stock cool.perf.	TWh_cool	0%	0%	0%	0%	0%	0%	0%
Share window heat loss of heat demand	%	0%	0%	0%	0%	0%	0%	0%

Table 113 Energy prices at 150%

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	67.8	44.1	47.7	46.5	45.4	44.3	43.2
Demolished	'10^6 m2/yr	-11.8	-15.4	-18.8	-23.6	-33.7	-36.1	-41.2
Sales replacements	'10^6 m2/yr	87.2	94.3	101.6	107.3	110.2	112.3	112.8
Total stock	'10^9 m2/yr	3.5	3.8	4.1	4.3	4.4	4.5	4.5
Heating energy	TWh_fuel	1307.7	985.2	642.5	334.8	153.0	83.8	58.9
Cooling energy	TWh_fuel	3.0	8.0	20.5	22.7	27.7	29.1	30.1
Final energy windows	**TWh_fuel/yr**	1310.7	993.2	663.0	357.6	180.8	113.0	89.0
	PJ_prim	4718.6	3575.5	2386.7	1287.3	650.8	406.7	320.3
GHG Emissions	Mt CO2 eq./yr	261.2	191.0	122.1	64.9	32.1	19.7	14.9
Mat. in	kt	1455.6	1284.4	1410.7	1470.3	1505.0	1531.6	1543.1
Mat. out	kt	-1005.9	-1150.4	-1316.5	-1417.7	-1519.0	-1514.8	-1539.2
Indirect energy IN	TWh_fuel	48.1	41.0	43.2	44.9	45.8	46.4	46.6
New+replace purchase costs	billion EUR (10^9)	48.4	37.6	37.3	29.1	23.2	18.6	14.9
Glazing replace./maintenance costs	billion EUR (10^9)	31.7	28.4	26.8	23.9	21.3	19.3	17.7
Energy costs	billion EUR (10^9)	129.1	98.8	68.6	39.0	22.5	16.1	13.9
Overall costs	billion EUR (10^9)	209.2	164.8	132.7	92.0	67.0	53.9	46.5
Employees	'000	0	0	280	280	279	283	290
Avg. heating perf. new	kWh/m2*yr	114	77	30	18	15	11	8
Avg. cooling perf. new	kWh/m2*yr	67	63	57	53	52	50	48
Stock cool.perf.	TWh_cool	246	256	261	255	247	239	232
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
				2015:	19%			
ABS.CHANGE		**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Sales new build	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Demolished	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sales replacements	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total stock	'10^9 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heating energy	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooling energy	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Final energy windows	**TWh_fuel/yr**	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	PJ_prim	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GHG Emissions	Mt CO2 eq./yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mat. in	kt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mat. out	kt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect energy IN	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New+replace purchase costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glazing replace./maintenance costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy costs	billion EUR (10^9)	43.0	32.9	22.9	13.0	7.5	5.4	4.6
Overall costs	billion EUR (10^9)	43.0	32.9	22.9	13.0	7.5	5.4	4.6
Employees	'000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. heating perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. cooling perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stock cool.perf.	TWh_cool	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Share window heat loss of heat demand	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REL.CHANGE		**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
Cooling energy	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
Final energy windows	**TWh_fuel/yr**	0%	0%	0%	0%	0%	0%	0%
		0%	0%	0%	0%	0%	0%	0%
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	0%	0%	0%	0%
Mat. in	kt	0%	0%	0%	0%	0%	0%	0%
Mat. out	kt	0%	0%	0%	0%	0%	0%	0%
Indirect energy IN	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	0%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	0%
Energy costs	billion EUR (10^9)	50%	50%	50%	50%	50%	50%	50%

Overall costs	billion EUR (10^9)	26%	25%	21%	16%	13%	11%	11%
Employees	'000	0%	0%	0%	0%	0%	0%	0%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Stock cool.perf.	TWh_cool	0%	0%	0%	0%	0%	0%	0%
Share window heat loss of heat demand	%	0%	0%	0%	0%	0%	0%	0%

The change in energy costs has a modest effect on overall costs as energy is only a fairly small part of the overall costs: The share of energy in overall costs is 13% for the normal prices, and increases to 19% for prices *1.5, and reduces to 7% when prices are *0.5.

7.3. Sensitivity for changing purchase costs

The methodology requires to consider a higher and lower (50%) purchase costs. This is modelled by applying a mark-up to the purchase costs of 0.5 (-50%) and 1.5 (+50%).

The effects are only indicated for the monetary categories, as no effect on window sales is assumed. The effect of 'not buying more expensive windows' is modelled in the BAU itself (assuming sales trends as before).

Table 114 Purchase costs at 50%

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	67.8	44.1	47.7	46.5	45.4	44.3	43.2
Demolished	'10^6 m2/yr	-11.8	-15.4	-18.8	-23.6	-33.7	-36.1	-41.2
Sales replacements	'10^6 m2/yr	87.2	94.3	101.6	107.3	110.2	112.3	112.8
Total stock	'10^9 m2/yr	3.5	3.8	4.1	4.3	4.4	4.5	4.5
Heating energy	TWh_fuel	1307.7	985.2	642.5	334.8	153.0	83.8	58.9
Cooling energy	TWh_fuel	3.0	8.0	20.5	22.7	27.7	29.1	30.1
Final energy windows	**TWh_fuel/yr**	1310.7	993.2	663.0	357.6	180.8	113.0	89.0
	PJ_prim	4718.6	3575.5	2386.7	1287.3	650.8	406.7	320.3
GHG Emissions	Mt CO2 eq./yr	261.2	191.0	122.1	64.9	32.1	19.7	14.9
Mat. in	kt	1455.6	1284.4	1410.7	1470.3	1505.0	1531.6	1543.1
Mat. out	kt	-1005.9	-1150.4	-1316.5	-1417.7	-1519.0	-1514.8	-1539.2
Indirect energy IN	TWh_fuel	48.1	41.0	43.2	44.9	45.8	46.4	46.6
New+replace purchase costs	billion EUR (10^9)	24.2	18.8	18.7	14.5	11.6	9.3	7.5
Glazing replace./maintenance costs	billion EUR (10^9)	31.7	28.4	26.8	23.9	21.3	19.3	17.7
Energy costs	billion EUR (10^9)	86.1	65.9	45.7	26.0	15.0	10.7	9.3
Overall costs	billion EUR (10^9)	142.0	113.1	91.1	64.5	47.9	39.3	34.4
Employees	'000	0	0	280	280	279	283	290
Avg. heating perf. new	kWh/m2*yr	114	77	30	18	15	11	8
Avg. cooling perf. new	kWh/m2*yr	67	63	57	53	52	50	48
Stock cool.perf.	TWh_cool	246	256	261	255	247	239	232
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
				2015:	19%			
ABS.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Demolished	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sales replacements	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total stock	'10^9 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heating energy	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooling energy	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Final energy windows	**TWh_fuel/yr**	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	PJ_prim	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GHG Emissions	Mt CO2 eq./yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mat. in	kt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mat. out	kt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect energy IN	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New+replace purchase costs	billion EUR (10^9)	-24.2	-18.8	-18.7	-14.5	-11.6	-9.3	-7.5
Glazing replace./maintenance costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Overall costs	billion EUR (10^9)	-24.2	-18.8	-18.7	-14.5	-11.6	-9.3	-7.5
Employees	'000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. heating perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. cooling perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stock cool.perf.	TWh_cool	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Share window heat loss of heat demand	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
Cooling energy	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
Final energy windows	**TWh_fuel/yr**	0%	0%	0%	0%	0%	0%	0%
		0%	0%	0%	0%	0%	0%	0%
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	0%	0%	0%	0%
Mat. in	kt	0%	0%	0%	0%	0%	0%	0%
Mat. out	kt	0%	0%	0%	0%	0%	0%	0%
Indirect energy IN	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
New+replace purchase costs	billion EUR (10^9)	-50%	-50%	-50%	-50%	-50%	-50%	-50%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	0%
Energy costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	0%
Overall costs	billion EUR (10^9)	-15%	-14%	-17%	-18%	-19%	-19%	-18%
Employees	'000	0%	0%	0%	0%	0%	0%	0%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Stock cool.perf.	TWh_cool	0%	0%	0%	0%	0%	0%	0%
Share window heat loss of heat demand	%	0%	0%	0%	0%	0%	0%	0%

Table 115 Purchase costs at 150%

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	67.8	44.1	47.7	46.5	45.4	44.3	43.2
Demolished	'10^6 m2/yr	-11.8	-15.4	-18.8	-23.6	-33.7	-36.1	-41.2
Sales replacements	'10^6 m2/yr	87.2	94.3	101.6	107.3	110.2	112.3	112.8
Total stock	'10^9 m2/yr	3.5	3.8	4.1	4.3	4.4	4.5	4.5
Heating energy	TWh_fuel	1307.7	985.2	642.5	334.8	153.0	83.8	58.9
Cooling energy	TWh_fuel	3.0	8.0	20.5	22.7	27.7	29.1	30.1
Final energy windows	**TWh_fuel/yr**	1310.7	993.2	663.0	357.6	180.8	113.0	89.0
	PJ_prim	4718.6	3575.5	2386.7	1287.3	650.8	406.7	320.3
GHG Emissions	Mt CO2 eq./yr	261.2	191.0	122.1	64.9	32.1	19.7	14.9
Mat. in	kt	1455.6	1284.4	1410.7	1470.3	1505.0	1531.6	1543.1
Mat. out	kt	-1005.9	-1150.4	-1316.5	-1417.7	-1519.0	-1514.8	-1539.2
Indirect energy IN	TWh_fuel	48.1	41.0	43.2	44.9	45.8	46.4	46.6
New+replace purchase costs	billion EUR (10^9)	72.6	56.4	56.0	43.6	34.8	27.9	22.4
Glazing replace./maintenance costs	billion EUR (10^9)	31.7	28.4	26.8	23.9	21.3	19.3	17.7
Energy costs	billion EUR (10^9)	86.1	65.9	45.7	26.0	15.0	10.7	9.3
Overall costs	billion EUR (10^9)	190.4	150.6	128.4	93.5	71.1	57.9	49.3
Employees	'000	0	0	280	280	279	283	290
Avg. heating perf. new	kWh/m2*yr	114	77	30	18	15	11	8
Avg. cooling perf. new	kWh/m2*yr	67	63	57	53	52	50	48
Stock cool.perf.	TWh_cool	246	256	261	255	247	239	232
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
				2015:	19%			
ABS.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Demolished	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sales replacements	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total stock	'10^9 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heating energy	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooling energy	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Final energy windows	**TWh_fuel/yr**	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	PJ_prim	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GHG Emissions	Mt CO2 eq./yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mat. in	kt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mat. out	kt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect energy IN	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New+replace purchase costs	billion EUR (10^9)	24.2	18.8	18.7	14.5	11.6	9.3	7.5
Glazing replace./maintenance costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Overall costs	billion EUR (10^9)	24.2	18.8	18.7	14.5	11.6	9.3	7.5
Employees	'000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. heating perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. cooling perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Stock cool.perf.	TWh_cool	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Share window heat loss of heat demand	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
Cooling energy	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
Final energy windows	**TWh_fuel/yr**	0%	0%	0%	0%	0%	0%	0%
		0%	0%	0%	0%	0%	0%	0%
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	0%	0%	0%	0%
Mat. in	kt	0%	0%	0%	0%	0%	0%	0%
Mat. out	kt	0%	0%	0%	0%	0%	0%	0%
Indirect energy IN	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
New+replace purchase costs	billion EUR (10^9)	50%	50%	50%	50%	50%	50%	50%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	0%
Energy costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	0%
Overall costs	billion EUR (10^9)	15%	14%	17%	18%	19%	19%	18%
Employees	'000	0%	0%	0%	0%	0%	0%	0%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Stock cool.perf.	TWh_cool	0%	0%	0%	0%	0%	0%	0%
Share window heat loss of heat demand	%	0%	0%	0%	0%	0%	0%	0%

If purchase prices are increased, the share remains at 57% and 44% in 2010 and 2050 respectively. If the purchase costs are reduced by 50% the share goes down to 30% and 21% respectively. Energy costs remain between 12% and 16% of overall costs.

7.4. Sensitivity for changing target levels

The impact analysis in Chapter 5 mentions that no clear or direct link between savings and policy options could be identified. Therefore the impact analysis presented scenario's indicating a "possible future" and only for these possible futures the impacts can be analysed.

The three scenario's (four if BAU is counted as well) represent a range in scenario's or effectiveness of policy options. Therefore the methodology requirement to assess changing target levels is considered to be met.

Timing of measures is not a variable in the assessment as the difference in the introduction of a possible measure a few years sooner or later will be within the range of uncertainty of the analysis.

Therefore this sensitivity parameter is considered to be dealt with in Chapter 5 Impact analysis.

7.5. Societal costs

The MEErP 2011 methodology requires for TASK 7 a consideration of the life cycle costs covering the relevant factors and, where appropriate external environmental costs (societal LCC).

The life cycle costs (required according MEErP 2011) are considered in TASK 3 for the whole of the EU28 and in TASK 6 for the various individual base cases.

The societal costs are considered in TASK 5 for the whole of the EU28.

7.6. SENSITIVITY FOR HIGHER BUILDING STOCK TURNOVER

Although not required by the methodology, this section analysis the influence of the rate of new builds and demolition as applied in the model calculation. These rates are a major influence in the renewal of the stock. Faster rates gives quicker 'updates' of windows.

The 'BAU' settings for demolishment and new builds are 1% (of stock per year) and -0.25% (of new builds in period 2000-2010) respectively.

Changing the settings to 2% (double the initial rate for demolishment) and 1.5% (not reduced, but higher new build rate) results in the same stock volume in period 2030-205 but with a faster renewal rate (renovation rate) of buildings.

The effects are:

Table 116 Higher building stock turnover

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	67.8	44.1	47.7	55.4	64.3	74.6	86.5
Demolished	'10^6 m2/yr	-11.8	-15.4	-18.8	-45.1	-59.4	-58.4	-62.2
Sales replacements	'10^6 m2/yr	87.2	94.3	101.6	104.1	105.3	109.4	115.5
Total stock	'10^9 m2/yr	3.5	3.8	4.1	4.2	4.2	4.4	4.6
Heating energy	TWh_fuel	1307.7	985.2	642.5	322.4	140.6	75.9	53.6
Cooling energy	TWh_fuel	3.0	8.0	20.5	22.7	27.7	29.1	30.1
Final energy windows	**TWh_fuel/yr**	1310.7	993.2	663.0	345.1	168.3	105.1	83.7
	PJ_prim	4718.6	3575.5	2386.7	1242.3	606.1	378.2	301.3
GHG Emissions	Mt CO2 eq./yr	261.2	191.0	122.1	62.6	29.9	18.4	14.1
Mat. in	kt	1455.6	1284.4	1410.7	1524.4	1640.3	1799.8	1998.9
Mat. out	kt	-1005.9	-1150.4	-1316.5	-1616.6	-1739.0	-1713.6	-1776.7
Indirect energy IN	TWh_fuel	48.1	41.0	43.2	46.5	49.9	54.6	60.4
New+replace purchase costs	billion EUR (10^9)	48.4	37.6	37.3	30.1	25.3	21.8	19.3
Glazing replace./maintenance costs	billion EUR (10^9)	31.7	28.4	26.8	23.4	20.7	18.9	17.8
Energy costs	billion EUR (10^9)	86.1	65.9	45.7	25.2	14.2	10.2	8.9
Overall costs	billion EUR (10^9)	166.2	131.9	109.8	78.7	60.1	51.0	46.0
Employees	'000	0	0	280	275	273	279	291
Avg. heating perf. new	kWh/m2*yr	114	77	30	18	15	11	8
Avg. cooling perf. new	kWh/m2*yr	67	63	57	53	52	50	48
Stock cool.perf.	TWh_cool	246	256	261	247	235	231	235
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
				2015:	19%			
ABS.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0.0	0.0	0.0	8.8	18.9	30.3	43.4
Demolished	'10^6 m2/yr	0.0	0.0	0.0	-21.5	-25.7	-22.4	-21.1
Sales replacements	'10^6 m2/yr	0.0	0.0	0.0	-3.2	-4.9	-2.9	2.7
Total stock	'10^9 m2/yr	0.0	0.0	0.0	-0.1	-0.2	-0.1	0.1
Heating energy	TWh_fuel	0.0	0.0	0.0	-12.5	-12.4	-7.9	-5.3
Cooling energy	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Final energy windows	**TWh_fuel/yr**	0.0	0.0	0.0	-12.5	-12.4	-7.9	-5.3
	PJ_prim	0.0	0.0	0.0	-45.0	-44.8	-28.5	-18.9
GHG Emissions	Mt CO2 eq./yr	0.0	0.0	0.0	-2.2	-2.1	-1.3	-0.8
Mat. in	kt	0.0	0.0	0.0	54.1	135.3	268.2	455.8
Mat. out	kt	0.0	0.0	0.0	-198.9	-220.0	-198.8	-237.5
Indirect energy IN	TWh_fuel	0.0	0.0	0.0	1.7	4.1	8.1	13.8
New+replace purchase costs	billion EUR (10^9)	0.0	0.0	0.0	1.1	2.1	3.3	4.4
Glazing replace./maintenance costs	billion EUR (10^9)	0.0	0.0	0.0	-0.5	-0.7	-0.3	0.1
Energy costs	billion EUR (10^9)	0.0	0.0	0.0	-0.8	-0.8	-0.5	-0.3
Overall costs	billion EUR (10^9)	0.0	0.0	0.0	-0.3	0.6	2.4	4.1
Employees	'000	0.0	0.0	0.0	-4.3	-6.6	-3.9	1.1
Avg. heating perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. cooling perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stock cool.perf.	TWh_cool	0.0	0.0	0.0	-7.8	-12.0	-7.6	3.6
Share window heat loss of heat demand	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	19%	42%	68%	101%
Demolished	'10^6 m2/yr	0%	0%	0%	91%	76%	62%	51%
Sales replacements	'10^6 m2/yr	0%	0%	0%	-3%	-4%	-3%	2%
Total stock	'10^9 m2/yr	0%	0%	0%	-3%	-4%	-3%	2%
Heating energy	TWh_fuel	0%	0%	0%	-4%	-8%	-9%	-9%
Cooling energy	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
Final energy windows	**TWh_fuel/yr**	0%	0%	0%	-3%	-7%	-7%	-6%

		0%	0%	0%	0%	0%	0%	0%
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	-3%	-7%	-7%	-5%
Mat. in	kt	0%	0%	0%	4%	9%	18%	30%
Mat. out	kt	0%	0%	0%	14%	14%	13%	15%
Indirect energy IN	TWh_fuel	0%	0%	0%	4%	9%	18%	30%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	4%	9%	18%	30%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	-2%	-3%	-2%	0%
Energy costs	billion EUR (10^9)	0%	0%	0%	-3%	-5%	-5%	-4%
Overall costs	billion EUR (10^9)	0%	0%	0%	0%	1%	5%	10%
Employees	'000	0%	0%	0%	-2%	-2%	-1%	0%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Stock cool.perf.	TWh_cool	0%	0%	0%	-3%	-5%	-3%	2%
Share window heat loss of heat demand	%	0%	0%	0%	-4%	-8%	-9%	-9%

The savings from increased demolition and new build rates is some 5 TWh_fuel in 2050, which is some 14% of the savings under Scenario A.

7.7. SENSITIVITY FOR CHANGING 'ORIGINAL WINDOW' RATES

Although not required by the methodology, this section analysis the influence of the rate applied to emulate the effect of a share of window stock that is not updated to new product standards.

The 'BAU' settings rate of 'original' windows is set at 5% of the stock. This means each period, 5% of the stock due for replacement is not fitted with windows that are state-of-the-art (average new window as in new builds), but remains in its original state. This rate is an estimate as no data has been retrieved to verify this rate.

Changing the settings to 0% (no 'old' windows remaining) results in the following effects.

Table 117 Sensitivity to 0% 'original window' rate

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	67.8	44.1	47.7	46.5	45.4	44.3	43.2
Demolished	'10^6 m2/yr	-11.8	-15.4	-18.8	-23.6	-33.7	-36.1	-41.2
Sales replacements	'10^6 m2/yr	87.2	94.3	101.6	107.3	110.2	112.3	112.8
Total stock	'10^9 m2/yr	3.5	3.8	4.1	4.3	4.4	4.5	4.5
Heating energy	TWh_fuel	1307.7	985.2	642.5	311.1	134.1	67.3	44.8
Cooling energy	TWh_fuel	3.0	8.0	20.5	22.7	27.7	29.1	30.1
Final energy windows	**TWh_fuel/yr**	1310.7	993.2	663.0	333.9	161.9	96.5	74.9
	PJ_prim	4718.6	3575.5	2386.7	1202.0	582.7	347.3	269.5
GHG Emissions	Mt CO2 eq./yr	261.2	191.0	122.1	60.6	28.8	17.0	12.7
Mat. in	kt	1455.6	1284.4	1410.7	1470.3	1505.0	1531.6	1543.1
Mat. out	kt	-1005.9	-1150.4	-1316.5	-1417.7	-1519.0	-1514.8	-1539.2
Indirect energy IN	TWh_fuel	48.1	41.0	43.2	44.9	45.8	46.4	46.6
New+replace purchase costs	billion EUR (10^9)	48.4	37.6	37.3	29.1	23.2	18.6	14.9
Glazing replace./maintenance costs	billion EUR (10^9)	31.7	28.4	26.8	23.9	21.3	19.3	17.8
Energy costs	billion EUR (10^9)	86.1	65.9	45.7	24.4	13.8	9.6	8.3
Overall costs	billion EUR (10^9)	166.2	131.9	109.8	77.5	58.3	47.5	41.0
Employees	'000	0	0	280	280	279	283	291
Avg. heating perf. new	kWh/m2*yr	114	77	30	18	15	11	8
Avg. cooling perf. new	kWh/m2*yr	67	63	57	53	52	50	48
Stock cool.perf.	TWh_cool	246	256	261	253	244	237	229
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
				2015:	19%			
ABS.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Demolished	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sales replacements	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total stock	'10^9 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Heating energy	TWh_fuel	0.0	0.0	0.0	-23.7	-18.9	-16.5	-14.1
Cooling energy	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Final energy windows	**TWh_fuel/yr**	0.0	0.0	0.0	-23.7	-18.9	-16.5	-14.1
	PJ_prim	0.0	0.0	0.0	-85.3	-68.1	-59.4	-50.7
GHG Emissions	Mt CO2 eq./yr	0.0	0.0	0.0	-4.2	-3.2	-2.7	-2.2
Mat. in	kt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mat. out	kt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indirect energy IN	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New+replace purchase costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glazing replace./maintenance costs	billion EUR (10^9)	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Energy costs	billion EUR (10^9)	0.0	0.0	0.0	-1.5	-1.2	-1.1	-0.9
Overall costs	billion EUR (10^9)	0.0	0.0	0.0	-1.5	-1.2	-1.1	-0.8
Employees	'000	0.0	0.0	0.0	0.0	0.0	0.0	1.4
Avg. heating perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. cooling perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stock cool.perf.	TWh_cool	0.0	0.0	0.0	-1.8	-2.2	-2.5	-2.5
Share window heat loss of heat demand	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Sales replacements	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Total stock	'10^9 m2/yr	0%	0%	0%	0%	0%	0%	0%
Heating energy	TWh_fuel	0%	0%	0%	-7%	-12%	-20%	-24%
Cooling energy	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
Final energy windows	**TWh_fuel/yr**	0%	0%	0%	-7%	-10%	-15%	-16%
		0%	0%	0%	0%	0%	0%	0%
GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	-7%	-10%	-14%	-15%
Mat. in	kt	0%	0%	0%	0%	0%	0%	0%

Mat. out	kt	0%	0%	0%	0%	0%	0%	0%
Indirect energy IN	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	0%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	0%	0%	0%	1%
Energy costs	billion EUR (10^9)	0%	0%	0%	-6%	-8%	-10%	-10%
Overall costs	billion EUR (10^9)	0%	0%	0%	-2%	-2%	-2%	-2%
Employees	'000	0%	0%	0%	0%	0%	0%	0%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Stock cool.perf.	TWh_cool	0%	0%	0%	-1%	-1%	-1%	-1%
Share window heat loss of heat demand	%	0%	0%	0%	-7%	-12%	-20%	-24%

The savings of 'forcing' each window that needs replacement to apply current state-of-the=art saves some 14 TWh_fuel in 2050, which is some 40% of the savings identified under scenario A "Modest".

7.8. SENSITIVITY OF IGU LIFE

The IGU (insulated glass unit) lifetime was 20 years in the draft final report, following the assumption that overall window life is close to 40 years and the IGU life is replaced once during the window life (see Minutes 1st stakeholder meeting).

In the second stakeholder meeting certain stakeholders argued for a 30 year window life. This life would not include a glazing replacement.

The assessment will therefore show results if window life is reduced to 30 years, and no IGU replacement takes place.

Table 118 Window life 30 yrs, no glazing replacement costs

OUTPUT		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	67.8	44.1	47.7	46.5	45.4	44.3	43.2
Demolished	'10^6 m2/yr	-11.8	-15.4	-18.8	-30.1	-35.2	-40.5	-40.8
Sales replacements	'10^6 m2/yr	87.2	94.3	101.6	140.9	144.3	145.6	146.3
Total stock	'10^9 m2/yr	3.5	3.8	4.1	4.2	4.3	4.4	4.4
Heating energy	TWh_fuel	1307.7	985.2	642.5	239.1	107.9	71.2	50.3
Cooling energy	TWh_fuel	3.0	8.0	20.5	22.7	27.7	29.1	30.1
Final energy windows	**TWh_fuel/yr**	1310.7	993.2	663.0	261.8	135.7	100.4	80.3
	PJ_prim	4718.6	3575.5	2386.7	942.4	488.4	361.3	289.2
GHG Emissions	Mt CO2 eq./yr	261.2	191.0	122.1	47.7	24.3	17.6	13.6
Mat. in	kt	1455.6	1284.4	1410.7	1791.5	1834.5	1857.2	1875.2
Mat. out	kt	-1005.9	-1150.4	-1316.5	-1778.9	-1807.2	-1834.2	-1867.0
Indirect energy IN	TWh_fuel	48.1	41.0	43.2	54.7	55.8	56.3	56.7
New+replace purchase costs	billion EUR (10^9)	48.4	37.6	37.3	35.4	28.2	22.5	18.1
Glazing replace./maintenance costs	billion EUR (10^9)	31.7	28.4	26.8	17.1	14.7	12.6	10.9
Energy costs	billion EUR (10^9)	86.1	65.9	45.7	19.7	12.1	9.9	8.7
Overall costs	billion EUR (10^9)	166.2	131.9	109.8	72.3	55.0	45.0	37.7
Employees	'000	0	0	280	223	213	204	197
Avg. heating perf. new	kWh/m2*yr	114	77	30	18	15	11	8
Avg. cooling perf. new	kWh/m2*yr	67	63	57	53	52	50	48
Stock cool.perf.	TWh_cool	246	256	261	242	235	228	221
Share window heat loss of heat demand	%	0	0	0	0	0	0	0
				2015:	17%			
ABS.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Demolished	'10^6 m2/yr	0.0	0.0	0.0	-6.5	-1.5	-4.4	0.3
Sales replacements	'10^6 m2/yr	0.0	0.0	0.0	33.6	34.1	33.3	33.6
Total stock	'10^9 m2/yr	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1
Heating energy	TWh_fuel	0.0	0.0	0.0	-95.8	-45.1	-12.6	-8.6
Cooling energy	TWh_fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Final energy windows	**TWh_fuel/yr**	0.0	0.0	0.0	-95.8	-45.1	-12.6	-8.6
	PJ_prim	0.0	0.0	0.0	-344.8	-162.4	-45.4	-31.0
GHG Emissions	Mt CO2 eq./yr	0.0	0.0	0.0	-17.2	-7.7	-2.1	-1.3
Mat. in	kt	0.0	0.0	0.0	321.2	329.5	325.7	332.0
Mat. out	kt	0.0	0.0	0.0	-361.2	-288.2	-319.4	-327.8
Indirect energy IN	TWh_fuel	0.0	0.0	0.0	9.8	10.0	9.9	10.0
New+replace purchase costs	billion EUR (10^9)	0.0	0.0	0.0	6.4	5.1	3.9	3.2
Glazing replace./maintenance costs	billion EUR (10^9)	0.0	0.0	0.0	-6.8	-6.6	-6.7	-6.8
Energy costs	billion EUR (10^9)	0.0	0.0	0.0	-6.3	-3.0	-0.8	-0.6
Overall costs	billion EUR (10^9)	0.0	0.0	0.0	-6.7	-4.5	-3.6	-4.2
Employees	'000	0.0	0.0	0.0	-56.7	-66.0	-78.4	-93.0
Avg. heating perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. cooling perf. new	kWh/m2*yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stock cool.perf.	TWh_cool	0.0	0.0	0.0	-12.6	-11.4	-11.2	-10.5
Share window heat loss of heat demand	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REL.CHANGE		1990	2000	2010	2020	2030	2040	2050
Sales new build	'10^6 m2/yr	0%	0%	0%	0%	0%	0%	0%
Demolished	'10^6 m2/yr	0%	0%	0%	27%	5%	12%	-1%
Sales replacements	'10^6 m2/yr	0%	0%	0%	31%	31%	30%	30%
Total stock	'10^9 m2/yr	0%	0%	0%	-2%	-2%	-3%	-3%
Heating energy	TWh_fuel	0%	0%	0%	-29%	-29%	-15%	-15%
Cooling energy	TWh_fuel	0%	0%	0%	0%	0%	0%	0%
Final energy windows	**TWh_fuel/yr**	0%	0%	0%	-27%	-25%	-11%	-10%
		0%	0%	0%	0%	0%	0%	0%

GHG Emissions	Mt CO2 eq./yr	0%	0%	0%	-26%	-24%	-11%	-9%
Mat. in	kt	0%	0%	0%	22%	22%	21%	22%
Mat. out	kt	0%	0%	0%	25%	19%	21%	21%
Indirect energy IN	TWh_fuel	0%	0%	0%	22%	22%	21%	22%
New+replace purchase costs	billion EUR (10^9)	0%	0%	0%	22%	22%	21%	22%
Glazing replace./maintenance costs	billion EUR (10^9)	0%	0%	0%	-28%	-31%	-35%	-39%
Energy costs	billion EUR (10^9)	0%	0%	0%	-24%	-20%	-8%	-6%
Overall costs	billion EUR (10^9)	0%	0%	0%	-8%	-8%	-7%	-10%
Employees	'000	0%	0%	0%	-20%	-24%	-28%	-32%
Avg. heating perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Avg. cooling perf. new	kWh/m2*yr	0%	0%	0%	0%	0%	0%	0%
Stock cool.perf.	TWh_cool	0%	0%	0%	-5%	-5%	-5%	-5%
Share window heat loss of heat demand	%	0%	0%	0%	-29%	-29%	-15%	-15%

CHAPTER 8 CONCLUSIONS & RECOMMENDATIONS

8.1. Introduction Conclusions and Recommendations

According the MEERP 2011 this section should summarise the main policy recommendations per product and summarise the main outcomes of the scenarios and the risk of possible negative impacts on health, safety, etc. in one +/- table.

8.2. Results of impact assessment

8.2.1. Discussion of scenario calculations

The main results of the various scenarios (for year 2050, residential sector only) are shown in the table below.

Table 119 Overview of scenario results 2050 (façade windows residential sector only)

Comparison 2050 values		Reference	Scenario A		Scenario B		Scenario C	
		BAU	**(abs.)**	(rel.%)	**(abs.)**	(rel.%)	**(abs.)**	(rel.%)
Sales new build	'10^6 m2/yr.	43	0	0%	0	0%	0	0%
Demolished	'10^6 m2/yr.	-41	0	0%	0	0%	0	0%
Sales replacements	'10^6 m2/yr.	113	0	0%	0	0%	0	0%
Total stock	'10^9 m2/yr.	4.5	0.0	0%	0.0	0%	0.0	0%
Heating energy	TWh_fuel	58.9	-32.0	-54%	-64.3	-109%	-98.5	-167%
Cooling energy	TWh_fuel	30.1	-3.2	-11%	-3.6	-12%	-4.1	-14%
Final energy windows	TWh_fuel/yr.	**89**	**-35.1**	**-39%**	**-67.9**	**-76%**	**-102.6**	**-115%**
	PJ_primary	**320**	**-126**		**-244**		**-369**	
GHG Emissions	Mt CO2 eq./yr.	14.9	-5	-33%	-10	-67%	-15	-102%
Mat. in	kt	1543.1	42	3%	100	6%	194	13%
Mat. out	kt	-1539.2	-42	3%	-100	6%	-194	13%
Indirect energy IN	TWh_fuel	46.6	1	3%	3	6%	6	13%
New+replace purchase costs	billion EUR (10^9)	14.9	1	5%	2	12%	4	26%
Glazing replace./maintenance costs	billion EUR (10^9)	17.7	0	1%	0	1%	0	2%
Energy costs	billion EUR (10^9)	9.3	-2	-23%	-4	-45%	-6	-70%
Overall costs	billion EUR (10^9)	41.8	-1	-3%	-2	-5%	-2	-5%
Employees	'000	290	1	1%	3	1%	5	2%
Avg. heating perf. new	kWh/m2*yr.	8	-8	-107%	-18	-231%	-28	-358%
Avg. cooling perf. new	kWh/m2*yr.	48	-1	-2%	-2	-4%	-3	-5%
Stock cool.perf.	TWh_cool	232	-6	-3%	-12	-5%	-19	-8%

It is assumed that total market and stock volume does not change when compared to the BAU scenario.

If the assumption that the average window placed on the market (including replacements) improves from average heating energy performance of 8 kWh/m^2*yr to 0 (zero), -10, or -20 kWh/m^2*yr. respectively, this will lead to savings of 39%, 68% to 115% of the BAU consumption of windows in stock.

In the above table the cooling performance of the window doesn't change significantly as the window represents the combined average of windows sold in all EU Member States. When looked at MS level, the cooling performance may change more significantly.

Emissions reduce by the somewhat smaller percentages as the emission profile of electricity generation changes over the period.

The material flow will increase as better performing windows are on average heavier than lesser performing windows (triple versus double glazing).

Purchase costs and maintenance costs will increase by 5-26%, but energy costs are decreasing at a higher rate, leading to overall differences in costs of -3% to -5% respectively when compared to BAU.

Additionally, the share of energy costs in the total costs reduces from 22% inBAU 2050 to 7% in Scenario C Extreme in 2050.

The increase in turnover will lead (assuming constant turnover per employee) to +2% to +14% extra employees in 2050 assuming constant turnover per employee.

For roof windows the differences are much less outspoken as the performances of the various roof windows placed on the market are closer together, and foremost, the absolute volume of the sector is much smaller than for façade windows. An overview of impacts is shown below.

Table 120 Overview of scenario results 2050 (roof window sector only)

Comparison 2050 values		Reference	Scenario A		Scenario B		Scenario C	
		BAU	(abs.)	(rel.%)	(abs.)	(rel.%)	(abs.)	(rel.%)
Sales new build	'10^6 m2/yr.	4	0.0	0%	0.0	0%	0.0	0%
Demolished	'10^6 m2/yr.	-4	0.0	0%	0.0	0%	0.0	0%
Sales replacements	'10^6 m2/yr.	10	0.0	0%	0.0	0%	0.0	0%
Total stock	'10^9 m2/yr.	0.4	0.0	0%	0.0	0%	0.0	0%
Heating energy	TWh_fuel	6.6	-1.1	-16%	-1.7	-25%	1.7	26%
Cooling energy	TWh_fuel	11.0	-0.7	-7%	-0.7	-7%	-1.4	-13%
Final energy windows	TWh_fuel/yr.	18	-1.8	-10%	-2.4	-14%	0.3	2%
	PJ_primary	63	-6.5		-8.6		1.2	
GHG Emissions	Mt CO2 eq./yr.	3.1	-0.2	-5%	-0.3	-8%	0.3	8%
Mat. in	kt	516	96.5	19%	96.5	19%	0.0	0%
Mat. out	kt	-487	-44.2	9%	-44.2	9%	0.0	0%
Indirect energy	TWh_fuel	1.6	0.6	35%	0.6	35%	0.0	0%
New+replace purchase costs	billion EUR (10^9)	3.5	0.8	24%	1.6	45%	0.4	10%
Glazing replace./ maintenance costs	billion EUR (10^9)	1.6	0.0	0%	0.0	0%	0.0	0%
Energy costs	billion EUR (10^9)	2.4	-0.1	-3%	-0.1	-4%	0.1	5%
Overall costs	billion EUR (10^9)	7.5	0.8	10%	1.5	20%	0.5	6%
Employees	'000	70	0.0	0%	0.0	0%	0.0	0%
Avg. heating perf. new	kWh/m2*yr.	18	-7.2	-40%	-11.1	-62%	11.6	65%
Avg. cooling perf. new	kWh/m2*yr.	110	-9.2	-8%	-9.2	-8%	-22.9	-21%
Stock cool.perf.	TWh_cool	46	-1.8	-4%	-1.8	-4%	-4.5	-10%
Share window heat loss of heat demand	%	6%	-1%	-16%	-2%	-25%	2%	26%

Roof window scenario C "Extreme", which assumes that 50% of sales in 2050 are windows with solar control glazing, shows that cooling energy is indeed reduced the most by such windows. On a downside, it also shows that the reduction of solar irradiance comes at a price for the heating performance, as the heating energy required stays about the same as the BAU scenario. The overall energy consumption for Scenario C is actually somewhat higher than for BAU (whereas scenario A "Modest" and B "Advanced" calculate both a saving in heating energy and cooling energy). The model 'assumes' that the spaces in which roof windows are applied need space heating too, and reduction of solar gains comes at a cost for space heating.

The conclusion on costs does not include 'knock-on' effects on other systems or aspects. One can imagine that reducing cooling loads by employing windows with improved performance may (eventually) help to avoid use of artificial cooling at all, including the investments related to that. The same can be said about use of windows with improved performance in buildings with other energy saving measures that (eventually) help to minimise or avoid the need for heating systems (greatly reducing heating systems already reduces costs). Such effects have however not been taken into account as these extend beyond the scope of the assignment.

The table below summarises the risk of possible negative impacts on health, safety, etc. (when compared to the Business-as-usual scenario) of the introduction of an EU window energy label.

Table 121 Possible negative impacts associated to a EU window energy labelling scheme

Possible impacts	Energy Labelling (scenario calculations)	
	score	Explanation
Functionality	0	No negative impacts expected
Health	0	No negative impacts expected
Safety	0	No negative impacts expected
Environment	(+)	Better information to consumers is expected to result in higher uptake of better performing windows
Affordability, life cycle costs	0	The scenario analysis shows that each scenario results in slightly lower costs for society (range: -1% to -5%)
Competitiveness of industry	0	No negative impacts expected
Proprietary technology	0	No negative impacts expected
Administrative burden	-/0	For most suppliers only a small negative impact is expected as most of the required information is already required under the CPR, and the additional effort for the label administration is limited (is aligned with mandatory CE marking information). For existing labelling schemes and the UK scheme in particular (as it is linked to national Building Codes) the impact would be substantial, as –in case the national scheme is abandoned and the EU scheme adopted – the existing registrations need to be reworked.

The BFRC stated that the costs for abandoning a national (UK) scheme in favour of an EU scheme should be considered as well. It cannot be denied that current WER ratings need to be changed and re-issued as EU labels. Nonetheless, an European Energy label could also lead to decreasing costs in the U.K. because the EU label would be based on characteristics most likely declared already for the CE marking. The additional costs for UK WER specific testing and certification would not be necessary any more.

Assessing the actual cost implications of the introduction of the EU label is therefore difficult as it requires assessment of the number of applicants that do not have the necessary CE marking data present. Whether the costs for providing data required for both CE marking as well as Energy Labelling are to be allocated to a possible Energy Label is a matter for discussion (one can argue that such costs are not due to the label, but due to the CE marking which was introduced earlier).

8.2.2. Discussion of 'detailed' information requirements

As stated in section 3.3.1 some stakeholders have proposed for **detailed** energy performance characteristics of windows to be included as information in the technical fiche. As Section 3.3.1. shows that requiring such information under Ecodesign (to be required for CE marking) could be affecting the provision of information regulated under the CPR (also required for CE marking) it was suggested that the energy label could convey this information.

The detailed information to be required under energy labelling would cover:

- Thermal transmittance frame Uf;
- Thermal transmittance glass Ug;
- Thermal transmittance panel Up;
- Linear transmittance frame / glass;
- Linear transmittance frame / panel;
- Linear transmittance Georgian bar;
- Additional thermal resistance of shutter (incl. cavity).

If this would be proposed, supplying this data would become mandatory for all suppliers of windows.

For many manufacturers this would entail additional testing costs and additional administrative burden, as currently most suppliers supply data for the whole window, based on total window measurement or use of tabulated data, and do not have these 'detailed information' available .

Additionally, the group of stakeholders benefitting from this information would be limited as this level of information is currently only required for passive house design and certification. Current standards for calculating building energy performance (such as ISO/EN 13790) require just the more generic data.

The table below summarises the risk of possible negative impacts on health, safety, etc. (when compared to the Business-as-usual scenario) of requiring "detailed energy performance properties" in a technical fiche of window.

Table 122 Possible negative impacts associated with "detailed energy performance properties"

Possible impacts	Information requirements / detailed energy properties (discussion)	
	score	Explanation
Functionality	0	No negative impacts expected
Health	0	No negative impacts expected
Safety	0	No negative impacts expected
Environment	(-/+)	An improvement of energy performance may be expected, but it will be limited as most building calculations will use the generic information only.
Affordability, life cycle costs	-	It is expected that certain companies will have to perform extra tests, increasing the costs of the product.
Competitiveness of industry	0	No negative impacts expected
Proprietary technology	0	No negative impacts expected
Administrative burden	-	It is expected that certain companies (especially small and micro-sized) will experience considerable additional administrative burden as extra tests need to be performed and administrative provisions need to be taken

For these reasons it is not recommended to introduce such 'detailed information' on window performance in the possible EU Energy Label for windows.

8.3. CONCLUSIONS

This section discusses the main conclusions that are relevant for the final recommendations and that have been drawn from various sections and Task reports.

Regarding the administrative analysis (TASK 1)

1. Under the CPR manufacturers shall declare the performance of their product when placed on the market. The CPR harmonises the way the performance information is established, but it does not force manufacturers to declare performances not required in that market.
2. Under the EPBD the requirements for building elements (possibly windows) set by Member States are driven towards the cost optimum point.
3. The European Waste Framework Directive is driving the member states towards reducing, reusing and recycling of Construction & Demolition Waste (CDW). In areas where landfills are restricted for different reasons, the rising price for dumping CDW on landfills creates an additional stimulus for recycling of non-ferrous materials until these processes will be cost-covering.

Regarding the market analysis (TASK 2)

1. The total market of windows (residential sector, non-residential sector and roof windows) is significant, both in size (units) and value. Windows sales in the EU are approximately some 130 million m^2 in 2010 (down from 157 million in 2007, before the economic crisis).
2. Extra EU trade is not significant.
3. The actual sales of windows by type could only be based on very limited data as regards window types in stock and expectations regarding sales based on minimum requirements set by Member States.
4. For roof windows, there is only a very limited number of suppliers. Market data is very sensitive and could not be retrieved.
5. Plastic windows (UPVC) hold a market share of approximately 60%, the remaining 40% is more or less evenly split between metal (aluminium, and steel) and wood, including wood with metal covering.
6. The market is characterised by a limited number of system houses supplying the main components (and knowledge of window performance) to a vast number of micro- and small sized enterprises that sell, assemble and install windows.

Regarding the user analysis (TASK 3)

1. The impacts of windows on affected energy systems for heating and cooling has been described. Residential and non-residential façade windows and roof windows together result in an energy demand for heating of some 766 TWh_fuel eq. in 2010.
2. The energy demand for cooling is estimated to be some 97 TWh_fuel eq. in 2010.
3. The calculation of energy demands includes corrections for various window aspects such as use of shutters or shading devices in summer and winter, for which little exact data was available.
4. The boundary conditions for the non-residential sector are believed to vary too much to allow a relatively straightforward assessment. The current calculation is based on data that is not validated.

Regarding the product analysis (TASK 4)

1. For an assessment of the indirect energy consumption of windows boundary conditions need to be defined that influence/determine the window performance.

2. For climate North and Central the BAT is for all investigated different building approaches (single room, single family house): Openable window with very low U-value and high g-value, moveable external shutter
3. For Climate South: The BAT differs depending on the building approach. For the single room approach the BAT is an openable window with low U-value and low g-value, moveable external shutter/sun shading device. For the approach considering a single family house the BAT is an openable window with very low U-value and high g-value, moveable external shutter
4. The proportions of the heating energy and the cooling energy to the combined energy are influenced by the ratio of heat gains to the heat losses of the building. For buildings with low heat losses, e.g. low U-values of the building envelope, compact buildings (multifamily houses => single room approach), no ventilative cooling the proportion of the cooling energy is increasing compared to buildings with higher heat losses.
5. At the End-of-Life, metal frames, which are most often to be found in non-residential buildings, have by far the highest recycling quota already. The producers of the frame material with the highest market share (uPVC) have established successful recycling initiatives in some member states where there is a viable amount of UPVC window frames reaching the end of their use phase.
6. For window frames made from wood as a renewable material, only the thermal use at the end of the life cycle is economically justifiable.
7. For the recycling quota of building glass an additional potential is seen by the industry and recommendations how to increase quotas have been offered to policy makers.

Regarding the environmental analysis (TASK 5)

1. For the average window, the use-phase is the dominant life cycle phase. For windows with a very high performance, the balance shifts towards the production phase, but this is mainly because the window offers a better balance of losses versus gains. A very efficient window could even have zero (or even negative) use phase impacts.
2. All window products, irrespective of their frame materials, provide a common benefit regarding their energy-saving potential. The current evidence base drawn from life-cycle analysis and end-of life strategies does not provide reasons to add criteria for eco-design other than energy related values in the use phase.

Regarding the analysis of life cycle costs (TASK 6)

1. The LLCC is different per window type, climate condition (north, Central, South) and subjective to changes in costs of main elements (product life, purchase costs, shutter costs, heating system efficiency, cooling efficiency/costs, discount/escalation rates) but the relative ranking of options stays fairly similar for all changes considered.
2. When the orientation of the window is considered, the ranking of options in climate condition 'South' changes significantly.

Regarding the policy analysis (TASK 7, Chapter 3):

1. Energy Labelling provides an opportunity to address some of the following barriers: improve consumer information and understanding of window energy performance; improve retailer knowledge and understanding of window energy performance, contribute to establishing consensus on window energy performance assessment, ie. the introduction of energy balance equations; avoid a proliferation of national window rating and labelling schemes, provide an opportunity to easily introduce requirements related to window energy performance based on energy balance equations in national building regulations;
2. Windows are already subject to measures under the Construction Products Regulation, the EPBD and some other flanking measures. Such measures can make the introduction of potential ecodesign

requirements inappropriate as they may overlap with aspects ready regulated (CE marking of performance under the CPR, minimum requirements on building elements under the EPBD);

Regarding the method for energy labelling of windows (TASK 7, Chapter 4):

1. There are acceptable methods for assessment of the energy performance of residential windows, although for the cooling performance the sensitivity as regards boundary conditions selected is larger than for the heating performance.
2. For daylight no method has been identified that would allow an energetic assessment, based on simple, main window characteristics. Assessment of the daylight potential factor is possible;
3. Stakeholders have expressed different wishes and desires as to the aspects to be covered by the window energy label and how;
4. the information in the report should suffice for preparing proposals that meet the main preferences of various stakeholders, although some proposals have consequences that make them less preferable than others;

Regarding the Scenario analysis (TASK 7, Chapter 5, 6 and 7):

1. The sales for the residential market will be some 150 million m^2, for the non-residential market some 45 million m^2, and for the roof window market some 13 million m^2 window in 2010.
2. The possible savings depend to a large degree on the minimum requirements that Member States place on building elements (could be the window itself, or larger building elements , or the whole building) and which set out the baseline (business-as-usual) for window properties now and in the future. More stringent requirements in Member States for window as component or whole buildings will reduce the saving potential identified for any measure under Ecodesign or Energy Labelling;
3. Depending on the market response on a possible window energy labelling, savings for both residential and non-residential windows, and roof windows, could range from some 40 TWh_fuel eq. (Scenario A 'Modest'), to 79 TWh_fuel eq. (Scenario 'Advanced') to almost 118 TWh_fuel eq. in 2050 (Scenario 'Extreme'). Cost impacts are relatively small (as higher purchase costs can be compensated by lower energy costs).

General comment regarding the non-residential sector:

1. Stakeholders have argued that energy labelling for windows intended for the non-residential sector makes much less sense as: 1) window selection is much more often performed by building specialists who can make their own assessment on the basis of the basic window properties (CE marking data), 2) due to the larger variations in boundary conditions, there is a greater risk that the label information will not be applicable to the specific situation.
2. Literature and stakeholders indicate that the boundary conditions applicable to non-residential buildings show a much larger variation than for residential buildings (larger variations in indoor temperature, ventilation rates, window-to-floor ratio, etc.). For non-residential buildings the possible differences in boundary conditions are considered to be too large to allow any simplified method as basis for ranking of performance.
3. At the moment the window is placed on the market (either sold to end user by window retailer/installer, or completed at building site as commissioned by building developer) it is not always known whether the window is installed in a residential or non-residential building. In case the window is labelled prior to moment of sales, it may mean the windows for non-residential applications are equipped with a label primarily intended for the residential market. It will be difficult for manufacturers to operate production lines specifically for the residential and non-residential markets only.

Conclusions related to the impact of ecodesign/labelling on CPR and EPBD legislation:

1. Specific Ecodesign requirements on energy performance could impact the implementation of the EPBD by Member States, as it would introduce requirements for parameters that Member States may also have regulated. In order to preserve the internal market the Ecodesign requirements would introduce harmonisation of requirements, reducing the options available to Member States to regulate the same parameters.
2. Generic Ecodesign requirements on energy performance or substances could impact the CPR. Currently the declaration of performance (and the CE marking) that windows carry when brought onto the market may depend on the requirements set per Member State. The CPR harmonised the way how the performance has to be assessed and declared. The CPR does not set which performances must be declared: this is considered the prerogative of Member States. Setting information requirements under Ecodesign could potentially lead to confusion in cases where Member States set requirements for the same parameters.

8.4. Recommendations

This section presents the recommendations of the study writers to the Commission Services.

These recommendations are in no way to be perceived as the opinion of the European Commission (see Disclaimer of all study reports).

The recommendations are based on the combined conclusions presented in previous sections, Chapters and also (other) TASK reports.

8.4.1. Recommendations

Our recommendations to the Commission Services are:

1) We recommend **ENERGY LABELLING** of windows, taking into account the following observations / conclusions:
   a) In the MS the minimum requirements at building level (holistic approach) apply mainly to new buildings and large renovations. Small scale replacement or retrofit may be regulated at component level, although it is not easy to identify whether and which requirements for replacement windows apply. In any case, we are convinced that in the market of small scale window replacement (mainly the residential sector) there is a need to better understand that window energy performance is not solely determined by heat losses (for which the U_w value is an indicator) but also by heat gains (for which the g-value is an important parameter) and other factors such as air leakage and use of shutters. An integrated assessment of all these parameters gives a better picture of window energy performance than just one single U_w value. The EU Energy label is proposed as a means to convey this message to window purchasers, especially when replacing windows. In MS where requirements apply to small scale replacement, the EU energy label can give advice to consumers looking for products with a better 'energy performance' than required by the MS.
   b) The recommendation for window labelling extends to both façade and roof windows, but the methodology (or better: the boundary conditions, resulting in specific fixed parameters) needs to be adapted to the respective typical usage.
   c) The POS label rating shall be relative / comparative only (not providing absolute values, e.g. in kWh/yr.), as the calculation of the absolute energy performance of windows can only be meaningful if applicable to a specific window installation, including its context.
   d) Solar shading devices (shutters) shall be considered in the performance of the window, provided the solar shading device is incorporated in the window when placed on the market. This is in accordance with the European product standard for windows EN 14351-1.
   e) As the ABC/XYZ approach allows for changing the use of the shading device, it is in principle possible to adjust the C and Z values according solar shading control device.

  f) It is recommended to present to the Consultation Forum more than one single label proposal (to be further elaborated in Working Documents).
  g) Following many stakeholder comments we recommend to include (a selection of) the generic performance parameters of the window (these being: Uw, g_w-value (both g_w and $g_{w,t}$ in case of windows incorporating solar shading), air leakage, daylight factor, frame fraction) on the label and in the technical fiche.
  h) We do not recommend the provision of very detailed energy performance properties (e.g. thermal resistance of the glass, spacer and frame, linear transmittance of the frame/glass, thermal resistance of the cavity, etc.) in the window energy label (including fiche) for the below reasons:
    (1) The information is not necessary for conventional calculation of building energy performance (for this the generic information on window performance suffices). The detailed information is only used for very specific forms of building energy performance calculations (passive house certification) and would only be used by a fairly small group of users. The savings (if any – to be proven) are expected to be small;
    (2) The introduction of mandatory information on detailed energy performance would pose a significant burden to those companies that currently present performance values based on either complete window assessment or tabulated values, which is perceived to be the procedure applied by the majority of window suppliers. These suppliers would need to perform additional testing;
    (3) Certain manufacturers are already voluntary providing such detailed information, which means the market is addressing the issue by itself;
    (4) A Member State may decide to require such detailed information, in which case it should notify other Member States of its plans. Provided this is not blocked (to preserve integrity of the Single Market), the relevant standard (in this case EN 14351-1) needs to be revised by the relevant TC to include these additional performance parameters, as regulated under the CPR, and other MS can decide to also require such information. This is another route (other than Ecodesign) through which information requirements may be implemented at MS level. The additional (new) requirement is however only necessary for the DoP / CE marking in the respective country and not required for other countries.

2) Introduction of **SPECIFIC** (= threshold values) ecodesign requirements on **ENERGY PERFORMANCE** is not recommended, for three reasons mainly (see also section 3.3.1 of Task 7)
  a) First, the EPBD requires Member States to set minimum requirements for building elements at cost optimal point, minimising possible additional savings to be achieved by Ecodesign requirements targeting the least life cycle cost point;
  b) Second, the life cycle cost analysis shows that the energy performance (kWh/yr.) and also the life cycle costs depend strongly on the final application / building context (dependent on climate condition, boundary condition, costs, etc.). This strong relation to local conditions and final application is a weak basis for harmonisation of minimum requirements;
  c) Third, the EPBD requires MS to set requirements for building elements at national level. In line with the EU principles of proportionality, according which the involvement of the institutions must be limited to what is necessary to achieve the objectives of the Treaty, and subsidiarity, according which the Union does not take action unless it is more effective than action taken at national, regional or local level, the EPBD placed the responsibility for setting minimum requirements at Member State level as they may (in principle) better take into account relevant (local) aspects like climate conditions, building properties, etc. If minimum requirements for windows would be set at EU level, this would be contrary to the approach set out for the EPBD. Having said this, we feel the approach set out in the EPBD for setting minimum requirements can be improved (see 'Observations' further down);

3) Introduction of **SPECIFIC or GENERIC** (= threshold values) ecodesign requirements on **RESOURCE EFFICIENCY** is not recommended for the following reasons:

   a) Often the issue is not window-specific and better treated horizontally (as may be the case for certain hazardous substances used in windows or in the production processes involved). The examples provided show that other instruments (e.g. REACH) are driving the change. A horizontal approach has the benefit that it applies generally and is not limited to a single product group;

   b) The methodology for certain RE parameters is still being developed and no consensus has been reached yet. In particular for parameters related to 'end-of-life', the long window product life (40 years on average) means that there is a methodological difficulty in identifying applicable and representative end-of-life strategies or scenario's as the parameter addresses activities taking place very far into the future, in 2055.

   c) The study has shown that for certain window materials, PVC and glass in particular, the recycling rate (the share of post-consumer material being brought back to a material loop at similar level) is relatively low and initiatives should be developed to further increase the recycling rate. Dealing with this issue from a Construction & Demolition Waste perspective appears indispensable

   d) For proper recycling to take place there is currently no need for (re)design of windows, but a need to identify economically viable business cases for recycling of windows. The available information shows such schemes currently exist for aluminium windows, and that for other frame materials and the window glass itself, more research into the viability of such schemes would be needed, but is outside the scope of the study (as the study deals with (re)design of products, not the design of end-of-life collection schemes).

