Preparatory Studies for Eco-design Requirements of EuPs

(Tender TREN/D1/40-2005)

LOT 14: Domestic Dishwashers & Washing Machines

Part II – IMPROVEMENT POTENTIAL

Task 7: Scenario, Policy, Impact and Sensitivity Analysis

Rev. 3.0

The policy measure proposals presented in this document are Authors' opinion and do not constitute any present or future agreement or commitment of the European Commission

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NOTE: according to international standards dealing with quantities and units, the numbers in this study are written according to the following rules:

- the comma “,“ is the separator between the integer and the decimal part of a number
- numbers with more than three digits are divided by a blank in groups of three digits
- in case of monetary values the numbers are divided by a dot in groups of three digits

7 Task 7: Targets, Scenarios and Policy Measures

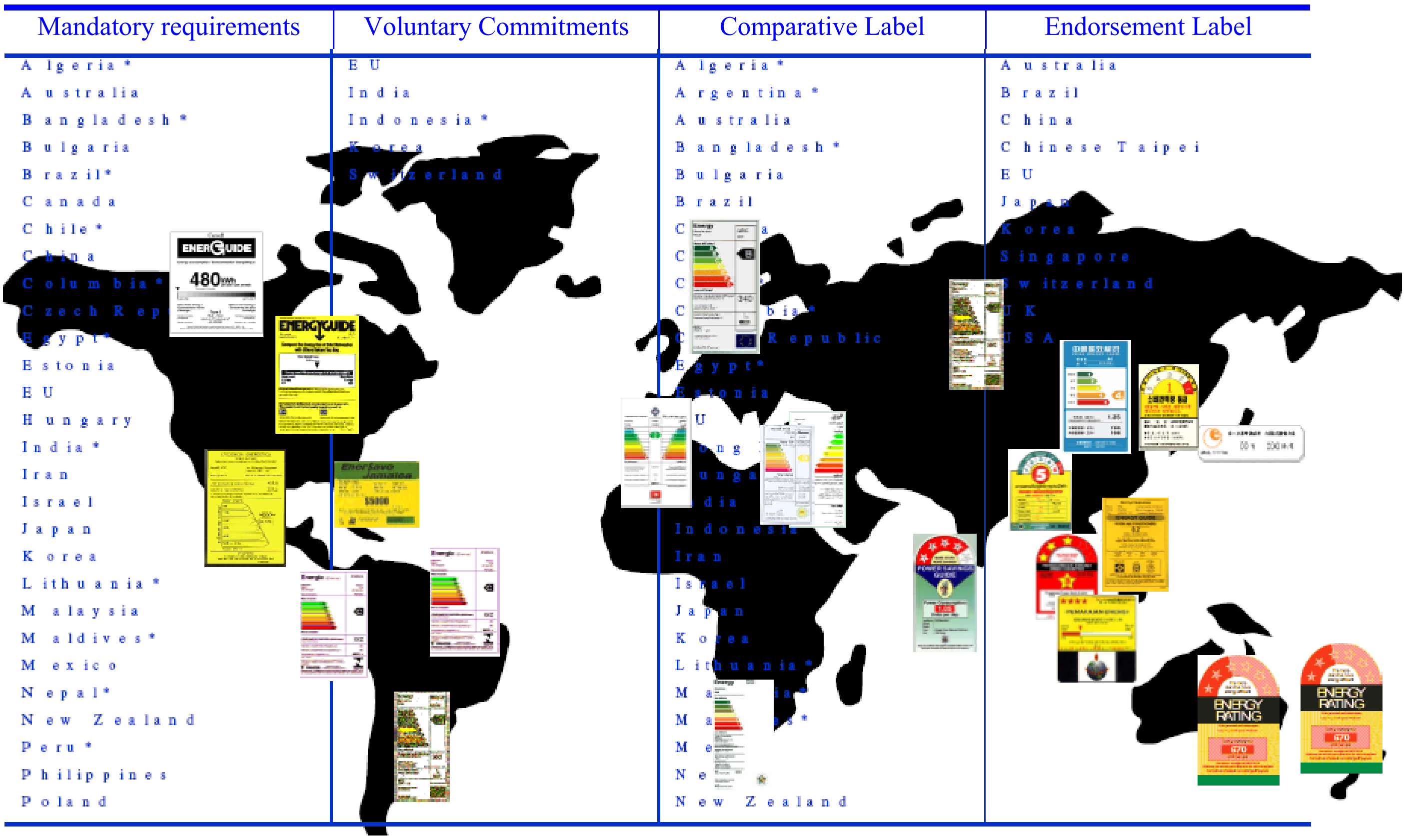
7.1 Subtask 7.1: Worldwide Scenarios for Wash Appliances

In this Subtask the main policy measures existing and planned worldwide for cold appliances will be summarised and tentatively compared with those of the EU to evaluate the European position in the international context.

7.1.1 A summary of the worldwide policy measures for wash appliances

As described in Task 1, household appliance policy measures (labelling schemes and efficiency requirements) are in force in most industrialised economies and many industrialising economies worldwide. The number of nations adopting energy efficiency requirements and labels for EuPs is growing rapidly, from 9 in 1984 to 36 in 1994 to over 54 in 2006 (Figure 7.1). The number of regulations worldwide on individual appliances and equipment is growing even more rapidly, increasing from 543 to 878 between 2000 and 2004[1].

Figure 7.1: International use of mandatory and voluntary policy measures in 2006[2]



Mandatory requirements	Voluntary Commitments	Comparative Label	Endorsement Label
Algeria*	EU	Algeria*	Australia
Australia	India	Argentina*	Brazil
Bangladesh*	Indonesia*	Australia	China
Bulgaria	Korea	Bangladesh*	Chinese Taipei
Brazil*	Switzerland	Bulgaria	EU
Canada		Brazil	Japan
Chile*		C [illegible] a	Korea
China		C [illegible]	Singapore
Columbia*		C [illegible]	Switzerland
Czech Rep		C [illegible] bia*	UK
Egypt*		C [illegible] Republic	USA
Estonia		Egypt*	
EU		Estonia	
Hungary		[illegible] U	
India*		[illegible] ong [illegible]	
Iran		[illegible] unga [illegible]	
Israel		[illegible] dia	
Japan		Indonesia	
Korea		Iran	
Lithuania*		Israel	
Malaysia		Japan	
Maldives*		Korea	
Mexico		Lithuania*	
Nepal*		M a [illegible] ia*	
New Zealand		M a [illegible] s*	
Peru*		M e [illegible]	
Philippines		N e [illegible]	
Poland		New Zealand	

The most common policies and measure for wash appliances are labelling (efficiency or other type) and efficiency requirements, implemented in many countries, as described in Table 7.1. The main outcome of the Table is that policy measures for dishwashers are less spread than for washing

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[1] Source: APEC," A Strategic Vision for International Cooperation on Energy Standards and Labelling", June 2006.

[2] Source: P. Waide, EEDAL End of Term Report, EEDAL 06, London, June 2006.

machines and that the harmonisation is either with the US scheme or with the EU one, depending mostly on the geographical position of the single Countries and the political influence area of the two main schemes.

Table 7.1: Labelling schemes and energy requirements for dishwashers and washing machines around the world[3]

Country	**Dishwashers**			**Washing machines**		
	Min. eff. requirements	labelling		Min. eff. requirements	labelling	
		comparative	endorsement		comparative	endorsement
Algeria	--	--	--	UC	--	--
Argentina	--	UC	--	--	UC	--
Australia	**M**[3,5]	**M**[3,5]	V	**M**[3,5]	**M**[3,5]	V
Brazil	--	UC	--	V	**M**[2]	V
Canada	**M**[4]	**M**[4]	V[4]	**M**[4]	**M**[4]	V[4]
Chile	--	UC	--	--	UC	--
China	--	--	--	**M**	--	V
Chinese Taipei	--	--	--	--	--	V[4]
Colombia	--	--	--	--	UC	--
Egypt	--	--	--	**M**	**M**[3]	--
EU27	**V**	**M**	V	**V**	**M**	V
Hong Kong (CN)	--	--	--	--	V	--
Indonesia	--	--	--	UC	--	--
Iran	--	--	--	--	**M**[3]	--
Israel	**M**	**M**	--	**M**	**M**	--
Jordan	--	--	--	--	**M**[3]	--
Korea	**M**	**M**	--	**M**	**M**	--
Malaysia	--	--	--	UC	--	--
Mexico	--	--	--	**M**[4]	**M**[4]	V
New Zealand	**M**[5]	**M**[5]	V	**M**[5]	**M**[5]	V
Peru	--	--	--	UC	UC	--
Russia	**M**	--	--	UC	--	--
Singapore	--	--	--	--	V[2]	--
Switzerland	**V**[2]	**M**[2]	V	**V**[2]	**M**[2]	V
South Africa	--	--	--	**V**[2]	--	--
Thailand	--	--	--	--	--	V
Turkey	**V**[2]	**M**[2]	--	**V**[2]	**M**[2]	--
United States	**M**	**M**	V	**M**	**M**	V
Vietnam	--	UC	--	--	UC	--

M = Mandatory, V = voluntary, UC = under consideration

[1] Framework legislation is passed but the implementing legislation is believed to still be under consideration.

[2] Harmonised with EU;

[3] Partially harmonised with EU;

[4] Partially or fully harmonised with USA

[5] Harmonised between Australia and New Zealand.

The comparison of the different efficiency requirements for wash appliances around the world with those applied in the EU could be an interesting exercise in order to see if there are any major differences in performance. However, the standard used to measure the energy consumption and the other parameters are based on different measurement methods as is applied in Europe, which makes comparison almost impossible. Wash appliance standards have been described in detail in Task 1 and are here summarised.

In particular for **dishwashers**:

- in Australia and New Zealand, AS/NZS 2007.1 standard includes a number of requirements

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[3] Source: www.clasponline.org .

derived from the 3rd Edition of IEC 60436: 2004, which will bring it closer to the IEC standard, but differences still occur;

- in USA dishwashers are measured under the US Department of Energy Code of Federal Regulations (CFR 10, Part 430, Subpart B, Appendix C - U*niform Test Method for Measuring the Energy Consumption of Dishwashers*), which incorporates and refers to the American National Standard, Household Electric Dishwashers, ANSI/AHAM DW-1-1992;
- in the EU, EN 50242 Ed.2/EN 60436, was published in October 2005. The standard contains the text of IEC60436, Edition 3 with the changes and added text as common modifications. The standard in Europe gets both numbers, EN60436 and EN50242 due to the labelling mandate of the European Commission.

For **washing machines**:

- in Australia and New Zealand AS/NZS 2040.1 is based on IEC 60456:1994, *Electric clothes washing machines for household use-Methods for measuring the performance*. But it differs from IEC standard in a number of ways:
- the standard for washing machine in Japan is JIS C 9811:1999 "*Electric clothes washing machines for household use - Methods for measuring the performance*", IEC 60456:1994 (MOD). JIS standard reflects the structure of the IEC standard for washing machines, but changes in structure are permitted provided that the altered structure permits easy comparison of the content of the two standards;
- in the EU, EN 60456:2004 includes the text of IEC 60456:2003 together with the common modifications prepared by CENELEC.

7.1.1.1 Australia and New Zealand

a) The energy efficiency requirements

Although no minimum energy efficiency requirements have been set for **dishwashers**, a number of requirements must be met by this product during a test for energy consumption. These include:

- *washing index*: the washing index of the test machine must exceed the specified value measured on the reference machine, which is tested in parallel. The reference machine is a dishwasher which specially constructed and calibrated for this purpose;
- *drying index*: the drying index of the test machine must exceed 50%;
- *rated capacity*: all specified load items shall be supported;
- *water consumption*: shall not exceed 110% of the value stated by the manufacturer.
- *water pressure*: machine shall be capable of operating at the maximum and minimum water pressure stated by the manufacturer;
- *energy consumption* is determined on the program recommended by the manufacturer for energy labelling that is capable of meeting the above mentioned requirements; from April 2004, all dishwashers are to be re-labelled using the "normal" program.

The same occurs for **washing machines**, to be eligible for an energy label. Products are classified into either drum type (generally front loading) or non drum type (all other types such as top loaders with impellers or agitators, twin tub machines). A number of performance requirements must be met by machines during a test for energy consumption. These include:

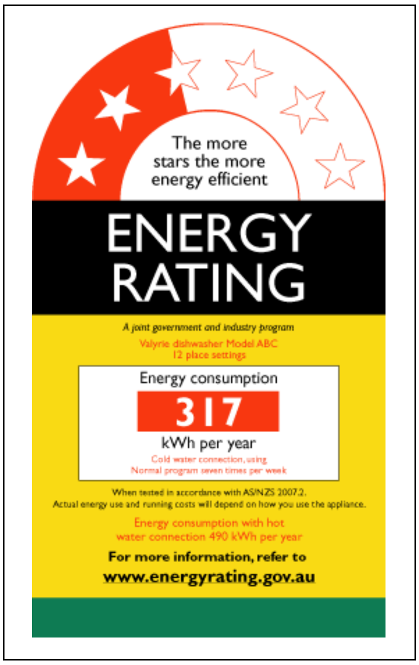
- *wash performance*: soil removal from soiled swatches which are attached to a clothes load of rated capacity, must exceed 80% (there are also limits on the variability of the wash)
- *spinning performance*: the water extraction index (defined as ratio of the remaining water in the load after the final spin to the bone dry mass) must not exceed 1,1;
- *severity of washing*: the severity of washing index must not exceed 0,3 after a single run;

- *water consumption*: shall not exceed 110% of the value stated by the manufacturer;
- *water pressure*: machine shall be capable of operating at the maximum and minimum water pressure stated by the manufacturer;
- *rinse performance*: from July 2006 a rinse performance requirement was set;
- *energy consumption* is determined on the program recommended by the manufacturer for a normally soiled cotton load at the rated capacity; the minimum wash temperature for energy labelling tests is 35°C.

b) The energy rating labelling scheme

AS/NZS 2007: *Performance of household electrical appliances - Dishwashers Part 2: Energy labelling requirements* – includes algorithms for the calculation of the energy efficiency star rating and projected energy usage, performance requirements, details of the energy label and requirements for the valid application thereof. Over a year, it is assumed that the dishwasher is used 7 times per week (365 times per year). This gives the Comparative Energy Consumption (CEC) shown in the Energy Rating label (Figure 7.2). The program used for the energy labelling program is the "normal" program. The Base Energy Consumption (BEC) defines the "1 star" line for the specific product. An additional star is awarded when the CEC of the model is reduced by a defined percentage from the BEC. The energy reduction per star is 30% for dishwashers. For example, a model that had a CEC that was 0,70 of the BEC or less would achieve 2 stars. Similar, a CEC of 0,49 (0,70 x 0,70) of the BEC or less would achieve 3 stars and so on

Figure 7.2: Energy rating for a 12 place settings dishwasher in Australia



The more
stars the more
energy efficient

ENERGY
RATING

A joint government and industry program

Valyrie dishwasher Model ABC
12 place settings

Energy consumption
317
kWh per year
Cold water connection, using
Normal program seven times per week

When tested in accordance with AS/NZS 2007.2.
Actual energy use and running costs will depend on how you use the appliance.

Energy consumption with hot
water connection 490 kWh per year

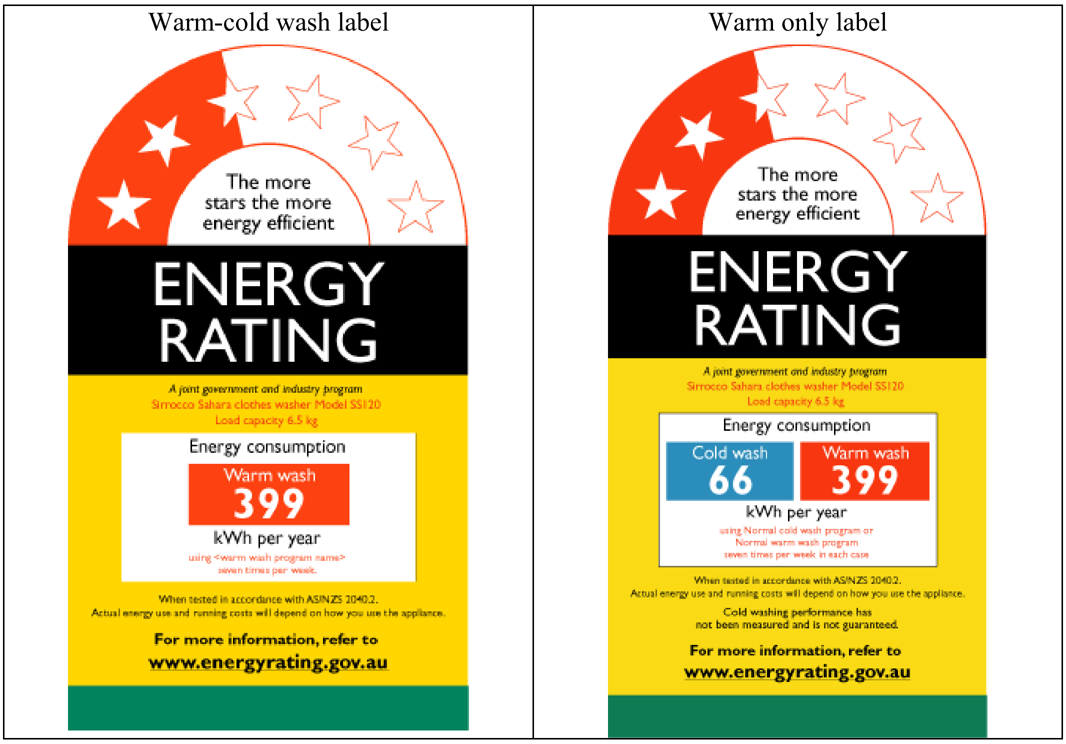
For more information, refer to
www.energyrating.gov.au

The warm wash energy consumption (warm CEC) and a component of residual moisture (spin performance) are used to define the star rating for **washing machines** in comparison with the BEC. Therefore a model that has a good spin performance may get a marginally higher star rating than a model of the same capacity and CEC with a poor spin performance. The Base Energy Consumption (BEC) defines the "1 star" line for the particular product. An additional star is awarded when the CEC of the model is reduced by a defined percentage from the BEC. The energy reduction per star is 27% for clothes washers. For example, a model that had a CEC that was 0,73 of the BEC or less would achieve 2 stars (Figure 7.3). Similar, a CEC of 0,533 (0,73 x 0,73) of the BEC or less would achieve 3 stars and so on. Front and top loading models are rated on the same basis.

The warm wash energy consumption (warm CEC) and a component of residual moisture (spin performance) are used to define the star rating in comparison with the BEC. Therefore a model that has a good spin performance may get a marginally higher star rating than a model of the same capacity and CEC with a poor spin performance.

Over a year, it is assumed that the machine is used 7 times per week at rated capacity on a warm wash (warm Comparative Energy Consumption, in red in the label shown in Figure 7.3); a value for a cold wash energy of 7 times per week is also shown on the label (cold CEC in blue). The washing machine is labelled on the "normal" or "regular" program (program specified for a normally soiled cotton load).

Figure 7.3: Energy rating for washing machines for machines with warm wash only and with warm and cold wash in Australia



Warm-cold wash label

Warm only label

c) The TESAW and the future Energy Star scheme

The Tower Energy Saver Award or TESAW[4] is an award system to help consumers quickly identify the most efficient products on the market. TESAW complements the mandatory labelling with an endorsement label. Each year, the energy efficiency of all products on the market is reviewed. the product must meet or exceed the performance requirements as set out in the performance criteria schedules. TESAW criteria for 2006 for wash appliances are[5]:

- dishwashers: appliances registered for energy labelling and have achieve 3,5 stars or more
- washing machines: appliances registered for energy labelling and achieve 4,5 stars or more.

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[4] http://www.energyrating.gov.au/tesaw-main.html.

[5] Source: Top Energy Saver Award Winner: Final Award Criteria for 2006 – January 2006.

In 2005 detailed discussions and negotiations were held with the US Environmental Protection Agency and the US Department of Energy, resulted in an in-principle agreement that Australia and New Zealand could set local Energy Star criteria for products that were sold in the Australasian market (such as white goods, where the USA had their own domestic criteria), subject to detailed review by EPA and DOE on a product by product basis. This has been agreed on the basis that the energy star label would be available on products that are specifically for sale in Australia and New Zealand and would not appear on the US market. To allow a smooth transition from TESAW to Energy Star, EEEC has decided to continue the TESAW scheme for each product until suitable Energy Star criteria are finalised. At present it is not known when this will happen.

d) The water efficiency labelling scheme

The Commonwealth Department of the Environment and Heritage introduced in 2003 a mandatory Water Efficient Labelling and Standards (WELS) Scheme that applies national mandatory water efficiency labelling and minimum performance requirements to household water-using products and replaces the voluntary scheme in force since 1998. The specified products are: washing machines, dishwashers, lavatory equipment, showers, tap equipment and urinal equipment; flow controllers may be voluntarily rated and labelled.

The requirements and timetable for the implementation of the WELS scheme apply in Australia only. For New Zealand, the exact details of the WELS process implementation date have yet to be finalised, but the date is intended to be 1st December 2007[6].

The requirements of the WELS scheme generally only apply to new products and not to second-hand products. However, products that are imported second-hand to be supplied in Australia will be subject to the requirements.

The dishwashers and washing machines SRI (Star Rating Index) is calculated as:

$$\text{Star Rating Index} = 1 + \frac{\log_e\left(\dfrac{WC}{BWC}\right)}{\log_e(1 - WRF)}$$

where:

- Star Rating Index = fractional star rating used to determine the number of stars to appear on the label, rounded down to the nearest half star rating
- WC = water consumption of the model in litres
- BWC = base water consumption = 2,5 + P × 1,6 and P = number of place settings of the *dishwasher*
- BWC = base water consumption = 30 × C and C = rated load capacity of the *washing machine* (kg) as determined under AS 2040.1, rounded to the nearest 0,1 litre
- WRF = water reduction factor per additional star (17,5%) = 0,175.

The water consumption of a washing machine is the higher of (a) the claimed total water consumption of the warm-wash or (b) the claimed total water consumption of the cold-wash. In Figure 7.4 the water rating label for dishwashers is shown.

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[6] Source: Water Efficiency Labelling Standards (WELS), at: www.mfte.govt.nz.

Figure 7.4: Water rating label for a 12 place setting dishwasher under WELS scheme

e) The rinse performance requirements

Assessment of the rinse performance of a washing machine is based upon the measurement of the apparent mass of retained marker (PBIS) in the load at the completion of the program. The pass mark for rinse performance has been set at 2,25 mg PBIS/kg load. The introduction of a rinse performance requirement facilitated the introduction of mandatory water efficiency rating and labelling: without a rinse performance requirement higher water efficiency rating could be achieved by reducing rinse performance levels that may not meet the needs of washing machine users.

The results of a test developed on 8 top loader machines and 5 front loader machines (a representative cross section of the product available in 2004 in the Australian market) including a wide range of water efficiencies are presented in Figure 7.5[7], where the mass of retained PBIS is plotted against the water efficiency (l/kg load). The trend lines show a clear relationship between water efficiency and rinse performance whereby an increase in water efficiency will result in a decrease in rinse performance. However, for a given water efficiency some significant variation in rinse performance between different models was found.

f) The standby requirements

The Australian Standby Power Strategy 2002-2012 contains a wide range of possible policy measures to address excessive standby power. The document sets out the long-term strategy to address excessive standby energy used by consumer appliances and equipment. The strategy

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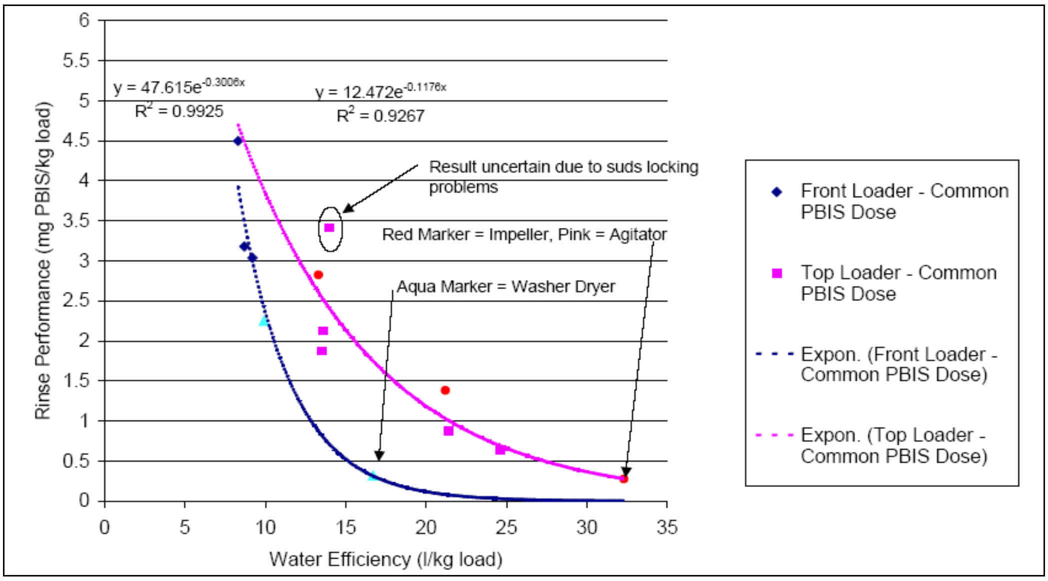
[7] Source: Energy Efficient Strategies, Method for the Determination of Rinse Performance in Clothes Washers, Summary Report, Report for The Department of Environment and Heritage – Australian Federal Government, June 2005

Figure 7.5: Rinse performance (PBIS) vs. water efficiency for a representative sample of washing machines in the Australian market in 2004



foresees:

1. outlines the measures that governments will use to address excessive standby;
2. identifies the products to be targeted in the first of three-year rolling plans under the strategy;
3. establishes the procedure whereby standby targets will be set for each of the targeted products (Stage 1 targets);
4. identifies the sanctions that will apply should suppliers not meet the targets for these products (Stage 2 targets).

Stage 1 and 2 targets for dishwashers and washing machines are:

- Stage 1 (2007): off mode power < 1W, end of cycle mode power < 4W
- Stage 2 (2012): off mode power < 0,3W, end of cycle mode power < 1W

where:

- off mode power = lowest power when connected to the mains. Limit is applicable to models which have an off mode;
- end of programme power = power consumed when the machine has ended the program or cycle, where the unit does not revert to off mode after a fixed period.

The strategy sets out a number of possible policy tools that were to be considered on a product by product basis as follows:

- Promotion of Energy Star
- Industry Codes of Conduct
- Publication of targets in Australian Standards
- Collection of data for new products
- Publication of standby data for products
- Inclusion of standby into the energy label for selected products
- Introduction of MEPS on standby for selected products
- Warning label for products with high standby.

The purpose is to provide that Australian products will meet the ultimate target, of one watt in 2012.

Contemporarily, investigations regarding low power modes and **the inclusion of standby power into the energy label** have been developed for wash appliances and these were implemented in late 2005 with a transition period to April 2007. After this date all dishwashers and washing machines will have standby energy consumption included in the energy label value, which will also affect the product star rating.

The initially proposed algorithms for the calculation of the CEC (Comparative Energy Consumption) including standby for wash appliances was:

$$CEC = E_t \times C + [P_d \times 2 \times C \ + \ P_e \times 15 \times C + (8760 – T_c \times C – 2 \times C – 15 \times C) \times P_o]$$

where:

- E_t = the cycle energy consumption measured according to the AU/NZS Part 1 standard
- C = is the defined number of cycles per year, 365 for washing machines and dishwashers
- P_d = the measured power (in W) in the “delay start” mode, it is 0 where the appliance does not have a delay start function; the delay start mode is assumed 2 hours where present
- P_e = the measured power (in W) in the “end of programme” mode, it is 0 where the appliance does not have end of programme mode; end of programme mode is assumed for 15 hours when present
- P_o = measured power in off mode (W), for the remaining standby time after delay start and end of programme modes
- T_c = cycle time (in hours).

The value of CEC is in Wh and should be divided by 1000 for use on the energy label.

The proposal was subsequently modified, considering only an average of “off mode” and “end of cycle mode” for inclusion into the energy label CEC and deleting the “delay start mode” from the overall standby calculation, to avoid any penalisation of this mode, which was recognised to have a positive impact on the machine use by allowing the delay of the washing cycle to off-peak hours. In addition, the overall standby power is considered 100% the time in “off mode” where the “end of cycle” mode is not present (when products automatically revert to “off” after the end of cycle) [8]:

$CEC = E_t \text{ x } C + [P_s \text{ x } (8760 - T_c \text{ x } C)]$

where P_s = the average measured standby power, in Watts which is the average of end of cycle mode and off mode, (where this mode is present). Again, the value of CEC is in Wh and should be divided by 1000 for use on the energy label.

7.1.1.2 USA

The US has both mandatory and voluntary policy measures for household appliances including dishwashers and washing machines.

a) US Energy efficiency labelling programmes

The US has two primary federally funded labelling programmes for consumer products and appliances: “Energy Guide” and “ENERGY STAR”.

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[8] For sake of coherence, the shown algorithm is not the one eventually published in the standard, but is presented in the same form as the previous formula.

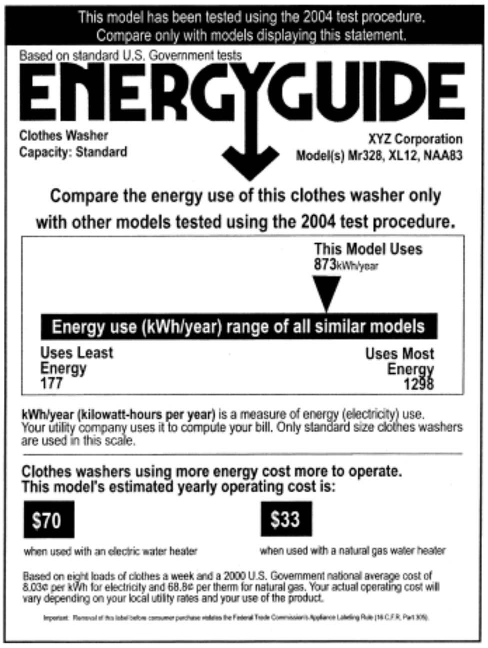
The **Energy Guide** label on **dishwashers** indicates how much electricity (in kWh) a particular model uses in one year. The program covers two dishwasher categories: ‘compact capacity’ and ‘standard capacity’. The standby power consumption is included when calculating estimated annual energy use for all dishwashers.

The 2006 ranges of comparability for ‘standard dishwashers’ are: *low energy consumption 176 kWh/year* and *high energy consumption 247 kWh/year*. Dishwasher manufacturers must base the disclosures of estimated annual operating cost required at the bottom of Energy Guide labels for dishwashers on 8,60 USD cents per kWh and natural gas 91,0 cents per therm.

The new ranges of comparability for ‘compact dishwashers’ effective from 23 January 2006 are: l*ow energy consumption 143 kWh/year* and *high energy consumption 320 kWh/year*. Compact dishwasher manufacturers must base the disclosures of estimated annual operating cost required at the bottom of Energy Guide labels for compact dishwashers on 9,06 USD cents per kWh and natural gas 1,09 USD per therm.

The Energy Guide label on **washing machines** (Figure 7.6) indicates how much electricity (in kWh) a particular model uses in one year. The program covers two machine categories: ‘compact capacity’ and ‘standard capacity’, where ‘‘compact’’ includes all domestic washing machines washers with a tub capacity of less than 1,6 cu. ft. (45 litre).

Figure 7.6: Example (black and white) of Energy Guide for standard washing machines



This model has been tested using the 2004 test procedure.
Compare only with models displaying this statement.

Based on standard U.S. Government tests

ENERGYGUIDE

Clothes Washer
Capacity: Standard

XYZ Corporation
Model(s) Mr328, XL12, NAA83

Compare the energy use of this clothes washer only with other models tested using the 2004 test procedure.

This Model Uses
873kWh/year

Energy use (kWh/year) range of all similar models

Uses Least Energy	Uses Most Energy
177	1298

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only standard size clothes washers are used in this scale.

Clothes washers using more energy cost more to operate.
This model's estimated yearly operating cost is:

$70	$33
when used with an electric water heater	when used with a natural gas water heater

Based on eight loads of clothes a week and a 2000 U.S. Government national average cost of 8.03¢ per kWh for electricity and 68.8¢ per therm for natural gas. Your actual operating cost will vary depending on your local utility rates and your use of the product.

Important: Removal of this label before consumer purchase violates the Federal Trade Commission's Appliance Labeling Rule (16 C.F.R. Part 305).

On January 2006 required range of comparability for *compact washing machines* were amended[9] as: *low energy consumption 125 kWh/year* and *high energy consumption 462 kWh/year*. When the above range of comparability is used on Energy Guide labels for compact washing machines, the estimated annual operating cost disclosure must be derived using a cost for electricity of 8,60 USD cent per kWh and for natural gas at 91,0 USD cent per therm.

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[9] See: Federal Register / Vol. 71, No. 20 / Tuesday, January 31, 2006 / Rules and Regulations.

The ranges of comparability for ‘standard washing machines’, have not been modified and the value in force since April 2005: *low energy consumption 113 kWh/year* and *high energy consumption 680 kWh/year* are currently valid.

ENERGY STAR (Figure 7.7), introduced in 1992, is a voluntary labelling program operated jointly by the Environmental Protection Agency (EPA) and Department of Energy (DOE). It is designed to reduce greenhouse gas emissions by identifying and promoting energy-efficient products. The program functions as a voluntary partnership between government and various businesses, including manufacturers and various trade allies like retailers, installers, utilities, and energy service companies.

Figure 7.7: US Energy Star logo

Qualified **dishwashers** must have a minimum Energy Factor from 1st January 2007, expressed in cycles per kWh, as the reciprocal of the sum of the machine electrical energy per cycle plus the water heater energy consumption per cycle as described in the federal energy efficiency legislation. Qualified dishwashers use at least 41% less energy than the federal minimum requirement for energy consumption. In detail criteria for dishwasher types are:

Product Type	**Federal EF**	**Energy Star EF**
Standard (≥ 8 place settings + six serving pieces)	≥ 0,46	≥ 0,65
Compact (< 8 place settings + six serving pieces)	≥ 0,62	≥ 0,88

Only standard sized (with a tub capacity larger than 1,6 ft^3 or 45 litre), front- or top-loading **washing machines** are eligible for the Energy Star. Qualified d machines must have a minimum Modified Energy Factor (MEF) of increasing from the current level of 1,42 to 1,72 plus a maximum water consumption factor (WF) of 8,0 where:

- MEF is the quotient of the cubic foot capacity of the clothes container divided by the total washing machine energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, the hot water energy consumption, and the energy required for removal of the remaining moisture in the wash load. The units are (ft^3/kWh/cycle). The higher the value, the more efficient the clothes washer.
- WF is the quotient of the total weighted per-cycle water consumption divided by the capacity of the clothes washer.

New qualifying levels for washing machines will be established not later than 1st January 2008, for clothes washers, effective beginning 1st January 2010.

b) The energy efficiency requirements

Efficiency requirements for **dishwashers** are based on the Energy Factor EF (in cycles/kWh), which must be not less than 0,62 for compact dishwashers and 0,46 for standard dishwashers, starting from 1st January 2004. It has to be noted that the annual energy and cost calculation include standby energy consumption, but it has not be included into the energy factor calculation. The average cycles per year is 215.

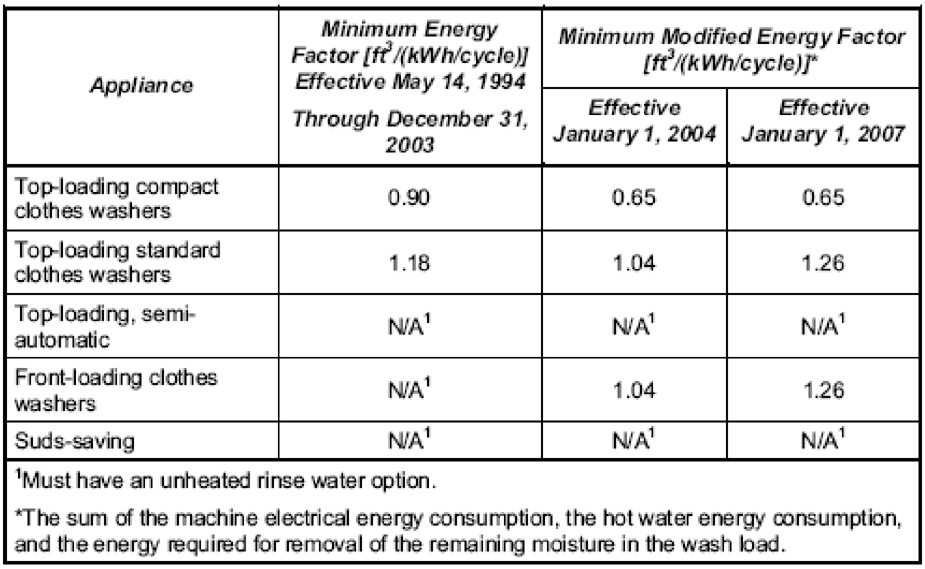
The Energy Factor EF (in cycles/kWh) of consumer dishwashers must be not less than 0,62 for compact dishwashers and 0,46 for standard dishwashers, starting from 1st January 2004.

Energy efficiency requirements for residential **washing machines** include the following appliance types:

- 'Compact clothes washer': a clothes washer which has a clothes container capacity of less than 45 litre (1,6 ft^3)
- 'Standard clothes washer': a clothes washer which has a clothes container capacity of 45 litre (1,6 ft^3) or greater
- 'Front-loading clothes washer': a clothes washer with the clothes container compartment access located on the front of the machine
- 'Top-loading clothes washer': clothes washer with the clothes container compartment access located on the top of the machine
- 'Suds-saving': a feature or option on a clothes washer, which allows the user to store, used wash water in an external laundry tub for use with subsequent wash loads.

The energy efficiency requirements for residential washing machines are described in Table 7.2. For top loading standard and compact washing machines and front loading washing machines the MEF Modified Energy Factor (in ft^3/kWh/cycle) must be higher than the indicated value.

Table 7.2: Energy efficiency requirements for residential washing machines in USA in 2003-2007



Appliance	Minimum Energy Factor [ft^3/(kWh/cycle)] Effective May 14, 1994 Through December 31, 2003	Minimum Modified Energy Factor [ft^3/(kWh/cycle)]*	
		Effective January 1, 2004	Effective January 1, 2007
Top-loading compact clothes washers	0.90	0.65	0.65
Top-loading standard clothes washers	1.18	1.04	1.26
Top-loading, semi-automatic	N/A[1]	N/A[1]	N/A[1]
Front-loading clothes washers	N/A[1]	1.04	1.26
Suds-saving	N/A[1]	N/A[1]	N/A[1]

[1] Must have an unheated rinse water option.

*The sum of the machine electrical energy consumption, the hot water energy consumption, and the energy required for removal of the remaining moisture in the wash load.

Top-loading semi-automatic and suds-saving washing machines do not need to meet the Modified Energy Factor standard but must have an unheated rinse water option. The MEF of a washing machine is the quotient of the ft^3 capacity of the clothes container divided by the total washing machine energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, the hot water energy consumption, and the energy required for removal of the remaining moisture in the wash load.

c) The 2006 Appliance Efficiency Regulations for California

The 2006 Appliance Efficiency Regulations includes requirements for both federally regulated appliances and non-federally-regulated appliances, among those wash appliances: for dishwashers the federal requirements apply, for domestic washing machines the federal requirements about energy efficiency apply, while for the water efficiency specific requirements have been set.

The Water Factor (in gallons per cubic foot) of washing machines must not be greater than the values shown in Table 7.3. The Water Factor is the quotient of the total weighted per-cycle water consumption divided by the capacity of the washing machine.

Table 7.3: Water efficiency requirements for washing machines in California in 2007 and 2010

Appliance	Maximum Water Factor (gallons/cubic foot)	
	effective 1st January 2007	effective 1st January 2010
Top loading	8,5	6,0
Front loading	8,5	6,0

d) The standby issue

Annual standby energy consumption for **dishwashers** is calculated in kWh per year as:

$S = S_m \times (H_s/1000)$ and
$H_s = H - (N \times L)$

where:

- S_m = measured average standby power (in Watt) and
- H = the total number of hours per year, or 8.766
- N = the representative average dishwasher use of 215 cycle/year
- L = the average of the duration (in hours) of the normal washing cycle, measured for the different types of dishwashers addressed in the test procedure

In order to determine standby power usage, the energy use of each dishwasher in the Energy Star products database was calculated. Since 60% of current qualified products use standby power and the trend for new products is to offer more features that will draw power in the standby mode, comments were required to stakeholders on the value of incorporating a standby power requirement into the new criteria for dishwashers. In addition, DoE is trying to determine whether it is preferable the (a) setting a maximum amount of standby power in terms of Watts or kWh/year or (b) setting the maximum total allowable Energy Star qualified product usage in terms of kWh/year instead of EF.

e) The tax incentives for manufacturers

The Energy Policy Act of 2005 offers incentives that promote the use of more efficient appliances. This legislation is expected to increase the market penetration of products meeting and exceeding the act's Energy Star criteria. The new legislation provides credits to the manufacturer for very efficient refrigerators, washing machines and dishwashers. The incentives are for products sold in 2006 and 2007, relative to *additional* sales by each manufacturer above the average of the previous three years. This type of policy has the distinct advantage of minimizing the problem of free riders that would have purchased the new model in any case; and thus is more effective than such policies as rebate or reduction in value added taxes, which allow and pay for free riders.

For washing machines there is only one efficiency tier, a 100 USD credit for units meeting the 2007 Energy Star criteria. The same applies for dishwashers where the amount of credit is 3 USD for every percent beyond the Energy Star criteria in force in 2005.

All the appliance credits only apply to products produced in the USA, which could affect the foreign production plans of US manufacturers and also means that imported products are not eligible. There is also a total cap per manufacturer of 75 million USD, a figure some larger manufacturers may reach but the smaller manufacturers will not.

7.1.1.3 Brazil

In Brazil the energy efficiency and the spinning performance of washing machines are respectively expressed in kWh per kg of load and as percentage of residual moisture and classified in an scale with 5 classes only, from A to E. The energy efficiency for the warm wash and for the cold wash for automatic and semi-automatic machines and the spinning performance are expressed in kWh/cycle/kg load in Table 7.4.

Table 7.4: Warm and cold wash energy consumption thresholds for washing machines labelling in Brazil

Classes	Warm wash	Cold wash		Spinning performance
		automatic	semi-automatic	
	(kWh/cycle/kg)			(%)
A	0,190	0,031	0,019	60
B	0,230	0,035	0,022	68
C	0,270	0,039	0,025	76
D	0,310	0,043	0,028	84
E	0,350	0,047	0,031	94

The washing performance is expressed as a continuous scale (Figure 7.8) between a minimum and a maximum values (Table 7.5) and where the position of the specific machine is indicated by an arrow. The scale is defined for the three types of machines: with heating, automatic without heating and semi-automatic with specific values for the more performing and less performing models.

Figure 7.8: Washing performance scale for automatic washing machines in Brazil

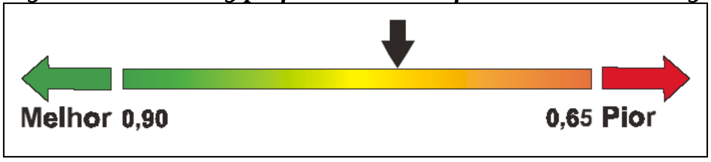


Table 7.5: Warm and cold wash for the washing machine labelling in Brazil

Washing machine types	Better	Worse
automatic with heating	1,00	0,65
automatic without heating	0,90	0,65
semi-automatic	0,80	0,55

7.1.1.4 China

Maximum allowable values of the energy consumption and energy efficiency grade for household electric washing machines have been established in China for all household electric washing machines (pulsator type and drum type) and spin dryer and are based on the values shown in Table 7.6. The requirements are effective since 1st May 2005. Dishwashers are not addressed at present.

No efficiency requirements are set for dishwashers.

Table 7.6: Maximum energy consumption for washing machines and spin dryers in China

Washing machine (type)	Machine technology	Maximum energy consumption (Wh/kg)
Pulsator type	Single-tub	24,0
	Twin-tub	28,0
	Half-automatic single-tub	29,0
	Half-automatic twin-tub	32,0
	Automatic	38,0
Drum type	Automatic without water heating	Not set
	Automatic with water heating	Not set
Spin dryer		4,0

In 2005[10], a new appliance noise regulation "*Noise Limit Value for Household and Similar Electrical Appliances* went into effect in China on 1st August. Appliance manufacturers are required to mark the noise value on the product label or instruction booklet. Products that exceed the noise limits will not be allowed on the market. For washing machines the noise limits are: wash 62 dBA, spin cycle 72dBA; microwave oven noise limits: 68 dBA. Dishwashers are not addressed for the moment by this regulation.

7.1.2 A worldwide approach to energy efficiency of wash appliances ?

A recently published APEC (ASIA-Pacific Economic Cooperation) monograph sponsored by Australian and co-sponsored by New Zealand and United States[11] presents a vision for international cooperation on energy efficiency requirements and labelling achieved through a series of invited workshops on four continents sponsored by the Australian Greenhouse Office to prompt discussion about a common strategic vision on energy-efficiency requirements and labelling, with the aim to develop a consensus on implementing the best possible scheme in each economy within APEC.

The issue was initiated by the recognition of the management within the Australian Greenhouse Office that the Australian program could benefit from a change to its then-insular approach. Rather than negotiating with resident industry representatives about possible improvements in the energy efficiency of products manufactured in, or imported into Australia, an opportunity existed to shift the focus to examining and matching the product-efficiency targets proposed in the major trading economies in North America, Asia and Europe. The Ministerial Council on Energy accepted

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[10] V. Han, China Implements Appliance Noise Standard, Appliance, October 2005, p.18

[11] A Strategic Vision for International Cooperation on Energy Standards and Labelling, A monograph with commentary by international experts, June 2006. Prepared as part of the self-funded APEC project, A Vision for Cooperation on Energy Standards and Labelling Programs. Published by Australian Greenhouse Office.

recommendations for sweeping changes to the Australian standards and labelling program, allowing any product consuming energy to be considered for inclusion in mandatory or voluntary measures based on equivalent efficiency standards in a major trading partner economy.