4) We do not recommend setting **GENERIC** (= information) ecodesign requirements, for the following reasons:

   a) Windows, being construction products, are subject to the Construction Products Regulation, which establishes *"harmonised rules on how to express the performance of construction products in relation to their essential characteristics and on the use of CE marking on those products"*. The specific performance parameters to be included in the Declaration of Performance and the CE marking are established at Member State level. Setting 'horizontal' information requirements for the same product under Ecodesign as well could be confusing as different requirements may apply to the same CE compliance procedure. As information relating to resource consumption during the use phase (= generic ecodesign requirements) can be requested under Energy labelling (on the label and/or the fiche) we recommend not to use (implementing measures under) the Ecodesign Directive for this purpose so that confusion is avoided.

   b) As to requiring information on proper use of windows, this is the responsibility of the retailer and is considered to be addressed by relevant market parties.

   c) Information relating to other phases than the use phase can currently not be required under Energy labelling (is limited to resource consumption during use phase). Therefore (environmental) information regarding the manufacturing process or end-of-life treatment can only be required under Ecodesign or following rules set out in the CPR (basic works requirement #7). The same issue as presented under a) (*"which information is required under Ecodesign and by MS and how is this established")* could emerge and should be avoided.

   d) The above also applies to requiring information on 'Eco profiles' of products, possibly by benchmarking. There are TC's working on standards that may be used to develop Eco profiles (life cycle assessment) and ultimately may be harmonised under the CPR. In parallel to this the market is voluntarily developing EPD's but these generally state that they should not be used for comparison.

In addition to the above recommendations we have some **<u>observations</u>**:

5) We observed that many MS establish requirements for windows in their national Building Codes that only consider the U_w value of the window. We want to convey the message that an integral assessment

of window energy performance, taking also into account the g-value, the air leakage , frame fraction and other generic performance parameters, is a better basis for regulating windows. The proposed EU Energy label provides a way to take the overall performance into account in an integrated approach. This recommendation does not mean a change to the EPBD that covers the setting of minimum requirements to building elements, but a change in the actual implementation of the EPBD by Member States. Of course each larger project (new built of replacement) should not base itself on EU energy label only, but should make specific and dedicated assessments of the overall building energy performance with appropriate consideration of the integral window performance;

6) We have learned that window installers / retailers generally can improve their advice as to how a certain window would perform in a specific application. The EU Energy label, and moreover, the technical fiche connected to this, could be instrumental as it may provide information of performance per orientation. Still this information should ideally be further complemented by more specific information on window performance to be provided by installers to their clients (such as the influence of obstacles to solar gains, etc.). This means that training and education should be improved.

ANNEX

ANNEX

ANNEX I - CALCULATION OF ABC VALUES

Boundary conditions

In order to calculate the use phase energy relation of the window to heating and cooling systems, boundary conditions have to be defined. "Realistic“ boundary conditions taking into account ventilation, transmission through the exterior wall and internal loads have the advantage that the absolute energy consumption of the room is more realistic, and that the (annual) energy balance for the window can be negative. The disadvantage of using 'realistic' boundary conditions is that it is not clear how the influence of the window has to be separated from these other effects. The boundary conditions are first described in the TASK 4 report. They are repeated below for easier reference:

- the basic calculations assumes either a 'single room' or a 'family house' – see following pages for a description;
- the outside conditions relate to a climate typical for Helsinki ("North"), Strasbourg ("Central") and Athens ("South"). These locations define hourly outside temperature and solar irradiance to the windows;
- The room is ventilated (n=0.5/hr), allowing ventilative cooling if necessary (n=2/hr): This reduces the cooling load;
- The internal set point for heating is 20ºC and for cooling 26ºC (EN 13760); The internal heat load is 5 W/m2;
- for solar shading the F_c-value is 1 (without) and 0.1 (with); The set-point is irradiance over 300 W/m^2 and outdoor temperature > 15ºC; The additional thermal resistance is 0.17 (m^2*K)/W; the calculations are made for a window with and without shutters[62];

All calculations apply to one m2 of window surface, but where physical size of the window is required, this is the standard format of 1.23 m * 1.48 m, which is then recalculated to 1 m^2.

Table 123 Necessary Characteristics of the window for the calculation of the energy performance index of windows according to ISO 18292

Symbol	Characteristic	Unit	Source
U_W	Thermal transmittance of the window	W/(m^{2}K)	CE Label for windows, Determination and declaration according to hEN 14351-1, Mandated characteristic
$U_{W,S}$	Thermal transmittance of the window with closed shutter	W/(m^{2}K)	Determination according to EN ISO 10077-1 or EN ISO 12567-1
ΔR	Additional thermal resistance of a closed shutter	(m^{2}K)/W	CE Label for shutters and external venetian blinds, Determination and declaration according to hEN 13659, Mandated characteristic

[62] The term shutters is to be understood comprising all kinds of solar shading devices, including blinds (if used externally).

Q_{100}	reference air permeability at a test pressure of 100 Pa	$m^3/(h\ m^2)$	CE Label for windows, Determination and declaration of the relevant class according to hEN 14351-1, Mandated characteristic Class 1 : 50 $m^3/(h\ m^2)$ Class 2 : 27 $m^3/(h\ m^2)$ Class 3 : 9 $m^3/(h\ m^2)$ Class 4 : 3 $m^3/(h\ m^2)$
g	Solar energy transmittance of the transparent part of the window	-	CE Label for windows, Determination and declaration according to hEN 14351-1, Mandated characteristic
gt	Total solar energy transmittance of the transparent part of the window in combination with a shutter/sun shading	-	CE Label for windows, Determination and declaration according to hEN 14351-1, Mandated characteristic
F_F	Frame fraction of the window	-	Determination according to EN ISO 10077-1 Note: hEN 14351-1 is currently amended regarding the determination of F_F. It is expected that F_F will become a mandated characteristic in near future

Table 124 Necessary Constants for the calculation of the energy performance index of windows according to ISO 18292

Symbol	Characteristic	Value	Unit	Source
Δp	Fixed pressure difference for the calculation of the infiltration	6	Pa	ISO 18292
$\rho\ c_p$	the thermal capacitance of air	0,344	$Wh/(m^3K)$	ISO 18292

Determination of the necessary parameters

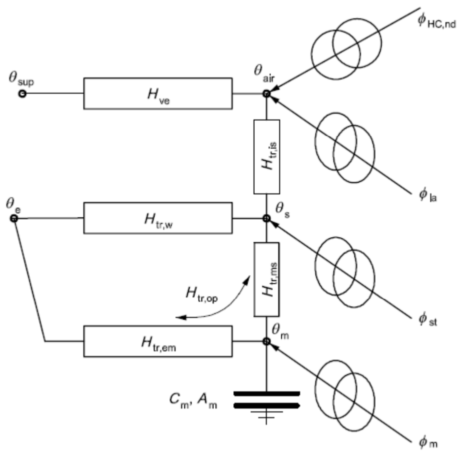
To determine the parameters A,B, C dynamic simulations according to the simple hourly calculation method defined in EN ISO 13790 were carried out.

The model is a simplification of a dynamic simulation, with the following advantages:

- clearly specified, limited set of equations, enabling traceability of the calculation process;
- reduction of the input data as much as possible;
- unambiguous calculation procedures;
- with main advantage that the hourly time intervals enable direct input of hourly patterns.

EN ISO 13790 states, that the model has an adequate level of accuracy, especially for room-conditioned buildings where the thermal dynamic of the room behaviour is of high impact. The model used is based on an equivalent resistance-capacitance (R-C) model. It uses an hourly time step and all building and system input data

Figure 9 RC network for the simple hourly method according to EN ISO 13790



To analyse the impact of different building designs on the Parameters two different "buildings" were considered.

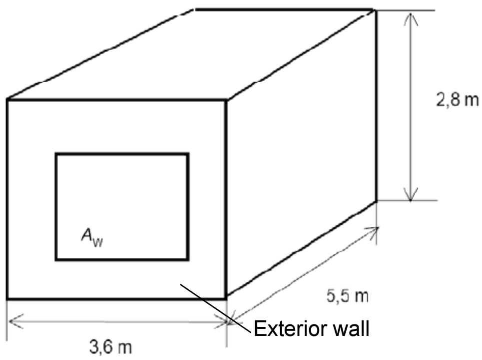
a) Single room model

The windows are “integrated” in the exterior wall of a single room defined in EN 13791. The exterior wall with the window is oriented to North, East, South and West to consider the effect of different window orientations.

Note: This single room model is also used in EN 15265 "Calculation of energy needs for space heating and cooling systems using dynamic methods- General criteria and validation procedures"

Due to the fact, that the single room model has "only" one exterior wall responsible for the heat losses by transmission it is more representing type of buildings with a high ratio of the floor area A_{floor} to the area of the building envelope A_{env}. Therefore the calculated results are more representative for such type of buildings e.g. apartment blocks.

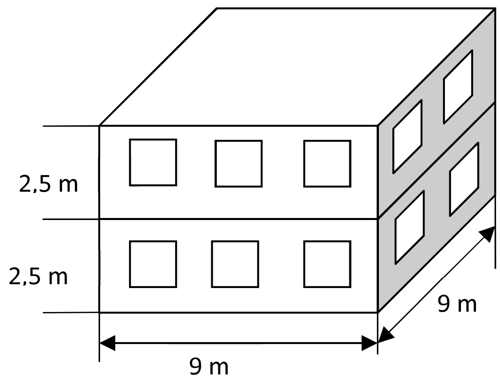
Figure 10 Single room model according to EN 13791; V = 55,4 m³; A_{floor} = 19,8 m²



b) Single family house

In contrast to apartment blocks the influence of the roof and the base plate on the total heat transmission of single family house is much higher. Therefore a two storey simple single family house was defined.

Figure 11 Simplified single family house; $V = 405\ m^3$; $A_{floor} = 2x81\ m^2 = 162\ m^2$



The orientation of the windows was assumed to be 25% on each facade. . The reason for that was, that there is no evidence available, that there is in average a non-uniform distribution of windows regarding the orientation. Only one source was found stating data on the distribution of windows regarding the orientation. This study[63] analysed two different databases to evaluate the distribution of different orientations. According to the data there is no significant change of the share of windows regarding the orientation. The British Fenestration Rating Council (BFRC) informed the consultants, that also the energy balance equation in the UK is based on the assumption of a uniform distribution of the windows regarding the orientation.

The single family house was calculated by the approach of a "one-zone" model. In a one-zone model it is assumed, that there is only one representative air temperature; meaning that the temperature in different rooms of the building is the same. Furthermore the "one-zone" model approach assumes that the solar gains achieved through a window will serve as an energy input for the complete building and not only for the room where the window is installed. The solar gains are distributed evenly; they are smoothed over the complete building. Therefore the so called utilization factor is the same for all windows.

Table 125: Distribution of windows according to the orientation in Belgian single family dwellings (Source: BBRI)

Orientation	EAP	SENVIVV
N	11%	10%
NO	13%	9%
O	12%	14%
SO	13%	14%
S	15%	15%
SE	15%	14%
E	12%	15%
NE	10%	10%

[63] Evaluation of the energy performance of fenestration systems for residential buildings in the Belgian context, Belgian Building research Institute, November 2011

Level of thermal insulation of the building

The degree hours for heating and cooling and also the usable solar radiation reducing the heating demand but also increasing the cooling demand depend on the insulation level of the building envelope. Therefore different levels of insulation of the opaque envelope were investigated to analyse the relevant influence.

Table 126 Level of thermal insulation of the investigated buildings

Climate		Mean U-value of the building envelope $\widetilde{U}_{env}$ in W/m^2K
North	Single room	0,6
	Single family house "old"	0,6
	Single family house "renovated"	0,3
Central	Single room	0,8
	Single family house "old"	0,8
	Single family house "renovated"	0,4
South	Single room	1,0
	Single family house "old"	1,0
	Single family house "renovated"	0,6

Other parameters and boundary conditions

The further following boundary conditions were assumed for the calculations for heating.

Table 127 Boundary conditions and other parameters used for the calculation in the heating season

Parameter		*Source*
Pressure difference Δp	Δp=6 Pa	ISO 18292
Temperature set point for heating	$T_{i,set}$ = 20°C	Table G.12 EN 13790
Ventilation rate	n=0.5 h^{-1}	
Internal heat sources (related to floor area)	Q_i =5 W/m^2	DIN 4108-2 , see also Table G.8 EN 13790
Usage	24 h/7 days a week	

For the heating period the parameters A, B and C were determined.

Table 128 Parameters required for calculation of HEATING energy performance

Symbol	Description	Unit	Source
A	Heating degree hours	kKh	Derived from hourly calculation
B	"Useable" solar radiation	kWh/m^2	Derived from hourly calculation

C	dimensionless fraction of accumulated temperature difference for period with shutter closed	-	Derived from hourly calculation

The factor A (heating degree hours) was calculated by hourly accumulation of the difference between the internal set point temperature $T_{i,set}$ (20°C) and the external temperature T_e.

To evaluate the factor B (usable solar radiation) the solar heat input was calculated for all days with a heating need. Therefore two separate steps were necessary. First, the thermal heat demand of the building was modelled with the actual characteristics of the window. Then a second calculation was done assuming the g value of the window to be zero. The difference between the two calculations is the usable heat gain. The ratio between the useable total heat gain per day and the total solar input per day defines the utilization factor for that day. B was then calculated by multiplying the daily accumulation of solar radiation on the window with the daily utilization factor. The accumulation of all these daily values leads to the factor B.

Stakeholders asked to calculate also B factors for different orientations to consider also the orientation in the Life Cycle Cost analyses. For the single family house this was done by assuming that the daily utilization factor is the same for every orientation. Multiplying this daily utilization factor with the daily accumulation of solar radiation on the window for the individual orientation and accumulation all these daily values lead to the factor B as a function of the orientation. The same approach was used to calculate the B values for roof windows with different inclinations.

The factor C is the dimensionless fraction of accumulated temperature difference for the hours with shutter closed. Two different usage scenarios were calculated.

Scenario 1: The shutter was closed from sunset to sun rise

Scenario 2: The shutter was closed from 22:00 to 6:00.

The calculation of A,B and C was done for the following window design options

Table 129 Analysed design options of windows

No.	U_w in W/m^2K	g	Air tightness class
1	5.8	0.85	2
2	2.8	0.78	3
3	1.7	0.65	4
4	1.3	0.60	4
5	1.0	0.55	4
6	0.8	0.60	4
7	1.0	0.58	4
8	0.6	0.47	4
9	2.8	0.35	3
10	1.3	0.35	4
11	0.8	0.35	4

Regarding roof windows the parameters A and C will be the same as for facade windows. Due to the inclination "only" the factor B will be different for roof windows. Therefore B was calculated for inclinations of 60°, 40°, 20° and 0° for the single family house. For the single room only 40° was calculated.

The following tables are showing the calculated Parameters A, B and C for the energy balance equation.

FAÇADE WINDOWS

NORTHERN CLIMATE

Single room model

Table 130 Calculated Parameters for the energy balance equation, façade windows, Northern climate, single room model U_{env}=0,6 W/m²K

					Degree hour					Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	A (uniform distr.)	A North	B East	B South	B West	B (uniform distr.)	B North	B East	B South	B West
1	5,8	0,85	30%	2	106	112	106	101	106	285	157	280	436	268
2	2,8	0,78	30%	3	96	107	97	85	96	205	126	194	307	193
3	1,7	0,65	30%	4	92	103	93	79	92	175	115	173	250	163
4	1,3	0,60	30%	4	90	102	91	77	91	167	111	162	239	155
5	1,0	0,55	30%	4	90	102	90	76	90	162	109	153	232	152
6	0,8	0,60	30%	4	86	99	87	72	87	146	102	135	201	145
7	1,0	0,58	30%	4	89	101	89	75	89	158	109	143	229	150
8	0,6	0,47	30%	4	89	101	90	76	90	159	106	144	230	154
9	2,8	0,35	30%	3	107	111	107	103	107	306	156	294	474	298
10	1,3	0,35	30%	4	99	107	100	92	99	228	130	212	360	212
11	0,8	0,35	30%	4	96	104	96	87	96	209	124	195	324	193
		Average (window 3-8)			89	101	90	76	90	161	109	152	230	153

Usage shutter (sunset - sunrise)					Usage shutter (22 - 6)				
C (uniform distr.)	C North	C East	C South	C West	C (uniform distr.)	C North	C East	C South	C West
0,65	0,64	0,65	0,65	0,65	0,36	0,36	0,36	0,36	0,36
0,66	0,65	0,66	0,67	0,67	0,35	0,36	0,35	0,35	0,35
0,67	0,66	0,67	0,68	0,67	0,35	0,35	0,35	0,35	0,35
0,67	0,66	0,67	0,69	0,68	0,35	0,35	0,35	0,35	0,35
0,68	0,66	0,68	0,69	0,68	0,35	0,35	0,35	0,35	0,35
0,68	0,66	0,68	0,70	0,68	0,35	0,35	0,35	0,34	0,35
0,68	0,66	0,68	0,69	0,68	0,35	0,35	0,35	0,34	0,35
0,68	0,66	0,68	0,69	0,68	0,35	0,35	0,35	0,34	0,35
0,65	0,65	0,65	0,65	0,65	0,36	0,36	0,36	0,36	0,36
0,66	0,65	0,66	0,66	0,66	0,35	0,36	0,35	0,35	0,35
0,66	0,65	0,67	0,67	0,67	0,35	0,35	0,35	0,35	0,35
0,68	0,66	0,67	0,69	0,68	0,35	0,35	0,35	0,35	0,35

Single family house

Single family house ($\widetilde{U}_{env}$ =0,6 W/m^{2}K)

Table 131 Calculated Parameters for the energy balance equation, façade windows, Northern climate, single family house U_{env}=0,6 W/m^{2}K

					Degree hour	Solar Factor					Usage shutter	
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	A	B (uniform distr.)	B North	B East	B South	B West	C (sunset - sunrise)	C (22 - 6)
1	5,8	0,85	30%	2	112	325	163	319	499	321	0,64	0,36
2	2,8	0,78	30%	3	108	299	144	286	473	292	0,65	0,36
3	1,7	0,65	30%	4	108	303	146	290	480	296	0,65	0,36
4	1,3	0,60	30%	4	108	303	146	290	478	297	0,65	0,36
5	1,0	0,55	30%	4	108	305	147	293	482	300	0,65	0,36
6	0,8	0,60	30%	4	107	294	140	281	468	289	0,65	0,36
7	1,0	0,58	30%	4	108	298	142	284	472	293	0,65	0,36
8	0,6	0,47	30%	4	109	312	150	299	494	306	0,65	0,36
9	2,8	0,35	30%	3	114	362	184	356	547	363	0,64	0,36
10	1,3	0,35	30%	4	112	333	163	323	518	327	0,64	0,36
11	0,8	0,35	30%	4	111	329	161	316	514	323	0,64	0,36
		Average (window 3-8)			108	303	145	289	479	297	0,65	0,36

Single family house ($\widetilde{U}_{env}$ =0,3 W/m^{2}K)

Table 132 Calculated Parameters for the energy balance equation, façade windows, Northern climate, single family house U_{env}=0,3 W/m^{2}K

					Degree hour	Solar Factor					Usage shutter	
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	A	B (uniform distr.)	B North	B East	B South	B West	C (sunset - sunrise)	C (22 - 6)
1	5,8	0,85	30%	2	109	307	151	297	482	300	0,64	0,36
2	2,8	0,78	30%	3	102	250	115	231	411	243	0,66	0,35
3	1,7	0,65	30%	4	100	233	107	215	388	224	0,66	0,35
4	1,3	0,60	30%	4	99	235	109	217	391	226	0,66	0,35
5	1,0	0,55	30%	4	99	235	108	216	390	225	0,66	0,35
6	0,8	0,60	30%	4	97	219	100	201	369	205	0,66	0,35
7	1,0	0,58	30%	4	98	228	105	208	383	218	0,66	0,35
8	0,6	0,47	30%	4	100	237	110	219	394	227	0,66	0,35
9	2,8	0,35	30%	3	110	325	158	312	512	319	0,64	0,36
10	1,3	0,35	30%	4	106	303	145	288	481	297	0,65	0,36
11	0,8	0,35	30%	4	105	275	126	257	447	271	0,65	0,35
		Average (window 3-8)			99	231	107	213	386	221	0,66	0,35

CENTRAL CLIMATE

Single room model

Table 133 Calculated Parameters for the energy balance equation, façade windows, Central climate, single room model U_{env}=0,8 W/m^{2}K

					Degree hour					Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	A (uniform distr.)	A North	A East	A South	A West	B (uniform distr.)	B North	B East	B South	B West
1	5,8	0,85	30%	2	68	73	68	62	67	241	150	228	340	245
2	2,8	0,78	30%	3	58	67	60	48	58	165	120	155	237	147
3	1,7	0,65	30%	4	55	63	56	44	55	142	107	127	204	129
4	1,3	0,60	30%	4	53	62	55	42	54	135	102	120	195	125
5	1,0	0,55	30%	4	53	62	54	42	54	135	99	119	196	126
6	0,8	0,60	30%	4	50	60	52	38	52	123	91	111	170	119
7	1,0	0,58	30%	4	52	61	54	41	53	131	99	115	189	122
8	0,6	0,47	30%	4	52	61	54	42	53	133	97	116	195	123
9	2,8	0,35	30%	3	67	72	68	63	67	245	149	229	358	245
10	1,3	0,35	30%	4	60	66	62	54	60	188	123	172	283	175
11	0,8	0,35	30%	4	57	64	59	50	57	163	111	151	242	147
		Average (window 3-8)			53	62	54	41	53	133	99	118	192	124

Usage shutter (sunset - sunrise)					Usage shutter (22 - 6)				
C (uniform distr.)	C North	C East	C South	C West	C (uniform distr.)	C North	C East	C South	C West
0,64	0,64	0,65	0,64	0,64	0,38	0,38	0,38	0,38	0,38
0,65	0,65	0,65	0,65	0,65	0,37	0,37	0,37	0,36	0,36
0,65	0,65	0,65	0,66	0,66	0,36	0,37	0,36	0,36	0,36
0,65	0,65	0,66	0,66	0,66	0,36	0,37	0,36	0,36	0,36
0,65	0,65	0,66	0,66	0,66	0,36	0,37	0,36	0,36	0,36
0,66	0,65	0,66	0,66	0,66	0,36	0,37	0,36	0,36	0,36
0,66	0,65	0,66	0,66	0,66	0,36	0,37	0,36	0,36	0,36
0,66	0,65	0,66	0,66	0,66	0,36	0,37	0,36	0,36	0,36
0,64	0,64	0,65	0,64	0,65	0,38	0,38	0,38	0,37	0,38
0,65	0,65	0,65	0,65	0,65	0,37	0,37	0,37	0,37	0,37
0,65	0,65	0,65	0,65	0,65	0,36	0,37	0,37	0,36	0,36
0,65	0,65	0,66	0,66	0,66	0,36	0,37	0,36	0,36	0,36

Single family house

Single family house ($\widetilde{U}_{env}$ =0,8 W/m^{2}K)

Table 134 Calculated Parameters for the energy balance equation, façade windows, Central climate, single family house U_{env}=0,8 W/m^{2}K

					Degree hour	Solar Factor					Usage shutter	
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	A	B (uniform distr.)	B North	B East	B South	B West	C (sunset - sunrise)	C (22 - 6)
1	5,8	0,85	30%	2	74	293	161	281	433	297	0,64	0,39
2	2,8	0,78	30%	3	71	270	144	252	412	271	0,64	0,38
3	1,7	0,65	30%	4	71	268	142	248	413	269	0,64	0,38
4	1,3	0,60	30%	4	71	271	143	251	417	272	0,64	0,38
5	1,0	0,55	30%	4	71	273	144	253	421	275	0,64	0,38
6	0,8	0,60	30%	4	70	262	138	242	408	263	0,64	0,38
7	1,0	0,58	30%	4	70	271	143	251	418	273	0,64	0,38
8	0,6	0,47	30%	4	71	281	149	261	431	282	0,64	0,38
9	2,8	0,35	30%	3	75	326	178	313	478	333	0,64	0,39
10	1,3	0,35	30%	4	74	311	169	296	466	313	0,64	0,39
11	0,8	0,35	30%	4	73	305	164	288	459	307	0,64	0,38
		Average (window 3-8)			71	271	143	251	418	272	0,64	0,38

Single family house ($\widetilde{U}_{env}$ =0,4 W/m^{2}K)

Table 135 Calculated Parameters for the energy balance equation, façade windows, Central climate, single family house U_{env}=0,4 W/m^{2}K

					Degree hour	Solar Factor					Usage shutter	
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	A	B (uniform distr.)	B North	B East	B South	B West	C (sunset - sunrise)	C (22 - 6)
1	5,8	0,85	30%	2	71	273	146	255	416	274	0,64	0,38
2	2,8	0,78	30%	3	65	224	118	201	357	222	0,65	0,37
3	1,7	0,65	30%	4	63	207	111	184	331	202	0,65	0,37
4	1,3	0,60	30%	4	63	206	111	183	328	201	0,65	0,37
5	1,0	0,55	30%	4	63	207	112	184	330	203	0,65	0,37
6	0,8	0,60	30%	4	61	190	103	169	305	184	0,65	0,37
7	1,0	0,58	30%	4	62	203	110	180	325	199	0,65	0,37
8	0,6	0,47	30%	4	63	210	113	187	334	205	0,65	0,37
9	2,8	0,35	30%	3	72	295	157	277	449	297	0,64	0,38
10	1,3	0,35	30%	4	68	261	138	239	406	260	0,64	0,38
11	0,8	0,35	30%	4	67	245	129	226	385	241	0,64	0,37
		Average (window 3-8)			63	204	110	181	326	199	0,65	0,37

SOUTHERN CLIMATE

Single room

Table 136 Calculated Parameters for the energy balance equation, façade windows, Southern climate, single room model U_{env}=1,0 W/m^{2}K

					Degree hour					Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	A (uniform distr.)	A North	A East	A South	A West	B (uniform distr.)	B North	B East	B South	B West
1	5,8	0,85	30%	2	19	27	19	11	19	189	119	203	240	195
2	2,8	0,78	30%	3	11	20	10	2	10	84	85	101	53	97
3	1,7	0,65	30%	4	8	17	7	1	6	56	63	70	30	60
4	1,3	0,60	30%	4	7	15	6	1	6	49	59	63	26	49
5	1,0	0,55	30%	4	7	15	6	1	6	44	57	57	16	47
6	0,8	0,60	30%	4	6	13	5	0	4	36	50	48	8	38
7	1,0	0,58	30%	4	6	14	6	1	5	41	55	52	12	47
8	0,6	0,47	30%	4	6	14	6	1	5	42	54	53	13	47
9	2,8	0,35	30%	3	19	25	19	11	19	190	113	201	251	195
10	1,3	0,35	30%	4	12	19	12	4	12	104	80	125	93	119
11	0,8	0,35	30%	4	9	17	9	2	9	76	65	99	52	88
		Average (window 2-4;9,10)			11	19	11	4	11	97	80	112	90	104

Usage shutter (sunset - sunrise)					Usage shutter (22 - 6)				
C (uniform distr.)	C North	C East	C South	C West	C (uniform distr.)	C North	C East	C South	C West
0,65	0,65	0,65	0,64	0,65	0,46	0,40	0,39	0,65	0,39
0,64	0,65	0,64	0,64	0,64	0,45	0,39	0,38	0,64	0,38
0,64	0,65	0,64	0,65	0,64	0,44	0,39	0,38	0,64	0,37
0,64	0,64	0,64	0,65	0,64	0,44	0,38	0,37	0,64	0,38
0,64	0,64	0,64	0,64	0,64	0,44	0,38	0,37	0,64	0,38
0,64	0,64	0,64	0,63	0,64	0,44	0,38	0,37	0,64	0,37
0,64	0,64	0,64	0,65	0,64	0,44	0,38	0,38	0,64	0,38
0,64	0,64	0,64	0,65	0,64	0,44	0,38	0,37	0,64	0,37
0,64	0,65	0,65	0,64	0,65	0,46	0,40	0,39	0,65	0,39
0,64	0,65	0,64	0,64	0,64	0,45	0,39	0,38	0,64	0,38
0,64	0,64	0,64	0,63	0,64	0,44	0,38	0,38	0,64	0,38
0,64	0,65	0,64	0,64	0,64	0,45	0,39	0,38	0,64	0,38

Single family house

Single family house ($\widetilde{U}_{env}$ =1 W/m^{2}K)

Table 137 Calculated Parameters for the energy balance equation, façade windows, Southern climate, single family house U_{env}=1,0 W/m^{2}K

					Degree hour	Solar Factor					Usage shutter	
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	A	B (uniform distr.)	B North	B East	B South	B West	C (sunset - sunrise)	C (22 - 6)
1	5,8	0,85	30%	2	27	283	116	266	479	270	0,65	0,41
2	2,8	0,78	30%	3	24	264	107	244	455	249	0,65	0,40
3	1,7	0,65	30%	4	24	261	106	242	451	246	0,65	0,40
4	1,3	0,60	30%	4	24	265	107	245	457	250	0,65	0,40
5	1,0	0,55	30%	4	24	268	109	249	463	253	0,65	0,40
6	0,8	0,60	30%	4	23	253	103	232	439	239	0,65	0,40
7	1,0	0,58	30%	4	24	266	108	247	459	251	0,65	0,40
8	0,6	0,47	30%	4	25	283	114	263	488	268	0,65	0,40
9	2,8	0,35	30%	3	30	320	131	304	540	307	0,65	0,41
10	1,3	0,35	30%	4	28	307	123	288	524	293	0,65	0,41
11	0,8	0,35	30%	4	28	305	122	285	522	290	0,65	0,40
		Average (window 2-4;9;10)			26	283	115	265	485	269	0,65	0,40

Single family house ($\widetilde{U}_{env}$ =0,6 W/m^{2}K)

Table 138 Calculated Parameters for the energy balance equation, façade windows, Southern climate, single family house U_{env}=0,6 W/m^{2}K

					Degree hour	Solar Factor					Usage shutter	
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	A	B (uniform distr.)	B North	B East	B South	B West	C (sunset - sunrise)	C (22 - 6)
1	5,8	0,85	30%	2	24	265	108	246	457	251	0,65	0,40
2	2,8	0,78	30%	3	18	202	82	184	356	188	0,64	0,39
3	1,7	0,65	30%	4	17	194	78	173	346	178	0,64	0,39
4	1,3	0,60	30%	4	17	188	75	168	336	173	0,64	0,39
5	1,0	0,55	30%	4	17	190	76	170	340	175	0,64	0,39
6	0,8	0,60	30%	4	15	177	70	157	319	164	0,64	0,39
7	1,0	0,58	30%	4	16	189	76	169	338	174	0,64	0,39
8	0,6	0,47	30%	4	18	201	80	180	358	185	0,64	0,39
9	2,8	0,35	30%	3	26	302	122	282	517	287	0,65	0,40
10	1,3	0,35	30%	4	23	261	104	238	452	247	0,64	0,40
11	0,8	0,35	30%	4	22	244	98	223	426	228	0,64	0,39
		Average (window 2-4;9;10)			20	229	92	209	401	215	0,65	0,39

ROOF WINDOWS

NORTHERN CLIMATE

Single room

No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	Degree hour A (uniform distr.)	A North	B East	B South	B West	Solar Factor B (uniform distr.)	B North	B East	B South	B West
1	5.8	0.85	30%	2	102	109	102	97	102	296	192	290	405	300
2	2.8	0.78	30%	3	92	103	92	82	91	200	145	210	245	201
3	1.7	0.65	30%	4	88	100	88	77	88	171	126	174	211	174
4	1.3	0.60	30%	4	87	99	86	77	87	158	121	151	200	162
5	1.0	0.55	30%	4	86	98	86	76	86	158	121	147	200	164
6	0.8	0.60	30%	4	83	95	83	73	83	139	116	130	182	130
7	1.0	0.58	30%	4	86	98	85	75	85	153	121	142	191	160
8	0.6	0.47	30%	4	86	97	85	76	86	157	122	145	200	161
9	2.8	0.35	30%	3	104	109	104	99	104	322	203	323	441	322
10	1.3	0.35	30%	4	96	104	96	89	95	243	159	242	331	242
11	0.8	0.35	30%	4	92	101	92	84	92	215	146	219	289	207
	Average (window 3-8)				86	98	85	76	86	156	121	148	197	158

No.	Usage shutter (sunset - sunrise) C (uniform distr.)	C North	C East	C South	C West	Usage shutter (22 - 6) C (uniform distr.)	C North	C East	C South	C West
1	0.63	0.63	0.63	0.64	0.63	0.35	0.36	0.35	0.35	0.35
2	0.65	0.64	0.65	0.66	0.65	0.35	0.35	0.35	0.35	0.35
3	0.66	0.64	0.66	0.67	0.66	0.35	0.35	0.35	0.34	0.35
4	0.66	0.64	0.66	0.68	0.66	0.35	0.35	0.35	0.34	0.35
5	0.66	0.64	0.66	0.68	0.66	0.35	0.35	0.35	0.34	0.35
6	0.67	0.65	0.67	0.68	0.67	0.35	0.35	0.35	0.34	0.34
7	0.66	0.64	0.67	0.68	0.66	0.35	0.35	0.35	0.34	0.35
8	0.66	0.64	0.67	0.68	0.66	0.35	0.35	0.35	0.34	0.35
9	0.63	0.63	0.63	0.64	0.63	0.35	0.36	0.35	0.35	0.35
10	0.64	0.64	0.64	0.65	0.65	0.35	0.35	0.35	0.35	0.35
11	0.65	0.64	0.65	0.66	0.65	0.35	0.35	0.35	0.35	0.35
	0.66	0.64	0.66	0.68	0.66	0.35	0.35	0.35	0.34	0.35

Single family house

Single family house ($\widetilde{U}_{env}$ =0,6 W/m^{2}K)

Table 139 Calculated Parameter B for the energy balance equation, roof windows, Northern climate, single family house U_{env}=0,6 W/m^{2}K

					Horizontal	20 ° inclination				
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	B	B (uniform distr.)	B North	B East	B South	B West
1	5,8	0,85	30%	2	448	440	332	441	548	440
2	2,8	0,78	30%	3	402	395	290	394	500	396
3	1,7	0,65	30%	4	406	400	293	399	506	401
4	1,3	0,60	30%	4	406	399	293	398	505	400
5	1,0	0,55	30%	4	409	403	296	401	509	404
6	0,8	0,60	30%	4	391	385	280	383	489	387
7	1,0	0,58	30%	4	396	390	285	388	494	392
8	0,6	0,47	30%	4	420	413	303	412	522	414
9	2,8	0,35	30%	3	504	494	376	494	610	496
10	1,3	0,35	30%	4	454	446	332	446	559	446
11	0,8	0,35	30%	4	446	439	325	438	551	440
		Average (window 3-8)			405	398	292	397	504	400

40 ° inclination					60 ° inclination				
B (uniform distr.)	B North	B East	B South	B West	B (uniform distr.)	B North	B East	B South	B West
424	243	426	600	425	398	198	397	599	396
383	211	381	555	384	362	175	355	559	360
387	213	386	562	389	367	177	360	567	364
387	214	385	560	389	367	177	360	565	365
390	216	389	565	392	370	178	363	570	368
374	204	371	545	376	355	169	347	551	354
379	207	376	550	381	359	172	351	556	358
400	220	399	580	401	378	182	372	584	376
474	276	476	665	480	444	224	443	661	448
430	242	431	616	432	405	198	402	617	403
424	237	423	609	426	400	196	394	611	398
386	212	384	560	388	366	176	359	566	364

Single family house ($\widetilde{U}_{env}$ =0,3 W/m²K)

Table 140 Calculated Parameter B for the energy balance equation, roof windows, Northern climate, single family house U_{env}=0,3 W/m²K

					Horizontal	20 ° inclination				
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	B	B (uniform distr.)	B North	B East	B South	B West
1	5,8	0,85	30%	2	417	410	304	410	515	410
2	2,8	0,78	30%	3	319	315	222	312	409	318
3	1,7	0,65	30%	4	295	292	205	289	380	293
4	1,3	0,60	30%	4	298	295	207	292	384	296
5	1,0	0,55	30%	4	297	294	207	291	382	295
6	0,8	0,60	30%	4	274	272	189	270	356	271
7	1,0	0,58	30%	4	287	284	198	281	372	286
8	0,6	0,47	30%	4	300	297	209	294	387	298
9	2,8	0,35	30%	3	441	433	320	432	546	435
10	1,3	0,35	30%	4	403	396	290	395	503	398
11	0,8	0,35	30%	4	355	350	249	346	452	354
		Average (window 3-8)			292	289	203	286	377	290

40 ° inclination					60 ° inclination				
B (uniform distr.)	B North	B East	B South	B West	B (uniform distr.)	B North	B East	B South	B West
396	222	397	569	396	374	184	369	572	369
310	162	303	463	312	298	139	284	475	295
288	152	281	432	287	278	131	264	445	272
291	154	284	436	290	280	132	266	449	275
290	154	283	435	289	280	132	266	447	273
269	142	264	407	265	260	122	247	421	250
281	148	273	424	281	272	128	256	438	265
294	156	287	439	293	283	134	269	452	277
419	233	418	604	421	395	193	389	607	393
385	211	382	560	388	366	175	357	566	364
343	179	336	510	348	329	152	315	520	330
286	151	279	429	284	275	130	261	442	269

Central Climate

Single room

Table 141 Calculated Parameters for the energy balance equation, roof windows, Central climate, single room U_{env}=0,8 W/m²K

					Degree hour					Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	A (uniform distr.)	A North	A East	A South	A West	B (uniform distr.)	B North	B East	B South	B West
1	5.8	0.85	30%	2	64	70	64	58	63	270	190	275	339	274
2	2.8	0.78	30%	3	54	62	55	46	54	179	136	169	237	172
3	1.7	0.65	30%	4	51	59	52	42	51	157	115	154	204	157
4	1.3	0.60	30%	4	50	58	51	40	50	154	109	154	196	157
5	1.0	0.55	30%	4	49	58	51	40	50	152	106	155	189	158
6	0.8	0.60	30%	4	47	56	48	36	47	139	98	140	169	149
7	1.0	0.58	30%	4	49	57	50	38	49	147	102	149	186	152
8	0.6	0.47	30%	4	49	57	50	40	49	151	101	156	192	156
9	2.8	0.35	30%	3	65	69	65	60	64	284	199	286	357	293
10	1.3	0.35	30%	4	57	63	57	52	57	198	149	192	263	187
11	0.8	0.35	30%	4	54	61	55	48	54	179	130	164	244	176
	Average (window 3-8)				49	58	50	39	49	150	105	151	189	155

Usage shutter (sunset - sunrise)					Usage shutter (22 - 6)				
C (uniform distr.)	C North	C East	C South	C West	C (uniform distr.)	C North	C East	C South	C West
0.63	0.63	0.63	0.63	0.63	0.37	0.38	0.38	0.37	0.37
0.64	0.63	0.64	0.64	0.64	0.36	0.37	0.36	0.36	0.36
0.64	0.64	0.64	0.64	0.64	0.36	0.37	0.36	0.36	0.36
0.64	0.64	0.64	0.64	0.64	0.36	0.36	0.36	0.36	0.36
0.64	0.64	0.64	0.65	0.64	0.36	0.36	0.36	0.36	0.36
0.64	0.64	0.64	0.65	0.64	0.36	0.36	0.36	0.36	0.36
0.64	0.64	0.64	0.65	0.64	0.36	0.36	0.36	0.36	0.36
0.64	0.64	0.64	0.65	0.64	0.36	0.36	0.36	0.36	0.36
0.63	0.63	0.63	0.63	0.63	0.37	0.38	0.37	0.37	0.37
0.63	0.63	0.64	0.64	0.64	0.36	0.37	0.36	0.36	0.36
0.64	0.63	0.64	0.64	0.64	0.36	0.37	0.36	0.36	0.36
0.64	0.64	0.64	0.65	0.64	0.36	0.36	0.36	0.36	0.36

Single family house

Single family house ($\widetilde{U}_{env}$ =0,8 W/m^{2}K)

Table 142 Calculated Parameters for the energy balance equation, roof windows, Central climate,

				Horizontal	20 ° inclination				
U_{window}	g_{gl}	Frame fraction	Air tight Class	B	B (uniform distr.)	B North	B East	B South	B West
5,8	0,85	30%	2	456	441	348	438	532	448
2,8	0,78	30%	3	408	396	304	392	485	402
1,7	0,65	30%	4	403	391	299	386	481	398
1,3	0,60	30%	4	407	395	302	390	486	403
1,0	0,55	30%	4	411	399	305	394	490	407
0,8	0,60	30%	4	393	381	289	376	470	388
1,0	0,58	30%	4	408	396	302	391	487	404
0,6	0,47	30%	4	423	410	314	406	504	418
2,8	0,35	30%	3	509	493	390	489	592	500
1,3	0,35	30%	4	480	465	364	462	564	472
0,8	0,35	30%	4	467	453	352	449	550	460
	Average (window 3-8)			408	395	302	390	486	403

single family house U_{env}=0,8 W/m^{2}K

40 ° inclination					60 ° inclination				
B (uniform distr.)	B North	B East	B South	B West	B (uniform distr.)	B North	B East	B South	B West
413	257	409	562	422	374	202	367	545	382
372	222	365	519	381	340	178	328	509	346
368	217	359	517	378	337	175	323	508	344
372	219	363	522	382	341	176	326	513	348
375	221	367	527	386	344	178	329	518	351
359	210	350	507	369	330	170	314	499	336
372	220	364	523	383	341	177	326	514	349
386	228	378	541	397	354	183	339	531	361
460	287	456	624	473	416	224	409	603	428
435	266	430	599	446	395	210	386	582	403
424	256	418	586	435	386	203	375	572	394
372	219	363	523	382	341	176	326	514	348

Single family house ($\widetilde{U}_{env}$ =0,4 W/m²K)

Table 143 Calculated Parameters for the energy balance equation, roof windows, Central climate, single family house U_{env}=0,4 W/m^{2}K

					Horizontal	20 ° inclination				
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	B	B (uniform distr.)	B North	B East	B South	B West
1	5,8	0,85	30%	2	413	400	308	396	490	407
2	2,8	0,78	30%	3	330	320	239	315	399	327
3	1,7	0,65	30%	4	303	293	219	289	366	300
4	1,3	0,60	30%	4	300	291	218	286	362	297
5	1,0	0,55	30%	4	302	293	220	288	365	299
6	0,8	0,60	30%	4	276	268	200	264	334	273
7	1,0	0,58	30%	4	295	287	214	282	358	293
8	0,6	0,47	30%	4	306	297	222	292	370	303
9	2,8	0,35	30%	3	448	434	335	430	531	442
10	1,3	0,35	30%	4	389	377	286	372	466	384
11	0,8	0,35	30%	4	363	352	265	349	437	357
		Average (window 3-8)			255	247	185	243	308	252

40 ° inclination					60 ° inclination				
B (uniform distr.)	B North	B East	B South	B West	B (uniform distr.)	B North	B East	B South	B West
376	225	369	525	386	344	180	332	514	350
303	176	292	434	311	280	146	262	431	284
279	165	268	399	285	259	138	240	397	259
277	165	266	394	282	257	139	238	393	257
279	167	268	398	285	259	140	240	396	259
256	154	246	365	259	237	129	220	364	236
273	163	262	390	279	254	137	235	388	254
283	169	271	403	288	262	141	243	401	263
408	244	401	568	418	373	195	360	556	380
356	209	346	503	365	327	170	311	496	332
333	194	326	473	339	307	159	293	468	308
235	140	226	335	240	218	118	202	334	218

SOUTHERN CLIMATE

Single room

					Degree hour					Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	A (uniform distr.)	A North	A East	A South	A West	B (uniform distr.)	B North	B East	B South	B West
1	5.8	0.85	30%	2	16	24	15	8	15	192	119	227	206	215
2	2.8	0.78	30%	3	8	18	6	2	6	74	79	93	46	79
3	1.7	0.65	30%	4	6	15	4	1	4	46	63	51	23	47
4	1.3	0.60	30%	4	5	14	3	1	3	41	61	46	17	42
5	1.0	0.55	30%	4	5	14	3	0	3	38	58	44	14	35
6	0.8	0.60	30%	4	4	12	2	0	2	31	55	30	9	29
7	1.0	0.58	30%	4	5	13	3	0	3	34	58	37	9	34
8	0.6	0.47	30%	4	5	13	3	0	3	37	59	42	13	36
9	2.8	0.35	30%	3	16	23	16	9	16	196	118	217	227	221
10	1.3	0.35	30%	4	9	18	8	3	8	94	77	115	78	107
11	0.8	0.35	30%	4	7	16	6	2	6	65	70	82	38	68
			Average (window 2-4;9,10)		9	18	8	3	7	90	79	104	78	99

Usage shutter (sunset - sunrise)					Usage shutter (22 - 6)				
C (uniform distr.)	C North	C East	C South	C West	C (uniform distr.)	C North	C East	C South	C West
0.63	0.64	0.63	0.63	0.63	0.39	0.40	0.39	0.38	0.39
0.63	0.63	0.63	0.63	0.63	0.38	0.39	0.38	0.37	0.37
0.64	0.63	0.64	0.65	0.63	0.37	0.38	0.37	0.37	0.37
0.64	0.63	0.64	0.66	0.63	0.38	0.38	0.37	0.38	0.37
0.64	0.63	0.64	0.65	0.64	0.38	0.38	0.37	0.38	0.37
0.63	0.63	0.63	0.63	0.64	0.37	0.38	0.36	0.37	0.37
0.63	0.63	0.64	0.63	0.64	0.37	0.38	0.37	0.37	0.37
0.64	0.63	0.63	0.64	0.64	0.37	0.38	0.37	0.38	0.37
0.63	0.63	0.63	0.63	0.63	0.39	0.39	0.39	0.38	0.39
0.63	0.63	0.63	0.63	0.63	0.38	0.38	0.38	0.37	0.38
0.63	0.63	0.63	0.64	0.63	0.38	0.38	0.37	0.37	0.38
0.63	0.63	0.63	0.64	0.63	0.38	0.39	0.38	0.38	0.37

Single family house

Single family house ($\widetilde{U}_{env}$ =1 W/m²K)

Table 144 Calculated Parameter B for the energy balance equation, roof windows, Southern climate, single family house U_{env}=1,0 W/m²K

					Horizontal	20 ° inclination				
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	B	B (uniform distr.)	B North	B East	B South	B West
1	5,8	0,85	30%	2	418	406	281	407	527	409
2	2,8	0,78	30%	3	381	371	251	371	487	374
3	1,7	0,65	30%	4	378	367	249	368	482	371
4	1,3	0,60	30%	4	383	372	252	373	489	375
5	1,0	0,55	30%	4	388	377	255	378	495	380
6	0,8	0,60	30%	4	364	354	238	354	466	358
7	1,0	0,58	30%	4	385	374	253	375	491	378
8	0,6	0,47	30%	4	411	399	271	400	524	403
9	2,8	0,35	30%	3	477	463	322	465	600	467
10	1,3	0,35	30%	4	451	438	300	439	572	442
11	0,8	0,35	30%	4	446	434	296	435	567	437
		Average (window 2-4;9;10)			414	402	275	403	526	406

40 ° inclination					60 ° inclination				
B (uniform distr.)	B North	B East	B South	B West	B (uniform distr.)	B North	B East	B South	B West
382	176	382	585	385	353	133	344	586	348
350	154	348	545	353	326	120	315	550	320
347	153	345	540	349	323	119	312	544	317
351	155	350	547	354	327	120	316	551	321
356	157	355	554	359	332	121	321	559	325
335	146	331	523	339	312	114	299	529	308
353	156	352	550	356	329	121	318	554	323
377	167	376	586	380	351	128	339	591	345
435	203	436	664	438	401	151	393	663	396
413	186	412	637	416	382	139	372	639	377
409	183	408	632	412	379	138	368	635	373
379	170	378	587	382	352	130	342	589	346

Single family house ($\widetilde{U}_{env}$ =0,6 W/m^{2}K)

Table 145 Calculated Parameter B for the energy balance equation, roof windows Southern climate, single family house U_{env}=0,6 W/m^{2}K

					Horizontal	20 ° inclination				
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	B	B (uniform distr.)	B North	B East	B South	B West
1	5,8	0,85	30%	2	385	374	254	375	491	378
2	2,8	0,78	30%	3	287	279	185	280	371	282
3	1,7	0,65	30%	4	269	262	170	262	352	265
4	1,3	0,60	30%	4	262	255	165	255	342	258
5	1,0	0,55	30%	4	265	258	167	258	346	260
6	0,8	0,60	30%	4	245	239	153	238	322	242
7	1,0	0,58	30%	4	263	256	166	256	343	259
8	0,6	0,47	30%	4	281	273	178	274	366	276
9	2,8	0,35	30%	3	441	429	293	430	561	433
10	1,3	0,35	30%	4	375	364	245	364	480	369
11	0,8	0,35	30%	4	348	339	226	340	448	342
		Average (window 2-4;9;10)			327	318	212	318	421	321

40 ° inclination					60 ° inclination				
B (uniform distr.)	B North	B East	B South	B West	B (uniform distr.)	B North	B East	B South	B West
353	157	352	549	356	329	122	318	552	323
265	111	263	418	266	248	90	237	425	241
249	101	247	400	251	236	85	223	408	228
242	97	240	389	244	230	82	217	397	222
245	98	242	393	246	232	83	219	402	224
227	89	223	367	230	216	76	201	376	210
243	98	241	391	245	231	83	218	399	223
260	105	257	415	261	245	88	232	424	237
404	181	403	625	408	375	137	364	628	370
344	149	340	539	349	321	116	307	545	317
321	137	319	505	323	300	109	288	511	293
301	128	299	474	303	282	102	270	481	276

Discussion of the results

A) Calculation of the heating performance index using the energy balance equation

The derived average Energy balance values A, B and C were used to calculate the energy performance index for heating for the eleven window design options in the investigated climates and "buildings". The values were calculated for windows without a shutter and also for windows with a shutter assuming an additional thermal resistance ΔR of 0.17 W/m2K and a usage scenario from sunset to sunrise.

Table 146 Calculated Heating performance index $P_{E,H,W}$ based on the derived Parameters for the investigated "buildings" for the eleven window design option without shutter

					Northern Climate			Central Climate			Southern Climate		
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	Single room model U_{env}=0,6	Single family house U_{env}=0,6	Single family house U_{env}=0,3	Single room model U_{env}=0,8	Single family house U_{env}=0,8	Single family house U_{env}=0,4	Single room model U_{env}=1,0	Single family house U_{env}=1,0	Single family house U_{env}=0,6
1	5,8	0,85	30%	2	546	598	576	303	351	333	22	19	8
2	2,8	0,78	30%	3	203	188	198	101	84	95	-17	-70	-60
3	1,7	0,65	30%	4	92	63	79	38	9	24	-24	-80	-67
4	1,3	0,60	30%	4	62	30	47	21	-10	6	-25	-81	-67
5	1,0	0,55	30%	4	41	8	26	10	-22	-6	-25	-79	-65
6	0,8	0,60	30%	4	18	-24	-2	-5	-46	-25	-30	-94	-77
7	1,0	0,58	30%	4	38	2	21	7	-28	-10	-27	-85	-70
8	0,6	0,47	30%	4	14	-18	-1	-4	-35	-19	-24	-73	-60
9	2,8	0,35	30%	3	252	279	267	141	166	156	12	16	9
10	1,3	0,35	30%	4	90	83	88	45	37	42	-8	-31	-27
11	0,8	0,35	30%	4	46	29	38	18	2	10	-13	-44	-37
				A	89	108	99	53	71	63	11	26	20
				B	161	303	231	133	271	204	97	283	229

Table 147 Calculated Heating performance index $P_{E,H,W}$ based on the derived Parameters for the investigated "buildings" for the eleven window design option with shutter

						Northern Climate			Central Climate			Southern Climate		
No.	U_{window}	g_{gl}	Frame fraction	ΔR	Air tight Class	Single room model U_{env}=0,6	Single family house U_{env}=0,6	Single family house U_{env}=0,3	Single room model U_{env}=0,8	Single family house U_{env}=0,8	Single family house U_{env}=0,4	Single room model U_{env}=1,0	Single family house U_{env}=1,0	Single family house U_{env}=0,6
1	5,8	0,85	30%	0,17	2	372	396	388	204	220	215	1	-30	-29
2	2,8	0,78	30%	0,17	3	148	124	139	70	43	58	-23	-85	-71
3	1,7	0,65	30%	0,17	4	69	36	54	25	-9	9	-26	-87	-72
4	1,3	0,60	30%	0,17	4	48	14	32	13	-21	-4	-26	-85	-70
5	1,0	0,55	30%	0,17	4	32	-2	16	5	-29	-12	-26	-81	-67
6	0,8	0,60	30%	0,17	4	12	-31	-9	-8	-50	-29	-31	-96	-78
7	1,0	0,58	30%	0,17	4	29	-8	11	2	-35	-16	-28	-87	-72
8	0,6	0,47	30%	0,17	4	11	-22	-5	-6	-38	-22	-24	-74	-61
9	2,8	0,35	30%	0,17	3	197	216	208	110	125	119	6	0	-2
10	1,3	0,35	30%	0,17	4	76	67	72	37	26	32	-9	-35	-30
11	0,8	0,35	30%	0,17	4	40	22	32	15	-3	6	-14	-46	-38
					A	89	108	99	53	71	63	11	26	20
					B	161	303	231	133	271	204	97	283	229
					C	0,68	0,65	0,66	0,65	0,64	0,65	0,64	0,65	0,65

Conclusion:

- Not possible to calculate an absolute energy performance (boundary conditions are generic);
- Ranking does not differ significantly;
- The difference in the heating performance index comparing different design options in both types of single family houses does in general not change;
- Only comparison of windows on a relative basis;

- Definition of the borders of the classes depends on the chosen boundary conditions;
- Also the orientation has an significant influence on the solar coefficient B. The B values for the individual orientation can be used to consider also the influence of the orientation => fiche concept.

B) Influence averaging the Parameters A,B and C

To compare the influence of averaging the parameters A and B for the energy balance equation for heating the energy performance index for heating was calculated using

a) the actual A and B values

b) the average A and B values

The following three tables are showing the results of the calculation.

The parameter C does not differ significantly for the analysed design options. There is no influence using the actual C values or the averaged ones.

Table 148 Comparison of calculated Heating performance index $P_{E,H,W}$ for the northern climate using
a) actual A, B values according to the simulation (column highlighted green)
b) averaged A, B values .