The number of nations adopting energy efficiency standards and labels is growing rapidly, from 9 in 1984 to 36 in 1994 to 56 in 2004. The number of regulations worldwide on individual appliances and equipment is growing even more rapidly, increasing from 543 to 878 between 2000 and 2004. There is a need among these countries for harmonized test facilities and protocols, mutual recognition of test results, common comparative energy label content, harmonized endorsement energy labels, harmonized minimum energy requirements for some markets, shared learning of the labelling process, and shared learning of the standard-setting process. Such an approach allows countries, companies, and consumers to avoid the costs of duplicative testing and non-comparable performance information, while benefiting from a reduction in non-tariff trade barriers and access to a wider market of goods. Such an approach reduces the aggregate cost among the world's governments of designing and implementing the energy-efficiency regulations and labels.

Some critical elements and priority list of actions emerged from the mentioned APEC document :

- The primary focus is on standards alignment, as the most useful basis for comparability and a pre-requisite for the benchmarking of product performance and policies. Harmonised (aligned) standards and test facilities is the first step towards mutual recognition of test results. However, when harmonising standards some of the local/regional specificity could be lost.
- Worldwide standardisation bodies IEC/ISO are working towards globally applicable standards, but there also needs to be recognition that there are bilateral treaties, multilateral organizations, such as APEC and several regional trading blocks, and global organizations, such as WTO, who are critical institutions when policy measures are set. This is also the institutional context within which the multi-nationals who deliver energy efficient products also operate to influence policies.
- Shared learning of the labelling and requirements setting process is part of the capacity building in markets and regions only recently starting to address the eco-energy efficiency of end-uses. It is the basis for the setting of comparative energy label content, harmonized endorsement energy labels, and harmonized energy efficiency requirements (at least for some markets).
- The importance of regional collaborations should not be understated towards international ones. They are crucial to the evolution of the practice of efficiency requirements setting and labelling, and in the long run the interregional activities will likely dominate.
- In the road towards harmonization and alignment, there is a need to recognize that the short- and long-term benefits for different local and global stakeholders may be different. More often than not, even countries in favour of alignment need to provide a time period or temporary incentives to enable the local industry to adjust. The experts working in the field of efficiency requirements and labelling must respect the pace of progress toward harmonization and alignment.
- The critical issue facing efficiency requirements and labelling programs is the need for establishing consistent and cost-effective mechanisms for collection and analysis of end-use data, which can, in turn, provide a baseline and monitored information on savings for the investor. Otherwise, the belief that efficient appliances leads to energy conservation or savings can be challenged.

Finally, it should be reminded that the adoption of the WTO (World Trade Organization) Technical Barriers to Trade Agreement (TBT) places an obligation on IEC to ensure that the International Standards it develops, adopts and publishes are globally relevant. International Standards and other type of Publications are globally relevant when they can be used or implemented as broadly as possible by all stakeholders in markets around the world. According to WTO[12], in order to serve the interests of the WTO membership in facilitating international trade and preventing unnecessary trade barriers, international standards need to be relevant and to effectively respond to regulatory and market needs, as well as scientific and technological developments in various countries. They should not distort the global market, have adverse effects on fair competition, or stifle innovation and technological development. In addition, they should not give preference to the characteristics or requirements of specific countries or regions when different needs or interests exist in other countries or regions. Whenever possible, international standards should be performance based rather than based on design or descriptive characteristics.

7.2 Subtask 7.2: Worldwide Compliance Assessment

Two elements should be taken into consideration in the discussion about the assessment of the compliance of major household appliances to policy measures:

- the measurement certification: the number of units to be tested by suppliers before any declaration or compliance to a criteria claimed is done (and relevant technical documentation reported to regulators) and the way the measured quantities are treated before declaration/compliance
- the enforcement verification of the declared values: either labelling declarations or minimum requirements (threshold values).

7.2.1 The Measurement Declaration

7.2.1.1 Australia

In Australia the registration for energy labelling and minimum energy efficiency requirements is mandatory. To obtain registration of a product, manufacturers are generally required to submit test reports to demonstrate compliance with the requirements of the relevant Australian standard. The veracity of the energy consumption, efficiency and performance values claimed in these reports are usually accepted on initial application without requirement for verification through independent testing.

For household appliances the number of units to be tested are reported in the relevant standard. In particular:

- **washing machines**: for the purpose of determining the CEC (Comparative Energy Consumption) of a model for labelling, three separate units of the model shall be tested for energy consumption and standby power. At the supplier's discretion, more than three units may be tested. Each unit shall be subjected to at least one valid test run to obtain values of E_t standby power and Water Extraction Index (WEI) for that unit. Where more than one test run is performed on a unit, the value of E_t and WEI shall be recorded for each run and then averaged and treated as the results for that unit. The measured values for the three units are averaged and declared rounded to the nearest whole kWh/year.

  The minimum performance criteria shall be met by each individual unit tested on the program for energy efficiency labelling;
- **dishwashers**: for the purpose of determining the CEC of a model for labelling, three separate units of the model shall be tested for energy consumption and standby power. At the supplier's discretion, more than three units may be tested. Each unit shall be subjected to at least one valid

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[12] Source: WTO second triennial review of the operation and implementation of the agreement on Technical Barriers to Trade, Annex 4.

test run to obtain values of E_t and standby power for that unit. Where more than one test run is performed on a unit, the value of E_t shall be recorded for each run and then averaged and treated as the result for that unit. The measured values for the three units are averaged and declared rounded to the nearest whole kWh/year.
The minimum performance criteria shall be met by each individual unit tested on the program for energy efficiency labelling,

- **cold appliances**: for the purpose of determining the CEC (Comparative Energy Consumption) of a model for labelling, three separate units of the model shall be tested for energy consumption. At the supplier's discretion, more than three units may be tested. Each unit shall be tested with sufficient test runs to enable a valid value of E_t to be determined for that unit. This determination shall be documented in a test report containing the test results for all test runs used to derive E_t (E_t is expressed in Wh per 24 hours and is rounded to the nearest whole number). After testing three or more separate units, the separate values of PAEC (in kWh/year to be calculated from E_t) shall be averaged and referred to as $PAEC_{av}$ The average PAEC is rounded to the nearest unit to obtain the minimum allowable value for CEC.
  The minimum performance criteria shall be met by each individual unit tested on the program for energy efficiency labelling.

7.2.1.2 USA

a) Energy and water conservation requirements

The CFR, Title 10: Energy, Part 430 - Energy Conservation Program for Consumer Products, Subpart F - *Certification and Enforcement*, sets forth the procedures to be followed for certification and enforcement testing to determine whether a basic model of a covered product complies with the applicable energy conservation requirements or water conservation requirements (in the case of faucets, showerheads, water closets, and urinals) set forth in Subpart C - *Energy and Water Conservation Standards* of Part 430. Energy conservation requirements and water conservation requirements include minimum levels of efficiency and maximum levels of consumption, and prescriptive energy design requirements.

For certification purposes, each manufacturer or private labeller before distributing in commerce any basic model of a covered product shall certify by means of a compliance statement and a certification report that each basic model(s) meets the applicable energy conservation requirements or water conservation requirements as prescribed in section 325 of the Act. The compliance statement, signed by the company official submitting the statement, and the certification report(s) shall be sent to DOE, Office of Energy Efficiency and Renewable Energy, Office of Codes and Standards.

The above mentioned Subpart F - *Certification and Enforcement* includes two Appendixes:

- Appendix A: Compliance Statement and Certification Report
- Appendix B: Sampling Plan for Enforcement Testing.

In Appendix A an example of the compliance statement and certification report is given. The compliance statement is signed by a responsible official of the above named company. The basic model(s) listed in certification reports comply with the applicable energy conservation standard or water (in the case of faucets, showerheads, water closets, and urinals) conservation standard. All testing on which the certification reports are based was conducted in conformance with applicable test requirements prescribed in 10 CFR part 430 subpart B. All information reported in the certification report(s) is true, accurate, and complete. The company is aware of the penalties associated with violations of the Act, the regulations there-under, and is also aware of the provisions that prohibits knowingly making false statements to the Federal Government.

For purposes of a certification of compliance, the determination that a basic model complies with the applicable energy/water requirements is based upon a defined sampling procedure[13]. The sample to be selected and tested comprises units which are production units, or are representative of production units of the basic model being tested, and shall meet the following applicable criteria:

a) for each basic model of **refrigerators, refrigerator-freezers and freezer**, a sample of sufficient size shall be tested to insure that:
- any represented value of estimated annual operating cost, energy consumption or other measure of energy consumption of a basic model for which consumers would favour lower values shall be no less than the higher of (A) the mean of the sample or (B) the upper 95% confidence limit of the true mean divided by 1,10, and
- any represented value of the energy factor or other measure of energy consumption of a basic model for which consumer would favour higher values shall be no greater than the lower of (A) the mean of the sample or (B) the lower 95% confidence limit of the true mean divided by 0,90;

b) for each basic model of **dishwashers**, a sample of sufficient size shall be tested to insure that:
- any represented value of estimated annual operating cost, energy consumption or other measure of energy consumption of a basic model for which consumers would favour lower values shall be no less than the higher of (A) the mean of the sample or (B) the upper 97,5% confidence limit of the true mean divided by 1,05, and
- any represented value of the energy factor or other measure of energy consumption of a basic model for which consumers would favour higher values shall be no greater than the lower of (A) the mean of the sample or (B) the lower 97,5% confidence limit of the true mean divided by 0,95;

c) for each basic model of **washing machine**, a sample of sufficient size shall be tested to insure that:
- any represented value of estimated annual operating cost, energy consumption or other measure of energy consumption of a basic model for which consumers would favour lower values shall be no less than the higher of (A) the mean of the sample or (B) the upper 97,5% confidence limit of the true mean divided by 1,05, and
- any represented value of the energy factor or other measure of energy consumption of a basic model for which consumers would favour higher values shall be no greater than the lower of (A) the mean of the sample or (B) the lower 97,5% confidence limit of the true mean divided by 0,95.

b) Appliance labelling

The CFR, Title 16, Part 305 - *Rule concerning disclosures regarding energy consumption and water use of certain home appliances and other products required under the energy policy and conservation act (“appliance labelling rule”)*, establishes requirements for consumer appliance products with respect to energy/water labelling and/or marking the products with information indicating their operating cost (or different useful measure of energy consumption) and related information. It states that the determinations of the estimated annual energy consumption, the estimated annual operating costs, the energy efficiency ratings, and the efficacy factors of refrigerators and refrigerator-freezers, freezers, dishwashers, water heaters, room air conditioners, washing machines, central air conditioners and heat pumps, furnaces, pool heater and fluorescent

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[13] CFR, Title 10: Energy, PART 430 - Energy Conservation Program for Consumer Products, Subpart B - Test Procedures, paragraph 430.24 – Units to be tested.

lamp ballasts, are those located in 10 CFR part 430, subpart B, where the Department of Energy has adopted and published test procedures for measuring energy usage or efficiency, according to the sampling procedures set forth in the same subpart B (except general service fluorescent lamps, medium base compact florescent lamps, and general service incandescent lamps, including incandescent reflector lamps).

Test data shall be kept on file by the manufacturer of a covered product for a period of two years after production of that model has been terminated. Upon notification by the Commission or its designated representative, a manufacturer or private labeller shall provide, within 30 days of the date of such request, the underlying test data from which the water use or energy consumption rate, the energy efficiency rating, the estimated annual cost of using each basic model, or the light output, energy usage and life ratings and, for fluorescent lamps, the colour rendering index, for each basic model or lamp type were derived.

7.2.1.3 The European Union

a) Energy labelling and efficiency requirements

In the EU the veracity of the energy consumption, efficiency and performance values and other information contained in the label and the fiche are accepted without requirement for verification through independent testing. But Member States shall take all necessary measures to ensure that all suppliers and dealers established in their territory fulfil their obligations under the different Directives.

Suppliers (manufacturers and importers) are required to establish technical documentation, sufficient to enable the accuracy of the information contained in the label and the fiche to be assessed. It shall include (i) a general description of the product, (ii) the results of design calculations carried out, where these are relevant, (iii) test reports, where available, including those carried out by relevant notified organizations as defined under other Community legislation, (iv) where values are derived from those obtained for similar models, the same information for these models. The supplier shall make this documentation available for inspection purposes for a period ending five years after the last product has been manufactured.

The information required by the relevant Directives shall be measured according to the harmonised standards, the reference numbers of which have been published in the Official Journal of the European Communities and for which Member States have published the reference numbers of the national standards transposing those harmonized standards.

Both in the energy labelling and efficiency requirement schemes and in the relevant standards there is no specific request to test more than one unit of the model.

b) The eco-label scheme

According to the Annex of Commission Decision (2004/669/EC) of 6 April 2004 establishing the ecological criteria for the award of the Community eco-label to **refrigerators**, and amending Decision 2000/40/EC, for the measurement declaration, the applicant has to provide a copy of the technical documentation referred to under article 2 paragraph 1 of Commission Directive 94/2/EC as amended by Commission Directive 2003/66/EC, including the reports of at least three measurements of energy consumption made according to EN 153 and the test guidelines as detailed in CECED's Operational Code. The arithmetic mean of these measurements shall be less or equal to the energy efficiency ecolabel requirement (energy efficiency class A+ or A++). In addition, the value declared on the energy label shall not be lower than this mean value, and the energy efficiency class indicated on the energy label shall correspond to this mean value.

According to the Annex of Commission Decision 2000/45/EC of 17 December 1999 establishing the ecological criteria for the award of the Community eco-label to **washing machines** (as amended by Decisions 2003/240/EC of 24.03.2003 and 2005/783/EC of 14 October 2005), the applicant has to provide a copy of the technical documentation referred to under Article 2(1) of Directive 95/12/EC. This documentation shall include the reports of at least 3 measurements of energy consumption, the water consumption, the spin extraction and the noise made according to EN 60456:1999, using the same standard 60°C cotton cycle as chosen for Directive 95/12/EC. The arithmetic mean of these measurements shall be less or equal to the above requirement. The value declared on the energy label shall not be lower than this mean value, and the energy efficiency class and the spin drying efficiency class indicated on the energy label shall correspond to this mean value. The noise value shall appear on the energy label. In case of verification, which is not required on application, competent bodies shall apply the tolerances and control procedures laid down in EN 60456:1999.

For **dishwashers**, according to the Annex of Commission Decision (2001/689/EC) of 28 August 1999 establishing the ecological criteria for the award of the Community eco-label to dishwashers (as amended by Decision 2005/783/EC, of 14 October 2005), the applicant has to provide a copy of the technical documentation referred to under Article 2(1) of Directive 97/17/EC. This documentation shall include the reports of at least three measurements of energy consumption, the water consumption and the noise made according to EN 50242, using the same programme cycle as chosen for Directive 95/12/EC. The arithmetic mean of these measurements shall be less or equal to the above requirement. The value declared on the energy label shall not be lower than this mean value, and the energy efficiency class indicated on the energy label shall correspond to this mean value. The noise value shall appear on the energy label. In case of verification, which is not required on application, competent bodies shall apply the tolerances and control procedures laid down in EN 50242.

7.2.1.4 Comparison of the declaration procedures

In Table 7.7 the described test procedures are compared to highlight the differences and similarities in the procedures.

Table 7.7: Comparison of the declaration procedures (minimum units to be tested) for household appliances in selected Countries worldwide

Country	**Product**	**RF** (n)	**FZ** (n)	**WM** (n)	**DW** (n)	Product registration (y/n)
AU/NZ	EE requirements	3	3	3	3	Y
AU/NZ	Labelling	3	3	3	3	Y
USA	EE requirements	sufficient size for 95% confidence limit		sufficient size for 97,5% confidence limit		N
USA	Labelling	sufficient size for 95% confidence limit		sufficient size for 97,5% confidence limit		N
EU	EE requirements	1	1	1	1	N
EU	Labelling	1	1	1	1	N
EU	Ecolabel	3	3	3	3	Y

7.2.2 The verification procedures

7.2.2.1 Australia

National Appliance and Equipment Energy Efficiency Program Administrative Guidelines"[14] have been developed and agreed by all Australian regulators. Although not legally binding, the purpose of the Guidelines is to explain how the national legislative scheme for energy labelling and minimum energy efficiency requirements are intended to be administered, to act as a guide to relevant State and Territory regulatory agencies to facilitate uniform and consistent practice among State and Territory regulatory agencies and to explain to stakeholders the responsibilities of relevant State and Territory regulatory agencies and the responsibilities of industry.

An essential element of the E_3 Program is ensuring that manufacturers' energy efficiency and performance claims accurately reflect the information contained within their original application for registration. This verification process is known as check testing and is effectively the major quality assurance procedure for the energy labelling and minimum energy efficiency requirements schemes in Australia., that ensures that the scheme maintains high levels of credibility both with consumers and manufacturers.

The Guidelines include, *inter alia*, a detailed description of the programme compliance monitoring through laboratory check testing. The E_3 Committee is charged with the ongoing management of these guidelines and conducts since 1991 a national "check testing" program to provide the community and stakeholders with data on accuracy of the labelling scheme and compliance by suppliers.

a) Check testing programme and principles

Appliances are purchased from retail outlets or obtained anonymously and tested in NATA accredited independent laboratories to verify the claims associated with the energy label and minimum requirements where applicable for six appliance types (air conditioners, ballasts, dryers, washing machines, dishwashers, electric motor, refrigerated display cabinets, refrigerators & freezers and water heaters).

As part of the National Greenhouse Strategy, the E_3 Committee allocates around a quarter of its budget (in excess of AU$ 300.000 in 2002) to conduct check testing in laboratories and related testing used for standards development and round robins, measures compliance on a regular basis and benchmarks against overseas results. From modest beginnings, the national program now tests as many as 100 products per year. Models **are not randomly selected** for check testing, rather **sophisticated selection criteria and market intelligence** are used to target testing towards **models more likely to fail**.

b) Selection criteria

Recommendations for appliance and equipment groups and models to be check tested are to be

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[14] "Administrative Guidelines for the Appliance and Equipment Energy Efficiency Program of Mandatory Labelling and Minimum Energy Performance Standards", Edition 5, June 2005, downloadable from: www.energyrating.gov.au/pubs/admin-guidelines.pdf

based on the following criteria, with reference to the listed information sources:

1 Group Selection:
2
1.1 Plan to cover all product groups: over a two to three year period, there is a strategic plan to ensure that most major categories and types of appliances and equipment are included to ensure a broad and consistent coverage of the entire market. Source of information: check test annual reports.
1.2 Number and turnover of models: regard should be given to the numbers of models and the annual turnover of new models of each appliance group. Appliance groups will be given attention in proportion to such numbers and or turnover; source of information: Energy Labelling Register and Energy Labelling Brochures.
1.3 History of non compliance in each appliance group: groups with a demonstrated history of high levels of non-compliance should be selected because of the likelihood of a continuation of such historical trends; source of information: check test data base.
2 Model Selection (a system of weighting and prioritisation for each the following factors is in use):
2.1 History of testing of specific models: models tested in previous years of the check test program should normally be excluded from any further testing unless specific evidence becomes available to suggest that a re-test is warranted; source of information: check test data base.
2.2 Age of models: newer models should normally be given preference when considering models for check testing because of their potential to remain on the market for a longer period as compared to older models. The exception to this rule is models that have been on the market for a considerable period of time (3 years or more) without being subjected to testing; source of information: Energy Labelling Register and Energy Labelling Brochures.
2.3 Volume of sales of models: models with high volumes of sales should normally be given preference when considering models for check testing because of their greater potential to impact on energy usage as compared to models with low sales volumes; source of information: market survey data (e.g. GFK white goods survey).
2.4 Star rating of models: models with the highest claims for energy efficiency (e.g. high star ratings) should normally be given preference when considering models for check testing because of the market's higher expectations with respect to the performance of these models as compared to models with low ratings. This is an important selection criteria; source of information: Energy Labelling Register and Energy Labelling Brochures, Galaxy award nominations.
2.5 Record of non compliance by supplier: suppliers with a demonstrated record of check testing non-compliance should be subject to greater scrutiny in the check testing program because of the likelihood of a continuation of such historical trends; source of information: check test data base.
2.6 Third party referrals: complaints as to the accuracy of express (labelling etc) or implied (minimum efficiency and performance requirements) energy use/efficiency claims from third parties such as competitors, consumers, consumer groups or regulatory agencies, will be considered by the Manager of the Check Testing Program, who will be responsible for establishing a complaints handling mechanism that reflects best practice, and will include a 'complaints' report in the Annual Check Testing Report; source of information: manufacturing competitors either directly or via regulators, ACA (Australian Consumer’s Association), or other sources.
2.7 New market entrants: a preference will be given to the selection of products that appear as new brands on the market or from suppliers that do not have any check testing track record; source of information: Energy Labelling Register and Energy Labelling Brochures.

c) The check testing process

In general, the check testing includes a two stage process:

- **Stage I** (also known as the *screen test*)
  Initially, a Stage I check test, which is a full or part test to the relevant Australian and New Zealand standard, is performed on **one sample of the model**. This sample will generally be independently purchased (usually through a retail outlet) and tested by a laboratory accredited for check testing on behalf of the regulatory authorities. In cases of Stage I check test non-compliance, the supplier may choose to request cancellation of the registration for the model in question on the basis of the Stage I check test result or, alternatively, may choose the option of proceeding to Stage II check testing.
  In accordance with the requirements of the relevant standards, prior to test measurements being collected, a laboratory is required to check each sample to ensure that it has no obvious operating defects. A manufacturer/importer who believes that the tested unit is in fact defective will be able to inspect the unit in situ (under supervision of the test laboratory) and report on their findings to the regulator. The onus is on the manufacturer/importer to provide evidence that a defect capable of affecting the test results does exist. Furthermore, it must be demonstrated that the "defect" is peculiar to the test unit alone and not common to other samples of the stock of the appliance. If such evidence is provided and accepted, the original check test will be voided and a new check test will be required to be undertaken at the same laboratory either on the original unit with repairs or on a randomly selected second sample of the stock. The costs associated with inspection and re-testing of defective samples shall be borne by the manufacturer/importer.
- **Stage II**
  Stage II check test procedures require that satisfactory test reports from an accredited check testing laboratory be supplied to the regulator. If the submissions provided by the registration holder are not, in the regulatory agency's opinion, satisfactory, or if the submissions set out details and a timetable for testing which is subsequently not complied with, the regulatory agency may decide to cancel the registration. The actual units to be tested in Stage II will be randomly selected from stock by a representative of the regulatory authority.
  For failures which fall into the "supplier declaration" category, three samples are required to be tested in Stage II check testing to establish whether the registration of a model will be maintained (however, the manufacturer or importer can choose to accept the results of check tests undertaken on fewer than three samples if the results of each sample subsequently tested also do not confirm the original claims made by the registration holder in the application for registration); for results which fall into the "energy efficiency/performance requirements" category, regulatory authorities require at least two samples have to be tested in Stage II check testing.

Additional conditions for check testing are:

- **Costs:** Stage I check test costs will generally be met by the regulatory agency. Where the registration holder elects to undertake Stage II check testing, the registration holder will be liable for all Stage II check testing related costs irrespective of the outcome. Where a unit selected for check testing is demonstrated to be defective in manufacture, then the registration holder will be liable for all resulting additional costs incurred for check testing.
- **Screening tests conducted by competitors**: where a product fails a screening test conducted at a NATA accredited laboratory (or one affiliated with an organisation with a mutual recognition agreement with NATA) and the test report is provided by the party that commissioned the test to a regulator or the E_3 Committee, the E_3 Committee will reimburse the (reasonable) costs of conducting the screening tests.

- **Laboratories accredited for Check Testing**: only NATA or other laboratories (not associated with the registration holder) accredited by bodies with a mutual recognition agreement with NATA, and with a registration that permits the laboratory to issue test reports for the test in question, will be accredited to undertake check testing. In circumstances where Stage II check testing can be undertaken at a supplier's own Australian located NATA registered laboratory, regulatory agencies will accept the results provided a NATA appointed witness is present throughout the testing. Costs associated with the provision of a NATA appointed witness will be borne by the supplier.
- **Test requirements**: all testing will be undertaken in accordance with the requirements of the relevant standard.
- **Public reporting on check testing program outcomes**: all State and Territory regulatory agencies, as well as the other members of E_3 will be informed of the identity of product suppliers and retailers whose products fail the check testing program. These agencies and/or the relevant Ministers may publicly report on check testing program outcomes.

The check testing flow chart is presented in Figure 7.8. The validity criteria are described in paragraph e).

d) The NATA accredited laboratories

The National Association of Testing Authorities (NATA) is Australia's national laboratory accreditation authority[15]. NATA accreditation provides a means of determining, recognising and promoting the competence of facilities to perform specific types of testing, measurement, inspection and calibration.

The latest list of NATA (National Association of Testing Authorities) accredited laboratories has been published on 27 July 2007[16]: 13 laboratories are included, of which 5 are accredited for household refrigerators and freezers (and an additional one is considered capable of doing the test but is yet to be accredited by NATA), 4 laboratories are accredited for both washing machines and dishwashers and only 1 laboratory is accredited for air conditioners (Figure 7.9). The Australian Consumers' Association Test Research is among accredited laboratories. NATA accreditation does not imply that the laboratory in NATA is accredited to do the full range of possible tests covered by the standard.

e) The statistical approach for check testing: validity criteria

The aim of a verification procedure is to ensure that manufacturers' energy efficiency and other performance claims accurately reflect the information contained within their original application for registration. A failed check test is generally subject to regulatory action so there needs to be a reasonable degree of certainty regarding the results of the test procedure.

The validity criteria should ideally be developed to account for inherent product variability, inter-laboratory variability (reproducibility) and intra-laboratory variability (repeatability) some of which will be attributable to testing apparatus, so that there is a low probability of:

– passing models where the label claims do not reflect the actual values for the entire population of the model in question and which should, therefore, fail check testing; or
– failing models that should pass.

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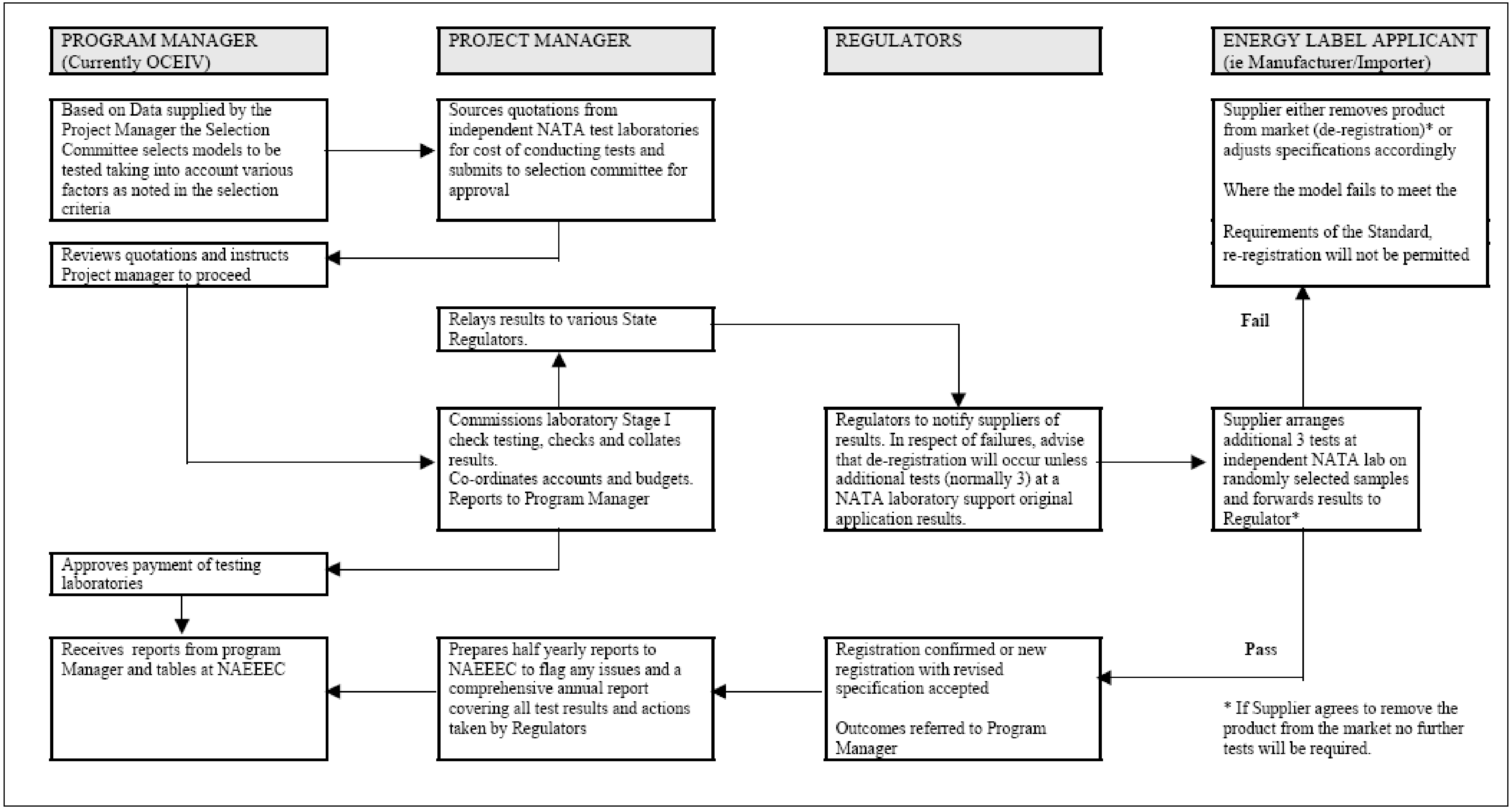
[15] See: http://www.nata.asn.au .

[16] Downloadable from: http://www.energyrating.gov.au/pubs/nata-laboratorylist.pdf .

Figure 7.8: Australian check testing flow chart



Based on Data supplied by the Project Manager the Selection Committee selects models to be tested taking into account various factors as noted in the selection criteria

Sources quotations from independent NATA test laboratories for cost of conducting tests and submits to selection committee for approval

Reviews quotations and instructs Project manager to proceed

Relays results to various State Regulators.

Commissions laboratory Stage I check testing, checks and collates results.
Co-ordinates accounts and budgets.
Reports to Program Manager

Regulators to notify suppliers of results. In respect of failures, advise that de-registration will occur unless additional tests (normally 3) at a NATA laboratory support original application results.

Supplier arranges additional 3 tests at independent NATA lab on randomly selected samples and forwards results to Regulator*

Supplier either removes product from market (de-registration)* or adjusts specifications accordingly

Where the model fails to meet the Requirements of the Standard, re-registration will not be permitted

Approves payment of testing laboratories

Receives reports from program Manager and tables at NAEEEC

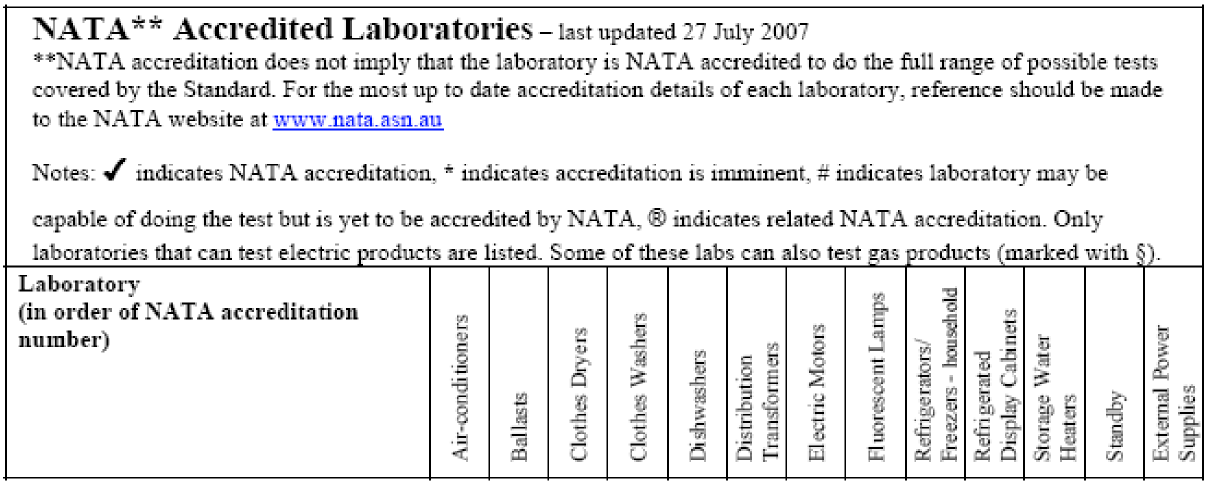
Prepares half yearly reports to NAEEEC to flag any issues and a comprehensive annual report covering all test results and actions taken by Regulators

Registration confirmed or new registration with revised specification accepted

Outcomes referred to Program Manager

* If Supplier agrees to remove the product from the market no further tests will be required.

Figure 7.9: NATA accredited laboratories list description



NATA Accredited Laboratories** – last updated 27 July 2007

**NATA accreditation does not imply that the laboratory is NATA accredited to do the full range of possible tests covered by the Standard. For the most up to date accreditation details of each laboratory, reference should be made to the NATA website at www.nata.asn.au

Notes: ✓ indicates NATA accreditation, * indicates accreditation is imminent, # indicates laboratory may be capable of doing the test but is yet to be accredited by NATA, ® indicates related NATA accreditation. Only laboratories that can test electric products are listed. Some of these labs can also test gas products (marked with §).

Laboratory (in order of NATA accreditation number)	Air-conditioners	Ballasts	Clothes Dryers	Clothes Washers	Dishwashers	Distribution Transformers	Electric Motors	Fluorescent Lamps	Refrigerators/ Freezers - household	Refrigerated Display Cabinets	Storage Water Heaters	Standby	External Power Supplies

There are two types of verification that occur during a check test: (i) verification of a supplier's declaration (e.g. energy, volume, capacity etc.) and (ii) verification that an energy efficiency/ performance requirement specified in the standard (i.e. minimum energy efficiency requirements in the case of energy) is achieved by the relevant model.

- **The verification of a supplier declaration**: a supplier declaration is a declaration of energy or performance made either within an energy labelling application or through manufacture information supplied with the product (accompanying literature, user manuals, information affixed to the product such as a rating plate) or at the point of sale (advertising).
  During the verification of a supplier declaration, the focus is on verifying that the average performance level of the model is as claimed by the manufacturer. While some units may have a worse performance level than claimed, these can be balanced by units with a better performance level provided the average performance level of the model is as claimed. The main purpose of a manufacturer declaration is to provide information to the consumer. The general rule for verification of a supplier's declaration is:
  - a single Stage I check test must not be more than 10% worse than the declaration (Stage I);
  - if this is found to be the case, a further three units are to be check tested at the supplier's expense (Stage II);
  - if the mean of the three additional units check tested for Stage II are found to be more than 10% worse than the declaration, the product fails.

  The Australian experts[17] found that for typical measurement errors and variability, the current rule of allowing a 10% variation as the trigger for additional check tests and as the basis of verification of a further 3 units is sound. The probability of deregistration of a model under this rule is extremely small if the supplier's original declaration is in fact accurate (Table 7.8).

  It is important to note that **verification tolerances are not applied** to checks of supplier declarations – the assumed limit of 10% (or the relevant limit for other variables) includes allowances for elements such as **production variability, measurement accuracy and uncertainties**.
  A special case is the **volume declaration for refrigerators and freezers**, where the standard specifies an allowable tolerance of 3% on the measurement (note that the precise rule depends on the compartment volume). Given that the measurement of gross volume by third parties is

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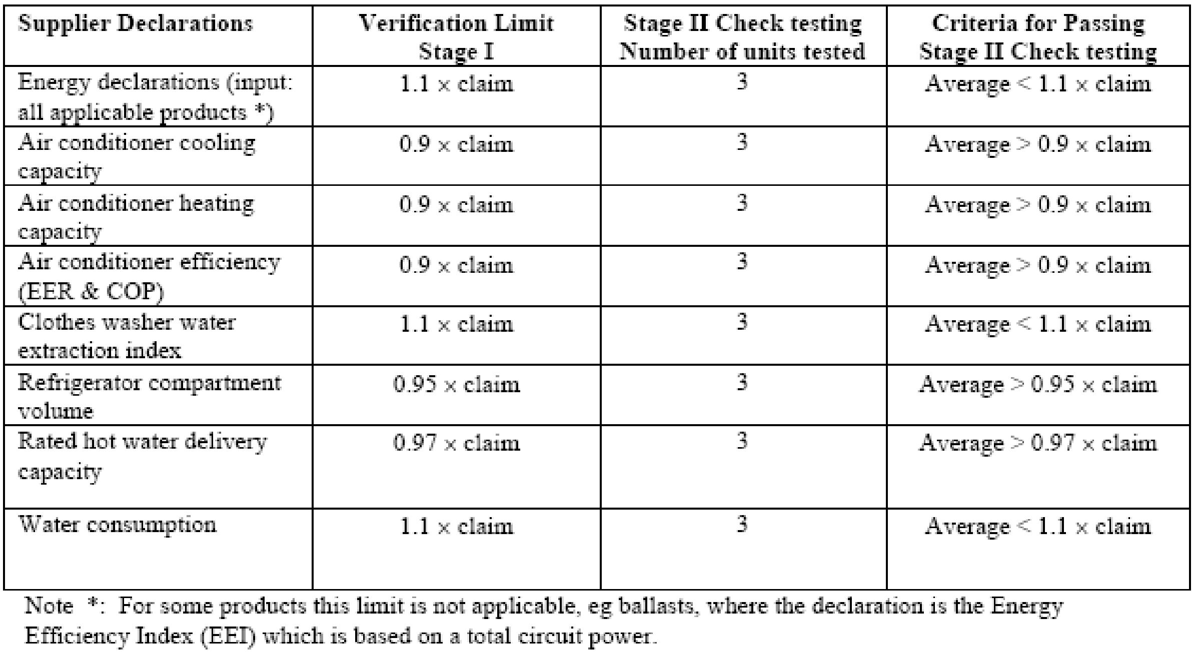
[17] During 1999, a statistical consultancy was commissioned to prepare a methodology to determine an approach for verification or rejection of a supplier's claim, based on the testing of up to three units via check tests.

difficult in some cases (and therefore subject to some uncertainties), the check testing tolerance for refrigerator volume is set at 5% less than the declared value before regulatory action is to be taken (i.e. an allowance of 2% above the tolerance value specified in the standard).

Table 7.8: Summary of verification limits for supplier declarations in Australia



Supplier Declarations	Verification Limit Stage I	Stage II Check testing Number of units tested	Criteria for Passing Stage II Check testing
Energy declarations (input: all applicable products *)	1.1 × claim	3	Average < 1.1 × claim
Air conditioner cooling capacity	0.9 × claim	3	Average > 0.9 × claim
Air conditioner heating capacity	0.9 × claim	3	Average > 0.9 × claim
Air conditioner efficiency (EER & COP)	0.9 × claim	3	Average > 0.9 × claim
Clothes washer water extraction index	1.1 × claim	3	Average < 1.1 × claim
Refrigerator compartment volume	0.95 × claim	3	Average > 0.95 × claim
Rated hot water delivery capacity	0.97 × claim	3	Average > 0.97 × claim
Water consumption	1.1 × claim	3	Average < 1.1 × claim

Note *: For some products this limit is not applicable, eg ballasts, where the declaration is the Energy Efficiency Index (EEI) which is based on a total circuit power.

The following supplier declarations are not verified directly (declared value defines test conditions): dryer capacity (0,5 kg steps), washing machine capacity (0,5 kg steps), dishwasher capacity (whole number of place settings), and electric motor output (kW).

- **The verification that a product meets energy efficiency/performance requirements**: verification of minimum requirements (threshold values) has a different objective. In principle, all units of the model should satisfy the performance limit. In practice, product variability might lead to some units of a model, which operates close to the set limit failing to meet it. This suggests that the verification of the limit(s) should allow for some percentage of failures, say 5% or 10%. The main purpose of a minimum requirement is to provide a degree of consumer protection (consumers are not normally explicitly informed of efficiency/performance minimum requirements).

  For the verification of minimum energy efficiency/performance limits, it is assumed that the actual energy efficiency/performance across individual units of the same model is **normally distributed**. But, under a normal distribution, it is not possible to be assured that all units will be able to pass the set requirements (see also Annex A of this Task).
  For the verification of energy efficiency/performance requirements, a practical requirement would be to allow the worst 10% of units of a particular model to fail the limit(s) (meaning that 90% are required to pass). If it is assumed that the measurement error is equal to the variability of the test measurement, during a check test it would be reasonable to allow about 18% of units to fail the requirement. The practical general application of this rule is:

  – a single initial Stage I check test is conducted and the unit must not fail the specified energy efficiency/performance requirements (**Stage I**);

- if it does fail, a further two units are to be tested - at the supplier's expense - (**Stage IIa**);
- if both of the additional units tested for Stage IIa are found to fail the specified energy efficiency/performance requirements, the product fails;
- if both of the additional units tested for Stage IIa are found to pass the specified energy efficiency/performance requirements, the product shall be deemed to pass;
- if one of the additional units tested for Stage IIa is found to fail the specified energy efficiency/performance requirements while one passes, one additional unit is tested (**Stage IIb**);
- if two of the additional three units tested in Stages IIa and IIb are found to fail the specified energy efficiency/performance requirements, the product shall fail;
- if two of the additional three units tested for Stages IIa and IIb are found to pass the specified energy efficiency/performance requirements, the product shall be deemed to pass.

If 3 units are initially tested in Stage II, then Stages IIa and IIb above are not required. However, 2 of the 3 units tested in Stage II must pass the requirements. For some products, a larger sample may be requested to verify the Stage II check test (e.g. for fluorescent lamps where product variability may be a factor). For some larger products, such as certain models of distribution transformers, a sample of 3 units may not be possible.

Table 7.9 summarises the verification procedures and criteria for the energy efficiency/performance requirements.

- **Verification tolerances**: where there is a known margin of error or uncertainty in the measurement procedure for a particular test, then this value will be used as a verification tolerance by the regulatory agencies on the specified energy efficiency/performance level. Generally, this measurement error is set **at a maximum of 2% of the specified level**, except in cases (see Table 7.10) that are documented to have different measurement errors on the basis of a series of round robin tests conducted for regulatory agencies or on error analysis. Regulatory agencies will also take into account other factors where these are known to impact on the energy efficiency/performance measure, such as the calibration of swatches used to assess washing performance of washing machines. These tolerances relate only to the verification of the claim associated with energy labelling or minimum requirements.

For cold appliances a different approach is followed. Unlike other products in Australia, domestic refrigerators and freezers follow an approach where the minimum efficiency requirement level (maximum energy consumption) applies to the average of production rather than defining an absolute maximum allowable for every individual product. To verify compliance for this product regulators have to establish the likely average energy for the product and whether this exceeds the set level or not so this product is subject to a different verification procedure.

For a model to fail minimum efficiency requirements, it's necessary to be confident that the average energy consumption of the model exceeds the minimum efficiency requirements level (is lower than the maximum permitted annual energy consumption). Based on the data collected in the Stage II test, the ***single sided t statistic*** is calculated to determine whether this is true to a specified level of confidence. A maximum allowable mean energy consumption limit (unadjusted) of 5% over the minimum efficiency requirements is also set as a secondary compliance criteria to take into account those cases that may have a larger than normal variability within a particular model and so pass the *t statistic* criteria. In some cases, further units beyond Stage II may have to be tested to provide certainty of the result.

Table 7.9: Summary of verification limits - Minimum requirements in Australia

Product (name)	**Parameter** (description)	**Requirement in policy measure** (description)	**Stage I verification limit** (description)	**Stage II tested units** (number)	**Stage II passing criteria** (description)
Cold appliances	pull down test	< 6 hours	< 6 hours	2 + 1	2 of the 3 units passes the verification limit*
Cold appliances	maximum annual energy consumption (minimum efficiency requirements)	defined by group in AS/NZS 4474.2	defined by group in AS/NZS 4474.2	3 (additional units may need to be tested to establish the criteria in some circumstances. The procedure to determine efficiency requirements validity for refrigerators and freezers is complex and was released for discussion in June 2005	90% confidence that the mean does not exceed the requirements level and mean energy with verification tolerance <1,03 limits
Washing machines	soil removal	>0,80	>0,80*	2+1	2 of the 3 units passes the verification limit*
	soil removal < 2 x SD	>0,72	>0,72*	2+1	2 of the 3 units passes the verification limit*
	water extraction index	< 1,1	< 1,1*	2+1	2 of the 3 units passes the verification limit*
Dryer	energy efficiency	< 1,36	< 1,36*	2+1	2 of the 3 units passes the verification limit*
Dishwasher	washing performance	>0,90	>0,90*	2+1	2 of the 3 units passes the verification limit*
	drying performance	>0,50	>0,50*	2+1	2 of the 3 units passes the verification limit*

*with a verification tolerance.

Table 7.10: Verification tolerances for specified products exceeding the 2% level

Product	Parameter	Verification tolerance
Washing machine	washing performance (if < 2 x SD)	0,03
Dishwasher	wash performance	0,03
	drying performance	0,03
Electric water heater	max. daily heat loss	3% of the limit
Air conditioner	EER minimum requirements	3% of the limit

g) Compliance Newsletter and check results

E_3 Newsletters are periodically prepared by the Australian Greenhouse Office (on behalf of the E_3 Committee) and they provide the latest news and information on energy efficient appliances and electrical equipment.

Since October 2006 *Compliance Newsletter* (formerly known as "*Switched-On*") is quarterly published, which shared with stakeholders the latest information about compliance and enforcement activities in Australia and New Zealand. Details of de-registered products and infringement notices (2005-2006) were published in Issue 1[18] (October 2006) of the Newsletter. In fact, the major sanction employed against manufacturers and importers of non-complying equipment is to withdraw the legal right to sell that equipment. Some models have been subsequently reregistered with revised performance claims in line with the results obtained in the verification test.

A total of 46 "check" tests were finalised during the 2005-2006 financial year (Table 7.11), of which 27 (58%) failed at least one of the screen test validity criteria (of particular note is the 87% failure rate of air-conditioners[19] which continues to be a major focus for the check programme). Of the 27 referred failures, 4 suppliers were able to establish to regulators' satisfaction that the equipment range met requirements: 3 of the screen test fail results were subsequently overturned when Stage II check testing failed to confirm the initial finding, and a further screen test fail result was overturned following evidence that the original tested unit (a refrigerated display cabinet) was in fact faulty and the screen test was invalid. At the end of the two-stage process, 23 models or 50% of the 46 initially selected models failed. The nature of failures was also reported:

- electric motors and refrigerated display cabinets typically failed to meet the required minimum efficiency requirements level. One refrigerated display cabinet model failed to meet its claim of "High Efficiency";
- a majority of air-conditioners failed due to either over statement of cooling capacity, EER or both. Many of these also failed the validity criteria in heating mode;
- the main reason that refrigerators failed was due to understating energy consumption; 2 units failed to meet the required minimum efficiency requirements level

one washing machine failed the soil removal validity test and one washing machine and one dishwasher failed due to understating the energy consumption.