					Northern Climate					
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	Single room model U_{env}=0,6		Single family house U_{env}=0,6		Single family house U_{env}=0,3	
1	5,8	0,85	30%	2	596	546	614	598	606	576
2	2,8	0,78	30%	3	202	203	192	188	196	198
3	1,7	0,65	30%	4	91	92	63	63	79	79
4	1,3	0,60	30%	4	62	62	30	30	46	47
5	1,0	0,55	30%	4	42	41	8	8	24	26
6	0,8	0,60	30%	4	22	18	-21	-24	1	-2
7	1,0	0,58	30%	4	39	38	4	2	21	21
8	0,6	0,47	30%	4	15	14	-20	-18	-3	-1
9	2,8	0,35	30%	3	275	252	284	279	282	267
10	1,3	0,35	30%	4	89	90	81	83	81	88
11	0,8	0,35	30%	4	40	46	26	29	33	38
				A	acc. to sim.	89	acc. to sim.	108	acc. to sim.	99
				B	acc. to sim.	161	acc. to sim.	303	acc. to sim.	231

Table 149 Comparison of calculated Heating performance index $P_{E,H,W}$ for the central climate using
a) actual A, B values according to the simulation (column highlighted green)
b) averaged A, B values

					Central Climate					
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	Single room model U_{env}=0,8		Single family house U_{env}=0,8		Single family house U_{env}=0,4	
1	5,8	0,85	30%	2	344	303	360	351	349	333
2	2,8	0,78	30%	3	100	101	85	84	90	95
3	1,7	0,65	30%	4	37	38	9	9	23	24
4	1,3	0,60	30%	4	21	21	-11	-10	5	6
5	1,0	0,55	30%	4	9	10	-23	-22	-7	-6
6	0,8	0,60	30%	4	-4	-5	-43	-46	-22	-25
7	1,0	0,58	30%	4	7	7	-29	-28	-11	-10
8	0,6	0,47	30%	4	-4	-4	-38	-35	-21	-19
9	2,8	0,35	30%	3	160	141	167	166	163	156
10	1,3	0,35	30%	4	42	45	32	37	35	42
11	0,8	0,35	30%	4	15	18	-5	2	4	10
				A	acc. to sim.	53	acc. to sim.	71	acc. to sim.	63
				B	acc. to sim.	133	acc. to sim.	271	acc. to sim.	204

Table 150 Comparison of calculated Heating performance index $P_{E,H,W}$ for the southern climate using
a) actual A, B values according to the simulation (column highlighted green)
b) averaged A, B values

					Southern Climate					
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	Single room model U_{env}=1,0		Single family house U_{env}=1,0		Single family house U_{env}=0,6	
1	5,8	0,85	30%	2	25	22	-11	19	-20	8
2	2,8	0,78	30%	3	-11	-17	-77	-70	-60	-60
3	1,7	0,65	30%	4	-11	-24	-78	-80	-59	-67
4	1,3	0,60	30%	4	-10	-25	-80	-81	-57	-67
5	1,0	0,55	30%	4	-9	-25	-79	-79	-56	-65
6	0,8	0,60	30%	4	-10	-30	-88	-94	-62	-77
7	1,0	0,58	30%	4	-9	-27	-84	-85	-60	-70
8	0,6	0,47	30%	4	-9	-24	-78	-73	-55	-60
9	2,8	0,35	30%	3	15	12	4	16	0	9
10	1,3	0,35	30%	4	-8	-8	-39	-31	-34	-27
11	0,8	0,35	30%	4	-10	-13	-53	-44	-42	-37
				A	acc. to sim.	11	acc. to sim.	26	acc. to sim.	20
				B	acc. to sim.	97	acc. to sim.	283	acc. to sim.	229

C) Comparison using different approaches to evaluate the energy demand for heating associated to the window

In the Task 4 report the energy demand for heating associated to the window was defined as follows: In a first step the energy demand of the room for heating was calculated with the real characteristics of the eleven window design options. In a second step the energy demand of the room for heating was calculated assuming an adiabatic window. The difference of both calculations is the energy demand for heating related to the window.

The energy balance equation (EBE) does also lead to the energy demand for heating associated to the window when using the relevant parameters A,B and C.

To show the difference of the two approaches the energy for heating associated to the window was calculated using both approaches for selected cases:

- Northern and Central Climate
- Single family house with two levels of insulation of the opaque envelope
- All eleven defined window design options without shutter
- All eleven defined window design options with shutter assuming an additional thermal resistance ΔR of 0.17 W/m2K. The calculations are for a usage scenario from sunset to sunrise

The following tables are showing the calculated figures.

Table 151 Calculated Heating performance index $P_{E,H,W}$ calculated for windows without shutters by a) the difference of "real window and adiabatic window" (green column) b) using the energy balance equation with the parameters A,B

					Northern Climate			
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	Single family house U_{env}=0,3		Single family house U_{env}=0,6	
1	5,8	0,85	30%	2	581	576	546	598
2	2,8	0,78	30%	3	197	198	170	188
3	1,7	0,65	30%	4	75	79	51	63
4	1,3	0,60	30%	4	44	47	21	30
5	1,0	0,55	30%	4	21	26	0	8
6	0,8	0,60	30%	4	-5	-2	-28	-24
7	1,0	0,58	30%	4	17	21	-5	2
8	0,6	0,47	30%	4	-7	-1	-25	-18
9	2,8	0,35	30%	3	273	267	253	279
10	1,3	0,35	30%	4	83	88	69	83
11	0,8	0,35	30%	4	32	38	19	29
				A		99		108
				B		231		303

					Central Climate			
No.	U_{window}	g_{gl}	Frame fraction	Air tight Class	Single family house U_{env}=0,4		Single family house U_{env}=0,8	
1	5,8	0,85	30%	2	343	333	316	351
2	2,8	0,78	30%	3	95	95	72	84
3	1,7	0,65	30%	4	21	24	0	9
4	1,3	0,60	30%	4	3	6	-17	-10
5	1,0	0,55	30%	4	-10	-6	-28	-22
6	0,8	0,60	30%	4	-29	-25	-48	-46
7	1,0	0,58	30%	4	-14	-10	-33	-28
8	0,6	0,47	30%	4	-25	-19	-40	-35
9	2,8	0,35	30%	3	161	156	146	166
10	1,3	0,35	30%	4	38	42	26	37
11	0,8	0,35	30%	4	5	10	-7	2
				A		63		71
				B		204		271

Table 152 Calculated Heating performance index $P_{E,H,W}$, North, Uenv 0.3

calculated for windows with a shutter by
a) the difference of "real window and adiabatic window" (green column)
b) using the energy balance equation with the parameters A,B,C

						Northern Climate	
No.	U_{window}	g_{gl}	Frame fraction	ΔR	Air tight Class	Single family house U_{env}=0,3	
1	5,8	0,85	30%	0,17	2	401	388
2	2,8	0,78	30%	0,17	3	139	139
3	1,7	0,65	30%	0,17	4	51	54
4	1,3	0,60	30%	0,17	4	28	32
5	1,0	0,55	30%	0,17	4	11	16
6	0,8	0,60	30%	0,17	4	-12	-9
7	1,0	0,58	30%	0,17	4	7	11
8	0,6	0,47	30%	0,17	4	-11	-5
9	2,8	0,35	30%	0,17	3	213	208
10	1,3	0,35	30%	0,17	4	68	72
11	0,8	0,35	30%	0,17	4	26	32
					A		99
					B		231
					C		0,66

Table 153 Calculated Heating performance index $P_{E,H,W}$, Central, Uenv 0.6

calculated for windows with a shutter by
a) the difference of "real window and adiabatic window" (green column)
b) using the energy balance equation with the parameters A,B,C

						Central Climate	
No.	U_{window}	g_{gl}	Frame fraction	ΔR	Air tight Class	Single family house U_{env}=0,4	
1	5,8	0,85	30%	0,17	2	227	215
2	2,8	0,78	30%	0,17	3	59	58
3	1,7	0,65	30%	0,17	4	6	9
4	1,3	0,60	30%	0,17	4	-7	-4
5	1,0	0,55	30%	0,17	4	-16	-12
6	0,8	0,60	30%	0,17	4	-32	-29
7	1,0	0,58	30%	0,17	4	-19	-16
8	0,6	0,47	30%	0,17	4	-27	-22
9	2,8	0,35	30%	0,17	3	122	119
10	1,3	0,35	30%	0,17	4	28	32
11	0,8	0,35	30%	0,17	4	1	6
					A		63
					B		204
					C		0,65

ANNEX II - CALCULATION OF XYZ VALUES

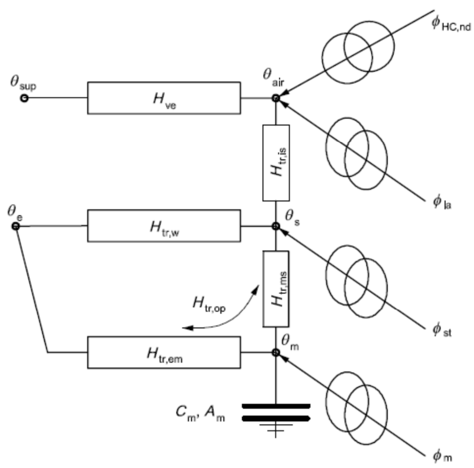
To determine the parameters X, Y and Z dynamic simulations according to the simplified hourly calculation method defined in EN ISO 13790 were carried out.

The model is a simplification of a dynamic simulation, with the following advantages:

- clearly specified, limited set of equations, enabling traceability of the calculation process;
- reduction of the input data as much as possible;
- unambiguous calculation procedures;
- with main advantage that the hourly time intervals enable direct input of hourly patterns.

EN ISO 13790 states, that the model has an adequate level of accuracy, especially for room-conditioned buildings where the thermal dynamic of the room behaviour is of high impact. The model used is based on an equivalent resistance-capacitance (R-C) model. It uses an hourly time step and all building and system input data.

Figure 12 RC network for the simple hourly method according to EN ISO 13790



To analyse the impact of different building designs on the Parameters two different "buildings" were considered.

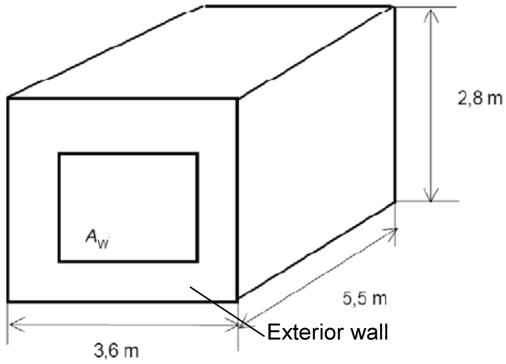
a) Single room model

The windows are “integrated” in the exterior wall of a single room defined in EN 13791. The exterior wall with the window is oriented to North, East, South and West to consider the effect of different window orientations.

Note: This single room model is also used in EN 15265 "Calculation of energy needs for space heating and cooling systems using dynamic methods- General criteria and validation procedures"

Due to the fact, that the single room model has "only" one exterior wall responsible for the heat losses by transmission it is more representing type of buildings with a high ratio of the floor area A_{floor} to the area of the building envelope A_{env}. Therefore the calculated results are more representative for such type of buildings e.g. apartment blocks.

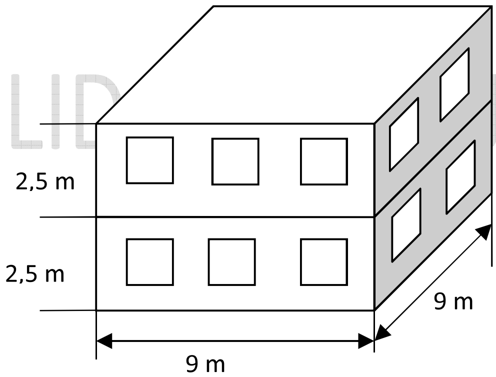
Figure 13 Single room model according to EN 13791; V = 55,4 m³; A_{floor} = 19,8 m²



b) Single family house

In contrast to apartment blocks the influence of the roof and the base plate on the total heat transmission of single family house is much higher. Therefore a two storey simple single family house was defined.

Figure 14 Simplified single family house; V = 405 m³; A_{floor} = 2x81 m²=162 m²



The orientation of the windows was assumed to be 25% on each facade. The reason for that was, that there is no evidence available, that there is in average a non-uniform distribution of windows regarding the orientation. Only one source was found stating data on the distribution of windows regarding the orientation. A study[64] analysed two different databases to evaluate the distribution of different orientations. According to the data there is no significant change of the share of windows regarding the orientation. The British Fenestration Rating Council (BFRC) informed the consultants, that also the energy balance equation in the U.K: is based on the assumption of a uniform distribution of the windows regarding the orientation.

[64] Evaluation of the energy performance of fenestration systems for residential buildings in the Belgian context, Belgian Building research Institute, November 2011

Table 154 Distribution of windows according to the orientation in Belgian single family dwellings (Source: BBRI)

Orientation	EAP	SENVIVV
N	11%	10%
NO	13%	9%
O	12%	14%
SO	13%	14%
S	15%	15%
SE	15%	14%
E	12%	15%
NE	10%	10%

The single family house was calculated by the approach of a "one-zone" model. In a one-zone model it is assumed, that there is only one representative air temperature; meaning that the temperature in different rooms is the same. Furthermore the "one-zone" model approach assumes that the solar gains achieved through a window will serve as an energy input for the complete building and not only for the room where the window is installed. The solar gains are distributed evenly; they are smoothed over the complete building. Therefore the so called utilization factor is the same for all windows.

Level of thermal insulation of the building

The degree hours for heating and cooling and also the usable solar radiation reducing the heating demand but also increasing the cooling demands depend on the insulation level of the building envelope. Therefore different levels of insulation of the opaque envelope were investigated to analyse the relevant influence.

Table 155 Level of thermal insulation of the investigated buildings

Climate		Mean U-value of the building envelope $\tilde{U}_{env}$ in W/m²K
North	Single room	0,6
	Single family house "old"	0,6
	Single family house "renovated"	0,3
Central	Single room	0,8
	Single family house "old"	0,8
	Single family house "renovated"	0,4
South	Single room	1,0
	Single family house "old"	1,0
	Single family house "renovated"	0,6

Other parameters and boundary conditions

The further following boundary conditions were assumed for the calculations

Table 156 Boundary conditions and other parameters used for the calculation in the heating season

Parameter		*Source*
Pressure Difference Δp	Δp=6 Pa	ISO 18292
Temperature set point for cooling	$T_{i,set}$ = 26°C	Table G.12 EN 13790
Heat Capacity	heavy C^*_m = 260 000 J/m²K (A_{floor})	EN ISO 13790
Ventilation rate general	n=0.5 h^{-1}	DIN 4108-2
Ventilation rate assuming ventilative cooling	n=2.0 h^{-1} for Ti>23°C and Ti>Te	DIN 4108-2 see also Table G.12 EN 13790
Internal heat sources (related to floor area)	Q_i =5 W/m²	DIN 4108-2 , see also Table G.8 EN 13790
Usage	24 h/7 days a week	
Set point for activation of the sun shading	I_{sol} > 300 W/m² and T_e > 15°C	EN ISO 13790

To analyse the influence of ventilative cooling two different scenarios were applied:

Scenario 1: no ventilative cooling; constant ventilation rate of n=0.5 h^{-1}

Scenario 2: considering ventilative cooling; with a general ventilation rate of n = 0.5 h^{-1} and an increased ventilation rate of n=2.0 h^{-1} for Ti > 23°C and Te > Ti

The factors X, Y for the energy balance for cooling were calculated with the same approaches as the factors A and B for heating.

The factor Z is the dimensionless fraction of accumulated solar radiation for the hours with solar shading closed for the days where there was a need for cooling.

The relevant standard for the calculation of energy use for space heating and cooling EN ISO 13790 states in its Annex G:

"Unless otherwise specified at national level, the solar shading shall be taken as being switched on if the intensity of the solar radiation on the surface at the given hour exceeds 300 W/m² and switched off if the hourly value is below this value."

Therefore the set point for the activation of the solar shading was defined at a level of I_{sol} = 300 W/m². The factor Z therefore is $Z = \sum_{cooling\ days} I_{sol>300W} / \sum_{cooling\ days} I_{sol}$

Note: The solar shading was activated only if the external temperature T_e was higher than 15°C.

The calculation of X,Y and Z values were calculated for the following window design options

Table 157 Analysed design options of windows

No.	U_w in W/m^2K	g	Air tightness class
1	5.8	0.85	2
2	2.8	0.78	3
3	1.7	0.65	4
4	1.3	0.60	4
5	1.0	0.55	4
6	0.8	0.60	4
7	1.0	0.58	4
8	0.6	0.47	4
9	2.8	0.35	3
10	1.3	0.35	4
11	0.8	0.35	4

Additionally the calculations were also performed assuming the windows in combination with an solar shading with a reduction factor of F_c = 0,1

The following tables are showing the calculated Parameters X, Y and Z for the energy balance equation for cooling.

The average values were calculated assuming a uniform distribution of the windows with regard to the orientation.

FAÇADE WINDOWS

NORTHERN CLIMATE

Single room model

Only values for the scenario 2 "with ventilative cooling" were calculated

Table 158 Calculated Parameters for the energy balance equation, façade windows, Northern climate, single room model U_{env}=0,6 W/m^{2}K, ventilative cooling

						Degree hour					Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X (uniform distr.)	X North	X East	X South	X West	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	0,7	0,0	1,1	0,9	0,9	29	4	38	40	34
2a	2,8	0,78	30%	1,0	3	1,3	0,1	2,0	1,8	1,6	45	6	61	62	52
3a	1,7	0,65	30%	1,0	4	1,1	0,1	1,7	1,5	1,2	43	6	59	58	49
4a	1,3	0,60	30%	1,0	4	1,0	0,1	1,6	1,3	1,1	41	5	56	55	47
5a	1,0	0,55	30%	1,0	4	0,9	0,1	1,4	1,1	1,0	37	5	51	49	43
6a	0,8	0,60	30%	1,0	4	1,2	0,1	1,8	1,6	1,3	46	6	62	62	52
7a	1,0	0,58	30%	1,0	4	1,0	0,1	1,6	1,3	1,1	41	5	56	55	47
8a	0,6	0,47	30%	1,0	4	0,6	0,0	0,9	0,7	0,7	31	4	42	42	36
9a	2,8	0,35	30%	1,0	3	0,1	0,0	0,1	0,1	0,1	11	2	14	14	13
10a	1,3	0,35	30%	1,0	4	0,1	0,0	0,2	0,2	0,2	16	3	20	21	19
11a	0,8	0,35	30%	1,0	4	0,2	0,0	0,3	0,2	0,2	18	3	23	23	21
1b	5,8	0,85	30%	0,1	2	0,0	0,0	0,0	0,0	0,0	4	4	5	5	5
2b	2,8	0,78	30%	0,1	3	0,0	0,1	0,0	0,0	0,0	7	6	7	7	7
3b	1,7	0,65	30%	0,1	4	0,0	0,1	0,0	0,0	0,0	6	5	7	7	7
4b	1,3	0,60	30%	0,1	4	0,0	0,1	0,0	0,0	0,0	6	5	7	6	7
5b	1,0	0,55	30%	0,1	4	0,0	0,0	0,0	0,0	0,0	6	5	6	6	6
6b	0,8	0,60	30%	0,1	4	0,0	0,1	0,0	0,0	0,0	7	6	7	7	8
7b	1,0	0,58	30%	0,1	4	0,0	0,1	0,0	0,0	0,0	6	5	7	6	7
8b	0,6	0,47	30%	0,1	4	0,0	0,0	0,0	0,0	0,0	5	4	6	5	6
9b	2,8	0,35	30%	0,1	3	0,0	0,0	0,0	0,0	0,0	2	2	2	2	2
10b	1,3	0,35	30%	0,1	4	0,0	0,0	0,0	0,0	0,0	3	3	3	3	3
11b	0,8	0,35	30%	0,1	4	0,0	0,0	0,0	0,0	0,0	4	3	4	4	4
			Average windows 3a-8a;3b-8b			0	0	1	1	1	23	5	30	30	26

Usage shading				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,73	0,03	0,69	0,80	0,78
0,69	0,04	0,62	0,78	0,75
0,71	0,04	0,64	0,79	0,77
0,71	0,04	0,66	0,79	0,77
0,72	0,04	0,66	0,79	0,77
0,70	0,04	0,64	0,79	0,76
0,71	0,04	0,65	0,79	0,76
0,73	0,03	0,70	0,81	0,77
0,77	0,00	0,83	0,81	0,80
0,77	0,00	0,81	0,80	0,80
0,76	0,00	0,79	0,79	0,79
0,71	0,04	0,66	0,79	0,77

Single family house

Single family house ($\widetilde{U}_{env}$ =0,6 W/m^{2}K)

Table 159 Calculated Parameters for the energy balance equation, façade windows, Northern climate, single family house U_{env}=0,6 W/m^{2}K, no ventilative cooling

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	0,9	27	14	32	31	30
2a	2,8	0,78	30%	1,0	3	2,3	52	29	62	59	58
3a	1,7	0,65	30%	1,0	4	2,5	55	31	66	63	61
4a	1,3	0,60	30%	1,0	4	2,3	55	30	66	62	61
5a	1,0	0,55	30%	1,0	4	2,1	52	29	63	59	58
6a	0,8	0,60	30%	1,0	4	2,9	64	36	77	73	71
7a	1,0	0,58	30%	1,0	4	2,4	57	32	68	65	63
8a	0,6	0,47	30%	1,0	4	1,6	47	26	56	53	52
9a	2,8	0,35	30%	1,0	3	0,2	11	6	14	13	12
10a	1,3	0,35	30%	1,0	4	0,5	22	12	27	25	24
11a	0,8	0,35	30%	1,0	4	0,7	27	15	33	31	30
1b	5,8	0,85	30%	0,1	2	0,0	6	3	7	7	6
2b	2,8	0,78	30%	0,1	3	0,2	11	6	13	12	12
3b	1,7	0,65	30%	0,1	4	0,2	13	7	16	14	14
4b	1,3	0,60	30%	0,1	4	0,2	13	8	16	15	14
5b	1,0	0,55	30%	0,1	4	0,2	13	7	16	15	14
6b	0,8	0,60	30%	0,1	4	0,3	16	9	20	18	17
7b	1,0	0,58	30%	0,1	4	0,2	14	8	17	16	15
8b	0,6	0,47	30%	0,1	4	0,2	12	7	15	14	13
9b	2,8	0,35	30%	0,1	3	0,0	4	2	5	5	5
10b	1,3	0,35	30%	0,1	4	0,0	7	4	9	8	8
11b	0,8	0,35	30%	0,1	4	0,1	9	5	11	10	10
			Average windows 3a-8a;3b-8b			1	34	19	41	39	38

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,65	0,04	0,71	0,77	0,74
0,60	0,03	0,61	0,75	0,72
0,60	0,03	0,61	0,75	0,72
0,60	0,03	0,61	0,75	0,72
0,60	0,03	0,62	0,75	0,72
0,59	0,03	0,59	0,75	0,71
0,60	0,03	0,61	0,75	0,71
0,61	0,03	0,68	0,73	0,70
0,69	0,03	0,79	0,81	0,79
0,67	0,05	0,77	0,77	0,76
0,66	0,04	0,77	0,76	0,74
0,60	0,03	0,62	0,75	0,71

Table 160 Calculated Parameters for the energy balance equation, façade windows, Northern climate, single family house U_{env}=0,6 W/m²K, ventilative cooling

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	0,2	14	7	16	16	16
2a	2,8	0,78	30%	1,0	3	0,3	19	10	22	22	21
3a	1,7	0,65	30%	1,0	4	0,3	17	9	20	19	19
4a	1,3	0,60	30%	1,0	4	0,2	15	8	18	18	17
5a	1,0	0,55	30%	1,0	4	0,2	14	7	17	16	16
6a	0,8	0,60	30%	1,0	4	0,3	17	9	20	19	19
7a	1,0	0,58	30%	1,0	4	0,2	15	8	18	18	17
8a	0,6	0,47	30%	1,0	4	0,1	12	6	14	13	13
9a	2,8	0,35	30%	1,0	3	0,0	5	3	5	5	5
10a	1,3	0,35	30%	1,0	4	0,0	6	3	7	7	7
11a	0,8	0,35	30%	1,0	4	0,0	7	4	8	8	8
1b	5,8	0,85	30%	0,1	2	0,0	3	2	4	4	4
2b	2,8	0,78	30%	0,1	3	0,0	4	2	5	5	5
3b	1,7	0,65	30%	0,1	4	0,0	4	2	5	4	4
4b	1,3	0,60	30%	0,1	4	0,0	4	2	4	4	4
5b	1,0	0,55	30%	0,1	4	0,0	3	2	4	4	4
6b	0,8	0,60	30%	0,1	4	0,0	4	2	5	5	5
7b	1,0	0,58	30%	0,1	4	0,0	4	2	4	4	4
8b	0,6	0,47	30%	0,1	4	0,0	3	2	3	3	3
9b	2,8	0,35	30%	0,1	3	0,0	1	1	1	1	1
10b	1,3	0,35	30%	0,1	4	0,0	1	1	2	2	2
11b	0,8	0,35	30%	0,1	4	0,0	2	1	2	2	2
			Average windows 3a-8a;3b-8b			0	9	5	11	11	11

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,70	0,05	0,79	0,81	0,80
0,67	0,04	0,75	0,79	0,77
0,69	0,05	0,77	0,79	0,79
0,69	0,05	0,77	0,79	0,79
0,70	0,04	0,80	0,81	0,80
0,68	0,05	0,77	0,79	0,79
0,69	0,05	0,77	0,79	0,79
0,70	0,04	0,81	0,80	0,80
0,73	0,03	0,84	0,83	0,84
0,70	0,02	0,83	0,81	0,77
0,70	0,02	0,83	0,81	0,77
0,69	0,05	0,78	0,79	0,79

Single family house ($\widetilde{U}_{env}$ =0,3 W/m²K)

Table 161 Calculated Parameters for the energy balance equation, façade windows, Northern climate, single family house U_{env}=0,3 W/m^2K, no ventilative cooling

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	1,8	44	24	53	51	49
2a	2,8	0,78	30%	1,0	3	5,7	100	56	120	114	110
3a	1,7	0,65	30%	1,0	4	6,9	120	68	143	137	132
4a	1,3	0,60	30%	1,0	4	7,2	125	71	149	143	137
5a	1,0	0,55	30%	1,0	4	7,1	127	72	151	145	139
6a	0,8	0,60	30%	1,0	4	8,8	147	84	175	168	161
7a	1,0	0,58	30%	1,0	4	7,6	134	76	159	152	146
8a	0,6	0,47	30%	1,0	4	6,6	126	71	150	143	137
9a	2,8	0,35	30%	1,0	3	0,7	30	17	36	35	33
10a	1,3	0,35	30%	1,0	4	2,3	66	37	79	75	72
11a	0,8	0,35	30%	1,0	4	3,2	83	47	100	95	92
1b	5,8	0,85	30%	0,1	2	0,1	9	5	11	10	10
2b	2,8	0,78	30%	0,1	3	1,0	32	18	39	37	35
3b	1,7	0,65	30%	0,1	4	1,6	50	28	59	56	54
4b	1,3	0,60	30%	0,1	4	1,7	55	32	66	63	61
5b	1,0	0,55	30%	0,1	4	1,8	58	33	70	66	64
6b	0,8	0,60	30%	0,1	4	2,9	75	43	91	85	82
7b	1,0	0,58	30%	0,1	4	2,1	63	36	76	71	69
8b	0,6	0,47	30%	0,1	4	1,7	61	35	73	70	67
9b	2,8	0,35	30%	0,1	3	0,1	10	5	12	11	11
10b	1,3	0,35	30%	0,1	4	0,3	24	14	29	27	25
11b	0,8	0,35	30%	0,1	4	0,6	34	19	41	39	36
			Average windows 3a-8a;3b-8b			5	95	54	114	108	104

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,61	0,03	0,61	0,76	0,73
0,55	0,03	0,50	0,72	0,69
0,53	0,02	0,48	0,71	0,67
0,53	0,02	0,48	0,70	0,67
0,53	0,02	0,48	0,70	0,67
0,52	0,02	0,46	0,69	0,65
0,53	0,02	0,48	0,70	0,66
0,54	0,02	0,49	0,71	0,68
0,64	0,04	0,74	0,75	0,73
0,59	0,02	0,64	0,73	0,70
0,59	0,02	0,60	0,74	0,70
0,53	0,02	0,48	0,70	0,67

Table 162 Calculated Parameters for the energy balance equation, façade windows, Northern climate, single family house U_{env}=0,3 W/m^{2}K, ventilative cooling

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	0,4	19	10	22	22	21
2a	2,8	0,78	30%	1,0	3	0,8	29	16	35	33	33
3a	1,7	0,65	30%	1,0	4	0,6	27	15	33	31	31
4a	1,3	0,60	30%	1,0	4	0,5	26	14	31	30	29
5a	1,0	0,55	30%	1,0	4	0,4	24	13	28	27	27
6a	0,8	0,60	30%	1,0	4	0,7	29	16	34	33	32
7a	1,0	0,58	30%	1,0	4	0,5	26	14	31	30	29
8a	0,6	0,47	30%	1,0	4	0,3	20	11	23	23	22
9a	2,8	0,35	30%	1,0	3	0,0	7	4	8	8	8
10a	1,3	0,35	30%	1,0	4	0,1	10	5	12	11	11
11a	0,8	0,35	30%	1,0	4	0,1	11	6	13	13	12
1b	5,8	0,85	30%	0,1	2	0,0	4	2	5	5	5
2b	2,8	0,78	30%	0,1	3	0,0	6	3	7	7	7
3b	1,7	0,65	30%	0,1	4	0,0	6	3	7	7	7
4b	1,3	0,60	30%	0,1	4	0,0	6	3	7	6	6
5b	1,0	0,55	30%	0,1	4	0,0	5	3	6	6	6
6b	0,8	0,60	30%	0,1	4	0,0	6	3	7	7	7
7b	1,0	0,58	30%	0,1	4	0,0	6	3	7	7	6
8b	0,6	0,47	30%	0,1	4	0,0	5	3	6	6	6
9b	2,8	0,35	30%	0,1	3	0,0	2	1	2	2	2
10b	1,3	0,35	30%	0,1	4	0,0	3	1	3	3	3
11b	0,8	0,35	30%	0,1	4	0,0	3	2	4	3	3
			Average windows 3a-8a;3b-8b			0	15	8	18	18	17

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,67	0,04	0,75	0,79	0,77
0,64	0,04	0,68	0,78	0,75
0,65	0,03	0,73	0,77	0,73
0,66	0,03	0,74	0,78	0,74
0,67	0,04	0,75	0,78	0,76
0,65	0,04	0,71	0,77	0,74
0,66	0,03	0,74	0,78	0,74
0,68	0,05	0,77	0,78	0,77
0,70	0,02	0,83	0,81	0,77
0,71	0,04	0,83	0,81	0,79
0,70	0,04	0,81	0,80	0,80
0,66	0,04	0,74	0,78	0,75

CENTRAL CLIMATE

Single room model

Only values for the scenario 2 "with ventilative cooling" were calculated

Table 163 Calculated Parameters for the energy balance equation, façade windows, Central climate, single room model U_{env}=0,8 W/m^{2}K, ventilative cooling

						Degree hour					Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X (uniform distr.)	X North	X East	X South	X West	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	0,3	-0,2	0,7	0,2	0,6	61	22	84	67	71
2a	2,8	0,78	30%	1,0	3	0,9	-0,1	1,4	0,9	1,2	82	29	115	90	95
3a	1,7	0,65	30%	1,0	4	0,7	-0,1	1,2	0,6	1,0	81	29	113	88	94
4a	1,3	0,60	30%	1,0	4	0,6	-0,1	1,1	0,5	0,8	79	29	111	86	92
5a	1,0	0,55	30%	1,0	4	0,4	-0,1	0,9	0,4	0,7	76	28	106	83	88
6a	0,8	0,60	30%	1,0	4	0,7	-0,1	1,3	0,7	1,1	86	31	120	93	99
7a	1,0	0,58	30%	1,0	4	0,6	-0,1	1,1	0,5	0,8	80	29	112	87	93
8a	0,6	0,47	30%	1,0	4	0,3	-0,1	0,6	0,1	0,4	70	26	96	76	80
9a	2,8	0,35	30%	1,0	3	-0,2	-0,2	-0,3	-0,3	-0,1	36	16	47	40	42
10a	1,3	0,35	30%	1,0	4	-0,1	-0,1	-0,1	-0,2	0,0	47	19	62	51	54
11a	0,8	0,35	30%	1,0	4	-0,1	-0,1	0,0	-0,2	0,0	51	21	68	56	59
1b	5,8	0,85	30%	0,1	2	-0,2	-0,2	-0,2	-0,2	-0,2	27	22	32	26	28
2b	2,8	0,78	30%	0,1	3	-0,1	-0,1	-0,1	-0,1	-0,1	35	29	42	33	36
3b	1,7	0,65	30%	0,1	4	-0,1	-0,1	-0,1	-0,1	-0,1	35	29	42	33	36
4b	1,3	0,60	30%	0,1	4	-0,1	-0,1	-0,1	-0,1	-0,1	34	29	40	33	35
5b	1,0	0,55	30%	0,1	4	-0,1	-0,1	-0,1	-0,1	-0,1	33	28	39	32	34
6b	0,8	0,60	30%	0,1	4	-0,1	-0,1	-0,1	-0,1	-0,1	38	31	45	36	39
7b	1,0	0,58	30%	0,1	4	-0,1	-0,1	-0,1	-0,1	-0,1	35	29	41	33	36
8b	0,6	0,47	30%	0,1	4	-0,1	-0,1	-0,1	-0,1	-0,1	31	26	35	30	33
9b	2,8	0,35	30%	0,1	3	-0,2	-0,2	-0,2	-0,1	-0,1	20	16	23	20	22
10b	1,3	0,35	30%	0,1	4	-0,1	-0,1	-0,1	-0,1	-0,1	24	19	27	24	26
11b	0,8	0,35	30%	0,1	4	-0,1	-0,1	-0,1	-0,1	-0,1	26	21	28	25	28
			Average windows 3a-8a;3b-8b			0	0	0	0	0	57	29	75	59	63

Usage shading				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,57	0,00	0,59	0,66	0,64
0,57	0,00	0,57	0,68	0,64
0,57	0,00	0,57	0,68	0,63
0,57	0,00	0,58	0,67	0,64
0,57	0,00	0,58	0,67	0,64
0,56	0,00	0,57	0,67	0,63
0,56	0,00	0,58	0,67	0,63
0,57	0,00	0,59	0,66	0,64
0,57	0,00	0,63	0,62	0,66
0,59	0,00	0,63	0,66	0,68
0,59	0,00	0,64	0,66	0,68
0,57	0,00	0,58	0,67	0,64

Single family house

Single family house ($\widetilde{U}_{env}$ =0,8 W/m²K)

Table 164 Calculated Parameters for the energy balance equation, façade windows, Central climate, single family house U_{env}=0,8 W/m²K, no ventilative cooling

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	0,4	51	33	62	54	57
2a	2,8	0,78	30%	1,0	3	1,3	76	48	92	80	84
3a	1,7	0,65	30%	1,0	4	1,5	79	51	95	83	87
4a	1,3	0,60	30%	1,0	4	1,4	78	50	94	82	86
5a	1,0	0,55	30%	1,0	4	1,3	76	49	91	80	84
6a	0,8	0,60	30%	1,0	4	1,7	86	55	104	90	94
7a	1,0	0,58	30%	1,0	4	1,5	80	51	97	84	88
8a	0,6	0,47	30%	1,0	4	1,0	71	46	84	74	78
9a	2,8	0,35	30%	1,0	3	0,0	36	25	43	38	40
10a	1,3	0,35	30%	1,0	4	0,2	48	33	56	50	52
11a	0,8	0,35	30%	1,0	4	0,4	53	36	62	55	58
1b	5,8	0,85	30%	0,1	2	-0,1	27	20	32	27	29
2b	2,8	0,78	30%	0,1	3	0,2	38	27	45	39	41
3b	1,7	0,65	30%	0,1	4	0,3	41	29	48	42	44
4b	1,3	0,60	30%	0,1	4	0,3	41	30	48	42	44
5b	1,0	0,55	30%	0,1	4	0,3	40	29	48	41	43
6b	0,8	0,60	30%	0,1	4	0,4	45	32	54	46	49
7b	1,0	0,58	30%	0,1	4	0,3	42	30	50	43	45
8b	0,6	0,47	30%	0,1	4	0,2	39	29	46	40	41
9b	2,8	0,35	30%	0,1	3	0,0	24	18	28	24	25
10b	1,3	0,35	30%	0,1	4	0,1	29	23	34	29	31
11b	0,8	0,35	30%	0,1	4	0,1	32	24	37	32	34
			Average windows 3a-8a;3b-8b			1	60	40	72	62	65

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,51	0,00	0,59	0,63	0,61
0,49	0,00	0,57	0,61	0,59
0,50	0,00	0,57	0,61	0,60
0,51	0,00	0,59	0,62	0,60
0,51	0,00	0,59	0,63	0,61
0,49	0,00	0,56	0,60	0,59
0,51	0,00	0,59	0,62	0,60
0,51	0,00	0,60	0,63	0,60
0,49	0,00	0,59	0,59	0,60
0,50	0,00	0,60	0,61	0,61
0,50	0,00	0,61	0,60	0,59
0,50	0,00	0,58	0,62	0,60

Table 165 Calculated Parameters for the energy balance equation, façade windows, Central climate, single family house U_{env}=0,8 W/m²K, ventilative cooling

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	-0,2	36	23	43	38	40
2a	2,8	0,78	30%	1,0	3	0,0	42	27	51	45	47
3a	1,7	0,65	30%	1,0	4	-0,1	39	26	47	41	44
4a	1,3	0,60	30%	1,0	4	-0,1	38	25	45	40	42
5a	1,0	0,55	30%	1,0	4	-0,2	36	24	42	37	39
6a	0,8	0,60	30%	1,0	4	-0,1	40	26	47	41	44
7a	1,0	0,58	30%	1,0	4	-0,1	37	25	44	39	41
8a	0,6	0,47	30%	1,0	4	-0,2	32	21	37	33	35
9a	2,8	0,35	30%	1,0	3	-0,2	20	14	24	21	22
10a	1,3	0,35	30%	1,0	4	-0,2	23	16	27	24	25
11a	0,8	0,35	30%	1,0	4	-0,2	24	17	28	24	26
1b	5,8	0,85	30%	0,1	2	-0,2	19	14	23	19	20
2b	2,8	0,78	30%	0,1	3	-0,1	22	16	26	22	23
3b	1,7	0,65	30%	0,1	4	-0,1	21	16	25	21	22
4b	1,3	0,60	30%	0,1	4	-0,1	20	16	24	20	21
5b	1,0	0,55	30%	0,1	4	-0,1	20	15	23	20	21
6b	0,8	0,60	30%	0,1	4	-0,1	21	16	25	21	22
7b	1,0	0,58	30%	0,1	4	-0,1	20	15	24	20	21
8b	0,6	0,47	30%	0,1	4	-0,1	19	14	22	19	20
9b	2,8	0,35	30%	0,1	3	-0,1	15	11	18	15	15
10b	1,3	0,35	30%	0,1	4	-0,1	16	12	19	16	17
11b	0,8	0,35	30%	0,1	4	-0,1	17	13	19	17	18
			Average windows 3a-8a;3b-8b			0	28	20	34	29	31

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,54	0,00	0,62	0,65	0,64
0,54	0,00	0,61	0,67	0,66
0,53	0,00	0,62	0,65	0,64
0,53	0,00	0,62	0,64	0,65
0,53	0,00	0,62	0,64	0,65
0,53	0,00	0,62	0,65	0,65
0,53	0,00	0,62	0,64	0,65
0,51	0,00	0,61	0,62	0,62
0,50	0,00	0,62	0,61	0,60
0,51	0,00	0,62	0,61	0,61
0,51	0,00	0,62	0,61	0,61
0,53	0,00	0,62	0,64	0,64

Single family house ($\widetilde{U}_{env}$ =0,4 W/m^{2}K)

Table 166 Calculated Parameters for the energy balance equation, façade windows, Central climate, single family house U_{env}=0,4 W/m^{2}K, no ventilative cooling

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	1,3	79	50	95	83	87
2a	2,8	0,78	30%	1,0	3	4,2	134	86	162	140	147
3a	1,7	0,65	30%	1,0	4	5,2	153	98	185	160	168
4a	1,3	0,60	30%	1,0	4	5,3	158	102	190	165	173
5a	1,0	0,55	30%	1,0	4	5,2	159	103	192	167	175
6a	0,8	0,60	30%	1,0	4	6,5	176	114	212	184	193
7a	1,0	0,58	30%	1,0	4	5,6	165	106	199	173	181
8a	0,6	0,47	30%	1,0	4	4,9	159	103	192	167	175
9a	2,8	0,35	30%	1,0	3	0,6	68	45	80	71	74
10a	1,3	0,35	30%	1,0	4	2,0	108	70	130	114	119
11a	0,8	0,35	30%	1,0	4	2,7	125	81	151	132	137
1b	5,8	0,85	30%	0,1	2	0,1	39	28	47	40	43
2b	2,8	0,78	30%	0,1	3	1,4	78	53	93	82	85
3b	1,7	0,65	30%	0,1	4	2,0	98	65	117	103	107
4b	1,3	0,60	30%	0,1	4	2,1	104	69	124	109	114
5b	1,0	0,55	30%	0,1	4	2,2	107	71	128	113	117
6b	0,8	0,60	30%	0,1	4	3,0	123	81	147	129	135
7b	1,0	0,58	30%	0,1	4	2,4	112	74	134	118	122
8b	0,6	0,47	30%	0,1	4	2,1	110	73	131	116	120
9b	2,8	0,35	30%	0,1	3	0,1	40	30	47	41	43
10b	1,3	0,35	30%	0,1	4	0,6	69	47	82	72	74
11b	0,8	0,35	30%	0,1	4	1,0	83	56	98	87	90
			Average windows 3a-8a;3b-8b			4	135	88	163	142	148

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,49	0,00	0,56	0,59	0,59
0,46	0,00	0,50	0,58	0,58
0,46	0,00	0,50	0,57	0,57
0,46	0,00	0,50	0,57	0,57
0,46	0,00	0,50	0,57	0,57
0,46	0,00	0,50	0,58	0,58
0,46	0,00	0,50	0,57	0,57
0,46	0,00	0,50	0,57	0,58
0,51	0,00	0,60	0,62	0,60
0,49	0,00	0,56	0,60	0,59
0,47	0,00	0,54	0,57	0,56
0,46	0,00	0,50	0,57	0,58

Table 167 Calculated Parameters for the energy balance equation, façade windows, Central climate, single family house U_{env}=0,4 W/m²K, ventilative cooling

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	0,0	46	30	56	49	52
2a	2,8	0,78	30%	1,0	3	0,3	61	39	73	64	68
3a	1,7	0,65	30%	1,0	4	0,2	59	38	70	62	66
4a	1,3	0,60	30%	1,0	4	0,2	57	37	68	60	64
5a	1,0	0,55	30%	1,0	4	0,1	54	35	65	57	60
6a	0,8	0,60	30%	1,0	4	0,2	61	39	73	64	68
7a	1,0	0,58	30%	1,0	4	0,2	57	37	68	60	64
8a	0,6	0,47	30%	1,0	4	-0,1	49	32	58	51	54
9a	2,8	0,35	30%	1,0	3	-0,2	28	19	32	29	30
10a	1,3	0,35	30%	1,0	4	-0,2	33	23	38	35	36
11a	0,8	0,35	30%	1,0	4	-0,2	36	25	41	37	39
1b	5,8	0,85	30%	0,1	2	-0,2	24	17	28	24	25
2b	2,8	0,78	30%	0,1	3	-0,1	29	22	34	29	31
3b	1,7	0,65	30%	0,1	4	-0,1	28	21	33	28	30
4b	1,3	0,60	30%	0,1	4	-0,1	28	21	32	28	30
5b	1,0	0,55	30%	0,1	4	-0,1	27	21	31	27	29
6b	0,8	0,60	30%	0,1	4	-0,1	29	22	34	30	32
7b	1,0	0,58	30%	0,1	4	-0,1	28	21	32	28	30
8b	0,6	0,47	30%	0,1	4	-0,1	25	20	29	25	27
9b	2,8	0,35	30%	0,1	3	-0,1	18	14	21	18	20
10b	1,3	0,35	30%	0,1	4	-0,1	21	16	24	21	22
11b	0,8	0,35	30%	0,1	4	-0,1	22	17	25	22	23
			Average windows 3a-8a;3b-8b			0	42	29	49	43	46

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,52	0,00	0,59	0,65	0,63
0,51	0,00	0,58	0,64	0,62
0,52	0,00	0,59	0,64	0,62
0,52	0,00	0,59	0,65	0,63
0,53	0,00	0,60	0,66	0,64
0,52	0,00	0,59	0,64	0,62
0,52	0,00	0,59	0,65	0,63
0,54	0,00	0,62	0,66	0,65
0,51	0,00	0,62	0,61	0,61
0,50	0,00	0,60	0,60	0,61
0,50	0,00	0,60	0,61	0,62
0,52	0,00	0,60	0,65	0,63

SOUTHERN CLIMATE

Single room model

Only values for the scenario 2 "with ventilative cooling" were calculated

Table 168 Calculated Parameters for the energy balance equation, façade windows, Southern climate, single room model U_{env}=1,0 W/m²K, ventilative cooling

						Degree hour					Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X (uniform distr.)	X North	X East	X South	X West	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	-3,5	-4,7	-3,4	-3,0	-3,0	340	157	416	366	420
2a	2,8	0,78	30%	1,0	3	-2,5	-4,4	-2,4	-1,2	-2,1	386	178	469	425	472
3a	1,7	0,65	30%	1,0	4	-2,8	-4,4	-2,6	-1,9	-2,2	393	183	478	429	482
4a	1,3	0,60	30%	1,0	4	-2,9	-4,4	-2,8	-2,1	-2,4	394	185	480	428	484
5a	1,0	0,55	30%	1,0	4	-3,1	-4,4	-2,9	-2,5	-2,6	393	186	479	424	483
6a	0,8	0,60	30%	1,0	4	-2,7	-4,3	-2,5	-1,7	-2,2	405	190	492	442	495
7a	1,0	0,58	30%	1,0	4	-2,9	-4,4	-2,8	-2,2	-2,4	397	187	484	431	488
8a	0,6	0,47	30%	1,0	4	-3,4	-4,5	-3,3	-3,1	-3,0	389	186	475	416	479
9a	2,8	0,35	30%	1,0	3	-4,5	-4,9	-4,5	-4,5	-4,3	326	158	402	336	407
10a	1,3	0,35	30%	1,0	4	-4,2	-4,8	-4,2	-4,1	-3,9	355	171	436	371	441
11a	0,8	0,35	30%	1,0	4	-4,1	-4,7	-4,1	-4,0	-3,8	365	176	447	383	452
1b	5,8	0,85	30%	0,1	2	-4,9	-4,7	-4,9	-4,9	-4,9	279	157	343	271	344
2b	2,8	0,78	30%	0,1	3	-4,6	-4,4	-4,7	-4,7	-4,7	314	178	384	309	386
3b	1,7	0,65	30%	0,1	4	-4,6	-4,4	-4,7	-4,6	-4,7	325	183	397	321	399
4b	1,3	0,60	30%	0,1	4	-4,6	-4,4	-4,7	-4,7	-4,7	328	185	400	325	403
5b	1,0	0,55	30%	0,1	4	-4,6	-4,4	-4,7	-4,7	-4,7	330	186	402	327	404
6b	0,8	0,60	30%	0,1	4	-4,5	-4,3	-4,6	-4,6	-4,7	337	190	411	335	414
7b	1,0	0,58	30%	0,1	4	-4,6	-4,4	-4,7	-4,6	-4,7	332	187	405	329	407
8b	0,6	0,47	30%	0,1	4	-4,7	-4,5	-4,7	-4,7	-4,8	331	186	404	328	406
9b	2,8	0,35	30%	0,1	3	-4,9	-4,9	-4,9	-4,9	-5,0	285	158	352	278	353
10b	1,3	0,35	30%	0,1	4	-4,8	-4,8	-4,9	-4,8	-4,9	308	171	378	303	379
11b	0,8	0,35	30%	0,1	4	-4,8	-4,7	-4,8	-4,8	-4,9	316	176	388	312	389
		Average windows 2a-4a,9a,10a; 2b-4b,9b,10b				-4	-5	-4	-4	-4	341	175	418	352	420

Usage shading				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,68	0,00	0,77	0,76	0,77
0,67	0,00	0,76	0,76	0,77
0,68	0,00	0,76	0,76	0,77
0,68	0,00	0,76	0,76	0,77
0,68	0,00	0,77	0,76	0,77
0,67	0,00	0,76	0,76	0,77
0,68	0,00	0,77	0,76	0,77
0,67	0,00	0,77	0,76	0,77
0,67	0,00	0,78	0,73	0,77
0,67	0,00	0,77	0,74	0,77
0,67	0,00	0,77	0,74	0,77
0,68	0,00	0,76	0,76	0,77

Single family house

Single family house ($\widetilde{U}_{env}$ =1,0 W/m^{2}K)

Table 169 Calculated Parameters for the energy balance equation, façade windows, Southern climate, single family house U_{env}=1,0 W/m^{2}K, no ventilative cooling

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	-3,3	296	159	362	300	364
2a	2,8	0,78	30%	1,0	3	-2,3	335	180	407	343	410
3a	1,7	0,65	30%	1,0	4	-2,3	343	184	416	352	419
4a	1,3	0,60	30%	1,0	4	-2,3	344	185	418	353	421
5a	1,0	0,55	30%	1,0	4	-2,4	344	185	418	352	421
6a	0,8	0,60	30%	1,0	4	-2,1	353	189	428	363	431
7a	1,0	0,58	30%	1,0	4	-2,3	347	186	422	356	424
8a	0,6	0,47	30%	1,0	4	-2,6	341	184	415	348	418
9a	2,8	0,35	30%	1,0	3	-4,0	289	156	355	289	355
10a	1,3	0,35	30%	1,0	4	-3,5	313	169	384	316	385
11a	0,8	0,35	30%	1,0	4	-3,3	322	174	393	325	394
1b	5,8	0,85	30%	0,1	2	-4,5	254	138	314	252	314
2b	2,8	0,78	30%	0,1	3	-4,0	286	155	351	286	352
3b	1,7	0,65	30%	0,1	4	-3,9	296	160	363	297	364
4b	1,3	0,60	30%	0,1	4	-3,9	299	161	366	300	367
5b	1,0	0,55	30%	0,1	4	-3,9	300	162	368	301	368
6b	0,8	0,60	30%	0,1	4	-3,8	306	165	375	308	376
7b	1,0	0,58	30%	0,1	4	-3,8	302	163	370	303	371
8b	0,6	0,47	30%	0,1	4	-3,9	301	162	369	302	369
9b	2,8	0,35	30%	0,1	3	-4,4	263	142	325	260	325
10b	1,3	0,35	30%	0,1	4	-4,2	283	153	348	282	348
11b	0,8	0,35	30%	0,1	4	-4,1	290	156	356	290	356
		Average windows 2a-4a,9a,10a; 2b-4b,9b,10b				-3	305	165	373	308	375

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,66	0,00	0,77	0,73	0,77
0,66	0,00	0,77	0,74	0,77
0,66	0,00	0,77	0,74	0,77
0,66	0,00	0,77	0,73	0,77
0,66	0,00	0,77	0,73	0,77
0,66	0,00	0,77	0,74	0,77
0,66	0,00	0,77	0,73	0,77
0,66	0,00	0,77	0,73	0,77
0,65	0,00	0,78	0,71	0,77
0,65	0,00	0,77	0,72	0,77
0,65	0,00	0,77	0,72	0,77
0,66	0,00	0,77	0,73	0,77

Table 170 Calculated Parameters for the energy balance equation, façade windows, Southern climate, single family house U_{env}=1,0 W/m^{2}K, ventilative cooling

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	-4,4	267	144	329	267	330
2a	2,8	0,78	30%	1,0	3	-4,1	291	157	356	291	358
3a	1,7	0,65	30%	1,0	4	-4,2	291	157	358	291	359
4a	1,3	0,60	30%	1,0	4	-4,3	291	157	358	290	359
5a	1,0	0,55	30%	1,0	4	-4,4	289	156	356	288	356
6a	0,8	0,60	30%	1,0	4	-4,2	296	160	364	296	365
7a	1,0	0,58	30%	1,0	4	-4,3	292	158	359	291	360
8a	0,6	0,47	30%	1,0	4	-4,5	285	154	351	283	351
9a	2,8	0,35	30%	1,0	3	-4,8	253	137	313	248	313
10a	1,3	0,35	30%	1,0	4	-4,7	265	144	328	261	328
11a	0,8	0,35	30%	1,0	4	-4,7	269	146	333	266	333
1b	5,8	0,85	30%	0,1	2	-4,9	233	126	289	227	289
2b	2,8	0,78	30%	0,1	3	-4,8	250	136	310	245	310
3b	1,7	0,65	30%	0,1	4	-4,8	254	138	314	248	314
4b	1,3	0,60	30%	0,1	4	-4,8	254	138	315	248	315
5b	1,0	0,55	30%	0,1	4	-4,8	254	138	315	248	315
6b	0,8	0,60	30%	0,1	4	-4,8	258	140	320	252	320
7b	1,0	0,58	30%	0,1	4	-4,8	256	139	317	250	317
8b	0,6	0,47	30%	0,1	4	-4,8	253	138	315	247	315
9b	2,8	0,35	30%	0,1	3	-4,9	234	127	292	227	292
10b	1,3	0,35	30%	0,1	4	-4,8	244	132	303	236	303
11b	0,8	0,35	30%	0,1	4	-4,8	247	134	307	240	307
		Average windows 2a-4a,9a,10a; 2b-4b,9b,10b				-5	263	142	325	259	325

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,65	0,00	0,77	0,73	0,77
0,65	0,00	0,77	0,73	0,77
0,65	0,00	0,77	0,72	0,77
0,65	0,00	0,77	0,72	0,77
0,65	0,00	0,77	0,72	0,77
0,65	0,00	0,77	0,72	0,77
0,65	0,00	0,77	0,72	0,77
0,66	0,00	0,77	0,72	0,77
0,66	0,00	0,78	0,72	0,77
0,66	0,00	0,78	0,71	0,77
0,66	0,00	0,78	0,71	0,78
0,66	0,00	0,77	0,72	0,77

Single family house ($\widetilde{U}_{env}$ =0,6 W/m²K)

Table 171 Calculated Parameters for the energy balance equation, façade windows, Southern climate, single family house U_{env}=0,6 W/m²K, no ventilative cooling

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	-2,4	338	181	410	347	413
2a	2,8	0,78	30%	1,0	3	-0,1	395	210	476	413	480
3a	1,7	0,65	30%	1,0	4	0,2	411	219	496	431	499
4a	1,3	0,60	30%	1,0	4	0,2	415	221	500	436	504
5a	1,0	0,55	30%	1,0	4	0,0	417	222	502	437	506
6a	0,8	0,60	30%	1,0	4	0,9	429	229	517	452	520
7a	1,0	0,58	30%	1,0	4	0,4	421	224	507	442	511
8a	0,6	0,47	30%	1,0	4	-0,3	417	223	502	437	507
9a	2,8	0,35	30%	1,0	3	-3,1	344	185	419	351	421
10a	1,3	0,35	30%	1,0	4	-2,0	383	206	464	396	467
11a	0,8	0,35	30%	1,0	4	-1,6	396	212	478	411	482
1b	5,8	0,85	30%	0,1	2	-4,2	288	156	354	288	355
2b	2,8	0,78	30%	0,1	3	-3,2	340	183	415	346	417
3b	1,7	0,65	30%	0,1	4	-2,7	361	194	439	369	441
4b	1,3	0,60	30%	0,1	4	-2,6	367	198	446	376	449
5b	1,0	0,55	30%	0,1	4	-2,6	371	200	450	380	453
6b	0,8	0,60	30%	0,1	4	-2,4	380	204	461	391	464
7b	1,0	0,58	30%	0,1	4	-2,5	373	201	453	383	456
8b	0,6	0,47	30%	0,1	4	-2,6	375	202	456	385	459
9b	2,8	0,35	30%	0,1	3	-4,1	309	167	379	312	380
10b	1,3	0,35	30%	0,1	4	-3,5	346	186	422	352	423
11b	0,8	0,35	30%	0,1	4	-3,2	358	193	436	365	438
		Average windows 2a-4a,9a,10a; 2b-4b,9b,10b				-2	367	197	446	378	448

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,66	0,00	0,77	0,74	0,77
0,65	0,00	0,75	0,73	0,76
0,65	0,00	0,75	0,73	0,76
0,65	0,00	0,75	0,73	0,76
0,65	0,00	0,76	0,73	0,76
0,65	0,00	0,75	0,73	0,76
0,65	0,00	0,75	0,73	0,76
0,65	0,00	0,76	0,73	0,76
0,65	0,00	0,77	0,72	0,77
0,66	0,00	0,77	0,73	0,77
0,65	0,00	0,76	0,73	0,77
0,65	0,00	0,76	0,73	0,76

Table 172 Calculated Parameters for the energy balance equation, façade windows, Southern climate, single family house U_{env}=0,6 W/m^{2}K, ventilative cooling

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	-4,1	296	159	362	297	364
2a	2,8	0,78	30%	1,0	3	-3,6	328	177	401	332	403
3a	1,7	0,65	30%	1,0	4	-3,7	332	179	406	336	408
4a	1,3	0,60	30%	1,0	4	-3,8	332	179	406	336	408
5a	1,0	0,55	30%	1,0	4	-3,9	331	178	405	334	407
6a	0,8	0,60	30%	1,0	4	-3,7	340	183	415	344	417
7a	1,0	0,58	30%	1,0	4	-3,8	334	180	409	338	411
8a	0,6	0,47	30%	1,0	4	-4,1	327	176	401	328	402
9a	2,8	0,35	30%	1,0	3	-4,7	282	152	348	279	348
10a	1,3	0,35	30%	1,0	4	-4,6	300	162	370	299	370
11a	0,8	0,35	30%	1,0	4	-4,5	307	166	378	306	378
1b	5,8	0,85	30%	0,1	2	-4,9	254	138	315	249	315
2b	2,8	0,78	30%	0,1	3	-4,7	279	151	345	276	345
3b	1,7	0,65	30%	0,1	4	-4,7	285	155	352	281	352
4b	1,3	0,60	30%	0,1	4	-4,7	286	155	354	283	354
5b	1,0	0,55	30%	0,1	4	-4,7	287	155	354	283	354
6b	0,8	0,60	30%	0,1	4	-4,6	292	158	360	289	361
7b	1,0	0,58	30%	0,1	4	-4,7	289	157	356	285	356
8b	0,6	0,47	30%	0,1	4	-4,7	286	155	353	282	353
9b	2,8	0,35	30%	0,1	3	-4,9	257	139	319	250	319
10b	1,3	0,35	30%	0,1	4	-4,8	270	147	335	264	335
11b	0,8	0,35	30%	0,1	4	-4,8	275	149	341	270	341
		Average windows 2a-4a,9a,10a; 2b-4b,9b,10b				-4	295	160	363	294	364

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,66	0,00	0,77	0,73	0,77
0,66	0,00	0,77	0,73	0,77
0,66	0,00	0,77	0,73	0,77
0,65	0,00	0,77	0,73	0,77
0,65	0,00	0,77	0,73	0,77
0,66	0,00	0,77	0,73	0,77
0,65	0,00	0,77	0,73	0,77
0,65	0,00	0,77	0,72	0,77
0,66	0,00	0,78	0,72	0,78
0,66	0,00	0,78	0,71	0,78
0,65	0,00	0,78	0,72	0,77
0,66	0,00	0,77	0,73	0,77

ROOF WINDOWS

Due to the amount of data only roof windows with an inclination of 40° were calculated

NORTHERN CLIMATE

Single room model

Uenv 0.6 W/(m2*K)

						Degree hour					Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X (uniform distr.)	X North	X East	X South	X West	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5.8	0.85	30%	1.0	2	1.9	0.5	2.3	2.9	1.9	76	20	86	123	76
2a	2.8	0.78	30%	1.0	3	3.2	1.2	3.7	4.8	3.2	112	35	128	174	111
3a	1.7	0.65	30%	1.0	4	2.8	1.0	3.4	4.1	2.8	108	34	124	167	106
4a	1.3	0.60	30%	1.0	4	2.6	0.9	3.1	3.7	2.5	103	32	118	160	102
5a	1.0	0.55	30%	1.0	4	2.2	0.7	2.8	3.2	2.2	96	29	110	150	95
6a	0.8	0.60	30%	1.0	4	2.9	1.0	3.5	4.2	2.9	113	36	130	174	111
7a	1.0	0.58	30%	1.0	4	2.5	0.9	3.1	3.6	2.5	104	32	119	161	102
8a	0.6	0.47	30%	1.0	4	1.7	0.5	2.0	2.6	1.6	82	24	92	131	80
9a	2.8	0.35	30%	1.0	3	0.3	0.0	0.3	0.5	0.3	29	8	30	47	29
10a	1.3	0.35	30%	1.0	4	0.5	0.1	0.6	0.9	0.5	41	11	45	67	42
11a	0.8	0.35	30%	1.0	4	0.6	0.1	0.8	1.1	0.6	47	13	52	76	46
1b	5.8	0.85	30%	0.1	2	0.0	0.2	0.0	0.0	0.0	8	11	7	8	6
2b	2.8	0.78	30%	0.1	3	0.2	0.4	0.0	0.2	0.0	12	18	10	12	9
3b	1.7	0.65	30%	0.1	4	0.1	0.4	0.0	0.1	0.0	12	18	11	11	9
4b	1.3	0.60	30%	0.1	4	0.1	0.3	0.0	0.0	0.0	12	17	10	11	9
5b	1.0	0.55	30%	0.1	4	0.1	0.2	0.0	0.0	0.0	11	16	10	10	8
6b	0.8	0.60	30%	0.1	4	0.1	0.4	0.0	0.1	0.0	13	20	12	12	10
7b	1.0	0.58	30%	0.1	4	0.1	0.3	0.0	0.0	0.0	12	17	10	11	9
8b	0.6	0.47	30%	0.1	4	0.0	0.2	0.0	0.0	0.0	10	13	8	9	7
9b	2.8	0.35	30%	0.1	3	0.0	0.0	0.0	0.0	0.0	4	6	3	3	2
10b	1.3	0.35	30%	0.1	4	0.0	0.0	0.0	0.0	0.0	6	7	5	5	4
11b	0.8	0.35	30%	0.1	4	0.0	0.0	0.0	0.0	0.0	6	8	6	6	5
Average windows 3a-8a;3b-8b						1.3	0.6	1.5	1.8	1.2	56	24	63	84	54
Average windows 3a-8a;3b-8b					NO SHADING	2.4	0.8	3.0	3.6	2.4	100.8	31.1	115.4	157.2	99.4
Average windows 3a-8a;3b-8b					SHADING	0.1	0.3	0.0	0.0	0.0	11.6	16.8	10.1	10.7	8.8

Usage shading				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0.78	0.36	0.71	0.85	0.86
0.71	0.32	0.67	0.74	0.84
0.74	0.33	0.68	0.79	0.84
0.74	0.32	0.68	0.80	0.85
0.76	0.33	0.69	0.85	0.85
0.73	0.33	0.68	0.78	0.84
0.74	0.32	0.68	0.80	0.85
0.78	0.33	0.73	0.86	0.85
0.85	0.39	0.86	0.91	0.87
0.83	0.37	0.82	0.89	0.87
0.83	0.39	0.81	0.89	0.86
0.75	0.33	0.69	0.81	0.85

Single family house

Single family house ($\widetilde{U}_{env}$ =0,6 W/m²K)

Table 173 Calculated Parameters for the energy balance equation, roof windows, Northern climate, single family house U_{env}=0,6 W/m²K, no ventilative cooling; 40° inclination

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	0,9	39	25	42	48	40
2a	2,8	0,78	30%	1,0	3	2,3	75	50	82	92	77
3a	1,7	0,65	30%	1,0	4	2,5	80	54	87	98	82
4a	1,3	0,60	30%	1,0	4	2,3	79	53	86	97	81
5a	1,0	0,55	30%	1,0	4	2,1	75	51	82	93	77
6a	0,8	0,60	30%	1,0	4	2,9	93	62	101	114	94
7a	1,0	0,58	30%	1,0	4	2,4	82	55	89	101	84
8a	0,6	0,47	30%	1,0	4	1,6	67	45	73	83	69
9a	2,8	0,35	30%	1,0	3	0,2	16	11	18	20	17
10a	1,3	0,35	30%	1,0	4	0,5	32	21	35	39	32
11a	0,8	0,35	30%	1,0	4	0,7	39	26	43	48	40
1b	5,8	0,85	30%	0,1	2	0,0	8	6	9	10	9
2b	2,8	0,78	30%	0,1	3	0,2	15	11	17	19	15
3b	1,7	0,65	30%	0,1	4	0,2	18	13	20	22	18
4b	1,3	0,60	30%	0,1	4	0,2	19	13	21	23	19
5b	1,0	0,55	30%	0,1	4	0,2	19	13	21	23	19
6b	0,8	0,60	30%	0,1	4	0,3	23	16	26	28	23
7b	1,0	0,58	30%	0,1	4	0,2	20	14	22	25	20
8b	0,6	0,47	30%	0,1	4	0,2	18	12	20	22	18
9b	2,8	0,35	30%	0,1	3	0,0	6	4	6	8	6
10b	1,3	0,35	30%	0,1	4	0,0	11	7	12	13	11
11b	0,8	0,35	30%	0,1	4	0,1	13	8	14	16	13
		Average windows 3a-8a;3b-8b				1	50	33	54	61	50

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,77	0,32	0,82	0,90	0,85
0,73	0,26	0,74	0,87	0,84
0,73	0,26	0,74	0,87	0,84
0,73	0,26	0,75	0,87	0,83
0,73	0,26	0,75	0,88	0,84
0,72	0,26	0,73	0,87	0,83
0,72	0,25	0,74	0,87	0,83
0,74	0,27	0,79	0,88	0,83
0,79	0,25	0,87	0,92	0,89
0,78	0,31	0,86	0,90	0,85
0,77	0,31	0,85	0,90	0,84
0,73	0,26	0,75	0,87	0,83

Table 174 Calculated Parameters for the energy balance equation, roof windows, Northern climate, single family house U_{env}=0,6 W/m^{2}K, ventilative cooling; 40° inclination

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	0,2	20	13	21	24	20
2a	2,8	0,78	30%	1,0	3	0,3	27	18	29	34	28
3a	1,7	0,65	30%	1,0	4	0,3	24	16	26	30	25
4a	1,3	0,60	30%	1,0	4	0,2	22	14	24	28	23
5a	1,0	0,55	30%	1,0	4	0,2	20	13	22	25	21
6a	0,8	0,60	30%	1,0	4	0,3	24	16	26	30	25
7a	1,0	0,58	30%	1,0	4	0,2	22	14	24	27	23
8a	0,6	0,47	30%	1,0	4	0,1	17	11	18	21	17
9a	2,8	0,35	30%	1,0	3	0,0	7	4	7	8	7
10a	1,3	0,35	30%	1,0	4	0,0	9	6	9	11	9
11a	0,8	0,35	30%	1,0	4	0,0	10	6	10	12	10
1b	5,8	0,85	30%	0,1	2	0,0	5	3	5	6	5
2b	2,8	0,78	30%	0,1	3	0,0	6	4	6	8	6
3b	1,7	0,65	30%	0,1	4	0,0	6	4	6	7	6
4b	1,3	0,60	30%	0,1	4	0,0	5	4	6	7	6
5b	1,0	0,55	30%	0,1	4	0,0	5	3	5	6	5
6b	0,8	0,60	30%	0,1	4	0,0	6	4	6	7	6
7b	1,0	0,58	30%	0,1	4	0,0	5	4	6	7	6
8b	0,6	0,47	30%	0,1	4	0,0	4	3	5	5	4
9b	2,8	0,35	30%	0,1	3	0,0	1	1	1	2	1
10b	1,3	0,35	30%	0,1	4	0,0	2	1	2	3	2
11b	0,8	0,35	30%	0,1	4	0,0	2	2	3	3	2
			Average windows 3a-8a;3b-8b			0	13	9	14	17	14

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,81	0,35	0,88	0,93	0,89
0,78	0,32	0,85	0,90	0,86
0,79	0,33	0,86	0,91	0,87
0,79	0,33	0,86	0,91	0,87
0,81	0,34	0,88	0,93	0,89
0,79	0,33	0,86	0,91	0,87
0,79	0,33	0,86	0,91	0,87
0,81	0,33	0,88	0,92	0,89
0,79	0,19	0,89	0,93	0,90
0,79	0,21	0,88	0,92	0,89
0,79	0,21	0,88	0,92	0,89
0,80	0,34	0,87	0,91	0,87

Single family house ($\widetilde{U}_{env}$ =0,3 W/m²K)

Table 175 Calculated Parameters for the energy balance equation, roof windows, Northern climate, single family house U_{env}=0,3 W/m²K, no ventilative cooling; 40° inclination

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	1,8	64	43	70	79	66
2a	2,8	0,78	30%	1,0	3	5,7	145	98	157	177	147
3a	1,7	0,65	30%	1,0	4	6,9	174	118	189	212	176
4a	1,3	0,60	30%	1,0	4	7,2	181	123	197	221	184
5a	1,0	0,55	30%	1,0	4	7,1	184	125	199	224	186
6a	0,8	0,60	30%	1,0	4	8,8	213	145	231	260	216
7a	1,0	0,58	30%	1,0	4	7,6	194	132	210	236	196
8a	0,6	0,47	30%	1,0	4	6,6	182	123	198	222	184
9a	2,8	0,35	30%	1,0	3	0,7	44	29	48	54	44
10a	1,3	0,35	30%	1,0	4	2,3	95	64	103	116	97
11a	0,8	0,35	30%	1,0	4	3,2	121	82	131	148	123
1b	5,8	0,85	30%	0,1	2	0,1	13	9	14	15	13
2b	2,8	0,78	30%	0,1	3	1,0	47	32	51	57	47
3b	1,7	0,65	30%	0,1	4	1,6	72	49	78	88	73
4b	1,3	0,60	30%	0,1	4	1,7	80	55	87	98	81
5b	1,0	0,55	30%	0,1	4	1,8	85	58	92	103	86
6b	0,8	0,60	30%	0,1	4	2,9	110	75	120	133	111
7b	1,0	0,58	30%	0,1	4	2,1	92	63	100	112	93
8b	0,6	0,47	30%	0,1	4	1,7	89	61	96	109	90
9b	2,8	0,35	30%	0,1	3	0,1	14	9	15	17	14
10b	1,3	0,35	30%	0,1	4	0,3	34	23	38	42	34
11b	0,8	0,35	30%	0,1	4	0,6	49	33	54	60	49
Average windows 3a-8a;3b-8b						5	138	94	150	168	140

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,74	0,27	0,75	0,88	0,85
0,68	0,22	0,66	0,83	0,82
0,67	0,22	0,65	0,82	0,80
0,66	0,21	0,65	0,82	0,80
0,66	0,21	0,65	0,82	0,80
0,65	0,21	0,63	0,81	0,79
0,66	0,21	0,65	0,82	0,79
0,67	0,22	0,65	0,82	0,80
0,76	0,29	0,83	0,89	0,83
0,73	0,26	0,76	0,87	0,82
0,72	0,24	0,74	0,87	0,83
0,66	0,21	0,65	0,82	0,80

Table 176 Calculated Parameters for the energy balance equation, roof windows, Northern climate, single family house U_{env}=0,3 W/m^{2}K, ventilative cooling; 40° inclination

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	0,4	27	18	29	33	28
2a	2,8	0,78	30%	1,0	3	0,8	42	28	45	52	43
3a	1,7	0,65	30%	1,0	4	0,6	39	26	43	49	41
4a	1,3	0,60	30%	1,0	4	0,5	37	24	40	46	38
5a	1,0	0,55	30%	1,0	4	0,4	34	22	37	42	35
6a	0,8	0,60	30%	1,0	4	0,7	42	27	45	51	43
7a	1,0	0,58	30%	1,0	4	0,5	37	25	40	46	39
8a	0,6	0,47	30%	1,0	4	0,3	28	18	31	35	29
9a	2,8	0,35	30%	1,0	3	0,0	10	7	11	13	11
10a	1,3	0,35	30%	1,0	4	0,1	14	9	15	17	14
11a	0,8	0,35	30%	1,0	4	0,1	16	10	17	20	16
1b	5,8	0,85	30%	0,1	2	0,0	6	4	6	7	6
2b	2,8	0,78	30%	0,1	3	0,0	8	6	9	10	9
3b	1,7	0,65	30%	0,1	4	0,0	8	6	9	10	9
4b	1,3	0,60	30%	0,1	4	0,0	8	5	9	10	8
5b	1,0	0,55	30%	0,1	4	0,0	8	5	8	10	8
6b	0,8	0,60	30%	0,1	4	0,0	9	6	10	11	9
7b	1,0	0,58	30%	0,1	4	0,0	8	6	9	10	9
8b	0,6	0,47	30%	0,1	4	0,0	7	5	7	9	7
9b	2,8	0,35	30%	0,1	3	0,0	3	2	3	3	3
10b	1,3	0,35	30%	0,1	4	0,0	4	3	4	5	4
11b	0,8	0,35	30%	0,1	4	0,0	4	3	5	5	5
			Average windows 3a-8a;3b-8b			0	22	15	24	27	23

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,78	0,32	0,85	0,90	0,86
0,76	0,31	0,80	0,90	0,86
0,77	0,31	0,83	0,90	0,85
0,78	0,31	0,84	0,90	0,86
0,78	0,31	0,85	0,90	0,86
0,77	0,32	0,82	0,90	0,85
0,78	0,31	0,84	0,90	0,86
0,78	0,32	0,86	0,90	0,86
0,79	0,21	0,88	0,92	0,89
0,82	0,35	0,89	0,93	0,89
0,81	0,33	0,88	0,92	0,89
0,78	0,31	0,84	0,90	0,85

CENTRAL CLIMATE

Single room model

Uenv 0.8 W/(m2*K)

						Degree hour					Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X (uniform distr.)	X North	X East	X South	X West	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5.8	0.85	30%	1.0	2	1.9	0.8	2.1	2.7	2.0	161	95	182	210	158
2a	2.8	0.78	30%	1.0	3	3.3	1.8	3.5	4.6	3.3	213	129	237	278	209
3a	1.7	0.65	30%	1.0	4	2.9	1.5	3.1	4.1	2.9	210	127	234	272	206
4a	1.3	0.60	30%	1.0	4	2.6	1.3	2.9	3.7	2.7	205	124	229	265	201
5a	1.0	0.55	30%	1.0	4	2.3	1.1	2.5	3.2	2.4	196	119	221	253	192
6a	0.8	0.60	30%	1.0	4	3.0	1.6	3.2	4.2	3.0	219	135	244	283	215
7a	1.0	0.58	30%	1.0	4	2.6	1.3	2.9	3.7	2.7	207	126	232	266	202
8a	0.6	0.47	30%	1.0	4	1.6	0.7	1.8	2.3	1.7	179	108	202	229	175
9a	2.8	0.35	30%	1.0	3	0.1	-0.2	0.1	0.2	0.1	94	55	105	123	93
10a	1.3	0.35	30%	1.0	4	0.3	0.0	0.5	0.5	0.4	120	72	136	154	118
11a	0.8	0.35	30%	1.0	4	0.5	0.0	0.6	0.7	0.5	129	78	146	166	128
1b	5.8	0.85	30%	0.1	2	-0.1	-0.1	-0.2	-0.2	-0.2	41	40	43	43	38
2b	2.8	0.78	30%	0.1	3	-0.1	0.1	-0.1	-0.1	-0.1	52	52	55	55	48
3b	1.7	0.65	30%	0.1	4	0.0	0.0	-0.1	-0.1	-0.1	53	53	55	55	48
4b	1.3	0.60	30%	0.1	4	0.0	0.0	-0.1	-0.1	0.0	52	52	54	54	48
5b	1.0	0.55	30%	0.1	4	0.0	0.0	-0.1	-0.1	-0.1	51	51	53	53	47
6b	0.8	0.60	30%	0.1	4	0.0	0.1	-0.1	-0.1	0.0	57	56	59	59	52
7b	1.0	0.58	30%	0.1	4	0.0	0.0	-0.1	-0.1	0.0	53	53	55	55	49
8b	0.6	0.47	30%	0.1	4	-0.1	0.0	-0.1	-0.1	-0.1	48	49	50	49	45
9b	2.8	0.35	30%	0.1	3	-0.1	-0.2	-0.1	-0.1	-0.1	32	31	33	32	31
10b	1.3	0.35	30%	0.1	4	-0.1	-0.1	-0.1	-0.1	-0.1	38	37	39	38	37
11b	0.8	0.35	30%	0.1	4	-0.1	-0.1	-0.1	-0.1	-0.1	40	40	42	40	39
Average windows 3a-8a;3b-8b						1.2	0.6	1.3	1.7	1.3	127	88	141	158	123
Average windows 3a-8a;3b-8b					NO SHADING	2.5	1.3	2.7	3.5	2.6	202.5	123.3	227.0	261.3	198.6
Average windows 3a-8a;3b-8b					SHADING	0.0	0.0	-0.1	-0.1	0.0	52.2	52.3	54.3	54.1	48.0

Usage shading				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0.76	0.60	0.74	0.82	0.82
0.74	0.58	0.71	0.79	0.81
0.75	0.59	0.73	0.80	0.81

0.75	0.59	0.73	0.80	0.81
0.76	0.59	0.73	0.81	0.81
0.75	0.58	0.72	0.80	0.81
0.75	0.59	0.73	0.81	0.81
0.76	0.59	0.74	0.82	0.81
0.79	0.60	0.79	0.84	0.82
0.79	0.62	0.78	0.84	0.82
0.78	0.61	0.78	0.84	0.82
0.75	0.59	0.73	0.81	0.81

Single family house

Single family house ($\widetilde{U}_{env}$ =0,8 W/m^{2}K)

Table 177 Calculated Parameters for the energy balance equation, roof windows, Central climate, single family house U_{env}=0,8 W/m^{2}K, no ventilative cooling; 40° inclination

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	0,4	83	66	89	94	83
2a	2,8	0,78	30%	1,0	3	1,3	123	98	132	140	123
3a	1,7	0,65	30%	1,0	4	1,5	128	102	137	144	127
4a	1,3	0,60	30%	1,0	4	1,4	126	101	136	143	126
5a	1,0	0,55	30%	1,0	4	1,3	123	98	132	139	123
6a	0,8	0,60	30%	1,0	4	1,7	139	111	149	157	138
7a	1,0	0,58	30%	1,0	4	1,5	129	103	139	146	129
8a	0,6	0,47	30%	1,0	4	1,0	114	91	122	128	114
9a	2,8	0,35	30%	1,0	3	0,0	58	48	62	65	58
10a	1,3	0,35	30%	1,0	4	0,2	77	62	82	86	77
11a	0,8	0,35	30%	1,0	4	0,4	84	68	90	95	85
1b	5,8	0,85	30%	0,1	2	-0,1	43	37	46	47	42
2b	2,8	0,78	30%	0,1	3	0,2	61	51	65	67	60
3b	1,7	0,65	30%	0,1	4	0,3	65	55	70	71	64
4b	1,3	0,60	30%	0,1	4	0,3	65	55	70	71	65
5b	1,0	0,55	30%	0,1	4	0,3	64	55	69	70	64
6b	0,8	0,60	30%	0,1	4	0,4	72	61	77	80	72
7b	1,0	0,58	30%	0,1	4	0,3	67	57	72	74	67
8b	0,6	0,47	30%	0,1	4	0,2	62	53	66	67	61
9b	2,8	0,35	30%	0,1	3	0,0	38	33	40	41	37
10b	1,3	0,35	30%	0,1	4	0,1	47	41	50	50	46
11b	0,8	0,35	30%	0,1	4	0,1	51	44	55	55	50
			Average windows 3a-8a;3b-8b			1	96	78	103	108	96

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,77	0,59	0,78	0,84	0,81
0,76	0,58	0,77	0,83	0,80
0,76	0,58	0,77	0,83	0,80
0,76	0,59	0,78	0,84	0,81
0,77	0,59	0,78	0,84	0,81
0,75	0,57	0,76	0,82	0,79
0,76	0,59	0,78	0,84	0,81
0,76	0,57	0,78	0,83	0,80
0,70	0,45	0,76	0,79	0,76
0,74	0,53	0,78	0,81	0,79
0,74	0,54	0,78	0,81	0,78
0,76	0,58	0,77	0,83	0,80

Table 178 Calculated Parameters for the energy balance equation, roof windows, Central climate, single family house U_{env}=0,8 W/m^{2}K, ventilative cooling; 40° inclination

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	-0,2	57	46	61	65	58
2a	2,8	0,78	30%	1,0	3	0,0	68	54	73	77	69
3a	1,7	0,65	30%	1,0	4	-0,1	63	51	67	71	64
4a	1,3	0,60	30%	1,0	4	-0,1	61	49	64	68	61
5a	1,0	0,55	30%	1,0	4	-0,2	57	46	61	64	57
6a	0,8	0,60	30%	1,0	4	-0,1	63	51	67	72	64
7a	1,0	0,58	30%	1,0	4	-0,1	60	48	64	68	61
8a	0,6	0,47	30%	1,0	4	-0,2	51	41	54	57	51
9a	2,8	0,35	30%	1,0	3	-0,2	32	27	34	35	32
10a	1,3	0,35	30%	1,0	4	-0,2	37	30	39	40	37
11a	0,8	0,35	30%	1,0	4	-0,2	38	31	40	42	38
1b	5,8	0,85	30%	0,1	2	-0,2	31	26	33	33	30
2b	2,8	0,78	30%	0,1	3	-0,1	35	30	37	37	34
3b	1,7	0,65	30%	0,1	4	-0,1	33	29	36	36	33
4b	1,3	0,60	30%	0,1	4	-0,1	32	28	35	35	32
5b	1,0	0,55	30%	0,1	4	-0,1	32	28	34	34	31
6b	0,8	0,60	30%	0,1	4	-0,1	34	29	36	36	33
7b	1,0	0,58	30%	0,1	4	-0,1	32	28	35	35	32
8b	0,6	0,47	30%	0,1	4	-0,1	30	26	32	32	30
9b	2,8	0,35	30%	0,1	3	-0,1	23	20	25	25	23
10b	1,3	0,35	30%	0,1	4	-0,1	25	22	27	27	25
11b	0,8	0,35	30%	0,1	4	-0,1	26	23	28	28	26
			Average windows 3a-8a;3b-8b			0	46	38	49	51	46

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,77	0,58	0,79	0,83	0,81
0,77	0,59	0,79	0,85	0,82
0,77	0,58	0,79	0,83	0,81
0,77	0,59	0,79	0,83	0,81
0,76	0,58	0,79	0,83	0,81
0,77	0,59	0,79	0,83	0,81
0,77	0,59	0,79	0,83	0,81
0,74	0,52	0,78	0,81	0,79
0,72	0,47	0,79	0,80	0,78
0,71	0,46	0,77	0,80	0,77
0,71	0,46	0,77	0,80	0,77
0,76	0,57	0,79	0,83	0,81

Single family house ($\widetilde{U}_{env}$ =0,4 W/m^{2}K)

Table 179 Calculated Parameters for the energy balance equation, roof windows, Central climate, single family house U_{env}=0,4 W/m^{2}K, no ventilative cooling; 40° inclination

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	1,3	127	101	137	144	127
2a	2,8	0,78	30%	1,0	3	4,2	218	174	234	247	217
3a	1,7	0,65	30%	1,0	4	5,2	249	199	267	281	248
4a	1,3	0,60	30%	1,0	4	5,3	257	206	275	290	256
5a	1,0	0,55	30%	1,0	4	5,2	260	208	278	293	259
6a	0,8	0,60	30%	1,0	4	6,5	287	230	307	324	286
7a	1,0	0,58	30%	1,0	4	5,6	269	215	288	303	268
8a	0,6	0,47	30%	1,0	4	4,9	259	208	278	293	258
9a	2,8	0,35	30%	1,0	3	0,6	109	88	116	122	109
10a	1,3	0,35	30%	1,0	4	2,0	175	140	188	198	175
11a	0,8	0,35	30%	1,0	4	2,7	203	162	218	230	203
1b	5,8	0,85	30%	0,1	2	0,1	63	53	68	69	63
2b	2,8	0,78	30%	0,1	3	1,4	126	103	135	141	126
3b	1,7	0,65	30%	0,1	4	2,0	158	128	169	178	158
4b	1,3	0,60	30%	0,1	4	2,1	168	136	180	189	168
5b	1,0	0,55	30%	0,1	4	2,2	173	140	185	195	173
6b	0,8	0,60	30%	0,1	4	3,0	199	160	213	224	198
7b	1,0	0,58	30%	0,1	4	2,4	181	146	193	204	180
8b	0,6	0,47	30%	0,1	4	2,1	177	143	190	200	177
9b	2,8	0,35	30%	0,1	3	0,1	64	55	69	70	64
10b	1,3	0,35	30%	0,1	4	0,6	110	90	118	123	109
11b	0,8	0,35	30%	0,1	4	1,0	133	107	142	149	132
			Average windows 3a-8a;3b-8b			4	220	177	235	248	219

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,75	0,58	0,76	0,83	0,80
0,74	0,57	0,73	0,82	0,79
0,73	0,57	0,73	0,81	0,79
0,73	0,57	0,73	0,81	0,79
0,74	0,56	0,73	0,81	0,79
0,73	0,56	0,72	0,81	0,79
0,73	0,57	0,73	0,81	0,79
0,73	0,56	0,73	0,81	0,79
0,75	0,56	0,78	0,83	0,80
0,75	0,56	0,76	0,82	0,79
0,74	0,55	0,75	0,81	0,78
0,73	0,56	0,73	0,81	0,79

Table 180 Calculated Parameters for the energy balance equation, roof windows, Central climate, single family house U_{env}=0,4 W/m^2K, ventilative cooling; 40° inclination

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	0,0	75	59	80	85	75
2a	2,8	0,78	30%	1,0	3	0,3	99	78	105	112	99
3a	1,7	0,65	30%	1,0	4	0,2	95	76	102	108	96
4a	1,3	0,60	30%	1,0	4	0,2	92	74	98	104	93
5a	1,0	0,55	30%	1,0	4	0,1	88	70	93	99	88
6a	0,8	0,60	30%	1,0	4	0,2	99	79	105	112	100
7a	1,0	0,58	30%	1,0	4	0,2	93	74	99	105	93
8a	0,6	0,47	30%	1,0	4	-0,1	79	63	83	88	79
9a	2,8	0,35	30%	1,0	3	-0,2	44	37	47	49	44
10a	1,3	0,35	30%	1,0	4	-0,2	53	44	56	59	53
11a	0,8	0,35	30%	1,0	4	-0,2	57	47	60	64	58
1b	5,8	0,85	30%	0,1	2	-0,2	38	32	40	41	37
2b	2,8	0,78	30%	0,1	3	-0,1	47	40	50	51	46
3b	1,7	0,65	30%	0,1	4	-0,1	45	39	48	49	45
4b	1,3	0,60	30%	0,1	4	-0,1	44	39	47	48	44
5b	1,0	0,55	30%	0,1	4	-0,1	43	38	45	46	43
6b	0,8	0,60	30%	0,1	4	-0,1	47	41	50	51	47
7b	1,0	0,58	30%	0,1	4	-0,1	45	39	47	48	44
8b	0,6	0,47	30%	0,1	4	-0,1	40	35	43	43	40
9b	2,8	0,35	30%	0,1	3	-0,1	29	26	31	32	29
10b	1,3	0,35	30%	0,1	4	-0,1	33	29	35	35	33
11b	0,8	0,35	30%	0,1	4	-0,1	35	30	36	37	35
			Average windows 3a-8a;3b-8b			0	68	56	72	75	68

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,77	0,58	0,78	0,84	0,81
0,77	0,59	0,78	0,84	0,81
0,77	0,59	0,78	0,84	0,81
0,77	0,59	0,78	0,84	0,81
0,77	0,59	0,78	0,84	0,82
0,77	0,59	0,78	0,84	0,81
0,77	0,59	0,78	0,84	0,81
0,77	0,58	0,79	0,84	0,81
0,71	0,46	0,77	0,80	0,77
0,72	0,50	0,77	0,80	0,77
0,73	0,52	0,77	0,81	0,78
0,77	0,58	0,78	0,84	0,81

SOUTHERN CLIMATE

Single room model

Uenv 1.0 W/(m2*K)

						Degree hour					Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X (uniform distr.)	X North	X East	X South	X West	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5.8	0.85	30%	1.0	2	-1.2	-2.9	-1.4	0.6	-1.1	698	517	717	842	717
2a	2.8	0.78	30%	1.0	3	0.6	-1.9	0.4	3.5	0.5	787	575	807	961	804
3a	1.7	0.65	30%	1.0	4	0.0	-2.1	-0.1	2.4	0.0	797	586	818	967	816
4a	1.3	0.60	30%	1.0	4	-0.3	-2.3	-0.5	1.8	-0.2	797	588	818	963	816
5a	1.0	0.55	30%	1.0	4	-0.7	-2.5	-0.9	1.1	-0.6	792	588	814	953	813
6a	0.8	0.60	30%	1.0	4	0.2	-2.1	0.0	2.6	0.1	817	601	839	992	836
7a	1.0	0.58	30%	1.0	4	-0.3	-2.3	-0.5	1.8	-0.2	802	593	824	969	822
8a	0.6	0.47	30%	1.0	4	-1.5	-3.0	-1.6	-0.1	-1.3	780	584	803	932	802
9a	2.8	0.35	30%	1.0	3	-3.7	-4.2	-3.8	-3.3	-3.6	661	508	678	774	683
10a	1.3	0.35	30%	1.0	4	-3.2	-3.9	-3.3	-2.6	-3.1	712	545	732	838	734
11a	0.8	0.35	30%	1.0	4	-3.0	-3.7	-3.1	-2.4	-2.9	730	557	750	859	752
1b	5.8	0.85	30%	0.1	2	-4.9	-4.8	-4.9	-4.9	-4.9	508	416	524	569	523
2b	2.8	0.78	30%	0.1	3	-4.7	-4.5	-4.8	-4.7	-4.8	570	464	586	642	587
3b	1.7	0.65	30%	0.1	4	-4.7	-4.5	-4.7	-4.7	-4.7	589	479	607	665	607
4b	1.3	0.60	30%	0.1	4	-4.7	-4.5	-4.7	-4.7	-4.7	595	483	613	672	613
5b	1.0	0.55	30%	0.1	4	-4.7	-4.5	-4.7	-4.7	-4.8	599	486	617	676	616
6b	0.8	0.60	30%	0.1	4	-4.6	-4.4	-4.7	-4.6	-4.7	611	495	629	691	630
7b	1.0	0.58	30%	0.1	4	-4.7	-4.5	-4.7	-4.7	-4.7	602	488	620	680	620
8b	0.6	0.47	30%	0.1	4	-4.7	-4.6	-4.8	-4.7	-4.8	601	488	620	678	619
9b	2.8	0.35	30%	0.1	3	-4.9	-4.9	-4.9	-4.9	-4.9	524	431	542	584	540
10b	1.3	0.35	30%	0.1	4	-4.9	-4.8	-4.9	-4.9	-4.9	563	460	582	631	580
11b	0.8	0.35	30%	0.1	4	-4.8	-4.8	-4.9	-4.8	-4.9	577	470	596	648	594
Average windows 2a-4a,9a,10a; 2b-4b,9b,10b						-3.0	-3.8	-3.1	-2.2	-3.0	659	512	678	770	678
Average windows 2a-4a,9a,10a					NO SHADING	-1.3	-2.9	-1.5	0.4	-1.3	750.6	560.5	770.6	900.6	770.7
Average windows 2b-4b,9b,10b					SHADING	-4.8	-4.6	-4.8	-4.8	-4.8	568.3	463.3	585.9	638.8	585.3

Usage shading				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0.88	0.82	0.89	0.90	0.91

0.87	0.80	0.88	0.86	0.91
0.88	0.81	0.88	0.89	0.91
0.88	0.81	0.89	0.89	0.91
0.88	0.81	0.89	0.90	0.91
0.88	0.81	0.88	0.88	0.91
0.88	0.81	0.89	0.89	0.91
0.89	0.82	0.90	0.91	0.91
0.90	0.82	0.91	0.92	0.91
0.90	0.82	0.91	0.92	0.91
0.90	0.82	0.91	0.92	0.91
0.88	0.81	0.89	0.89	0.91

Single family house

Single family house ($\widetilde{U}_{env}$ =1,0 W/m^{2}K)

Table 181 Calculated Parameters for the energy balance equation, roof windows, Southern climate, single family house U_{env}=1,0 W/m^{2}K, no ventilative cooling; 40° inclination

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	-3,3	545	437	562	618	564
2a	2,8	0,78	30%	1,0	3	-2,3	613	488	632	699	634
3a	1,7	0,65	30%	1,0	4	-2,3	628	499	647	715	649
4a	1,3	0,60	30%	1,0	4	-2,3	630	502	650	718	652
5a	1,0	0,55	30%	1,0	4	-2,4	630	502	649	717	652
6a	0,8	0,60	30%	1,0	4	-2,1	645	513	665	736	668
7a	1,0	0,58	30%	1,0	4	-2,3	636	506	655	724	658
8a	0,6	0,47	30%	1,0	4	-2,6	626	500	646	712	648
9a	2,8	0,35	30%	1,0	3	-4,0	534	431	552	603	552
10a	1,3	0,35	30%	1,0	4	-3,5	578	464	596	654	597
11a	0,8	0,35	30%	1,0	4	-3,3	592	475	611	671	612
1b	5,8	0,85	30%	0,1	2	-4,5	473	384	488	531	488
2b	2,8	0,78	30%	0,1	3	-4,0	529	428	546	597	547
3b	1,7	0,65	30%	0,1	4	-3,9	547	441	564	617	565
4b	1,3	0,60	30%	0,1	4	-3,9	551	444	569	623	570
5b	1,0	0,55	30%	0,1	4	-3,9	553	446	571	625	572
6b	0,8	0,60	30%	0,1	4	-3,8	565	455	583	639	584
7b	1,0	0,58	30%	0,1	4	-3,8	557	449	575	629	576
8b	0,6	0,47	30%	0,1	4	-3,9	555	447	573	627	573
9b	2,8	0,35	30%	0,1	3	-4,4	489	397	505	549	505
10b	1,3	0,35	30%	0,1	4	-4,2	524	423	541	590	541
11b	0,8	0,35	30%	0,1	4	-4,1	536	432	553	605	554
		Average windows 2a-4a,9a,10a; 2b-4b,9b,10b				-3	562	452	580	636	581

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,89	0,80	0,91	0,92	0,91
0,89	0,79	0,91	0,92	0,91
0,89	0,79	0,91	0,92	0,91
0,89	0,79	0,91	0,92	0,91
0,89	0,79	0,91	0,92	0,91
0,89	0,79	0,91	0,92	0,91
0,89	0,79	0,91	0,92	0,91
0,89	0,80	0,91	0,92	0,91
0,90	0,82	0,91	0,92	0,92
0,89	0,81	0,91	0,92	0,92
0,89	0,81	0,91	0,92	0,92
0,89	0,80	0,91	0,92	0,91

Table 182 Calculated Parameters for the energy balance equation, roof windows, Southern climate, single family house U_{env}=1,0 W/m^{2}K, ventilative cooling

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	-4,4	495	400	511	558	512
2a	2,8	0,78	30%	1,0	3	-4,1	537	433	554	606	555
3a	1,7	0,65	30%	1,0	4	-4,2	540	435	557	608	558
4a	1,3	0,60	30%	1,0	4	-4,3	539	435	556	607	557
5a	1,0	0,55	30%	1,0	4	-4,4	536	433	553	603	554
6a	0,8	0,60	30%	1,0	4	-4,2	548	442	565	618	566
7a	1,0	0,58	30%	1,0	4	-4,3	541	437	558	609	559
8a	0,6	0,47	30%	1,0	4	-4,5	528	428	545	594	546
9a	2,8	0,35	30%	1,0	3	-4,8	471	384	486	527	487
10a	1,3	0,35	30%	1,0	4	-4,7	493	401	509	553	510
11a	0,8	0,35	30%	1,0	4	-4,7	501	407	517	562	518
1b	5,8	0,85	30%	0,1	2	-4,9	435	355	449	485	449
2b	2,8	0,78	30%	0,1	3	-4,8	467	382	482	522	483
3b	1,7	0,65	30%	0,1	4	-4,8	473	387	489	529	489
4b	1,3	0,60	30%	0,1	4	-4,8	475	388	490	530	490
5b	1,0	0,55	30%	0,1	4	-4,8	475	388	490	530	490
6b	0,8	0,60	30%	0,1	4	-4,8	482	393	497	538	498
7b	1,0	0,58	30%	0,1	4	-4,8	477	390	493	533	493
8b	0,6	0,47	30%	0,1	4	-4,8	474	388	489	528	490
9b	2,8	0,35	30%	0,1	3	-4,9	439	360	453	489	454
10b	1,3	0,35	30%	0,1	4	-4,8	456	374	471	508	472
11b	0,8	0,35	30%	0,1	4	-4,8	462	379	477	515	478
		Average windows 2a-4a,9a,10a; 2b-4b,9b,10b				-5	489	398	505	548	506

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,89	0,80	0,91	0,92	0,91
0,89	0,80	0,91	0,92	0,91
0,89	0,81	0,91	0,92	0,92
0,89	0,81	0,91	0,92	0,92
0,89	0,81	0,91	0,92	0,92
0,89	0,81	0,91	0,92	0,92
0,89	0,81	0,91	0,92	0,92
0,90	0,81	0,91	0,92	0,92
0,90	0,82	0,92	0,92	0,92
0,90	0,82	0,92	0,92	0,92
0,90	0,82	0,92	0,92	0,92
0,90	0,81	0,91	0,92	0,92

Single family house ($\widetilde{U}_{env}$ =0,6 W/m²K)

Table 183 Calculated Parameters for the energy balance equation, roof windows, Southern climate, single family house U_{env}=0,6 W/m²K, no ventilative cooling; 40° inclination

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	-2,4	619	492	637	705	640
2a	2,8	0,78	30%	1,0	3	-0,1	717	564	739	824	741
3a	1,7	0,65	30%	1,0	4	0,2	746	586	769	858	771
4a	1,3	0,60	30%	1,0	4	0,2	753	591	776	867	779
5a	1,0	0,55	30%	1,0	4	0,0	756	594	779	870	782
6a	0,8	0,60	30%	1,0	4	0,9	777	609	801	896	803
7a	1,0	0,58	30%	1,0	4	0,4	763	598	786	878	789
8a	0,6	0,47	30%	1,0	4	-0,3	757	595	779	870	783
9a	2,8	0,35	30%	1,0	3	-3,1	632	505	652	718	653
10a	1,3	0,35	30%	1,0	4	-2,0	700	555	721	799	724
11a	0,8	0,35	30%	1,0	4	-1,6	722	571	743	826	747
1b	5,8	0,85	30%	0,1	2	-4,2	533	431	550	601	551
2b	2,8	0,78	30%	0,1	3	-3,2	626	501	645	710	647
3b	1,7	0,65	30%	0,1	4	-2,7	662	528	682	753	684
4b	1,3	0,60	30%	0,1	4	-2,6	673	536	693	766	696
5b	1,0	0,55	30%	0,1	4	-2,6	680	541	700	774	703
6b	0,8	0,60	30%	0,1	4	-2,4	695	553	716	793	719
7b	1,0	0,58	30%	0,1	4	-2,5	683	544	704	779	707
8b	0,6	0,47	30%	0,1	4	-2,6	688	547	708	783	711
9b	2,8	0,35	30%	0,1	3	-4,1	571	458	589	646	590
10b	1,3	0,35	30%	0,1	4	-3,5	635	508	655	721	657
11b	0,8	0,35	30%	0,1	4	-3,2	658	526	678	747	680
		Average windows 2a-4a,9a,10a; 2b-4b,9b,10b				-2	671	533	692	766	694

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,89	0,79	0,91	0,92	0,91
0,88	0,79	0,90	0,91	0,91
0,88	0,79	0,90	0,91	0,91
0,89	0,79	0,90	0,91	0,91
0,89	0,79	0,91	0,92	0,91
0,88	0,78	0,90	0,91	0,91
0,88	0,79	0,90	0,91	0,91
0,89	0,79	0,91	0,92	0,91
0,89	0,80	0,91	0,92	0,91
0,89	0,79	0,91	0,92	0,91
0,89	0,79	0,91	0,92	0,91
0,89	0,79	0,91	0,92	0,91

Table 184 Calculated Parameters for the energy balance equation, roof windows, Southern climate, single family house U_{env}=0,6 W/m^{2}K, ventilative cooling; 40° inclination

						Degree hour	Solar Factor				
No.	U_{window}	g_{gl}	Frame fraction	Fc	Air tight Class	X	Y (uniform distr.)	Y North	Y East	Y South	Y West
1a	5,8	0,85	30%	1,0	2	-4,1	546	440	563	617	565
2a	2,8	0,78	30%	1,0	3	-3,6	604	484	623	685	625
3a	1,7	0,65	30%	1,0	4	-3,7	612	491	631	693	633
4a	1,3	0,60	30%	1,0	4	-3,8	613	492	632	693	633
5a	1,0	0,55	30%	1,0	4	-3,9	610	491	630	691	631
6a	0,8	0,60	30%	1,0	4	-3,7	626	502	645	709	647
7a	1,0	0,58	30%	1,0	4	-3,8	616	495	636	698	637
8a	0,6	0,47	30%	1,0	4	-4,1	604	486	623	682	624
9a	2,8	0,35	30%	1,0	3	-4,7	524	425	540	588	541
10a	1,3	0,35	30%	1,0	4	-4,6	557	451	575	627	575
11a	0,8	0,35	30%	1,0	4	-4,5	569	460	587	640	588
1b	5,8	0,85	30%	0,1	2	-4,9	474	386	489	530	489
2b	2,8	0,78	30%	0,1	3	-4,7	519	422	536	582	536
3b	1,7	0,65	30%	0,1	4	-4,7	530	431	547	594	547
4b	1,3	0,60	30%	0,1	4	-4,7	532	433	550	597	550
5b	1,0	0,55	30%	0,1	4	-4,7	533	433	550	598	551
6b	0,8	0,60	30%	0,1	4	-4,6	543	441	560	609	561
7b	1,0	0,58	30%	0,1	4	-4,7	536	436	554	602	554
8b	0,6	0,47	30%	0,1	4	-4,7	532	433	549	596	550
9b	2,8	0,35	30%	0,1	3	-4,9	480	393	495	535	496
10b	1,3	0,35	30%	0,1	4	-4,8	505	413	521	564	522
11b	0,8	0,35	30%	0,1	4	-4,8	514	419	530	574	531
		Average windows 2a-4a,9a,10a; 2b-4b,9b,10b				-4	547	443	565	616	566

Usage sun protection				
Z (uniform distr.)	Z North	Z East	Z South	Z West
0,89	0,80	0,91	0,92	0,91
0,89	0,79	0,91	0,92	0,91
0,89	0,80	0,91	0,92	0,91
0,89	0,80	0,91	0,92	0,91
0,89	0,80	0,91	0,92	0,91
0,89	0,80	0,91	0,92	0,91
0,89	0,80	0,91	0,92	0,91
0,89	0,81	0,91	0,92	0,92
0,90	0,82	0,92	0,92	0,92
0,90	0,82	0,92	0,92	0,92
0,90	0,82	0,91	0,92	0,92
0,89	0,81	0,91	0,92	0,92

ANNEX III - SCENARIO - BACKGROUND DATA

COUNTRY DEPENDENT DATA

Table 185 Floor area

Floor area [10^3 m2] Sector ↓	Subsector ↓		Member State / Zone ↓ AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR
residential	single family	'000 m2,	278797	440132	140149	22203	220303	2508727	277903	18146	147525	714710	171654	1840292	127217
residential	multi family	'000 m2	152976	69019	107788	9892	168842	1614197	99457	28231	252999	1228101	73404	891221	49309
residential	all res	'000 m2	431773	509152	247937	32095	389145	4122924	377360	46377	400523	1942811	245058	2731512	176525
non-residential	offices	'000 m2	58,463	74,032	23,229	1,050	31,368	**588,800**	15,630	4,083	14,360	**54,300**	15,029	449,371	5,775
non-residential	educational	'000 m2	29,589	37,469	11,540	1,491	16,574	**298,000**	28,725	2,157	20,389	**77,100**	27,621	227,433	8,200
non-residential	health	'000 m2	25,528	32,326	8,413	495	2,576	**257,100**	9,837	335	6,770	**25,600**	9,458	196,218	2,723
non-residential	gastro	'000 m2	19,481	24,669	22,634	1,114	5,870	**196,200**	3,198	764	15,232	**57,600**	3,075	149,740	6,126
non-residential	trade	'000 m2	48,692	61,660	23,750	2,941	35,697	**490,400**	8,087	4,646	40,223	**152,100**	7,776	374,273	16,177
non-residential	sports	'000 m2	6,552	8,297	9,099	951	13,022	**65,989**	7,355	1,695	13,003	**49,170**	7,072	50,363	5,230
non-residential	other	'000 m2	53,013	67,131	73,618	7,693	105,358	**533,911**	59,510	13,712	105,207	**397,830**	57,221	407,480	42,312
non-residential	all non-res	'000 m2	241,307	305,570	172,283	15,736	210,464	**2,430,300**	132,342	27,392	215,184	**813,700**	127,253	1,854,802	86,543
roofwindow	roofwindow res	'000 m2													
roofwindow	roofwindow non-res	'000 m2													
roofwindow	roofwindow all	'000 m2													

Sector ↓	Subsector ↓		HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28
residential	single family	'000 m2,	299807	223636	982606	67357	13640	43782	9957	725687	678505	337259	391392	204151	34251	105991	1952157	12,977,936
residential	multi family	'000 m2	87376	14936	2196825	61848	7042	40201	3963	86691	506360	181468	183640	161881	30402	65060	245434	8,618,562
residential	all res	'000 m2	387183	238571	3179431	129205	20682	83983	13921	812378	1184864	518727	575032	366032	64654	171051	2197590	21,596,497
non-residential	offices	'000 m2	**31,200**	28,684	78,207	11,016	3,347	7,015	536	117,197	**118,100**	14,222	69,622	**25,900**	6,270	16,636	431,728	2,295,170
non-residential	educational	'000 m2	**15,500**	14,517	111,046	5,821	1,694	3,706	762	59,315	**62,400**	20,194	34,588	**47,600**	3,115	8,790	218,504	1,393,839
non-residential	health	'000 m2	**11,300**	12,525	36,871	905	1,461	576	253	51,174	**9,700**	6,705	25,216	**16,300**	2,271	1,366	188,514	942,518
non-residential	gastro	'000 m2	**30,400**	9,558	82,960	2,061	1,115	1,313	569	39,052	**22,100**	15,087	67,837	**5,300**	6,109	3,113	143,860	936,138
non-residential	trade	'000 m2	**31,900**	23,890	219,067	12,537	2,788	7,983	1,503	97,611	**134,400**	39,838	71,184	**13,400**	6,411	18,932	359,578	2,307,442
non-residential	sports	'000 m2	**12,221**	3,215	70,819	4,573	375	2,912	486	13,135	**49,027**	12,879	27,271	**12,188**	2,456	6,906	48,385	504,644
non-residential	other	'000 m2	**98,879**	26,010	572,987	37,001	3,035	23,561	3,930	106,272	**396,673**	104,199	220,646	**98,612**	19,872	55,876	391,481	4,083,030
non-residential	all non-res	'000 m2	**231,400**	118,393	1,171,956	73,914	13,815	47,066	8,039	483,737	**792,400**	213,124	516,363	**219,300**	46,504	111,619	1,781,977	12,462,483
roofwindow	roofwindow res	'000 m2																7,000,000
roofwindow	roofwindow non-res	'000 m2																6,300,000
roofwindow	roofwindow all	'000 m2																13,300,000

Table 186 Age of building

Age of building [% of floor area]		Member State / Zone →	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28
Sector ↓	Subsector ↓	Age group ↓																													
residential	single family	1945	19.7%	20.7%	22.0%	7.1%	29.5%	23.7%	32.6%	44.7%	7.1%	18.7%	12.6%	14.9%	11.7%	13.0%	14.6%	38.4%	23.2%	31.9%	21.0%	7.1%	26.5%	17.2%	12.6%	16.4%	22.6%	29.4%	29.8%	25.6%	22.4%
residential	single family	1970	26.8%	23.1%	33.2%	27.2%	24.8%	26.9%	25.3%	25.6%	27.2%	18.0%	19.9%	22.4%	26.8%	25.9%	13.4%	27.8%	25.8%	24.2%	21.9%	27.2%	23.9%	20.3%	15.4%	35.2%	22.6%	19.4%	24.1%	30.3%	25.1%