In addition a further Dishwasher sold in New Zealand that failed its check test was found not to be registered and was therefore banned from further sale.

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[18] Compliance Newsletter, Issue 1, October 2006, downloadable from: http://www.energyrating.gov.au/newsletters.html

[19] After several instances over some years, energy efficiency regulators complained to the Australian Competition and Consumer Commission about LG and problems with air conditioner efficiency claims. The ACCC and LG subsequently agreed to a $3,1 million package recompensing purchasers for their likely additional energy costs plus a set of additional requirements to be fulfilled by the company.

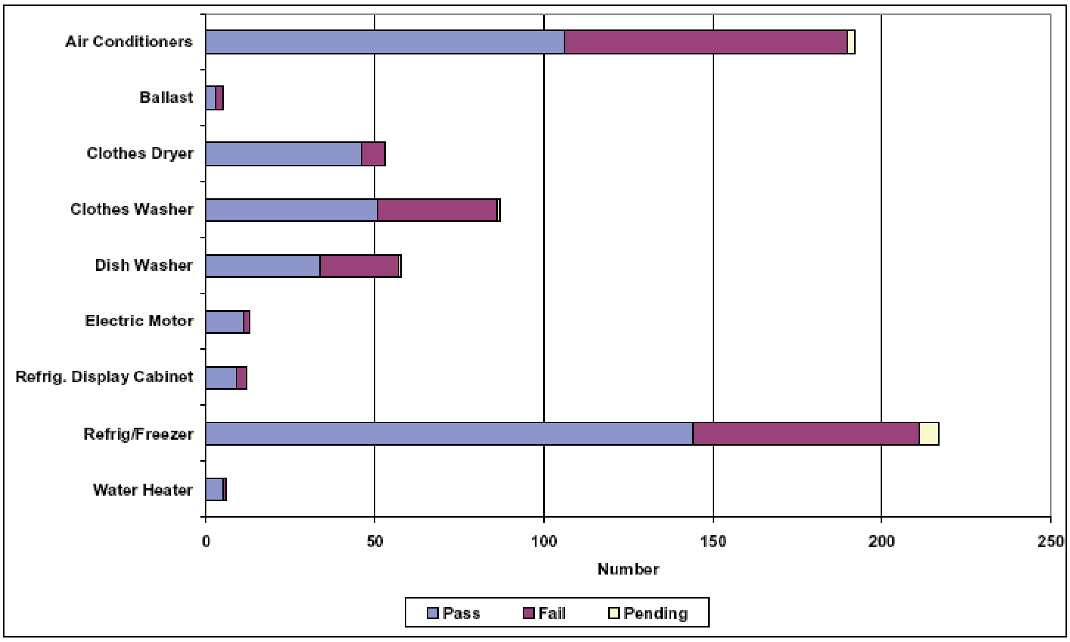
Table 7.11: Final outcome of the validating manufacturers' energy rating and or energy efficiency claim in fiscal year 2005/2006

Appliance type	Screen test (n)	Passed the screen test (n)	Failed the screen test (n)	Negative results overturned (n)	Confirmed (n)
Air conditioner	15	2	13	1	12
Washing machine	2	0	2	0	2
Dishwasher	8	6	2	0	2
Electric Motor	6	5	1	0	1
Refrigerated display cabinet	10	6	4	1	3
Refrigerator & freezer	5	0	5	2	3
Total	**46**	**19**	**27**	**4**	**23**

In 2007, two Issues of the Compliance Newsletter were published, the February issues dealing with white goods and the May issue dealing with air-conditioners. The planned check tests to be undertaken during the first half of 2007 for white goods include 2 dryers, 2 washing machines, 2 dishwashers and 6 refrigerators & freezers.

The E_3 Committee and its predecessors have undertaken verification testing for some years. Since its inception the program has tested a total of 643 products (in over 10 product categories). The tests target product suspected of being at risk of failing. Detailed in the chart over is a summary of all the check test results conducted since 1991 by product type (Figure 7.10)[20]. Over that time, one third (35%) of these verification tests failed. It should be noted that this high rate of failure reflects a policy of selecting product with a higher risk of failing the test. Risk assessment is based on a number of factors as detailed in the administrative guidelines

Figure 7.10: Summary of all the check test results since 1991 by product type in Australia/New Zealand



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[20] Source: E_3 Compliance Newsletter, AIR CONDITIONER EDITION May 2007.

7.2.2.2 USA

a) Energy and water conservation requirements

In the case of performance requirements, upon receiving information in writing concerning the energy/water performance of a particular covered product of a particular manufacturer or private labeller which indicates that the covered product may not be in compliance with the applicable energy/water requirements, the Secretary may conduct testing of that covered product under 10 CFR, 430 Subpart F - *Certification and Enforcement* by means of a test notice addressed to the manufacturer in accordance with the following requirements.

The test notice will specify the model to be selected for testing, the method of selecting the test sample, the timetable for testing and the facility at which testing will be conducted. The Secretary may require that the manufacturer ships at his expense a reasonable number of units of the specified basic model to a designated testing laboratory. The number of units of a basic model specified in a test notice shall not exceed 20. A DOE inspector will select a batch, a batch sample of up to 20 units randomly selected within the batch, and test units randomly selected from the batch sample

Such a procedure will only be followed after the Secretary or his designated representative has examined the underlying test data provided by the manufacturer and after the manufacturer has been offered the opportunity to meet with DOE to verify compliance with the applicable requirements. A representative designated by the Secretary shall be permitted to observe any re-verification procedures, and to inspect the results of such re-verification.

The Appendix B - *Sampling Plan for Enforcement Testing* of Subpart F includes the sampling plan for enforcement testing. A **Double Sampling** procedure is used, including the following Steps:

Step 1. The first sample size (n_1) must be four or more units.

Step 2. Compute the mean (x_1) of the measured energy/water performance of the n_1 units in the first sample as follows:

$$\bar{x}_1 = \frac{1}{n_1}\left(\sum_{i=1}^{n_1} x_i\right) \qquad (1)$$

where (x_i) is the measured energy efficiency, energy or water consumption of unit *i*.

Step 3. Compute the standard deviation (s_1) of the measured energy or water performance of the (n_1) units in the first sample as follows:

$$s_1 = \sqrt{\frac{\sum_{i=1}^{n_1} \left(x_i - \bar{x}_1\right)^2}{n_1 - 1}} \qquad (2)$$

Step 4. Compute the standard error (S_{X1}) of the units in the first sample as follows:

$$s_{\bar{x}_1} = \frac{s_1}{\sqrt{n_1}} \qquad (3)$$

Step 5. Compute the upper control limit (*UCL$_1$*) and lower control limit (*LCL$_1$*) for the mean of the first sample using the applicable DOE energy or water performance requirements (*EPS*) as the desired mean and a probability level of 95% (two-tailed test) as follows:

$$LCL_1 = EPS - ts_{\bar{x}_1} \qquad (4)$$

$$UCL_1 = EPS + ts_{\bar{x}_1} \qquad (5)$$

where t is a statistic based on a 95% two-tailed probability level and a sample size of n_1.

Step 6(a). For an energy efficiency requirement, compare the mean of the first sample (x_1) with the upper and lower control limits (*UCL$_1$* and *LCL$_1$*) to determine one of the following:

1) if the mean of the first sample is below the lower control limit, then the basic model is in non-compliance and testing is at an end;
2) if the mean of the first sample is equal to or greater than the upper control limit, then the basic model is in compliance and testing is at an end;
3) if the sample mean is equal to or greater than the lower control limit, but less than the upper control limit, then no determination of compliance or non compliance can be made and a second sample size is determined by Step 7(a).

Step 6(b). For an energy or water consumption requirement, compare the mean of the first sample (x_1) with the upper and lower control limits(*UCL$_1$* and *LCL$_1$*) to determine one of the following:

1) if the mean of the first sample is above the upper control limit, then the basic model is in non-compliance and testing is at an end;
2) if the mean of the first sample is equal to or less than the lower control limit, then the basic model is in compliance and testing is at an end;
3) if the sample mean is equal to or less than the upper control limit but greater than the lower control limit, then no determination of compliance or non-compliance can be made and a second sample size is determined by Step 7(b).

Step 7(a). For an energy efficiency requirement, determine the second sample size (n_2) as follows:

$$n_2 = \left(\frac{ts_1}{0.05\,EPS} \right)^2 - n_1 \qquad (6a)$$

where s_1 and t have the values used in Steps 4 and 5, respectively. The term '0,05 EPS' is the difference between the applicable energy efficiency requirement and 95% of the requirement, where 95% of the requirement is taken as the lower control limit.

This procedure yields a sufficient combined sample size (n_1 + n_2) to give an estimated 97,5% probability of obtaining a determination of compliance when the true mean efficiency is equal to the applicable requirement. Given the solution value of n_2, determine one of the following:

1) if the value of n_2 is ≤0 and if the mean energy efficiency of the first sample (x_1) is either equal to or greater than the lower control limit (*LCL$_1$*) or ≥ 95% of the applicable energy efficiency requirement (EES), whichever is greater, i.e., if $n_2 \leq 0$ and $x_1 \geq$ max (*LCL$_1$*, 0,95 *EES*), the basic model is in compliance and testing is at an end;
2) if the value of n_2 is ≤0 l and the mean energy efficiency of the first sample (x_1) is less than the lower control limit (*LCL$_1$*) or less than 95% of the applicable energy efficiency requirement (*EES*), whichever is greater, i.e., if $n_2 \leq 0$ and $x_1 \geq$ max (*LCL$_1$*, 0,95 *EES*), the basic model is in non-compliance and testing is at an end;

3) if the value of $n_2>0$, then value of the second sample size is determined to be the smallest integer equal to or greater than the solution value of n_2 for equation (6a). If the value of n_2 so calculated is greater than $(20-n_1)$, set n_2 equal to $(20-n_1)$

Step 7(b). For an energy or water consumption requirement, determine the second sample size (n_2) as follows:

$$n_2 = \left(\frac{ts_1}{0.05\,EPS} \right)^2 - n_1 \qquad (6b)$$

where s_1 and t have the values used in Steps 4 and 5, respectively. The term '0,05 *EPS*' is the difference between the applicable energy or water consumption requirement and 105% of the requirement, where 105% of the requirement is taken as the upper control limit. This procedure yields a sufficient combined sample size ($n_1 + n_2$) to give an estimated 97,5% probability of obtaining a determination of compliance when the true mean consumption is equal to the applicable requirement. Given the solution value of n_2, determine one of the following:

1) if the value of $n_2 \leq 0$ and if the mean energy or water consumption of the first sample (x_1) is either equal to or less than the upper control limit (UCL_1) or equal to or less than 105% of the applicable energy or water performance requirement (*EPS*), whichever is less, i.e., if $n_2 \leq 0$ and $x_1 \leq$ min (UCL_1, 1,05 EPS), the basic model is in compliance and testing is at an end;
2) if the value of $n_2 \leq 0$ and the mean energy or water consumption of the first sample (x_1) is greater than the upper control limit (UCL_1) or more than 105% of the applicable energy or water performance requirement (*EPS*), whichever is less, i.e., if $n_2 \leq 0$ and $x_1 >$ min (UCL_1, 1,05 *EPS*), the basic model is in non-compliance and testing is at an end;
3) if the value of $n_2>0$, then the value of the second sample size is determined to be the smallest integer equal to or greater than the solution value of n_2 for equation (6b). If the value of n_2 so calculated is greater than $(20-n_1)$, set n_2 equal to $(20-n_1)$.

Step 8. Compute the combined mean (x_2) of the measured energy or water performance of the n_1 and n_2 units of the combined first and second samples as follows :

$$\bar{x}_2 = \frac{1}{n_1 + n_2} \left(\sum_{i=1}^{n_1+n_2} x_i \right) \qquad (7)$$

Step 9. Compute the standard error (S_{x1}) of the measured energy or water performance of the n_1 and n_2 units in the combined first and second samples as follows (s_1 is the value obtained in Step 3):

$$s_{\bar{x}_2} = \frac{s_1}{\sqrt{n_1 + n_2}} \qquad (8)$$

Step 10(a). For an energy efficiency requirement, compute the lower control limit (LCL_2) for the mean of the combined first and second samples using the DOE energy efficiency requirement (*EES*) as the desired mean and a one-tailed probability level of 97,5% (equivalent to the two-tailed probability level of 95% used in Step 5) as follows:

$$LCL_2 = EES - ts_{\bar{x}_2} \qquad (9a)$$

where the t-statistic has the value obtained in Step 5.

Step 10(b). For an energy or water consumption requirement, compute the upper control limit (UCL_2) for the mean of the combined first and second samples using the DOE energy or water performance requirement (*EPS*) as the desired mean and a one-tailed probability level of 102,5% (equivalent to the two-tailed probability level of 95% used in Step 5) as follows:

$$UCL_2 = EPS + ts_{\bar{x}_2} \qquad (9b)$$

where the t-statistic has the value obtained in Step 5.

<u>Step 11(a)</u>. For an energy efficiency requirement, compare the combined sample mean (x_2) to the lower control limit (LCL_2) to find one of the following:

1) if the mean of the combined sample (x_2) is less than the lower control limit (LCL_2) or 95% of the applicable energy efficiency requirement (*EES*), whichever is greater, i.e., if x_2 < max (LCL_2, 0,95 *EES*), the basic model is in non-compliance and testing is at an end;
2) if the mean of the combined sample (x_2) is equal to or greater than the lower control limit (LCL_2) or 95% of the applicable energy efficiency requirement (*EES*), whichever is greater, i.e., if $x_2 \geq$ max (LCL_2, 0,95 *EES*), the basic model is in compliance and testing is at an end;

<u>Step 11(b)</u>. For an energy or water consumption requirement, compare the combined sample mean (x_2) to the upper control limit (UCL_2) to find one of the following:

1) if the mean of the combined sample (x_2) is greater than the upper control limit (UCL_2) or 105% of the applicable energy or water performance requirement (*EPS*), whichever is less, i.e., if $x_2 >$ min (UCL_2, 1,05 *EPS*), the basic model is in non-compliance and testing is at an end;
2) if the mean of the combined sample (x_2) is equal to or less than the upper control limit (UCL_2) or 105% of the applicable energy or water performance requirement (*EPS*), whichever is less, i.e., if $x_2 \leq$ min (UCL_2, 1,05 *EPS*), the basic model is in compliance and testing is at an end.

Manufacturer-Option Testing: if a determination of non-compliance is made in Steps 6, 7 or 11, the manufacturer may request that additional testing be conducted, in accordance with the following procedures:

<u>Step A</u>. The manufacturer requests that an additional number, n_3, of units be tested, with n_3 chosen such that (n_1+n_2+n_3) does not exceed 20;

<u>Step B</u>. Compute the mean energy or water performance, standard error, and lower or upper control limit of the new combined sample in accordance with the procedures prescribed in Steps 8, 9, and 10, above;

<u>Step C</u>. Compare the mean performance of the new combined sample to the revised lower or upper control limit to determine one of the following:

- a.1) for an Energy Efficiency Standard, if the new combined sample mean is equal to or greater than the lower control limit or 95% of the applicable energy efficiency standard, whichever is greater, the basic model is in compliance and testing is at an end;
- a.2) for an Energy or Water Consumption Standard, if the new combined sample mean is equal to or less than the upper control limit or 105% of the applicable energy or water consumption standard, whichever is less, the basic model is in compliance and testing is at an end;
- b.1) for an Energy Efficiency Standard, if the new combined sample mean is less than the lower control limit or 95% of the applicable energy efficiency standard, whichever, is greater, and the value of (n_1+n_2+n_3) is less than 20, the manufacturer may request that additional units be tested. The total of all units tested may not exceed 20. Steps A, B, and C are then repeated;
- b.2) for an Energy or Water Consumption Standard, if the new combined sample mean is greater than the upper control limit or 105% of the applicable energy or water consumption standard, whichever is less, and the value of (n_1+n_2+n_3) is less than 20, the manufacturer may request that additional units be tested. The total of all units tested may not exceed 20. Steps A, B, and C are then repeated;
- c) otherwise, the basic model is determined to be in non-compliance.

The manufacturer bears the cost of all testing conducted under this Option.

b) Appliance labelling

The CFR, Title 16, Part 305 - *Rule concerning disclosures regarding energy consumption and water use of certain home appliances and other products required under the energy policy and conservation act (“appliance labelling rule”)*, establishes requirements for consumer appliance products with respect to energy/water labelling and/or marking the products with information indicating their operating cost (or different useful measure of energy consumption) and related information.

It states that upon notification by the Federal Trade Commission or its designated representative, a manufacturer of a covered product shall supply, at the manufacturer's expense, no more than two of each model of each product to a laboratory, which will be identified by the Commission or its designated representative in the notice, for the purpose of ascertaining whether the estimated annual energy consumption, the estimated annual operating cost, or the energy efficiency rating, or the light output, energy usage and life ratings or, for general service fluorescent lamps, the colour rendering index, disclosed on the label or fact sheet or in an industry directory, or, as required in a catalogue, or the representation made by the label that the product is in compliance with applicable requirements is accurate.

Such a procedure will only be followed after the Commission or its staff has examined the underlying test data provided by the manufacturer and after the manufacturer has been afforded the opportunity to re-verify test results from which the estimated annual energy consumption, the estimated annual operating cost, or the energy efficiency rating for each basic model was derived, or the light output, energy usage and life ratings or, for general service fluorescent lamps, the colour rendering index, for each basic model or lamp type was derived. A representative designated by the Commission shall be permitted to observe any re-verification procedures required by this part, and to inspect the results of such re-verification.

The Commission will pay the charges for testing by designated laboratories

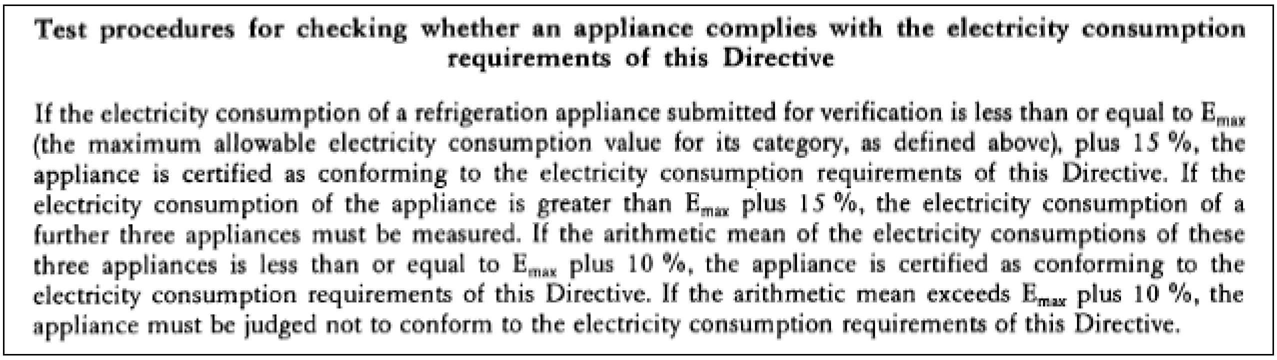
c) Laboratory accreditation

No accredited laboratories are requested for household appliances, while the testing for general service fluorescent lamps, general service incandescent lamps, incandescent reflector lamps, and medium base compact fluorescent lamps, shall be conducted by test laboratories accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) or by an accrediting organization recognized by NVLAP. NVLAP is a program of the National Institute of Standards and Technology, U.S. Department of Commerce. NVLAP standards for accreditation of laboratories that test for compliance with standards for lamp efficacy and CRI are given in 15 CFR part 285 as supplemented by NVLAP Handbook 150–01, “Energy Efficient Lighting Products, Lamps and Luminaires.” A manufacturer's or importer's own laboratory, if accredited, may conduct the applicable testing.

7.2.2.3 The European Union

a) Energy efficiency requirements

The energy efficiency requirement directive 96/57/EC for cold appliances bases the verification on a two stage procedure: in **Stage 1** the check is performed on one sample of the model. In case of non-compliance, the **Stage 2** check is developed on three additional samples of the model. The test procedures are described in Annex 1 of the directive "*Method for calculating the maximum allowable electricity consumption of a refrigeration appliance and procedure for checking conformity*" as:



Test procedures for checking whether an appliance complies with the electricity consumption requirements of this Directive

If the electricity consumption of a refrigeration appliance submitted for verification is less than or equal to E_{max} (the maximum allowable electricity consumption value for its category, as defined above), plus 15 %, the appliance is certified as conforming to the electricity consumption requirements of this Directive. If the electricity consumption of the appliance is greater than E_{max} plus 15 %, the electricity consumption of a further three appliances must be measured. If the arithmetic mean of the electricity consumptions of these three appliances is less than or equal to E_{max} plus 10 %, the appliance is certified as conforming to the electricity consumption requirements of this Directive. If the arithmetic mean exceeds E_{max} plus 10 %, the appliance must be judged not to conform to the electricity consumption requirements of this Directive.

b) Energy labelling

The energy labelling schemes for household appliances base the verification on the provisions included in a specific Clause or normative Annex of the relevant standards, which are mentioned in the specific directives. In general, the verification is based on a two stage procedure: in Stage 1 the check is performed on one sample of the model. In case of non-compliance, the Stage 2 check is developed on three additional samples of the model. Depending on the parameter to be verified, a verification tolerance is applied to both Stages.

For cold appliances, Annex C - Rated characteristics and control procedure of EN 153, states the control procedure for :

1) Volumes and areas

- **Rated gross volume**: the measured value shall not be less than the rated value by more than 3% or 1 litre, whichever is the greater value;
- **Rated storage volume**: the measured value shall not be less than the rated value by more than 3% or 1 litre, whichever is the greater value. Where the volumes of the cellar compartment and fresh-food storage compartment are adjustable relative to one another by the user, this requirement applies when the cellar compartment is adjusted to its minimum volume;
- **Rated storage shelf area**: the measured storage shelf area, including that of any cellar and chill compartment, shall not be less than the rated storage shelf area by more than 3%;
- **Control procedure**: if the previous requirements are not met on a single refrigerating appliance, the measurements shall be made on a further 3, randomly selected, refrigerating appliances. The arithmetical mean of the measured values of these 3 refrigerating appliances shall be in accordance with the requirements.

2) Performance characteristics

- **Storage temperatures**: the values on the first refrigerating appliance tested shall comply with the requirements of the standard. If any result of the test carried out on the first refrigerating appliance is outside the specified values, the test shall be carried out on a further 3, randomly selected, refrigerating appliances. All the values on these 3 refrigerating appliances tested shall comply with requirements given in the standard;
- **Freezing capacity**: the value measured on the first refrigerating appliance tested shall not be less than the rated value by more than 15%. If the result of the test carried out on the first refrigerating appliance is less than the rated value minus 15% , the test shall be carried out on a

further 3 randomly selected refrigerating appliances. The arithmetical mean of the values of these 3 refrigerating appliances shall be equal to or greater than the rated value minus 10%.
The value obtained either on the first refrigerating appliance tested or the arithmetical mean value obtained on a further 3 refrigerating appliances shall be in accordance with the minimum stated values;

- **Energy consumption, Ice making, Temperature rise time**: the value measured shall not be greater than the rated value by more than 15%. If the result of the test carried out on the first refrigerating appliance is greater than the rated value plus 15%, the test shall be carried out on a further 3 randomly selected refrigerating appliances. The arithmetical mean of the values of these 3 refrigerating appliances shall be equal to or less than the rated value plus 10%.

For wash appliances:

1) **Dishwashers**: Clause Z2 of - Tolerances and control procedures of EN 50242 Ed.2 and EN 60436, states the control procedure for:

- **Cleaning performance**: the cleaning performance shall not be less than the value declared by the manufacturer minus 6%. If the result of the test carried out on the first appliance is less than the value declared by the manufacturer minus 6% the test shall be carried out on a further 3 appliances. The arithmetic mean of the values of these 3 appliances shall not be less than the declared value minus 4%;
- **Drying performance**: the drying performance shall not be less than the value declared by the manufacturer minus 15%. If the result of the test carried out on the first appliance is less than the value declared by the manufacturer minus 15% the test shall be carried out on a further 3 randomly selected appliances. The arithmetic mean of the values of these 3 appliances shall not be less than the declared value minus 10%;
- **Energy consumption**, **Water consumption**, **Cycle time**: the measured value shall not be greater than the value declared by the manufacturer plus 15%. If the result of the test carried out on the first appliance is greater than the declared value plus 15%, the test shall be carried out on a further 3 randomly selected appliances. The arithmetical mean of the values of these 3 appliances shall not be greater than the declared value plus 10%;

By retesting the further 3 appliances with limited tolerances all values shall be specified (cleaning, drying, energy, water and time).

2) **Washing machines**: Clause Z3 - Tolerances and control procedures of EN 60456, states the control procedure for :

- **Energy consumption**, **Water consumption, Spin extraction**: the measured value shall not be greater than the value declared by the manufacturer plus 15%. If the result of the test carried out on the first appliances is greater than the declared value plus 15% , the test shall be carried out on a further 3 appliances, which shall be randomly selected from the market. The arithmetic mean of the values of these 3 appliances shall not be greater than the declared value plus 10%;
- **Spin speed**: the spin speed shall not be less than the value declared by the manufacturer minus 10% or minus 100 rpm, whichever is the smaller value. If the result of the test carried out on the first appliances is less than the declared value minus 10% or minus 100 rpm (whichever is the smaller value), the test shall be carried out on a further 3 appliances, which shall be randomly selected from the market. The value of each of these 3 appliances shall not be less than the declared value minus 10% or minus 100 rpm, whichever is the smaller value;
- **Washing performance**: the washing performance, shall not be less than the value declared by the manufacturer minus 0,03. If the result of the test carried out on the first appliance is less than the declared value minus 0,03, the test shall be carried out on a further 3 appliances, which shall

be randomly selected from the market. The arithmetic mean of the values of these 3 appliances shall not be less than the declared value minus 0,02;

- **Programme duration**: the programme duration shall not be longer than the value declared by the manufacturer plus 15 %. If the result of the test carried out on the first appliances is longer than the declared value plus 15%, the test shall be carried out on a further 3 appliances, which shall be randomly selected from the market. The arithmetic mean of the values of these 3 appliances shall not be longer than the declared value plus 10%.

A summary of the EU verification system for the energy consumption declarations in the energy labelling and energy efficiency requirement schemes is presented in Table 7.12.

Table 7.12: Summary of the EU verification system for energy consumption in labelling and efficiency requirements

Appliance	Implementing Directives	Standard	Verification procedure			
			Stage 1		Stage 2	
			Units (number)	Tolerance (%)	Units (number)	Tolerance (%)
Energy labelling scheme						
Refrigerators & freezers	94/2/EC, 2003/66/EC	EN 153	1	15%	3	10%
Washing machines	95/12/EC, 96/89/EC	EN 60456	1	15%	3	10%
Tumble dryers	95/13/EC	EN 61121	1	15%	3	10%
Washer-dryers	96/60/EC	EN 50229	1	15%	3	10%
Dishwashers	97/17/EC, 99/9/EC	EN 50242	1	15%	3	10%
Air conditioning	2002/31/EC	EN 14511	1	15%	3	10%
Ovens	2002/40/EC	EN 50304	1	40Wh+10%	3	10%
Efficiency requirements						
Refrigerators & freezers	96/57/EC	EN 153	1	15%	3	10%

c) The eco-label scheme

In the Annex of Commission Decision (2004/669/EC) of 6 April 2004 establishing the ecological criteria for the award of the Community eco-label to refrigerators, and amending Decision 2000/40/EC, only the procedure for the measurement declaration are described. A brief mention of the verification procedure and criteria was included in previous Decision 2000/40/EC, which reported: “in case of verification, which is not required on application, competent bodies shall apply the tolerances and control procedures laid down in EN 153”.

No verification procedure is described for washing machines and dishwashers in the respective Commission Decisions.

d) Laboratory accreditation:

No accreditation is requested in the European Union to laboratories for the verification activity.

7.2.2.4 Conclusions for the verification procedures

A comparison of the test procedures described in the previous paragraphs shows that that there are some common elements:

- the most important outcome is that under the different form of a measurement error considered equal to the variability of the test measurement, or a verification limit taking care of measurement uncertainty, systematic and random errors and production variability, a 'tolerance' is always used in testing, both for the labelling declarations and for the compliance with minimum requirements;
- countries foreseeing accredited laboratories for verification generally use a lower value of 'tolerance', usually set equal to the error of the laboratory (reproducibility of the measurement method); but only accredited laboratories can then run official verification tests;
- a complete and correct verification procedure includes at least 2 Stages (sometimes three), and 4 or more units of the tested models (from 4 up to 20 units in US);
- the verification of the energy consumption for cold appliances is more complex than for other household appliances in Australia and US, while in the EU the same procedure is followed for all household appliance.

7.2.3 The Enforcement and market surveillance

7.2.3.1 The Australian market compliance control

As reported in the Issue 2 of Compliance Newsletter, a registration compliance audit was undertaken in the second half of 2006 into air conditioners on the Australian marketplace. The in store compliance audit consisted of comparing a list of air conditioner unit sales supplied by the marketing firm GfK and of advertising on the internet against the list of models included in the Energy Rating database in order to uncover potentially unregistered product. The search was extended to air conditioners Internet websites and other supply outlets to look for unregistered models.

A number of unregistered models were found and relevant suppliers were contacted. An ongoing dialogue commenced and actions may be taken against suppliers of unregistered stock.

This audit was considered successful by regulators because a number of previously unknown suppliers were contacted and made aware of labelling and energy efficiency requirements. The main sanction used against electrical equipment retailers is infringement notices. During the 2005-2006 financial year, Australian energy regulators concentrated on using educative approaches to retailers explaining their responsibilities in relation to labelled appliances.

A similar audit for white goods targeting dryers, washing machines, dishwashers, refrigerators and freezers is to be undertaken during 2007. A further audit will be conducted in 2007 for air conditioners and at that time sanctions other than discussion and correspondence with regulators will be used where instances of non-compliance are detected.

7.2.3.2 The European Union

The EU market surveillance is based on Article 3 of directive 94/2/EC, Member States shall take all necessary measures to ensure that all suppliers and dealers established in their territory fulfil their obligations under this Directive.

Starting 1996, the European Commission DG TREN promoted under the SAVE programme three monitoring studies to evaluate the impact of the EU legislation on the market transformation of cold appliances and energy consumption under the leadership of the French Agency ADEME- Agence de l'Environnement et le Maîtrise de l'Énergie (ADEME, 1998[21]; ADEME, 2000[22]; ADEME, 2001[23]). No other major studies or reports on the overall implementation of the labelling scheme and the efficiency requirements in the EU have been promoted or prepared. Some more recent projects developed in the framework of the SAVE-II[24] and the Intelligent Energy Europe[25] programmes have addressed the implementation of the energy labelling scheme in groups of member States.

Single Member States have developed market surveillance activities at national level in a discontinue way over the years. For example, the 2001 document "Evaluating the Implementation of the Energy Consumption Labelling Ordinance", Research Project on behalf of the German Federal Ministry of Economics and Technology[26] states the energy labelling implementation in Germany, or the document "Ten Years of Energy Labelling of Domestic Appliances 1995–2005"[27] of the Swedish Energy Agency stating the conclusion after ten years and showing also the result of appliance testing from one single test:

- 101 cold appliances, 15 deviated more than allowed (14,9%).
- 19 ovens, 2 deviated more than allowed (10,5%).
- 28 dishwashers, 13 deviated more than allowed (46,4%).
- 48 washing machines, 20 deviated more than allowed (41,7%).
- 14 tumble dryers, 2 deviated more than allowed (14,3%).

since only the Step 1 of the two stage verification procedure of the labelling scheme has been completed, it is not possible to draw conclusions about the actual compliance rate.

The CECED Voluntary Commitment on Reducing Energy Consumption of **Household Refrigerators, Freezers and their Combinations** (2002-2010), foresee a monitoring and reporting actions. In particular, the monitoring system of the Commitment supervises both the fulfilment of the conditions and the progress in energy saving resulting from the Commitment itself. The compliance with the targets is based on data that are declared on the energy label for household refrigerating appliances (according to the energy labelling Directive).

A Notary monitors on an annual basis the results achieved by the Commitment, in terms of an overall production weighted energy consumption figure, calculated on the basis of the complete production/ import range in the EU of all participants. Participants to the Commitment are responsible for the accuracy of the data communicated to the Notary and for this purpose, they commit themselves to have such data validated by an independent (responsible) auditor. Each participant remains responsible for the data declared on the label and communicated to CECED, which will ensure that the information is passed consistently in the database.

As far as the reporting is concerned, the Notary collects on a confidential basis from each manufacturer the production weighted energy efficiency index and the total production quantity for

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[21] ADEME, Monitoring of energy efficiency trends of European domestic refrigeration appliances: final report, PW Consulting for ADEME on behalf of the European Commission, 1998.

[22] ADEME, Monitoring of energy efficiency trends of refrigerators, freezers, washing machines and washer-dryers in the EU, Final Report, PW Consulting for ADEME on behalf of the European Commission, 2000.

[23] ADEME, Monitoring of energy efficiency trends of refrigerators, freezers, washing machines, washer-dryers and household lamps in the EU, Final Report, PW Consulting for ADEME on behalf of the European Commission, 2001.

[24] SAVE project "Energy Labels - Making a Greener Choice", contract 4.1031/Z/01-024/2001, 2004.

[25] IEE project "CEECAP – Implementing EU Appliance Policy in Central and Eastern Europe project", http://www.ceecap.org/cntnt/ceecap/library .

[26] Fraunhofer ISI, "Evaluating the Implementation of the Energy Consumption Labelling Ordinance", Executive Summary, Research Project on behalf of the German Federal Ministry of Economics and Technology, No. 28/00, March 2001.

[27] The Swedish Energy Agency, Ten Years of Energy Labelling of Domestic Appliances 1995–2005, ER 2006:18.

each product category and for each energy efficiency class. The Notary will provide CECED with an aggregated summary and anonymous ranking of the participants.
CECED collects a database that contains technical data of all models of household refrigerating appliances placed on the Community market by all the participants. For each single model the data mandatory on the energy label are given. The database is available to the European Commission, national authorities and, for study purposes, to experts appointed by them. The copyright is owned by CECED.
Based on the data provided, CECED submits each calendar year starting from 01.01.2003 to the European Commission a report including the following information:

- on the base of the Notary summary:
  - the overall production weighted energy efficiency index;
  - a histogram of production weighted energy efficiency index for each efficiency classes and product category;
  - the ranking of the production weighted energy efficiency indexes of the participants in an anonymous way;

- on the base of the CECED technical database:
  - the respective share of each product category
  - some charts showing the trend in the technology

The annual report will be made available to the public free of charge.

A similar procedure is foreseen also for the “Second Voluntary Commitment on Reducing Energy Consumption of Domestic **Washing Machines** (2002-2008)” and the “Voluntary Commitment on Reducing Energy Consumption of Household **Dishwashers** (2000-2004)”.

7.3 Subtask 7.3: The Business as Usual Scenario

The definition of the Business as Usual (BaU) scenario for the wash appliances is based on qualitative assumptions rather then factual evidences.

It is worth remembering that the notable technological progress and the high energy efficiency gains achieved by this manufacturing sector during the last 10-12 years are entirely due to the effective mandatory and voluntary policies and measures enforced or promoted by the European Commission and the Members States.

This does not mean that, without these policies, the sector would have not improved the energy efficiency of its products, but there is no evidence to which extent this could have been achieved and what technological innovation would have resulted. Actually, significant improvements of the energy efficiency were realised during the ‘80s and the beginning of the ‘90s (see Table 7.13[28] showing the average annual energy consumption for wash appliances starting from 1950) but at that time the energy efficiency and technological improvement potentials were high and the energy savings relatively easy to obtain. Today any further improvement is more difficult to achieve for the household appliances industry and needs to be justified by the market demand.

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[28] Source: CECED

Table 7.13: Unitary energy consumption of washing machines

Year	Average energy consumption (kWh/cycle)	Number of cycles (cycle/year)
1953-1981	3,250	277
1982-1992	1,830	256
1993-1996	1,350	251
1997	1,177	251
1998-1999	1,177	245
2000	1,081	245
2001-2002	1,081	245
2003-2004	1,081	234
2005	0,997	234

All this leads to the assumption that, without further policy measures (the latest industry voluntary commitment on washing machines will end in 2008), a very little or even no additional energy efficiency improvement is expected for these appliances. Possible hypothesis are:

- for dishwashers, the A class (i.e. the LLCC model) will reach 100% of the market in year 2015. No other new energy efficiency classes entries are envisaged during this period;
- for washing machines, being the specific energy consumption of the LLCC model in the range of the “A+” class, it is reasonable to envisage that this class will spread into the market in the next decade (probably around year 2020). This means that the A and A+ classes will dominate the market during the next decade and the A+ class (named here LLCC), will reach 100% in year 2020.

These scenario assumption are presented in Tables 7.14 and 7.15 and in Figures 7.11 and 7.12 that show the market transformation trend respectively for washing machines and dishwashers. In the lower rows of the Tables the average energy consumption per kg of load (for the washing machines only), per cycle and per year are shown. It is worth noting that the overall annual stock and average energy consumptions include the standby mode consumption, hypothesised in 11,8 kWh/year for the washing machines and in 12,4 kWh/year for the dishwashers.

Table 7.14: BaU Scenario for washing machines, energy efficiency classes trend in 2005-2030

Year	A+ (%)	A (%)	B (%)	C (%)	Tot. (%)
2005	38	52	6	4	100
2009	55	45	0	0	100
2014	70	30	0	0	100
2019	10	0	0	0	100
2025	100%	0	0	0	100
2030	100	0	0	0	100
Energy consumption (kWh/kg)	0,17	0,19	0,23	0,27	--
Energy consumption (kWh/cycle)	0,91	1,02	1,23	1,45	--
Energy consumption (kWh/y)	212	236	283	330	--

Table 7.15: BaU Scenario for dishwashers, energy efficiency classes trend in 2005-2030

Year	A (%)	B (%)	C (%)	Tot. (%)
2005	91	8	2	100
2009	97	3	0	100
2014	100	0	0	100
2019	100	0	0	100
2025	100	0	0	100
2030	100	0	0	100
Energy consumption (kWh/cycle)	1,06	1,26	1,45	--
Energy consumption (kWh/y)	309	364	420	--

Figure 7.11: Market transformation for washing machines, BaU Scenario (percentage of models in each class are shown)

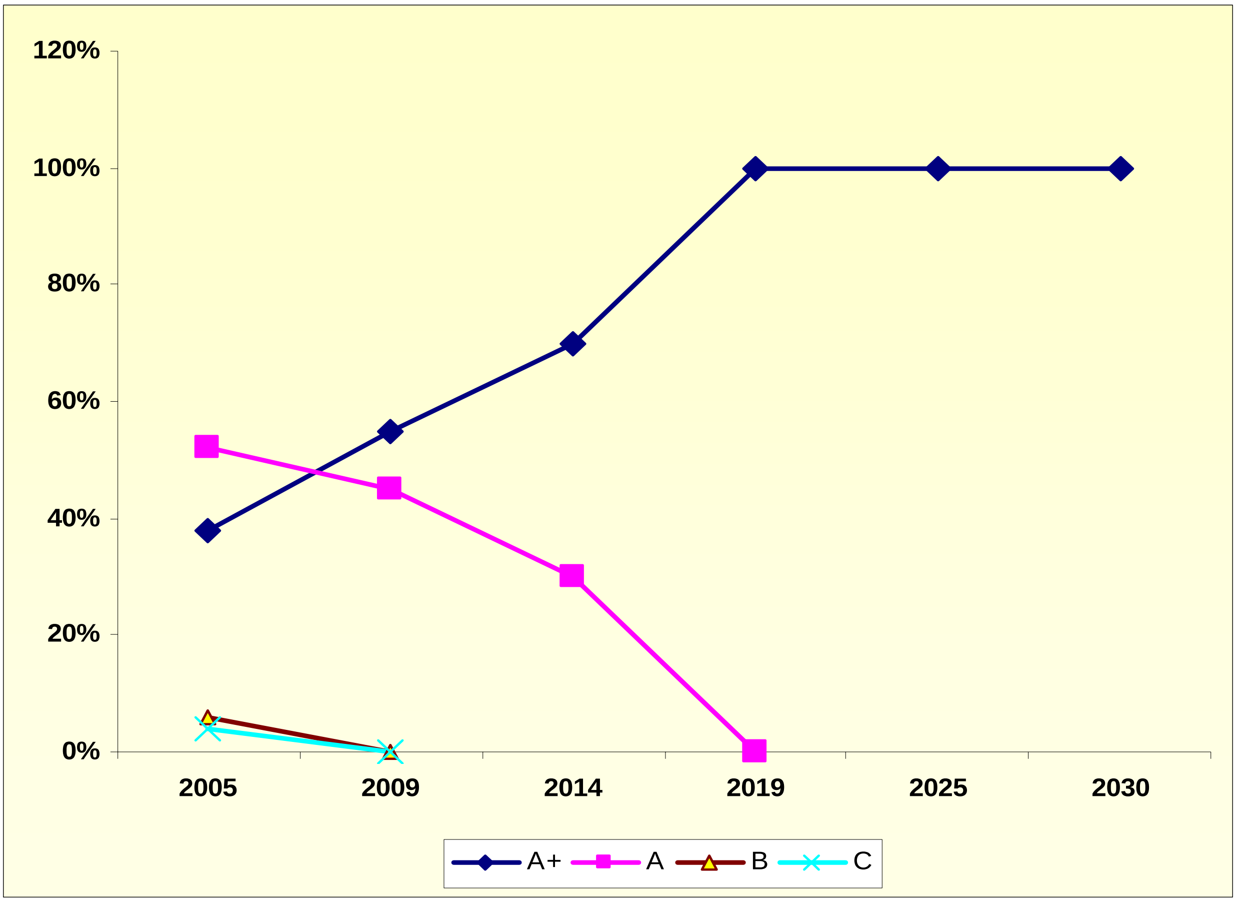
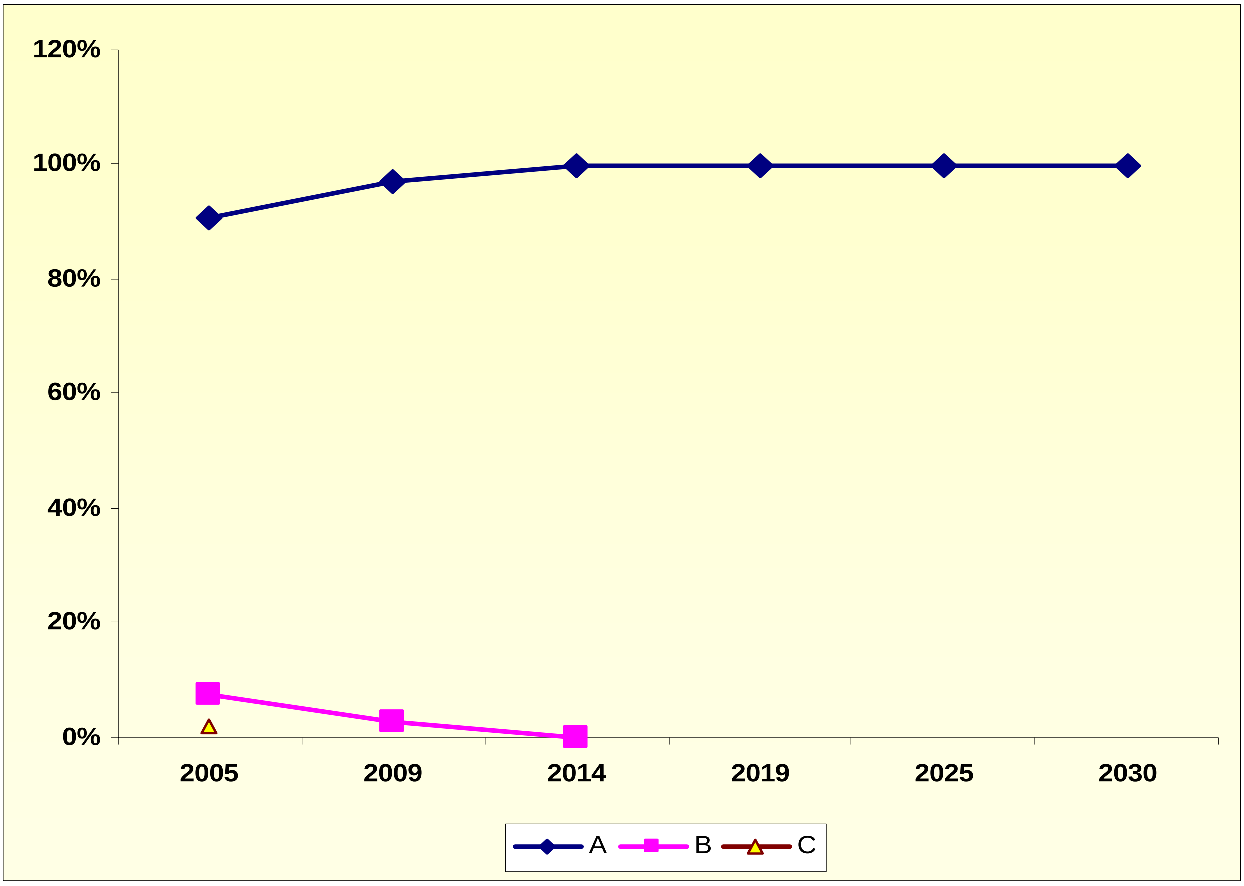


Figure 7.12: Market transformation for dishwashers, BaU Scenario (percentage of models in each class are shown)



Tables 7.16-7.18 and Figures 7.13-7.15 for washing machines and Tables 7.19-7.21 and Figures 7.16-7.18 for dishwashers, show the appliance stock, the stock energy consumption and the average energy consumption trends for the years 1990-2020 in accordance with the BAU Scenario assumptions and the stock growth rates provided by the stock model described in Task 2.

As far as **washing machines** are concerned, the stock energy consumption (Figure 7.14) shows a peak in 1995, decreases steadily until 2010 and then slowly increases again due to the household growth rate (the washing machine ownership is estimated to saturate at 90% around the year 2005). This trend, clearly showing the effect of the policies implemented during the past decade, is consistent with the average energy consumption values that stop decreasing around 2015. Due to the ownership rate saturation (96% for EU15 at 2020 and 92% for EU10 in the same year), to keep the stock energy consumption at least constant, the average energy consumption per unit should decrease steadily at a rate at least equal to the household number growth rate.

Figure 7.16 and 7.17 show respectively the appliance stock and the stock energy consumption trends for **dishwashers**. For EU15 it is assumed that the ownership reaches 60% in year 2020, while the for EU10 the situation is different but available data are less reliable. From the assessment carried out within the SACHA[29] project during the second half of the '90s (see Task 2) very few or even no dishwashers were installed in these countries in 1995. But the sales of this product, although concentrated in few countries, are lively, with +50% in three years in four Eastern

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[29] The SACHA 1 and SACHA 2 projects, developed under the DG TREN SAVE-I programme in 1995-1998, evaluated the refrigerators and washing machines state of the art in seven Central and Eastern European countries, including former Accession Countries.