Age of building [% of floor area]		Member State / Zone →	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28
residential	single family	1980	17.5%	19.4%	16.2%	24.6%	10.0%	14.5%	18.3%	9.1%	24.6%	13.0%	16.5%	24.6%	23.8%	16.6%	13.3%	15.2%	16.0%	15.5%	14.5%	24.6%	14.3%	13.5%	18.1%	14.4%	17.4%	18.3%	9.8%	8.4%	15.5%
residential	single family	1990	14.0%	17.2%	13.3%	20.9%	14.1%	12.0%	7.3%	7.8%	20.9%	13.9%	22.6%	19.4%	21.9%	25.8%	11.8%	10.7%	16.0%	12.3%	15.0%	20.9%	14.9%	14.0%	18.9%	23.4%	14.9%	11.8%	14.1%	19.8%	15.8%
residential	single family	2000	15.6%	11.5%	6.7%	15.0%	11.3%	12.4%	7.2%	7.6%	15.0%	12.9%	13.8%	9.6%	11.0%	8.6%	15.7%	4.3%	9.0%	7.7%	10.9%	15.0%	13.4%	14.0%	20.2%	6.5%	10.5%	11.8%	11.4%	8.4%	10.5%
residential	single family	2010	6.4%	8.1%	8.6%	5.1%	10.2%	10.4%	9.3%	5.3%	5.1%	23.5%	14.6%	9.0%	4.7%	10.1%	31.3%	3.5%	9.9%	8.4%	16.7%	5.1%	7.1%	20.9%	14.8%	4.1%	12.0%	9.3%	10.8%	7.5%	10.7%
residential	multi family	1945	26.8%	27.0%	5.0%	7.9%	16.2%	15.7%	44.6%	10.1%	7.9%	9.4%	10.8%	28.3%	11.0%	38.4%	9.6%	20.6%	8.3%	16.6%	8.9%	7.9%	25.8%	19.5%	7.0%	3.0%	27.7%	35.1%	16.2%	19.1%	18.5%
residential	multi family	1970	27.0%	24.0%	24.2%	27.3%	36.6%	31.3%	28.1%	28.4%	27.3%	20.5%	25.4%	21.0%	25.1%	25.2%	6.2%	35.9%	25.4%	27.0%	22.9%	27.3%	26.9%	17.8%	14.4%	22.6%	26.8%	20.3%	34.8%	15.7%	24.7%
residential	multi family	1980	13.9%	18.4%	18.2%	23.2%	15.1%	22.3%	10.3%	25.7%	23.2%	21.5%	26.6%	22.0%	22.2%	11.6%	5.2%	20.1%	24.3%	13.7%	22.9%	23.2%	14.8%	13.8%	21.8%	28.6%	18.4%	18.2%	14.4%	7.2%	18.4%
residential	multi family	1990	11.8%	12.7%	19.7%	19.6%	18.5%	13.8%	4.8%	24.4%	19.6%	11.5%	13.7%	12.1%	20.5%	5.4%	6.6%	13.9%	24.3%	11.5%	17.9%	19.6%	13.3%	14.5%	19.0%	38.1%	9.2%	8.0%	17.8%	30.0%	16.6%
residential	multi family	2000	14.8%	9.9%	12.5%	13.5%	6.6%	12.8%	4.9%	6.2%	13.5%	11.9%	12.3%	7.5%	10.2%	8.9%	14.5%	5.3%	9.2%	10.7%	10.5%	13.5%	12.3%	14.5%	25.5%	1.1%	8.6%	8.0%	6.5%	9.3%	10.1%
residential	multi family	2010	5.7%	7.9%	20.4%	8.3%	6.9%	4.3%	7.3%	5.1%	8.3%	25.2%	11.3%	9.0%	11.0%	10.5%	57.9%	4.2%	8.6%	20.6%	16.9%	8.3%	6.8%	19.8%	12.4%	6.7%	9.3%	10.5%	10.4%	18.7%	11.6%
residential	all res	1945	22.2%	21.6%	14.6%	7.4%	23.8%	20.6%	35.7%	23.7%	7.6%	12.8%	12.0%	19.3%	11.5%	18.7%	14.3%	26.1%	16.1%	26.7%	15.2%	7.4%	26.4%	18.2%	10.6%	12.1%	24.8%	32.1%	24.6%	24.9%	20.9%
residential	all res	1970	26.9%	23.2%	29.3%	27.3%	29.9%	28.6%	26.0%	27.3%	27.3%	19.5%	21.6%	22.0%	26.3%	25.7%	13.0%	33.3%	25.6%	25.2%	22.4%	27.3%	24.2%	19.3%	15.0%	31.2%	24.4%	19.9%	28.2%	28.7%	25.0%
residential	all res	1980	16.2%	19.3%	17.1%	24.2%	12.2%	17.6%	16.2%	19.2%	23.7%	18.4%	19.5%	23.8%	23.4%	15.5%	12.8%	18.6%	20.0%	14.9%	18.5%	24.2%	14.3%	13.6%	19.4%	18.9%	17.9%	18.3%	11.5%	8.3%	16.7%
residential	all res	1990	13.2%	16.6%	16.1%	20.5%	16.0%	12.7%	6.6%	17.9%	20.1%	12.4%	19.9%	17.1%	21.5%	21.2%	11.4%	12.9%	20.0%	12.0%	16.4%	20.5%	14.7%	14.3%	18.9%	28.1%	12.4%	10.0%	15.5%	21.0%	16.1%
residential	all res	2000	15.3%	11.3%	9.2%	14.6%	9.3%	12.6%	6.6%	6.8%	14.1%	12.2%	13.3%	8.9%	10.8%	8.6%	15.6%	5.0%	9.1%	8.8%	10.7%	14.6%	13.3%	14.3%	22.1%	4.8%	9.7%	10.0%	9.5%	8.5%	10.3%
residential	all res	2010	6.2%	8.0%	13.7%	6.1%	8.8%	8.0%	8.8%	5.2%	7.2%	24.6%	13.6%	9.0%	6.5%	10.2%	33.0%	4.0%	9.3%	12.5%	16.8%	6.1%	7.1%	20.4%	13.9%	4.9%	10.8%	9.8%	10.7%	8.7%	11.0%
non-residential	offices	1945	24%	24%	6%	30%	20%	24%	21%	32%	20%	13%	14%	24%	22%	23%	34%	30%	32%	24%	32%	30%	24%	28%	30%	22%	22%	22%	17%	34%	27%
non-residential	offices	1970	10%	10%	43%	23%	11%	10%	22%	21%	20%	6%	19%	10%	22%	21%	12%	23%	21%	10%	21%	23%	10%	18%	23%	22%	26%	22%	17%	12%	12%
non-residential	offices	1980	8%	8%	20%	11%	11%	8%	16%	15%	14%	6%	19%	8%	26%	16%	6%	11%	15%	8%	15%	11%	8%	16%	11%	26%	17%	26%	21%	6%	7%
non-residential	offices	1990	17%	17%	14%	12%	11%	17%	13%	17%	17%	14%	22%	17%	10%	10%	16%	12%	17%	17%	17%	12%	17%	2%	12%	10%	19%	10%	20%	16%	14%
non-residential	offices	2000	28%	28%	7%	12%	17%	28%	13%	9%	14%	26%	10%	28%	10%	10%	16%	12%	9%	28%	9%	12%	28%	11%	12%	10%	8%	10%	16%	16%	24%
non-residential	offices	2010	12%	12%	11%	12%	31%	12%	15%	7%	14%	35%	15%	12%	9%	21%	16%	12%	7%	12%	7%	12%	12%	25%	12%	9%	4%	9%	9%	16%	16%
non-residential	educational	1945	52%	52%	6%	28%	38%	52%	14%	24%	24%	22%	14%	52%	24%	32%	28%	28%	24%	52%	24%	28%	52%	36%	28%	24%	11%	24%	23%	28%	45%
non-residential	educational	1970	22%	22%	43%	60%	18%	22%	19%	27%	24%	11%	19%	22%	24%	25%	14%	60%	27%	22%	27%	60%	22%	27%	60%	24%	45%	24%	23%	14%	19%
non-residential	educational	1980	10%	10%	20%	4%	18%	10%	19%	20%	11%	11%	19%	10%	29%	21%	8%	4%	20%	10%	20%	4%	10%	14%	4%	29%	14%	29%	22%	8%	12%
non-residential	educational	1990	7%	7%	14%	2%	18%	7%	22%	20%	14%	30%	22%	7%	9%	13%	17%	2%	20%	7%	20%	2%	7%	3%	2%	9%	7%	9%	21%	17%	10%
non-residential	educational	2000	5%	5%	7%	3%	4%	5%	10%	7%	13%	22%	10%	5%	9%	5%	17%	3%	7%	5%	7%	3%	5%	9%	3%	9%	7%	9%	8%	17%	9%
non-residential	educational	2010	2%	2%	11%	3%	5%	2%	15%	2%	13%	5%	15%	2%	6%	5%	17%	3%	2%	2%	2%	3%	2%	11%	3%	6%	4%	6%	3%	17%	4%
non-residential	health	1945	40%	40%	6%	13%	34%	40%	11%	24%	13%	15%	11%	40%	20%	27%	28%	13%	24%	40%	24%	13%	40%	30%	13%	20%	9%	20%	21%	28%	37%
non-residential	health	1970	17%	17%	43%	13%	18%	17%	23%	23%	13%	4%	23%	17%	20%	28%	14%	13%	23%	17%	23%	13%	17%	13%	13%	20%	41%	20%	21%	14%	16%
non-residential	health	1980	8%	8%	20%	13%	18%	8%	18%	19%	13%	4%	18%	8%	27%	22%	8%	13%	19%	8%	19%	13%	8%	15%	13%	27%	23%	27%	12%	8%	10%
non-residential	health	1990	13%	13%	14%	23%	18%	13%	20%	24%	23%	17%	20%	13%	10%	12%	17%	23%	24%	13%	24%	23%	13%	2%	23%	10%	11%	10%	25%	17%	13%

Age of building [% of floor area]	Member State / Zone →	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28
non-residentialhealth	2000	13%	13%	7%	23%	7%	13%	13%	8%	23%	21%	13%	13%	10%	5%	17%	23%	8%	13%	8%	23%	13%	15%	23%	10%	7%	10%	15%	17%	13%
non-residentialhealth	2010	9%	9%	11%	16%	5%	9%	15%	3%	16%	31%	15%	9%	12%	5%	17%	16%	3%	9%	3%	16%	9%	24%	16%	12%	4%	12%	7%	17%	11%
non-residentialgastro	1945	39%	39%	11%	22%	37%	39%	17%	17%	10%	26%	17%	39%	22%	16%	28%	22%	17%	39%	17%	22%	39%	39%	22%	22%	34%	22%	17%	28%	38%
non-residentialgastro	1970	17%	17%	42%	38%	8%	17%	21%	21%	10%	13%	21%	17%	22%	27%	14%	38%	21%	17%	21%	38%	17%	11%	38%	22%	21%	22%	17%	14%	16%
non-residentialgastro	1980	13%	13%	20%	16%	8%	13%	14%	14%	10%	13%	14%	13%	24%	18%	8%	16%	14%	13%	14%	16%	13%	13%	16%	24%	9%	24%	16%	8%	10%
non-residentialgastro	1990	21%	21%	14%	12%	8%	21%	20%	20%	21%	15%	20%	21%	11%	20%	17%	12%	20%	21%	20%	12%	21%	3%	12%	11%	19%	11%	30%	17%	18%
non-residentialgastro	2000	9%	9%	7%	6%	17%	9%	11%	11%	21%	14%	11%	9%	11%	8%	17%	6%	11%	9%	11%	6%	9%	14%	6%	11%	9%	11%	14%	17%	10%
non-residentialgastro	2010	2%	2%	7%	5%	21%	2%	17%	17%	27%	19%	17%	2%	10%	11%	17%	5%	17%	2%	17%	5%	2%	21%	5%	10%	8%	10%	5%	17%	8%
non-residentialtrade	1945	28%	28%	6%	12%	29%	28%	5%	16%	12%	26%	5%	28%	18%	16%	49%	12%	16%	28%	16%	12%	28%	29%	12%	18%	8%	18%	0%	49%	30%
non-residentialtrade	1970	12%	12%	42%	12%	12%	12%	15%	16%	12%	13%	15%	12%	18%	26%	12%	12%	16%	12%	16%	12%	12%	15%	12%	18%	25%	18%	25%	12%	13%
non-residentialtrade	1980	9%	9%	20%	12%	12%	9%	21%	12%	12%	13%	21%	9%	20%	17%	5%	12%	12%	9%	12%	12%	9%	10%	12%	20%	28%	20%	30%	5%	8%
non-residentialtrade	1990	12%	12%	14%	22%	12%	12%	23%	11%	22%	18%	23%	12%	15%	20%	11%	22%	11%	12%	11%	22%	12%	1%	22%	15%	11%	15%	24%	11%	11%
non-residentialtrade	2000	19%	19%	7%	23%	17%	19%	12%	16%	23%	19%	12%	19%	15%	8%	11%	23%	16%	19%	16%	23%	19%	12%	23%	15%	11%	15%	13%	11%	17%
non-residentialtrade	2010	21%	21%	11%	20%	17%	21%	24%	30%	20%	17%	24%	21%	13%	14%	11%	20%	30%	21%	30%	20%	21%	33%	20%	13%	14%	13%	7%	11%	21%
non-residentialsports	1945	36%	36%	10%	13%	19%	36%	6%	6%	13%	23%	6%	36%	10%	17%	28%	13%	6%	36%	6%	13%	36%	33%	13%	10%	15%	10%	11%	28%	36%
non-residentialsports	1970	15%	15%	10%	13%	21%	15%	12%	12%	13%	12%	12%	15%	10%	26%	14%	13%	12%	15%	12%	13%	15%	19%	13%	10%	35%	10%	11%	14%	15%
non-residentialsports	1980	10%	10%	17%	13%	21%	10%	10%	10%	13%	12%	10%	10%	17%	17%	8%	13%	10%	10%	10%	13%	10%	20%	13%	17%	17%	17%	22%	8%	10%
non-residentialsports	1990	19%	19%	25%	22%	21%	19%	16%	16%	22%	8%	16%	19%	25%	19%	17%	22%	16%	19%	16%	22%	19%	2%	22%	25%	12%	25%	30%	17%	11%
non-residentialsports	2000	8%	8%	25%	23%	10%	8%	18%	18%	23%	8%	18%	8%	25%	8%	17%	23%	18%	8%	18%	23%	8%	10%	23%	25%	8%	25%	18%	17%	8%
non-residentialsports	2010	11%	11%	13%	16%	8%	11%	38%	38%	16%	37%	38%	11%	13%	13%	17%	16%	38%	11%	38%	16%	11%	16%	16%	13%	6%	13%	8%	17%	19%
non-residentialother	1945	36%	36%	27%	41%	41%	36%	41%	41%	41%	23%	41%	36%	27%	17%	23%	41%	41%	36%	41%	41%	36%	33%	41%	27%	15%	27%	41%	23%	36%
non-residentialother	1970	15%	15%	27%	23%	23%	15%	23%	23%	23%	12%	23%	15%	27%	26%	16%	23%	23%	15%	23%	23%	15%	19%	23%	27%	35%	27%	23%	16%	15%
non-residentialother	1980	10%	10%	19%	14%	14%	10%	14%	14%	14%	2%	14%	10%	19%	17%	10%	14%	14%	10%	14%	14%	10%	20%	14%	19%	17%	19%	14%	10%	10%
non-residentialother	1990	19%	19%	10%	12%	12%	19%	12%	12%	12%	8%	12%	19%	10%	19%	17%	12%	12%	19%	12%	12%	19%	2%	12%	10%	12%	10%	12%	17%	11%
non-residentialother	2000	8%	8%	10%	6%	6%	8%	6%	6%	6%	8%	6%	8%	10%	8%	17%	6%	6%	8%	6%	6%	8%	10%	6%	10%	8%	10%	6%	17%	8%
non-residentialother	2010	11%	11%	7%	5%	5%	11%	5%	5%	5%	37%	5%	11%	7%	13%	17%	5%	5%	11%	5%	5%	11%	16%	5%	7%	6%	7%	5%	17%	19%
non-residentialall non-res	1945	34%	34%	9%	19%	27%	34%	17%	25%	19%	23%	13%	34%	21%	19%	32%	19%	25%	34%	25%	19%	34%	32%	19%	21%	14%	21%	23%	32%	34%
non-residentialall non-res	1970	15%	15%	39%	21%	15%	15%	20%	22%	18%	11%	18%	15%	21%	25%	14%	21%	22%	15%	22%	21%	15%	19%	21%	21%	36%	21%	21%	14%	15%
non-residentialall non-res	1980	9%	9%	20%	12%	14%	9%	17%	16%	13%	11%	19%	9%	23%	18%	7%	12%	16%	9%	16%	12%	9%	17%	12%	23%	17%	23%	18%	7%	9%
non-residentialall non-res	1990	15%	15%	14%	18%	14%	15%	17%	17%	18%	13%	22%	15%	12%	17%	16%	18%	17%	15%	17%	18%	15%	2%	18%	12%	12%	12%	22%	16%	12%
non-residentialall non-res	2000	15%	15%	8%	17%	13%	15%	12%	10%	16%	13%	11%	15%	12%	8%	16%	17%	10%	15%	10%	17%	15%	10%	17%	12%	8%	12%	11%	16%	13%
non-residentialall non-res	2010	11%	11%	10%	14%	18%	11%	17%	11%	16%	28%	18%	11%	10%	13%	16%	14%	11%	11%	11%	14%	11%	20%	14%	10%	6%	10%	5%	16%	16%

Age of building [% of floor area]	Member State / Zone →		AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28
roofwindow	roofwindow res	**1945**	22%	22%	15%	7%	24%	21%	36%	24%	8%	13%	12%	19%	12%	19%	14%	26%	16%	27%	15%	7%	26%	18%	11%	12%	25%	32%	25%	25%	21%
roofwindow	roofwindow res	1970	27%	23%	29%	27%	30%	29%	26%	27%	27%	20%	22%	22%	26%	26%	13%	33%	26%	25%	22%	27%	24%	19%	15%	31%	24%	20%	28%	29%	25%
roofwindow	roofwindow res	1980	16%	19%	17%	24%	12%	18%	16%	19%	24%	18%	19%	24%	23%	15%	13%	19%	20%	15%	19%	24%	14%	14%	19%	19%	18%	18%	12%	8%	17%
roofwindow	roofwindow res	1990	13%	17%	16%	21%	16%	13%	7%	18%	20%	12%	20%	17%	22%	21%	11%	13%	20%	12%	16%	21%	15%	14%	19%	28%	12%	10%	16%	21%	16%
roofwindow	roofwindow res	2000	15%	11%	9%	15%	9%	13%	7%	7%	14%	12%	13%	9%	11%	9%	16%	5%	9%	9%	11%	15%	13%	14%	22%	5%	10%	10%	10%	9%	10%
roofwindow	roofwindow res	2010	6%	8%	14%	6%	9%	8%	9%	5%	7%	25%	14%	9%	6%	10%	33%	4%	9%	13%	17%	6%	7%	20%	14%	5%	11%	10%	11%	9%	11%
roofwindow	roofwindow non-res	**1945**	34%	34%	9%	19%	27%	34%	17%	25%	19%	23%	13%	34%	21%	19%	32%	19%	25%	34%	25%	19%	34%	32%	19%	21%	14%	21%	23%	32%	34%
roofwindow	roofwindow non-res	1970	15%	15%	39%	21%	15%	15%	20%	22%	18%	11%	18%	15%	21%	25%	14%	21%	22%	15%	22%	21%	15%	19%	21%	21%	36%	21%	21%	14%	15%
roofwindow	roofwindow non-res	1980	9%	9%	20%	12%	14%	9%	17%	16%	13%	11%	19%	9%	23%	18%	7%	12%	16%	9%	16%	12%	9%	17%	12%	23%	17%	23%	18%	7%	9%
roofwindow	roofwindow non-res	1990	15%	15%	14%	18%	14%	15%	17%	17%	18%	13%	22%	15%	12%	17%	16%	18%	17%	15%	17%	18%	15%	2%	18%	12%	12%	12%	22%	16%	12%
roofwindow	roofwindow non-res	2000	15%	15%	8%	17%	13%	15%	12%	10%	16%	13%	11%	15%	12%	8%	16%	17%	10%	15%	10%	17%	15%	10%	17%	12%	8%	12%	11%	16%	13%
roofwindow	roofwindow non-res	2010	11%	11%	10%	14%	18%	11%	17%	11%	16%	28%	18%	11%	10%	13%	16%	14%	11%	11%	11%	14%	11%	20%	14%	10%	6%	10%	5%	16%	16%
roofwindow	roofwindow all	**1945**	27%	26%	12%	11%	25%	26%	31%	24%	12%	16%	12%	25%	15%	19%	20%	24%	19%	30%	19%	12%	29%	24%	13%	17%	21%	28%	24%	28%	26%
roofwindow	roofwindow all	1970	22%	20%	33%	25%	25%	23%	25%	25%	24%	17%	20%	19%	25%	26%	13%	30%	24%	21%	22%	25%	21%	19%	17%	27%	29%	21%	25%	22%	21%
roofwindow	roofwindow all	1980	14%	16%	18%	20%	13%	15%	16%	18%	20%	16%	19%	18%	23%	16%	11%	17%	18%	13%	18%	20%	12%	15%	17%	21%	18%	20%	14%	8%	14%
roofwindow	roofwindow all	1990	14%	16%	15%	20%	15%	14%	9%	18%	19%	13%	20%	16%	18%	20%	13%	14%	19%	13%	17%	19%	15%	9%	19%	20%	12%	11%	18%	19%	15%
roofwindow	roofwindow all	2000	15%	13%	9%	15%	10%	14%	8%	8%	15%	12%	13%	11%	11%	8%	16%	8%	9%	11%	10%	16%	14%	13%	21%	8%	9%	11%	10%	12%	11%
roofwindow	roofwindow all	2010	8%	9%	12%	9%	12%	9%	11%	7%	10%	26%	15%	10%	8%	11%	27%	7%	10%	12%	15%	9%	9%	20%	14%	7%	9%	10%	8%	12%	13%

Building demolition: 1% (all sectors)

New build rate: -0.25% of increase between 200-2010 (all sectors)

Table 187 Demolition / new build rates

Rates	2010	2020	2030	2040	2050
removed (% of 2010 value)	100%	90%	82%	74%	67%
new built (% of 2010 new build)	100%	98%	95%	93%	90%

Table 188 Window-to-floor ratio

Window-to-floor ratio [%], 2010 reference value	Member State / Zone ↓					63%				16%				8%								9%			4%				← share zone in total
Sector ↓	Subsector ↓	AT	BE	BG	CY	CZ	**DE**	DK	EE	EL	**ES**	FI	FR	HR	**HU**	IE	IT	LT	LU	LV	MT	NL	**PL**	PT	RO	**SE**	SI	SK	UK	EU28

residential	single family	20%	20%	20%	20%	20%	**20%**	20%	20%	20%	**20%**	20%	20%	20%	**20%**	20%	20%	20%	20%	20%	20%	20%	**20%**	20%	20%	**20%**	20%	20%	20%	20%
residential	multi family	20%	20%	20%	20%	20%	**20%**	20%	20%	20%	**20%**	20%	20%	20%	**20%**	20%	20%	20%	20%	20%	20%	20%	**20%**	20%	20%	**20%**	20%	20%	20%	20%
residential	all res	20%	20%	20%	20%	20%	**20%**	20%	20%	20%	**20%**	20%	20%	20%	**20%**	20%	20%	20%	20%	20%	20%	20%	**20%**	20%	20%	**20%**	20%	20%	20%	20%
non-residential	offices	21%	21%	14%	10%	16%	**21%**	14%	16%	10%	**10%**	14%	21%	10%	**14%**	21%	10%	16%	21%	16%	10%	21%	**16%**	10%	14%	**14%**	14%	16%	21%	19%
non-residential	educational	5%	5%	13%	8%	8%	**5%**	9%	8%	8%	**8%**	9%	5%	8%	**13%**	5%	8%	8%	5%	8%	8%	5%	**8%**	8%	13%	**9%**	13%	8%	5%	7%
non-residential	health	7%	7%	12%	14%	21%	**7%**	10%	21%	14%	**14%**	10%	7%	14%	**12%**	7%	14%	21%	7%	21%	14%	7%	**21%**	14%	12%	**10%**	12%	21%	7%	9%
non-residential	gastro	5%	5%	13%	8%	8%	5%	9%	8%	8%	8%	9%	5%	8%	13%	5%	8%	8%	5%	8%	8%	5%	8%	8%	13%	9%	13%	8%	5%	7%
non-residential	trade	5%	5%	13%	8%	8%	5%	9%	8%	8%	8%	9%	5%	8%	13%	5%	8%	8%	5%	8%	8%	5%	8%	8%	13%	9%	13%	8%	5%	7%
non-residential	sports	5%	5%	13%	8%	8%	5%	9%	8%	8%	8%	9%	5%	8%	13%	5%	8%	8%	5%	8%	8%	5%	8%	8%	13%	9%	13%	8%	5%	7%
non-residential	other	5%	5%	13%	8%	8%	5%	9%	8%	8%	8%	9%	5%	8%	13%	5%	8%	8%	5%	8%	8%	5%	8%	8%	13%	9%	13%	8%	5%	7%
non-residential	all non-res	9%	9%	13%	8%	10%	*9%*	9%	10%	8%	*8%*	9%	9%	8%	*13%*	9%	8%	10%	9%	10%	8%	9%	*10%*	8%	13%	*9%*	13%	10%	9%	9%
roofwindow	roofwindow res	DE: all facade wdws=(I146*(I9/(I17+I9))) + (I154*(I17/(I17+I9)))																												5.0%
roofwindow	roofwindow non-res																													0.5%
roofwindow	roofwindow all																													3.4%

Table 189 Allocation of climate conditions to MS

MS by % condition	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28
North	10%				10%	10%	10%	50%			100%			10%			40%		50%			20%		10%	90%		10%	10%	8%
Central	90%	90%	60%		90%	90%	90%	50%		10%		60%	60%	60%	100%	30%	60%	100%	50%		90%	80%		60%	10%	90%	90%	90%	61%
South		10%	40%	100%					100%	90%		40%	40%	30%		70%		0%		100%	10%		100%	30%		10%			31%

Table 190 Heating degree days and cooling degree days, used to correct allocation of climate conditions and correction Z

HDD & CDD		AT	BE	BU	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU
Population weighted average heating degree days HDD for EU28, 2009 (VHK calculation on the basis of Eurostat database extract April 2014)	HDD	3301	2696	2403	600	3327	3063	3235	4302	1449	1686	5596	2340	2316	2594	2841	1829	3931	2967	4161	499	2727	3439	1166	2773	5291	2774	3160	2990	2,670
Cooling Degree Days (CDD) at base outdoor temperature 20.5 °C (means ~25 °C indoor, incl. internal gains 1.5 K, solar gains and heat island 3 K), Aug. 2013-July 2014.	CDD	213	84	275	972	116	168	57	78	893	652	97	138	277	282	5	420	105	103	102	714	75	216	324	379	81	187	260	94	242

Table 191 Correction factor for parameter Z to correct for 'real' shutter use

CORRECTION factor for value C / OPTIMAL USE of SHUTTERS for HEATING

Share used 'with shutters'	max value setting		AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28
heating based on HDD	23%	(empty)	0.14	0.11	0.10	0.02	0.14	0.13	0.13	0.18	0.06	0.07	0.23	0.10	0.10	0.11	0.12	0.08	0.16	0.12	0.17	0.02	0.11	0.14	0.05	0.11	0.22	0.11	0.13	0.12	0.11
all res	**% windows using shutters**	residential	**0.14**	**0.11**	**0.10**	**0.02**	**0.14**	**0.13**	**0.13**	**0.18**	**0.06**	**0.07**	**0.23**	**0.10**	**0.10**	**0.11**	**0.12**	**0.08**	**0.16**	**0.12**	**0.17**	**0.02**	**0.11**	**0.14**	**0.05**	**0.11**	**0.22**	**0.11**	**0.13**	**0.12**	**0.11**
heating based on HDD	23%	(empty)	0.14	0.11	0.10	0.02	0.14	0.13	0.13	0.18	0.06	0.07	0.23	0.10	0.10	0.11	0.12	0.08	0.16	0.12	0.17	0.02	0.11	0.14	0.05	0.11	0.22	0.11	0.13	0.12	0.11
all non-res	**% windows using shutters**	non-residential	**0.14**	**0.11**	**0.10**	**0.02**	**0.14**	**0.13**	**0.13**	**0.18**	**0.06**	**0.07**	**0.23**	**0.10**	**0.10**	**0.11**	**0.12**	**0.08**	**0.16**	**0.12**	**0.17**	**0.02**	**0.11**	**0.14**	**0.05**	**0.11**	**0.22**	**0.11**	**0.13**	**0.12**	**0.11**
roofwindow		roofwindow	0.14	0.11	0.10	0.02	0.14	0.13	0.13	0.18	0.06	0.07	0.23	0.10	0.10	0.11	0.12	0.08	0.16	0.12	0.17	0.02	0.11	0.14	0.05	0.11	0.22	0.11	0.13	0.12	0.11

CORRECTION factor for value Z / OPTIMAL USE of SHUTTERS for COOLING

Share used 'with shutters'			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28
cooling based on CDD	40%	(empty)	0.09	0.03	0.11	0.40	0.05	0.07	0.02	0.03	0.37	0.27	0.04	0.06	0.11	0.12	0.00	0.17	0.04	0.04	0.04	0.29	0.03	0.09	0.13	0.16	0.03	0.08	0.11	0.04	0.11
all res	**% windows using shutters**	residential	**0.09**	**0.03**	**0.11**	**0.40**	**0.05**	**0.07**	**0.02**	**0.03**	**0.37**	**0.27**	**0.04**	**0.06**	**0.11**	**0.12**	**0.00**	**0.17**	**0.04**	**0.04**	**0.04**	**0.29**	**0.03**	**0.09**	**0.13**	**0.16**	**0.03**	**0.08**	**0.11**	**0.04**	**0.11**
cooling based on CDD	40%	(empty)	0.09	0.03	0.11	0.40	0.05	0.07	0.02	0.03	0.37	0.27	0.04	0.06	0.11	0.12	0.00	0.17	0.04	0.04	0.04	0.29	0.03	0.09	0.13	0.16	0.03	0.08	0.11	0.04	0.11
all non-res	**% windows using shutters**	non-residential	**0.09**	**0.03**	**0.11**	**0.40**	**0.05**	**0.07**	**0.02**	**0.03**	**0.37**	**0.27**	**0.04**	**0.06**	**0.11**	**0.12**	**0.00**	**0.17**	**0.04**	**0.04**	**0.04**	**0.29**	**0.03**	**0.09**	**0.13**	**0.16**	**0.03**	**0.08**	**0.11**	**0.04**	**0.11**
roofwindow		roofwindow	0.09	0.03	0.11	0.40	0.05	0.07	0.02	0.03	0.37	0.27	0.04	0.06	0.11	0.12	0.00	0.17	0.04	0.04	0.04	0.29	0.03	0.09	0.13	0.16	0.03	0.08	0.11	0.04	0.11

Table 192 Heating demand / residential

HEATING demand [TWh_heat/yr, year 2010]	Member State / Zone ↓																														
Sector ↓	Subsector ↓		AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28
residential	single family	TWh/yr	31.5	62.1	10.7	0.7	22.9	250.9	22.0	3.4	10.2	26.4	27.1	147.2	6.9	27.0	22.6	53.1	6.9	1.7	6.5	0.2	79.8	70.6	8.4	29.7	24.1	4.2	9.9	183.5	1081.7
residential	multi family	TWh/yr	17.3	9.7	8.2	0.3	17.6	161.4	7.9	5.3	17.5	45.4	11.6	71.3	2.7	7.9	1.5	118.6	6.3	0.9	6.0	0.1	9.5	52.7	4.5	14.0	19.1	3.8	6.1	23.1	718.3
residential	all res	TWh/yr	48.8	71.8	18.8	1.0	40.5	412.3	29.8	8.6	27.6	71.9	38.7	218.5	9.5	34.8	24.1	171.7	13.2	2.5	12.5	0.2	89.4	123.2	13.0	43.7	43.2	8.0	15.9	206.6	1800.0

Table 193 Heating demand / non-residential

Sector ↓	Subsector ↓		EU28
non-residential	offices	TWh/yr	50.9
non-residential	educational	TWh/yr	62.0
non-residential	health	TWh/yr	61.8

non-residential	gastro	TWh/yr	56.3
non-residential	trade	TWh/yr	52.1
non-residential	sports	TWh/yr	56.3
non-residential	other	TWh/yr	56.3
non-residential	all non-res	TWh/yr	1320.0

Table 194 Share RAC by MS

MS Share in total RAC stock (res+non-res)			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28
residential	all res	2005	0.29%	0.47%	1.18%	0.49%	0.12%	1.08%	0.24%	0.06%	5.23%	11.50%	0.21%	2.80%	0.65%	0.09%	0.16%	14.53%	0.15%	0.02%	0.11%	0.06%	0.74%	0.16%	0.18%	3.30%	0.35%	0.31%	0.82%	2.48%	48%
residential	all res	2010	0.32%	0.51%	1.16%	0.45%	0.11%	1.01%	0.26%	0.07%	4.78%	11.24%	0.24%	3.01%	0.64%	0.08%	0.19%	14.51%	0.16%	0.02%	0.12%	0.06%	0.79%	0.15%	0.18%	3.25%	0.41%	0.30%	0.81%	2.86%	48%
residential	all res	2030	0.41%	0.65%	1.08%	0.28%	0.05%	0.71%	0.33%	0.09%	3.01%	10.23%	0.37%	3.86%	0.60%	0.05%	0.29%	14.43%	0.21%	0.03%	0.15%	0.06%	1.01%	0.08%	0.14%	3.03%	0.63%	0.28%	0.76%	4.37%	47%
non-residential	all non-res	2005	0.13%	1.06%	2.15%	0.21%	0.39%	2.48%	0.55%	0.14%	2.18%	6.19%	0.25%	6.61%	1.19%	1.21%	0.20%	10.59%	0.34%	0.05%	0.27%	0.11%	1.66%	0.37%	1.31%	6.02%	0.43%	0.56%	1.51%	4.03%	52%
non-residential	all non-res	2010	0.14%	1.14%	2.06%	0.19%	0.37%	2.33%	0.58%	0.15%	2.00%	6.06%	0.27%	7.07%	1.14%	1.19%	0.21%	10.63%	0.37%	0.05%	0.29%	0.11%	1.77%	0.37%	1.25%	5.79%	0.46%	0.54%	1.45%	4.32%	52%
non-residential	all non-res	2030	0.18%	1.43%	1.73%	0.12%	0.31%	1.74%	0.74%	0.19%	1.26%	5.53%	0.35%	8.91%	0.96%	1.13%	0.27%	10.81%	0.46%	0.07%	0.36%	0.09%	2.23%	0.35%	1.03%	4.84%	0.59%	0.45%	1.21%	5.46%	53%
roofwindow		2010	0.32%	0.51%	1.16%	0.45%	0.11%	1.01%	0.26%	0.07%	4.78%	11.24%	0.24%	3.01%	0.64%	0.08%	0.19%	14.51%	0.16%	0.02%	0.12%	0.06%	0.79%	0.15%	0.18%	3.25%	0.41%	0.30%	0.81%	2.86%	48%
roofwindow		2030	0.41%	0.65%	1.08%	0.28%	0.05%	0.71%	0.33%	0.09%	3.01%	10.23%	0.37%	3.86%	0.60%	0.05%	0.29%	14.43%	0.21%	0.03%	0.15%	0.06%	1.01%	0.08%	0.14%	3.03%	0.63%	0.28%	0.76%	4.37%	47%
skylight		2010	0.14%	1.14%	2.06%	0.19%	0.37%	2.33%	0.58%	0.15%	2.00%	6.06%	0.27%	7.07%	1.14%	1.19%	0.21%	10.63%	0.37%	0.05%	0.29%	0.11%	1.77%	0.37%	1.25%	5.79%	0.46%	0.54%	1.45%	4.32%	52%
skylight		2030	0.18%	1.43%	1.73%	0.12%	0.31%	1.74%	0.74%	0.19%	1.26%	5.53%	0.35%	8.91%	0.96%	1.13%	0.27%	10.81%	0.46%	0.07%	0.36%	0.09%	2.23%	0.35%	1.03%	4.84%	0.59%	0.45%	1.21%	5.46%	53%
MS Share in total CAC stock (res+non-res)	all non-res	2010	2.4%	2.8%	0.9%	0.3%	2.0%	10.0%	0.4%	0.1%	2.3%	12.5%	0.9%	7.0%	0.5%	2.7%	1.7%	21.9%	0.2%	0.0%	0.2%	0.1%	4.0%	1.2%	1.2%	2.2%	2.3%	0.2%	0.9%	19.0%	100.0%

Table 195 Relative cooling load

Relative artificial cooling load		AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28
residential	based on RAC	108%	73%	133%	152%	71%	99%	58%	81%	161%	151%	89%	98%	88%	102%	53%	116%	66%	95%	84%	159%	78%	57%	171%	133%	81%	88%	105%	54%	100%
non-residential	based on RAC	108%	84%	121%	138%	86%	102%	75%	73%	136%	127%	82%	102%	94%	106%	75%	112%	81%	99%	81%	137%	89%	74%	133%	121%	85%	94%	106%	78%	100%
roofwindow	(see 'residential')	108%	73%	133%	152%	71%	99%	58%	81%	161%	151%	89%	98%	88%	102%	53%	116%	66%	95%	84%	159%	78%	57%	171%	133%	81%	88%	105%	54%	100%

Table 196 Heating efficiency

Heating efficiency year 2010 [%]		avgEU	Member State / Zone ↓																												
Sector ↓	Subsector ↓	avgEU	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28

residential	1.08	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%
non-residential		59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	59%	58.6%
roofwindow		58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%	58.6%

Table 197 Energy costs

ENERGY COSTS			AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28
Natural gas price (MEERP, part 1, p.44)	residential	EUR/kWh_fuel	0.068	0.07	0.05	0.07	0.06	0.07	0.09	0.05	0.07	0.08	0.12	0.07	0.05	0.04	0.07	0.08	0.06	0.05	0.05	0.07	0.08	0.049	0.093	0.031	0.118	0.067	0.051	0.06	0.07
	non-residential	EUR/kWh_fuel	0.043	0.032	0.035	0.049	0.032	0.045	0.037	0.035	0.049	0.037	0.047	0.039	0.042	0.04	0.041	0.038	0.041	0.043	0.035	0.049	0.042	0.038	0.043	0.03	0.05	0.043	0.037	0.037	0.039
Average heating costs	residential	EUR/kWh_fuel	0.06	0.07	0.04	0.14	0.06	0.06	0.10	0.06	0.06	0.09	0.13	0.06	0.04	0.03	0.08	0.06	0.06	0.04	0.05	0.10	0.06	0.05	0.09	0.03	0.17	0.06	0.05	0.06	0.07
	non-residential	EUR/kWh_fuel	0.04	0.04	0.03	0.10	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.03	0.04	0.03	0.05	0.03	0.04	0.03	0.03	0.09	0.03	0.04	0.05	0.03	0.07	0.04	0.03	0.03	0.04

COOLING	residential	EUR/kWh_elec	0.2	0.21	0.09	0.21	0.14	0.25	0.28	0.1	0.13	0.18	0.14	0.15	0.14	0.17	0.19	0.21	0.12	0.18	0.11	0.15	0.26	0.14	0.17	0.11	0.2	0.14	0.16	0.15	0.18
COOLING	non-residential	EUR/kWh_elec	0.11	0.11	0.06	0.15	0.1	0.11	0.09	0.07	0.09	0.12	0.07	0.07	0.1	0.12	0.11	0.14	0.1	0.1	0.09	0.15	0.1	0.1	0.09	0.09	0.08	0.1	0.12	0.1	0.1

Table 198 Purchase cost calculation

PURCHASE PRICE (and split up)

STREET PRICE, incl VAT + INSTALLATION	no shutters		AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	EU28
facade window	01_single	154	181	208	62	118	92	180	217	88	107	137	184	194	89	78	174	164	71	193	72	99	189	81	98	68	226	109	83	139	154
facade window	02_double IGU, standard	234	267	300	121	187	157	265	313	152	177	212	272	282	155	142	258	246	132	278	133	165	275	145	166	130	323	178	147	215	234
facade window	03_double IGU, lowE, argon	255	291	326	134	205	173	289	341	168	194	232	297	307	172	157	281	268	147	303	148	182	300	160	183	144	352	196	162	235	255
facade window	04_double IGU,lowE, argon, impr	256	291	326	134	205	173	295	341	168	194	232	297	307	172	157	281	268	147	303	148	182	300	160	183	144	352	196	162	235	256
facade window	05_triple IGU, lowE, argon	298	334	369	177	246	216	331	385	211	238	274	340	349	215	201	325	311	190	344	191	224	342	204	227	188	396	239	205	278	298
facade window	06_triple IGU, lowE, argon, impr.	403	448	494	249	335	299	445	515	292	328	371	458	468	299	281	437	420	265	460	268	308	459	284	313	264	530	327	285	377	403
facade window	07_coupled	370	410	451	233	309	277	407	471	271	303	342	419	428	277	262	400	385	247	420	249	285	420	264	290	247	484	302	264	347	370
facade window	08_quadruple	510	554	601	356	437	405	550	626	398	437	476	567	574	408	392	544	526	373	562	376	413	565	393	422	374	641	434	391	483	510
facade window	09_as 02, solar	288	327	366	155	232	198	325	382	192	221	262	334	345	196	180	317	302	168	340	170	207	337	183	208	166	395	222	185	265	288
facade window	10_as 04, solar	299	339	380	161	241	206	337	396	199	230	272	346	357	204	187	329	314	175	352	177	215	349	191	217	173	409	231	193	276	299

facade window	11_as 06, solar		**456**	505	556	285	380	340	502	581	332	372	420	516	527	340	321	493	474	303	517	306	350	517	324	356	302	597	372	324	427	**456**
roofwindow	roof_01		150	308	353	103	205	155	307	364	147	179	236	312	330	151	130	296	280	118	333	118	167	324	134	164	113	379	185	140	235	**262**
roofwindow	roof_02		200	411	472	137	273	207	409	489	196	239	315	418	441	202	174	397	375	158	441	158	223	433	180	219	151	509	248	186	313	**350**
roofwindow	roof_03		300	560	640	201	378	292	557	667	278	335	434	572	599	287	251	543	514	228	595	228	312	589	257	309	220	693	346	265	432	**480**
roofwindow	roof_04		475	820	935	311	562	441	815	976	420	503	642	841	874	435	385	798	757	350	865	350	468	862	392	466	339	1014	518	402	638	**708**
roofwindow	roof_05		600	1059	1209	395	722	565	1051	1265	537	646	827	1087	1130	557	491	1032	977	446	1115	446	600	1113	501	598	432	1314	665	514	822	**913**
roofwindow	roof_06		350	675	773	236	452	348	671	807	330	400	521	690	722	341	297	655	619	269	716	269	372	710	305	369	259	839	414	314	518	**578**

INSTALLATION COSTS			**AT**	**BE**	**BG**	**CY**	**CZ**	**DE**	**DK**	**EE**	**EL**	**ES**	**FI**	**FR**	**HR**	**HU**	**IE**	**IT**	**LT**	**LU**	**LV**	**MT**	**NL**	**PL**	**PT**	**RO**	**SE**	**SI**	**SK**	**UK**	**EU28**
facade window		EUR/m2 window	62	73	6	34	20	61.5	75	18	26	42	62	67	18	12	58	54	10	69	10	24	65	14	22	8	79	28	16	42	49
roofwindow		EUR/m2 window	200	239	19	110	65	200	245	58	84	135	200	219	58	39	187	174	32	226	32	77	213	45	71	26	258	90	52	135	159

		AT	**BE**	**BG**	**CY**	**CZ**	**DE**	**DK**	**EE**	**EL**	**ES**	**FI**	**FR**	**HR**	**HU**	**IE**	**IT**	**LT**	**LU**	**LV**	**MT**	**NL**	**PL**	**PT**	**RO**	**SE**	**SI**	**SK**	**UK**	**EU28**
TAX RATES	2011	20	21	20	15	20	19	25	20	23	18	23	19.6	23	25	21	20	21	15	22	18	19	23	23	24	25	20	20	20	20
	2014	20	21	20	19	21	19	25	20	23	21	24	20	25	27	23	22	21	15	21	18	21	23	23	24	25	22	20	20	21.1

OVERHEAD COSTS			**AT**	**BE**	**BG**	**CY**	**CZ**	**DE**	**DK**	**EE**	**EL**	**ES**	**FI**	**FR**	**HR**	**HU**	**IE**	**IT**	**LT**	**LU**	**LV**	**MT**	**NL**	**PL**	**PT**	**RO**	**SE**	**SI**	**SK**	**UK**	**EU28**
facade window	01_single	01_single	35	42	3	19	11	35	43	10	15	24	35	39	10	7	33	31	6	40	6	14	38	8	13	5	46	16	9	24	26
facade window	02_double IGU, standard	02_double IGU, standard	50	60	5	27	16	50	61	15	21	34	50	55	15	10	47	44	8	56	8	19	53	11	18	6	64	23	13	34	37
facade window	03_double IGU, lowE, argon	03_double IGU, lowE, argon	56	67	5	31	18	56	68	16	23	38	56	61	16	11	52	49	9	63	9	22	59	13	20	7	72	25	14	38	41
facade window	04_double IGU,lowE, argon, impr	04_double IGU,lowE, argon, impr	56	67	5	31	18	**59**	68	16	23	38	56	61	16	11	52	49	9	63	9	22	59	13	20	7	72	25	14	38	41
facade window	05_triple IGU, lowE, argon	05_triple IGU, lowE, argon	56	67	5	31	18	56	68	16	23	38	56	61	16	11	52	49	9	63	9	22	59	13	20	7	72	25	14	38	41
facade window	06_triple IGU, lowE, argon, impr.	06_triple IGU, lowE, argon, impr.	79	95	8	44	26	79	97	23	33	54	79	87	23	15	74	69	13	90	13	31	85	18	28	10	102	36	20	54	59
facade window	07_coupled	07_coupled	68	81	7	37	22	68	83	20	28	46	68	74	20	13	63	59	11	76	11	26	72	15	24	9	87	31	17	46	50
facade window	08_quadruple	08_quadruple	79	95	8	44	26	79	97	23	33	54	79	87	23	15	74	69	13	90	13	31	85	18	28	10	102	36	20	54	59
facade window	09_as 02, solar	09_as 02, solar	65	77	6	35	21	65	79	19	27	44	65	71	19	13	61	56	10	73	10	25	69	15	23	8	83	29	17	44	48
facade window	10_as 04, solar	10_as 04, solar	68	81	7	37	22	68	83	20	28	46	68	74	20	13	63	59	11	76	11	26	72	15	24	9	87	31	17	46	50
facade window	11_as 06, solar	11_as 06, solar	91	109	9	50	29	91	112	26	38	62	91	100	26	18	85	79	15	103	15	35	97	21	32	12	118	41	24	62	68
	CHECK #04		29%	32%	5%	21%	14%	30%	32%	13%	17%	23%	29%	31%	13%	9%	28%	27%	8%	31%	8%	16%	30%	11%	15%	7%	33%	18%	12%	23%	25%
roofwindow	roof_01		23	27	2	12	7	23	28	7	9	15	23	25	7	4	21	20	4	25	4	9	24	5	8	3	29	10	6	15	17
roofwindow	roof_02		50	60	5	27	16	50	61	15	21	34	50	55	15	10	47	44	8	56	8	19	53	11	18	6	65	23	13	34	37
roofwindow	roof_03		75	90	7	41	24	75	92	22	31	51	75	82	22	15	70	65	12	85	12	29	80	17	27	10	97	34	19	51	56
roofwindow	roof_04		160	191	16	88	52	160	197	47	67	109	160	176	47	31	150	140	26	181	26	62	171	36	57	21	207	72	41	109	119

roofwindow	roof_05		203	242	20	111	65	203	248	59	85	137	203	222	59	39	189	176	33	229	33	78	216	46	72	26	261	91	52	137	150
roofwindow	roof_06		96	115	9	53	31	96	118	28	40	65	96	106	28	19	90	84	16	109	16	37	102	22	34	12	124	43	25	65	71
RETAIL / WHOLESALE MARGIN		15%						15%																							
rest OVERHEAD		15%						15%																							
LABOUR COSTS			**AT**	**BE**	**BG**	**CY**	**CZ**	**DE**	**DK**	**EE**	**EL**	**ES**	**FI**	**FR**	**HR**	**HU**	**IE**	**IT**	**LT**	**LU**	**LV**	**MT**	**NL**	**PL**	**PT**	**RO**	**SE**	**SI**	**SK**	**UK**	**EU28**
facade window	01_single		24	28	2	13	8	24	29	7	10	16	24	26	7	5	22	20	4	27	4	9	25	5	8	3	30	11	6	16	17
facade window	02_double IGU, standard		33	40	3	18	11	33	41	10	14	23	33	37	10	6	31	29	5	38	5	13	35	8	12	4	43	15	9	23	25
facade window	03_double IGU, lowE, argon		37	44	4	20	12	37	46	11	16	25	37	41	11	7	35	32	6	42	6	14	40	8	13	5	48	17	10	25	28
facade window	04_double IGU,lowE, argon, impr		37	44	4	20	12	**39**	46	11	16	25	37	41	11	7	35	32	6	42	6	14	40	8	13	5	48	17	10	25	28
facade window	05_triple IGU, lowE, argon		37	44	4	20	12	37	46	11	16	25	37	41	11	7	35	32	6	42	6	14	40	8	13	5	48	17	10	25	28
facade window	06_triple IGU, lowE, argon, impr.		53	63	5	29	17	53	65	15	22	36	53	58	15	10	50	46	9	60	9	20	56	12	19	7	68	24	14	36	39
facade window	07_coupled		45	54	4	25	15	45	55	13	19	31	45	49	13	9	42	39	7	51	7	17	48	10	16	6	58	20	12	31	33
facade window	08_quadruple		53	63	5	29	17	53	65	15	22	36	53	58	15	10	50	46	9	60	9	20	56	12	19	7	68	24	14	36	39
facade window	09_as 02, solar		43	51	4	24	14	43	53	13	18	29	43	47	13	8	40	38	7	49	7	17	46	10	15	6	56	19	11	29	32
facade window	10_as 04, solar		45	54	4	25	15	45	55	13	19	31	45	49	13	9	42	39	7	51	7	17	48	10	16	6	58	20	12	31	33
facade window	11_as 06, solar		61	73	6	33	20	61	74	18	25	41	61	67	18	12	57	53	10	69	10	24	65	14	22	8	78	27	16	41	45
roofwindow	roof_01		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
roofwindow	roof_02		36	43	3	20	12	36	44	10	15	24	36	39	10	7	34	31	6	41	6	14	38	8	13	5	46	16	9	24	27
roofwindow	roof_03		90	107	9	49	29	90	110	26	38	61	90	99	26	17	84	78	15	102	15	35	96	20	32	12	116	41	23	61	67
roofwindow	roof_04		143	170	14	78	46	143	175	41	60	97	143	156	41	28	133	124	23	161	23	55	152	32	51	18	184	64	37	97	106
roofwindow	roof_05		243	290	24	133	78	243	298	71	102	165	243	267	71	47	227	212	39	274	39	94	259	55	86	31	314	110	63	165	180
roofwindow	roof_06		142	169	14	78	46	142	174	41	59	96	142	155	41	27	133	123	23	160	23	55	151	32	50	18	183	64	37	96	105
			AT	**BE**	**BG**	**CY**	**CZ**	**DE**	**DK**	**EE**	**EL**	**ES**	**FI**	**FR**	**HR**	**HU**	**IE**	**IT**	**LT**	**LU**	**LV**	**MT**	**NL**	**PL**	**PT**	**RO**	**SE**	**SI**	**SK**	**UK**	**EU28**
LABOUR COSTS			19%	21%	3%	14%	9%	20%	22%	9%	11%	16%	19%	20%	9%	6%	19%	18%	5%	21%	5%	11%	20%	7%	10%	4%	22%	12%	8%	16%	17%
	Hourly wages in construction sector		**31**	**37**	**3**	**17**	**10**	**31**	**38**	**9**	**13**	**21**	**31**	**34**	**9**	**6**	**29**	**27**	**5**	**35**	**5**	**12**	**33**	**7**	**11**	**4**	**40**	**14**	**8**	**21**	**23**
	Correction factor for personall costs (wages/overhead), DE as reference		1.0	1.2	0.1	0.5	0.3	1.0	1.2	0.3	0.4	0.7	1.0	1.1	0.3	0.2	0.9	0.9	0.2	1.1	0.2	0.4	1.1	0.2	0.4	0.1	1.3	0.5	0.3	0.7	0.7
	Turnover per employee	000 EUR	110	119	70	90	80	110	120	79	84	96	110	114	79	75	107	104	73	116	73	83	113	76	82	72	123	86	77	96	99
		euro						**30**																							
MATERIAL COSTS		combined (material+complexity) correction																													
facade window	01_single	0.40	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
facade window	02_double IGU, standard	0.85	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88	88
facade window	03_double IGU, lowE, argon	0.95	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98

facade window	04_double IGU,lowE, argon, impr	0.95	98	98	98	98	98	**98**	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
facade window	05_triple IGU, lowE, argon	1.29	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134	134
facade window	06_triple IGU, lowE, argon, impr.	1.84	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190	190
facade window	07_coupled	1.73	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178
facade window	08_quadruple	2.70	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279
facade window	09_as 02, solar	1.10	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113	113
facade window	10_as 04, solar	1.15	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119
facade window	11_as 06, solar	2.11	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218	218
			51%	47%	92%	66%	77%	50%	46%	78%	72%	61%	51%	49%	78%	84%	53%	55%	87%	48%	87%	73%	50%	82%	75%	89%	45%	70%	80%	61%	59%
roofwindow	roof_01		68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68	68
roofwindow	roof_02		90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
roofwindow	roof_03		135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
roofwindow	roof_04		214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214
roofwindow	roof_05		270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270
roofwindow	roof_06		158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158

			material	labour	overhead
		no VAT, no installation	45%	30%	25%
roofwindow	roof_01	150	68	45	38
roofwindow	roof_02	200	90	60	50
roofwindow	roof_03	300	135	90	75
roofwindow	roof_04	475	214	143	119
roofwindow	roof_05	600	270	180	150
roofwindow	roof_06	350	158	105	88

TIME DEPENDENT DATA

Table 199 Window market by MS (sales %)

			BAU													BAU					A-Modest					B-Advanced					C - Extreme			
Member State / Zone	Sector	Window type		1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010		2020	2030	2040	2050	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
AT	residential	01_	100%	100%	100%	100%	100%	100%	75%	50%	40%	30%	15%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
AT	residential	02_							25%	50%	60%	45%	50%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
AT	residential	03_										24%	30%	45%		25%	17%	8%	0%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%
AT	residential	04_										0%	0%	45%		60%	60%	60%	60%		70%	63%	57%	50%		50%	43%	37%	30%		0%	0%	0%	0%
AT	residential	05_										1%	5%	10%		15%	10%	5%	0%		15%	10%	5%	0%		25%	17%	8%	0%		10%	7%	3%	0%
AT	residential	06.														0%	13%	27%	40%		5%	20%	35%	50%		25%	40%	55%	70%		90%	93%	97%	100%
AT	residential	07_														0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
AT	residential	08_														0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
AT	residential	09_														0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
AT	residential	10_														0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
AT	residential	11_														0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
AT	residential		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												3.42	2.83	1.45	145%	1.36	1.27	1.19	1.10	145 %	1.27	1.20	1.12	1.05	145 %	1.10	1.05	1.00	0.95	145 %	0.82	0.81	0.81	0.80
BE	residential	01_		100%	100%	100%	100%	100%	75%	50%	40%	47%	10%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
BE	residential	02_							25%	50%	60%	38%	30%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
BE	residential	03_										15%	50%	68%		50%	33%	17%	0%		20%	13%	7%	0%		0%	0%	0%	0%		0%	0%	0%	0%
BE	residential	04_										0%	10%	30%		45%	57%	68%	80%		70%	63%	57%	50%		50%	43%	37%	30%		0%	0%	0%	0%
BE	residential	05_										0%	0%	2%		5%	7%	8%	10%		10%	7%	3%	0%		45%	30%	15%	0%		10%	7%	3%	0%
BE	residential	06.														0%	3%	7%	10%		0%	17%	33%	50%		5%	27%	48%	70%		90%	93%	97%	100%
BE	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
BE	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
BE	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
BE	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
BE	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
BE	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												4.05	2.40	1.57	157%	1.49	1.40	1.31	1.22	157 %	1.35	1.25	1.15	1.05	157 %	1.14	1.08	1.01	0.95	157 %	0.82	0.81	0.81	0.80

			BAU													BAU					A-Modest					B-Advanced					C - Extreme			
BG	residential	01_	100%	100%	100%	100%	100%	100%	100%	80%	60%	49%	25%	5%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
BG	residential	02_								20%	40%	48%	45%	10%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
BG	residential	03_										1%	25%	65%		75%	67%	58%	50%		75%	60%	45%	30%		25%	20%	15%	10%		0%	0%	0%	0%
BG	residential	04_										2%	5%	20%		15%	23%	32%	40%		25%	33%	42%	50%		70%	67%	63%	60%		50%	42%	33%	25%
BG	residential	05_										0%	0%	0%		0%	3%	7%	10%		0%	7%	13%	20%		5%	7%	8%	10%		50%	42%	33%	25%
BG	residential	06.															0%	0%	0%			0%	0%	0%			7%	13%	20%			17%	33%	50%
BG	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
BG	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
BG	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
BG	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
BG	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
BG	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%
												4.23	3.20	1.94	194%	1.75	1.66	1.56	1.47	194%	1.60	1.52	1.44	1.36	194%	1.39	1.33	1.27	1.21	194%	1.15	1.09	1.03	0.98
CY	residential	01_	100%	100%	100%	100%	100%	100%	100%	90%	80%	59%	50%	30%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
CY	residential	02_								10%	20%	40%	45%	60%		55%	48%	42%	35%	70.00%	65%	47%	28%	10%		35%	23%	12%	0%		0%	0%	0%	0%
CY	residential	03_										1%				20%	25%	30%	35%		20%	20%	20%	20%		50%	33%	17%	0%		45%	30%	15%	0%
CY	residential	04_										0%					0%	0%				13%	27%	40%			23%	47%	70%		40%	50%	60%	70%
CY	residential	05_										0%					0%	0%				0%	0%				0%	0%			0%	0%	0%	0%
CY	residential	06.															0%	0%				0%	0%				0%	0%				0%	0%	0%
CY	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
CY	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
CY	residential	09_										0%	5%	10%		15%	20%	25%	30%		15%	20%	25%	30%		15%	17%	18%	20%		15%	10%	5%	0%
CY	residential	10_														0%	0%	0%	0%		0%	0%	0%	0%		0%	3%	7%	10%		0%	10%	20%	30%
CY	residential	11_															0%	0%				0%	0%				0%	0%			0%	0%	0%	0%
CY	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%
												4.56	4.30	3.70	370%	2.88	2.73	2.57	2.42	370%	2.58	2.38	2.18	1.98	370%	2.25	2.03	1.82	1.60	370%	1.71	1.57	1.44	1.30
CZ	residential	01_	100%	100%	100%	100%	100%	100%	75%	60%	50%	42%	20%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
CZ	residential	02_							25%	40%	50%	55%	40%	10%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
CZ	residential	03_										3%	35%	60%		50%	42%	33%	25%		25%	17%	8%	0%		10%	7%	3%	0%		0%	0%	0%	0%
CZ	residential	04_										0%	5%	30%		45%	52%	58%	65%		70%	72%	73%	75%		50%	43%	37%	30%		0%	0%	0%	0%
CZ	residential	05_										0%	0%	0%		5%	7%	8%	10%		5%	3%	2%	0%		40%	27%	13%	0%		100%	67%	33%	0%

			BAU													BAU					A-Modest					B-Advanced					C - Extreme			
CZ	residential	06.														0%	0%	0%	0%		0%	8%	17%	25%		0%	23%	47%	70%		0%	33%	67%	100%
CZ	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
CZ	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
CZ	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
CZ	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
CZ	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
CZ	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%
												4.03	2.94	1.69	169%	1.49	1.45	1.41	1.37	169%	1.39	1.32	1.25	1.18	169%	1.22	1.13	1.04	0.95	169%	1.00	0.93	0.87	0.80
DE	residential	01_	100%	100%	100%	100%	100%	100%	75%	30%	0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
DE	residential	02_							25%	70%	5%	0%	5%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
DE	residential	03_									95%	99%	78%	23%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
DE	residential	04_										0%	15%	61%		45%	40%	35%	30%		40%	30%	20%	10%		20%	17%	13%	10%		0%	0%	0%	0%
DE	residential	05_										1%	3%	15%		38%	29%	19%	10%		45%	33%	22%	10%		25%	17%	8%	0%		15%	10%	5%	0%
DE	residential	06.														0%	13%	27%	40%		5%	23%	42%	60%		45%	53%	62%	70%		75%	77%	78%	80%
DE	residential	07_												1%		2%	3%	4%	5%		5%	5%	5%	5%		5%	5%	5%	5%		5%	5%	5%	5%
DE	residential	08_															2%	3%	5%			2%	3%	5%			2%	3%	5%			2%	3%	5%
DE	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
DE	residential	10_														5%	7%	8%	10%		5%	7%	8%	10%		5%	5%	5%	5%		5%	3%	2%	
DE	residential	11_															0%	0%				0%	0%				2%	3%	5%			3%	7%	10%
DE	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%
												1.69	1.68	1.34	134%	1.22	1.15	1.09	1.02	134%	1.13	1.06	0.99	0.92	134%	0.99	0.95	0.91	0.88	134%	0.87	0.84	0.82	0.80
DK	residential	01_	100%	100%	100%	100%	100%	100%	75%	30%	10%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
DK	residential	02_							25%	70%	90%	5%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
DK	residential	03_									0%	94%	83%	30%		20%	17%	13%	10%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%
DK	residential	04_										0%	15%	60%		53%	55%	58%	60%		65%	60%	55%	50%		50%	43%	37%	30%		0%	0%	0%	0%
DK	residential	05_										1%	3%	5%		15%	10%	5%	0%		15%	10%	5%	0%		25%	17%	8%	0%		25%	17%	8%	0%
DK	residential	06.														3%	8%	14%	20%		5%	17%	28%	40%		20%	33%	47%	60%		50%	50%	50%	50%
DK	residential	07_											0%	5%		10%	7%	3%	0%		5%	3%	2%	0%		5%	3%	2%	0%		25%	17%	8%	0%
DK	residential	08_														0%	3%	7%	10%		0%	3%	7%	10%		0%	3%	7%	10%		0%	17%	33%	50%
DK	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
DK	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	

			BAU													BAU					A-Modest					B-Advanced					C - Extreme			
DK	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
DK	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												1.75	**1.62**	**1.39**	**13 9%**	**1.29**	**1.25**	**1.21**	**1.17**	**139 %**	**1.26**	**1.18**	**1.11**	**1.03**	**139 %**	**1.11**	**1.05**	**0.99**	**0.93**	**139 %**	**0.90**	**0.83**	**0.77**	**0.70**
EE	residential	01_	100%	100%	100%	100%	100%	100%	100%	75%	45%	33%	25%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
EE	residential	02_								25%	50%	54%	60%	25%		20%	15%	10%	5%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%
EE	residential	03_										2%	10%	50%		38%	38%	39%	40%		50%	48%	47%	45%		20%	13%	7%	0%		0%	0%	0%	0%
EE	residential	04_										0%	5%	25%		40%	40%	40%	40%		30%	27%	23%	20%		50%	48%	47%	45%		45%	30%	15%	0%
EE	residential	05_									5%	11%	0%	0%		3%	5%	8%	10%		5%	3%	2%	0%		25%	17%	8%	0%		0%	0%	0%	0%
EE	residential	06.															0%	0%	0%			7%	13%	20%		0%	13%	27%	40%		50%	57%	63%	70%
EE	residential	07_															2%	3%	5%		5%	5%	5%	5%		5%	5%	5%	5%		5%	5%	5%	5%
EE	residential	08_															0%	0%			0%	3%	7%	10%			3%	7%	10%		0%	8%	17%	25%
EE	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
EE	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
EE	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
EE	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												3.57	**3.37**	**1.88**	**18 8%**	**1.74**	**1.66**	**1.57**	**1.49**	**188 %**	**1.62**	**1.51**	**1.40**	**1.30**	**188 %**	**1.29**	**1.20**	**1.11**	**1.02**	**188 %**	**1.04**	**0.94**	**0.85**	**0.76**
EL	residential	01_	100%	100%	100%	100%	100%	100%	100%	100%	75%	59%	40%	15%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
EL	residential	02_								0%	25%	40%	53%	70%		60%	43%	27%	10%		50%	37%	23%	10%		0%	3%	7%	10%		0%	0%	0%	0%
EL	residential	03_										1%	2%	5%		15%	28%	42%	55%		30%	30%	30%	30%		80%	53%	27%	0%		40%	27%	13%	0%
EL	residential	04_										0%				0%	0%	0%	0%		0%	8%	17%	25%		0%	18%	37%	55%		40%	27%	13%	0%
EL	residential	05_										0%					0%	0%				0%	0%				0%	0%			0%	0%	0%	0%
EL	residential	06.															0%	0%				0%	0%				0%	0%				22%	43%	65%
EL	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
EL	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
EL	residential	09_										0%	5%	10%		15%	22%	28%	35%		20%	18%	17%	15%		20%	13%	7%	0%		0%	0%	0%	0%
EL	residential	10_														0%	0%	0%	0%		0%	7%	13%	20%		0%	12%	23%	35%		20%	25%	30%	35%
EL	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
EL	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												4.56	**3.98**	**3.20**	**32 0%**	**2.94**	**2.69**	**2.44**	**2.20**	**320 %**	**2.47**	**2.25**	**2.02**	**1.80**	**320 %**	**1.92**	**1.76**	**1.61**	**1.45**	**320 %**	**1.46**	**1.30**	**1.14**	**0.98**
ES	residential	01_		100%	100%	100%	100%	100%	100%	60%	50%	59%	30%	15%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
ES	residential	02_								40%	50%	40%	45%	40%		25%	20%	15%	10%		25%	20%	15%	10%		10%	7%	3%	0%		20%	13%	7%	0%

			BAU													BAU					A-Modest					B-Advanced					C - Extreme			
ES	residential	03_										1%	10%	20%		35%	35%	35%	35%		45%	40%	35%	30%		40%	38%	37%	35%		30%	20%	10%	0%
ES	residential	04_										0%	5%	10%		10%	13%	17%	20%		10%	15%	20%	25%		30%	30%	30%	30%		28%	37%	46%	55%
ES	residential	05_										0%					0%	0%				0%	0%				0%	0%			3%	3%	4%	5%
ES	residential	06.															0%	0%				0%	0%				0%	0%				2%	3%	5%
ES	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
ES	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
ES	residential	09_											10%	15%		20%	25%	30%	35%		20%	20%	20%	20%		20%	17%	13%	10%		0%	0%	0%	0%
ES	residential	10_														0%	0%	0%	0%		0%	5%	10%	15%		0%	8%	17%	25%		20%	25%	30%	35%
ES	residential	11_															0%	0%				0%	0%				0%	0%			0%	0%	0%	
ES	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
									1,960			4.56	3.52	2.88	28 8%	2.57	2.42	2.27	2.12	288 %	2.16	2.06	1.97	1.87	288 %	1.91	1.80	1.70	1.59	288 %	1.71	1.56	1.41	1.26
FI	residential	01_	100%	100%	100%	100%	100%	50%	25%	15%	10%	6%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
FI	residential	02_						50%	75%	85%	50%	38%	25%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
FI	residential	03_								0%	30%	36%	33%	20%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
FI	residential	04_								0%	0%	0%	10%	40%		25%	23%	22%	20%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%
FI	residential	05_								0%	10%	20%	25%	30%		40%	35%	30%	25%		20%	25%	30%	35%		10%	13%	17%	20%		0%	0%	0%	0%
FI	residential	06.								0%	0%	0%	0%	0%		10%	17%	23%	30%		40%	32%	23%	15%		20%	20%	20%	20%		10%	15%	20%	25%
FI	residential	07_										0%	5%	10%		15%	10%	5%	0%		30%	25%	20%	15%		35%	23%	12%	0%		20%	13%	7%	0%
FI	residential	08_														0%	8%	17%	25%		0%	12%	23%	35%		35%	43%	52%	60%		70%	72%	73%	75%
FI	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
FI	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
FI	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
FI	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												2.22	1.83	1.26	12 6%	1.13	1.05	0.98	0.90	126 %	0.95	0.91	0.87	0.83	126 %	0.82	0.79	0.75	0.72	126 %	0.70	0.68	0.67	0.65
FR	residential	01_	100%	100%	100%	100%	100%	100%	100%	75%	60%	47%	30%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
FR	residential	02_								25%	40%	38%	30%	30%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
FR	residential	03_										15%	35%	45%		55%	42%	28%	15%		73%	57%	41%	25%		30%	25%	20%	15%		20%	13%	7%	0%
FR	residential	04_										0%	5%	20%		25%	35%	45%	55%		15%	23%	32%	40%		55%	55%	55%	55%		60%	57%	53%	50%
FR	residential	05_										0%	0%	0%		0%	0%	0%	0%		3%	2%	1%	0%		5%	3%	2%	0%		10%	7%	3%	0%
FR	residential	06.														0%	3%	7%	10%		0%	5%	10%	15%		0%	3%	7%	10%		0%	10%	20%	30%
FR	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	

			BAU													BAU					A-Modest					B-Advanced					C - Extreme			
FR	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
FR	residential	09_												5%		10%	13%	17%	20%		10%	10%	10%	10%		10%	7%	3%	0%		0%	0%	0%	0%
FR	residential	10_														0%	0%	0%	0%		0%	3%	7%	10%		0%	7%	13%	20%		10%	13%	17%	20%
FR	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
FR	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												4.05	**3.24**	**2.01**	**20 1%**	**1.82**	**1.75**	**1.68**	**1.61**	**201 %**	**1.73**	**1.65**	**1.56**	**1.48**	**201 %**	**1.56**	**1.47**	**1.39**	**1.31**	**201 %**	**1.35**	**1.28**	**1.22**	**1.15**
HR	residential	01_	100%	100%	100%	100%	100%	100%	100%	80%	75%	59%	30%	10%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
HR	residential	02_								20%	25%	40%	45%	20%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
HR	residential	03_										1%	25%	50%		65%	63%	62%	60%		63%	57%	41%	25%		30%	25%	20%	15%		20%	13%	7%	0%
HR	residential	04_										0%	0%	15%		20%	20%	20%	20%		25%	23%	32%	40%		55%	55%	55%	55%		60%	57%	53%	50%
HR	residential	05_										0%	0%	0%		0%	0%	0%	0%		3%	2%	1%	0%		5%	3%	2%	0%		10%	7%	3%	0%
HR	residential	06.														0%	3%	7%	10%		0%	5%	10%	15%		0%	3%	7%	10%		0%	10%	20%	30%
HR	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
HR	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
HR	residential	09_												5%		5%	7%	8%	10%		10%	10%	10%	10%		10%	7%	3%	0%		0%	0%	0%	0%
HR	residential	10_														0%	0%	0%	0%		0%	3%	7%	10%		0%	7%	13%	20%		10%	13%	17%	20%
HR	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
HR	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												4.56	**3.43**	**2.33**	**23 3%**	**1.79**	**1.74**	**1.69**	**1.64**	**233 %**	**1.69**	**1.65**	**1.56**	**1.48**	**233 %**	**1.56**	**1.47**	**1.39**	**1.31**	**233 %**	**1.35**	**1.28**	**1.22**	**1.15**
HU	residential	01_	100%	100%	100%	100%	100%	100%	100%	80%	60%	42%	25%	5%		5%	3%	2%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
HU	residential	02_								20%	40%	52%	50%	20%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
HU	residential	03_										3%	20%	45%		25%	17%	8%	0%		20%	13%	7%	0%		0%	0%	0%	0%		0%	0%	0%	0%
HU	residential	04_										0%	0%	20%		65%	67%	68%	70%		70%	63%	57%	50%		50%	43%	37%	30%		0%	0%	0%	0%
HU	residential	05_										3%	5%	10%		5%	3%	2%	0%		10%	7%	3%	0%		45%	30%	15%	0%		10%	7%	3%	0%
HU	residential	06.														0%	10%	20%	30%		0%	17%	33%	50%		5%	27%	48%	70%		90%	93%	97%	100%
HU	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
HU	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
HU	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
HU	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
HU	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
HU	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%

ANNEX III - SCENARIO - background data

			BAU													BAU					A-Modest					B-Advanced					C - Extreme			
												3.97	3.24	1.98	198%	1.61	1.46	1.30	1.15	198%	1.35	1.25	1.15	1.05	198%	1.14	1.08	1.01	0.95	198%	0.82	0.81	0.81	0.80
IE	residential	01_	100%	100%	100%	100%	100%	100%	100%	80%	60%	47%	25%	10%		5%	5%	5%	5%		5%	3%	2%	0%		0%	0%	0%	0%		0%	0%	0%	0%
IE	residential	02_	0%	0%	0%	0%	0%	0%	0%	20%	40%	48%	55%	35%		35%	27%	18%	10%		5%	5%	5%	5%		0%	0%	0%	0%		0%	0%	0%	0%
IE	residential	03_	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	20%	35%		33%	34%	34%	35%		38%	32%	26%	20%		20%	13%	7%	0%		0%	0%	0%	0%
IE	residential	04_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%		25%	31%	36%	42%		50%	53%	57%	60%		70%	63%	57%	50%		0%	0%	0%	0%
IE	residential	05_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		2%		3%	4%		2%	1%	1%	0%		10%	7%	3%	0%		100%	67%	33%	0%
IE	residential	06.														0%	1%	3%	4%		0%	5%	10%	15%		0%	17%	33%	50%		0%	33%	67%	100%
IE	residential	07_														0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
IE	residential	08_														0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
IE	residential	09_														0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
IE	residential	10_														0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
IE	residential	11_														0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
IE	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%
												4.16	3.33	2.42	242%	2.18	2.05	1.91	1.78	242%	1.75	1.62	1.50	1.38	242%	1.35	1.25	1.15	1.05	242%	1.00	0.93	0.87	0.80
IT	residential	01_		100%	100%	100%	100%	100%	100%	90%	80%	59%	40%	5%		5%	3%	2%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
IT	residential	02_								10%	20%	40%	45%	75%		35%	28%	22%	15%	35.00%	20%	17%	13%	10%		10%	7%	3%	0%		0%	0%	0%	0%
IT	residential	03_										1%	10%	10%		30%	27%	23%	20%		55%	43%	32%	20%		50%	42%	33%	25%		0%	0%	0%	0%
IT	residential	04_										0%	5%	10%		20%	23%	27%	30%		15%	20%	25%	30%		30%	27%	23%	20%		40%	35%	30%	25%
IT	residential	05_										0%					0%	0%				2%	3%	5%		5%	10%	15%	20%		40%	33%	27%	20%
IT	residential	06.															0%	0%				0%	0%				0%	0%			0%	7%	13%	20%
IT	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
IT	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
IT	residential	09_												5%		10%	13%	17%	20%		10%	13%	17%	20%		5%	7%	8%	10%		0%	0%	0%	0%
IT	residential	10_														0%	5%	10%	15%		0%	5%	10%	15%		0%	8%	17%	25%		20%	25%	30%	35%
IT	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
IT	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	105%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%
												4.56	3.82	2.83	283%	2.32	2.18	2.04	1.91	283%	1.97	1.92	1.87	1.82	283%	1.71	1.64	1.56	1.49	283%	1.18	1.17	1.15	1.14
LT	residential	01_	100%	100%	100%	100%	100%	100%	100%	75%	45%	33%	25%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
LT	residential	02_								25%	50%	54%	60%	40%		25%	17%	8%	0%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%
LT	residential	03_										2%	10%	35%		40%	40%	40%	40%		45%	40%	35%	30%		25%	17%	8%	0%		0%	0%	0%	0%

			BAU													BAU					A-Modest					B-Advanced					C - Extreme			
LT	residential	04_										0%	5%	25%		30%	33%	37%	40%		40%	37%	33%	30%		50%	50%	50%	50%		50%	33%	17%	0%
LT	residential	05_									5%	11%	0%	0%		5%	7%	8%	10%		5%	3%	2%	0%		25%	17%	8%	0%		25%	17%	8%	0%
LT	residential	06.															3%	7%	10%			10%	20%	30%		0%	13%	27%	40%		25%	42%	58%	75%
LT	residential	07_															0%	0%			0%	0%	0%				0%	0%				0%	0%	
LT	residential	08_															0%	0%			0%	3%	7%	10%			3%	7%	10%		0%	8%	17%	25%
LT	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
LT	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
LT	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
LT	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												3.57	**3.37**	**2.04**	204%	**1.82**	**1.67**	**1.53**	**1.38**	204 %	**1.62**	**1.48**	**1.34**	**1.20**	204 %	**1.33**	**1.23**	**1.13**	**1.03**	204 %	**1.10**	**0.98**	**0.87**	**0.75**
LU	residential	01_		100%	100%	100%	100%	100%	75%	50%	40%	47%	30%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
LU	residential	02_							25%	50%	60%	38%	30%	20%		5%	3%	2%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
LU	residential	03_										15%	35%	60%		50%	42%	33%	25%		30%	20%	10%	0%		15%	10%	5%	0%		0%	0%	0%	0%
LU	residential	04_										0%	5%	20%		45%	52%	58%	65%		65%	72%	78%	85%		50%	55%	60%	65%		0%	0%	0%	0%
LU	residential	05_										0%	0%	0%		0%	3%	7%	10%		5%	7%	8%	10%		35%	27%	18%	10%		10%	7%	3%	0%
LU	residential	06.														0%	0%	0%	0%		0%	2%	3%	5%		0%	8%	17%	25%		90%	93%	97%	100%
LU	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
LU	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
LU	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
LU	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
LU	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
LU	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												4.05	**3.24**	**1.84**	184%	**1.58**	**1.51**	**1.44**	**1.37**	184 %	**1.41**	**1.35**	**1.30**	**1.25**	184 %	**1.26**	**1.22**	**1.18**	**1.15**	184 %	**0.82**	**0.81**	**0.81**	**0.80**
LV	residential	01_	100%	100%	100%	100%	100%	100%	100%	75%	45%	33%	25%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
LV	residential	02_								25%	50%	54%	60%	40%		25%	17%	8%	0%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%
LV	residential	03_										2%	10%	35%		40%	40%	40%	40%		45%	40%	35%	30%		25%	17%	8%	0%		0%	0%	0%	0%
LV	residential	04_										0%	5%	25%		30%	33%	37%	40%		40%	37%	33%	30%		50%	50%	50%	50%		50%	33%	17%	0%
LV	residential	05_									5%	11%	0%	0%		5%	7%	8%	10%		5%	3%	2%	0%		25%	17%	8%	0%		25%	0%	0%	0%
LV	residential	06.															3%	7%	10%			10%	20%	30%		0%	13%	27%	40%		25%	58%	67%	75%
LV	residential	07_															0%	0%			0%	0%	0%				0%	0%				0%	0%	
LV	residential	08_															0%	0%			0%	3%	7%	10%			3%	7%	10%		0%	8%	17%	25%

			BAU													BAU					A-Modest					B-Advanced					C - Extreme			
LV	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
LV	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
LV	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
LV	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												3.57	3.37	2.04	20 4%	1.82	1.67	1.53	1.38	204 %	1.62	1.48	1.34	1.20	204 %	1.33	1.23	1.13	1.03	204 %	1.10	0.95	0.85	0.75
MT	residential	01_		100%	100%	100%	100%	100%	100%	90%	80%	59%	50%	30%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
MT	residential	02_								10%	20%	40%	45%	60%		55%	48%	42%	35%		60%	47%	33%	20%		35%	30%	25%	20%		20%	13%	7%	0%
MT	residential	03_										1%				20%	23%	27%	30%		25%	27%	28%	30%		50%	40%	30%	20%		65%	55%	45%	35%
MT	residential	04_															0%	0%	0%			5%	10%	15%			7%	13%	20%		0%	10%	20%	30%
MT	residential	05_															0%	0%				0%	0%				0%	0%			0%	0%	0%	0%
MT	residential	06.															0%	0%				0%	0%				0%	0%			0%	0%	0%	0%
MT	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
MT	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
MT	residential	09_											5%	10%		15%	22%	28%	35%		15%	18%	22%	25%		15%	13%	12%	10%		0%	0%	0%	0%
MT	residential	10_														0%	0%	0%	0%		0%	3%	7%	10%		0%	8%	17%	25%		15%	22%	28%	35%
MT	residential	11_															0%	0%				0%	0%				0%	0%			0%	0%	0%	0%
MT	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	98%	97%	95%		100 %	100 %	100 %	100%
												4.56	4.30	3.70	37 0%	2.88	2.74	2.61	2.47	370 %	2.53	2.38	2.24	2.10	370 %	2.25	2.09	1.93	1.77	370 %	1.86	1.72	1.58	1.44
NL	residential	01_		100%	100%	100%	100%	100%	75%	50%	40%	47%	30%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
NL	residential	02_							25%	50%	60%	38%	30%	5%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
NL	residential	03_										15%	35%	75%		48%	35%	23%	10%		20%	13%	7%	0%		0%	0%	0%	0%		0%	0%	0%	0%
NL	residential	04_										0%	5%	20%		50%	60%	70%	80%		75%	75%	75%	75%		75%	65%	55%	45%		0%	0%	0%	0%
NL	residential	05_										0%	0%	0%		2%	5%	7%	10%		5%	8%	12%	15%		25%	25%	25%	25%		50%	33%	17%	0%
NL	residential	06.														0%	0%	0%	0%		0%	3%	7%	10%		0%	10%	20%	30%		50%	67%	83%	100%
NL	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
NL	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
NL	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
NL	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
NL	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
NL	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												4.05	3.24	1.68	16 8%	1.49	1.43	1.37	1.31	168 %	1.37	1.31	1.26	1.21	168 %	1.23	1.18	1.13	1.08	168 %	0.90	0.87	0.83	0.80

			BAU													BAU					A-Modest					B-Advanced					C - Extreme			
PL	residential	01_	100%	100%	100%	100%	100%	100%	100%	75%	50%	30%	20%	5%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
PL	residential	02_								25%	50%	65%	40%	20%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
PL	residential	03_										5%	38%	40%		50%	42%	33%	25%		25%	17%	8%	0%		10%	7%	3%	0%		0%	0%	0%	0%
PL	residential	04_										0%	0%	30%		40%	35%	30%	25%		55%	53%	52%	50%		40%	33%	27%	20%		0%	0%	0%	0%
PL	residential	05_									0%	0%	3%	5%		10%	10%	10%	10%		20%	17%	13%	10%		40%	37%	33%	30%		90%	60%	30%	0%
PL	residential	06.														0%	13%	27%	40%		0%	13%	27%	40%		10%	23%	37%	50%		10%	40%	70%	100%
PL	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
PL	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
PL	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
PL	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
PL	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
PL	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												3.65	2.94	1.97	19 7%	1.47	1.37	1.27	1.17	197 %	1.34	1.25	1.16	1.07	197 %	1.17	1.10	1.03	0.96	197 %	0.98	0.92	0.86	0.80
PT	residential	01_	100%	100%	100%	100%	100%	100%	100%	90%	80%	59%	40%	10%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
PT	residential	02_								10%	20%	40%	55%	70%		65%	48%	32%	15%		40%	33%	27%	20%		20%	13%	7%	0%		10%	7%	3%	0%
PT	residential	03_										1%	4%	15%		20%	30%	40%	50%		25%	27%	28%	30%		30%	20%	10%	0%		40%	27%	13%	0%
PT	residential	04_										0%				5%	3%	2%	0%		25%	22%	18%	15%		40%	53%	67%	80%		40%	48%	57%	65%
PT	residential	05_										0%					0%	0%				0%	0%			0%	0%	0%			0%	0%	0%	0%
PT	residential	06.															0%	0%				0%	0%				0%	0%			0%	0%	0%	0%
PT	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
PT	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
PT	residential	09_											1%	5%		10%	15%	20%	25%		10%	10%	10%	10%		10%	7%	3%	0%		0%	0%	0%	0%
PT	residential	10_												0%		0%	3%	7%	10%		0%	8%	17%	25%		0%	12%	23%	35%		10%	18%	27%	35%
PT	residential	11_															0%	0%				0%	0%			0%	0%	0%	0%			0%	0%	
PT	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	105 %	110 %	115 %		100 %	100 %	100 %	100%
												4.56	3.96	2.94	29 4%	2.51	2.37	2.24	2.10	294 %	2.15	2.06	1.96	1.87	294 %	1.87	1.75	1.62	1.50	294 %	1.61	1.51	1.40	1.30
RO	residential	01_	100%	100%	100%	100%	100%	100%	100%	80%	60%	50%	25%	10%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
RO	residential	02_								20%	40%	45%	65%	50%		15%	10%	5%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
RO	residential	03_										5%	10%	40%		60%	52%	43%	35%		55%	37%	18%	0%		35%	23%	12%	0%		0%	0%	0%	0%
RO	residential	04_										0%	0%	0%		25%	35%	45%	55%		40%	57%	73%	90%		40%	48%	57%	65%		50%	50%	50%	50%
RO	residential	05_										0%	0%	0%		0%	3%	7%	10%		5%	7%	8%	10%		25%	25%	25%	25%		50%	33%	17%	0%

			BAU													BAU					A-Modest					B-Advanced					C - Extreme			
RO	residential	06.														0%	0%	0%	0%		0%	0%	0%	0%		0%	3%	7%	10%		0%	17%	33%	50%
RO	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
RO	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
RO	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
RO	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
RO	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
RO	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%
												4.25	3.44	2.66	266%	1.77	1.65	1.53	1.41	266%	1.51	1.43	1.35	1.27	266%	1.37	1.30	1.24	1.18	266%	1.15	1.12	1.08	1.05
SE	residential	01_	100%	100%	100%	100%	100%	50%	25%	15%	10%	6%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
SE	residential	02_	0%	0%	0%	0%	0%	50%	75%	85%	50%	38%	25%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
SE	residential	03_	0%	0%	0%	0%	0%	0%	0%	0%	30%	36%	33%	20%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
SE	residential	04_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	10%	40%		25%	23%	22%	20%		10%	7%	3%	0%		0%	0%	0%	0%		0%	0%	0%	0%
SE	residential	05_	0%	0%	0%	0%	0%	0%	0%	0%	10%	20%	25%	30%		40%	35%	30%	25%		20%	25%	30%	35%		10%	13%	17%	20%		0%	0%	0%	0%
SE	residential	06.	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		10%	17%	23%	30%		40%	32%	23%	15%		20%	20%	20%	20%		10%	15%	20%	25%
SE	residential	07_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	10%		15%	10%	5%	0%		30%	25%	20%	15%		35%	23%	12%	0%		20%	13%	7%	0%
SE	residential	08_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%		17%	25%		0%	12%	23%	35%		35%	43%	52%	60%		70%	72%	73%	75%
SE	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
SE	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
SE	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
SE	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%
												2.22	1.83	1.26	126%	1.13	1.05	0.98	0.90	126%	0.95	0.91	0.87	0.83	126%	0.82	0.79	0.75	0.72	126%	0.70	0.68	0.67	0.65
SI	residential	01_		100%	100%	100%	100%	100%	100%	90%	80%	42%	20%	5%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
SI	residential	02_								10%	20%	52%	75%	45%		15%	10%	5%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
SI	residential	03_										3%		45%		60%	52%	43%	35%		55%	37%	18%	0%		35%	23%	12%	0%		0%	0%	0%	0%
SI	residential	04_										0%				25%	35%	45%	55%		40%	57%	73%	90%		40%	48%	57%	65%		50%	50%	50%	50%
SI	residential	05_										3%				0%	3%	7%	10%		5%	7%	8%	10%		25%	25%	25%	25%		50%	33%	17%	0%
SI	residential	06.														0%	0%	0%	0%		0%	0%	0%	0%		0%	3%	7%	10%		0%	17%	33%	50%
SI	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
SI	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
SI	residential	09_											5%	5%			0%	0%				0%	0%				0%	0%				0%	0%	
SI	residential	10_												0%			0%	0%				0%	0%				0%	0%				0%	0%	

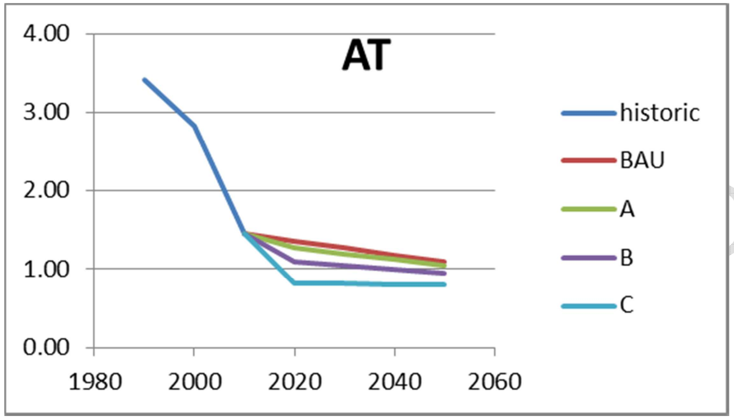
			BAU													BAU					A-Modest					B-Advanced					C - Extreme			
SI	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
SI	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%
												3.97	3.40	2.46	246%	1.77	1.65	1.53	1.41	246%	1.51	1.43	1.35	1.27	246%	1.37	1.30	1.24	1.18	246%	1.15	1.12	1.08	1.05
SK	residential	01_	100%	100%	100%	100%	100%	100%	75%	60%	50%	42%	30%	10%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
SK	residential	02_							25%	40%	50%	55%	35%	20%		15%	10%	5%	0%		5%	3%	2%	0%		0%	0%	0%	0%		0%	0%	0%	0%
SK	residential	03_										3%	30%	55%		40%	40%	40%	40%		20%	13%	7%	0%		10%	7%	3%	0%		0%	0%	0%	0%
SK	residential	04_										0%	5%	15%		43%	45%	48%	50%		70%	72%	73%	75%		50%	43%	37%	30%		0%	0%	0%	0%
SK	residential	05_										0%	0%	0%		2%	5%	7%	10%		5%	3%	2%	0%		40%	27%	13%	0%		100%	67%	33%	0%
SK	residential	06.														0%	0%	0%	0%		0%	8%	17%	25%		0%	23%	47%	70%		0%	33%	67%	100%
SK	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
SK	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
SK	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
SK	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
SK	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
SK	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%
												4.03	3.30	2.27	227%	1.68	1.60	1.51	1.43	227%	1.44	1.35	1.26	1.18	227%	1.22	1.13	1.04	0.95	227%	1.00	0.93	0.87	0.80
UK	residential	01_	100%	100%	100%	100%	100%	100%	100%	80%	60%	47%	25%	10%		5%	5%	5%	5%		5%	3%	2%	0%		0%	0%	0%	0%		0%	0%	0%	0%
UK	residential	02_								20%	40%	48%	55%	35%		35%	27%	18%	10%		5%	5%	5%	5%		0%	0%	0%	0%		0%	0%	0%	0%
UK	residential	03_										5%	20%	35%		33%	34%	34%	35%		38%	32%	26%	20%		20%	13%	7%	0%		0%	0%	0%	0%
UK	residential	04_										0%	0%	20%		25%	31%	36%	42%		50%	53%	57%	60%		70%	63%	57%	50%		0%	0%	0%	0%
UK	residential	05_										0%	0%	0%		2%	3%	3%	4%		2%	1%	1%	0%		10%	7%	3%	0%		100%	67%	33%	0%
UK	residential	06.											0%	0%		0%	1%	3%	4%		0%	5%	10%	15%		0%	17%	33%	50%		0%	33%	67%	100%
UK	residential	07_															0%	0%				0%	0%				0%	0%				0%	0%	
UK	residential	08_															0%	0%				0%	0%				0%	0%				0%	0%	
UK	residential	09_															0%	0%				0%	0%				0%	0%				0%	0%	
UK	residential	10_															0%	0%				0%	0%				0%	0%				0%	0%	
UK	residential	11_															0%	0%				0%	0%				0%	0%				0%	0%	
UK	residential	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%		100%	100%	100%	100%
												4.16	3.33	2.42	242%	2.18	2.05	1.91	1.78	242%	1.75	1.62	1.50	1.38	242%	1.35	1.25	1.15	1.05	242%	1.00	0.93	0.87	0.80
EU28	residential	01_		100%	100%	100%	100%	99%	90%	64%	47%	38%	22%	5%		2%	2%	1%	1%		1%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
EU28	residential	02_	0%	0%	0%	0%	0%	1%	10%	36%	34%	35%	35%	30%		16%	13%	9%	5%		8%	7%	5%	4%		3%	2%	1%	0%		2%	1%	1%	0%

			BAU													BAU					A-Modest					B-Advanced					C - Extreme			
EU28	residential	03_	0%	0%	0%	0%	0%	0%	0%	0%	19%	26%	34%	32%		33%	29%	24%	20%		34%	27%	20%	13%		22%	18%	13%	9%		7%	5%	2%	0%
EU28	residential	04_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	27%		30%	33%	36%	38%		34%	35%	36%	37%		40%	38%	35%	33%		21%	20%	19%	19%
EU28	residential	05_	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	5%		10%	8%	7%	5%		12%	10%	8%	5%		16%	13%	10%	7%		34%	24%	14%	4%
EU28	residential	06.	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%	5%	10%	14%		2%	9%	16%	23%		11%	18%	26%	33%		24%	35%	47%	58%
EU28	residential	07_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%		1%	1%	1%	1%		2%	2%	2%	1%		2%	2%	1%	1%		2%	2%	1%	1%
EU28	residential	08_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%	1%	1%	2%		0%	1%	1%	2%		1%	2%	2%	3%		2%	3%	3%	4%
EU28	residential	09_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	3%		5%	7%	8%	10%		5%	6%	6%	7%		5%	4%	3%	2%		0%	0%	0%	0%
EU28	residential	10_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		1%	2%	3%	4%		1%	3%	6%	8%		1%	4%	8%	11%		8%	9%	11%	13%
EU28	residential	11_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	1%	1%		0%	1%	1%	2%
EU28	residential	checks um	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	101%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
												3.63	2.99	2.12	21 2%	1.83	1.73	1.63	1.52	212 %	1.61	1.52	1.44	1.36	212 %	1.39	1.31	1.24	1.17	212 %	1.12	1.06	1.01	0.96
EU28	non-residential	01_	100%	100%	100%	100%	100%	99%	90%	64%	47%	38%	22%	5%	0%	2%	2%	1%	1%	0.00 %	1%	0%	0%	0%	0.00 %	0%	0%	0%	0%	0.00 %	0%	0%	0%	0%
EU28	non-residential	02_	0%	0%	0%	0%	0%	1%	10%	36%	34%	35%	35%	30%	0%	16%	13%	9%	5%	0%	8%	7%	5%	4%	0%	3%	2%	1%	0%	0%	2%	1%	1%	0%
EU28	non-residential	03_	0%	0%	0%	0%	0%	0%	0%	0%	19%	26%	34%	32%	0%	33%	29%	24%	20%	0%	34%	27%	20%	13%	0%	22%	18%	13%	9%	0%	7%	5%	2%	0%
EU28	non-residential	04_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	27%	0%	30%	33%	36%	38%	0%	34%	35%	36%	37%	0%	40%	38%	35%	33%	0%	21%	20%	19%	19%
EU28	non-residential	05_	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	5%	0%	10%	8%	7%	5%	0%	12%	10%	8%	5%	0%	16%	13%	10%	7%	0%	34%	24%	14%	4%
EU28	non-residential	06.	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	10%	14%	0%	2%	9%	16%	23%	0%	11%	18%	26%	33%	0%	24%	35%	47%	58%
EU28	non-residential	07_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0	1%	1%	1%	1%	0	2%	2%	2%	1%	0	2%	2%	1%	1%	0	2%	2%	1%	1%
EU28	non-residential	08_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0	0%	1%	1%	2%	0	0%	1%	1%	2%	0	1%	2%	2%	3%	0	2%	3%	3%	4%
EU28	non-residential	09_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	3%	0	5%	7%	8%	10%	0	5%	6%	6%	7%	0	5%	4%	3%	2%	0	0%	0%	0%	0%
EU28	non-residential	10_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0	1%	2%	3%	4%	0	1%	3%	6%	8%	0	1%	4%	8%	11%	0	8%	9%	11%	13%
EU28	non-residential	11_	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0	0%	0%	0%	0%	0	0%	0%	0%	0%	0	0%	0%	1%	1%	0	0%	1%	1%	2%
EU28	non-residential	checks um	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	101%		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
			5.80	5.80	5.80	5.80	5.80	5.76	5.50	4.72	3.98	3.63	2.99	2.12		1.83	1.73	1.63	1.52		1.61	1.52	1.44	1.36		1.39	1.31	1.24	1.17		1.12	1.06	1.01	0.96
EU28	roofwindow	roof_01	100%		100%	100%	100%	100%	90%	50%	35%	20%	10%	5%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
EU28	roofwindow	roof_02							10%	50%	65%	80%	80%	35%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
EU28	roofwindow												0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
EU28	roofwindow	roof_03											10%	60%		100 %	100 %	100 %	100 %		100 %	83%	67%	50%		100 %	83%	67%	50%		100 %	83%	67%	50%
EU28	roofwindow	roof_04														0%	0%	0%	0%		0%	17%	33%	50%		0%	0%	0%	0%		0%	0%	0%	0%
EU28	roofwindow	roof_05															0%	0%				0%	0%	0%			17%	33%	50%			0%	0%	0%
EU28	roofwindow																0%	0%				0%	0%				0%	0%				0%	0%	
EU28	roofwindow																0%	0%				0%	0%				0%	0%				0%	0%	

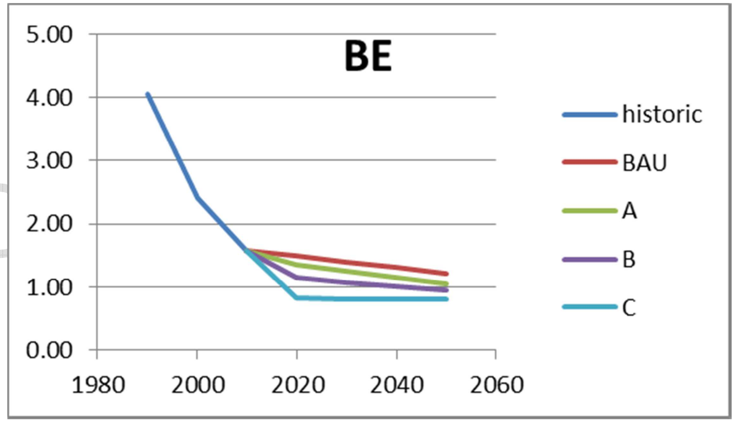
			BAU												
EU28	roofwindow											0%	0%	0%	
EU28	roofwindow	roof_06												0%	
EU28	roofwindow													0%	
EU28	roofwindow	checksum	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100 %	100%	
			5.80	5.80	5.80	5.80	5.80	5.80	5.50	4.30	3.85	3.40	2.95	2.05	205%

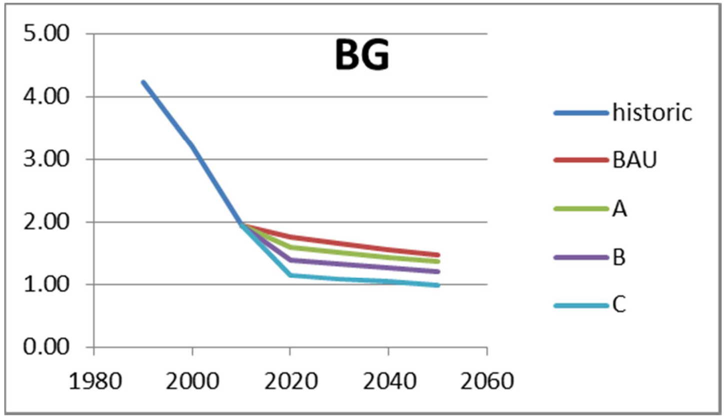
			BAU					A-Modest					B-Advanced					C - Extreme			
EU28	roofwindow		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
EU28	roofwindow	roof_06	0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	17%	33%	50%
EU28	roofwindow		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%		0%	0%	0%	0%
EU28	roofwindow	checksum	100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100 %		100 %	100 %	100 %	100%
			1.30	1.30	1.30	1.30	205 %	1.30	1.25	1.20	1.15	205 %	1.30	1.22	1.13	1.05	205 %	1.30	1.30	1.30	1.30

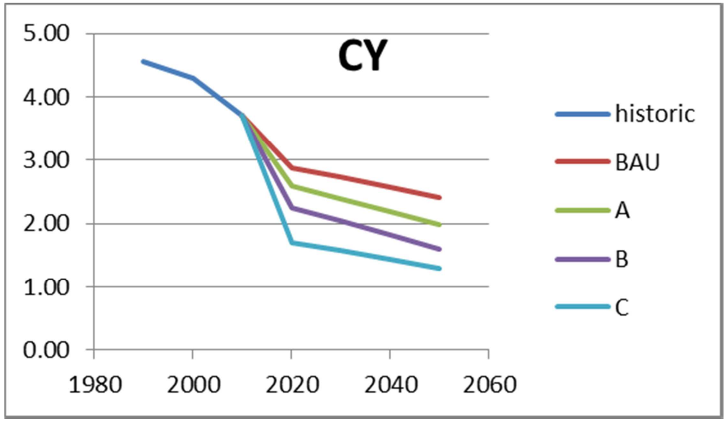
Uw according scenarios by MS

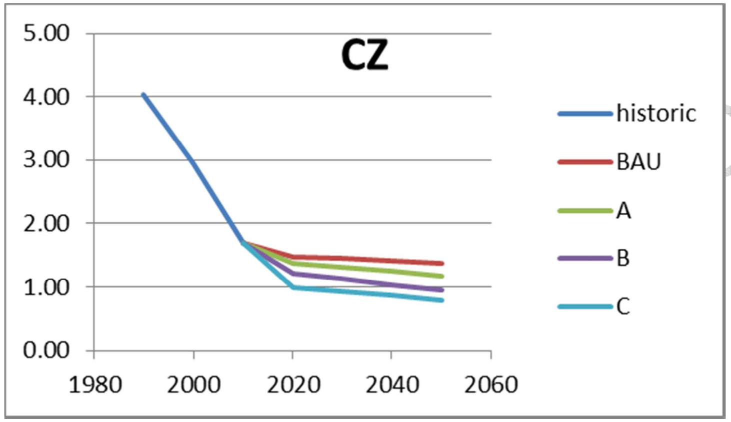


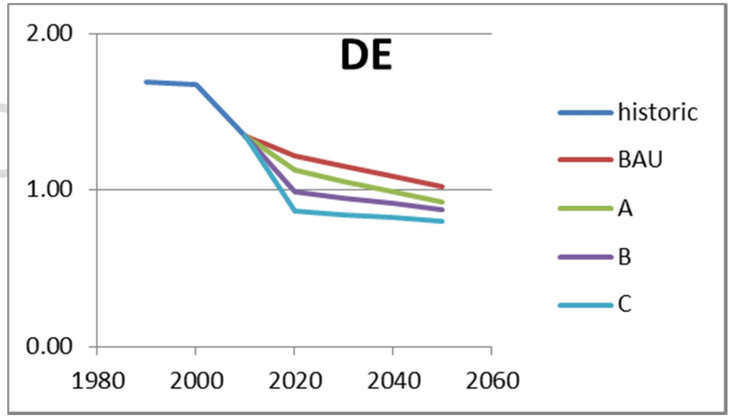
Uw according scenarios by MS

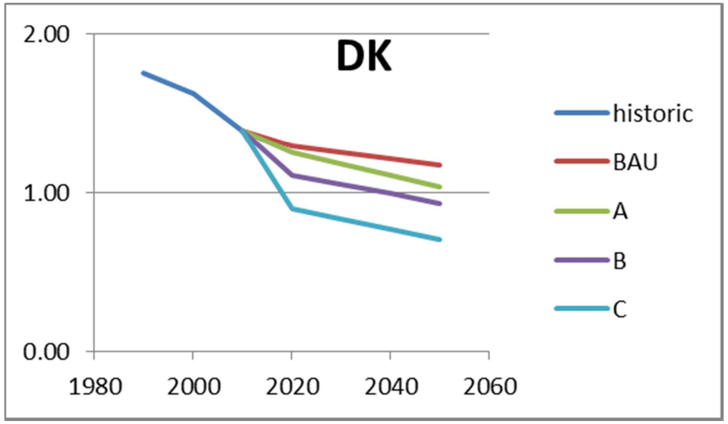


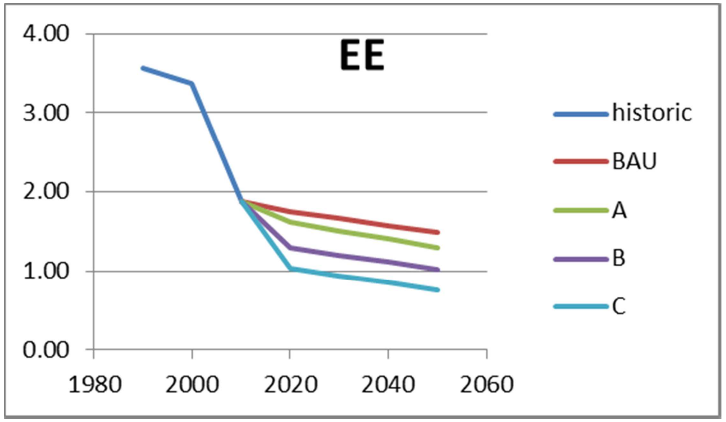

BG
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

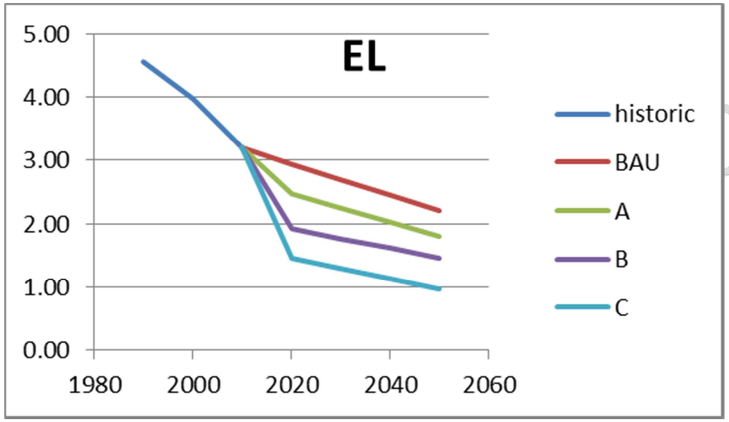

CY
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

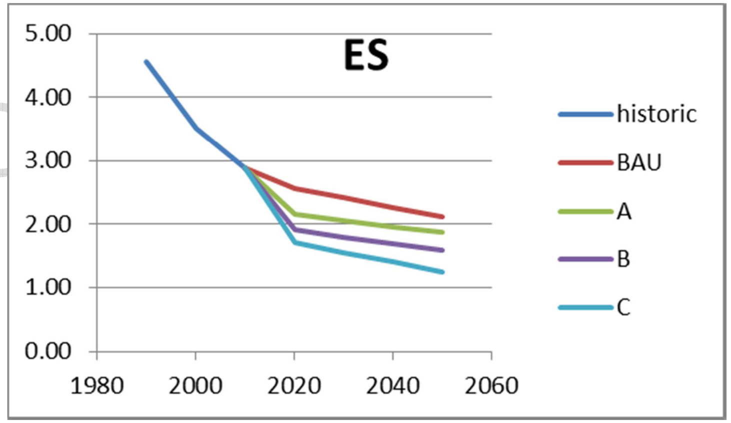

CZ
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

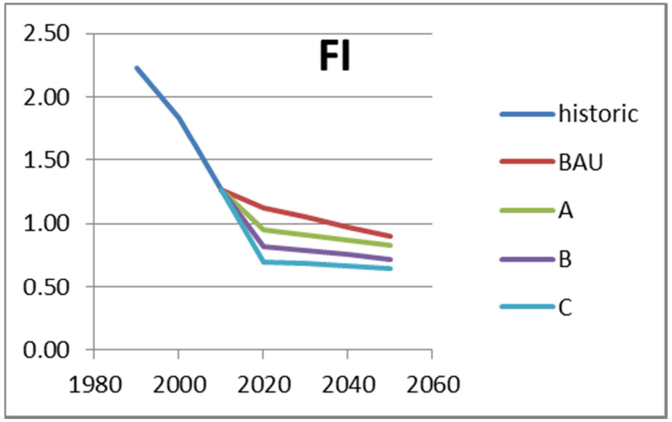

DE
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

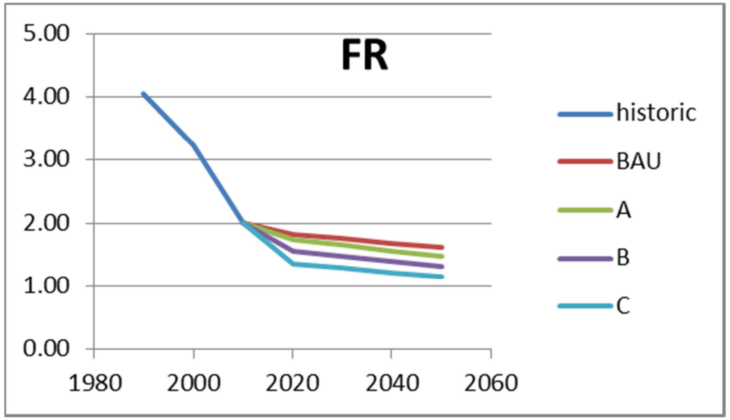

DK
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

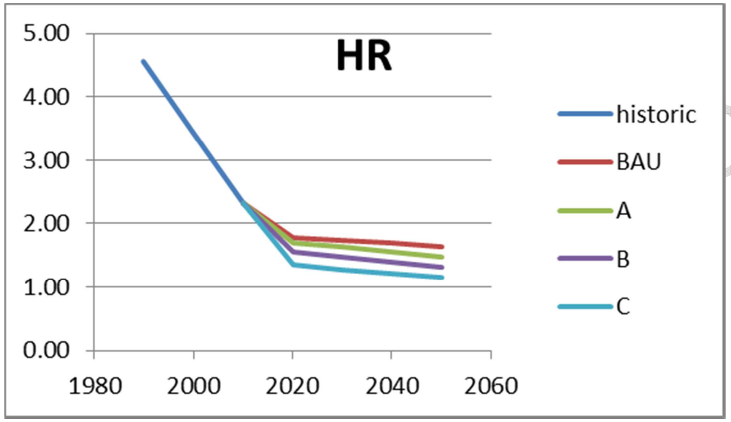

EE
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

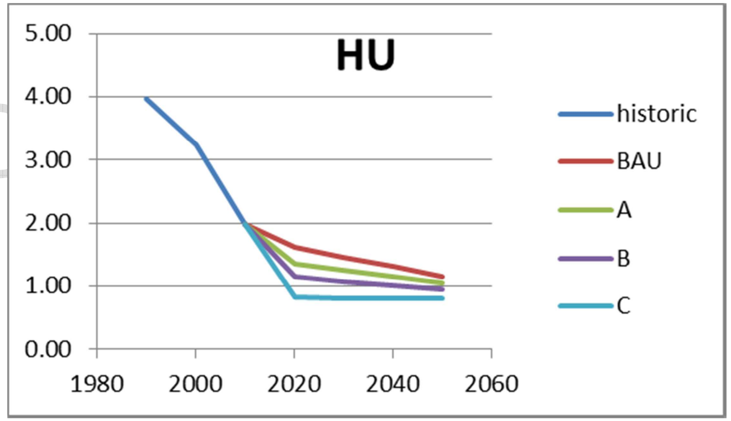

EL
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C


ES
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C


FI
2.50
2.00
1.50
1.00
0.50
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C


FR
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C


HR
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C


HU
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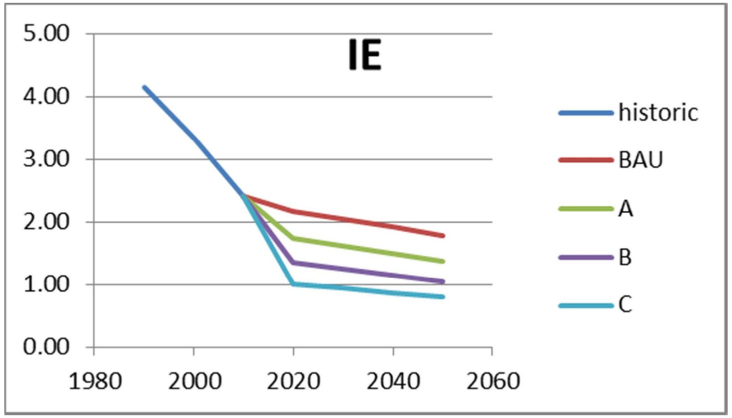
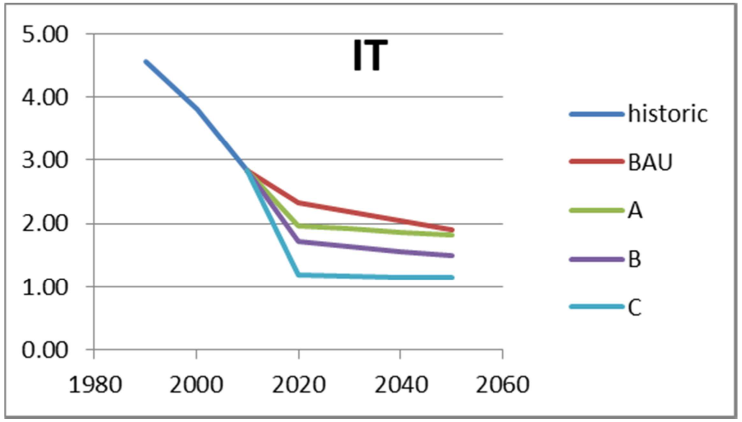
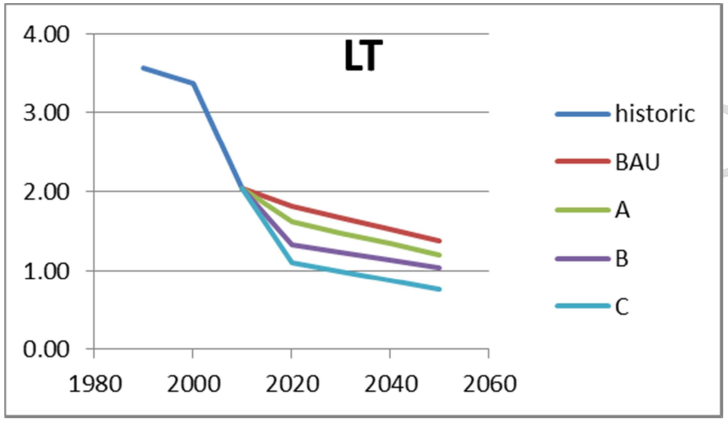
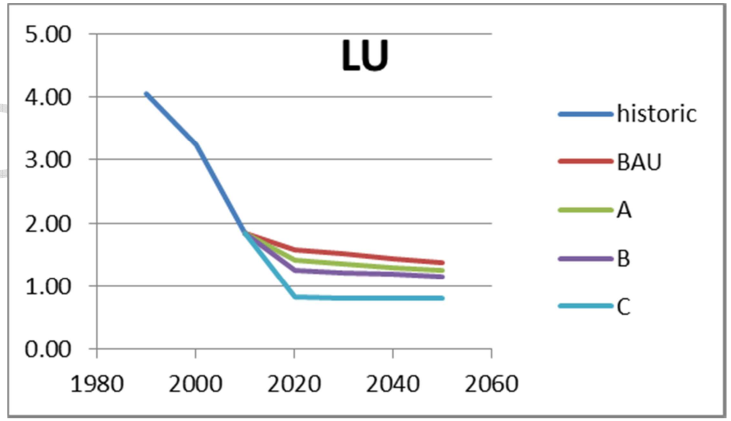
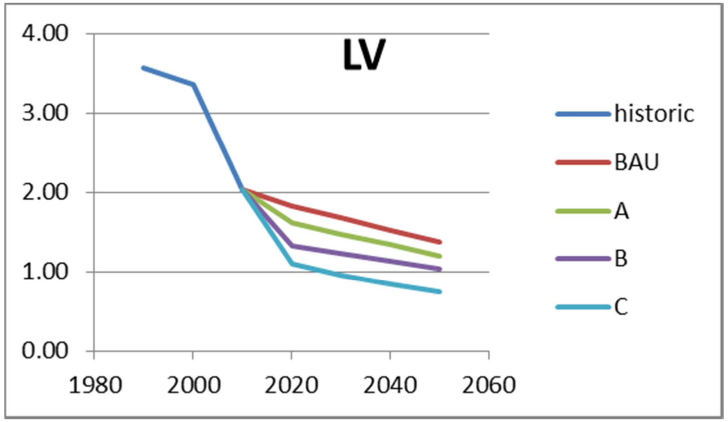
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