European countries. Therefore a rapid penetration of dishwashers in new Member States in East Europe can be expected, with an estimated ownership of 20% in 2020.

Due to the combined effect of the households' number growth and the increase in ownership the dishwasher stock is still sharply increasing and despite a strong decrease of the unitary energy consumption (see Figure 7.16) the stock energy consumption, especially in Eastern Member States increases rather steadily.

Table 7.16: Washing machine stock trend in the EU countries in 1990-2030, BaU Scenario (million of units)

Years	Stock		
	EU 25	EU 15	EU 10
1990	122	109	12,8
1995	141	124	16,5
2000	157	136	20,2
2005	167	143	24,1
2009	177	151	26,3
2014	188	160	27,9
2019	197	169	28,6
2025	208	179	29,5
2030	217	187	30,2

Table 7.17: Stock energy consumption trend for washing machines in EU countries in 1990-2030, BaU Scenario (GWh/year)

Years	**Energy consumption**		
	EU 25	EU 15	EU 10
1990	52 092	46 527	5 565
1995	54 857	48 368	6 489
2000	52 400	45 465	6 935
2005	47 704	40 553	7 151
2009	45 356	38 348	7 008
2014	44 188	37 456	6 732
2019	44 261	37 730	6 531
2025	45 120	38 667	6 454
2030	46 502	39 998	6 504

Table 7.18: Average energy consumption trend for washing machines in EU countries in 1990-2030, BaU Scenario (kWh/year)

Years	Average energy consumption		
	EU 25	EU 15	EU 10
1990	427	427	434
1995	389	389	394
2000	335	333	343
2005	285	283	296
2009	256	254	266
2014	235	234	242
2019	224	224	228
2025	217	217	219
2030	214	214	215

Figure 7.13: Washing machines stock trend in the EU countries in 1990-2030, BaU Scenario (million of units)

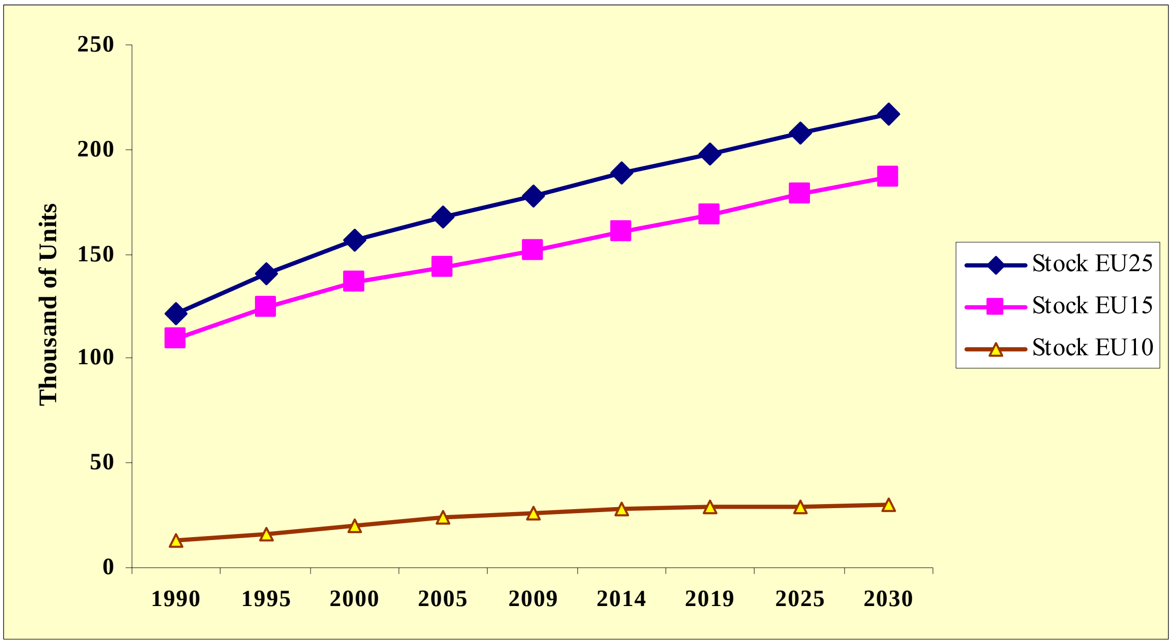


Figure 7.14: Stock energy consumption trend for washing machines in EU countries in 1990-2030, BaU Scenario (GWh/year)

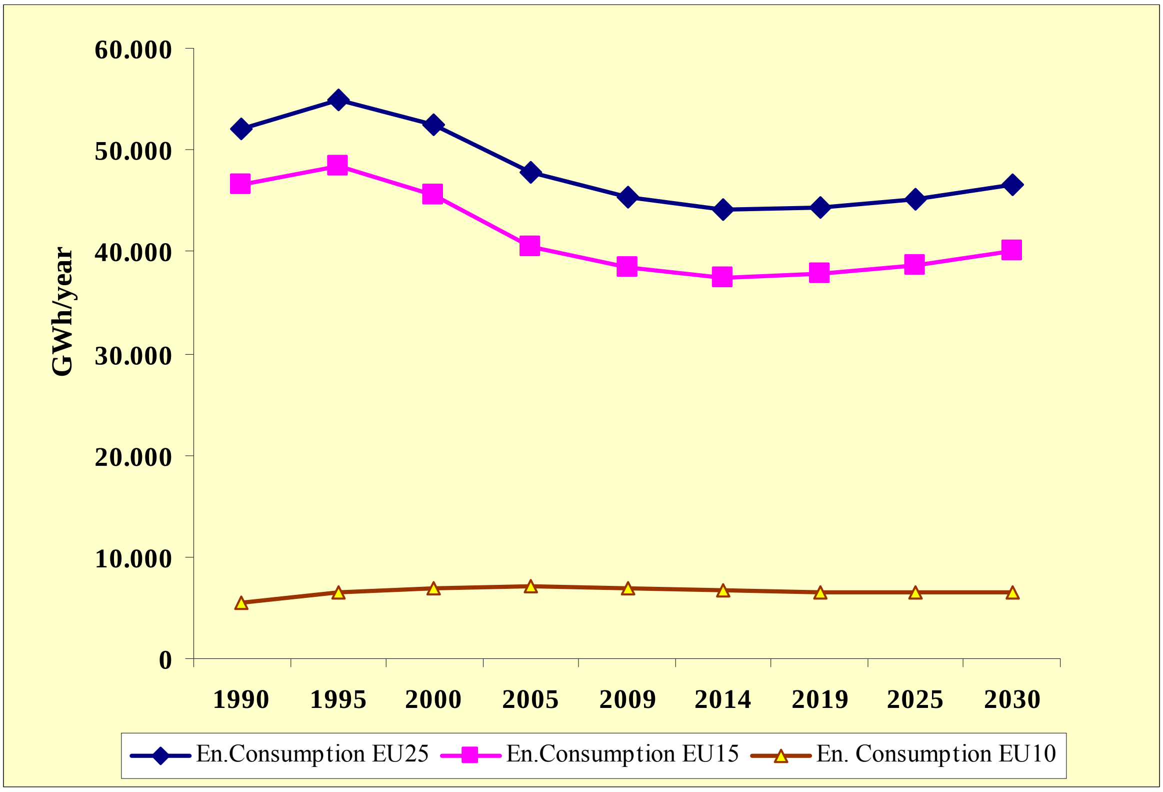


Figure 7.15: Average energy consumption trend for washing machines in EU countries in 1990-2030, BaU Scenario (kWh/year)

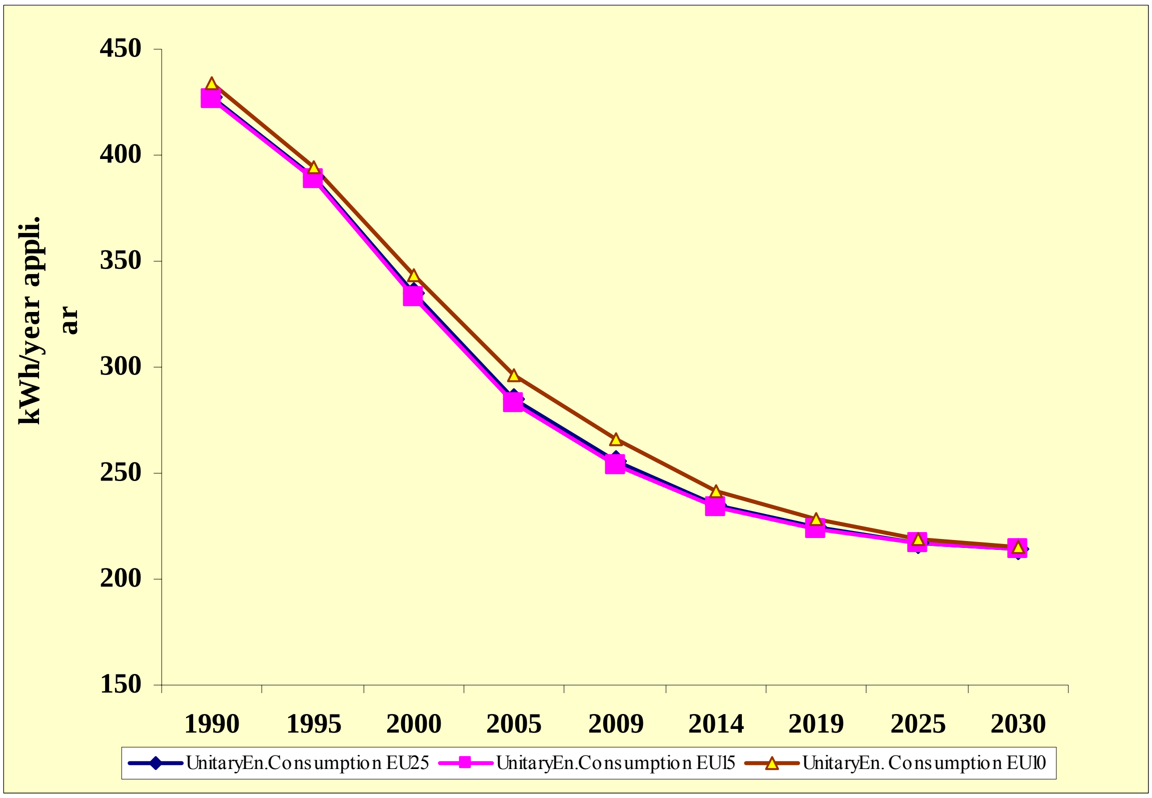


Table 7.19: Dishwasher stock trend in the EU countries in 1990-2030, BaU Scenario (million of units)

Years	Stock		
	EU 25	EU 15	EU 10
1990	36	36	0,00
1995	47	47	0,13
2000	58	57	0,54
2005	69	68	1,28
2009	81	79	2,11
2014	96	92	3,43
2019	111	106	5,06
2025	131	123	7,44
2030	149	139	9,78

Table 7.20: Stock energy consumption trend for dishwashers in EU countries in 1990-2030, BaU Scenario (GWh/year)

Years	Energy consumption		
	EU 25	EU 15	EU 10
1990	23 190	23 190	0
1995	27 456	27 390	67
2000	29 678	29 436	242
2005	29 907	29 407	500
2009	30 372	29 623	749
2014	31 865	30 737	1 127
2019	34 993	33 399	1 593
2025	40 421	38 118	2 303
2030	45 981	42 961	3 020

Table 7.21: Average energy consumption trend for dishwashers in EU countries in 1990-2030, BaU Scenario (kWh/year)

Years	Unitary energy consumption		
	EU 25	EU 15	EU 10
1990	644	644	--
1995	587	587	525
2000	512	513	448
2005	434	435	392
2009	376	377	355
2014	334	334	328
2019	315	315	315
2025	309	309	310
2030	309	309	309

Figure 7.16: Dishwashers trend in the EU countries in 1990-2030, BaU Scenario (million of units)

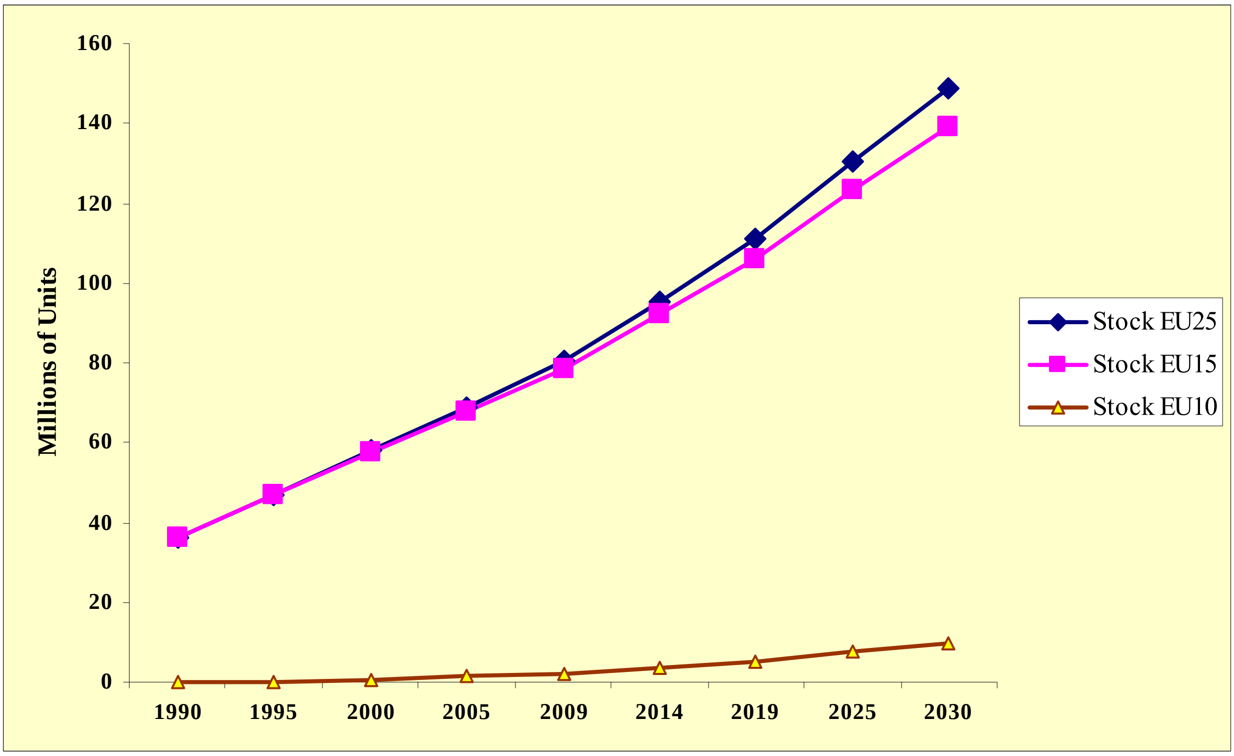


Figure 7.17 Stock energy consumption trend for dishwashers in EU countries in 1990-2030, BaU Scenario (GWh/year)

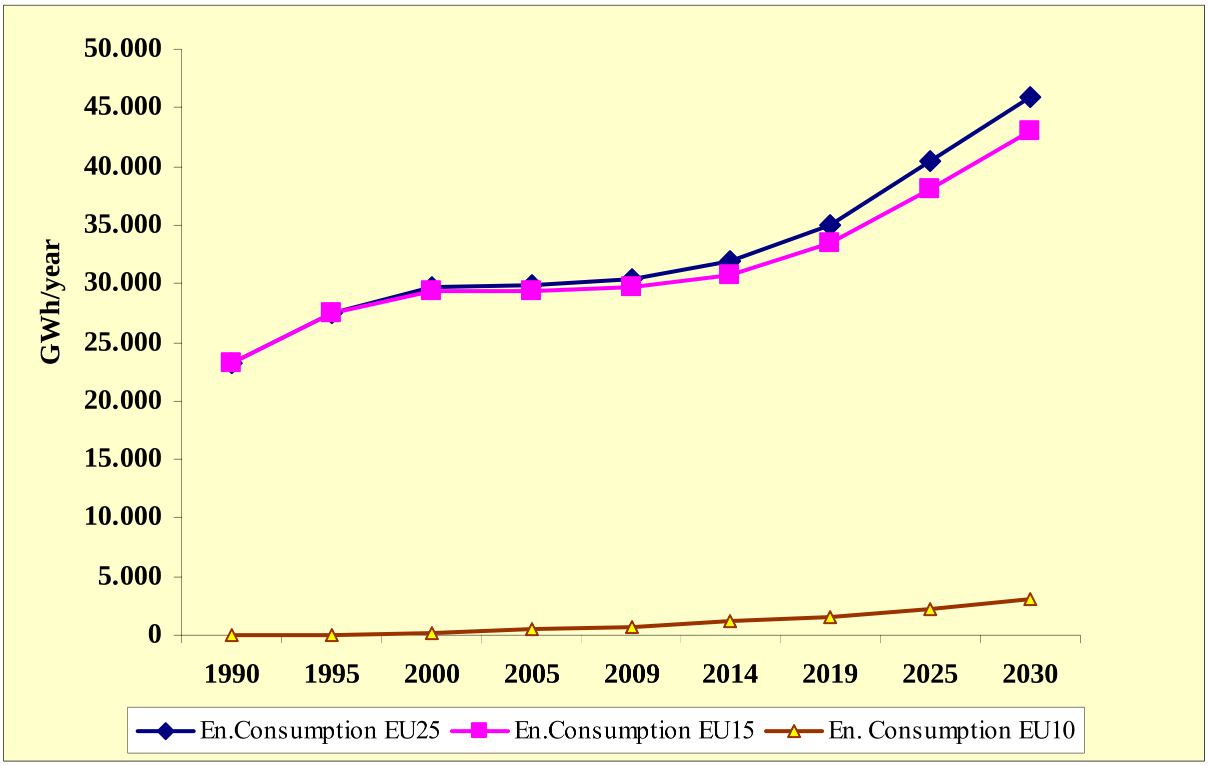
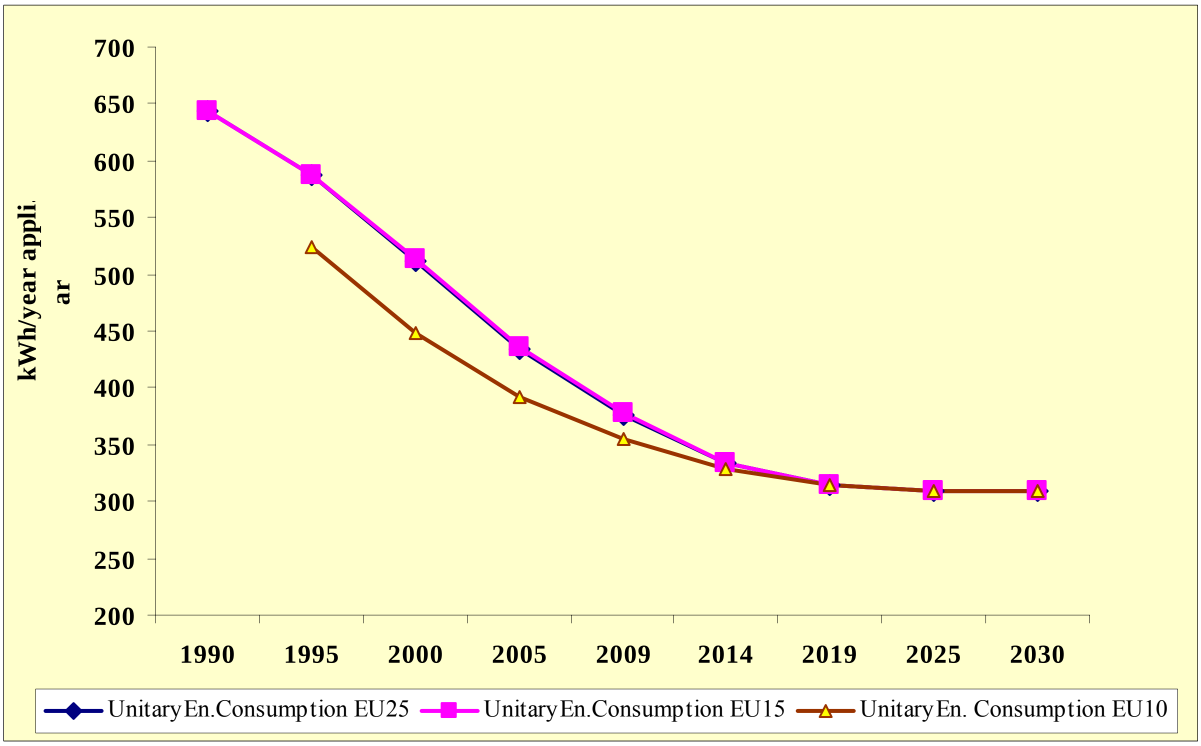


Figure 7.18 Average energy consumption trend for dishwashers in EU countries in 1990-2030, BaU Scenario (kWh/year)



7.4 Subtask 7.4: Manufacturers Impact Analysis

The impact analysis on manufacturers will be run using the E-GRIM model, developed by ENEA in the framework of previous SAVE projects and already successfully applied in the analysis of the WASH-2 project.

Cost data used in the NPV and Life Cycle Cost methods is further disaggregated and used as input in E-GRIM (European Government Regulatory Impact Model) model. Quantitative market data, industry structure, consumers' habits provided by previous phases of the study or by literature will be used to establish a framework to describe the linkages of the market and the technological improvement. E-GRIM model is expressly designed to allow the analysis of the effects of a single policy measure upon a single product. By combining multiple iterations it is also possible to analyse multiple products with policy measures taking effects over a period of time and/or multiple policy measures on the same product. The program simulates the sales, all main elements of cost and the cash flow, each year for fifteen years and then determines the present value of those cash flows without policy measure – the Base case – and with policy measure – the Policy Measure case. Output consists in the complete cash flow calculations, summary statistics, and graphs of major variables, including net cash flow for industry and for consumers (due to electricity savings), employment, investments required and impact on profits.

Average values to be used as input to E-GRIM model is presented at the sector level in terms of the “typical manufacturer”.

7.4.1 The E-GRIM model

The white goods appliance market is essentially one of low growth and substitution among models, favouring higher efficiency categories, the only exception being air conditioners, a relative latecomer to the European market. Overall unit sales growth are usually between one or two percent, whereas new models gain market share relatively rapidly. In this context a new type of E-GRIM was developed incorporating dual production lines: one for the newer, higher share penetration model and a second for the typical model being substituted. For simplicity, both lines are assumed to be within the same facility of one million units nominal capacity. One more unit of sales (and production) of the higher penetration model corresponds to one less unit of sales and production of the typical substituted model. For more complex situations, additional growth rates above the substitution rates can be introduced, relaxing the assumption of constant production capacity, allowing capacity to grow slightly.

The dual production line model of E-GRIM was first introduced in a study for CECED in 2006[30] and subsequently in 2007[31]. It results in more realistic representation of the industrial dynamics because it explicitly considers the losses due to substitution that inevitably occur within industry and normally within the same firm. Only in the situation of a firm rapidly gaining market share in the new models over the other firms can this substitution be partially avoided within the firm. The traditional single-line production model overestimates cash flows and profits in this context, not subtracting the substituted cash flows lost. Fortunately the margin of the newer higher penetration

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[30] Mebane, William (November 2006) *Final Report on Production Tax Credits*, site: www.ceced.org (see Statements and Press Info)

[31] Mebane, William and Piccino, Emanuele (2007), *New Policy Instruments for Energy Efficient Home Appliances in Europe*, 9th IAEE European Energy Conference, Energy Markets and Sustainability in a Larger Europe, Florence, Italy

models is greater than that on the older models and after substitution there remain profits. This is consistent with the practice of product life cycles, introducing the newer higher margin product with gradually decreasing price and margins over time.

The original GRIM was developed by Arthur D. Little and subsequently modified by ENEA and William Mebane for an European context[32]. It has been utilized in several studies for industry and the European Commission[33].

The primary purpose of the method is to simulate the impact of changes in policy due to the introduction of new or improved technologies that modify the cost of manufacturing. The impact of these changes are simulated by the model through annual projections of the profit/loss and cash flow statements of a production facility, projected forward in time for fifteen years.. It is this cost structure and along with the evolution of prices that determine the future cash flows. Policies introduce changes in these inputs and the resulting outputs and cash flows can be compared to base case.

Since the energy savings and price savings are known between a base case product and an improved product, the various impacts for consumers can be estimated. Similarly changes in value added, manufacturers' profits and income tax can be calculated for new products. These changes impact on the national government where the production facility is located, and these impacts on government revenues may be estimated

7.4.2 Impact Analysis

The more general aspects of the impact analysis are presented here. Instead the specific data input and results regarding the base case, the LLCC and BAT for washing machines and dishwashers are given successively together with their corresponding scenarios.

7.4.2.1 General Input Data

The most single group of important set of inputs is undoubtedly the structure of the production costs. Unfortunately there are not detailed income statements available for many of the producers and the ones available often involve other products. The cost structure also is not available for different appliances or for different models within the same appliance group. Often this reflects the industrial reality where it is difficult to follow costs at a detailed and rapidly evolving level of production. Therefore over the years we have developed a consensus model of costs, which is retained by industry to fairly accurately represent the cost structure of a large plant of one million units of nominal capacity. The cost assumptions have been reviewed by industry representatives recently as part of this task.

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[32] Arthur D. Little, Inc. of Cambridge, Massachusetts developed the original model. It was modified and upgraded by ENEA on March 11, 1997 and subsequently modified by William M. Mebane on July 26, 2006.

[33] E-GRIM has been utilized in the following studies:

- ISIS/ENEA, Study of the Environmental Impact of Dishwashers, promoted by CECED, September 2005.
- Enhancing the Government Regulatory Energy Measures Impact and Diffusion Speed Appraisal Method (E-GRIDS), project number NNE5-2001-00147, contract number ENG1-CT2001-80550, 2002.
- Government Regulatory Energy Measures Impact and Diffusion Speed Appraisal Method (GRIDS), project number NNE5-1999-00657, contract number ENK6-CT-1999-00016, 2001.
- Proposal for the Revision of Energy Labelling and the 2nd Stage of Minimum Energy Efficiency Standards for Domestic Refrigerators and Freezers and their Combinations, contract number XVII/4.1031/Z/98-269, 2000.
- Revision of energy labelling & targets washing machines (clothes), contract number XVII/4.1031/Z/98-091, 2000.

These costs are presented in Table 7.22 and shown on the assumption page of every simulation of the E-GRIM.

Table 7.22: General Cost Assumptions

Income Tax Rate	48%
Working Capital	18% of Revenue
Sales, General and Admin. (SG&A)	10% of Revenue
Research and Development	2,5% of Revenue
Ordinary Depreciation	4,3% of Revenue
Ordinary Capital Expenditures	4,5 % of Revenue
Variable Overhead as % of Total Overhead	60%
Total Unit Manufacturing Cost	about 78% of revenue
Within the Unit Manufacturing Costs:	
Materials and Components	72%
Labour	15%
Overhead (only variable part)	7%
Depreciation	6%
Total	100%

Usually we have a net income of between 2 and 6% of revenue depending on the model and price levels.

For example, applying this structure of costs to the washing machine LLCC model the outcome of Figure 7.19 results.
Notice that net income is not net cash flow, which is shown for the above example as a percent of sales.

Net Income:	7,19%
Depreciation	4,30%
Change in Working Capital	-1,11%
Total (Cash Flows from Operations)	10,38%

From this we subtract cash used in investments:

Extra Productivity capital expenditure	0
Ordinary Capital Expenditures	-4,50%
Extra Conversion Capital Expenditures (for example, an ad hoc marketing campaign)	0
Total Cash Used In Investment	-4,50%
Net Cash Flow	5,80%

It so happens that this is the first and most profitable year in the simulation. A strong negative impact of prices in the case of washing machines brings these profits down. Average cash flow and net income margins are 2 and 3 percent lower that that shown above.

As suggested, one of the most important data input is the appliance price trend. These trends have been analyzed over the latest available 8 years and are reported in Table 7.23.

Figure 7.19: Example of composition of Industry Costs Washing Machine LLCC Model, year 2007

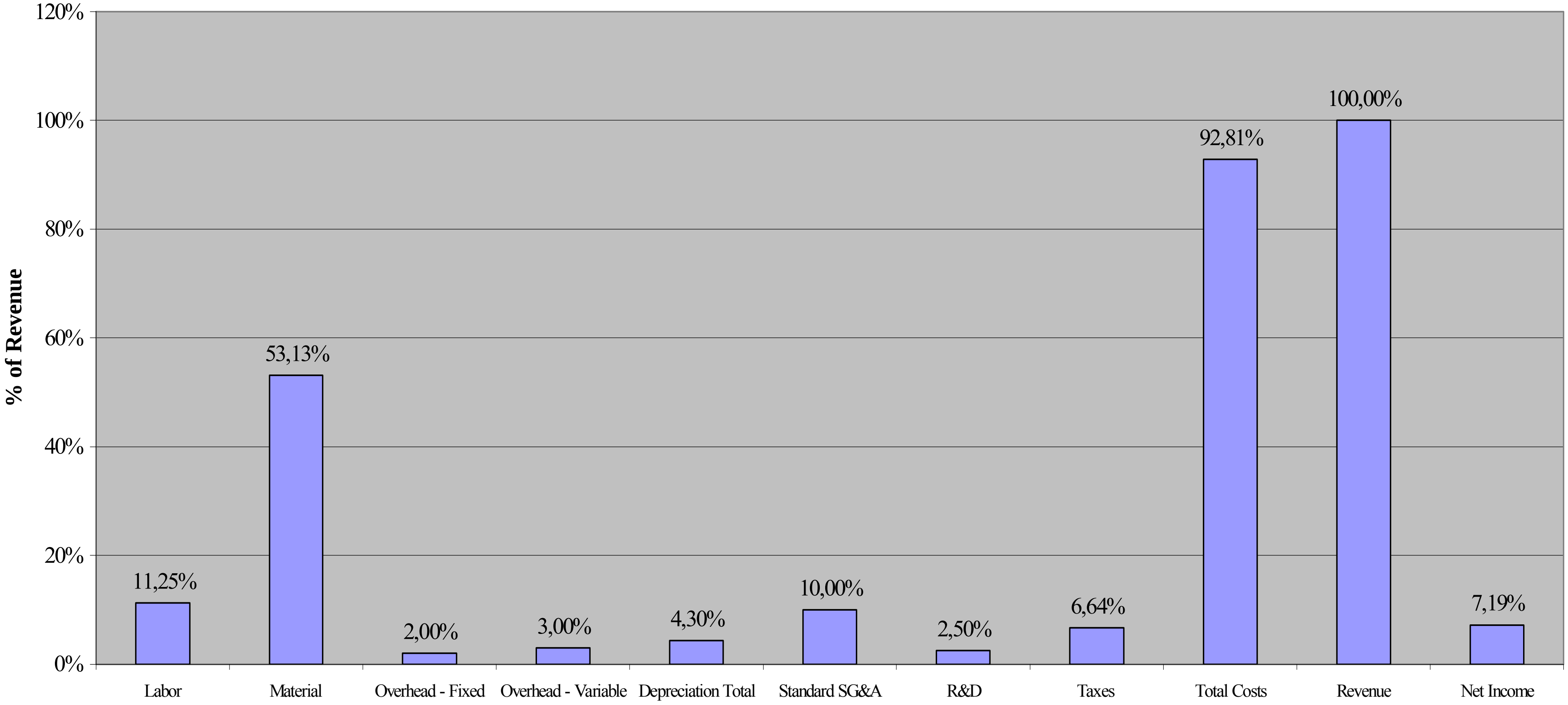


Table 7.23: Real Price Growth of Appliances in Europe

Real Price Growth (1996-2004, Source: GfK)										
Appliance/Data	Country:									
	Austria	Belgium	Germany	Spain	France	Great Britain	Italy	Netherlands	Sweden	
Refrigerators										
Real Price, 1996	532,8338703	566,3930263	526,7301793	570,159144	512,1198398	375,8941111	418,9888412	537,7363588	713,061262	
Sales * 1000, 1996	203	272,9	2559,2	862	1562,4	1761,7	774,4	486,6	115,7	8597,9
	12,5804296	17,97748949	156,783386	57,16246783	93,06179854	77,02027885	37,73769858	30,4333049	9,595504485	492,3523583
Real Price, 2004	460,2620873	491,4491177	436,2766235	519,4741337	495,2822413	505,3400139	456,6635709	400,6570273	622,1368576	
Sales, 2004	219290,2457	314658,9158	2448339,72	1279777,695	2122244,399	2711370,182	1485652,152	494875,7549	197110,8162	11273319,88
	8,953084565	13,71724108	94,75056129	58,97210553	93,23872414	121,5404033	60,18131519	17,5880265	10,87788736	479,819349
									Ratio 2004/1996	0,974544634
								% decrease in 8 years		0,025455366
							Refrigerators Annual Price Growth:			-0,003217931
Washing Machines										
Real Price, 1996	730,679358	765,4887567	772,3900528	449,6679959	575,5683155	494,8901758	428,565729	782,7187546	753,8076198	
Sales * 1000, 1996	187	208,3	1977,5	964,8	1708,4	1817,8	1145,9	401,8	91	8502,5
	16,07021934	18,75346169	179,6414383	51,0249553	115,6484458	105,8055115	57,75871436	36,98869693	8,067802811	589,7592461
Real Price, 2004	552,3884656	594,2049788	506,021695	644,6829427	393,2977434	483,3249826	471,1059306	445,7067093	573,025708	
Sales, 2004	217530,2319	266720,624	2225274,997	1406644,64	2089027,873	2717126,812	1453263,414	507287,988	187303,8784	11070180,46
	10,85449253	14,31654374	101,7180732	81,9173463	74,21829764	118,6299784	61,84551514	20,4243879	9,695409932	493,6200448
									Ratio 2004/1996	0,836985682
								% decrease in 8 years		0,163014318
							Washing Machine Annual Price Growth:			-0,021997976
Freezers										
Real Price, 1996	521,5926494	470,2778461	494,6394751	337,8720853	396,5529733	298,0462183	319,6286303	426,2693687	588,558502	
Sales, 1996	47840	43009	418725	40651	226244	189922	82002	53013	34529	1135935
	21,96691919	17,80575463	182,3325403	12,09121837	78,98139497	49,8316663	23,07366789	19,89358374	17,89040439	423,8671498
Real Price, 2004	394,9810871	434,4190221	350,8892083	322,8991454	404,1354721	378,1123786	271,1807008	308,0327134	339,4571126	
Sales, 2004	96877,17883	136585,3415	898414,7617	137434,8129	618152,8707	970442,922	320555,2355	183951,6251	106197,6127	3468612,361
	11,03168917	17,10634233	90,88477225	12,79404529	72,02231793	105,7876878	25,06143217	16,33596156	10,39307112	361,4173196
									Ratio 2004/1996	0,852666501
								% decrease in 8 years		0,147333499
							Freezers Annual Price Growth:			-0,019726189
							Refr+WM+ Freez. Annual Price Growth:			-0,013288408
								(weighted by sales, GfK data)		
							EU25 Large Appliance Price Index Growth:			-0,008
								(1996-2006, EU official data)		

GfK gathered price data for the latest available years for the above countries. The percent change in the average, weighted by sales, was computed for the period 1996-2004. As shown this results in real price declines of 0,032%/year, 1,97%, and 2,19% for refrigerators, freezers, and washing machines respectively. This is a very strong negative growth rate for real prices of washing machines. For dishwashers the EU25 average of -0,8%/year is used. As a check the average price decline for these three appliances is calculated weighting again by sales and compared to the EU25 large appliance price index. The three-appliance average is -1,3%/year compared to -0,8%/year for the EU25 appliance index, which appears reasonable.

7.4.2.2 Other General Assumptions

The base year is 2007, the year of announcement of a policy is 2008 and the first year of the policy implementation is 2009. Including the first year of the policy, 15 years of production are simulated ending in 2023. Since the last appliance sold in year 2023 has a fifteen-year lifetime that produces savings through year 2038, which is the last year simulated for consumers.

As in the original version of E-GRIM, it is assumed that the normal activities of production including the normal level of capital investment, assumed to be 4,5% of sales, produces the historic increase in labour productivity of 1,5% per year. This increase of labour productivity may come through automation or relocation of facilities. It is applied to direct labour and variable overheads in both the BAU and policy scenarios. There is also an option to increase these types of investments.

The real discount rate of 5% is used. This compares with a real risk free discount rate of 2 to 3% in Europe (for long term government bonds for example) plus a very low risk premium in keeping with the social aspects of public policy.

In these simulations the Base Case or business as usual scenario (BAU) is defined as a continuation of the affects of present policies through year 2008, then from year 2009 and forward the relative quota of sales and production remain constant. No new policies are introduced and producers keep their quotas constant. Instead the policy scenario, here called ‘Scenario Evolution’ represents a possible tendency of the quotas without a well-defined instrument on the part of the governments, European Commission or producers to achieve that new tendency. It is an exploration on the production side to see the implication of achieving such a new tendency without the extra costs in promotion to achieve it, in terms of extra marketing costs, a production tax scheme or EC policy. More detailed policy analysis will be made subsequently in Task 7.

In the dual production model depreciation is treated as a more rapidly changing variable than usual. This is believed to better represent the cost of conversion, which will involve more re-tooling costs with a shorter lifetime (typically 5 years). Essentially depreciation is a lagged amount of capital expenditures for each production line.

7.4.2.3 General Output Information

Starting from the first year, a profit/loss and cash flow statement is projected forward for 15 years based on all the various cost and price assumptions. For each year a complete profit/loss and cash flow statement is available. In the case of the dual production model this applies to each line of production and a summary of the profits, taxes and cash flow for the combination of both lines, that is the entire production facility. Thus for the 15 year period we have all the key production variables: units shipped, manufacturer’s price, revenue, all the major costs, the profit before taxes, the corporate taxes, net profits, depreciation, change in working capital, operating cash flow, capital investments, net (or free) cash flow. These may be displayed in table or graphic form. A key summary variable for the manufacturers' is the net present value (or discounted value) of the net cash flows. This is industry value that has been added over the years and is used as a summary comparison of policies.

The model calculates the various impacts on consumers assuming that all the models produced are sold, assuming zero change in inventories in the long run. Consumers' purchases, and the difference in the price between the newer and the substituted model are calculated. This difference is the investment cost for the relative energy saving between the two models, as hypothesized in the LCC optimization in Task 6. Economic savings, electricity savings and avoided carbon dioxide emissions are calculated as a result of sales and use by the consumer for each year through 2038, after the last product sold has exhausted its average lifespan.

A new feature was introduced in E-GRIM for estimating the changes in cash flows of a government that introduces production tax credits. This is a new type of policy instrument currently being utilized by the US government to promote high efficiency appliances that appears to be more effective than traditional rebates (or reduction in value added tax) and costs less for the government.

7.4.3 Impact Analysis and Results for Washing Machines

From Task 6, Tables 6.31 and 6.32, we have the characteristic of each of the three models of washing machine (Table 7.24)

Table 7.24: Characteristics of the Washing Machine Models

Model	Energy consumption		Water consumption	Manufacturer Price	Consumer Price
	(kWh/cycle)	(kWh/kg)	(litre/cycle)	(€)	(€)
BAT	0,855	0,1596	38,7	180	540,8
LLCC	0,900	0,168	38,7	153	459,7
Base	0,998	0,186	50,7	148	443,5

7.4.3.1 Formulation of preliminary Scenarios for washing machines

Let us consider the evolution of washing machine energy efficiency classes given in Task 2 and disaggregating where necessary for models in years 2003, 2004 and 2005. For year 2008 an estimate for a continuation of the affects of the present policies for the 5,36 kg machine (defined in Task 5) is made as shown in Table 7.25.

Table 7.25: Trend (2003-2008) of Market Quota (%) by model type for washing machines

WM models	Energy consumption (kWh/cycle)	2003 (%)	2004 (%)	2005 (%)	2008 (%)
BAT	0,855	0	0	1	2
LLCC	0,900	0	21	37	55
Base case	0,998	18	67	53	35
Energy efficiency class B	--	11	6	5	4
Energy efficiency class C	--	9	5	4	4
Energy efficiency class D	--	2	1	0	0

At the factory level, two sets of hypotheses are made:
1) maximizing the quota of the LLCC
2) rapid introduction of BAT.

Within each set we have the BAU and Evolution Scenarios. The factory is simulated with two production lines.

In the first case we can imagine a producer who has a little over half of his production in the LLCC model and desires to produce a maximum amount in the future, phasing out the base model production.

Instead, the second case represents a manufacturer who is already fully producing the LLCC model and just introducing the BAT model. He wishes to bring them to a 50%/50% capacity in the future. In both hypotheses the Business-as-Usual (BAU) scenario is represented by a fixed continuation of the 2008 production quotas (Table 7.26).

Table 7.26: Production hypotheses for washing machines

Hypothesis Set	Model	Factory capacity (%)		
		2008	2023 BAU	2023 Evolution
Maximum quota LLCC	LLCC	55	55	100
	Base	45	45	0
Fast introduction of BAT	BAT	5	5	50
	Base	95	95	50

The Evolution Scenario is a representation of the producers' wishes without the introduction of specific policy instruments to achieve the desired changes in production. Only the costs of production are included, not even extra costs of a marketing campaign for promoting the desired changes. Policy will be fully studied subsequently.

7.4.3.2 Inputs and results of washing machine hypothesis set: 'Maximum Quota LLCC'

The input data for the base case model production line is as shown in Table 7.27.

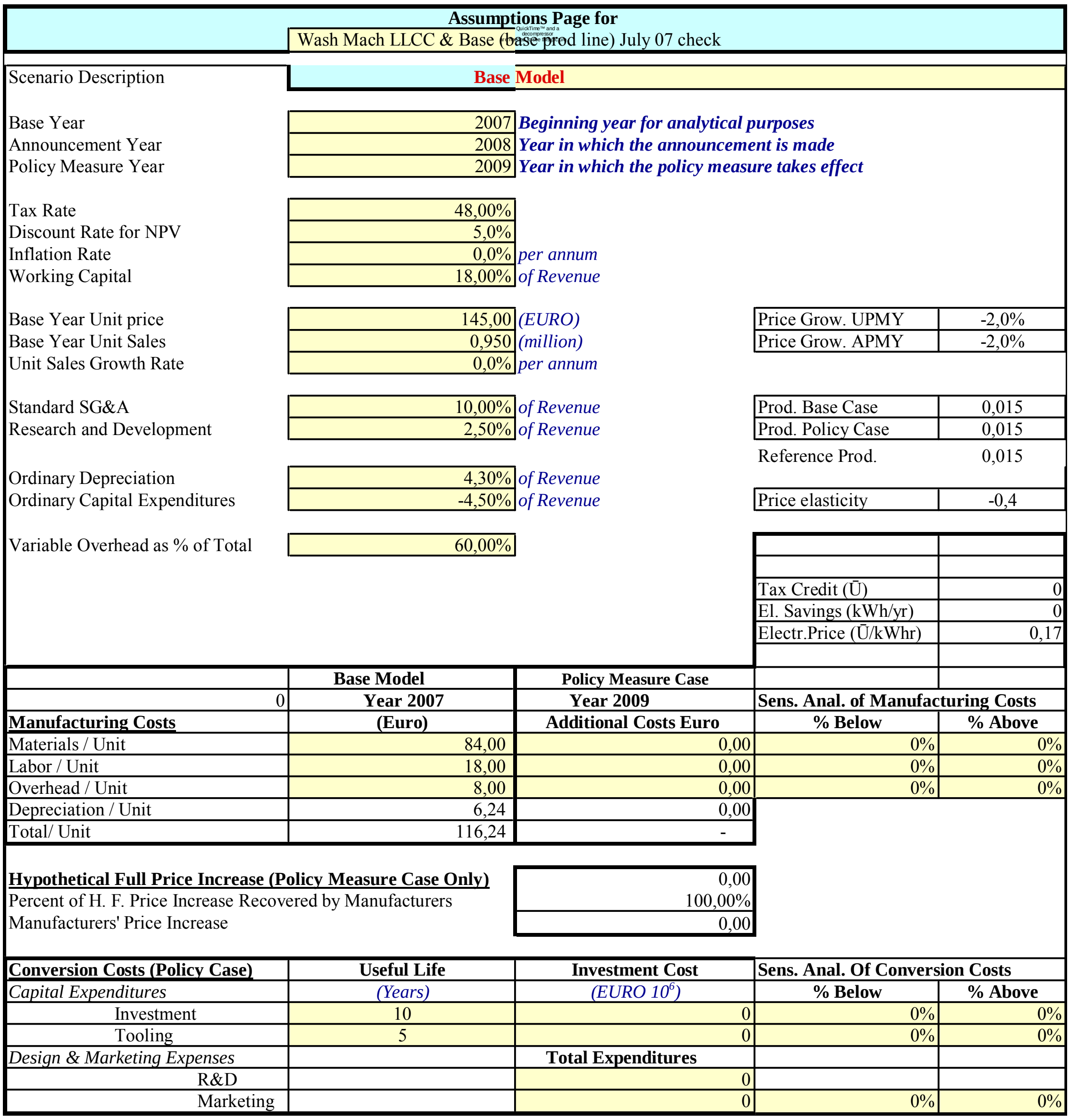
In this first hypothesis, for the Base Case Model we have hypothesized a manufacturing (unit) cost of 116 €, or about 80% of manufacturing price of 145 €. The more detailed manufacturing costs are as given above. Notice that a very strong decrease in real prices is input at 2,0%/year, near the recent historic average of minus 2,2%/year as reported earlier.

The data assumptions and input for the second production line with the LLCC model costs are illustrated in Table 7.28.

Notice that the shipments of BAU and Evolution Scenarios are specifically included, along the distribution/retail mark-up given as 3 and an input of water savings per year estimated at 9,77 € (2,64 m^3 x 3,7 €/m^3). Again the real price decline is given as -2,0%/year, as illustrated in Figure 7.20.

A similar trend is working on the base model prices. The resulting cash flows are seen in Figure 7.21 for the BAU scenario.

Table 7.27: Input for the Washing Machine Base Model



Assumptions Page for

Wash Mach LLCC & Base (base prod line) July 07 check

Scenario Description	**Base Model**			
Base Year	2007	***Beginning year for analytical purposes***		
Announcement Year	2008	***Year in which the announcement is made***		
Policy Measure Year	2009	***Year in which the policy measure takes effect***		
Tax Rate	48,00%			
Discount Rate for NPV	5,0%			
Inflation Rate	0,0%	*per annum*		
Working Capital	18,00%	*of Revenue*		
Base Year Unit price	145,00	*(EURO)*	Price Grow. UPMY	-2,0%
Base Year Unit Sales	0,950	*(million)*	Price Grow. APMY	-2,0%
Unit Sales Growth Rate	0,0%	*per annum*		
Standard SG&A	10,00%	*of Revenue*	Prod. Base Case	0,015
Research and Development	2,50%	*of Revenue*	Prod. Policy Case	0,015
			Reference Prod.	0,015
Ordinary Depreciation	4,30%	*of Revenue*		
Ordinary Capital Expenditures	-4,50%	*of Revenue*	Price elasticity	-0,4
Variable Overhead as % of Total	60,00%			
			Tax Credit (Ū)	0
			El. Savings (kWh/yr)	0
			Electr.Price (Ū/kWhr)	0,17

	Base Model	**Policy Measure Case**		
0	**Year 2007**	**Year 2009**	**Sens. Anal. of Manufacturing Costs**	
Manufacturing Costs	**(Euro)**	**Additional Costs Euro**	**% Below**	**% Above**
Materials / Unit	84,00	0,00	0%	0%
Labor / Unit	18,00	0,00	0%	0%
Overhead / Unit	8,00	0,00	0%	0%
Depreciation / Unit	6,24	0,00		
Total/ Unit	116,24	-		

Hypothetical Full Price Increase (Policy Measure Case Only)	0,00
Percent of H. F. Price Increase Recovered by Manufacturers	100,00%
Manufacturers' Price Increase	0,00

Conversion Costs (Policy Case)	**Useful Life**	**Investment Cost**	**Sens. Anal. Of Conversion Costs**	
Capital Expenditures	*(Years)*	*(EURO 10^6)*	**% Below**	**% Above**
Investment	10	0	0%	0%
Tooling	5	0	0%	0%
Design & Marketing Expenses		**Total Expenditures**		
R&D		0		
Marketing		0	0%	0%

Table 7.28: Input for the Washing Machine LLCC Model

Assumptions Page for				
Situation Studied	**Wash Mach LLCC &BASE Ver July 07**			
Situation Studied in Base Prod.	**Wash Mach LLCC & Base (base prod line) July 07 check**			
	Wash Mach LLCC & Base (base prod line) July 07 check			
Base Year	2007			
Announcement Year	2008	***Year in which the announcement is made***		
Policy Measure Year	2009	***Year in which the policy measure takes effect***		
Tax Rate	48,00%			
Discount Rate for NPV	5,0%			
Inflation Rate	0,0%	*per annum*		
Working Capital	18,00%	*of Revenue*		
Base Year Unit price	160,00	*(EURO)*	Price Grow. UPMY	-2,0%
Base Year Unit Sales	0,050	*(million)*	Price Grow. APMY	-2,000%
Unit Sales Growth Rate	0,0%	*per annum*		
Standard SG&A	10,00%	*of Revenue*	Prod. Base Case	0,015
Research and Development	2,50%	*of Revenue*	Prod. Policy Case	0,015
			Reference Prod.	0,015
Ordinary Depreciation	4,30%	*of Revenue*		
Ordinary Capital Expenditures	-4,50%	*of Revenue*	Price elasticity	-0,4
Variable Overhead as % of Total	60,00%		Dist. Mark-up	3,00
			Tax Credit (Ū)	0
			El. Savings (kWh/yr)	21,56
			Electr.Price (Ū/kWhr)	0,17
			Water Savings (Ū/yr)	9,77
	BAT Case	**Policy Measure Case**		
0	**Year 2007**	**Year 2009**	**Sens. Anal. of Manufacturing Costs**	
Manufacturing Costs	**(Euro)**	**Additional Costs Euro**	**% Below**	**% Above**
Materials / Unit	**85,00**	0,00	0%	0%
Labor / Unit	**18,00**	0,00	0%	0%
Overhead / Unit	**8,00**	0,00	0%	0%
Depreciation / Unit	6,88	0,00		
Total/ Unit	117,88	-		
Hypothetical Full Price Increase (Policy Measure Case Only)		0,00		
Percent of H. F. Price Increase Recovered by Manufacturers		100,00%		
Manufacturers' Price Increase		0,00		
Conversion Costs (Policy Case)	**Useful Life**	**Investment Cost**	**Sens. Anal. Of Conversion Costs**	
Capital Expenditures	*(Years)*	*(EURO 10^6)*	**% Below**	**% Above**
Investment	10		0%	0%
Tooling	5		0%	0%
Design & Marketing Expenses		**Total Expenditures**		
R&D		0		
Marketing		0	0%	0%
	Shipments BAU Scenario	**Shipments Evolution Scenario**		
(Year)	*(%)*	*(%)*		
2007	**48,00%**	**48,00%**		
2008	**52,00%**	**52,00%**		
2009	**55,00%**	**56,00%**		
2010	55,00%	**62,00%**		
2011	55,00%	**68,00%**		
2012	55,00%	**74,00%**		
2013	55,00%	**79,00%**		
2014	55,00%	**84,00%**		
2015	55,00%	**88,00%**		
2016	55,00%	**93,00%**		
2017	55,00%	**96,00%**		
2018	55,00%	**98,00%**		
2019	55,00%	**99,00%**		
2020	55,00%	**100,00%**		
2021	55,00%	**100,00%**		
2022	55,00%	**100,00%**		
2023	55,00%	**100,00%**		

Figure 7.20: Real Manufacturer's Price of the LLCC Model Washing Machine

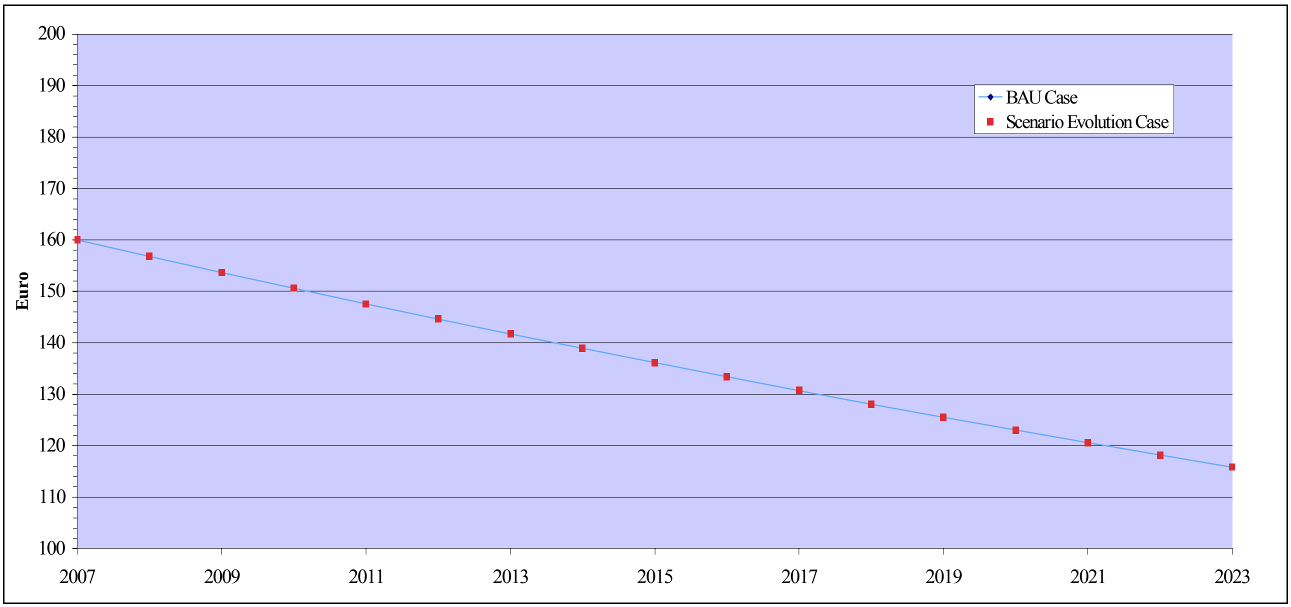
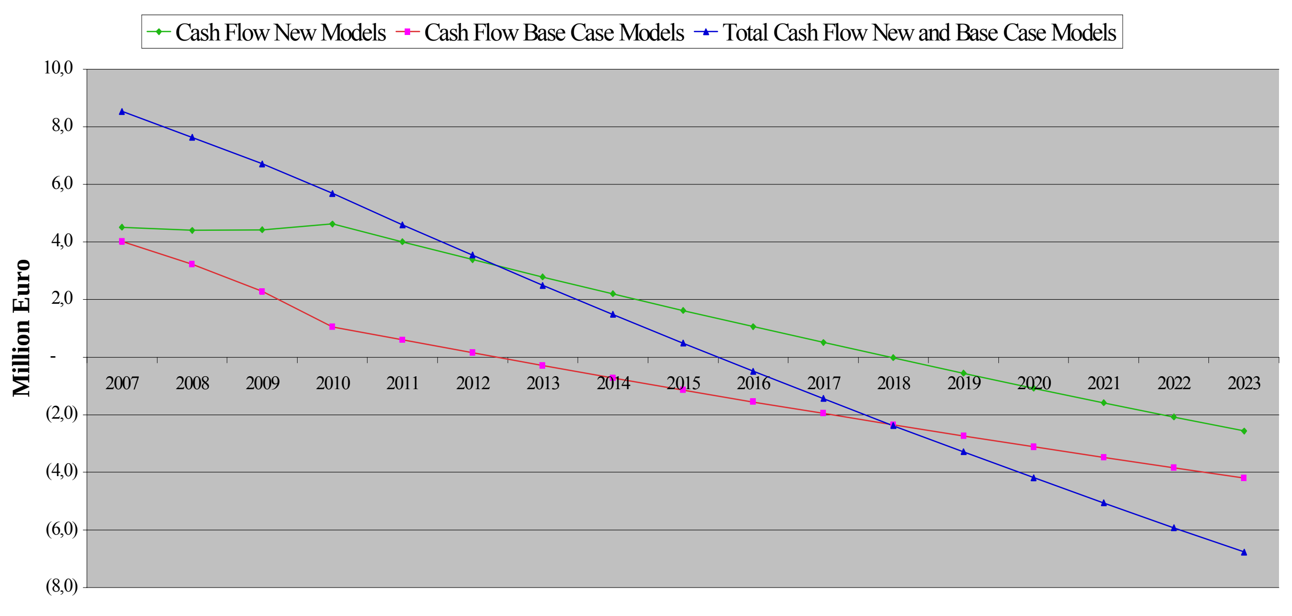


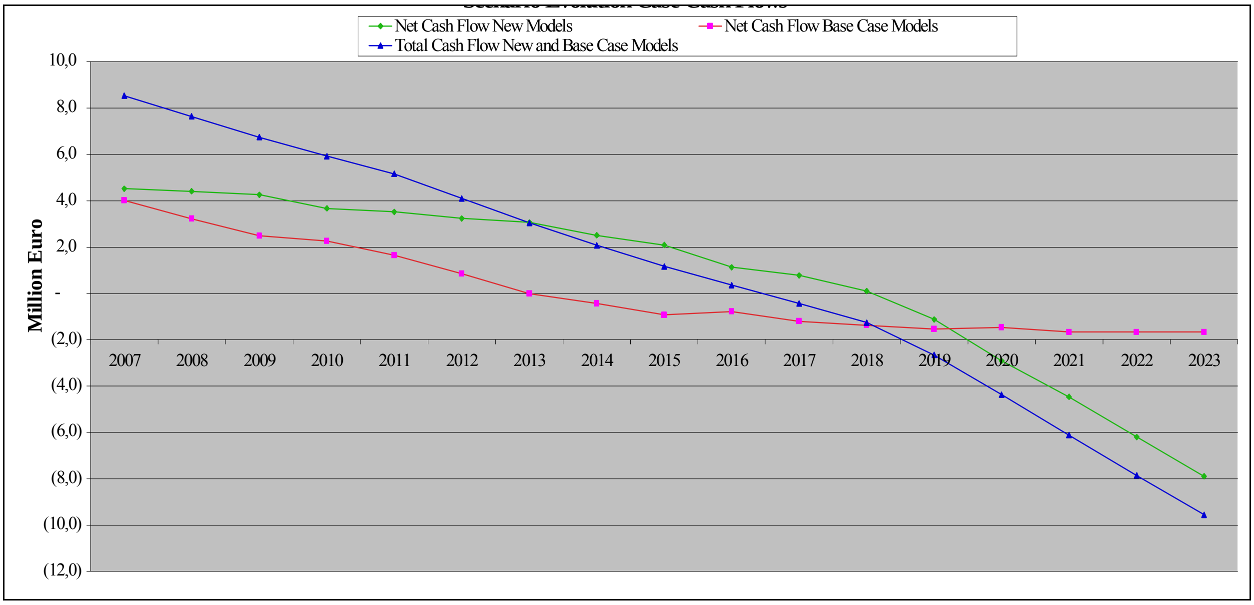
Figure 7.21: Base Model and LLCC Model (New Model) Cash Flow in the BAU



The initial years are more profitable. The LLCC production line in the beginning (year 2007) has a 5% net cash flow margin, that of the base model slightly less because it is an early product. In fact the LLCC cash flow increases while the LLCC production quota is rising. Once the quota is fixed in the BAU scenario (in 2009) then the LLCC cash flow begins to decline shortly thereafter. This is due to the dramatic impact of the price decreases. At some year around 2017 it is no longer profitable to produce.

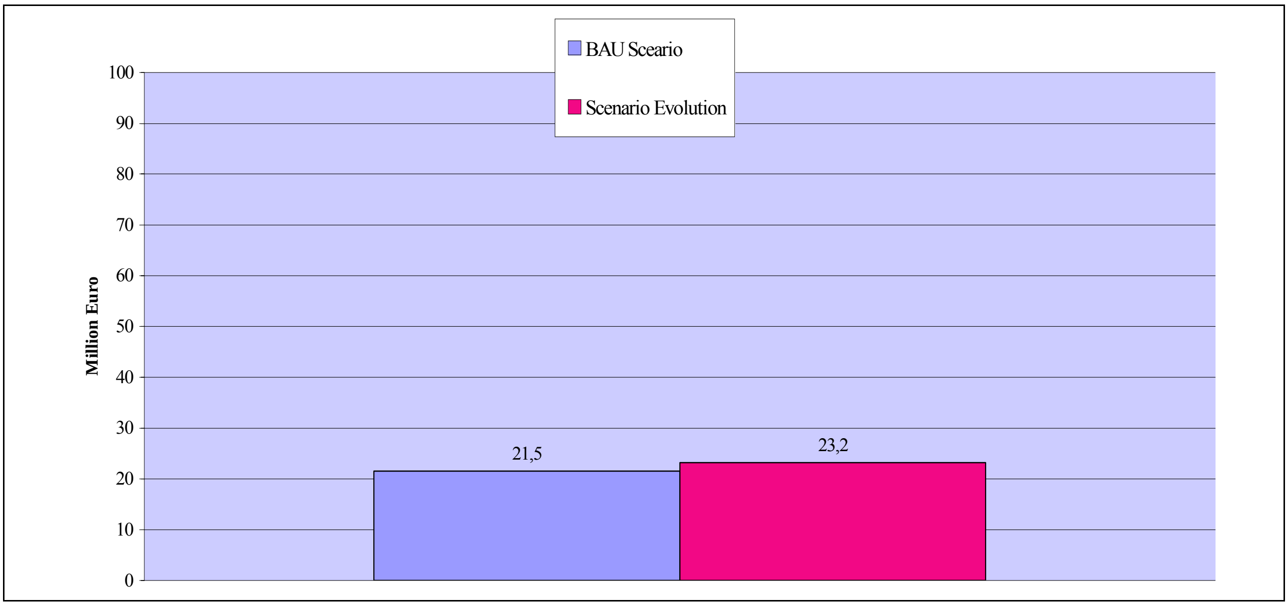
Turning to the Evolution Scenario matters are not that much different, primarily because there is not much difference in the cost structure of the two models. The LLCC is slightly more profitable, but taking into consideration the substitution impacts, which this model does, this difference is minimal. The cash flows in the Evolution Scenario are illustrated in Figure 7.22.

Figure 7.22: Cash Flows in the Evolution Scenario of the Base Model and LLCC Model Lines of Production



In the midyears, between 2011 and 2016, the cash flows of the LLCC model are slightly higher than those of the previous BAU scenario as the quota of the LLCC rise. Once the LLCC capacity reaches 100%, the price impact is seen in full. It is interesting to see the net present value of the total cash flows, called industry value, between the BAU and Evolution scenarios (Figure 7.23).

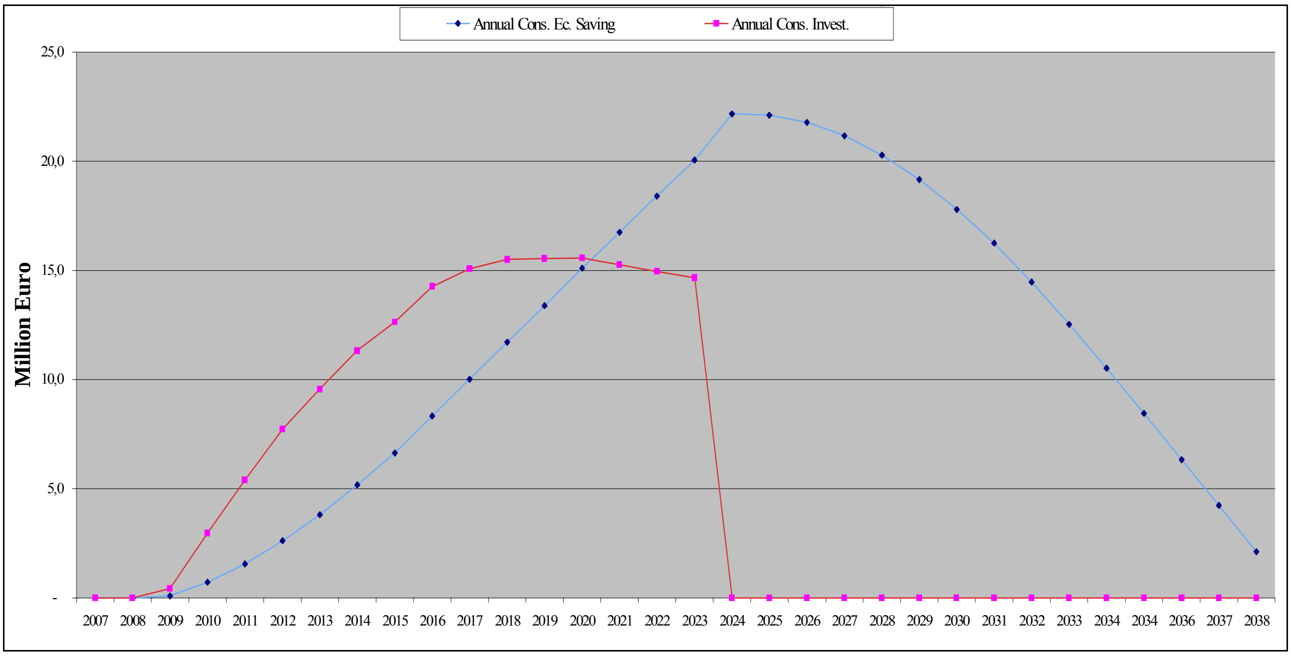
Figure 7.23: Industry Value in the BAU and Evolution Scenarios



First, the industry value is quite low in an absolute sense; 20 million Euro in 15 years of production is quite small, considering the cost of a one million-unit plant. Also in the latter years the plant is accumulating losses. This also rings a cost reduction warning, which is not explored here. Second, there is almost no difference in the industry value between the two scenarios. Converting from the base case to the LLCC model helps very marginally in front of the onslaught of such rapid price deterioration.

From the consumers' point of view matters are encouraging. The change in model has a relatively low price difference, which is declining in time, and there are significant water savings between the two models (12 litre/cycle). The payback time is 4,4 years. The annual investments (difference in consumer prices) and economic savings are shown in Figure 7.24. The consumers' discounted net benefits are some 40 million Euro, double that of industry.

Figure 7.24: Consumers' Investments and Benefits (electricity and water) in the Evolution Scenario



7.4.3.3 Inputs and results of washing machine hypothesis set: 'Accelerated Introduction of BAT'

Turning to the next hypothesis set of washing machines with a fast introduction of BAT, the input data for the BAT line of production is shown in Table 7.29.

Notice that the conversion to 50% occurs in four years, from 2009 to 2012, more rapidly than originally hypothesized. This is important to show the substitution impact in the early stages. The price decline is dramatic as usual at -2,0% per year and as a result the initial cash flow margins are set seemingly high. The BAT manufacturing initial price is set at 200 € with the manufacturing unit costs at 137 €.
The other line is characterized by a LLCC initial manufacturer's price of 153 € and a production cost of 121 €. In the BAU scenario this produces a cash flow margin of the BAT line of production above 7% in the first five years, but an average of 4,8% for the period. The LLCC line has an early margin around 3%, which goes to a negative -1,8% for the period, under the impact of strong price declines.

As a whole in the BAU scenario, where the quotas are fixed, there is a strong linear decline in cash flows as illustrated in Figure 7.25. In the Evolution Scenario we see more clearly the dynamics of substitution between the models and the relentless impact of rapidly declining prices (Figure 7.26).

Table 7.29: Input Data for BAT Production Line

Assumptions Page for				
Situation Studied	**Wash Mach BAT & LLCC (BAT Prod Line)**			
Situation Studied in Base Prod.	**Wash Mach BAT & LLCC (LLCC prod line)**			
	Wash Mach BAT & LLCC (LLCC prod line)			
Base Year	2007			
Announcement Year	2008	***Year in which the announcement is made***		
Policy Measure Year	2009	***Year in which the policy measure takes effect***		
Tax Rate	48,00%			
Discount Rate for NPV	5,0%			
Inflation Rate	0,0%	*per annum*		
Working Capital	18,00%	*of Revenue*		
Base Year Unit price	200,00	*(EURO)*	Price Grow. UPMY	-2,0%
Base Year Unit Sales	0,050	*(million)*	Price Grow. APMY	-2,000%
Unit Sales Growth Rate	0,0%	*per annum*		
Standard SG&A	10,00%	*of Revenue*	Prod. Base Case	0,015
Research and Development	2,50%	*of Revenue*	Prod. Policy Case	0,015
			Reference Prod.	0,015
Ordinary Depreciation	4,30%	*of Revenue*		
Ordinary Capital Expenditures	-4,50%	*of Revenue*	Price elasticity	-0,4
Variable Overhead as % of Total	60,00%		Dist. Mark-up	3,00
			Tax Credit (Ū)	0
			El. Savings (kWh/yr)	9,9
			Electr.Price (Ū/kWhr)	0,17
			Water Savings (Ū/yr)	0
	BAT Case	**Policy Measure Case**		
0	**Year 2007**	**Year 2009**	**Sens. Anal. of Manufacturing Costs**	
Manufacturing Costs	**(Euro)**	**Additional Costs Euro**	**% Below**	**% Above**
Materials / Unit	**99,00**	0,00	0%	0%
Labor / Unit	**20,00**	0,00	0%	0%
Overhead / Unit	**9,00**	0,00	0%	0%
Depreciation / Unit	8,60	0,00		
Total/ Unit	136,60	-		
Hypothetical Full Price Increase (Policy Measure Case Only)		0,00		
Percent of H. F. Price Increase Recovered by Manufacturers		100,00%		
Manufacturers' Price Increase		0,00		
Conversion Costs (Policy Case)	**Useful Life**	**Investment Cost**	**Sens. Anal. Of Conversion Costs**	
Capital Expenditures	*(Years)*	*(EURO 10^6)*	**% Below**	**% Above**
Investment	10		0%	0%
Tooling	5		0%	0%
Design & Marketing Expenses		**Total Expenditures**		
R&D		0		
Marketing		0	0%	0%
	Shipments BAU Scenario	**Shipments Evolution Scenario**		
(Year)	*(%)*	*(%)*		
2007	**4,00%**	**4,00%**		
2008	**5,00%**	**5,00%**		
2009	**5,00%**	**10,00%**		
2010	5,00%	**20,00%**		
2011	5,00%	**35,00%**		
2012	5,00%	**50,00%**		
2013	5,00%	**50,00%**		
2014	5,00%	**50,00%**		
2015	5,00%	**50,00%**		
2016	5,00%	**50,00%**		
2017	5,00%	**50,00%**		
2018	5,00%	**50,00%**		
2019	5,00%	**50,00%**		
2020	5,00%	**50,00%**		
2021	5,00%	**50,00%**		
2022	5,00%	**50,00%**		
2023	5,00%	**50,00%**		

Figure 7.25: Washing machine (BAT= New Production Line and LLCC=Base Production Line) Cash Flows in the Business-As-Usual Scenario

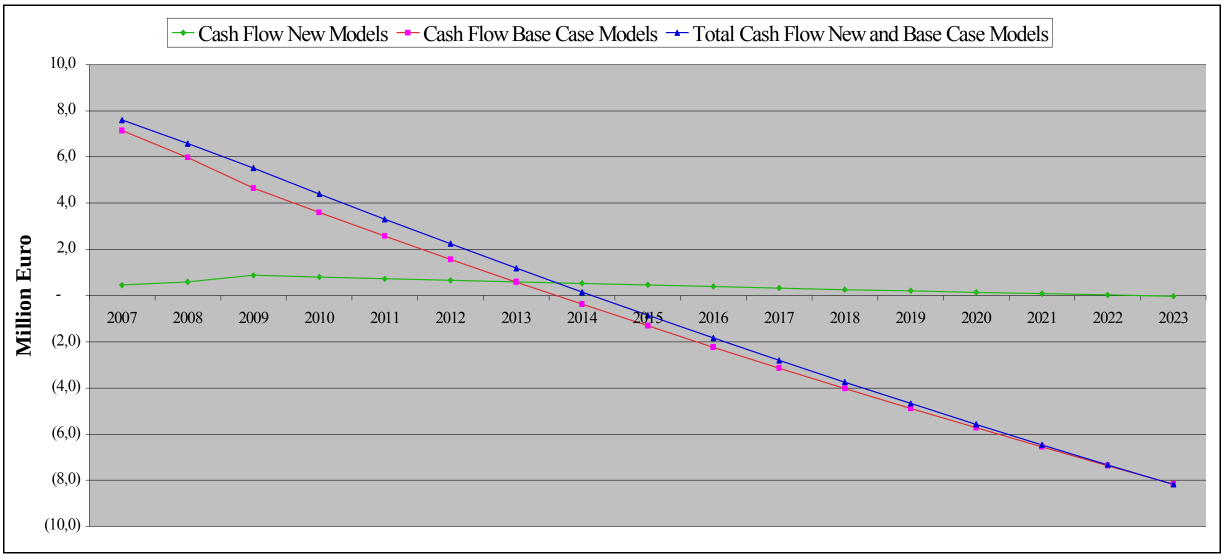
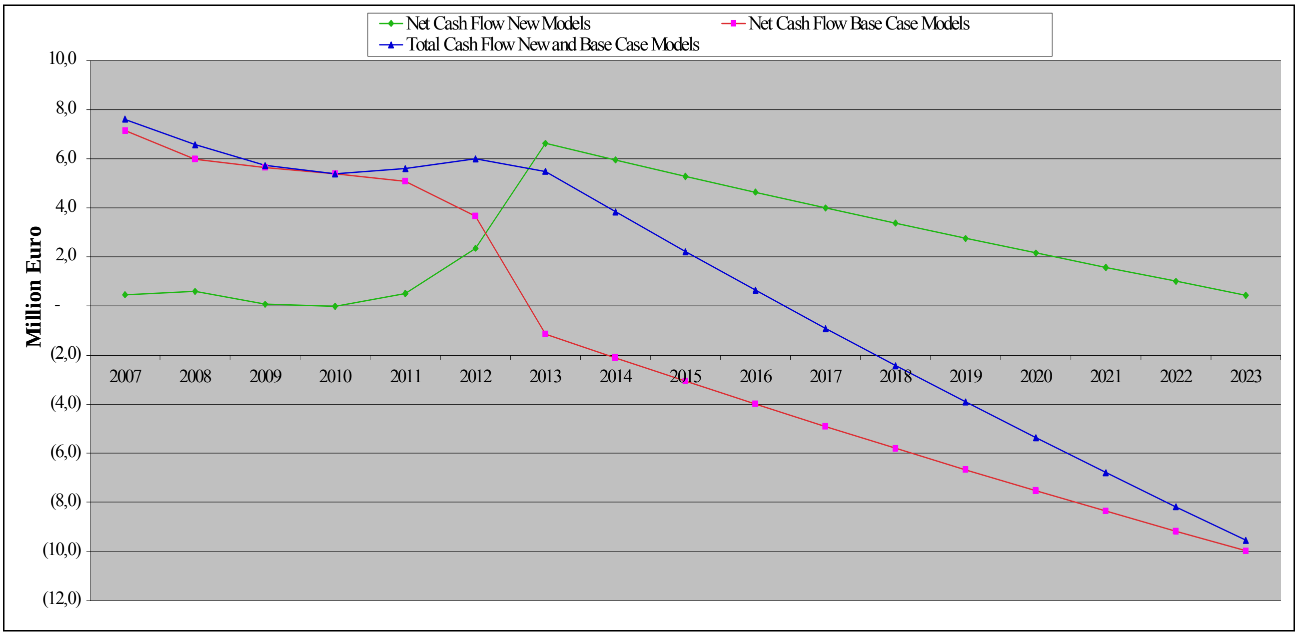


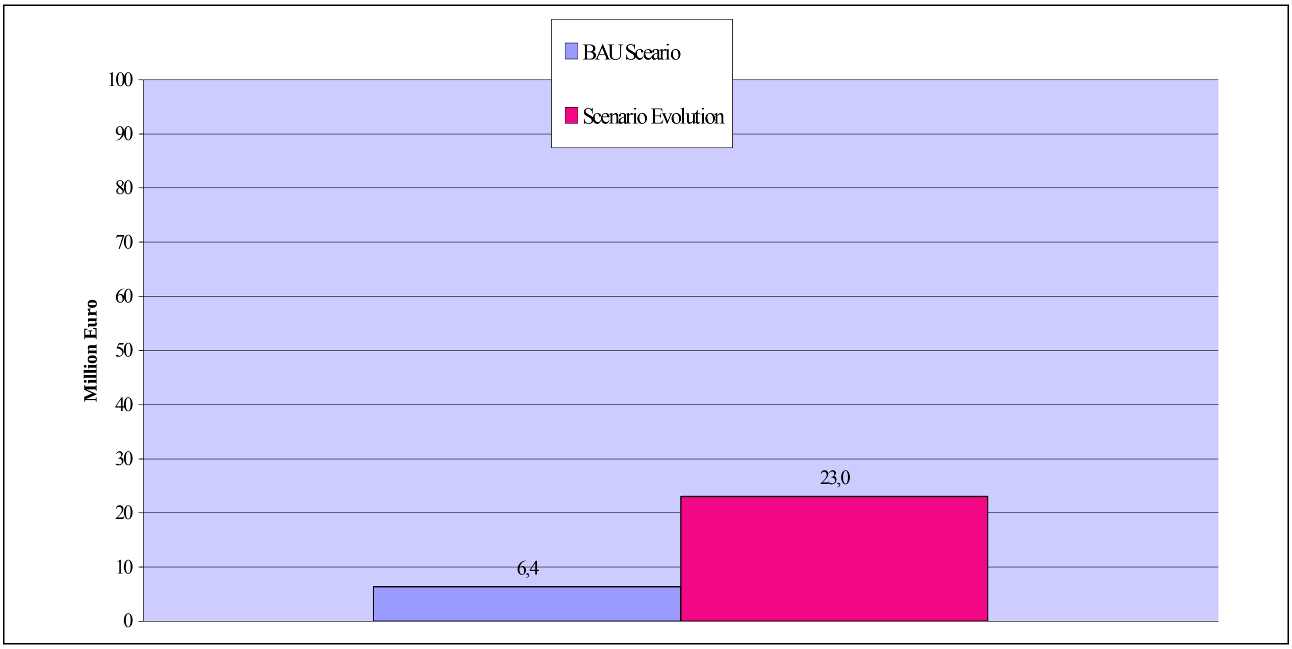
Figure 7.26: Washing machine (BAT= New Production Line and LLCC=Base Production Line) Cash Flows in the Evolution Scenario



Events go as desired up until 2012: the net cash flow of BAT increases while that of LLCC decreases and the total cash flow even begins to rise between 2010 and 2012.

In fact, in 2012 the maximum quota for BAT at 50% and the maximum value of the total net cash flow is reached (Figure 7.27); from then onward the price takes over. Clearly it would be helpful to continue the increase in the production quota for BAT, market permitting.

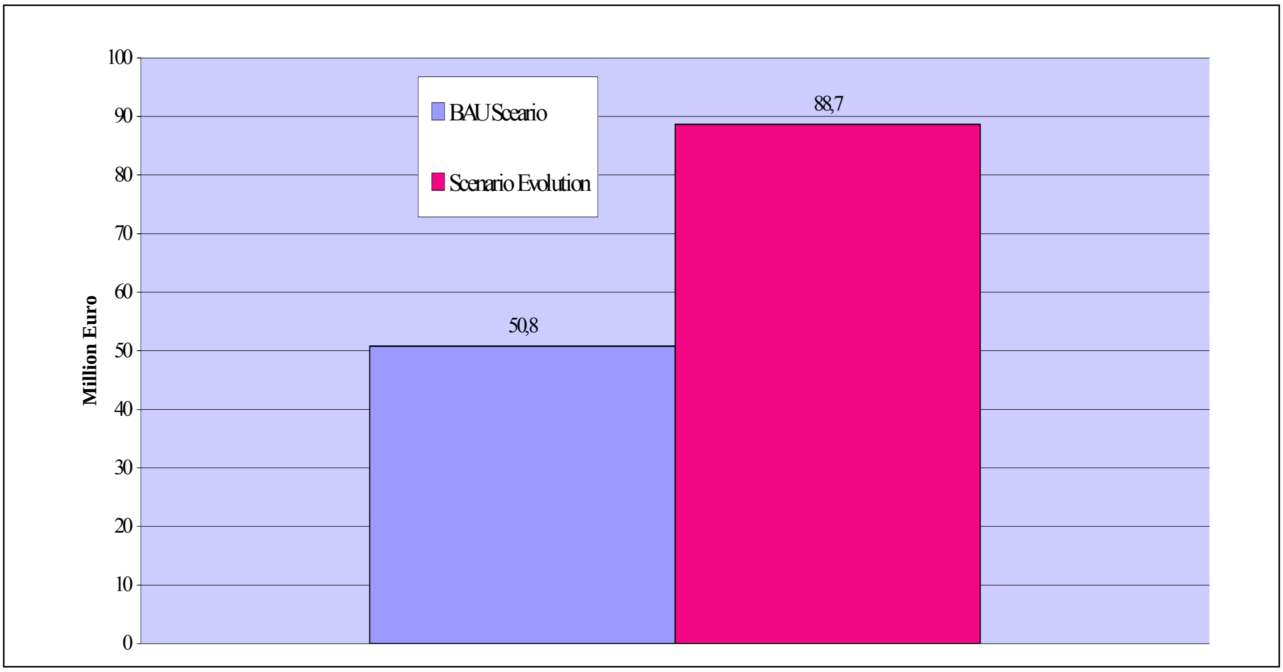
Figure 7.27: Washing machine Industry Value (NPV of Total Cash Flows) in BAU and Evolution Scenarios (Hypothesis of Accelerated BAT Introduction)



Under these circumstances what are the levels of the industry value under the two scenarios?

Again the absolute values are low, and the price affect reduces the overall values and the difference in the industry values under the two scenarios. We can show this, in an experiment reducing the real price decline to one percent/year as illustrated in Figure 7.28.

Figure 7.28: Industry Values (NPV of Total Cash Flows) under A One-Percent Real Price Decline



This is a new world! The total industrial values have quadrupled and the absolute difference between the two scenarios, the advantage of quickly introducing the BAT model, has gone from 17 to 38 million Euro.

The strategic emphasis for manufacturers of washing machines is still on differentiating the product in order to defend prices and on lowering costs.

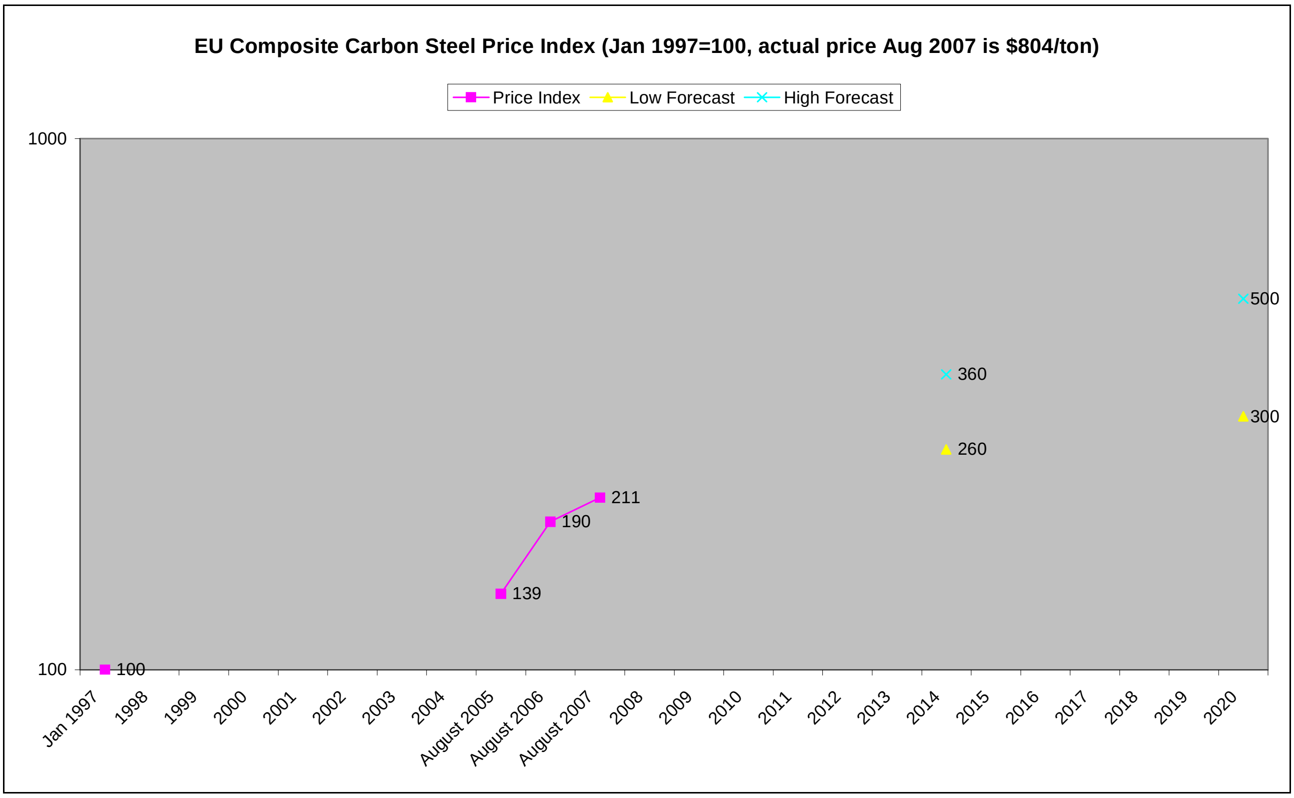
In contrast for the consumer, purchasing a BAT washing machines instead of a LLCC one, results in a small savings in electricity, valued at about 2€ per year and no savings in water. The difference in consumer price is around 80 € due to the high marginal cost of the additional technology and high mark-up in the distribution/retail sector given at 300% (consumer price = 300% manufacturer price). Clearly the informed consumer will purchase the BAT also for other reasons than electricity savings.

7.4.3.4 Cost sensitivity analysis and conclusions regarding washing machines

Price sensitivity was seen for the individual models and hypothesis. Here the sensitivity to cost changes in the base case and then in some instances the LLCC and BAT cases are analysed.

Steel prices[34] have risen dramatically recently as shown for the EU in Figure 7.29. The index has doubled in the last ten years, suggesting that it will at least do so in the next decade, given the very strong infrastructure demand in the developing world.

Figure 7.29: EU steel price trend



Using this conservative estimate we have a mid-period index price of 310, which would correspond to 1.181 € or € 844 € per ton. This represents a 270 €/ton increase over today’s prices. The metal composition of the base case washing machine, as reported in Task 5, is shown in Table 7.30.

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[34] Source: MPS Co., U.K.

Table 7.30: Metal composition of the base case washing machine

Ferrous Metal Composition of Washing Machine Base Model (kg.)	
Cast Iron	6,214
Iron	4,978
Total Cast Iron and Iron	11,192
Stainless Steel	1,939
Stainless Steel Sheet	0,564
Steel	12,521
Steel Strip	6,145
Total Steel	**21,169**
Total	**32,361**

With 21,2 kg of steel used to make the washing machine, the above represents a materials price increase of 5,70€ per unit or an increase in unit manufacturing cost by the same amount. Using a conservative one-third of the price increase for iron and cast iron adds 1,00€ for a total of 6,70€/unit. Electricity consumption during assembly is on the average 29 kWh/unit. Assuming that the price increases in the order of 0,02 to 0,04 €/kWh, this represents a 0,58 to 1,16 €/unit increase.

How much might we reasonably gain from extra labour productivity investments?

Let us assume that they still have a reasonable rate of return of between 3 and 5 years of payback time, beginning with 3 in the early years and ending at 5 years in the last. Let us assume we can add an extra 1,5% reduction in labour cost per year, that is we go from the usual historical 1,5% to its double 3,0%/year. In the case of the base case and LLCC hypothesis, the new Evolution Scenario, which contains this new productivity investment, the net present value of cash flow increases from 34,5 to 37,0 million Euro, a 2,5 million Euro increase. This in itself could offer some further limited financial advantage to manufacturers. The cost of labour can be brought down by automation or other means, but these have costs and the overall trade-off leads to these relative modest benefits.

With the BAT and LLCC production hypothesis, the productivity improvement is slightly greater with a 3,7 million Euro increase.

Compared to the potential increase in steel and ferrous metal prices however the labour productivity does not compensate the difference. On an undiscounted basis the 2,5 million Euro in productivity gains becomes about 3,4 million Euro and divided by the roughly 10 million units produced over the period, amounts to 0,34 € savings per unit, compared to possible increase in the cost of steel and iron from 5,70€ to 6,70 €, not to mention electricity cost increases. For the BAT and LLCC production, the equivalent is 0,50 €.

Could some of the component costs come down? Some of the largest items are the motor and pumps. The steel in these items has already been accounted for, but there might be labour cost savings in their production or some learning curve phenomenon. Suppose that the motor/pumps cost to the manufacturers is 50 €/unit about one-third of the materials and components total. In order to compensate for these possible cost changes due increase in steel prices, electricity prices and productivity investments by the washing machine producer, this would require cost reductions due to further automation or learning on the part of motor/pump producers in the order of 5,90 € to 7,40 €/unit, 12 to15% of their price.

This overall cost analysis may be summarised in Table 7.31.

Table 7.31: Sensitivity analysis of key costs for washing machine (changes mid-period)

Source	Estimated Impact on Average Unit Cost (€/unit)
Steel Price Increase	+5,70 to + 6,70
Electricity Price Gains	+0,58 to +1,16
Labour Productivity	-0.34 to -0,50
Component Maker Productivity Or Learning Efforts	Not estimated.

In general, these simulations for washing machines illustrate that:

1) **There is a high degree of sensitivity in cash flow due to price.** This is because price acts directly on revenues, cash flow is a difference equation (revenue minus costs) and the historic level of profit margin in the household appliance sector is low, from the 3 to 5%. To not overestimate these effects the fixed costs have been assumed to be a minimum.

2) **In the specific context of severe and continued decline in real prices (-2,0%/year), that have historically characterised the washing machine market, rather low levels of industry value are generated in both the BAU and Evolution scenario.** This is true despite an increase in labour productivity of 1,5% per year, which is applied in the simulation. Industry value is slightly greater with the BAT model due to higher value added.

3) Evidently there is a l**ack of pricing power on the part of the appliance producers**. Few large distributors in given geographic areas may exert a greater concentration of power, not allowing the household appliance producers much flexibility in pricing. Almost no producer has direct sales through Internet, although some distributors are beginning this.

4) **Also in this context of strong price decline, differences in margins of the products (2% here) have less impact on the improvement in industry values between the BAU and Evolution scenarios.** In the Base model LLCC model hypothesis, the investment in the conversion to more new product capacity is rewarded with a 15% increase in enterprise value over the period, which normally would be considered barely sufficient to cover the financial risks involved in a new investment. In the LLCC BAT case there is more improvement in industry value, but in part was due to the greater difference in margins between the two models.

5) **The sensitivity analysis of costs reveals the strongest cost increases coming from possible gains in steel prices.** Productivity investments within the freezer plant may help, but are an order of magnitude less than possible impact due to steel prices. Possible reductions in the cost of major components are not estimated but they would have to be substantial to offset other gains. If these steel price gains materialize, the washing machine production might be hard pressed to make a profit.

6) **Possible benefits from policy actions, for example production tax credits are yet to be analyzed.** This will be explored in the policy section. Public policy could be aimed at the energy saving products that are the most critical to introduce.

7.4.4 *Impact Analysis and Results for Dishwashers*

The general inputs and general outputs as outlined previously apply to both wash appliances, washing machines and dishwashers. From Task 6, Table 6.13: we have the characteristics of each model for the 12ps dishwasher (Table 7.32).

Table 7.32: Characteristics of the 12ps dishwasher models

Model	Energy consumption (kWh/cycle)	(EEI)	Water consumption (litre/cycle)	Noise (dBA)	Consumer Price (€)
BAT	0,914	0,554	10.64	50	779,5
LLCC	1,009	0,611	11,0	50	571,1
Base	1,070	0,648	15,2	50	548,4

7.4.4.1 Formulation of preliminary Scenarios for dishwashers

Let us consider the evolution of energy efficiency classes given in Task 2 and disaggregating where necessary for the models in years 2003, 2004 and 2005. For year 2008 an estimate for a continuation of the affects of the present policies is made in Table 7.33.

Table 7.33: Trend (2003-2008) of Market Quota (%) by model type for dishwashers

DW models	Energy consumption (kWh/cycle)	2003 (%)	2004 (%)	2005 (%)	2008 (%)
BAT	0,914	0	0	0,5	1,0
LLCC	1,009	0	0,5	1,0	1,5
Base case	1,070	72,9	80,3	88,7	95,0
Energy efficiency class B	--	17,4	13,3	7,7	2,0
Energy efficiency class C	--	9,1	5,4	2,3	0,5
Energy efficiency class D	--	0,6	0,5	0	0

At the factory level, again two sets of hypothesis (Table 7.34) are made:
1) Maximizing the quota of the LLCC
2) Rapid introduction of BAT.
Within each set we have the BAU and Evolution Scenarios. The factory has only two production lines.