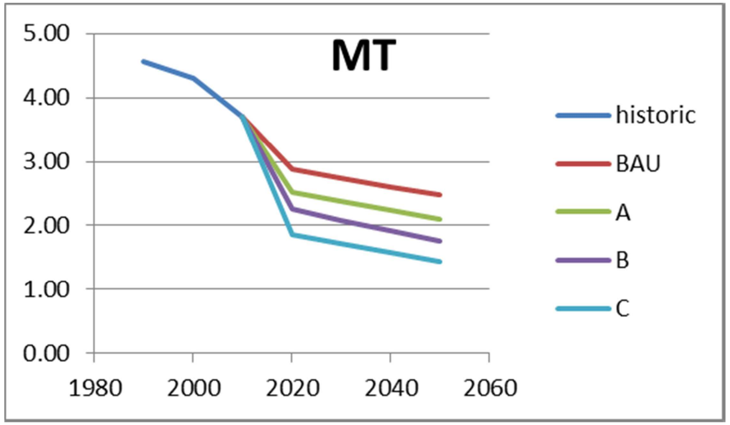

IE
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

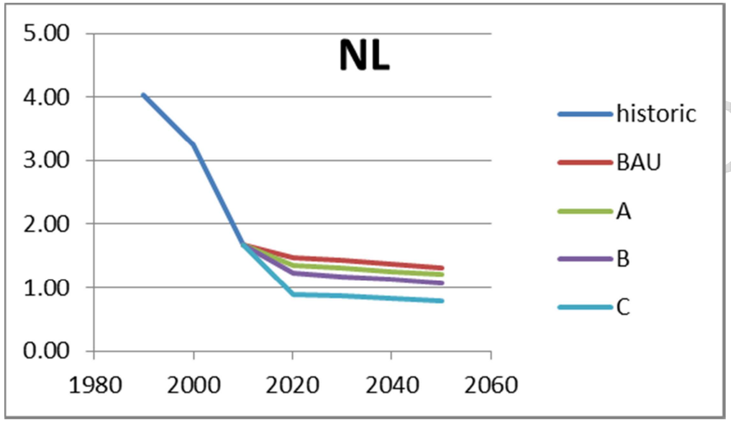

IT
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

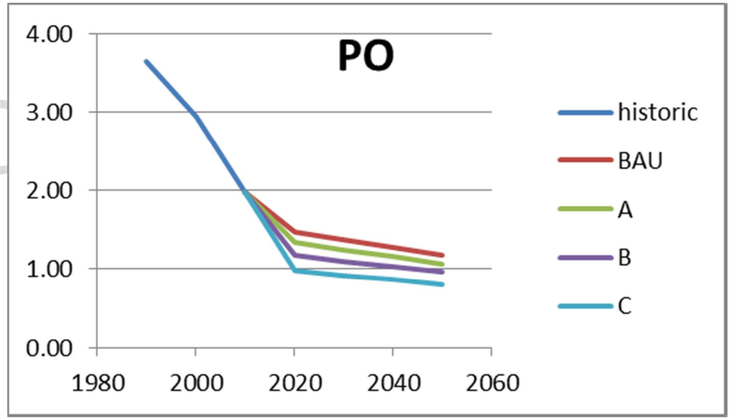

LT
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

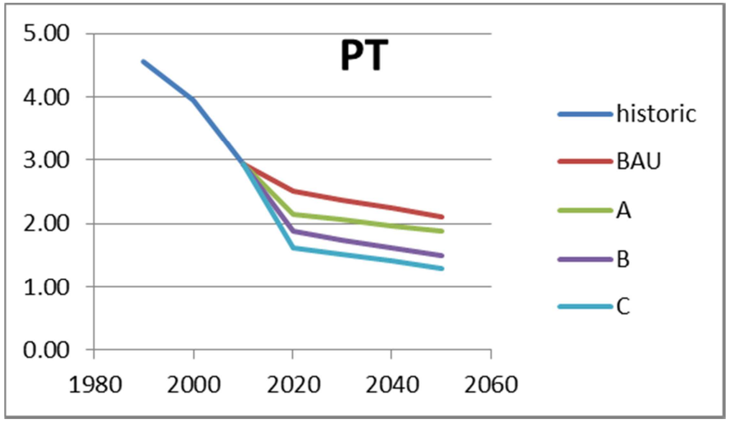

LU
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

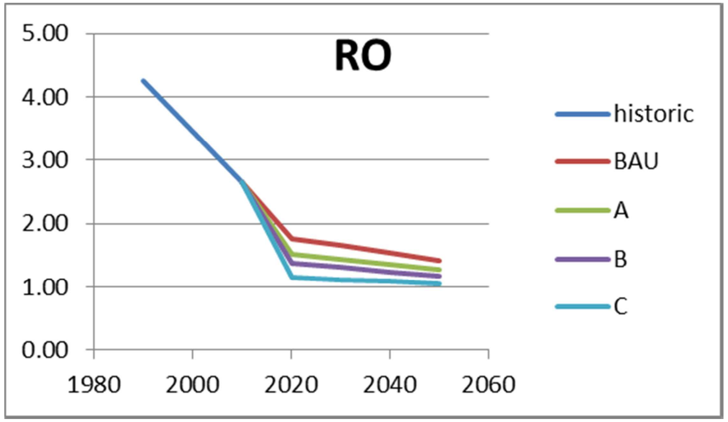

LV
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

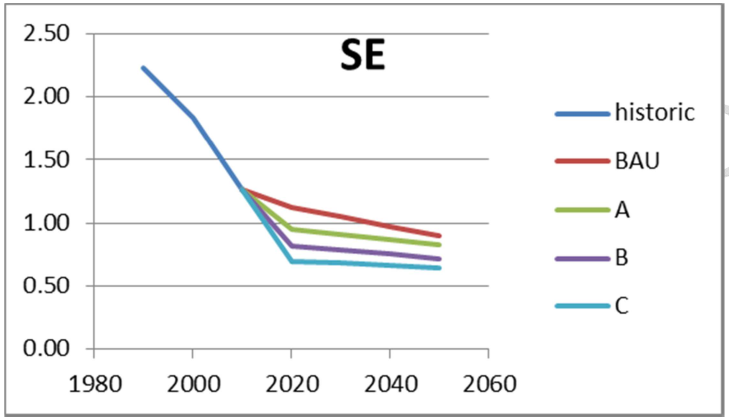

MT
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

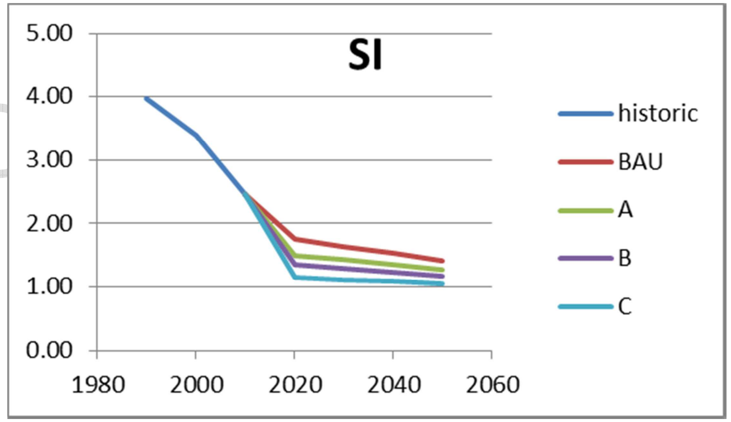

NL
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

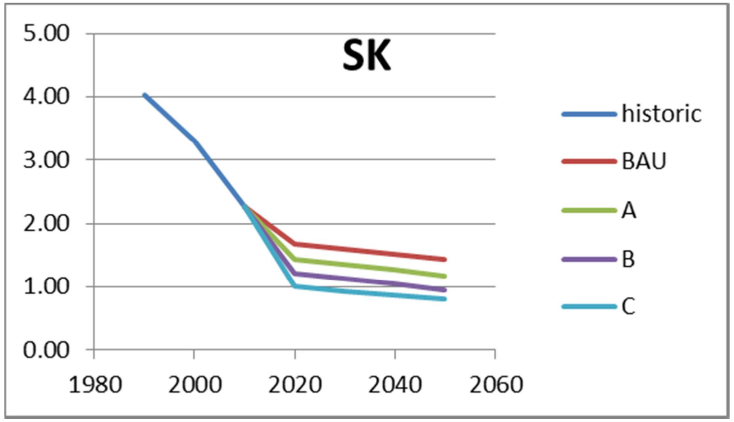

PO
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

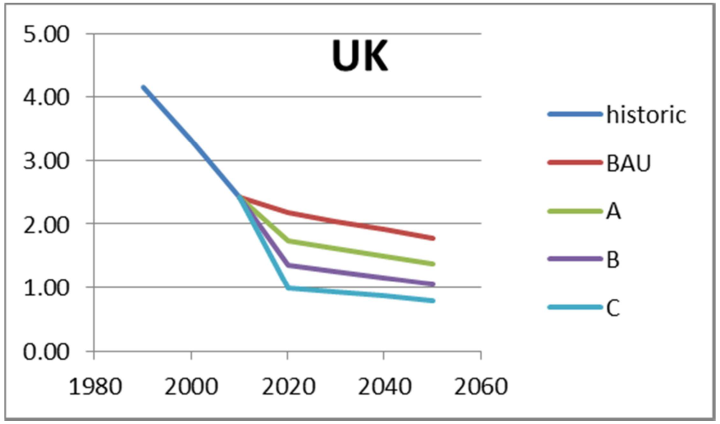

PT
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

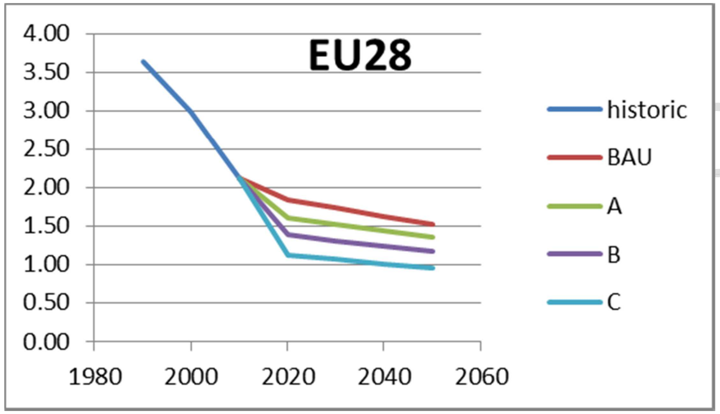

RO
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C


SE
2.50
2.00
1.50
1.00
0.50
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C


SI
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C


SK
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C


UK
5.00
4.00
3.00
2.00
1.00
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C


EU28
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1980
2000
2020
2040
2060
historic
BAU
A
B
C

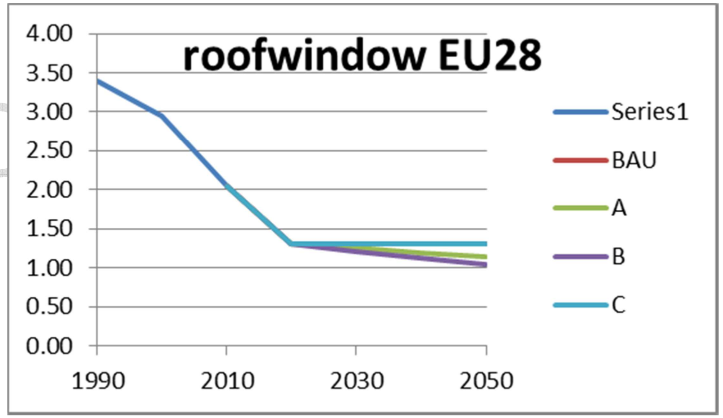

roofwindow EU28
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1990
2010
2030
2050
Series1
BAU
A
B
C

Table 200 Allocation of cooling demand over sectors

				1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020	2030	2040	2050
all RAC			TWh_cool	0	0	0	0	0	0	1	1	3	5.1	16	56	96	141	157	168
	residential			0	0	0	0	0	0	1	1	3	5	16	56	96	141	157	168
	non-residential			0	0	0	0	0	0	1	1	3	5	16	56	96	141	157	168
all comm.AC	non-residential		TWh_cool	0	0	0	1	2	3	6	13	25	51	94	164	209	211	202	188
Sector ↓	Subsector ↓			1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2020	2030	2040	2050
residential	single family	48%		0	0	0	0	0	0	0	1	1	2	8	26	46	67	75	80
residential	multi family	48%		0	0	0	0	0	0	0	1	1	2	8	26	46	67	75	80
residential	all res	**95%**		0	0	0	0	0	0	1	1	2	5	15	53	91	134	149	159
non-residential	offices	40%	18%	0	0	0	0	1	1	3	6	11	22	44	87	122	140	143	142
non-residential	educational	18%	11%	0	0	0	0	0	1	1	3	5	10	20	40	55	64	65	65
non-residential	health	16%	8%	0	0	0	0	0	1	1	2	5	9	18	36	50	58	59	58
non-residential	gastro	8%	8%	0	0	0	0	0	0	1	1	2	5	9	18	25	29	29	29
non-residential	trade	10%	19%	0	0	0	0	0	0	1	1	3	6	11	22	31	35	36	36
non-residential	sports	0%	4%	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	2
non-residential	other	7%	33%	0	0	0	0	0	0	0	1	2	4	8	16	22	25	25	25
non-residential	all non-res	100%	100%	0	0	0	1	2	3	7	14	28	56	110	220	306	353	358	356
roofwindow	roofwindow res	2%	5.0%	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	4
roofwindow	roofwindow non-res	2%	0.5%	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	4
roofwindow	roofwindow all	**5%**	3.4%	0	0	0	0	0	0	0	0	0	0	1	3	4	6	7	8

ANNEX IV – DISCUSSION ON CLIMATE CONDITIONS

Virtually all stakeholders agree that it is not possible to calculate the performances for each individual window in the EU28 building stock, and all stakeholders agree that some form of simplification is required.

For the Task 3 calculation of (indirect energy use) and the Task 7 calculation of scenario's a simplified approach has been applied to describe the effects of windows for three climate conditions and then partition these conditions to Member States and thus the whole of the EU28. These three conditions describe the average (population weighted) climate in the EU28 (condition "Central") and two extreme conditions: one for colder applications ("North") and one for warmer applications ("South"). The conditions are based on real weather data for the Strasbourg area (Central), Helsinki area (North) and Athens area (South).

The choice for these three climate conditions is partially given in by the fact that current EU energy labels for heating and cooling products (the affected energy systems) also reference their performance according these three climate conditions.

Several stakeholders expressed a desire to know more about how and why these three conditions were selected in the first place and argued that the selection of three climate conditions is too limited and should be widened to incorporate four or five climate 'zones'.

Climate conditions: origins

The three conditions first appeared in the Lot 10 study by Ecole des Armines (main author: P. Riviere) on room air conditioning appliances[65]. In Task 4 the author writes: *"Since heat pump product performances are sensitive to climate, (…) there is a need to indicate the end-user with climatic sensitivity. Three main climate zones have been considered there, Northern Europe with Helsinki as the reference climate, Central Europe with Strasbourg and Southern Europe with Athens."*

So the basic idea for selecting three climate zones was to give the end user a sense of sensitivity of the performance dependent on climate conditions. This explanation shows that we are actually not discussing 'zones' (as 'representative' areas) but 'conditions' (to assess the climatic sensitivity of the modelling). Of course one selects extreme conditions as only a small change in conditions may not be sufficient to show the sensitivity. The Lot 10 Task 4 report identified Strasbourg as the closest climate to the "average" EU climate; average here is to be understood as "population averaged".

Since then these three climate conditions have been used in test standards for heat pumps and air conditioners (EN 14825:2013) and (delegated) Regulations for cooling and heating appliances.

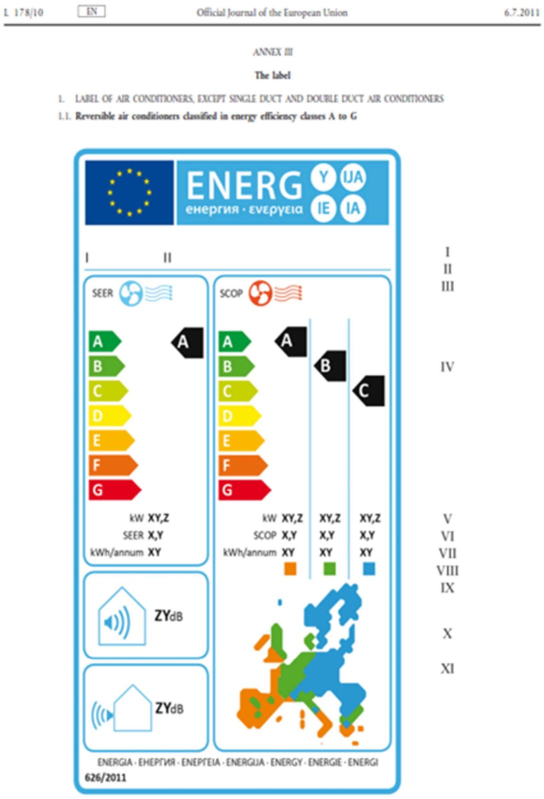
Use of three climate conditions in Task 3, Task 4, Task 5, Task 6 and Task 7

The map as used in regulation 811/2013 and 812/2013 is intended to provide consumers with some indication that the performance of the product varies by climate condition, and that when selecting products one should look at the performance established under conditions closest to actual conditions.

When looked at carefully, the EU map for heating (811/2013) shows that several countries show multiple 'climate conditions' within their borders (e.g. Spain, Italy, UK, Germany: all cover two or more colours). So the map conveys the message that one should not look at the country, but rather at the local conditions (a high altitude area in Southern Europe may still have very cold winters). However, the resolution does not allow for exact 'pinpointing' of location.

[65] Preparatory study on the environmental performance of residential room conditioning appliances (airco and ventilation), CO-ORDINATOR: Philippe RIVIERE, ARMINES, France, Contract TREN/D1/40-2005/LOT10/S07.56606, Final report of Task 4 TECHNICAL ANALYSIS OF EXISTING PRODUCTS , March 2009

Figure 15 Room air conditioner label



Each approach for dividing the EU28 in continuous climate 'zones', possibly on the basis of administrative borders, misses the point that even within a single (geographically bound) zone, two or more climate conditions may occur.

The current selection of three climate conditions represent an average condition (Strasbourg), a heating dominated condition (North = Helsinki) and a cooling dominated condition (South – Athens).

For the calculation of energy performance of windows in Task 3, 5, 6 and Task 7 (Scenario's) each country in the EU28 and the EU28 itself, has been attributed one or more climate conditions that are weighted according the heating degree days and/or cooling degree days. To give an example: Finland is 100% 'North' climate condition, France is 60% 'Central' and 40% 'South', Greece is 100% South. The resulting average EU28 weighting (corrected for floor space) is 8% North, 61% Central and 31% South.

For the proposals of Energy labels presented in Task 7 there is no mandatory requirement to use the same conditions as in other (delegated) Regulations. That is why the proposals range from a single condition, to three conditions to a separate heating and cooling condition. However, the arguments to present three conditions (one representative for the average EU28 condition and two extremes) are however the same, which is why the label options using three zones have been aligned with existing, labels.

ANNEX V – EU MAP

EU Map based on HDD (Eurostat)

Several stakeholders[66] asked for a map to be included in the label design, to allow consumers to match their approximate location with an approximate rating (and performance) according a map on the label.

We have investigated the following options for an EU map:

1. For heating performance: A map based on HDD
2. For cooling performance: A map based on solar irradiance

As the heating performance of windows varies mainly because of differences in outdoor temperatures (parameter A varies the most per climate condition and is very significant, parameter B varies also but to a lesser degree) the heating performance can be approximated by a map representing heating season outdoor temperatures. This can be based on heating degree days. We've used the HDD collected by Eurostat at NUTS2 level.

The cooling performance is mainly determined by the solar gains collected and varies according solar irradiance. For this we've used data for horizontal irradiance by SolarGIS. We used the horizontal plane as reference as this is not influenced by orientation (for orientation specific data see Annex II).

As climates do not adhere to political borders, it makes sense to construct a map using a grid of pixels rather than MS borders.

For this we have constructed a map of the EU28 based on a 28*28 'pixel' grid[67]. The pixels represent an area of roughly some 100*100 km. The grid applied (28*28 "pixels") is not at the level of NUTS2 (The Netherlands alone has already 12 provinces) but provides an acceptable level of detail to be shown at small energy labels.

As NUTS2 HDD data is not available for all MS, some MS have no internal differentiation (examples are: Croatia, Estonia, Latvia, Lithuania, see Annex IV for an overview of NUTS2 HDD data).

Figure 16 Pixel map of Member States / random colours

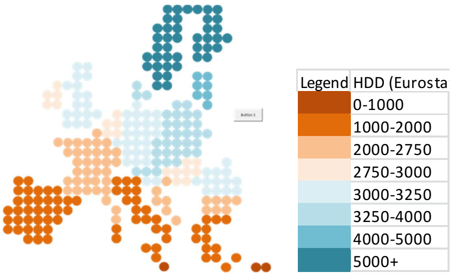
Heating: HDD levels

[66] The mentioning of stakeholders only means a support based on principle. In most cases this support is conditional (depends on other factors besides discussed in this paragraph).

[67] The most northern parts of Sweden and Finland have been 'compressed' to attain a more or less square pixel field.The information 'lost' is considered negligible.

The below two maps are based on heating degree day data (HDD) collected by Eurostat at Member States (directly below) and at NUTS2 level (further down below).

Figure 17 HDD by Member State

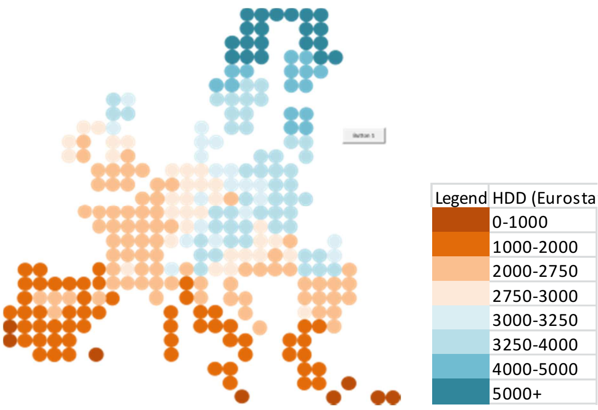


Pixel resolution: pixels grouped at MS level

MS	HDD (Eurostat)	MS	HDD (Eurostat)	MS	HDD (Eurostat)	MS	HDD (Eurostat)
AT	3574	**EE**	4445	**IE**	2906	**PL**	3616
BE	2872	**EL**	1663	**IT**	1971	**PT**	1282
BG	2687	**ES**	1842	**LT**	4094	**RO**	3129
CY	782	**FI**	5850	**LU**	3210	**SE**	5444
CZ	3571	**FR**	2483	**LV**	4265	**SI**	3053
DE	3239	**HR**	2595	**MT**	560	**SK**	3453
DK	3503	**HU**	2922	**NL**	2902	**UK**	3115
EU28	3254[68]						

The second map shows much better that within the borders of single Member States there may be different climate conditions (NUTS2 HDD are presented at the end of this Annex).

Figure 18 HDD by EU28 pixel

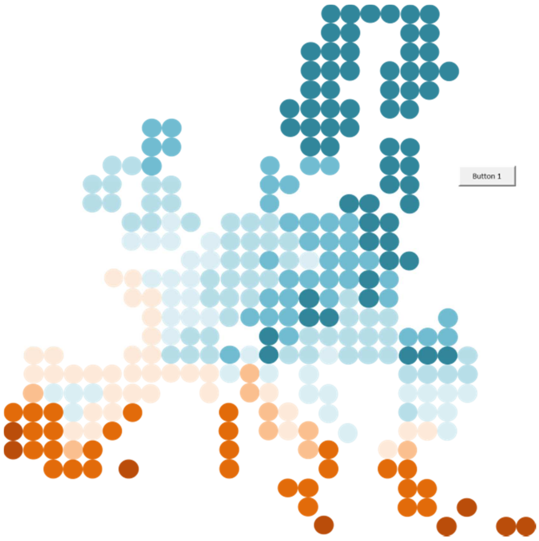


Pixel resolution: regional level (roughly 100*100 km)

When one applies a different classification (less classes for highest HDD, more classes for medium HDD) the resulting map shows even better the different conditions within MS.

[68] The EU28 data is based on the geographic average (each km2 counts as much, regardless of population). When corrected for population then Strasbourg is a better representation of average EU28 HDD

Figure 19 HDD by EU28 pixel, more resolution in mid HDD values



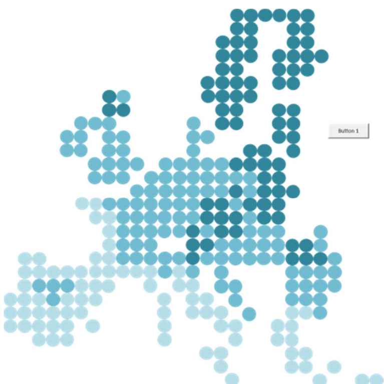
Pixel resolution: regional level (roughly 100*100 km)

Legend	HDD (Eurostat)
	0-1000
	1000-1400
	1400-1800
	1800-2200
	2200-2600
	2600-3000
	3000-3400
	3400+

Of course a higher resolution could even show more detailed influences, such as altitude (for example: the Pyrenees climate is hidden in the average HDD of regions in Northern Spain and Southern France, same for Gran Sasso mountains in Italy).

With three HDD colour classes at thresholds 2200 and 3250 HDD the resulting picture is quite similar to the existing space heater map as in Regulation (EU) No 811/2013.

Figure 20 HDD by EU28 pixel, three 'zones'



(figure right: from Commission delegated Regulation (EU) No 811/2013 of 18 February 2013)

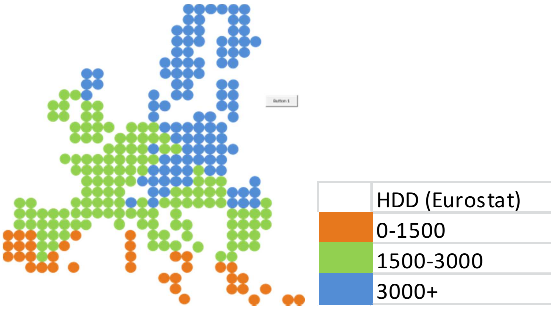
Legend	HDD (Eurostat)
	0-2200

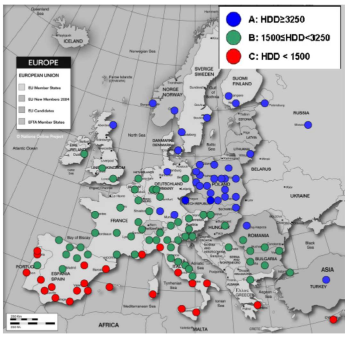
2200-3250
3250+

The differences can be explained by the method (the 211/2013 are not HDD) map resolution, the underlying data, the exact threshold level for a colour class, etc.

Using the same grid and NUTS2 data, but with a different classification into three HDD categories, a map can be constructed with HDD classes (left) fairly similar to the map suggested by EAA[69] (right).

Figure 21 HDD by EU28 pixel, three 'zones', adapted to EAA map



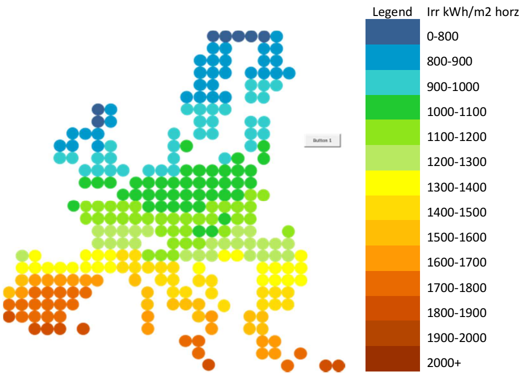


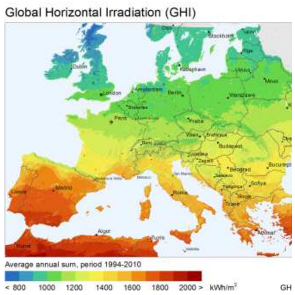
(figure right: from Prof. Dr.-Ing. Dimitris Bikas, Dr.-Ing. Katerina Tsikaloudaki, Window Energy labelling in Cooling Season: Fenestration & Glazed Structures, Additional Report on Task 3: Climate zones, Aristotle University of Thessaloniki, January 2010)

Cooling: Irradiance levels

Horizontal irradiation levels have been assigned to individual pixels in our pixel map using data supplied by SolarGIS.

Figure 22 Irradiance by EU28 pixels (source: SolarGIS © 2015 GeoModel Solar)



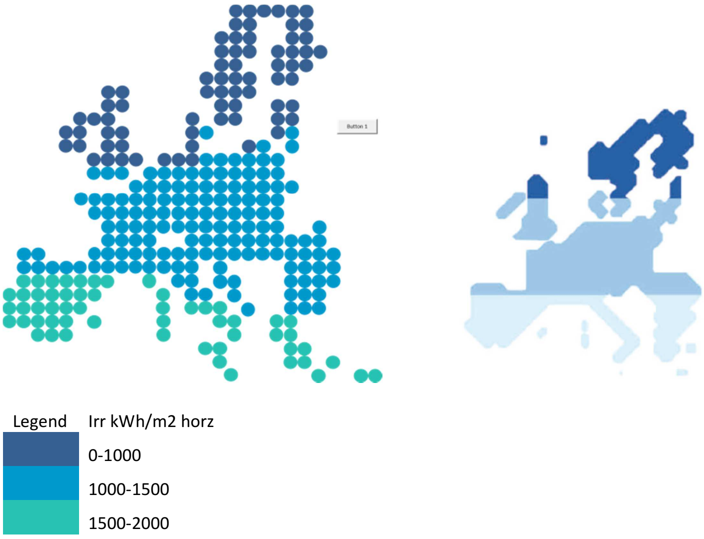


(right: SolarGIS source file)

By applying a classification into three zones on the basis of the irradiance levels, a picture similar to that of regulation 812/2013, Energy labelling of Water heaters, can be created.

[69] "Window energy labelling in cooling season: Fenestration & glazed structures – Additional report on TASK 3: Climate zones", by Prof.Dr.-Ing D. Bikas, Dr.-Ing. K. Tsikaloudaki, Aristotle University of Thessaloniki, January 2010

Figure 23 Irradiance by EU28 pixels in three 'zones', adapted to 812/2013



(right: 812/2013)

(figure right: from Commission delegated Regulation (EU) No 812/2013 of 18 February 2013)

Combined heating and cooling

Now as to the combined heating and cooling map: the map needs to consider the relevant conditions for heating and cooling in one chart, effectively combining HDD and solar irradiance. How should these different units be combined? Simple summed? multiplied? In fact, there no straightforward way of combining these values meaningfully, other than the ABC/XYZ equations.

The overall performance of a window is determined by both the U value*parameter A/X and the g value * parameter B/Y.

But these equations (combining the ABC and XYZ equations) also introduce other variables: the U value, g value, etc. In fact, any attempt to draw a map for the combined annual performance, is not reflecting the conditions for performance assessment, but introducing the subject, the window, itself and reflecting the actual performance of the window.

Maps based on the performance of the window introduce an inherent conflict with defining a generic template for label designs: as the map is actually a performance map, the contents are different per window type considered.

Table 201 HDD at NUTS2 level, period 2000-2009

Heating degree-days by NUTS 2 regions - annual data [nrg_esdgr_a]
Last update 26.06.13
Extracted on 08.04.15
Source of data Eurostat
INDIC_EN Actual heating degree-days

	GEO/TIME	AVERAGE	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
EU27	European Union (27 countries)	3067	2,926.239	3,164.371	3,013.225	3,172.193	3,163.239	3,162.339	3,038.301	2,943.226	3,007.747	3,076.313
BE00	Belgium	2638	2,521.509	2,729.844	2,535.422	2,696.070	2,797.805	2,668.858	2,590.588	2,436.729	2,706.909	2,695.950
BE01	Région de Bruxelles-Capitale / Brussels Hoofdstedelijk Gewest	2452	2,381.900	2,571.500	2,368.500	2,521.800	2,548.200	2,457.800	2,430.500	2,236.650	2,513.800	2,487.200
BE02	Prov. Antwerpen	2479	2,326.062	2,519.028	2,369.501	2,527.980	2,668.182	2,501.669	2,463.242	2,289.637	2,569.103	2,559.586
BE03	Prov. Limburg (BE)	2531	2,392.500	2,599.694	2,431.773	2,607.639	2,678.989	2,561.113	2,495.815	2,345.916	2,613.903	2,584.061
BE04	Prov. Oost-Vlaanderen	2414	2,276.367	2,438.936	2,295.309	2,446.822	2,568.192	2,446.011	2,396.911	2,250.489	2,516.366	2,504.938
BE05	Prov. Vlaams-Brabant	2465	2,383.476	2,574.312	2,385.433	2,543.328	2,561.313	2,475.187	2,434.735	2,268.966	2,539.991	2,485.521
BE06	Prov. West-Vlaanderen	2426	2,328.402	2,491.748	2,319.762	2,503.419	2,494.527	2,374.018	2,411.720	2,273.035	2,512.574	2,547.870
BE07	Prov. Brabant Wallon	2496	2,420.605	2,609.862	2,421.314	2,587.614	2,598.913	2,513.585	2,450.342	2,279.463	2,563.486	2,519.001
BE08	Prov. Hainaut	2577	2,506.401	2,690.870	2,487.782	2,673.910	2,722.232	2,623.070	2,502.058	2,329.153	2,622.458	2,616.838
BE09	Prov. Liège	2837	2,700.944	2,947.281	2,716.137	2,870.784	3,040.237	2,883.416	2,781.170	2,633.605	2,894.797	2,898.839
BE10	Prov. Luxembourg (BE)	2982	2,834.703	3,084.810	2,868.542	2,990.363	3,212.073	3,078.068	2,931.006	2,774.907	3,039.199	3,010.568
BE11	Prov. Namur	2785	2,689.854	2,938.005	2,699.519	2,866.664	2,955.041	2,800.425	2,683.045	2,552.446	2,834.388	2,831.240
BG00	Bulgaria	2528	2,430.724	2,501.116	2,512.771	2,868.992	2,500.486	2,649.681	2,622.938	2,356.843	2,430.349	2,403.153
BG01	Severozapaden	2517	2,336.048	2,479.915	2,484.869	2,913.685	2,508.845	2,730.832	2,544.518	2,286.982	2,425.305	2,463.525
BG02	Severen tsentralen	2449	2,334.392	2,419.199	2,423.905	2,877.966	2,398.055	2,583.432	2,501.763	2,244.856	2,353.176	2,350.059
BG03	Severoiztochen	2400	2,312.223	2,370.059	2,369.532	2,807.072	2,359.699	2,522.949	2,519.858	2,216.230	2,271.328	2,252.104
BG04	Yugoiztochen	2283	2,225.095	2,240.118	2,261.872	2,662.769	2,243.230	2,334.262	2,404.631	2,167.570	2,176.407	2,116.439
BG05	Yugozapaden	2857	2,753.371	2,857.431	2,859.768	3,055.264	2,870.177	3,012.040	2,989.302	2,705.600	2,757.356	2,711.231
BG06	Yuzhen tsentralen	2589	2,541.884	2,566.649	2,596.070	2,878.613	2,545.404	2,657.440	2,698.410	2,433.479	2,517.428	2,459.429
CZ00	Czech Republic	3355	3,095.820	3,555.211	3,254.462	3,441.044	3,488.372	3,564.195	3,444.609	3,175.341	3,204.210	3,326.648
CZ01	Praha	3249	3,010.590	3,464.698	3,171.246	3,377.948	3,392.126	3,438.647	3,292.975	2,993.768	3,140.543	3,208.533
CZ02	Strední Cechy	3234	2,996.669	3,433.865	3,156.458	3,358.444	3,358.034	3,419.238	3,293.143	3,006.407	3,109.984	3,208.769
CZ03	Jihozápad	3452	3,212.478	3,620.018	3,304.322	3,477.557	3,624.111	3,669.093	3,567.156	3,281.073	3,341.760	3,426.663
CZ04	Severozápad	3340	3,102.876	3,537.227	3,239.985	3,394.084	3,526.670	3,513.064	3,352.856	3,110.949	3,261.157	3,362.608
CZ05	Severovýchod	3407	3,110.517	3,624.634	3,329.266	3,530.294	3,515.623	3,609.079	3,480.230	3,227.499	3,229.153	3,409.174
CZ06	Jihovýchod	3294	3,025.981	3,501.908	3,200.769	3,371.590	3,404.764	3,524.594	3,440.366	3,129.441	3,118.780	3,223.143
CZ07	Strední Morava	3356	3,098.336	3,580.154	3,269.699	3,481.258	3,467.100	3,563.466	3,447.685	3,213.480	3,140.846	3,301.832
CZ08	Moravskoslezsko	3354	3,057.946	3,564.025	3,263.094	3,476.460	3,449.736	3,609.907	3,438.444	3,227.415	3,135.121	3,314.078
DK00	Denmark	3194	3,106.128	3,469.974	3,166.773	3,315.434	3,305.221	3,262.072	3,074.012	2,988.156	3,016.878	3,235.390
DK01	København og Frederiksberg Kommuner (NUTS 1999)	3319	3,286.300	3,711.100	3,467.050	3,613.100	3,476.500	3,326.700	3,151.900	2,984.900	2,984.200	3,192.900
DK02	Københavns amt (NUTS 1999)	3310	3,276.570	3,696.624	3,444.749	3,598.224	3,466.438	3,319.168	3,144.792	2,980.358	2,979.722	3,193.289
DK03	Frederiksborg amt (NUTS 1999)	3258	3,205.807	3,590.974	3,333.343	3,430.906	3,366.946	3,288.447	3,135.248	2,978.367	3,001.742	3,245.105
DK04	Roskilde amt (NUTS 1999)	3197	3,098.717	3,419.239	3,163.892	3,318.129	3,300.451	3,300.734	3,128.856	2,967.789	3,023.053	3,253.653
DK05	Vestsjællands amt (NUTS 1999)	3158	3,042.548	3,370.563	3,092.660	3,249.634	3,247.403	3,271.883	3,113.985	2,976.172	2,992.967	3,226.744
DK06	Storstrøms amt (NUTS 1999)	3097	2,999.414	3,293.147	3,077.323	3,239.522	3,227.133	3,190.406	3,036.095	2,901.285	2,882.676	3,119.180
DK07	Bornholms amt (NUTS 1999)	3254	3,034.141	3,398.889	3,203.030	3,412.315	3,457.696	3,308.409	3,191.276	3,084.136	3,062.292	3,389.469
DK08	Fyns amt (NUTS 1999)	3076	2,964.844	3,352.023	3,067.592	3,220.965	3,217.606	3,177.285	2,969.078	2,817.812	2,854.762	3,115.799
DK09	Sønderjyllands amt (NUTS 1999)	3126	3,020.496	3,394.843	3,113.980	3,237.535	3,270.224	3,244.154	2,981.654	2,875.826	2,968.120	3,151.940
DK10	Ribe amt (NUTS 1999)	3142	3,027.715	3,429.120	3,127.116	3,273.206	3,247.673	3,228.695	2,987.676	2,903.086	2,979.675	3,218.619
DK11	Vejle amt (NUTS 1999)	3290	3,148.847	3,586.110	3,254.442	3,408.845	3,419.582	3,430.173	3,131.950	3,057.444	3,126.697	3,333.235
DK12	Ringkøbing amt (NUTS 1999)	3131	3,012.156	3,378.429	3,103.931	3,257.197	3,231.804	3,178.609	3,002.763	2,943.794	2,976.909	3,228.335
DK13	Århus amt (NUTS 1999)	3365	3,209.242	3,640.348	3,337.932	3,505.873	3,544.603	3,449.200	3,237.518	3,200.812	3,197.043	3,330.696
DK14	Viborg amt (NUTS 1999)	3187	3,126.645	3,483.766	3,162.897	3,302.934	3,281.770	3,199.029	3,072.075	3,009.001	3,014.001	3,218.885
DK15	Nordjyllands amt (NUTS 1999)	3250	3,301.940	3,595.923	3,177.473	3,318.120	3,274.965	3,239.946	3,106.491	3,079.437	3,092.724	3,315.916
DE00	Germany (until 1990 former territory of the FRG)	3015	2,781.504	3,118.980	2,960.869	3,124.444	3,185.970	3,136.936	3,012.448	2,798.436	2,971.087	3,063.245
DE01	Stuttgart	2956	2,734.215	2,984.582	2,807.628	2,979.206	3,161.466	3,135.522	2,980.236	2,798.619	2,957.577	3,021.365
DE02	Karlsruhe	2799	2,567.718	2,841.534	2,680.011	2,858.912	2,961.991	2,940.079	2,802.505	2,626.759	2,830.539	2,880.967
DE03	Freiburg	2974	2,740.324	3,035.560	2,836.958	3,029.898	3,091.698	3,101.302	2,996.520	2,858.701	3,043.553	3,004.952
DE04	Tübingen	3252	3,046.340	3,322.466	3,091.223	3,313.207	3,424.039	3,406.787	3,310.215	3,062.429	3,265.082	3,276.819
DE05	Oberbayern	3198	2,928.516	3,247.799	3,011.423	3,279.193	3,400.545	3,490.080	3,303.323	2,997.515	3,137.301	3,186.652
DE06	Niederbayern	3275	3,017.908	3,342.578	3,106.258	3,365.988	3,489.461	3,568.513	3,405.560	3,041.055	3,172.540	3,239.827
DE07	Oberpfalz	3325	3,126.195	3,473.541	3,272.832	3,450.000	3,477.679	3,512.752	3,332.833	3,076.301	3,224.536	3,301.457
DE08	Oberfranken	3348	3,097.317	3,470.589	3,277.736	3,432.620	3,550.887	3,504.259	3,350.759	3,112.489	3,290.153	3,389.629
DE09	Mittelfranken	3158	2,952.020	3,258.073	3,084.657	3,258.764	3,303.566	3,356.699	3,157.868	2,931.704	3,089.460	3,188.892
DE10	Unterfranken	2999	2,767.671	3,052.012	2,908.594	3,055.906	3,161.739	3,169.193	3,028.835	2,803.046	2,989.842	3,050.514
DE11	Schwaben	3316	3,049.262	3,356.468	3,114.887	3,354.167	3,539.604	3,563.409	3,383.300	3,132.929	3,310.901	3,353.430
DE12	Berlin	2933	2,641.406	3,098.820	2,967.058	3,079.260	3,052.539	3,043.409	2,941.820	2,702.387	2,803.890	2,997.525
DE13	Brandenburg - Nordost (NUTS 2006)	3005	2,706.297	3,151.122	3,012.278	3,138.948	3,140.502	3,129.253	3,017.827	2,772.182	2,888.054	3,090.080
DE14	Brandenburg - Südwest (NUTS 2006)	2942	2,607.735	3,047.644	2,938.596	3,068.655	3,090.256	3,101.574	2,961.333	2,718.529	2,846.717	3,034.344
DE15	Bremen	2890	2,696.456	3,053.036	2,913.738	3,116.145	3,005.133	2,905.089	2,824.929	2,639.834	2,839.919	2,905.461
DE16	Hamburg	2991	2,766.483	3,162.358	3,020.191	3,141.399	3,156.991	3,113.686	2,934.122	2,723.206	2,873.898	3,013.386
DE17	Darmstadt	2780	2,574.179	2,842.837	2,682.548	2,818.464	2,922.715	2,850.971	2,802.810	2,615.547	2,828.572	2,864.022
DE18	Gießen	3053	2,825.184	3,072.103	2,946.485	3,072.514	3,245.040	3,109.139	3,092.727	2,917.305	3,097.945	3,148.798
DE19	Kassel	3153	2,909.089	3,234.416	3,081.919	3,212.741	3,391.252	3,255.981	3,151.434	2,964.931	3,119.334	3,210.064
DE20	Mecklenburg-Vorpommern	3031	2,822.875	3,212.292	3,053.247	3,182.881	3,142.355	3,075.313	3,000.614	2,768.367	2,914.259	3,138.013
DE21	Braunschweig	2977	2,700.001	3,092.661	2,988.876	3,110.407	3,149.322	3,092.040	2,956.004	2,746.140	2,894.006	3,040.950
DE22	Hannover	2875	2,621.863	2,986.637	2,894.391	3,060.996	2,995.735	2,962.472	2,831.318	2,645.157	2,843.717	2,911.386
DE23	Lüneburg	2938	2,706.328	3,094.635	2,948.322	3,125.951	3,077.553	3,014.897	2,874.664	2,686.647	2,873.385	2,974.787
DE24	Weser-Ems	2805	2,657.147	2,967.536	2,830.748	3,017.278	2,911.568	2,789.792	2,716.213	2,546.922	2,785.980	2,822.861
DE25	Düsseldorf	2581	2,380.229	2,629.406	2,493.925	2,655.293	2,793.901	2,623.568	2,568.304	2,370.431	2,647.252	2,650.515
DE26	Köln	2781	2,595.137	2,854.457	2,683.070	2,838.778	3,033.843	2,835.896	2,750.138	2,571.750	2,817.918	2,833.970
DE27	Münster	2705	2,516.054	2,774.693	2,665.357	2,834.076	2,906.975	2,745.623	2,636.675	2,464.766	2,738.816	2,764.653
DE28	Detmold	2878	2,625.546	2,971.138	2,852.225	3,004.498	3,047.992	2,963.026	2,838.037	2,652.235	2,867.522	2,960.911
DE29	Arnsberg	2977	2,759.315	3,063.207	2,932.765	3,058.994	3,226.099	3,050.367	2,933.086	2,765.675	2,977.974	3,002.343
DE30	Koblenz	2950	2,856.937	2,979.055	2,879.593	3,033.912	3,183.007	2,998.807	2,920.685	2,738.429	2,953.456	2,953.332
DE31	Trier	2973	2,802.348	3,044.929	2,878.004	2,997.405	3,234.536	3,067.915	2,951.786	2,767.973	3,011.789	2,977.923
DE32	Rheinhessen-Pfalz	2726	2,529.120	2,788.677	2,643.758	2,797.604	2,875.221	2,822.937	2,718.407	2,540.541	2,763.980	2,783.464
DE33	Saarland	2843	2,653.045	2,930.249	2,763.963	2,888.668	3,060.006	2,932.917	2,798.070	2,657.159	2,898.212	2,849.073
DE34	Chemnitz (NUTS 2006)	3331	3,048.477	3,492.799	3,252.410	3,398.659	3,550.331	3,507.745	3,320.976	3,126.758	3,253.527	3,354.851
DE35	Dresden	3097	2,806.663	3,270.727	3,088.282	3,234.563	3,231.023	3,243.235	3,100.827	2,873.402	2,986.084	3,139.299
DE36	Leipzig (NUTS 2006)	2939	2,645.114	3,057.381	2,957.490	3,100.351	3,074.718	3,055.189	2,952.058	2,732.352	2,839.638	2,974.961
DE37	Dessau (NUTS 1999)	2912	2,613.970	3,024.801	2,935.838	3,057.682	3,076.768	3,049.106	2,899.805	2,656.977	2,801.466	3,001.904
DE38	Halle (NUTS 2003)	2942	2,674.780	3,028.268	2,967.074	3,108.093	3,073.761	3,033.536	2,928.985	2,716.628	2,880.464	3,011.932

DE39	Magdeburg (NUTS 2003)	2933	2,649.431	3,044.646	2,951.805	3,085.039	3,095.703	3,054.771	2,921.485	2,686.792	2,843.850	3,000.390
DE40	Schleswig-Holstein	3007	2,837.511	3,189.488	2,978.867	3,137.461	3,171.323	3,067.334	2,937.979	2,760.465	2,912.363	3,072.941
DE41	Thüringen	3186	2,925.441	3,284.288	3,161.451	3,305.875	3,383.595	3,297.850	3,168.401	2,976.576	3,120.908	3,231.339
EE00	Estonia	4192	3,908.069	4,345.996	4,261.457	4,422.363	4,287.700	4,318.541	4,154.075	4,041.441	3,873.192	4,302.366
EE01	Eesti	4192	3,908.069	4,345.996	4,261.457	4,422.363	4,287.700	4,318.541	4,154.075	4,041.441	3,873.192	4,302.366
EI00	Ireland	2724	2,815.961	2,826.119	2,734.115	2,661.584	2,721.281	2,632.969	2,623.768	2,552.412	2,826.933	2,841.357
EI01	Border, Midland and Western	2801	2,888.273	2,925.945	2,814.951	2,734.051	2,794.174	2,714.737	2,706.093	2,623.666	2,897.721	2,908.986
EI02	Southern and Eastern	2654	2,750.995	2,736.434	2,661.492	2,596.480	2,655.794	2,559.508	2,549.806	2,488.398	2,763.337	2,780.599
EL00	Greece	1555	1,580.919	1,539.262	1,489.650	1,712.619	1,545.333	1,624.180	1,685.238	1,488.836	1,434.164	1,448.978
EL01	Anatoliki Makedonia, Thraki (NUTS 2010)	1906	1,889.560	1,876.719	1,866.136	2,179.349	1,860.872	1,937.888	2,030.063	1,832.614	1,791.232	1,791.999
EL02	Kentriki Makedonia (NUTS 2010)	1854	1,847.603	1,878.683	1,817.748	2,054.942	1,826.163	1,910.677	1,976.999	1,777.056	1,699.390	1,749.788
EL03	Dytiki Makedonia (NUTS 2010)	2421	2,456.422	2,457.125	2,312.020	2,577.258	2,513.402	2,504.995	2,573.756	2,268.903	2,299.090	2,246.657
EL04	Thessalia (NUTS 2010)	1684	1,681.872	1,683.265	1,592.825	1,822.455	1,691.687	1,779.236	1,841.074	1,641.433	1,532.714	1,572.228
EL05	Ipeiros (NUTS 2010)	1836	1,854.548	1,822.001	1,715.174	1,966.140	1,827.768	1,910.759	1,979.075	1,771.184	1,744.941	1,768.285
EL06	Ionia Nisia (NUTS 2010)	1200	1,192.923	1,150.041	1,109.421	1,284.617	1,184.597	1,357.918	1,352.075	1,164.384	1,084.411	1,122.698
EL07	Dytiki Ellada (NUTS 2010)	1331	1,400.358	1,303.070	1,275.856	1,430.051	1,288.463	1,432.685	1,470.926	1,282.636	1,197.037	1,229.889
EL08	Sterea Ellada (NUTS 2010)	1386	1,390.065	1,366.710	1,312.987	1,535.891	1,368.952	1,461.190	1,536.640	1,312.820	1,272.978	1,299.406
EL09	Peloponnisos (NUTS 2010)	1328	1,426.570	1,334.447	1,310.731	1,446.448	1,288.064	1,386.126	1,408.869	1,244.926	1,197.570	1,240.361
EL10	Attiki	1073	1,032.083	1,008.744	968.024	1,228.354	1,059.549	1,150.373	1,217.746	1,016.417	1,023.783	1,028.947
EL11	Voreio Aigaio	1188	1,254.540	1,087.631	1,113.260	1,413.986	1,189.127	1,251.714	1,321.445	1,131.430	1,076.228	1,038.375
EL12	Notio Aigaio	672	750.144	580.372	603.193	794.302	712.400	717.137	742.981	649.228	615.118	552.142
EL13	Kriti	862	912.881	793.723	784.998	968.433	889.048	912.013	999.594	865.207	770.004	727.340
ES00	Spain	1773	1,805.694	1,750.709	1,632.001	1,754.093	1,895.836	1,937.212	1,654.864	1,788.785	1,828.601	1,686.245
ES01	Galicia	1874	1,867.783	1,824.316	1,699.904	1,888.625	1,980.924	1,973.596	1,797.101	1,902.236	1,969.862	1,833.885
ES02	Principado de Asturias	1857	1,896.512	1,834.934	1,665.703	1,737.418	1,907.301	1,921.613	1,754.463	1,951.453	2,002.889	1,893.926
ES03	Cantabria	1896	1,888.744	1,852.903	1,694.400	1,750.510	1,956.079	1,946.872	1,724.102	2,060.431	2,105.902	1,983.981
ES04	País Vasco	1877	1,822.731	1,830.924	1,652.610	1,715.482	1,976.980	1,978.190	1,745.501	1,968.367	2,100.823	1,974.211
ES05	Comunidad Foral de Navarra	1911	1,848.214	1,856.609	1,694.842	1,848.416	2,063.510	2,157.062	1,764.660	1,929.821	2,000.365	1,947.254
ES06	La Rioja	2126	2,150.544	2,090.174	1,928.216	2,047.978	2,251.620	2,337.576	2,058.634	2,148.024	2,190.094	2,060.680
ES07	Aragón	2070	2,077.500	2,064.019	1,890.672	2,006.199	2,162.423	2,352.230	1,916.957	2,082.100	2,160.035	1,983.367
ES08	Comunidad de Madrid	1901	1,894.853	1,925.480	1,778.872	1,870.080	1,961.610	1,982.540	1,765.605	1,958.697	2,006.442	1,862.599
ES09	Castilla y León	2335	2,362.798	2,350.571	2,176.310	2,273.484	2,443.653	2,462.221	2,220.360	2,372.827	2,453.966	2,235.044
ES10	Castilla-la Mancha	1888	1,962.701	1,862.361	1,758.358	1,886.143	2,012.576	2,022.431	1,721.459	1,945.910	1,931.081	1,773.801
ES11	Extremadura	1347	1,379.693	1,316.467	1,202.248	1,329.445	1,479.948	1,483.688	1,275.297	1,395.605	1,379.490	1,224.439
ES12	Cataluña	1826	1,796.193	1,849.560	1,631.184	1,749.519	1,901.037	2,066.121	1,684.207	1,824.585	1,958.448	1,795.874
ES13	Comunidad Valenciana	1331	1,304.885	1,268.736	1,208.133	1,358.966	1,450.850	1,553.377	1,182.400	1,339.175	1,348.883	1,293.592
ES14	Illes Balears	998	1,026.960	1,039.032	880.857	1,020.556	1,135.482	1,286.284	884.495	854.516	928.828	919.055
ES15	Andalucía	1219	1,297.998	1,153.639	1,142.598	1,273.785	1,399.240	1,379.697	1,145.763	1,160.108	1,161.265	1,074.328
ES16	Región de Murcia	1177	1,265.703	1,154.829	1,153.929	1,262.111	1,331.041	1,391.284	1,026.533	1,035.209	1,058.541	1,086.296
ES17	Ciudad Autónoma de Ceuta (ES)	400	358.450	329.450	252.750	388.600	396.200	579.550	482.600	387.300	397.400	431.000
ES18	Ciudad Autónoma de Melilla (ES)	688	693.263	509.506	702.783	608.305	859.351	949.448	646.072	670.919	681.613	562.383
FR00	France	2327	2,222.658	2,376.435	2,176.495	2,343.717	2,467.066	2,456.640	2,274.986	2,212.215	2,397.252	2,340.114
FR01	Île de France	2376	2,288.939	2,434.261	2,218.470	2,434.019	2,500.220	2,434.636	2,362.697	2,204.685	2,447.920	2,435.606
FR02	Champagne-Ardenne	2614	2,439.796	2,689.017	2,456.501	2,652.118	2,794.895	2,718.230	2,578.436	2,455.996	2,702.308	2,654.151
FR03	Picardie	2541	2,433.216	2,613.757	2,404.814	2,594.002	2,671.085	2,604.299	2,520.208	2,361.054	2,588.252	2,614.569
FR04	Haute-Normandie	2478	2,428.077	2,558.958	2,336.646	2,487.052	2,573.853	2,519.259	2,459.387	2,303.326	2,535.994	2,572.505
FR05	Centre (FR)	2338	2,196.595	2,413.512	2,150.125	2,391.360	2,485.941	2,424.028	2,320.725	2,192.715	2,425.936	2,378.067
FR06	Basse-Normandie	2347	2,309.718	2,372.132	2,177.067	2,340.272	2,430.268	2,366.910	2,301.328	2,266.057	2,462.225	2,446.279
FR07	Bourgogne	2516	2,350.985	2,589.623	2,334.444	2,537.860	2,654.792	2,646.228	2,509.959	2,414.467	2,593.993	2,531.271
FR08	Nord - Pas-de-Calais	2452	2,397.532	2,545.443	2,350.570	2,503.067	2,567.266	2,469.074	2,446.205	2,238.264	2,487.178	2,520.141
FR09	Lorraine	2746	2,498.012	2,812.374	2,614.519	2,797.565	2,942.247	2,850.997	2,744.177	2,613.303	2,820.123	2,766.060
FR10	Alsace	2629	2,355.796	2,686.377	2,528.143	2,756.122	2,762.261	2,756.406	2,643.716	2,494.205	2,672.557	2,636.327
FR11	Franche-Comté	2778	2,565.596	2,859.019	2,627.649	2,761.575	2,939.824	2,952.516	2,798.438	2,671.169	2,850.261	2,751.985
FR12	Pays de la Loire	2117	2,076.770	2,171.840	1,942.695	2,131.546	2,260.216	2,164.888	2,100.360	1,945.589	2,200.228	2,174.344
FR13	Bretagne	2128	2,134.903	2,202.762	1,989.711	2,117.856	2,224.957	2,130.914	2,076.291	1,995.747	2,220.120	2,183.734
FR14	Poitou-Charentes	2049	1,943.693	2,105.510	1,865.663	2,043.998	2,206.660	2,160.169	2,029.032	1,922.346	2,137.917	2,077.522
FR15	Aquitaine	1847	1,759.868	1,856.218	1,642.489	1,818.364	2,002.129	2,016.096	1,773.667	1,841.537	1,909.393	1,849.239
FR16	Midi-Pyrénées	2147	2,056.215	2,178.196	2,013.519	2,123.233	2,292.027	2,341.707	2,019.665	2,128.327	2,201.164	2,119.493
FR17	Limousin	2459	2,373.262	2,568.359	2,329.455	2,422.062	2,637.000	2,592.437	2,323.883	2,372.214	2,535.498	2,431.002
FR18	Rhône-Alpes	2626	2,461.875	2,629.569	2,494.859	2,632.499	2,758.089	2,878.560	2,606.623	2,512.029	2,698.906	2,582.152
FR19	Auvergne	2875	2,748.498	2,999.174	2,753.334	2,881.575	3,031.916	3,027.202	2,732.111	2,794.086	2,960.900	2,825.778
FR20	Languedoc-Roussillon	2002	1,964.052	2,029.300	1,866.020	2,045.397	2,149.895	2,177.570	1,884.359	1,875.665	2,041.568	1,989.463
FR21	Provence-Alpes-Côte d'Azur	2171	2,146.558	2,143.239	2,053.416	2,210.121	2,264.340	2,392.966	2,086.424	2,016.743	2,230.998	2,163.565
FR22	Corse	1118	1,171.560	1,077.027	1,044.379	1,241.984	1,227.113	1,315.072	985.518	963.763	1,088.794	1,063.028
HR00	Croatia	2368	2,091.827	2,352.025	2,216.309	2,606.158	2,461.307	2,720.402	2,443.946	2,233.534	2,243.034	2,315.740
IT00	Italy	1816	1,694.949	1,767.110	1,710.701	1,913.452	1,882.810	2,050.727	1,824.291	1,714.985	1,775.891	1,828.968
IT01	Piemonte	2235	2,112.264	2,203.449	2,161.201	2,336.175	2,282.687	2,377.973	2,228.355	2,114.164	2,266.730	2,266.305
IT02	Valle d'Aosta/Vallée d'Aoste	3053	2,822.977	2,874.704	2,853.717	2,891.456	3,123.803	3,277.821	3,206.616	3,024.697	3,286.630	3,164.420
IT03	Liguria	1765	1,701.969	1,738.788	1,653.881	1,831.907	1,786.547	1,858.806	1,715.234	1,727.352	1,813.924	1,823.241
IT04	Lombardia	2285	2,226.646	2,352.928	2,243.974	2,378.775	2,364.282	2,510.600	2,246.884	2,051.575	2,181.188	2,288.338
IT05	Provincia Autonoma Bolzano/Bozen (NUTS 2006)	4023	3,965.609	4,095.817	4,006.609	4,102.494	4,202.162	4,273.950	3,993.578	3,838.137	3,880.070	3,867.596
IT06	Provincia Autonoma Trento (NUTS 2006)	3440	3,349.576	3,496.071	3,296.247	3,437.785	3,635.642	3,701.734	3,489.411	3,208.730	3,376.427	3,403.823
IT07	Veneto (NUTS 2006)	2250	2,160.785	2,254.654	2,142.906	2,350.421	2,322.804	2,560.769	2,228.070	2,043.148	2,203.944	2,232.363
IT08	Friuli-Venezia Giulia (NUTS 2006)	2299	2,119.715	2,265.745	2,128.774	2,407.843	2,418.359	2,675.795	2,360.436	2,109.318	2,255.532	2,243.497
IT09	Emilia-Romagna (NUTS 2006)	2013	1,889.531	1,993.336	1,919.384	2,148.553	2,088.441	2,288.841	1,999.762	1,867.270	1,924.087	2,007.588
IT10	Toscana (NUTS 2006)	1733	1,574.807	1,678.124	1,619.765	1,853.141	1,748.831	2,016.067	1,743.166	1,623.452	1,711.606	1,762.869
IT11	Umbria (NUTS 2006)	1928	1,701.834	1,811.891	1,726.324	2,076.005	1,919.063	2,142.992	2,030.091	1,916.447	1,973.764	1,980.751
IT12	Marche (NUTS 2006)	1857	1,671.165	1,765.401	1,785.060	2,066.759	1,985.200	2,212.768	1,898.896	1,626.160	1,734.126	1,819.860
IT13	Lazio (NUTS 2006)	1571	1,402.523	1,461.995	1,372.193	1,664.820	1,641.832	1,790.547	1,654.616	1,531.635	1,565.591	1,624.959
IT14	Abruzzo	1826	1,625.858	1,624.790	1,690.312	1,994.389	1,962.008	2,140.468	1,913.787	1,747.166	1,710.858	1,849.509
IT15	Molise	1716	1,583.588	1,575.164	1,618.646	1,851.475	1,814.792	1,957.986	1,746.865	1,630.734	1,639.501	1,744.277
IT16	Campania	1422	1,278.230	1,326.804	1,244.417	1,507.608	1,510.435	1,645.727	1,467.320	1,408.823	1,397.234	1,433.158
IT17	Puglia	1393	1,254.493	1,283.610	1,279.195	1,516.665	1,445.079	1,590.612	1,455.974	1,373.792	1,312.193	1,414.821
IT18	Basilicata	1546	1,440.423	1,480.965	1,424.369	1,629.007	1,620.084	1,736.902	1,563.633	1,527.505	1,470.791	1,561.374
IT19	Calabria	1148	1,081.334	1,098.265	1,067.330	1,193.064	1,156.502	1,312.545	1,163.287	1,110.971	1,122.839	1,171.413
IT20	Sicilia	1048	975.042	964.624	950.915	1,106.349	1,060.324	1,247.333	1,020.229	1,041.438	1,023.937	1,092.839
IT21	Sardegna	1133	1,022.278	1,114.581	1,070.508	1,200.731	1,215.639	1,367.337	1,039.324	1,042.125	1,117.078	1,138.703
CY00	Cyprus	684	803.347	581.739	656.365	730.765	767.047	644.318	723.581	693.991	640.154	600.216
CY01	Kypros	684	803.347	581.739	656.365	730.765	767.047	644.318	723.581	693.991	640.154	600.216
LV00	Latvia	4034	3,742.096	4,155.020	4,039.758	4,243.604	4,195.940	4,183.873	4,009.869	3,888.613	3,724.937	4,160.745
LV01	Latvija	4034	3,742.096	4,155.020	4,039.758	4,243.604	4,195.940	4,183.873	4,009.869	3,888.613	3,724.937	4,160.745
LT00	Lithuania	3854	3,570.032	3,936.455	3,823.114	4,079.390	4,046.016	4,014.178	3,873.241	3,723.797	3,542.630	3,931.401