Table 7.34: Production hypotheses for dishwashers

Hypothesis Set	Model	Factory capacity (%)		
		2008	2023 BAU	2023 Evolution
Maximum quota LLCC	LLCC	60	60	100
	Base	40	40	0
Fast introduction of BAT	BAT	1	1	50
	Base	99	99	50

The first hypothesis corresponds to the situation of a producer who is already producing a majority of LLCC models, 60% of capacity, and 40% capacity of the base model, in his large one-million unit plant. He could continue in this manner, the BAU hypothesis, or may explore the possibility of converting the all of his capacity to LLCC production over the next 5 years.

7.4.4.2 Inputs and results of dishwasher hypothesis set of 'Maximum Quota LLCC'

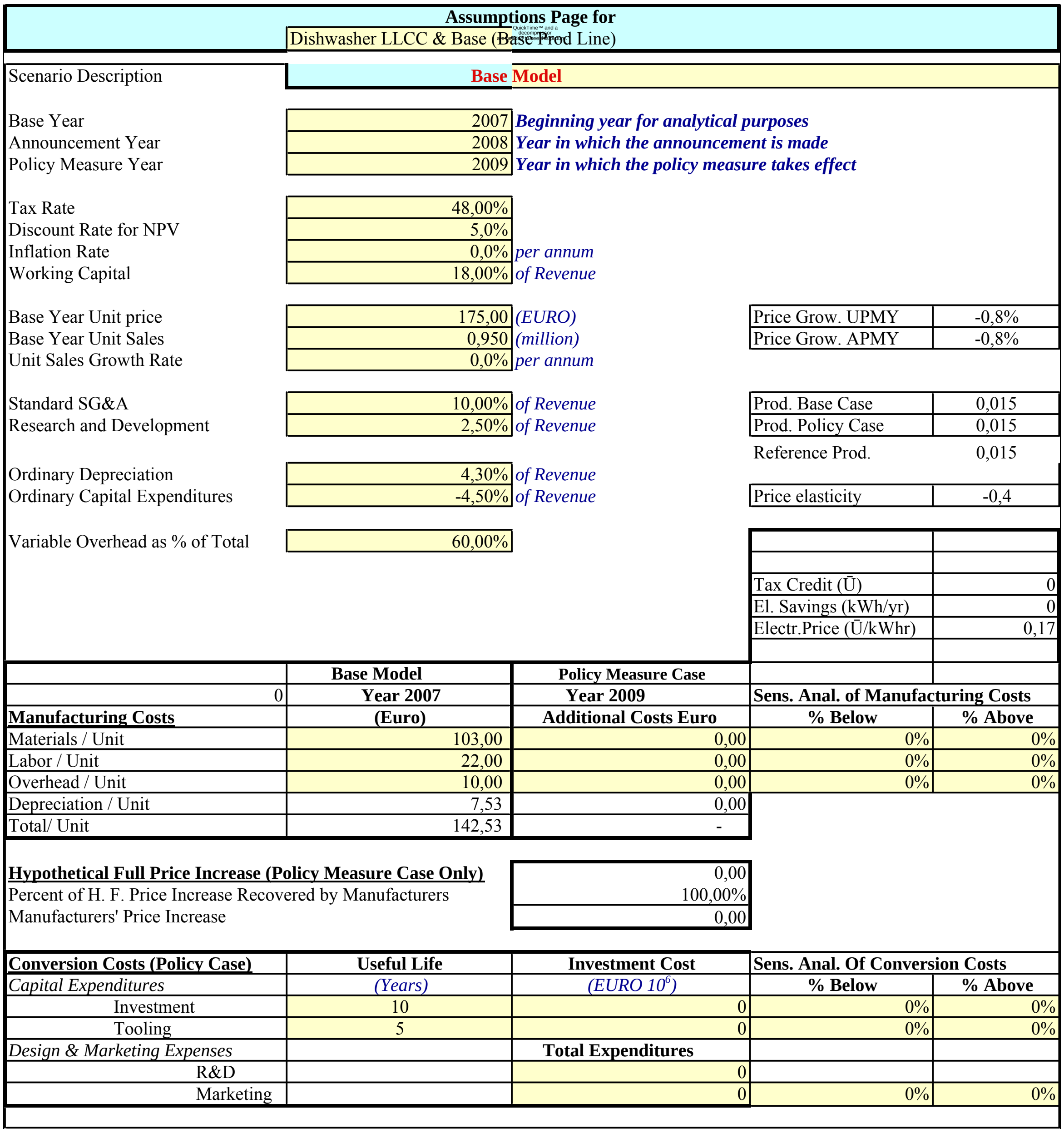
The input data and assumptions for the LLCC line of production are shown in Table 7.35.

Table 7.35: Inputs for the dishwasher LLCC line of production

Assumptions Page for				
Situation Studied	**Dishwasher LLCC & Base (LLCC Prod Line)**			
Situation Studied in Base Prod.	**Dishwasher LLCC & Base (Base Prod Line)**			
	Dishwasher LLCC & Base (Base Prod Line)			
Base Year	2007			
Announcement Year	2008	***Year in which the announcement is made***		
Policy Measure Year	2009	***Year in which the policy measure takes effect***		
Tax Rate	48,00%			
Discount Rate for NPV	5,0%			
Inflation Rate	0,0%	*per annum*		
Working Capital	18,00%	*of Revenue*		
Base Year Unit price	190,00	*(EURO)*	Price Grow. UPMY	-0,8%
Base Year Unit Sales	0,050	*(million)*	Price Grow. APMY	-0,800%
Unit Sales Growth Rate	0,0%	*per annum*		
Standard SG&A	10,00%	*of Revenue*	Prod. Base Case	0,015
Research and Development	2,50%	*of Revenue*	Prod. Policy Case	0,015
			Reference Prod.	0,015
Ordinary Depreciation	4,30%	*of Revenue*		
Ordinary Capital Expenditures	-4,50%	*of Revenue*	Price elasticity	-0,4
Variable Overhead as % of Total	60,00%		Dist. Mark-up	3,00
			Tax Credit (Ū)	0
			El. Savings (kWh/yr)	17
			Electr.Price (Ū/kWhr)	0,17
			Water Savings (Ū/yr)	4,35
	BAT Case	**Policy Measure Case**		
0	**Year 2007**	**Year 2009**	**Sens. Anal. of Manufacturing Costs**	
Manufacturing Costs	**(Euro)**	**Additional Costs Euro**	**% Below**	**% Above**
Materials / Unit	**105,00**	0,00	0%	0%
Labor / Unit	**22,20**	0,00	0%	0%
Overhead / Unit	**10,40**	0,00	0%	0%
Depreciation / Unit	8,17	0,00		
Total/ Unit	145,77	-		
Hypothetical Full Price Increase (Policy Measure Case Only)		0,00		
Percent of H. F. Price Increase Recovered by Manufacturers		100,00%		
Manufacturers' Price Increase		0,00		
Conversion Costs (Policy Case)	**Useful Life**	**Investment Cost**	**Sens. Anal. Of Conversion Costs**	
Capital Expenditures	*(Years)*	*(EURO 10^6)*	**% Below**	**% Above**
Investment	10		0%	0%
Tooling	5		0%	0%
Design & Marketing Expenses		**Total Expenditures**		
R&D		0		
Marketing		0	0%	0%
	Shipments BAU Scenario	**Shipments Evolution Scenario**		
(Year)	*(%)*	*(%)*		
2007	**57,00%**	**57,00%**		
2008	**60,00%**	**60,00%**		
2009	**60,00%**	**65,00%**		
2010	60,00%	**75,00%**		
2011	60,00%	**85,00%**		
2012	60,00%	**95,00%**		
2013	60,00%	**100,00%**		
2014	60,00%	**100,00%**		
2015	60,00%	**100,00%**		
2016	60,00%	**100,00%**		
2017	60,00%	**100,00%**		
2018	60,00%	**100,00%**		
2019	60,00%	**100,00%**		
2020	60,00%	**100,00%**		
2021	60,00%	**100,00%**		
2022	60,00%	**100,00%**		
2023	60,00%	**100,00%**		

The producer's price is 190 € and the manufacturing cost 147 €/unit which, results in an average cash flow margin of 3,9% for the period in the BAU scenario. A most important input is the real price dynamic that is hypothesized here as -0,8 %/year, the EU25 average for appliances. This is applied to both the LLCC and Base models. As seen energy savings is 0,061 kWh/cycle for 280 cycles per year or 17 kWh/year. Water savings is 4,2 litres/cycle or 1,176 m^3/year valued at 4,35€/year. The inputs for the base model is shown in Table 7.36.

Table 7.36: Inputs for the dishwasher Base Model line of Production



Assumptions Page for
Dishwasher LLCC & Base (Base Prod Line)

Scenario Description	**Base Model**			
Base Year	2007	*Beginning year for analytical purposes*		
Announcement Year	2008	*Year in which the announcement is made*		
Policy Measure Year	2009	*Year in which the policy measure takes effect*		
Tax Rate	48,00%			
Discount Rate for NPV	5,0%			
Inflation Rate	0,0%	*per annum*		
Working Capital	18,00%	*of Revenue*		
Base Year Unit price	175,00	*(EURO)*	Price Grow. UPMY	-0,8%
Base Year Unit Sales	0,950	*(million)*	Price Grow. APMY	-0,8%
Unit Sales Growth Rate	0,0%	*per annum*		
Standard SG&A	10,00%	*of Revenue*	Prod. Base Case	0,015
Research and Development	2,50%	*of Revenue*	Prod. Policy Case	0,015
			Reference Prod.	0,015
Ordinary Depreciation	4,30%	*of Revenue*		
Ordinary Capital Expenditures	-4,50%	*of Revenue*	Price elasticity	-0,4
Variable Overhead as % of Total	60,00%			
			Tax Credit (Ū)	0
			El. Savings (kWh/yr)	0
			Electr.Price (Ū/kWhr)	0,17

	Base Model	Policy Measure Case		
0	**Year 2007**	**Year 2009**	**Sens. Anal. of Manufacturing Costs**	
Manufacturing Costs	**(Euro)**	**Additional Costs Euro**	**% Below**	**% Above**
Materials / Unit	103,00	0,00	0%	0%
Labor / Unit	22,00	0,00	0%	0%
Overhead / Unit	10,00	0,00	0%	0%
Depreciation / Unit	7,53	0,00		
Total/ Unit	142,53	-		

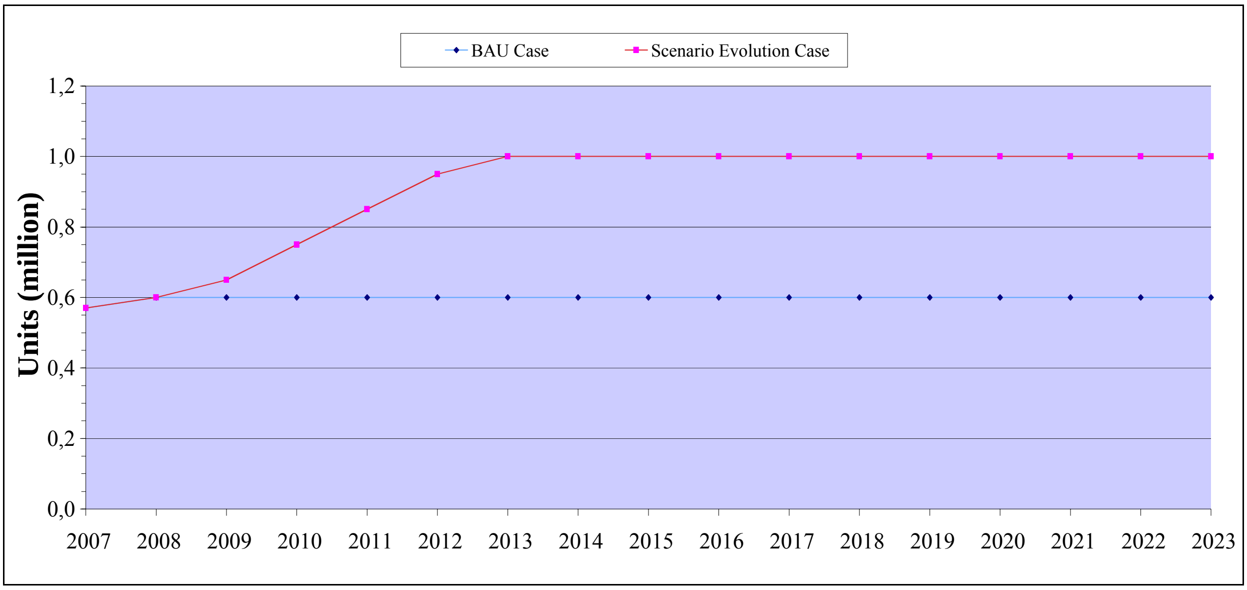
Hypothetical Full Price Increase (Policy Measure Case Only)	0,00
Percent of H. F. Price Increase Recovered by Manufacturers	100,00%
Manufacturers' Price Increase	0,00

Conversion Costs (Policy Case)	**Useful Life**	**Investment Cost**	**Sens. Anal. Of Conversion Costs**	
Capital Expenditures	*(Years)*	*(EURO 10^6)*	**% Below**	**% Above**
Investment	10	0	0%	0%
Tooling	5	0	0%	0%
Design & Marketing Expenses		**Total Expenditures**		
R&D		0		
Marketing		0	0%	0%

The manufacturer's price is 175 € and the total manufacturing cost reaches 142,5 €, which results in an average net cash flow margin of 1,5% for the base model for the period in the BAU scenario. This is lower than that of the LLCC in keeping with product life cycle dynamics. This is shown on the detailed table giving the calculation of the cash flows for the BAU.

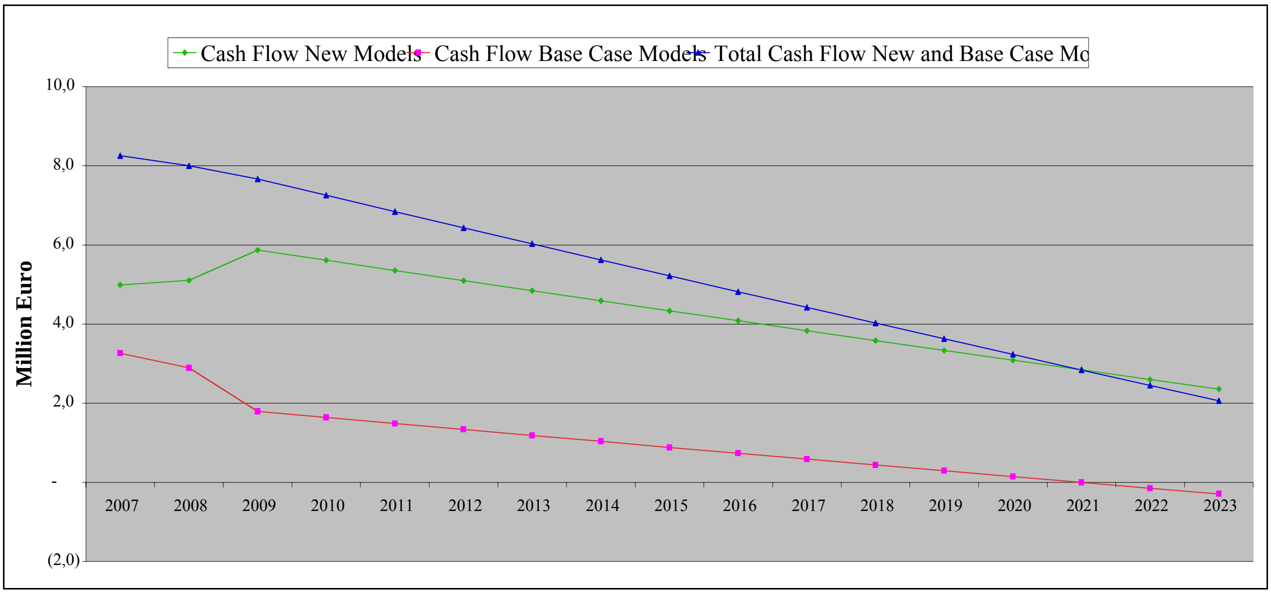
The shipments (and capacity utilization) are shown in Figure 7.30 for the dishwasher LLCC model, as hypothesized in the two scenarios.

Figure 7.30: Shipments of the LLCC dishwasher



In the BAU scenario there are very few surprises with the fixed quotas, as illustrated by the cash flow in Figure 7.31

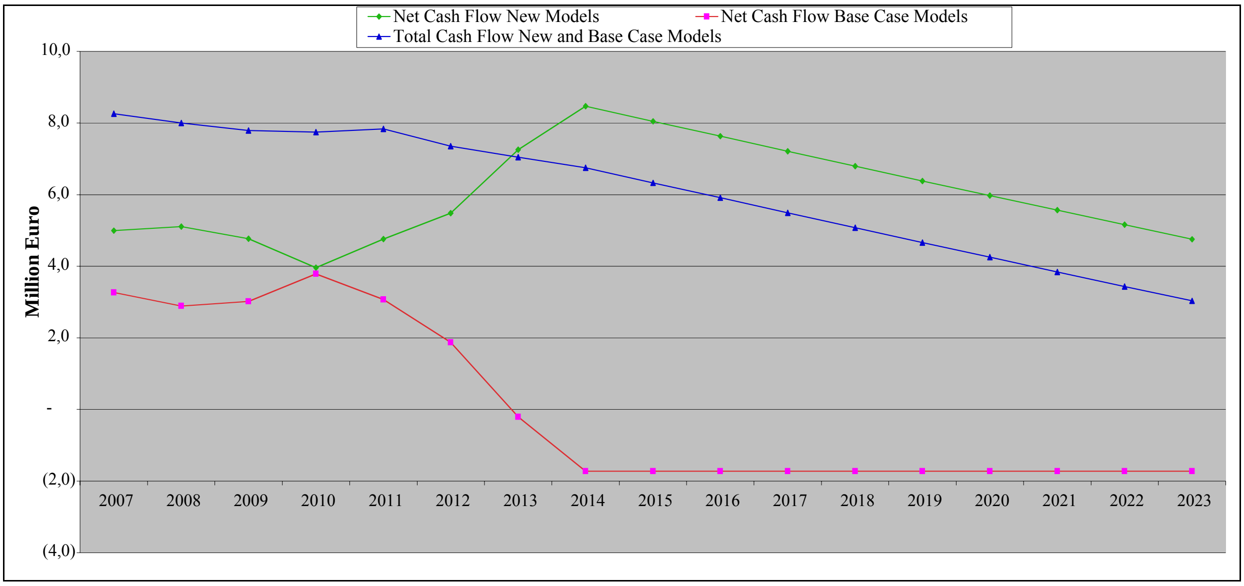
Figure 7.31: Net Cash Flows of the LLCC (New) and Base Model dishwasher in the BAU Scenario



After the initial brief increase in LLCC capacity between 2007 and 2008, the quotas are fixed and there is a gradual decline in cash flows due to the price erosion. Small gains in labour productivity are not sufficient to make the difference.

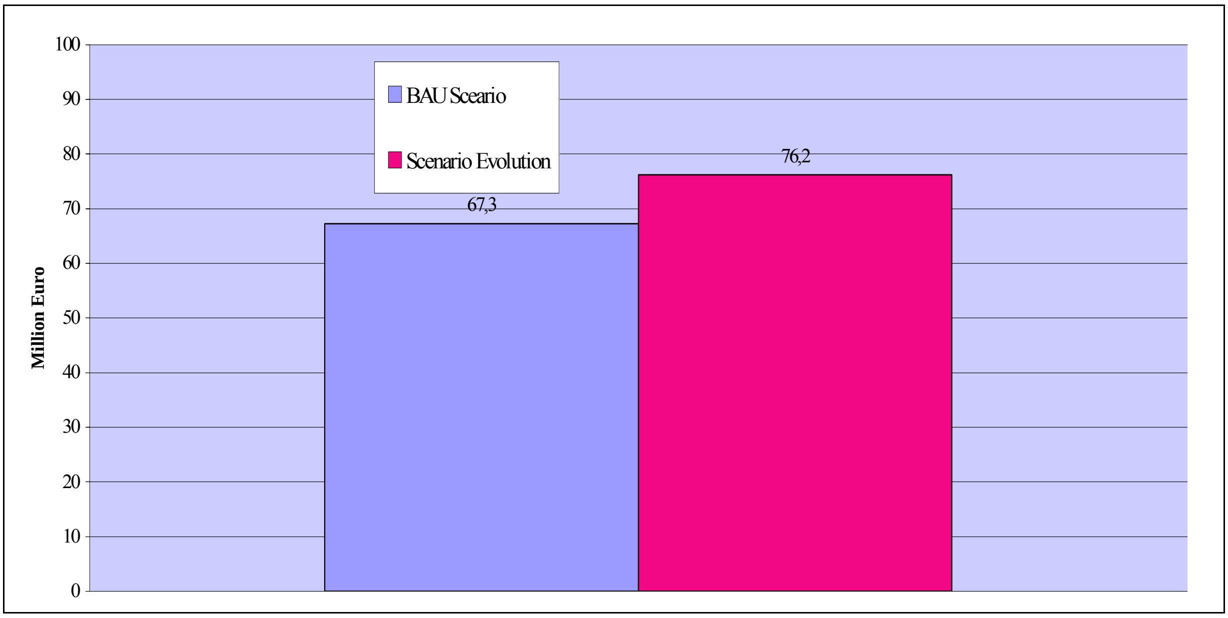
Instead in the Evolution Scenario the dynamics of the substitution between models becomes evident.

Figure 7.32: Net Cash Flows of the LLCC (New) and Base Model Dishwasher in the Evolution Scenario



The new model (LLCC) cash flows increase and those of the base model decrease until the quotas again become fixed in 2014. Beyond that year the price dynamics appear more evident. The net present value of the cash flows (industry value) is given for the two scenarios (Figure 7.33).

Figure 7.33: Industry Value for the Dishwasher (Hypothesis: Max Quota for LLCC)



These substantial absolute values of industry value for dishwashers reflect the more favourable circumstances of moderate price declines of 0,8 %/year compared to the situation of -2,0 %/year in the case of washing machines. The relatively moderate difference between the Evolution and BAU scenario, 9 million Euro, is due to the fact that there are not dramatic price and cost differences between the base and LLCC models.

Even though we introduced a margin of 3,9% for the LLCC model and 1,5% for the base case, this produced only moderate impact, taking into consideration the substitution affect. For the consumer the payback time is about 7 years with an initial difference in consumer price of 45 €.

7.4.4.3 Inputs and results of dishwasher hypothesis set of 'Fast Introduction of BAT'

For the fast introduction of the BAT dishwasher, we have hypothesised a rapid conversion of the production market and production capacity, going from 1% in 2007 to 50% five years later in year 2001, as shown on the input page for BAT (Table 7.37).

Table 7.37: Input parameters for BAT dishwashers

Assumptions Page for				
Situation Studied	**Dishwasher LLCC & Base (LLCC Prod Line)**			
Situation Studied in Base Prod.	**Dishwasher LLCC & Base (Base Prod Line)**			
	Dishwasher LLCC & Base (Base Prod Line)			
Base Year	2007			
Announcement Year	2008	***Year in which the announcement is made***		
Policy Measure Year	2009	***Year in which the policy measure takes effect***		
Tax Rate	48,00%			
Discount Rate for NPV	5,0%			
Inflation Rate	0,0%	*per annum*		
Working Capital	18,00%	*of Revenue*		
Base Year Unit price	262,00	*(EURO)*	Price Grow. UPMY	-0,8%
Base Year Unit Sales	0,050	*(million)*	Price Grow. APMY	-0,800%
Unit Sales Growth Rate	0,0%	*per annum*		
Standard SG&A	10,00%	*of Revenue*	Prod. Base Case	0,015
Research and Development	2,50%	*of Revenue*	Prod. Policy Case	0,015
			Reference Prod.	0,015
Ordinary Depreciation	4,30%	*of Revenue*		
Ordinary Capital Expenditures	-4,50%	*of Revenue*	Price elasticity	-0,4
Variable Overhead as % of Total	60,00%		Dist. Mark-up	3,00
			Tax Credit (€)	0
			El. Savings (kWh/yr)	26,6
			Electr.Price (€/kWhr)	0,17
			Water Savings (€/yr)	0,37
	BAT Case	**Policy Measure Case**		
0	**Year 2007**	**Year 2009**	**Sens. Anal. of Manufacturing Costs**	
Manufacturing Costs	**(Euro)**	**Additional Costs Euro**	**% Below**	**% Above**
Materials / Unit	**140,00**	0,00	0%	0%
Labor / Unit	**30,00**	0,00	0%	0%
Overhead / Unit	**14,00**	0,00	0%	0%
Depreciation / Unit	11,27	0,00		
Total/ Unit	195,27	-		
Hypothetical Full Price Increase (Policy Measure Case Only)		0,00		
Percent of H. F. Price Increase Recovered by Manufacturers		100,00%		
Manufacturers' Price Increase		0,00		
Conversion Costs (Policy Case)	**Useful Life**	**Investment Cost**	**Sens. Anal. Of Conversion Costs**	
Capital Expenditures	*(Years)*	*(EURO 10^6)*	**% Below**	**% Above**
Investment	10		0%	0%
Tooling	5		0%	0%
Design & Marketing Expenses		**Total Expenditures**		
R&D		0		
Marketing		0	0%	0%
	Shipments BAU Scenario	**Shipments Evolution Scenario**		
(Year)	*(%)*	*(%)*		
2007	**1,00%**	**1,00%**		
2008	**1,00%**	**10,00%**		
2009	**1,00%**	**25,00%**		
2010	1,00%	**45,00%**		
2011	1,00%	**50,00%**		
2012	1,00%	**50,00%**		
2013	1,00%	**50,00%**		
2014	1,00%	**50,00%**		
2015	1,00%	**50,00%**		
2016	1,00%	**50,00%**		
2017	1,00%	**50,00%**		
2018	1,00%	**50,00%**		
2019	1,00%	**50,00%**		
2020	1,00%	**50,00%**		

Note that the consumer savings in purchasing a BAT dishwasher, instead of a LLCC model, is limited to 26,6 kWh/year and 0,37 Euro/year in water savings. The difference in consumer price is about 200€.

The manufacturers' unit costs are 195 €/unit with base year manufacturers' price at 262 €. This results in an average cash flow margin of 4,5% for the new BAT model as compared to the 3,9% for the LLCC model production, which is shown in the profit/loss and cash flow statements for the base case scenario shown in Table 7.38.

Table 7.38: Profit/Loss and Cash Flow Statement for dishwasher Base Case Scenario

New (and Base Case)		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Income Statement															
Price/Unit		262,0	259,9	257,8	255,8	253,7	251,7	249,7	247,7	245,7	243,7	241,8	239,8	237,9	236,0
Unit Sales		0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Revenues		2,6	2,6	2,6	2,6	2,5	2,5	2,5	2,5	2,5	2,4	2,4	2,4	2,4	2,4
Cost of Sales															
Labor		0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,2
Material		1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4
Overhead - Fixed		0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Overhead - Variable		0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Depreciation Productivity Cap. Exp.			-	-	-	-	-	-	-	-	-	-	-	-	-
Depreciation Ordin. & Convers.		0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Depreciation Total		0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Selling, General and Administrative															
Standard SG&A		0,3	0,3	0,3	0,3	0,3	0,3	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2
R&D		0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Product Conversion Expense		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Profit Before Tax		0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,2	0,2	0,2	0,2	0,2	0,2
% Profit B.T./ Revenue		13,0%	12,63%	12,28%	11,9%	11,6%	11,20%	10,84%	10,47%	10,09%	9,71%	9,33%	8,94%	8,54%	8,14%
Taxes		0,2	0,2	0,2	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Net Income Before Financing		0,2	0,2	0,2	0,2	0,2	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Cash Flow Statement		**2007**	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Net Income		0,2	0,2	0,2	0,2	0,2	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Depreciation		0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Change in Working Capital		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
Cash Flows from Operations		0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,2	0,2	0,2	0,2	0,2	0,2	0,2
Productivity capital expenditure			-	-	-	-	-	-	-	-	-	-	-	-	-
Ordinary Capital Expenditures		(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)
Conversion Capital Expenditures		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cash Used In Investment		(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)	(0,1)
Average Base Model Margin	**3,9%**	5,15%	4,96%	4,77%	4,58%	4,38%	4,19%	3,99%	3,78%	3,58%	3,37%	3,16%	2,95%	2,74%	2,52%
Cash Flow New Models		0,2	0,2	0,2	0,2	0,2	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Cash Flow Base Case Models		9,6	9,2	8,7	8,3	7,9	7,5	7,1	6,7	6,2	5,8	5,4	5,0	4,6	4,2
Total Cash Flow New and Base Case Models		9,8	9,3	8,9	8,5	8,1	7,6	7,2	6,8	6,4	6,0	5,5	5,1	4,7	4,3
Average New Model Margin	**4,5%**	6,69%	6,51%	6,33%	6,15%	5,96%	5,77%	5,58%	5,39%	5,19%	4,99%	4,79%	4,59%	4,39%	4,18%
Present Value Factor		1,000	0,952	0,907	0,864	0,823	0,784	0,746	0,711	0,677	0,645	0,614	0,585	0,557	0,530
Discounted Cash Flow		9,8	8,9	8,1	7,3	6,6	6,0	5,4	4,8	4,3	3,8	3,4	3,0	2,6	2,3
Total Cash Flow as % of Revenue	3,9%	5,2%	5,0%	4,8%	4,6%	4,4%	4,2%	4,0%	3,8%	3,6%	3,4%	3,2%	3,0%	2,8%	2,5%
Industry Value (Net Present V.)	**76,3**														

The cash flows of the base case with the constant production shares of one and 99% for BAT and LLCC models respectively display a constant decline as in Figure 7.34.

Instead, in the Evolution Scenario there is a strong substitution of BAT for LLCC models reaching 50% with five years (Figure 7.35).

Figure 7.34: Net Cash Flow for BAU Scenario of BAT(new) and LLCC(base) dishwasher models

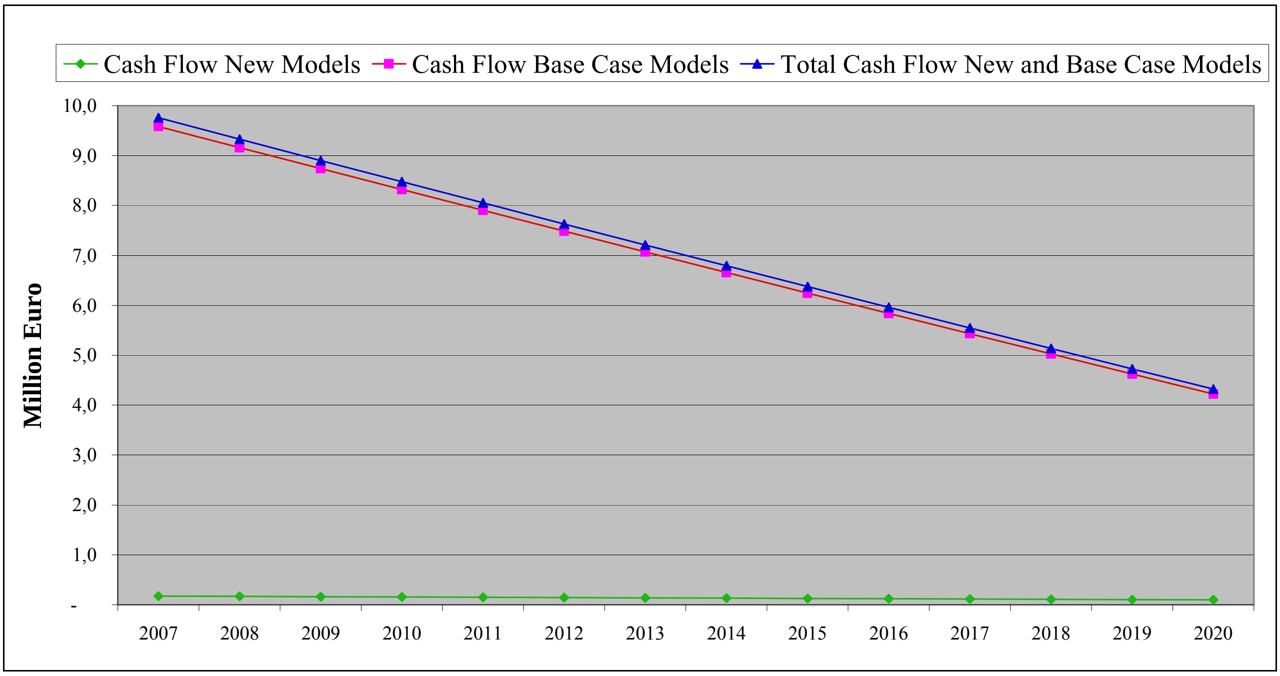
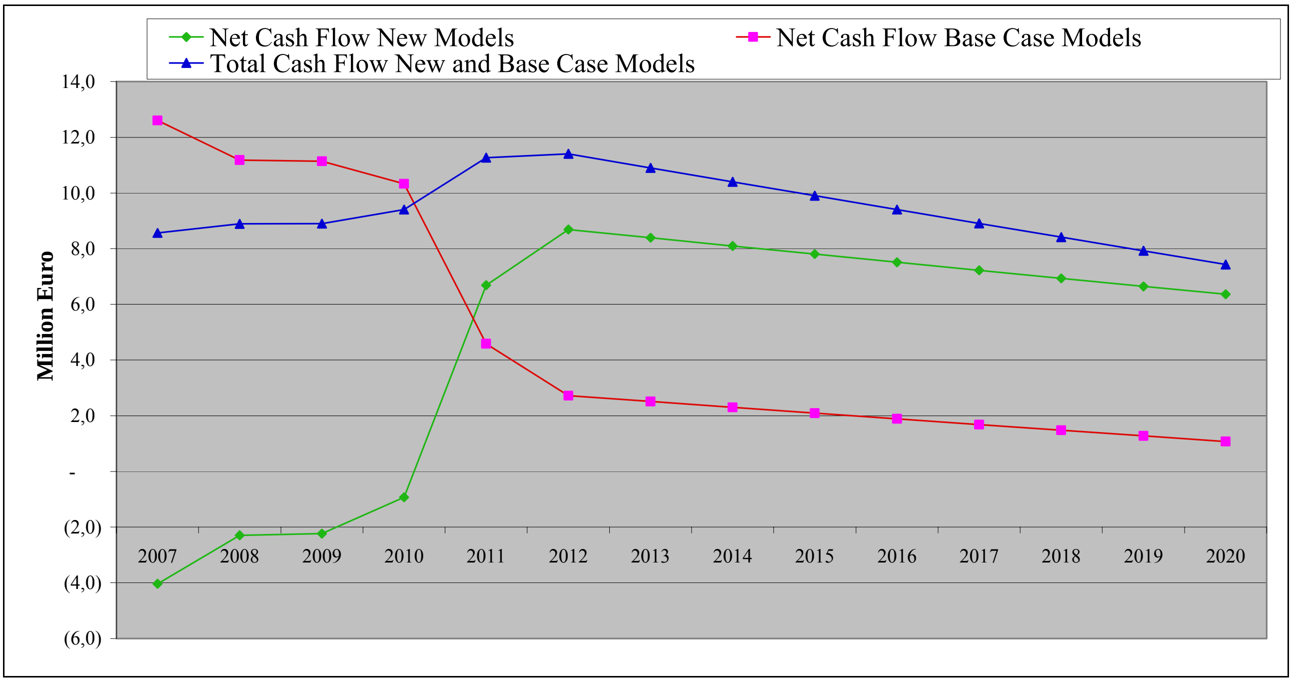
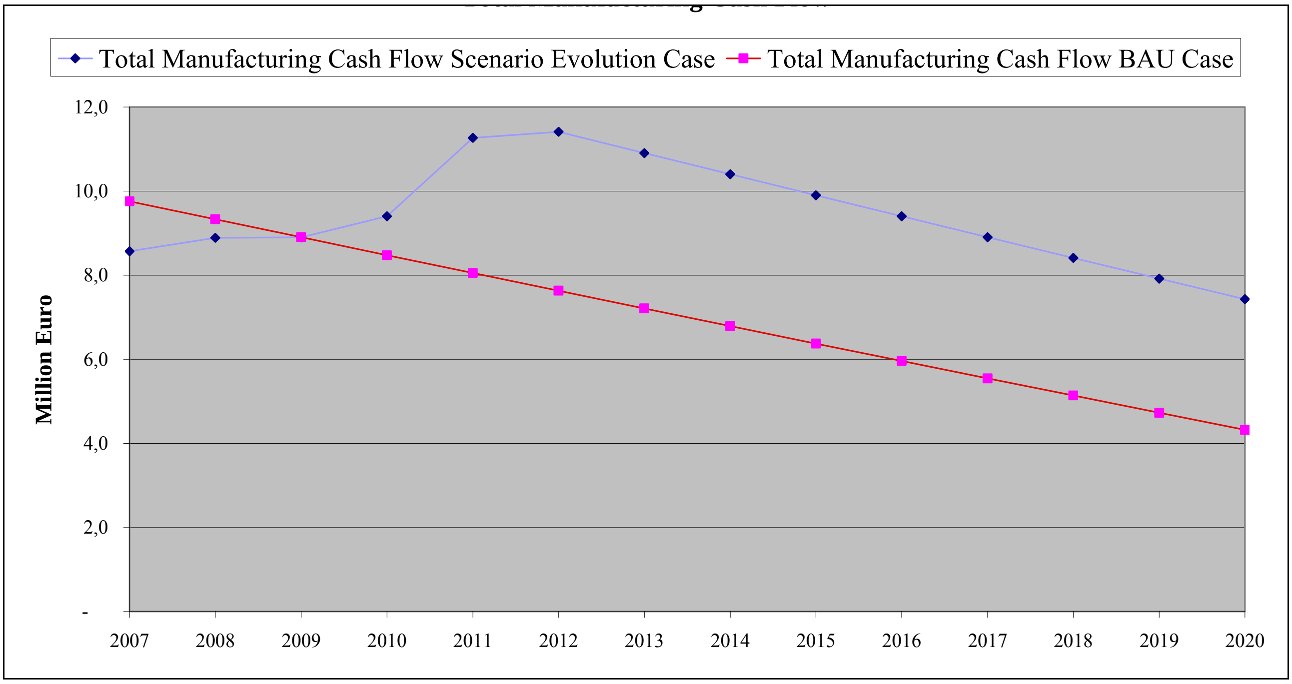


Figure 7.35: Net Cash Flow for Evolution Scenario of BAT(new) and LLCC(base) dishwasher models



The cash flow margin is highest for the newer BAT model and the overall cash flow (blue line in Figure 7.36) reaches a peak in the years 2011-2012, when the BAT reaches the maximum quota, and subsequently the total cash flows gradually decline. Total cash flows are higher in the evolution than BAU scenario.

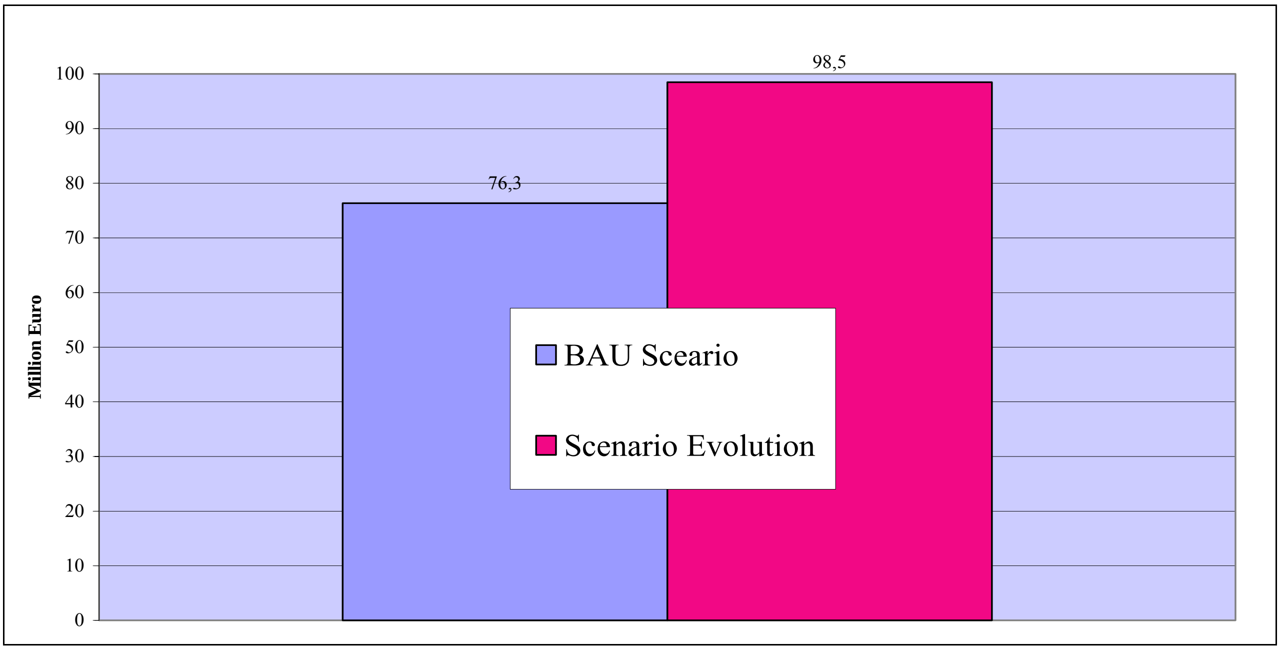
Figure 7.36: Total Net Cash Flows in the BAU and Evolution Scenario of dishwasher models



This produces a increase in the discounted net cash flow between the two scenarios (Figure 7.37). The absolute amounts of the industry value are substantial, which is consistent with the initial margins around four percent and a relative mild real price decrease of 0,8% per year. The difference between the two values, 22 million Euro is due to the slightly higher margin for BAT models coupled with their rapid penetration.

Instead for the consumer as previously indicated the benefits relative to the difference in price results in a payback time of 44 years. Again the consumer must be purchasing the BAT model for additional reasons.

Figure 7.37: Present Value of Net Cash Flows in the BAU and Evolution Scenario of dishwasher models



7.4.4.4 Cost Sensitivity Analysis and Conclusions regarding Dishwashers

The same cost factors that were considered in the case of washing machine are analyzed for dishwashers. The ferrous metal composition of the 12 place setting dishwashers is presented in Table 7.39.

Table 7.39: Ferrous Metal Composition of 12 ps dishwasher Base Model

Material	kg
Galvanized Steel	0,403
Iron	2,303
Total Iron and Galv. Steel	**2,706**
Mixed & Plastic	0,967
Prepainted Steel	1,269
Stainless Steel	8,691
Steel	6,536
Steel Strip	7,097
Total Steel	**23,593**
Total	**27,266**

The rising cost of steel is also a preoccupation for relative large amount contained in these units.

Using the same hypothesis of increase in the price of steel of 0,27 €/kg., with 23,6 kg of steel used to make the 12ps dishwasher, this represents a materials price increase of 6,37 € per unit or an increase in unit manufacturing cost by the same amount. Using a conservative one-third of the price increase for iron and galvanized steel adds 0,24 € for a total of 6,61 €/unit.

Electricity consumption during assembly is on the average 17 kWh/unit. Assuming that the price increases in the order of 0,02 € to 0,04 €/kWh, this represents a 0,34 € to 0,68 €/unit increase.

Turning to labour costs, let us examine the possible from additional labour productivity investments. Let us assume that they still have a reasonable rate of return of between 3 and 5 years of payback time, beginning with three in the early years and ending at five years in the last years of investment. The improvements occur gradually over the production period. Let us hypothesize that we can add an *extra* 1,5% percent reduction in labour cost per year, that is we go from the usual historical 1,5% to its double 3,0%/year. This would appear to be a reasonable upper limit.
In the hypothesis of the Base case and LLCC dishwasher, in the new Evolution Scenario, which contains this new productivity investment, the net present value of cash flow increases from 71,2 € to 73,0 million Euro, a 2,8 million Euro increase. This in itself is important and could offer some further financial advantage to manufacturers. The cost of labour can be brought down by automation or other means, but these have capital and the overall trade-off leads to these relative modest benefits. With the LLCC and BAT model hypothesis, the productivity improvement is slightly less with a 2,6 million Euro increase.

Compared to the potential increase in steel and ferrous metal prices however the labour productivity does not compensate the difference. On an undiscounted basis the 2,8 million Euro in productivity gains becomes about 3,8 million Euro and divided by the roughly 10 million units produced over the period, amounts to 0,38 € savings per unit, compared to possible increase in the cost of steel and iron from 6,40 € to 6,60 €, not to mention electricity cost increases. For the LLCC BAT production the equivalent is 0,35 €.

Could some of the component cost come down? Undoubtedly the largest items are the pumps/motors. The steel has already been accounted for, but there might be labour cost savings in the production of pumps/motors or some learning curve phenomenon. Suppose that the pumps/motors cost to the manufacturers is about 40 €/unit. To offset the possible cost changes occurring to the dishwasher producer due to steel prices, electricity prices and reduction in labour costs, this would imply cost reductions due to further automation or learning on the part of pump/motor producers in the order of 6,40 € to 6,90 €/unit, 16 to17% of their price.

Table 7.40: Sensitivity Analysis of Key Costs for dishwashers

Source	Estimated Impact on Average Unit Cost (€/unit)
Steel Price Increase	+6,37 to + 6,61
Electricity Price Gains	+0,34 to +0,68
Labour Productivity	-0,35 to -0,38
Component Maker Productivity or Learning Efforts	Not estimated

In general, these preliminary simulations for dishwashers illustrate that:

1) **There is a high degree of sensitivity in cash flow due to price**. This is because price acts directly on revenues, cash flow is a difference equation (revenue minus costs) and the historic level of profit margin in the household appliance sector is low, from the three to five percent. To not overestimate these effects the fixed costs have been assumed to be a minimum.
2) **In the specific context of moderate decline in real prices (-0,8%/year), that have historically characterised the dishwasher market, substantial levels of industry value are generated in both the BAU and Evolution scenarios**.
3) **Also in this context, differences in margins of the products (from 1,7 to 0,6%) do produce significant differences in industry values of the BAU and Evolution scenarios**. The Base model LLCC model production yielded an improvement of 12%, and the LLCC BAT hypothesis gave an improvement of 29%, for an average of 20%. The margins on a the higher priced BAT model yield greater profits. **In a healthy price environment, market incentives to invest in improved LLCC and BAT model do exist.** Obviously the faster the market moves to higher margin products, and the margins are sustained, the better for the producer.
4) **In all cases, including dishwashers and washing machines, greater potential cash flows exist for the higher value added BAT model, which however has the longest payback time for the consumer**. The payback times are coming from Task 6 and are only slightly changed by the price dynamics of the E-GRIM simulations. Sometimes these returns to the consumer do not have a positive net present value at a real discount rate of five percent.
5) **The cost sensitivity analysis reveals the strongest cost problems coming from possible increases in steel prices.** Productivity investments within the freezer plant may help, but are an order of magnitude less than possible impact due to steel prices. Possible reductions in the cost of major components are not estimated, but they would have to be substantial to offset other gains. If these steel price gains materialize, the dishwasher model profits likely will be compressed.
6) **Possible benefits from policy actions, such as production tax credits are yet to be analyzed**. This will be explored in the policy section. Public policy could be aimed at the most critical products, those energy saving products having the most difficulty of introduction. In this case washing machines would have a higher priority than dishwashers.

7.5 Subtask 7.5 - Sensitivity Analysis

The sensitivity analysis of the main parameters allows to evaluate the robustness of the analysis outcome.

The sensitivity of the manufacturer impact analysis has been developed in the previous paragraphs. A sensitivity analysis covering the most relevant factors: the price of energy, the production costs and discount rates, was carried out in Task 6 for the standard base cases to check if there are significant changes in results and if the overall LCC conclusions, BATs and BNATs are reliable. The main outcome are here reported.

7.5.1.1 The LCC sensitivity analysis for dishwashers

The Life Cycle Cost sensitivity analysis has been developed for the two average standard base cases, the 9ps and the 12ps machines. The technical and financial assumptions were modified, one at time, to evaluate the impact on the LCC output values. It is worth highlighting that in the sensitivity analysis the application order of the technological options is that resulting as the most profitable for the consumers according to the MNPV analysis for the average standard base case and the basic technical and financial assumptions. The variation of parameters such as the energy and water price and the number of cycles per year might have an influence on the optimum technological option combination (corresponding to the LLCC) and more in general to the options application order, but this more sophisticated sensitivity analysis was not compatible with the time and budget constraints of the study.

The most important result is that in practice the Least Life Cycle Cost point occurs at the same technological option combination when the investigated parameters are varied. In addition, there is no effect on the overall LCC results robustness when the disposal and recycling costs are decreased from 61 € to 10 €.

The second most important outcome of the sensitivity analysis is the large variation of the LCC at the LLCC point due to the combination of technical and economical factors. For the **9ps dishwasher**, when 208 washing cycles are run per year, the life cycle cost over a lifetime of 10 years is 1.033 Euro; on the contrary when the electricity price is 0,25 €/kWh, the life cycle cost over a lifetime of 17 years is 1.554 Euro, with a difference of 521 Euro. For the **12ps dishwasher** when 208 washing cycles are run per year, the life cycle cost over a lifetime of 10 years is 1.139 Euro; on the contrary when the electricity price is 0,25 €/kWh, the life cycle cost over a lifetime of 17 years is 1.776 Euro, with a difference of 635 €.

For the 9ps machine, the energy savings going from the average standard base case to the $LLCC_{av}$ are in the range 1,6-2,2 €/year depending on the annual washing cycles, the water savings in the range 2,6-3,6 €/year, for a total of 4,2-5,7 €/year against an increase in purchase price of 23 Euro; the energy savings going from the average standard base case to the BAT_{av} at a noise of 50 dB(A) are in the range 3,7-5,0 €/year and the water savings in the range 2,8-3,8 €/year, for a total of 6,6-8,8 €/year against an increase in purchase price of 173 Euro. When the noise is decrease to 41 dB(A) there is a slight increase of the energy expenses (-0,8-1,1 €/year), while the water savings are in the range 2,8-3,8 €/year, with a price increase of 265 €.

For the 12ps machine the energy savings going from the average standard base case to the $LLCC_{av}$ are in the range 2,2-2,9 €/year depending on the annual washing cycles, the water savings in the range 3,2-4,4 €/year, for a total of 5,4-7,3 €/year against an increase in purchase price of 23 €; the energy savings going from the average standard base case to the BAT_{av} at 50 dB(A) are in the range

5,5-7,4 €/year depending on the annual washing cycles and the water savings in the range 3,5-4,8 €/year, for a total of 9,1-12,2 €/year against an increase in purchase price of 231 €. When the noise is decrease to 41 dB(A) there is no energy savings, while the water savings are in the range 3,5-4,8 €/year, with a price increase of 335 €.

7.5.1.2 The LCC sensitivity analysis for washing machines

The LCC analyses of the standard base case 5,36 washing machine was developed for the three different values of annual washing cycles. The most important result is that the Least Life Cycle Cost point occurs at the same technological option combination when the investigated parameters are varied and as in the case of dishwashers, there is no effect on the overall LCC when the disposal and recycling costs are varied. The second most important outcome of the sensitivity analysis is the large variation of the LCC at the LLCC point due to the combination of technical and economical factors: when 200 washing cycles are run per year, the life cycle cost over a lifetime of 10 years is 1.411 €; on the contrary when the electricity price is 0,25 €/kWh, the life cycle cost over a lifetime of 17 years is 2.162 Euro, with a difference of 751 €.

The energy savings for the LLCC_{av} are in the range 3,3-4,1 €/year depending on the annual washing cycles, the water savings[35] in the range 8,9-10,9 €/year, for a total of 12,2-15,0 €/year against an increase in purchase price of 16 € the energy savings going from the average standard base case to the BAT_{av} are in the range 4,95-6,0 €/year and the water savings in the range 8,9-10,9 €/year, for a total of 13,7-16,8 €/year against an increase in purchase price of 97 €. When the spin speed is increased to 1 600 rpm or when the capacity increases to 6kg the savings decrease and the price increase of 123 €.

7.6 Subtask 7.6: Hypothesised policy measures for wash appliances

7.6.1 The Policy Measures Portfolio

7.6.1.1 The mandatory vs. the voluntary approach in Europe

After the first experience in setting minimum efficiency requirements for products, resulting in the issue of directive 96/57/EC for cold appliances and directive 2000/55/EC ballast for fluorescent lamps, a set of five Industry Voluntary Commitments (described in Task 1) have been discussed and agreed upon by the household appliance manufacturers' European industry association, CECED, the European Commission, and Member States.

However, on 21 March 2007 with a Press Release[36], CECED, called for legislative measures to ensure future energy performance standards as an alternative to continued updating of the voluntary agreements that industry introduced a decade ago.

The strategy change was announced after a meeting of the CECED steering committee in Brussels. Patchy government enforcement of the EU's energy labelling scheme, the vehicle whereby energy efficiency information is shared with the public, has undermined industry's ability to go to the next phase of voluntary measures. CECED's voluntary agreements on energy efficiency have delivered

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[35] the modification of the rinsing performance (if any) due to the decrease of the water consumption is not known.

[36] "Top Executives Discontinue Voluntary Energy Efficiency Agreements for Large Appliances", Embargo: 17.00 hrs, 21 March 2007, downloadable from http://www.ceced.org.

major performance improvements, estimated to have cut 17 million tons of CO_2 from Europe's emissions tally, equivalent to the carbon output of nine 500 MW thermo-electric power plants.

"European manufacturers are as committed as ever to designing and marketing energy efficient appliances because it is the right thing to do and consumers expect that of us," said CECED President, Magnus Yngen of Electrolux. "But governments must guarantee fair competition by enforcing the law and ensuring that product declarations are genuine–or our investment in high performing products is compromised. The next round of improvements needs to be driven by legislation that applies to all and is enforced on all."

Covering on average 90% of the market for large appliances, CECED's five existing voluntary agreements (for washing machines, refrigerators and freezers, dishwashers and water storage heaters) have been widely recognised as progressive and pro-active. These have required an investment by European manufacturers of €10 billion over the past decade.

"Too many governments are not stopping careless or unscrupulous operators from marketing products that claim better energy efficiency than they actually deliver," says Yngen. "Free-riding must be strongly discouraged. Today we have a very worrisome situation where politicians set rules, expect companies to abide by them and then fail to invest the resources needed to stop the lawbreakers."

To show that market surveillance is not working, the top managers also announced that CECED will launch a one-off market testing programme, using independent laboratories to check products sampled from the market against the performance claims stated on their labels. The results will be made public later this year. The exercise will demonstrate that market surveillance is feasible and not prohibitively expensive for governments. Sampling will cover refrigeration appliances in the market, regardless of source.

7.6.1.2 The extension of the Energy Star programme to household appliances

In 2005 detailed discussions and negotiations were held with the US Environmental Protection Agency and the US Department of Energy. These resulted in an in principle agreement that Australia and New Zealand could set local Energy Star "high efficiency" criteria for products that were sold in the Australasian market (such as white goods where the USA had their own domestic Energy Star criteria), subject to detailed review by EPA and DOE on a product by product basis. On this basis, E3 decided to move towards the use of the Energy Star label as the primary endorsement label for appliances and equipment in Australia and to discontinue TESAW as an endorsement label.

One of the key decisions made at the E3 Stakeholder Working Group meetings in 2005 was that any Energy Star criteria to recognise high efficiency refrigerators and freezers needs to be linked to the star rating system. This is critical as it provides a consistent message with regard to the relative efficiency of products for both program elements (comparative energy label and the Energy Star endorsement label). So in principle, an Energy Star qualification level should be defined in terms of star ratings under the new energy labelling algorithm under preparation by the Australian authorities (see Task 1 for details).

At this stage, no draft Energy Star criteria have been proposed. Further analysis needs to be undertaken to refine the likely criteria and the approval of proposed levels needs to be sought from US authorities prior to their implementation. In fact, setting Energy Star levels that are comparable with or better than US levels (i.e. 10% to 15% better than current 2005 efficiency requirements levels) and also where 20% to 30% of products on the Australia and New Zealand market can attain the criteria would be ideal. But using these criteria together with the new star rating index could create some mismatches and complications that may need to be examined and resolved. Other issues for implementation that require some consideration are frequency of review of qualification levels and whether there should be any tag or identifier on the Energy Star label used for locally developed high efficiency levels to distinguish this from the standard EPA Energy Star label which is used internationally.

The Energy Star Program, commenced in the USA in 1992, applies to a vast array of products in that country, including equipment, appliances, materials and even buildings. A large part of the US Energy Star program is set up as a domestic endorsement labelling system that works in conjunction with other domestic programs such as minimum efficiency requirements and energy labelling (the Energy Guide) or as a stand-alone program for selected unregulated products. The use of Energy Star as an endorsement of high efficiency products at this stage is used in North America (USA and Canada) only, but neither the US nor the Canadian energy labels have a star rating system or its equivalent categorical rating system (such as the EU labelling scheme) so this potential information miss-match is not an issue there.

If the criteria of the Energy Star and the categorical labelling scheme are the same, and the Energy Star approach calls for a 20% of the models fulfilling the criteria at the time of enforcement, there is little scope is setting this endorsement label.

The justification given by Australia is that Energy Star, as the former TESAW scheme, allows consumer to quickly recognise highly efficient product on the market. But if high efficient dishwashers or washing machines are identified by energy efficiency classes A (and A+), and the label is mandatory on models displayed in shops or offered for sale, high efficient models are immediately recognisable by consumers. An additional Energy Star logo (or any other efficiency mark) is not only useless, but can also create the impression of a poor quality of the categorical labelling scheme, that needs to be supported by the endorsement label to be sure that highly efficient appliances are identified.

7.6.1.3 The standby approach

Two approaches are possible to address the so-called ‘standby’ mode and the other ’low power modes’:

- a “simple” way is to define specific requirements for each single mode(s): once maximum power consumption (in Watt) are enforced the overall machine energy consumption for those modes will depend only from their duration.

- an alternative more global approach is to calculate the energy consumption in each mode (once the power consumption and the duration are measured, but not regulated) and to add it to the on-mode consumption, to calculate the overall appliance energy consumption (annual or per cycle).

7.6.1.4 A new labelling scheme

The possibility of an updated labelling scheme will be addressed. The options of an upgraded A-G scale or as alternative a new categorical label will be discussed and examples given.

7.6.1.5 Specific and generic requirements

The EuP directive calls for the level of energy efficiency or energy consumption in use to be set aiming at the life cycle cost minimum to end-users, taking into account the consequences on other environmental aspects. This will be addressed through the proposal of specific requirements. Also some considerations about noise will be drafted, to evaluate the possibility and the opportunity to set specific requirements on this aspect. If necessary, generic requirements will complement the specific ones.

7.6.1.6 Policy measures for washing temperature different from 60°C and partial load

Possible policy measures addressing resource consumption at washing temperature different from the 60°C cycle are briefly presented along with the constraints deriving from an insufficient standardisation. Elements for a mandate of the European Commission to CENELEC will be also drafted.

7.6.2 The standby approach

As already described, two approaches are possible to address the standby and low power mode consumption: setting mandatory minimum requirements – possibly of a horizontal nature across several appliances - for the identified modes; or their incorporation into the algorithm (a new Energy Efficiency Index) for the energy label. A mixed approach could also be hypothesised.

7.6.2.1 A summary of the EU and worldwide situation

a) Australia and New Zealand

According to an Australian market survey in 2005, there is an important issue regarding washing machines and dishwashers: most European products (which are imported into the Australian market) have an off-switch, which usually disconnects power to most parts of the machines and drops the power consumption close to zero Watts. However to achieve this, the consumer must manually turn the machine off when the cycle has been completed and the load removed. During the intrusive (in-home) survey in 2005 around 40% of the European front load machines were found left on when not in use (i.e. the users did not manually turn the machines off when the washing cycle was completed). This means that the off-mode power consumption for many European machines is probably not all that relevant. A more relevant figure is the end of cycle mode. All non-European (usually top loading, vertical axis) machines automatically revert to off-mode at the end of the cycle, so only off mode measurements for these machines are relevant.

The Standby Power Strategy 2002-2012 contains a wide range of possible policy measures to address excessive standby power. The document sets out the long-term strategy to address excessive standby energy used by consumer appliances and equipment. In particular the report contains:

- the measures that governments will use to address excessive standby;
- the identification of the products to be targeted in the first of three-year rolling plans under the strategy;
- the procedure whereby standby targets will be set for each of the targeted products (Stage 1 targets);
- the sanctions that will apply should suppliers not meet the targets for these products (Stage 2 targets);

– a proposal for the Australian products to meet the ultimate target, of 1 Watt in 2012.

The strategy sets out a number of possible policy tools that were to be considered on a product by product basis as follows:

- Promotion of Energy Star
- Industry Codes of Conduct
- Publication of targets in Australian Standards
- Collection of data for new products
- Publication of standby data for products
- Inclusion of standby into the energy label for selected products
- Introduction of minimum requirements on standby for selected products
- Warning label for products with high standby.

Investigation regarding modes and the inclusion of standby power into the energy label have been concluded for dishwashers and washing machines and these were implemented in late 2005 with a transition period to April 2007. After this date all dishwashers and washing machines will have standby energy consumption included in the energy label value, which will also affect the product star rating.

The initially proposed algorithms for the calculation of the CEC (Comparative Energy Consumption) including standby for wash appliances were:

$$CEC = E_t \times C + [P_d \times 2 \times C + P_e \times 15 \times C + (8760 - T_c \times C - 2 \times C - 15 \times C) \times P_o]$$

where:

- E_t = the cycle energy consumption measured according to the AU/NZS Part 1 standard
- C = is the defined number of cycles per year, 365 for washing machines and dishwashers
- P_d = the measured power (in W) in the “delay start” mode, it is 0 where the appliance does not have a delay start function; the delay start mode is assumed 2 hours where present
- P_e = the measured power (in W) in the “end of programme” mode, it is 0 where the appliance does not have end of programme mode; end of programme mode is assumed for 15 hours when present
- P_o = measured power in off mode (W), for the remaining standby time after delay start and end of programme modes
- T_c = cycle time (in hours).

The value of CEC is in Wh and should be divided by 1000 for use on the energy label. The proposal was subsequently modified, considering only an average of “off mode” and “end of cycle mode” for inclusion into the energy label CEC and deleting the “delay start mode” from the overall standby calculation, to avoid any penalisation of this mode, which was recognised to have a positive impact on the machine use by allowing the delay of the washing cycle to off-peak hours. In addition, the overall standby power is considered 100% the time in “off mode” where the “end of cycle” mode is not present (when products automatically revert to “off” after the end of cycle)[37]:

$CEC = E_t \times C + [P_s \times (8760 - T_c \times C)]$

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[37] For sake of coherence, the shown algorithm is not the one eventually published in the standard, but is presented in the same form as the previous formula.

where P_s = the average measured standby power, in Watts which is the average of end of cycle mode and off mode, (where this mode is present). Again, the value of CEC is in Wh and should be divided by 1000 for use on the energy label. The new algorithms are in force since 1 April 2007.

b) USA

Also in USA, the latest proposal calls for the introduction of the so called "low power modes" in the calculation of the annual energy consumption of appliances – and therefore subject to the relevant policy measures - since the main goal is save energy and improve efficiency, and not to strictly define in which of the modes this energy should be saved.

Annual standby energy consumption for *dishwashers* and is calculated in kWh per year as:

$S = S_m \times (H_s/1000)$ and
$H_s = H - (N \times L)$

where:

- S_m = measured average standby power (in Watt) and
- H = the total number of hours per year, or 8.766
- N = the representative average dishwasher use of 215 cycle/year
- L = the average of the duration (in hours) of the normal washing cycle, measured for the different types of dishwashers addressed in the test procedure

In order to determine standby power usage, the energy use of each dishwasher in the Energy Star products database was calculated. Since 60% of current qualified products use standby power and the trend for new products is to offer more features that will draw power in the standby mode, comments were required to stakeholders on the value of incorporating a standby power requirement into the new criteria for dishwashers. In addition, DoE is trying to determine whether it is preferable the (a) setting a maximum amount of standby power in terms of Watts or kWh/year or (b) setting the maximum total allowable Energy Star qualified product usage in terms of kWh/year instead of EF.

c) The latest EU proposals

More recently, a working document[38] of the European Commission, circulated and discussed during the second EuP Forum meeting, proposed to set minimum requirements for the 'off-mode' and 'standby mode' of electrical and electronic household and office equipment, depending on energy input from the mains power source, where:

- off mode = a condition where the equipment is connected to the mains power source and provides no function (a mere indication n of the off-mode condition is also considered off-mode

- standby = a condition where the equipment is connected to the mains power source and provides one of more of reactivation functions, information or status display depending on energy input from the mains power source to work as intended

- preheating function, sensor-based safety functions, network reactivation and network integrity functions are not considered as being standby.

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[38] Working document on possible ecodesign requirements for standby and off-mode electric power consumption of electrical and electronic household and office equipment, Bruxelles, 19 October 2007

The proposed requirements for off mode and standby are:

a) one year after the implementing measure is enforced:
- any off mode condition ≤ 1W
- standby (reactivation function, with/without mere indication of enabled reactivation function) ≤1W
- standby (information or status display with/without reactivation function) ≤ 2W;

b) three years after the implementing measure is enforced:
- any off mode condition ≤ 0,5 W
- standby (reactivation function, with/without mere indication of enabled reactivation function) ≤ 0,5W
- standby (information or status display with/without reactivation function) ≤ 1W.

In addition, equipment shall offer a *power management* function or a similar function that, after the shortest possible period of time appropriate for the intended use, switches the equipment automatically into a condition with reduced energy consumption when the equipment is not providing the main functions

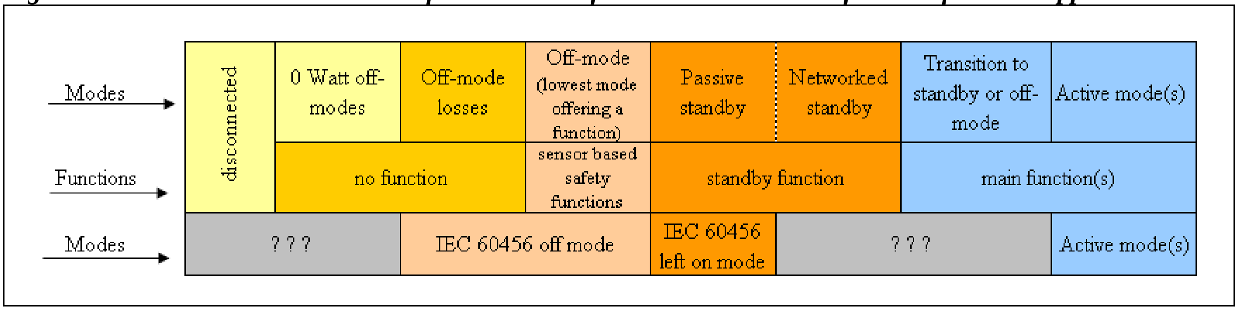
7.6.2.2 Proposed approach for off- and left-on modes

In Task 6 a detailed analysis was developed about the 'low power modes' comparing the draft definitions of the June 2007 draft of IEC 60456 "*Clothes washing machines for household use - Methods for measuring the performance*" 5th Edition with the definitions proposed "Lot 6-Standby and Off-mode losses of EuPs". As conclusion, the definitions given in IEC 60456, 5th edition draft are seen here as being more appropriate for washing machines, considering that they will in a short time be included also in the new edition of the EN 60456 standard:

- *off mode*: is where the product is switched off using appliance controls or switches that are accessible and intended for operation by the user during normal use to attain the lowest power consumption that may persist for an indefinite time while connected to a mains power source and used in accordance with the manufacturer's instructions. Where there are no controls, the washing machine is left to revert to a steady state power consumption of its own accord;
- *left on mode*: is the lowest power consumption mode that may persist for an indefinite time after the completion of the programme and unloading of the machine without any further intervention of the user. In some products this mode may be an equivalent power to off mode.

A compromise solution for an acceptable harmonisation of Lot 6 and the draft IEC 60456 5th Ed. definitions was developed as presented in Figure 7.38.

Figure 7.38: Possible harmonisation of Lot 6 and draft IEC 60456 5th Ed. definitions for wash appliance modes



Modes →	disconnected	0 Watt off-modes	Off-mode losses	Off-mode (lowest mode offering a function)	Passive standby	Networked standby	Transition to standby or off-mode	Active mode(s)
Functions →		no function		sensor based safety functions	standby function		main function(s)	
Modes →	? ? ?		IEC 60456 off mode		IEC 60456 left on mode	? ? ?		Active mode(s)

It is also clear that the possibility to evaluate an overall annual energy consumption and to set a new Energy Efficiency Index based on the global annual energy consumption will be jeopardized when horizontal limits are set for some ‘modes’, with lower product differentiation, lower consumer choice and no higher savings.

As conclusion, the proposal is to include the ‘off-mode’ and the ‘left-on mode’ in a new energy efficiency algorithm within a revised energy labelling scheme and/or the setting of specific requirements.

7.6.3 A revised labelling scheme

7.6.3.1 Manufacturers position

CECED position about a revised labelling is that where technological scope still exits, CECED supports the revision of current labels to allow better market differentiation and the promotion of more efficient appliances. However, when further improvements appear technically not achievable, the label should be substituted by specific efficiency requirements, to avoid the deterioration of the market.

While supporting the label revision, a recent study shows that the modification process of the current label may turn into a very critical phase for manufacturers, retailers and consumers. To avoid that the revision negatively affects manufacturers and the return on their investments, CECED invites authorities to take in great care the concerns of the main stakeholders, in particular avoiding that the revision is carried out as a simple rescale of the current A to G scale. The label is a communication tool towards consumers and retailers; therefore, while discussing label revision any possible reaction or impact on them must always be carefully taken into account.

7.6.3.2 Washing machines

a) Elements to be updated in the present labelling scheme

Elements of the present labelling scheme that should be updated in a revised scheme for washing machines are:

- Energy Efficiency (Index) calculation algorithm: to be amended to include low power modes and to consider the machine annual energy consumption;

- Energy Efficiency Classes: existing thresholds to be amended and new thresholds defined; in addition, the rescaling the present A-G scale or the definition of a new categorisation should be investigated;

- information to be disclosed: information in the label and the fiche to be revised and if necessary amended.

b) The Energy Efficiency (Index) algorithms for the 60°C cotton programme

The opportunity of amending the algorithms in directive 95/12/EC will be discussed. Possible alternatives are:

i. to calculate the Energy Efficiency Index (EEI) based on the annual energy consumption (in kWh); the EEI is given by the ratio between the energy consumption per cycle of any given appliance and the reference energy consumption of the same appliance;
ii. to use the Energy Consumption (E_c) per washing cycle (in kWh/cycle);
iii. to follow the present approach based on the specific energy consumption 'C' per kg of load.

Off mode and left-on mode power consumption can be added to the three approaches to give an overall value.

To evaluate the average energy consumption (AE_c) of a machine per year, the Energy Consumption (E_c) per cycle should be measured according to the standard and then multiplied for an agreed number of washing cycles per year. The average number of washing cycles per year used in Task 6 is 220 for washing machines.

$AE_c = E_c \times n$ where n = number of washing cycles per year.

The Energy Efficiency Index is the ratio between the energy consumption of a specific appliance and the standard energy consumption (SEC) of that appliance. The standard energy consumption (SEC) can be any agreed reference line. The energy consumption can be addressed through the annual value (AE_c) - with (or without) the low power modes contribution - or through the per cycle consumption:

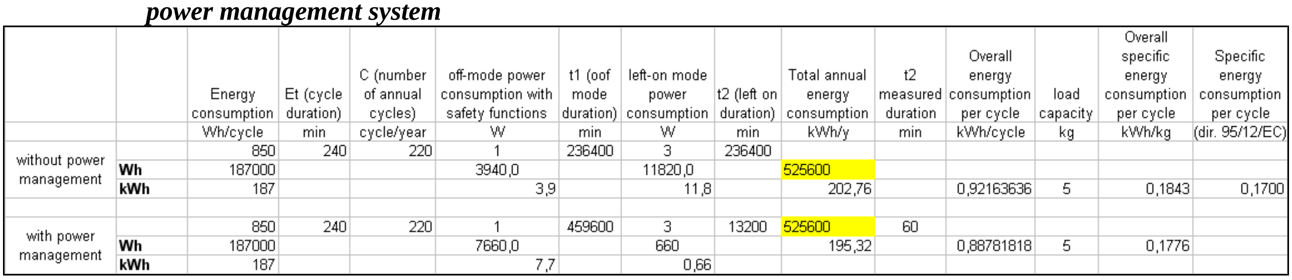
$EEI = AE_c/SEC$

The overall annual energy consumption including 'low power modes' can be calculated, as shown in Table 7.39, as:

- including *off-mode* and *left-on mode* each working for half of the residual time after 220 washing cycles per year;
- in case a 'power management system' is implemented and *left-on mode* reverts to *off mode* within, lets say, about 1 hour, resulting in the hours in left-on mode hypothesised equal to the number of the annual washing cycles plus the time in off mode.

The contribution of the low power modes to the annual energy consumption is modest, as clearly shown in Table 7.41.

Table 7.41: Methods to calculate the machine energy consumption including low power modes, with and without a power management system



		Energy consumption	Et (cycle duration)	C (number of annual cycles)	off-mode power consumption with safety functions	t1 (oof mode duration)	left-on mode power consumption	t2 (left on duration)	Total annual energy consumption	t2 measured duration	Overall energy consumption per cycle	load capacity	Overall specific energy consumption per cycle	Specific energy consumption per cycle
		Wh/cycle	min	cycle/year	W	min	W	min	kWh/y	min	kWh/cycle	kg	kWh/kg	(dir. 95/12/EC)
without power management		850	240	220	1	236400	3	236400						
	Wh	187000			3940,0		11820,0		525600					
	kWh	187			3,9		11,8		202,76		0,92163636	5	0,1843	0,1700
with power management		850	240	220	1	459600	3	13200	525600	60				
	Wh	187000			7660,0		660		195,32		0,88781818	5	0,1776	
	kWh	187			7,7		0,66							

The formula to calculate the overall AE_c (when the power management is not enforced) is:

$$AE_c = E_c \times C + \{P_s \times [525\,600 - (T_c \times C)]/2 + P_l \times [525\,600\ - (T_c \times C)]/2\ \} / (60 \times 1\,000)$$

which can be also written as:

$$AE_c = E_c \times C + \frac{\left[P_s \times \frac{525.600 - (T_c \times C)}{2 \times 60} + P_l \times \frac{525.600 - (T_c \times C)}{2 \times 60} \right]}{1.000}$$

where :

- AE_c = annual energy consumption (in kWh)
- E_c = the cycle energy consumption (in kWh)
- C = is the defined number of cycles per year, 220 for washing machines
- P_l = the measured power (in W) in the "left-on mode"
- P_s = measured power in "off-mode" (W)
- T_c = washing cycle time (in minutes)
- 525.600 = total number of minutes in a year (= 60 min/h × 24 h/day × 365 days/year).

When a power management is enforced the formula should be modified to take into consideration the effective duration of the "off-mode" and the "left-on mode" as:

$AE_c = E_c \times C + \{(P_l \times T_{Pl} \times C) + P_s \times [525\ 600\ - (T_c \times C) - (T_{Pl} \times C)]\} / (60 \times 1\ 000)$

where T_{Pl} is the measured time in "left-on mode" (in minutes).

In addition, the overall low power modes power is considered 100% the time in "off mode" where the "end of cycle" mode is not present (when products automatically revert to "off" after the end of cycle).

The overall annual energy consumption can be used as such to calculate an Energy Efficiency Index, or can be divided by the number of the cycles per year (resulting in an overall consumption per cycle) or by the number of the cycles per year and by the machine load capacity resulting in an overall value of energy consumption per kg load, as in the present directive 95/15/EC.

Starting from 2005 CECED technical database, a set of energy consumption straight lines (Table 7.42) have been calculated through linear regressions for different clusters of load capacity machines, trying to identify models with similar thermodynamic properties. Energy consumption per cycle is expressed as function of the machine load capacity. In addition, the straight line deriving from the 1997 CECED technical database is also added.

Table 7.42: Straight lines and R^2 values for different cluster of washing machines

Load clusters (kg)	Straight line parameters		
	M	**N**	**R^2**
3-4kg	0,0852	0,4286	0,9908
4,5-6kg	**0,0951**	**0,4863**	0,9957
7-9kg	0,2793	-0,7407	0,9911
3-7kg	0,1337	0,2726	0,9816
4,5-7kg	0,1163	0,3785	0,9823
8-9kg	0,2730	-0,6875	0,9837
3-9kg	0,1676	0,0213	0,9344
4,5-6,5 kg, 1997	0,201	0,2213	0,9514

The R^2 value for the different machine clusters has also been calculated. The clusters resulting in the highest R^2 value (best linearity) are presented in Figure 7.39 and have been then considered as thermodynamically similar machines. The three straight lines of the optimum clusters ($R^2>0{,}99$) were then compared to evaluate if one line can be used to represent all washing machines: the 4,5-6,5kg load machine cluster has been then selected since it represents about 92,4% of the machines in the 2005 technical database.

When the 4,5-6 kg cluster reference line is used to characterise smaller 3-4 kg load machines, they show a higher efficiency than the actual one. Small capacity machines have lower dimensions compared to the more traditional (L×D×H: 60cm×60cm×85cm) 5-6kg machines: 4kg machines might have a 33cm depth, while 3,5kg machines have (51cm×44cm×69,5cm) dimensions and 3kg machines have (50cm×52cm×67cm) dimensions.

On the contrary, larger capacity machines ≥ 7kg load, result in having a lower energy efficiency than in the present system. Higher capacity machines have dimensions larger than the 5-6kg machines, such as for example: 9kg (68,6cm×78,5cm×96,5cm), 10kg (69cm×79cm×97cm), although 7kg and 8kg machines are on the market with dimensions close to standard ones, for example: (60cm×64cm×84,2cm) for a 8kg machine or with standard dimensions. Unfortunately the CECED technical database does not provide the machine dimensions.

Machine with a load capacity ≤4kg represent 2,04% of the models in the 2005 technical database; machine with a load capacity ≥7kg represent 5,5% of the machine models in 2005, with 7kg responsible for 3,5%.

The second best choice is to consider the straight line of the cluster 4,5-7kg (Figure 7.40). The 1997 straight lines are presented in Figure 7.41.

b.1) Hypothesis One

When the 4,5-6kg cluster reference line is considered representative of all the models in 2005 database, the average energy consumption ($E_{c,aver}$) per cycle (in kWh/cycle) of an appliance in 2005 can be calculated using the formula:

$E_{c,aver} = 0{,}0951 \times c + 0{,}486$ where *c* is the machine load capacity in kg.

In Figure 7.42 the $E_{c,aver}$ line is compared with the straight lines of the other machine clusters and with the lines representing energy efficiency class A (directive 95/12/EC), A+ (CECED Voluntary Agreement) and C<0,15 kWh/kg.

The standard energy consumption (SEC) is the straight line parallel to the average 2005 line and matching the reference value of 0,30 kWh/kg for the 5kg machine resulting from the 1996 VhK study[39] (already used in the CECED Industry Commitments for washing machines) or:

$SEC = 0{,}1483 \times c + 0{,}758$ where *c* is the machine load capacity in kg.

In Figure 7.43 the $E_{c,aver}$ line is compared with the *SEC* line.

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[39] Source: Sensitivity Analysis of Energy Efficiency Improvements for Washing Machines carried out by Van Holsteijn en Kemna (NL), (Final Report, April 1996).

Figure 7.39: Optimised energy consumption straight lines and relevant R^2 for different load capacity machines with similar thermodynamic properties in 2005 CECED technical database. Energy consumption per cycle is expressed as function of the machine load capacity

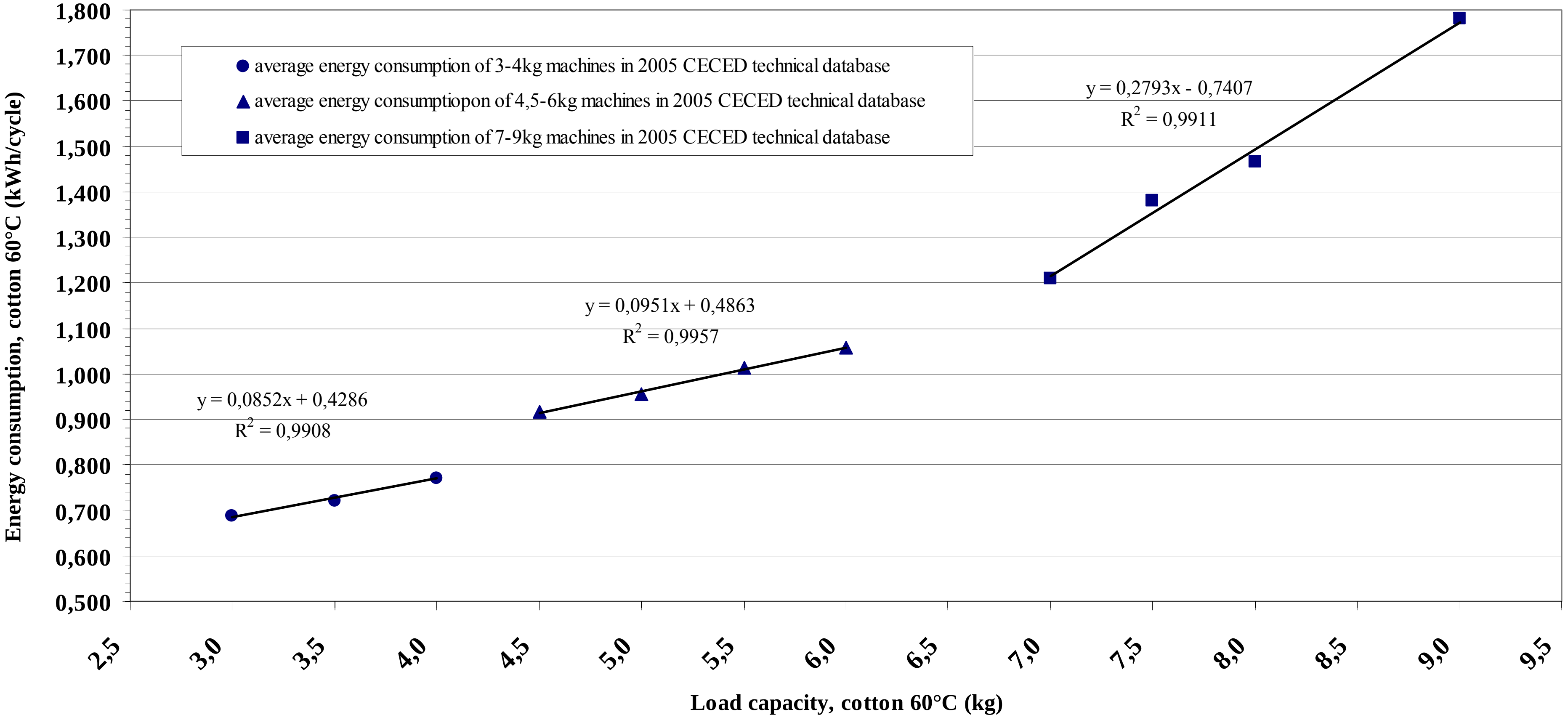


Figure 7.40: Second best choice for the energy consumption straight lines and relevant R^2 for different load capacity machines with similar thermodynamic properties in 2005 CECED technical database. Energy consumption per cycle is expressed as function of the machine load capacity

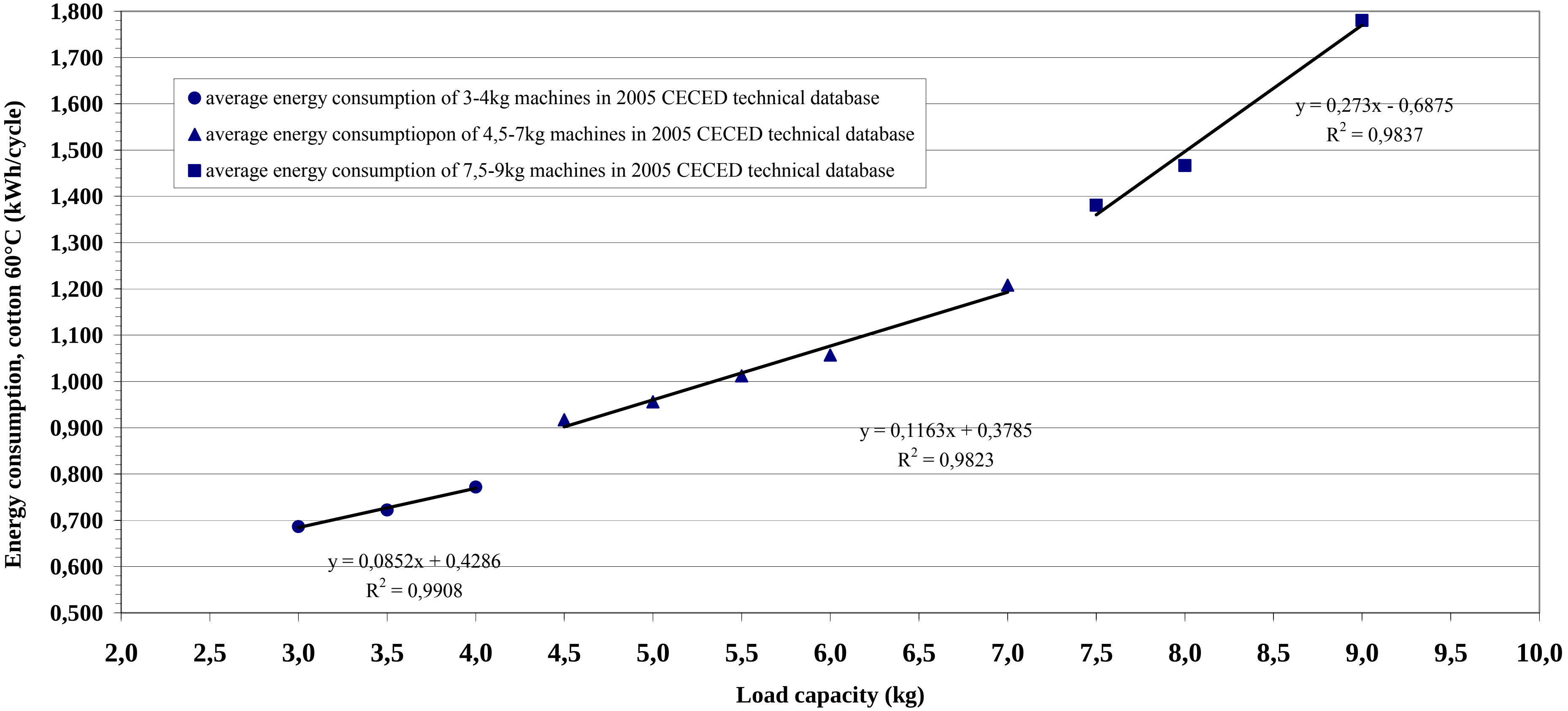


Figure 7.41: Energy consumption straight lines and relevant R^2 for different load capacity machines with similar thermodynamic properties in 1997 CECED technical database. Energy consumption per cycle is expressed as function of the machine load capacity

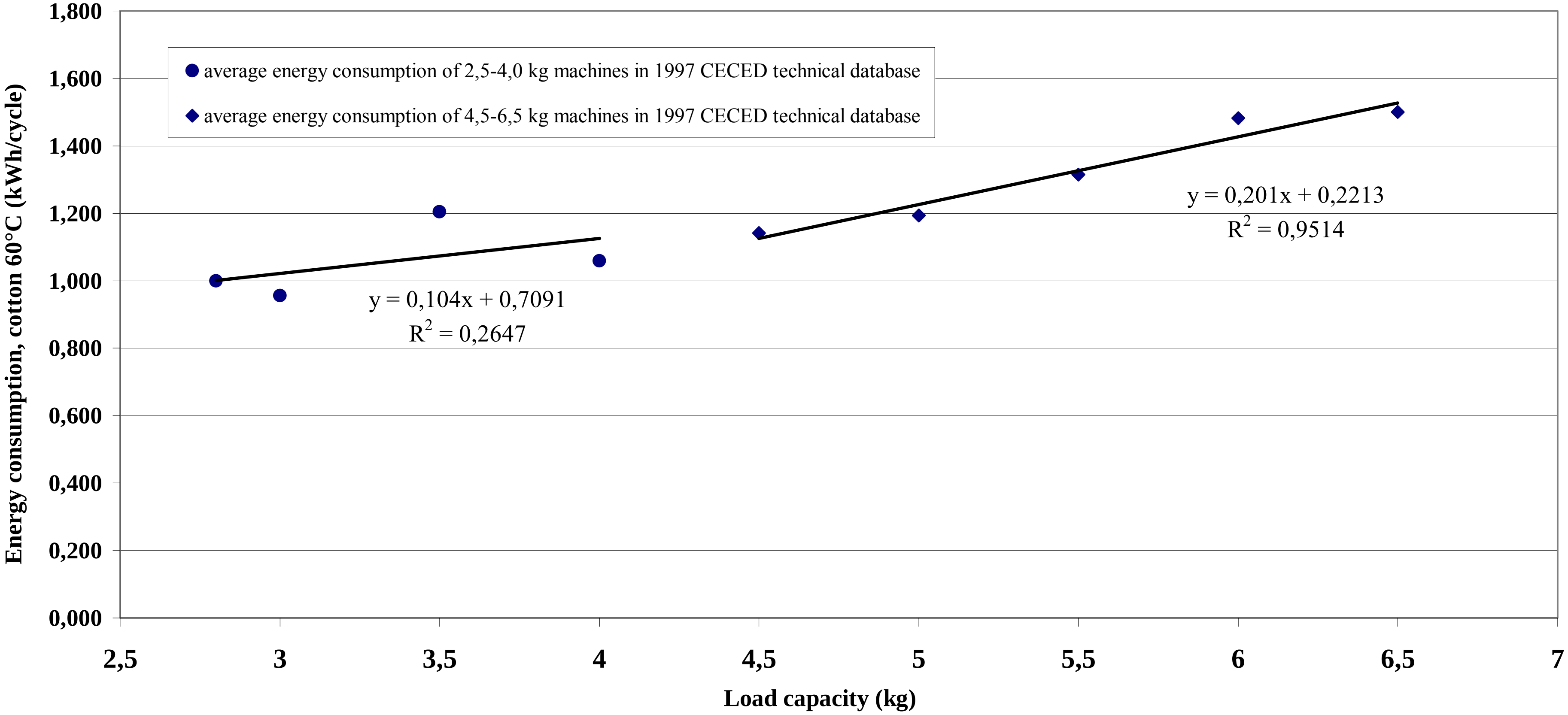


Figure 7.42: Straight lines for energy consumption and 2005 CECED technical database and comparison with the present labelling system, Hypothesis One

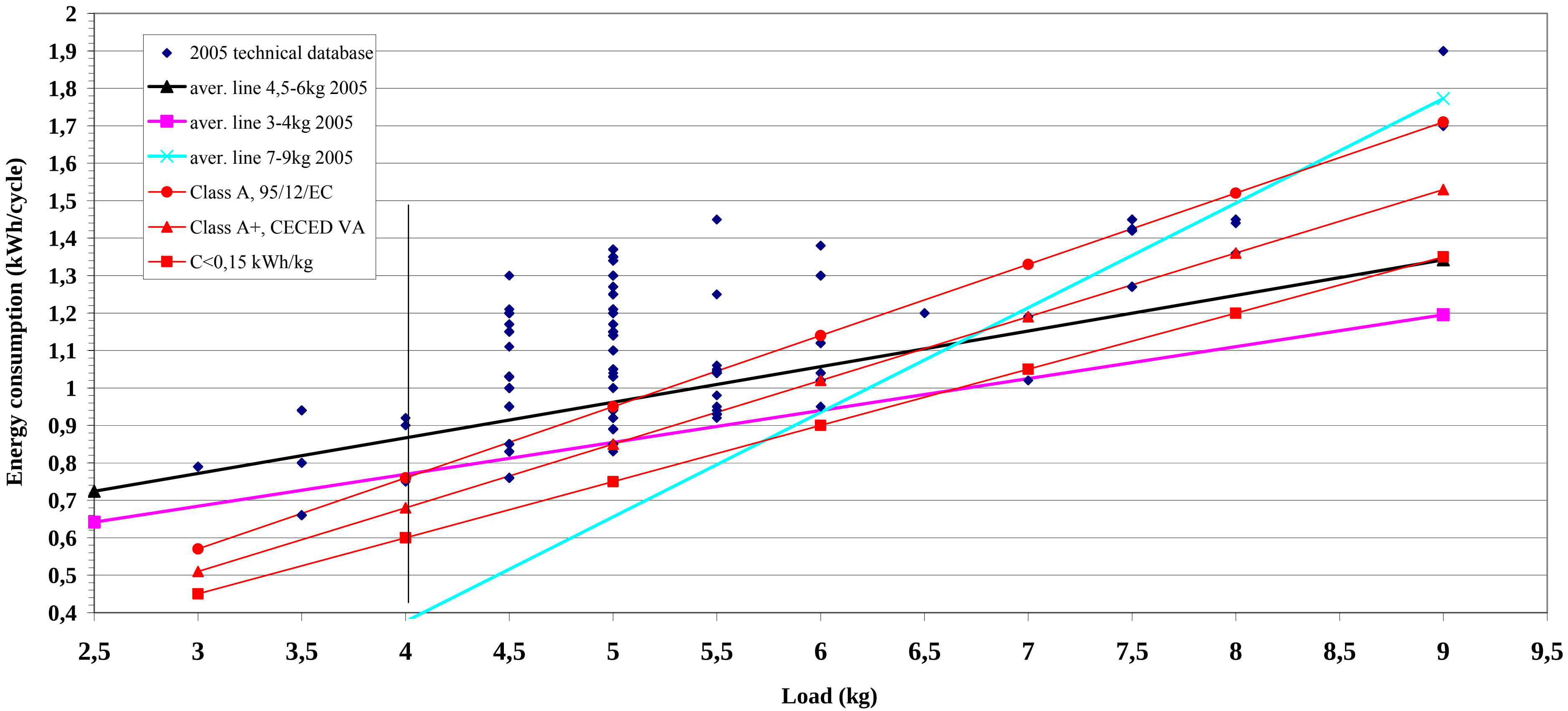
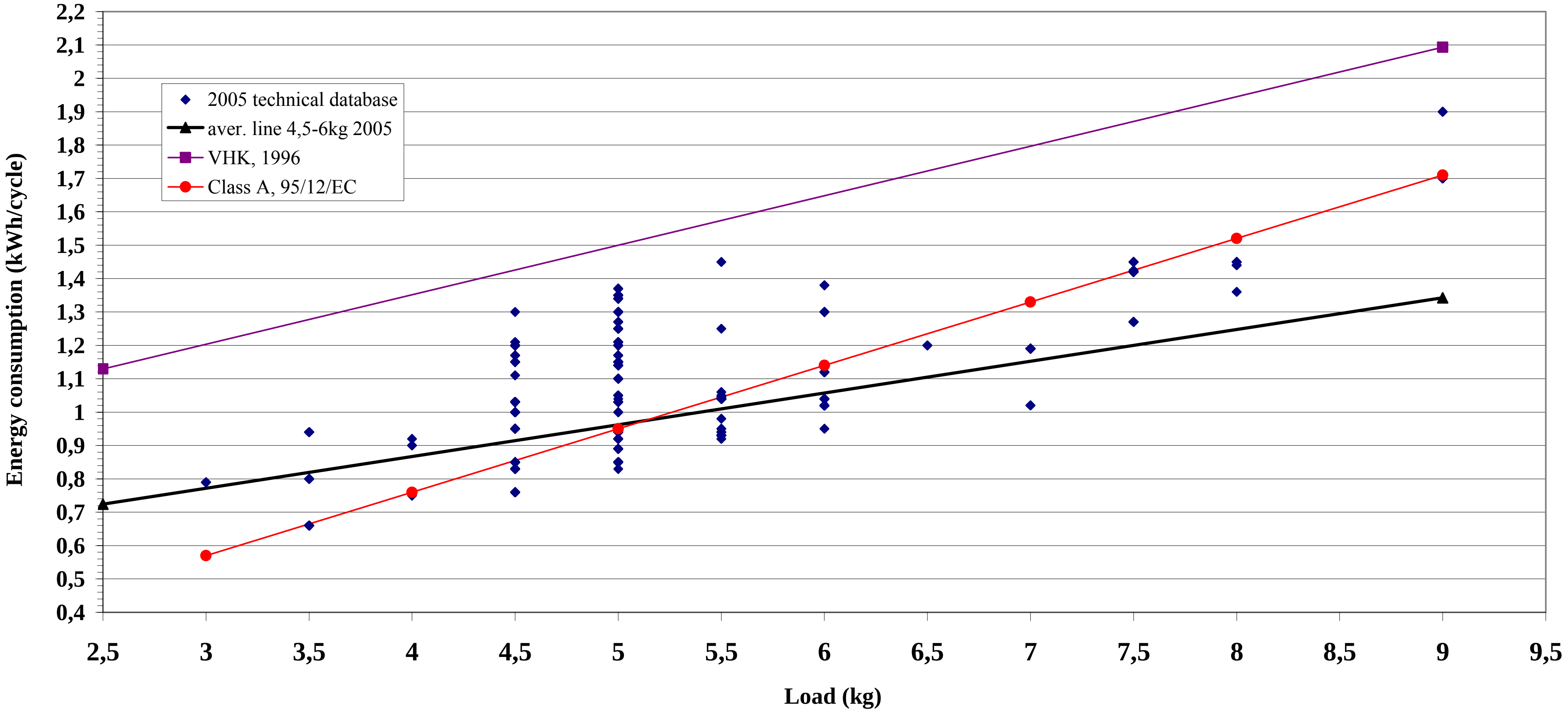


Figure 7.43: Comparison of the $E_{c,aver}$, the SEC and the A class lines with 2005 CECED technical database, Hypothesis One



b.2) Hypothesis Two

When the 4,5-7kg cluster reference line is considered representative of all the models in 2005 database, the average energy consumption ($E_{c,aver}$) per cycle (in kWh/cycle) of an appliance in 2005 can be calculated using the formula:

$E_{c,aver} = 0{,}1163 \times c + 0{,}3785$ where c is the machine load capacity in kg.