ANNEX V – EU MAP

LT01	Lietuva	3854	3,570.032	3,936.455	3,823.114	4,079.390	4,046.016	4,014.178	3,873.241	3,723.797	3,542.630	3,931.401
LU00	Luxembourg	2938	2,754.065	3,020.065	2,827.405	2,933.867	3,183.585	3,041.225	2,923.365	2,737.625	2,993.109	2,966.694
LU01	Luxembourg	2938	2,754.065	3,020.065	2,827.405	2,933.867	3,183.585	3,041.225	2,923.365	2,737.625	2,993.109	2,966.694
HU00	Hungary	2747	2,495.262	2,826.067	2,669.341	3,089.414	2,865.679	3,029.948	2,808.534	2,551.714	2,540.841	2,594.484
HU01	Közép-Magyarország	2743	2,495.164	2,836.689	2,678.366	3,064.329	2,902.908	3,010.143	2,790.180	2,516.515	2,533.183	2,597.653
HU02	Közép-Dunántúl	2757	2,481.833	2,827.839	2,669.986	3,056.831	2,920.074	3,044.113	2,802.517	2,550.928	2,571.068	2,643.363
HU03	Nyugat-Dunántúl	2755	2,481.424	2,772.352	2,609.267	3,014.172	2,923.533	3,076.808	2,857.518	2,584.748	2,570.983	2,654.649
HU04	Dél-Dunántúl	2655	2,363.954	2,704.820	2,509.680	2,985.728	2,754.094	2,974.597	2,732.496	2,511.693	2,473.706	2,538.971
HU05	Észak-Magyarország	2898	2,715.778	2,982.649	2,874.553	3,197.482	3,005.344	3,114.495	2,959.589	2,688.598	2,686.832	2,751.398
HU06	Észak-Alföld	2784	2,561.854	2,880.580	2,759.176	3,160.932	2,878.800	3,061.801	2,849.703	2,558.048	2,545.590	2,580.942
HU07	Dél-Alföld	2663	2,385.716	2,778.605	2,586.503	3,094.728	2,753.994	2,949.873	2,696.609	2,469.338	2,446.907	2,467.898
MT00	Malta	464	469.772	381.251	418.533	597.456	500.385	661.853	473.726	331.563	306.604	498.731
MT01	Malta	464	469.772	381.251	418.533	597.456	500.385	661.853	473.726	331.563	306.604	498.731
NL00	Netherlands	2645	2,487.724	2,721.201	2,596.162	2,759.265	2,804.954	2,657.974	2,573.464	2,423.705	2,694.417	2,726.587
NL01	Groningen	2813	2,688.244	2,979.184	2,826.393	3,004.330	2,906.906	2,802.759	2,707.847	2,542.489	2,789.741	2,886.958
NL02	Friesland (NL)	2769	2,685.134	2,950.709	2,797.083	2,954.479	2,820.899	2,750.356	2,657.880	2,496.576	2,750.658	2,827.156
NL03	Drenthe	2797	2,643.938	2,947.564	2,804.428	2,982.513	2,889.207	2,803.155	2,691.303	2,550.369	2,801.084	2,857.389
NL04	Overijssel	2740	2,555.776	2,826.588	2,692.940	2,876.765	2,892.675	2,771.337	2,648.155	2,533.719	2,788.381	2,817.951
NL05	Gelderland	2639	2,452.837	2,684.786	2,570.401	2,747.845	2,852.344	2,646.694	2,558.391	2,444.722	2,718.752	2,714.844
NL06	Flevoland	2672	2,537.335	2,771.637	2,638.647	2,812.197	2,820.053	2,667.946	2,568.133	2,452.130	2,722.906	2,729.445
NL07	Utrecht	2585	2,448.504	2,666.820	2,553.401	2,736.458	2,762.144	2,562.629	2,490.725	2,341.333	2,632.780	2,655.164
NL08	Noord-Holland	2616	2,479.548	2,663.919	2,551.944	2,669.402	2,788.963	2,645.743	2,569.601	2,399.585	2,668.700	2,720.914
NL09	Zuid-Holland	2525	2,370.281	2,547.474	2,469.386	2,601.128	2,718.419	2,539.848	2,480.823	2,303.663	2,594.576	2,629.311
NL10	Zeeland	2400	2,231.660	2,397.209	2,335.126	2,430.732	2,578.002	2,426.194	2,389.999	2,210.815	2,494.639	2,502.437
NL11	Noord-Brabant	2558	2,378.613	2,592.208	2,458.557	2,633.304	2,752.236	2,585.655	2,518.171	2,358.549	2,642.917	2,655.715
NL12	Limburg (NL)	2567	2,368.522	2,602.421	2,446.270	2,630.871	2,789.317	2,622.414	2,540.684	2,364.628	2,646.842	2,655.552
AT00	Austria	3377	3,163.592	3,497.253	3,225.494	3,464.692	3,560.452	3,649.622	3,487.330	3,171.321	3,252.289	3,300.883
AT01	Burgenland (AT)	2785	2,496.121	2,834.818	2,671.306	3,020.116	2,953.565	3,074.785	2,879.686	2,613.384	2,616.166	2,693.376
AT02	Niederösterreich	3123	2,882.179	3,258.568	2,987.657	3,264.987	3,266.441	3,363.556	3,247.466	2,922.349	2,986.766	3,054.069
AT03	Wien	2833	2,591.545	2,950.318	2,741.160	3,052.105	2,948.697	3,049.005	2,917.424	2,628.107	2,683.367	2,764.142
AT04	Kärnten	3405	3,185.181	3,445.920	3,200.753	3,458.100	3,647.239	3,677.498	3,588.462	3,187.341	3,310.913	3,353.449
AT05	Steiermark	3428	3,211.066	3,569.904	3,270.325	3,524.352	3,599.273	3,714.803	3,560.217	3,252.040	3,254.378	3,327.051
AT06	Oberösterreich	3329	3,155.204	3,501.452	3,202.415	3,482.305	3,497.970	3,545.719	3,442.420	3,054.670	3,178.179	3,231.379
AT07	Salzburg	3681	3,429.704	3,800.237	3,477.424	3,644.768	3,930.965	4,035.418	3,821.344	3,494.986	3,568.001	3,610.002
AT08	Tirol	3728	3,557.327	3,826.065	3,584.438	3,704.769	3,933.363	4,041.776	3,743.006	3,533.951	3,676.007	3,680.263
AT09	Vorarlberg	3496	3,365.045	3,635.580	3,380.688	3,587.296	3,645.787	3,730.793	3,488.127	3,262.802	3,459.467	3,402.592
PL00	Poland	3394	3,091.958	3,581.125	3,337.193	3,593.874	3,510.323	3,547.423	3,454.257	3,222.061	3,164.472	3,439.097
PL01	Lódzkie	3322	2,985.386	3,529.792	3,285.402	3,499.153	3,407.189	3,481.981	3,403.392	3,172.462	3,083.267	3,371.892
PL02	Mazowieckie	3458	3,161.102	3,641.707	3,384.966	3,660.453	3,595.334	3,591.057	3,547.877	3,285.398	3,194.407	3,516.056
PL03	Malopolskie	3468	3,150.734	3,675.568	3,368.461	3,671.668	3,568.772	3,702.233	3,588.233	3,322.670	3,180.453	3,453.975
PL04	Slaskie	3360	3,042.423	3,592.520	3,289.250	3,524.128	3,455.720	3,590.639	3,440.522	3,220.429	3,105.015	3,341.769
PL05	Lubelskie	3476	3,176.794	3,662.032	3,400.955	3,707.956	3,569.226	3,618.487	3,595.506	3,334.005	3,194.194	3,503.062
PL06	Podkarpackie	3381	3,096.789	3,544.372	3,313.200	3,644.185	3,450.692	3,601.540	3,460.592	3,233.424	3,114.451	3,348.493
PL07	Swietokrzyskie	3418	3,090.945	3,597.304	3,342.418	3,634.806	3,491.629	3,587.585	3,542.934	3,293.960	3,170.577	3,430.554
PL08	Podlaskie	3721	3,382.546	3,861.024	3,624.170	3,935.313	3,890.636	3,885.141	3,812.052	3,547.971	3,470.797	3,799.628
PL09	Wielkopolskie	3231	2,913.658	3,428.800	3,201.103	3,425.397	3,318.981	3,374.055	3,265.767	3,047.386	3,041.382	3,295.987
PL10	Zachodniopomorskie	3258	2,993.505	3,434.905	3,270.804	3,433.087	3,391.785	3,339.337	3,229.524	3,041.701	3,096.415	3,344.627
PL11	Lubuskie	3082	2,799.270	3,244.982	3,075.967	3,264.267	3,187.057	3,229.782	3,080.765	2,879.664	2,919.277	3,135.542
PL12	Dolnoslaskie	3286	2,998.846	3,475.468	3,220.703	3,468.308	3,378.546	3,477.784	3,350.197	3,104.011	3,082.008	3,305.306
PL13	Opolskie	3228	2,883.637	3,413.152	3,144.156	3,412.533	3,326.604	3,445.952	3,334.863	3,085.162	2,999.624	3,235.253
PL14	Kujawsko-Pomorskie	3388	3,072.001	3,575.383	3,331.568	3,579.696	3,508.610	3,515.090	3,447.657	3,208.202	3,194.519	3,451.965
PL15	Warminsko-Mazurskie	3599	3,314.975	3,789.673	3,524.633	3,799.162	3,782.217	3,721.340	3,628.588	3,409.207	3,356.113	3,668.046
PL16	Pomorskie	3440	3,178.396	3,653.015	3,407.409	3,631.249	3,593.862	3,534.095	3,390.359	3,230.731	3,245.946	3,537.481
PT00	Portugal	1259	1,267.807	1,256.727	1,159.654	1,248.074	1,379.995	1,360.332	1,197.027	1,258.079	1,298.769	1,165.898
PT01	Norte	1740	1,780.902	1,804.970	1,647.703	1,711.532	1,851.758	1,832.676	1,622.073	1,703.296	1,793.787	1,651.965
PT02	Algarve	793	761.827	774.952	658.699	784.792	927.965	892.648	796.515	820.290	798.076	715.446
PT03	Centro (PT)	1332	1,343.022	1,315.386	1,239.116	1,322.962	1,480.750	1,432.156	1,246.867	1,323.498	1,377.308	1,240.688
PT04	Área Metropolitana de Lisboa	833	767.492	774.331	734.973	823.827	943.055	976.806	844.582	875.872	828.378	764.883
PT05	Alentejo	980	977.177	951.985	874.788	977.907	1,080.217	1,084.147	959.250	1,001.106	1,013.918	876.570
RO00	Romania	2940	2,773.542	2,964.092	2,860.862	3,264.089	3,008.323	3,154.799	3,072.404	2,749.831	2,776.271	2,772.712
RO01	Nord-Vest	3113	2,993.154	3,223.793	3,037.516	3,430.029	3,217.194	3,386.604	3,236.143	2,893.805	2,855.579	2,860.907
RO02	Centru	3413	3,235.413	3,386.109	3,222.905	3,586.867	3,582.458	3,714.425	3,701.036	3,251.798	3,273.049	3,174.118
RO03	Nord-Est	3274	3,053.053	3,364.833	3,273.105	3,600.309	3,352.922	3,437.744	3,434.854	3,057.557	3,072.241	3,094.168
RO04	Sud-Est	2653	2,536.445	2,687.228	2,616.082	3,046.025	2,633.960	2,763.873	2,771.607	2,467.125	2,473.621	2,534.231
RO05	Sud - Muntenia	2685	2,557.746	2,646.592	2,665.601	3,081.261	2,691.158	2,817.484	2,754.278	2,500.902	2,583.657	2,552.446
RO06	Bucuresti - Ilfov	2620	2,507.577	2,596.466	2,671.059	3,041.130	2,595.804	2,741.354	2,648.192	2,410.943	2,499.112	2,491.090
RO07	Sud-Vest Oltenia	2675	2,545.940	2,633.710	2,585.924	3,008.195	2,713.528	2,879.144	2,742.310	2,464.860	2,598.852	2,578.960
RO08	Vest	2719	2,445.389	2,749.560	2,557.503	3,042.756	2,829.125	3,060.310	2,814.569	2,570.283	2,544.711	2,577.223
SI00	Slovenia	2862	2,583.116	2,874.425	2,673.057	3,048.061	3,049.293	3,187.896	2,970.324	2,677.689	2,781.574	2,773.908
SI01	Slovenija	2862	2,583.116	2,874.425	2,673.057	3,048.061	3,049.293	3,187.896	2,970.324	2,677.689	2,781.574	2,773.908
SK00	Slovakia	3256	3,007.064	3,390.271	3,197.342	3,444.609	3,389.635	3,519.416	3,352.525	3,075.656	3,023.267	3,159.530
SK01	Bratislavský kraj	2777	2,544.131	2,918.786	2,733.755	2,975.535	2,886.160	2,995.778	2,810.253	2,590.524	2,618.665	2,697.007
SK02	Západné Slovensko	2963	2,696.468	3,108.750	2,907.832	3,145.617	3,099.497	3,227.392	3,025.166	2,798.073	2,763.172	2,856.966
SK03	Stredné Slovensko	3473	3,245.953	3,638.285	3,418.693	3,649.816	3,598.671	3,731.481	3,573.873	3,296.374	3,205.714	3,372.929
SK04	Východné Slovensko	3373	3,116.679	3,463.897	3,305.058	3,578.727	3,515.853	3,646.930	3,506.541	3,175.475	3,135.428	3,287.742
FI00	Finland	5483	5,218.505	5,744.070	5,715.342	5,659.913	5,529.500	5,293.414	5,425.506	5,311.705	5,335.564	5,596.087
FI01	Itä-Suomi (NUTS 2006)	5342	5,043.040	5,624.124	5,599.206	5,519.558	5,444.110	5,152.873	5,319.925	5,125.673	5,094.992	5,491.818
FI02	Etelä-Suomi (NUTS 2006)	4545	4,243.566	4,742.319	4,730.867	4,843.385	4,666.503	4,484.437	4,475.647	4,360.835	4,209.807	4,691.918
FI03	Länsi-Suomi	4879	4,562.710	5,167.578	5,052.909	5,132.673	4,978.248	4,780.905	4,766.036	4,704.700	4,628.421	5,020.606
FI04	Pohjois-Suomi (NUTS 2006)	6142	5,931.955	6,401.799	6,403.195	6,246.380	6,108.827	5,866.900	6,092.448	6,000.341	6,156.178	6,210.433
FI05	Åland	4030	3,743.404	3,963.300	4,048.976	4,174.182	4,170.592	4,199.157	4,033.171	3,958.882	3,827.072	4,177.690
SE00	Sweden	5148	4,940.029	5,402.281	5,156.375	5,230.118	5,240.360	5,097.061	4,982.173	5,068.272	5,075.714	5,291.188
SE01	Stockholm	3882	3,602.076	4,012.150	3,946.159	4,029.020	3,966.522	3,900.899	3,820.676	3,807.920	3,718.880	4,016.642
SE02	Östra Mellansverige	3994	3,749.249	4,218.931	4,070.158	4,148.912	4,069.664	3,989.036	3,900.937	3,879.554	3,791.811	4,120.587
SE03	Småland med öarna	3812	3,585.843	4,072.986	3,842.400	3,953.549	3,972.295	3,846.021	3,655.385	3,620.979	3,619.182	3,922.118
SE04	Sydsverige	3394	3,271.710	3,658.230	3,396.569	3,492.894	3,548.431	3,439.592	3,304.378	3,153.230	3,192.562	3,481.346
SE05	Västsverige	3762	3,560.402	4,028.546	3,798.877	3,891.215	3,903.941	3,775.780	3,650.879	3,596.240	3,571.737	3,845.928
SE06	Norra Mellansverige	4756	4,505.651	5,050.442	4,810.287	4,813.410	4,800.652	4,682.020	4,587.393	4,706.979	4,650.797	4,957.085
SE07	Mellersta Norrland	5403	5,217.276	5,635.728	5,273.802	5,453.209	5,415.460	5,345.260	5,189.688	5,405.986	5,426.799	5,669.099
SE08	Övre Norrland	6233	6,039.688	6,488.075	6,257.464	6,296.429	6,357.858	6,141.702	6,042.682	6,164.044	6,224.901	6,321.788
UK00	United Kingdom	2926	2,978.539	3,092.587	2,883.896	2,880.322	2,881.295	2,879.371	2,813.508	2,817.598	3,043.248	2,989.817
UK01	Tees Valley and Durham	3154	3,171.654	3,317.983	3,123.903	3,065.448	3,047.235	3,133.828	3,064.451	3,087.789	3,310.504	3,221.154

UK02	Northumberland and Tyne and Wear	3218	3,293.389	3,387.713	3,220.918	3,118.238	3,107.527	3,185.672	3,105.728	3,180.046	3,348.196	3,236.047
UK03	Cumbria	3101	3,148.604	3,258.709	3,064.876	3,025.539	3,035.962	3,082.258	2,995.633	2,998.018	3,211.409	3,189.896
UK04	Cheshire (NUTS 2006)	2778	2,804.997	2,911.544	2,690.970	2,732.942	2,713.857	2,733.170	2,670.348	2,693.692	2,913.189	2,910.496
UK05	Greater Manchester	2880	2,892.083	2,911.464	2,673.975	2,804.334	2,873.780	2,918.440	2,819.630	2,832.405	3,047.853	3,024.766
UK06	Lancashire	2831	2,811.636	2,991.940	2,776.800	2,776.169	2,787.243	2,822.663	2,736.033	2,761.495	2,951.702	2,894.498
UK07	Merseyside (NUTS 2006)	2625	2,602.070	2,721.023	2,520.568	2,577.545	2,551.673	2,658.289	2,553.093	2,548.959	2,767.357	2,751.699
UK08	East Yorkshire and Northern Lincolnshire	2736	2,886.945	2,840.074	2,586.361	2,715.044	2,728.484	2,721.445	2,640.099	2,609.404	2,850.381	2,777.152
UK09	North Yorkshire	2994	3,072.173	3,123.918	2,903.017	2,943.899	2,941.077	2,953.601	2,898.528	2,905.429	3,133.779	3,067.219
UK10	South Yorkshire	2730	2,751.477	2,766.930	2,497.317	2,701.409	2,727.165	2,753.097	2,669.275	2,658.910	2,922.344	2,854.855
UK11	West Yorkshire	2890	2,923.240	2,903.996	2,661.056	2,841.488	2,891.995	2,911.082	2,815.906	2,838.485	3,077.412	3,040.126
UK12	Derbyshire and Nottinghamshire	2782	2,859.432	2,943.386	2,690.202	2,732.428	2,767.030	2,754.241	2,651.822	2,672.106	2,914.209	2,838.517
UK13	Leicestershire, Rutland and Northamptonshire	2665	2,728.521	2,879.888	2,636.589	2,671.943	2,629.837	2,596.282	2,497.878	2,507.755	2,767.566	2,731.317
UK14	Lincolnshire	2663	2,784.117	2,820.878	2,533.948	2,588.162	2,662.709	2,646.471	2,554.770	2,549.641	2,775.482	2,710.811
UK15	Herefordshire, Worcestershire and Warwickshire	2728	2,748.883	2,945.066	2,762.261	2,812.175	2,688.623	2,612.755	2,554.540	2,556.322	2,795.991	2,807.083
UK16	Shropshire and Staffordshire	2836	2,882.534	3,048.637	2,853.669	2,888.465	2,769.219	2,711.067	2,670.703	2,694.678	2,923.082	2,920.133
UK17	West Midlands	2739	2,783.571	2,967.515	2,776.417	2,819.881	2,719.653	2,619.353	2,555.247	2,570.412	2,808.942	2,764.024
UK18	East Anglia	2608	2,648.622	2,764.342	2,494.484	2,604.520	2,648.546	2,621.368	2,496.550	2,465.941	2,692.171	2,643.057
UK19	Bedfordshire and Hertfordshire	2647	2,629.181	2,813.983	2,551.554	2,609.354	2,654.664	2,681.534	2,526.855	2,510.748	2,774.104	2,714.372
UK20	Essex	2548	2,570.013	2,719.000	2,471.719	2,555.023	2,583.388	2,566.446	2,436.014	2,366.800	2,633.274	2,580.379
UK21	Inner London (NUTS 2010)	2477	2,496.250	2,686.350	2,434.450	2,528.400	2,542.750	2,520.700	2,339.000	2,261.050	2,499.900	2,461.150
UK22	Outer London (NUTS 2010)	2482	2,498.020	2,673.065	2,427.132	2,515.782	2,552.115	2,530.976	2,346.227	2,269.853	2,523.586	2,478.259
UK23	Berkshire, Buckinghamshire and Oxfordshire	2624	2,659.513	2,730.517	2,489.447	2,555.242	2,633.231	2,631.759	2,518.209	2,516.927	2,763.845	2,737.174
UK24	Surrey, East and West Sussex	2510	2,574.760	2,592.155	2,349.401	2,440.301	2,672.087	2,589.665	2,411.790	2,331.771	2,587.916	2,554.646
UK25	Hampshire and Isle of Wight	2532	2,493.665	2,688.504	2,465.332	2,556.764	2,535.878	2,555.353	2,422.021	2,365.893	2,628.927	2,603.555
UK26	Kent	2429	2,448.838	2,559.195	2,301.666	2,444.357	2,517.480	2,502.001	2,348.729	2,235.021	2,482.035	2,449.257
UK27	Gloucestershire, Wiltshire and Bristol/Bath area	2612	2,583.894	2,776.735	2,622.590	2,672.136	2,584.884	2,571.557	2,469.236	2,454.896	2,704.185	2,675.095
UK28	Dorset and Somerset	2553	2,540.416	2,727.806	2,575.716	2,604.093	2,534.158	2,502.799	2,377.342	2,410.477	2,641.811	2,612.999
UK29	Cornwall and Isles of Scilly	2375	2,451.020	2,406.296	2,295.546	2,303.340	2,415.668	2,407.573	2,289.428	2,201.021	2,499.480	2,483.702
UK30	Devon	2566	2,617.845	2,636.079	2,515.012	2,525.397	2,538.743	2,524.306	2,391.580	2,518.190	2,706.459	2,686.549
UK31	Isle of Anglesey	2621	2,651.005	2,795.804	2,686.651	2,630.673	2,596.318	2,513.183	2,478.621	2,468.156	2,686.520	2,708.051
UK32	Gwynedd	2788	2,797.580	2,953.378	2,801.947	2,771.674	2,724.787	2,721.941	2,677.892	2,661.996	2,876.695	2,893.357
UK33	Conwy and Denbighshire	2936	2,942.098	3,125.655	2,949.972	2,943.701	2,883.659	2,886.085	2,809.116	2,796.124	2,999.186	3,019.892
UK34	South West Wales	2744	2,823.751	2,884.023	2,740.471	2,723.304	2,700.826	2,639.210	2,632.617	2,614.321	2,840.374	2,838.001
UK35	Central Valleys	2593	2,528.481	2,698.979	2,750.511	2,719.471	2,541.378	2,492.356	2,424.356	2,434.393	2,672.961	2,671.166
UK36	Gwent Valleys	2584	2,547.500	2,705.450	2,689.700	2,690.500	2,487.900	2,459.450	2,429.550	2,451.800	2,706.700	2,672.650
UK37	Bridgend and Neath Port Talbot	2604	2,535.900	2,713.300	2,772.750	2,733.000	2,568.150	2,499.600	2,452.350	2,423.350	2,666.200	2,672.600
UK38	Swansea	2580	2,507.504	2,686.241	2,692.123	2,663.622	2,553.421	2,500.175	2,450.649	2,425.864	2,662.160	2,653.456
UK39	Monmouthshire and Newport	2596	2,559.935	2,718.309	2,699.089	2,699.460	2,501.864	2,469.139	2,442.377	2,462.329	2,719.847	2,685.404
UK40	Cardiff and Vale of Glamorgan	2594	2,533.213	2,720.177	2,725.449	2,708.815	2,534.395	2,493.423	2,428.548	2,433.967	2,685.192	2,679.356
UK41	Flintshire and Wrexham	2921	2,926.942	3,098.049	2,911.954	2,913.143	2,863.609	2,873.405	2,791.805	2,799.404	3,004.134	3,023.463
UK42	Powys	2952	2,987.758	3,135.103	2,988.550	2,993.141	2,873.709	2,806.548	2,804.255	2,833.024	3,042.600	3,050.640
UK43	Aberdeen City, Aberdeenshire and North East Moray (NUTS 2003)	3442	3,586.769	3,622.005	3,383.899	3,260.116	3,376.429	3,387.968	3,337.408	3,398.119	3,577.705	3,489.850
UK44	Angus and Dundee City	3318	3,462.353	3,527.022	3,304.153	3,174.710	3,203.304	3,233.651	3,228.382	3,207.433	3,440.258	3,398.556
UK45	Clackmannanshire and Fife	3222	3,329.048	3,457.472	3,278.424	3,165.636	3,093.725	3,107.021	3,082.416	3,127.770	3,341.884	3,232.459
UK46	East Lothian and Midlothian	3341	3,399.889	3,628.046	3,431.691	3,322.964	3,190.389	3,200.432	3,151.657	3,322.126	3,442.677	3,320.531
UK47	Scottish Borders	3352	3,446.263	3,597.145	3,398.278	3,287.219	3,228.173	3,258.412	3,180.498	3,311.306	3,452.815	3,356.308
UK48	Edinburgh, City of	3476	3,492.008	3,770.372	3,575.226	3,474.126	3,322.109	3,358.160	3,309.802	3,340.625	3,609.467	3,507.607
UK49	Falkirk	3242	3,343.098	3,468.038	3,292.949	3,197.399	3,123.798	3,119.847	3,105.949	3,139.188	3,366.525	3,261.370
UK50	Perth & Kinross and Stirling	3357	3,420.629	3,561.446	3,357.990	3,280.112	3,248.100	3,247.950	3,263.300	3,254.669	3,502.699	3,431.560
UK51	West Lothian	3466	3,484.635	3,756.322	3,561.934	3,461.851	3,316.018	3,347.717	3,301.063	3,331.486	3,598.677	3,498.795
UK52	East Dunbartonshire, West Dunbartonshire and Helensburgh & Lomond	3177	3,267.794	3,399.721	3,227.768	3,171.838	3,014.106	3,018.695	3,053.616	3,046.336	3,324.422	3,240.708
UK53	Dumfries & Galloway	3134	3,192.415	3,338.878	3,144.705	3,093.491	3,038.152	3,077.144	3,017.588	3,014.946	3,230.084	3,195.388
UK54	East Ayrshire and North Ayrshire mainland	3231	3,247.534	3,481.941	3,303.277	3,223.165	3,071.413	3,107.739	3,174.490	3,158.736	3,339.788	3,202.477
UK55	Glasgow City	3289	3,303.484	3,548.301	3,364.244	3,283.611	3,101.677	3,127.268	3,260.403	3,244.544	3,408.945	3,251.540
UK56	Inverclyde, East Renfrewshire and Renfrewshire	3223	3,254.458	3,451.623	3,285.563	3,203.511	3,059.526	3,078.868	3,172.007	3,157.883	3,352.233	3,216.625
UK57	North Lanarkshire	3313	3,335.641	3,577.614	3,396.603	3,307.416	3,133.267	3,156.632	3,240.871	3,236.585	3,438.969	3,303.719
UK58	South Ayrshire	3100	3,133.407	3,297.715	3,131.660	3,081.421	3,018.350	3,043.615	2,990.612	2,964.844	3,200.577	3,137.826
UK59	South Lanarkshire	3379	3,405.845	3,641.282	3,431.747	3,357.967	3,225.803	3,277.783	3,289.817	3,292.597	3,492.932	3,373.805
UK60	Caithness & Sutherland and Ross & Cromarty	3384	3,460.225	3,620.637	3,321.111	3,228.065	3,279.058	3,320.021	3,306.211	3,344.967	3,527.756	3,436.426
UK61	Inverness & Nairn and Moray, Badenoch & Strathspey	3480	3,542.436	3,662.433	3,386.036	3,306.681	3,411.206	3,383.881	3,404.976	3,444.549	3,677.670	3,577.987
UK62	Lochaber, Skye & Lochalsh, Arran & Cumbrae and Argyll & Bute	3172	3,237.889	3,348.570	3,134.590	3,083.621	3,073.800	3,119.477	3,087.277	3,098.637	3,310.495	3,221.876
UK63	Eilean Siar (Western Isles)	3139	3,255.689	3,368.560	3,122.981	3,005.040	3,104.054	3,155.304	2,972.634	3,064.380	3,256.553	3,083.620
UK64	Orkney Islands	3331	3,456.944	3,565.908	3,277.908	3,110.794	3,273.938	3,341.764	3,257.701	3,352.830	3,415.394	3,260.359
UK65	Northern Ireland (UK)	2916	2,977.433	3,048.312	2,892.793	2,860.883	2,879.328	2,834.500	2,844.870	2,762.908	3,053.714	3,008.864

ANNEX VI – THE FORMER (DRAFT) WINDOW ENERGY LABEL PROPOSAL (24 FEB 2015)

A proposal for energy labelling of windows was presented in the draft TASK 7 report published 24 February 2015, based on the assessment of the heating performance using energy balance equations and a cooling performance based on the $g_{W,eff}$.

HEATING PERFORMANCE (FORMER PROPOSAL)

The heating performance was based on the ABC values, as established on the basis of the single family house, and averaged over high and low U_{env} values.

Table 202 Former (draft) ABC values, single family house, average of high and low Uenv

	A	B	C	
			sunset to sunrise	22:00 to 06:00
North	103	267	0,66	0,36
Central	67	238	0,65	0,38
South	23	256	0,65	0,40

A classification for heating performance was applied as shown below. It applied equally to windows with or without shutters.

Table 203 Energy label classes for heating of façade windows (proposal)

Energy Class	'North'		'Central'		'South'	
	class borders	class incr.	class borders	class incr.	class borders	class incr.
A	$P_{E,H,W} < -5$		$P_{E,H,W} < -20$		$P_{E,H,W} < -75$	
B	$-5 \le P_{E,H,W} < 5$	10	$-20 \le P_{E,H,W} < -10$	10	$-75 \le P_{E,H,W} < -70$	5
C	$5 \le P_{E,H,W} < 20$	15	$-10 \le P_{E,H,W} < 5$	15	$-70 \le P_{E,H,W} < -65$	10
D	$20 \le P_{E,H,W} < 40$	20	$5 \le P_{E,H,W} < 25$	20	$-65 \le P_{E,H,W} < -50$	15
E	$40 \le P_{E,H,W} < 65$	25	$25 \le P_{E,H,W} < 50$	25	$-50 \le P_{E,H,W} < -25$	25
F	$65 \le P_{E,H,W} < 115$	50	$50 \le P_{E,H,W} < 100$	50	$-25 \le P_{E,H,W} < 0$	25
G	$115 \le P_{E,H,W}$		$100 \le P_{E,H,W}$		$0 \le P_{E,H,W}$	

The classification was defined to allow only the best performing windows in the highest classes, based on energy performance only.

Using the A, B and C values the energy performance index and energy efficiency class for heating was calculated for the 11 different design options.

Table 204 Energy label classes for heating of façade windows (proposal)

Table 205 Calculated $P_{E;H;W}$ values for three climatic conditions

without shutter	North	Central	South

Uw 5.8 / g 0.85	588	340	14
Uw 2.8 / g 0.78	193	88	-64
Uw 1.7 / g 0.65	71	16	-74
Uw 1.3 / g 0.6	39	-3	-74
Uw 1 / g 0.55	17	-14	-72
Uw 0.8 / g 0.6	-13	-36	-85
Uw 1 / g 0.58	11	-19	-77
Uw 0.6 / g 0.47	-9	-28	-67
Uw 2.8 / g 0.35	273	160	13
Uw 1.3 / g 0.35	85	39	-29
Uw 0.8 / g 0.35	34	6	-41
Uw 5.8 / g 0.85 shading	391	215	-29
Uw 2.8 / g 0.78 shading	131	49	-78
Uw 1.7 / g 0.65 shading	45	-1	-79
Uw 1.3 / g 0.6 shading	22	-13	-77
Uw 1 / g 0.55 shading	7	-21	-74
Uw 0.8 / g 0.6 shading	-20	-40	-87
Uw 1 / g 0.58 shading	1	-26	-79
Uw 0.6 / g 0.47 shading	-13	-30	-68
Uw 2.8 / g 0.35 shading	211	121	-1
Uw 1.3 / g 0.35 shading	69	29	-33
Uw 0.8 / g 0.35 shading	27	2	-42

The resulting window performance classes (for heating, facade windows) are shown below.

Table 206 Energy performance classes by façade window type

Facade windows	North	Central	South
Uw 5.8 / g 0.85	G	G	G
Uw 2.8 / g 0.78	G	F	D
Uw 1.7 / g 0.65	F	D	B
Uw 1.3 / g 0.6	D	C	B
Uw 1 / g 0.55	C	B	B
Uw 0.8 / g 0.6	A	A	A
Uw 1 / g 0.58	C	B	A
Uw 0.6 / g 0.47	A	A	C
Uw 2.8 / g 0.35	G	G	G
Uw 1.3 / g 0.35	F	E	E
Uw 0.8 / g 0.35	D	D	E
Uw 5.8 / g 0.85 shading	G	G	E
Uw 2.8 / g 0.78 shading	G	E	A
Uw 1.7 / g 0.65 shading	E	C	A
Uw 1.3 / g 0.6 shading	D	B	A
Uw 1 / g 0.55 shading	C	A	B

Uw 0.8 / g 0.6 shading	A	A	A
Uw 1 / g 0.58 shading	B	A	A
Uw 0.6 / g 0.47 shading	A	A	C
Uw 2.8 / g 0.35 shading	G	G	F
Uw 1.3 / g 0.35 shading	F	E	E
Uw 0.8 / g 0.35 shading	D	C	E

Whether all three or just one (or a mix of conditions) is selected for establishing the ranking was a matter of label design (see next section).

As regards the consideration of a possible integrated shutter the draft report stated that 'ignoring the shutter' is not preferred over awarding the possible proper use of a shutter.

The labelling schemes in the UK and Denmark were used to compare the proposed approach with existing labels. The results are shown in Table 14 and 15. The schemes in UK and Denmark were used because the system in the UK is already implemented in the national regulation. Also the energy balance equation used for the calculation in the Danish Label is the requirement for the energy efficiency of windows in the Danish regulation.

The following issues are pointed out:

- In contrast to a possible European label based on the Energy Labelling Directive the current UK label uses 8 classes (A+ to G) instead of 7 (A to G) according to the ELD
- In contrast to a possible European label based on the Energy Labelling Directive the current Danish label uses 6 classes (A to F) instead of 7 (A to G)according to the ELD
- The current minimum requirement in the UK is class C according to the WERS in the UK
- The current minimum requirement in Denmark is class C according to the energy label in Denmark
- The energy balance equation used in Denmark does not consider the air leakage rate of the window.

Table 207 Comparison of the $P_{E;H;W}$ values and the classification between the existing window label in the UK and the Climate Central

Heating performance	WERS UK		Central	
without shutter	$P_{E,H,W}$	class	$P_{E,H,W}$	class
Uw 5.8 / g 0.85	300	G	340	G
Uw 2.8 / g 0.78	91	G	88	F
Uw 1.7 / g 0.65	29	D	16	D
Uw 1.3 / g 0.6	9	B	-3	C
Uw 1 / g 0.55	-5	A	-14	B
Uw 0.8 / g 0.6	-26	A+	-36	A
Uw 1 / g 0.58	-9	A	-19	B
Uw 0.6 / g 0.47	-21	A+	-28	A
Uw 2.8 / g 0.35	150	G	160	G
Uw 1.3 / g 0.35	43	E	39	E
Uw 0.8 / g 0.35	9	B	6	D
A	68.5		67	
B	218.6		238	

Table 208 Comparison of the $P_{E;H;W}$ values and the classification between the existing window label in Denmark and the Climate North

Heating performance	Denmark		Central	
without shutter	$P_{E,H,W}$	class	$P_{E,H,W}$	class
Uw 5.8 / g 0.85	407	F	588	G
Uw 2.8 / g 0.78	146	F	193	G
Uw 1.7 / g 0.65	64	F	71	F
Uw 1.3 / g 0.6	35	D	39	D
Uw 1 / g 0.55	15	B	17	C
Uw 0.8 / g 0.6	-10	A	-13	A
Uw 1 / g 0.58	11	B	11	C
Uw 0.6 / g 0.47	-10	A	-9	A
Uw 2.8 / g 0.35	205	F	273	G
Uw 1.3 / g 0.35	69	F	85	F
Uw 0.8 / g 0.35	24	C	34	D
A	90.36		103	
B	196.4		267	

The draft report suggested to use the same classification for roof windows, as the increased U value (for inclined application) and the increased irradiance levels (inclination 40 º assumed) would cancel each other out partially.

For the draft label design in which only one 'average' EU climate condition is used as basis, the ABC values for North, Central and South were corrected for their respective share of windows, as assessed on country-by-country on the basis of heating degree days: North is 8%, Central is 61% and South is 31% (calculated as shares as shown in Table 189 corrected by residential floor area according Table 185).

Cooling performance (former proposal)

The cooling performance (energy in kWh/m^2) is mainly determined by the factor Y which applies to the solar irradiance. The factor X (that is related to the U_W value) is relatively small, reducing the significance of the U_W value in the cooling performance.

The value of the parameter Y (solar radiation leading to cooling amount) depends on the location (and orientation, inclination) but also on the boundary conditions of the building e.g. the insulation level of the building envelope , whether ventilative cooling applies, etc.. Furthermore the parameter Y depends on the characteristic of the window itself. If a representative parameter Y could be defined / chosen, the energy performance index for cooling is almost entirely determined by the g-value of the window and the presence of solar shading system.

Value Z considers the presence of shading and how this is used and incorporated in the parameter $g_{W,eff}$, to be used in combination with value Y.

In the draft report the authors suggested that for consumers interested in the cooling performance of a window the classification of the cooling season performance can be based on the $g_{W,eff}$-value of the window, acknowledging that the highest cooling loads are related to windows with the highest $g_{W,eff}$ -values and vice versa. $g_{W,eff}$ Is established as:

Equation 21

$$g_{W,eff} = (1 - F_F) \cdot \left[(1 - Z) \cdot g + Z \cdot g_t \right]$$

The consequence of the above conclusion is that the cooling performance (when based on $g_{W,eff}$) is not climate condition dependent as the parameter X and Y are not used.

The Z value would be based on a single (average) climate. The general parameter Z proposed is a weighted average of the three climate dependent parameters Z, whereby North represents 8%, Central 61% and South 31%. The average Z parameter is then 0.56.

The class differences are not assumed to be constant. The reason for that is, that the analysis showed, that the parameter Y (solar factor) depends on the g-value of the window. Assuming as an approximation, that the parameter Y is a linear function of the g-value than the energy demand for cooling will be proportional to the square of g. This is quadric relationship is considered in the class differences. The following classification is proposed.

Table 209 Example classification of cooling performance (proposal)

Class	Class boundaries (-)	class difference	Example windows
A	$g_{W,eff} \leq 0.10$		Windows with IGU with reduced g-value (e.g.solar control) and/or external solar shading device)
B	$0.10 < g_{W,eff} \leq 0.13$	0.03	Windows with IGU with reduced g-value (e.g.solar control) and/or external solar shading device)
C	$0.13 < g_{W,eff} \leq 0.19$	0.06	Windows with IGU with reduced g-value (e.g.solar control) and/or external solar shading device)
D	$0.19 < g_{W,eff} \leq 0.28$	0.09	Windows with IGU with reduced g-value (e.g.solar control) g > 0.27 or with external shading device
E	$0.28 < g_{W,eff} \leq 0.40$	0.12	Windows with IGU with reduced g-value (e.g.solar control) g > 0.40 or with internal shading device
F	$0.40 < g_{W,eff} \leq 0.55$	0.15	Windows with double IGU with high g-value g > 0.58
G	$0.55 < g_{W,eff}$		Windows with double IGU without low e and single glass g > 0.78

LABEL DESIGN (FORMER PROPOSAL)

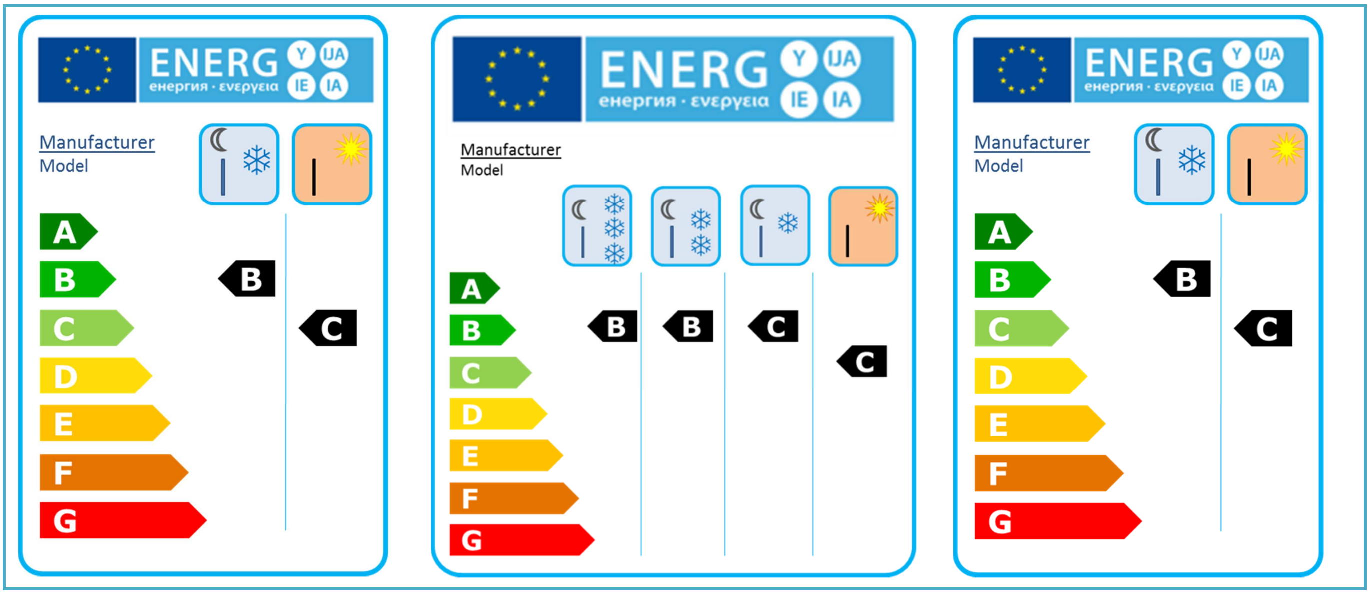
The draft TASK 7 report of 24 February 2015 showed three options for a label design (Note: this is a discussion of the former proposal in the draft report and not the final recommended proposal!):

1. The first option was based on the heating and cooling performance of the 'average' EU climate. The 'Central' climate condition fulfils this requirement. The label design would be limited to presenting heating and cooling performance for this climate condition only (cooling performance was based on the $g_{W,eff}$-value (and a Z value) and thus independent from climate conditions)..
2. The second option presented heating performance for three climate conditions (cooling performance was based on the $g_{W,eff}$-value (and a Z value) and thus independent from climate conditions).
3. The third option presented a heating performance based on the coldest climate condition (cooling performance was based on the $g_{W,eff}$-value (and a Z value) and thus independent from climate conditions).

The draft report label designs did not include a map, nor the main window energy characteristics.

Figure 24 Draft window rating label label Design I, II and III

Design I	Design III	Design III



Note: The 'snow flakes' represented the severity of the heating season, the 'sun' represented the summer season. The 'moon' indicated the option for shading devices that the device may be used during night time.

→ Fiche information

The draft proposal also described the possible contents of the fiche. The information in the fiche is more comprehensive than the information on the POS[70] label itself. Information presented in the fiche may also be required in case of distance selling and other forms of selling (Article 7, Directive 2010/30/EC).

The fiche would present the values to be used for calculating heating performance per orientation (see Installer label).

→ Installer label

And the draft proposal described possibilities for an "installer" or "package" label, which could present the overall performance of a package of products, using a configuration established by the retailer.

The package fiche would allow the installer/retailer, through a relatively simple calculation procedure, to better take into account the effect of window orientation and size, by taking the performance per orientation shown on the fiche and calculating a weighing factor per orientation based on window area per orientation. This allows a more adequate overall performance of windows to be shown (and thus also the effects of changing performance of a window in a certain orientation).

Comparing current cooling and combined annual performance with UFME approach

As certain stakeholders have asked for a comparison with the UFME window label (France) the following tables shows, for façade windows and roof windows, the classification according the UFME approach and the 'Lot 32' approach.

The UFME label presents the cooling performance (based on kWh/m^2) and the combined annual performance (based on the difference with a reference window) separately. One cannot compare the

[70] POS = Point-of-sale

absolute values of the UFME versus the Lot 32 approach as there are substantial differences in either method. For instance the UFME equations do not include a consideration of the leakage class of the window. Also the boundary conditions as regards orientation of window, U value of opaque envelope, ventilation rates, etc are different.

The UFME label uses three climate 'zones' for France. In order to make a more representative comparison, the UFME zone Z2 is compared to Lot 32's 'Central' condition and UFME zone Z3 is compared to Lot 32's 'South' condition. Note that this introduces again another difference in outcome of calculations.

The below comparison is therefore only comparing the relative ranking of windows according either method.

Table 210 Comparison with UFME approach

Window type	UFME Z2		UFME Z3		Lot 32 Central			Lot 32 South		
	cooling	combined	cooling	combined	cooling	combined, RAC correct.	combined, uncorrect.	cooling	combined, RAC correct.	combined, uncorrect.
classification according					Table 54	Table 69	Table 211	Table 54	Table 69	Table 211
Performance calculated	All rankings using U_w as stated in first column and assuming F_F of 0.3. No correction for radiative properties of opaque elements				All rankings based on performance as calculated in Table 67, with classification as in					
Uw 5.8 / g 0.85	D	G	F	G	D	G	G	F	F	G
Uw 2.8 / g 0.78	C	F	F	F	C	E	F	E	C	F
Uw 1.7 / g 0.65	C	C	E	C	C	C	C	D	A	C
Uw 1.3 / g 0.6	B	B	E	A	B	B	B	C	A	A
Uw 1 / g 0.55	B	A	D	A	B	A	A	C	A	A
Uw 0.8 / g 0.6	B	A	E	A	B	A	A	C	A	A
Uw 1 / g 0.58	B	A	D	A	B	A	A	C	A	A
Uw 0.6 / g 0.47	A	A	C	A	B	A	A	B	A	A
Uw 2.8 / g 0.35	A	G	A	F	A	G	G	B	E	F
Uw 1.3 / g 0.35	A	C	A	A	A	D	D	B	D	A
Uw 0.8 / g 0.35	A	A	A	A	A	B	B	B	D	A

The overview shows that UFME **cooling ranking** for Z2 and lot 32 Central are almost identical (apart from window type Uw 0.6, g 0.47). For Z3 the values are different as the Lot 32 cooling ratings are based on 'single room' values only (family house values are used only if used for combined annual values). But with different class boundaries (see Table 212) the exact same classification as under UFME can be established.

The overview shows that UFME **combined annual ranking** for Z2 and lot 32 Central are almost identical (apart from windows with lower g valus). For Z3 the Lot 32 uncorrected values 'South" are exactly the same (see Table 211 for class borders). For the RAC corrected values the rankings are quite different for high U and low g windows. When applying different classification (see Table 212) to have high Uw windows in the same categories, the low g value windows rank worse than before. No exact alignment could be established.

Table 211 Class borders for comparison UFME with Lot 32 uncorrected combined annual performance

Classification	Class Borders	
Class	Central	South

A	10	50
B	30	60
C	40	70
D	70	80
E	100	90
F	120	110
G		

Table 212 Class borders for better alignment with UFME cooling & combined performance

Classification	Class Borders for cooling (single family approach)		for combined performance	
Class	Central	South	Central	South
A	10	85	-5	-65
B	15	90	10	-62
C	20	100	30	-59
D	25	120	60	-56
E	30	150	100	-53
F	35	200	150	-50
G				