In Figure 7.44 the $E_{c,aver}$ line is compared with the straight lines of the other machine clusters and with the lines representing energy efficiency class A (directive 95/12/EC), A+ (CECED Voluntary Agreement) and C<0,15 kWh/kg. The standard energy consumption (SEC) matching the reference value of 0,30 kWh/kg for the 5kg machine resulting from the 1996 VhK study is:

$SEC = 0{,}1817 \times c + 0{,}591$ where c is the machine load capacity in kg.

In Figure 7.45 the $E_{c,aver}$ line is compared with the *SEC* line and the models in the 2005 technical database.

b.3) Hypothesis Three

As alternative, the 1997 4,5-6,5 kg cluster reference line:

$E_{c,aver,1997} = 0{,}201 \times c + 0{,}2213$ where c is the machine load capacity in kg,

can be used to derive the standard energy consumption (SEC) matching the reference value of 0,30 kWh/kg for the 5kg machine resulting from the 1996 VhK study or:

$SEC = 0{,}246 \times c + 0{,}270$ where c is the machine load capacity in kg.

In Figure 7.46 the $E_{c,aver,1997}$ line is compared with the *SEC* line and the models in the 2005 technical database.

Under all the three hypothesis, EEI can be calculated as percentage of reduction from the SEC line, or from the same line but considering the annual energy consumption (once the annual or the per cycle energy consumption is known) with or without the Low Power Modes. Since the contribution of the low power modes (see Table 7.40) is modest, the SEC reference line can be still considered representative of the washing machine consumption.

c) The Water Consumption and Efficiency algorithms for the 60°C cotton programme

To complement the energy consumption algorithms, the possibility and opportunity of introducing water efficiency algorithms in the revision of directive 95/12/EC:
(i) to calculate a Water Efficiency Index (WEI) based on the annual water consumption (in m^3)
(ii) to use the Water Consumption (W_c) per washing cycle (in litre/cycle)

is here discussed.

Figure 7.44: Straight lines for energy consumption and 2005 CECED technical database and comparison with the present labelling system, Hypothesis Two

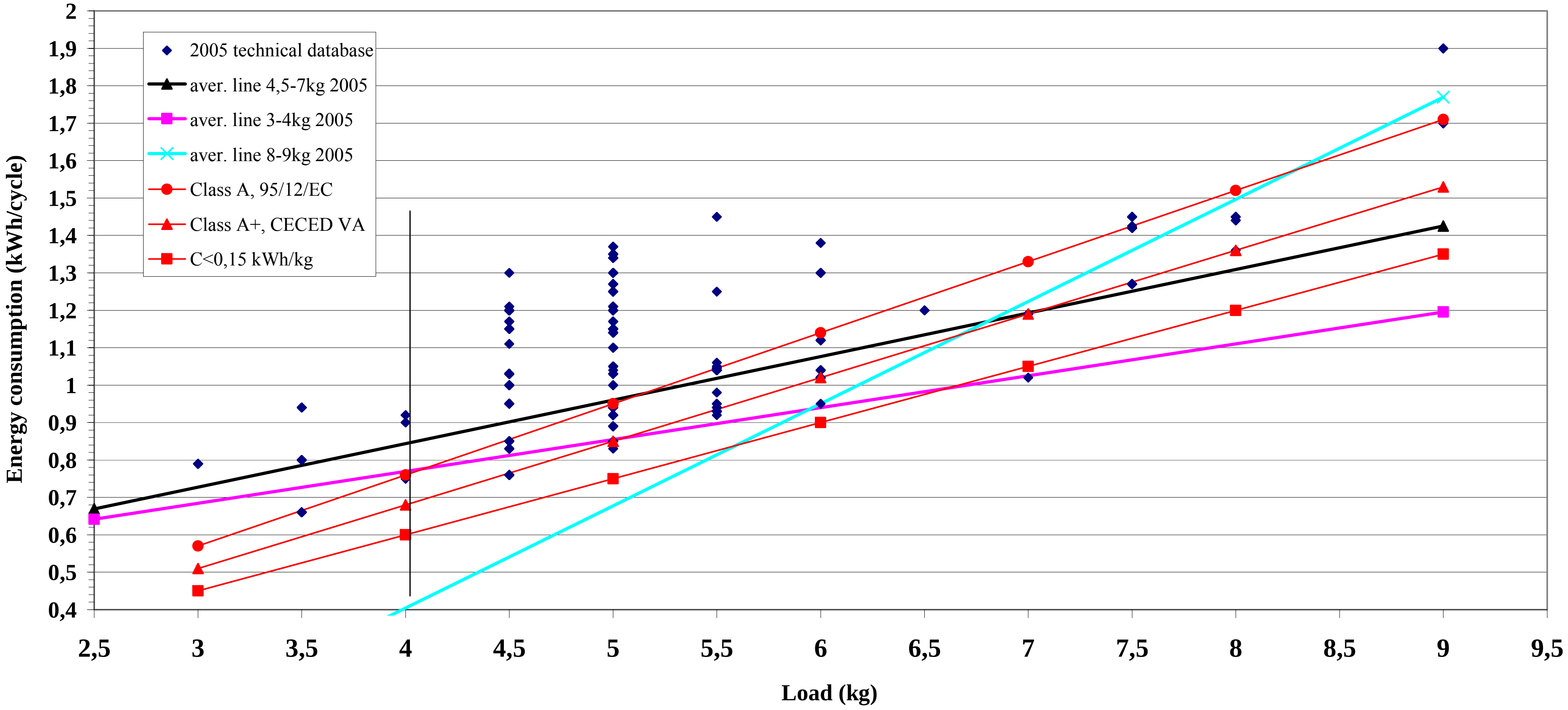


Figure 7.45: Comparison of the $E_{c,aver}$, the SEC and the A class lines with 2005 CECED technical database, Hypothesis Two

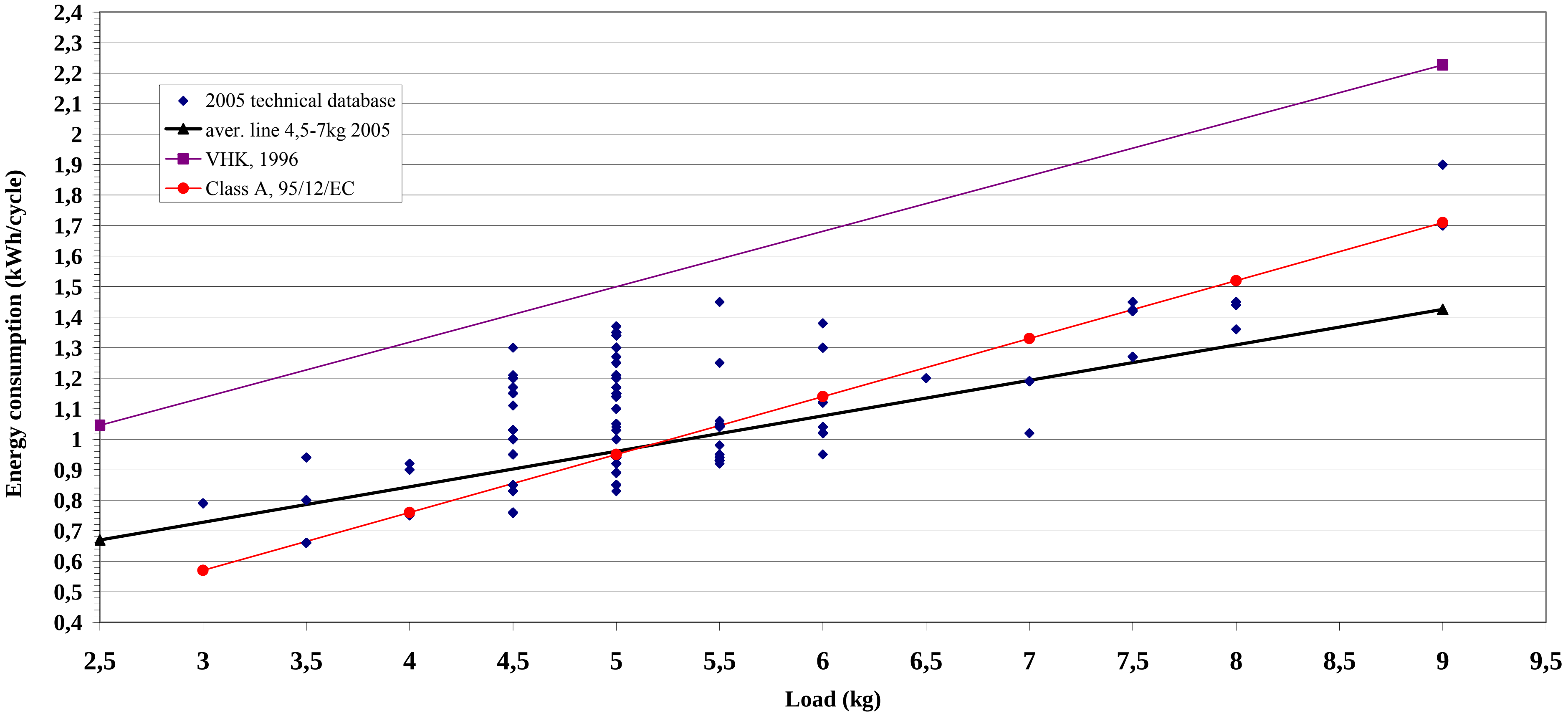
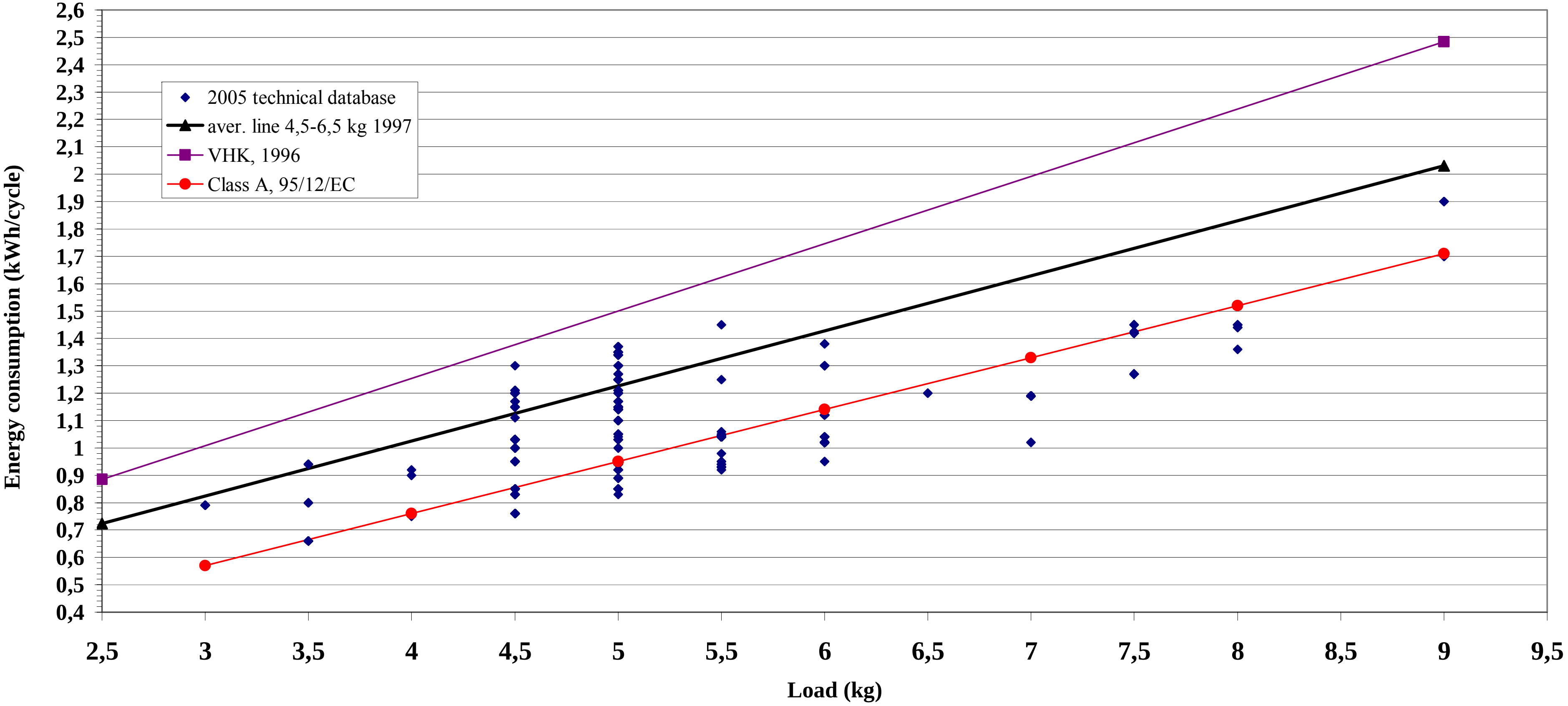


Figure 7.46: Comparison of the 1997 $E_{c,aver}$, the SEC and the A class lines with 2005 CECED technical database, Hypothesis Three



To evaluate the average Water consumption per year (AW_c) of an appliance in 2005 per cycle (in litre/cycle) the Water Consumption (W_c) per cycle should be measured according to the standard and then multiplied for an agreed number of washing cycles per year. The same average number of washing cycles per year already proposed for the energy consumption will be used.

$AW_c = W_c \times n$ where n = number of washing cycles per year.

When considering the average water consumption per cycle as function of the load capacity for the models in 2005 CECED technical database, Figure 7.47 results. The average water consumption $W_{c,aver}$ (in litre/cycle) over the load capacity is represented by the straight line resulting from the linear regression of the average points:

$W_{c,aver} = 5{,}05 \times c + 25{,}1$ where c is the machine load capacity in kg.

For the water consumption, no specific model clusters could be identified from the 2005 CECED technical database, therefore the straight line deriving from the regression of the average values for each load capacity was used, although the R^2 value (R^2=0,7748) is lower than for the energy consumption, but still acceptable.

Once the water consumption per cycle of a model is measured, the average annual consumption is calculated and can be used to calculate a Water Efficiency Index. The water consumption per cycle can be divided by the machine load capacity resulting in water consumption per kg load (similarly to the energy consumption in the present directive 95/15/EC).

The WEI is the ratio between the water consumption of a specific appliance and the standard water consumption of that appliance. The water consumption can be both the annual value and the cycle consumption:

$WEI = AW_c/SWC$

The standard water consumption (SWC) may be represented by a straight line (Figure 7.48) matching the reference value of 18,5 litre/kg for the 5kg machine (equal to 92,5 litre/cycle) resulting from the mentioned 1996 VhK study as the water consumption of the standard base case machine in 1995:

$SWC = 9{,}28 \times c + 46{,}1$ where c is the machine load capacity in kg.

WEI can be calculated as percentage of reduction from this line once the water consumption of the specific model is known.

d) Energy Efficiency Classes: definition and thresholds

It has to be discussed whether a revised A-G scale should be adopted or if a new categorical system is a better approach and whether the present system base on horizontal thresholds for specific energy consumption (in kWh per cycle and per kg of load) should be retained or modified to consider an overall annual energy consumption including low power modes.

Figure 7.47: The average water consumption and regression line for the washing machines in 2005 CECED technical database

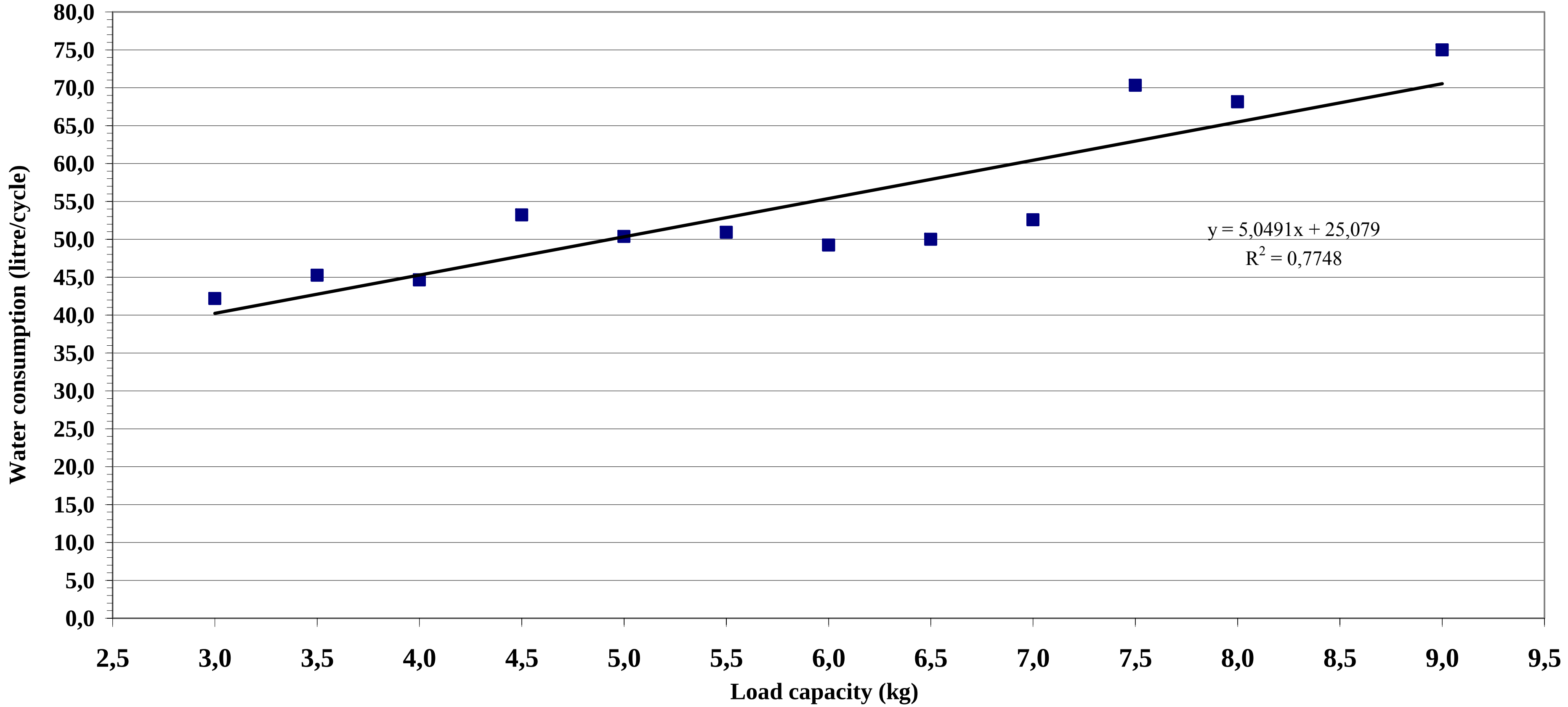
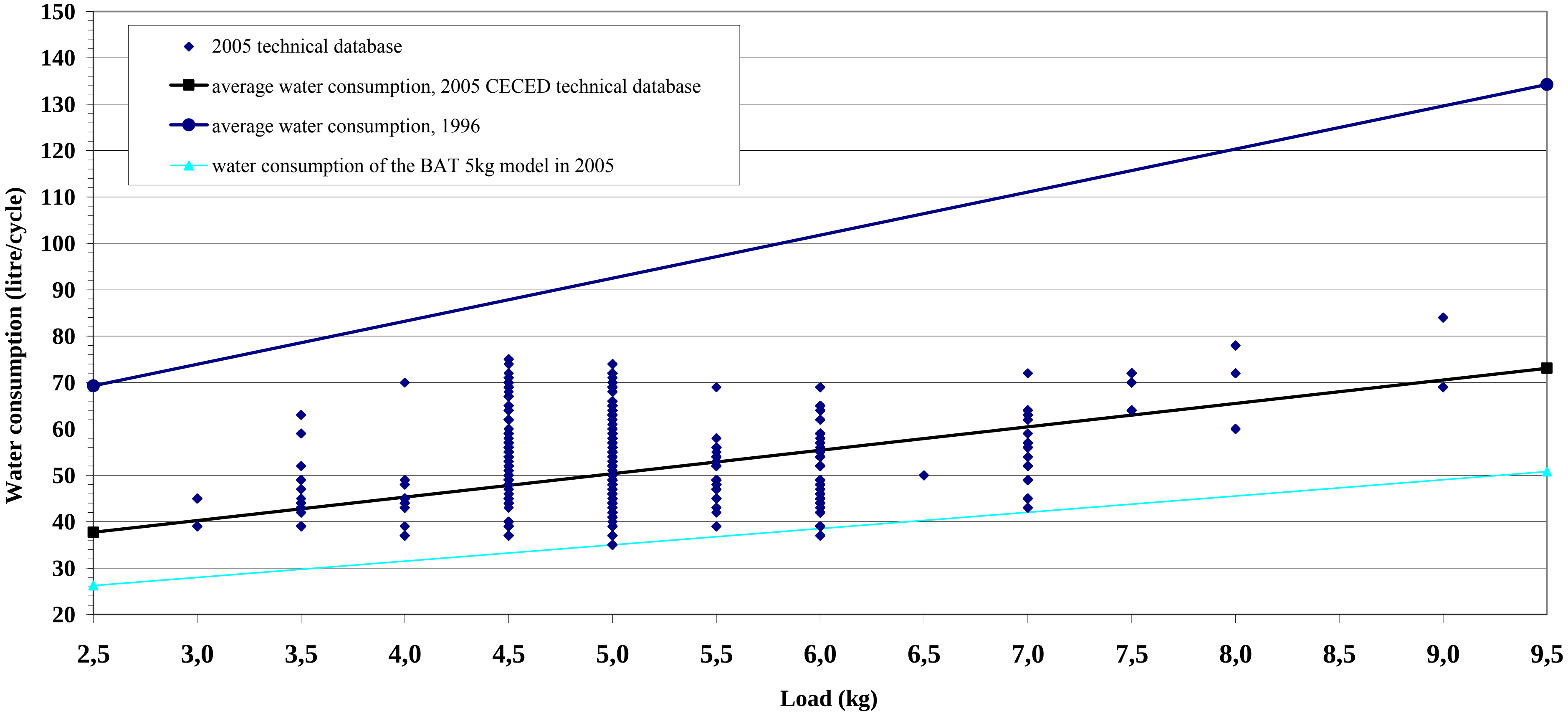


Figure 7.48: Straight lines for water consumption and 2005 CECED technical database



In addition, the value of the classes' thresholds has to be proposed. Again two alternatives are possible:

- retain the existing ones and create new ones on top, following the same pace;
- redesign the entire threshold systems, taking into consideration that the A+ class and threshold was defined in 2003 only through a commercial agreement to address a strong market need.

The present labelling scheme is based on a series of horizontal thresholds of energy consumption per kg of load for the 60°C cotton programme, measured under EN 60456 standard, 3rd edition. It was developed in 1995 when the large majority of the machines had a load capacity of 5kg (see Task 2). In 2003 an industry commercial agreement established a further 17% better threshold to address a strong market need of higher efficiency product identification, after the so called Labelling Committee negatively voted the upgrading of the directive 95/12/EC efficiency classes system. More recently, models with a larger load capacity and with an energy consumption lower than 0,15 kWh/kg appeared on the market, which were named "class A++" from some non-EU manufacturers, trying to exploit as much as possible the effective marketing and communication tool represented by anything related the EU labelling scheme.

The EU energy label is the current format and is not protected by copyright, i.e. the label is not a trademark. Article 7(b) of the framework directive 92/75/EC only provides an indirect and incomplete way to protect the EU energy label, i.e. by Member States taking action when other labels are likely to mislead or confuse.

d.1) Upgrading of the current labelling scheme, with or without A-G rescaling

The energy labelling scheme for washing machines in directive 95/12/EC considers the specific energy consumption in kWh/kg load:

CLASS	ENERGY EFFICIENCY	WASHING PERFORMANCE	WATER EXTRACTION EFFICIENCY
A	$C \leq 0,19$	$P > 1,03$	$D < 45\%$
B	$0,19 < C \leq 0,23$	$1,03 \geq P > 1,00$	$45\% \leq D < 54\%$
C	$0,23 < C \leq 0,27$	$1,00 \geq P > 0,97$	$54\% \leq D < 63\%$
D	$0,27 < C \leq 0,31$	$0,97 \geq P > 0,94$	$63\% \leq D < 72\%$
E	$0,31 < C \leq 0,35$	$0,94 \geq P > 0,91$	$72\% \leq D < 81\%$
F	$0,35 < C \leq 0,39$	$0,91 \geq P > 0,88$	$81\% \leq D < 90\%$
G	$0,39 < C$	$0,88 \geq P$	$90\% \leq D$

Note: C is the specific energy consumption in kWh/kg load; P is the ratio of the average reflectance of the test machine and the reference machine; D is the residual moisture content in percentage.

A new set of energy efficiency classes going from G to A3 (or as alternative from class 1 to class 10) can be created (Labelling Scheme Option 1), based on specific energy consumption (kWh/kg) thresholds with just a little modification of the current thresholds. As alternative, it is possible to defined a shorter classification from G to A (Labelling Scheme Option 2), as shown in Table 7.43

d.2) New categorical scheme based on annual energy consumption with low power modes

Based on the scale of specific energy consumption in Table 7.43 a set of EEI are created for the 5kg machine taking into consideration that a specific energy consumption of 0,31 kWh/kg (the same value identified in previous paragraph as the consumption of the standard base case in 1996 and used as basis of CECED voluntary commitments for washing machines) is already defined in

Table 7.43: Comparison of directive 95/12/EC and the updated labelling scheme based on specific energy consumption (kWh/kg) for washing machines

Directive 95/12/EC				**Revised labelling scheme**					
Specific energy consumption	EE classes	improvement		Specific energy consumption	improvement		EE classes		
							Option 1		**Option 2**
(kWh/kg)	(class)	(units)	(%)	(kWh/kg)	(units)	(%)	(class)		(class)
				C ≤ 0,14	--	--	A3	10	A
C ≤ 0,15		--	--	0,14 < C ≤ 0,16	0,02	12,5	A2	9	B
C ≤ 0,17	A+	0,02	10,5	0,16 < C ≤ 0,18	0,02	11,1	A1	8	C
C ≤ 0,19	A	0,02	17,4	0,18 < C ≤ 0,21	0,03	14,3	A	7	D
0,19 < C ≤ 0,23	B	0,04	14,8	0,21 < C ≤ 0,24	0,03	12,5	B	6	E
0,23 < C ≤ 0,27	C	0,04	12,9	0,24 < C ≤ 0,27	0,03	11,1	C	5	F
0,27 < C ≤ 0,31	D	0,04	11,4	0,27 < C ≤ 0,31	0,04	12,9	D	4	G
0,31 < C ≤ 0,35	E	0,04	10,3	0,31 < C ≤ 0,35	0,04	11,4	E	3	
0,35 < C ≤ 0,39	F	0,04	11,8	0,35 < C ≤ 0,39	0,04	10,3	F	2	
C > 0,39	G	--	--	C > 0,39	--	--	G	1	

directive 95/12/EC as threshold between Classes D and E (Table 7.44). If this value is taken as having EEI=100, then the following straight line can be considered as the SEC (under the hypothesis of the 4,5-6kg cluster reference line representative of all washing machine models):

$$SEC_{cycle} = 0{,}1532 \times c + 0{,}7836$$

where *c* is the machine load capacity (in kg) and the energy consumption in kWh per cycle is considered. When the annual energy consumption is instead used, for 220 cycles per year, the following formula results:

$$SEC_{year} = 33{,}7 \times c + 172{,}4$$ where *c* is the machine load capacity (in kg).

For a 5kg machine, this formula results in (33,7 × 5 + 172,4) = 340,9 kWh/year. When the other specific energy consumption values are considered, the annual energy consumptions and EEIs shown in Table 7.43 are calculated, which are almost overlapping with the value of Table 7.44.

The SEC formula does not take into consideration the low power modes consumption. For example an annual consumption of 11,8 kWh can be calculated for washing machines from Table 7.41 when 'off-mode' power consumption is 1W and 'left-on mode' power consumption is 2W and should be added to the on-mode annual consumption to have the overall annual energy consumption

The EEI of a washing machine, under this new approach, is calculated as the ratio of the overall annual energy consumption (energy consumption for 220 cycles/year plus the low power modes consumption) with the standard energy consumption (calculated through the relevant SEC formula, which does not include the low power modes). According to the proposed approach, for a 5kg machine no differences will arise in terms of energy efficiency, compared to the current labelling scheme, when the low power modes consumption is not considered. In Table 7.45 a set of energy efficiency classes are proposed: Labelling Scheme Option 3 foreseen a rating system from class G to class A3 (or as alternative from class 1 to class 10) while Labelling Scheme Option 4 foreseen a scale from G to A.

Table 7.44: Calculation at the basis of the upgrading of the washing machine labelling scheme based on EEI and overall annual energy consumption(based on a 5kg washing machine)

Annual energy consumption		Energy consumption		difference		Specific energy consumption		difference		Energy efficiency index		difference	
(kWh/year)		(kWh/cycle)		(%)	(kWh/cycle)	(kWh/kg)		(%)	(n)	(EEI)		(%)	(n)
<154		<0,700		--	--	< 0,14		--	--	< 45,2		--	--
154	176	0,700	0,800	12,5	0,100	0,14	0,16	12,5	0,020	45,2	51,6	12,5	6,5
176	198	0,800	0,900	11,1	0,100	0,16	0,18	11,1	0,020	51,6	58,1	11,1	6,5
198	231	0,900	1,050	14,3	0,150	0,18	0,21	14,3	0,030	58,1	67,7	14,3	9,7
231	264	1,050	1,200	12,5	0,150	0,21	0,24	12,5	0,030	67,7	77,4	12,5	9,7
264	297	1,200	1,350	11,1	0,150	0,24	0,27	11,1	0,030	77,4	87,1	11,1	9,7
297	341	1,350	1,550	12,9	0,200	0,27	**0,31**	12,9	0,040	87,1	**100,0**	12,9	12,9
341	385	1,550	1,750	11,4	0,200	**0,31**	0,35	11,4	0,040	**100,0**	112,9	11,4	12,9
385	429	1,750	1,950	10,3	0,200	0,35	0,39	10,4	0,040	112,9	125,8	10,4	12,9
>429		>1,950		--	--	> 0,39		--	--	>125,8		--	--

Table 7.45: Updated labelling scheme based on EEI and overall annual energy consumption for a 5kg washing machine

Annual energy consumption		Energy consumption		difference		Specific energy consumption		**Energy efficiency index**		difference		EE classes		
(kWh/year)		(kWh/cycle)		(%)	(kWh/cycle)	(kWh/kg)		(EEI)		(%)	(n)	**Option 3** (class)		**Option 4** (class)
<153,4		<0,697		--	--	< 0,139		< 45		--	--	A3	10	A
153,4	177,3	0,697	0,806	13,5	0,108	0,139	0,161	45	52	13,5	7	A2	9	B
177,3	201,1	0,806	0,914	11,9	0,108	0,161	0,183	52	59	11,9	7	A1	8	C
201,1	231,8	0,914	1,054	13,2	0,139	0,183	0,211	59	68	13,2	9	A	7	D
231,8	262,5	1,054	1,193	11,7	0,139	0,211	0,239	68	77	11,7	9	B	6	E
262,5	296,6	1,193	1,348	11,5	0,155	0,239	0,270	77	87	11,5	10	C	5	F
296,6	340,9	1,348	1,550	13,0	0,201	0,270	**0,310**	87	**100**	13,0	**13**	D	4	G
340,9	385,2	1,550	1,751	11,5	0,201	**0,310**	0,350	**100**	113	11,5	13	E	3	
385,2	429,5	1,751	1,952	10,3	0,201	0,350	0,390	113	126	10,3	13	F	2	
>429,5		>1,952		--	--	> 0,390		>126		--	--	G	1	

The effect for other capacity machines is presented in Figure 7.49. In the same Figure the current A, A+ and 'C'≤ 0,15 kWh/kg classes are shown for sake of comparison.

Under the hypothesis of the 4,5-7kg cluster reference line representative of all washing machines, and using the same set of EEIs shown in Table 7.45, if the of 0,31 kWh/kg value is taken as having EEI = 100, then the following line can be considered as the SEC:

$SEC_{cycle} = 0{,}1878 \times c + 0{,}6111$ where c is the machine load capacity (in kg) and the energy consumption in kWh per cycle is considered. When the annual energy consumption is used, for 220 cycles per year, the following formula results:

$SEC_{year} = 41{,}3 \times c + 134{,}4$ where c is the machine load capacity (in kg).

For a 5kg machine, this formula gives (41,3 × 5 + 134,4) = 340,9 kWh/year. When the other specific energy consumption values are considered, the values of the annual energy consumption and EEI shown in previous Table 7.45 are calculated. Again the SEC formula does not take into consideration the low power modes consumption. The same options for the energy labelling classification already presented in Table 7.45 (set of energy efficiency classes from G/class 1 to A3/class10 or from G to A) are also possible when this second SEC reference line is used.

The effect of this approach is presented in Figure 7.50. In the same Figure the current A, A+ and 'C'≤0,15 kWh/kg classes are shown for sake of comparison.

Under the third hypothesis of using the 1997 4,5-6,5kg cluster reference line, and considering again the 0,31 kWh/kg value in Table 7.45 as having EEI = 100, then the following line can be considered as the SEC:

$SEC_{cycle} = 0{,}2541 \times c + 0{,}2794$ where c is the machine load capacity (in kg) and the energy consumption in kWh per cycle is considered. When the annual energy consumption is used, for 220 cycles per year, the following formula results:

$SEC_{year} = 55{,}9 \times c + 61{,}5$ where c is the machine load capacity (in kg).

For a 5kg machine, this formula gives (55,9 × 5 + 61,5) = 341,0 kWh/year. When the other specific energy consumption values are considered, the values of the annual energy consumption and EEI shown in previous Table 7.44 are calculated. Again the SEC formula does not take into consideration the low power modes consumption. The same options for the energy labelling classification already presented in Table 7.45 (set of energy efficiency classes from G/class 1 to A3/class10 or from G to A) are also possible when this second SEC reference line is used.

The effect of this approach is presented in Figure 7.51. In the same Figure the current A, A+ and 'C'≤0,15 kWh/kg classes are shown for sake of comparison.

Figure 7.49: Straight lines for annual energy consumption including low power modes and 2005 CECED technical database (hypothesis of the 4,5-6kg cluster reference)

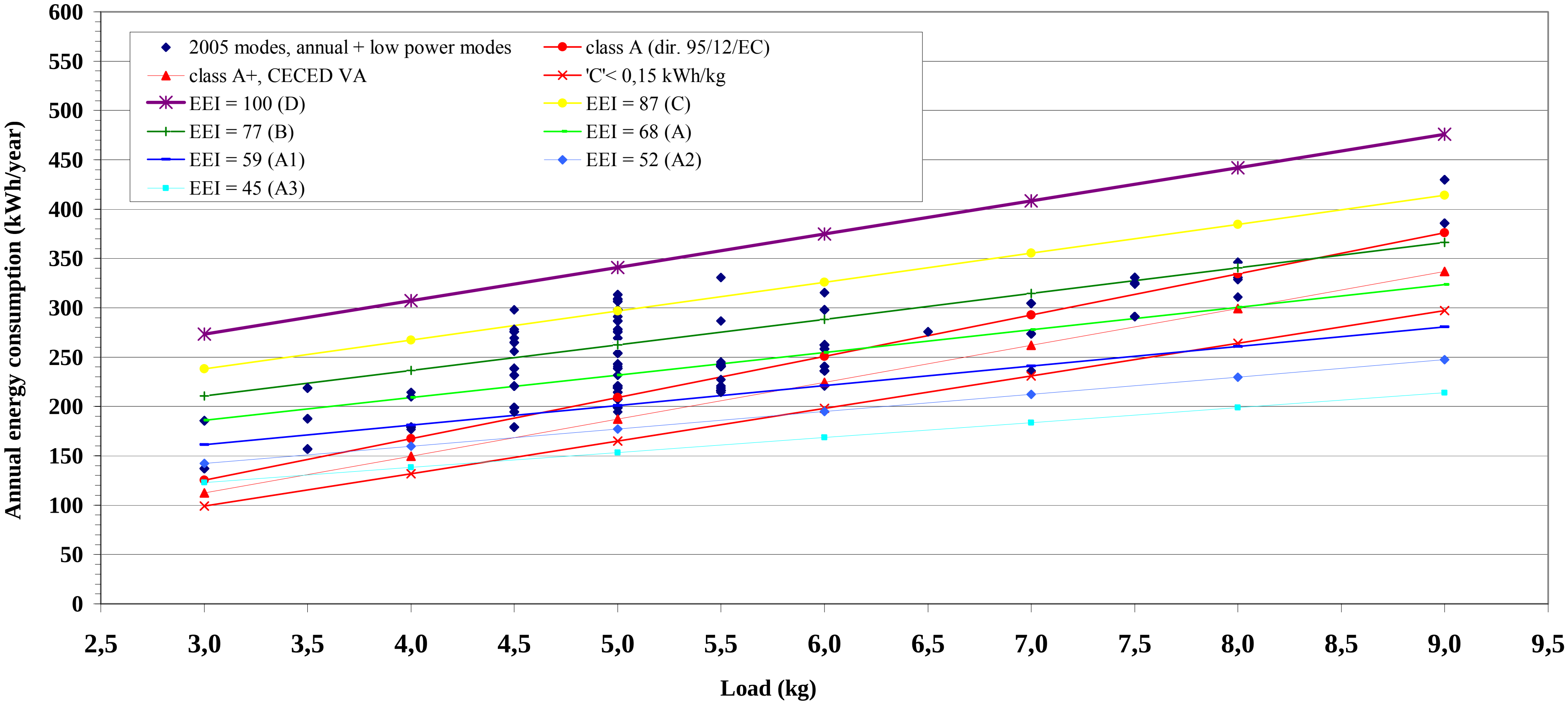


Figure 7.50: Straight lines for annual energy consumption including low power modes and 2005 CECED technical database (hypothesis of the 4,5-7kg cluster reference)

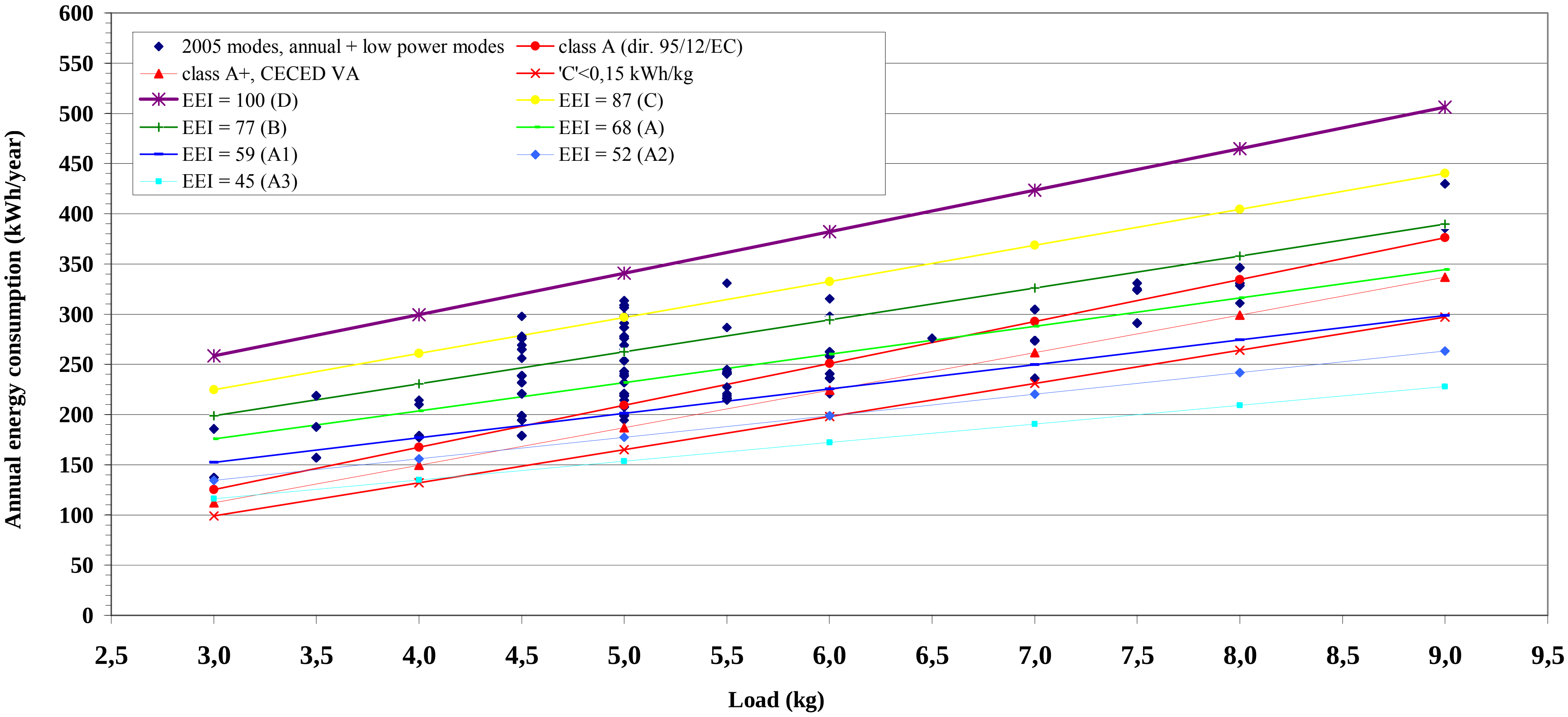
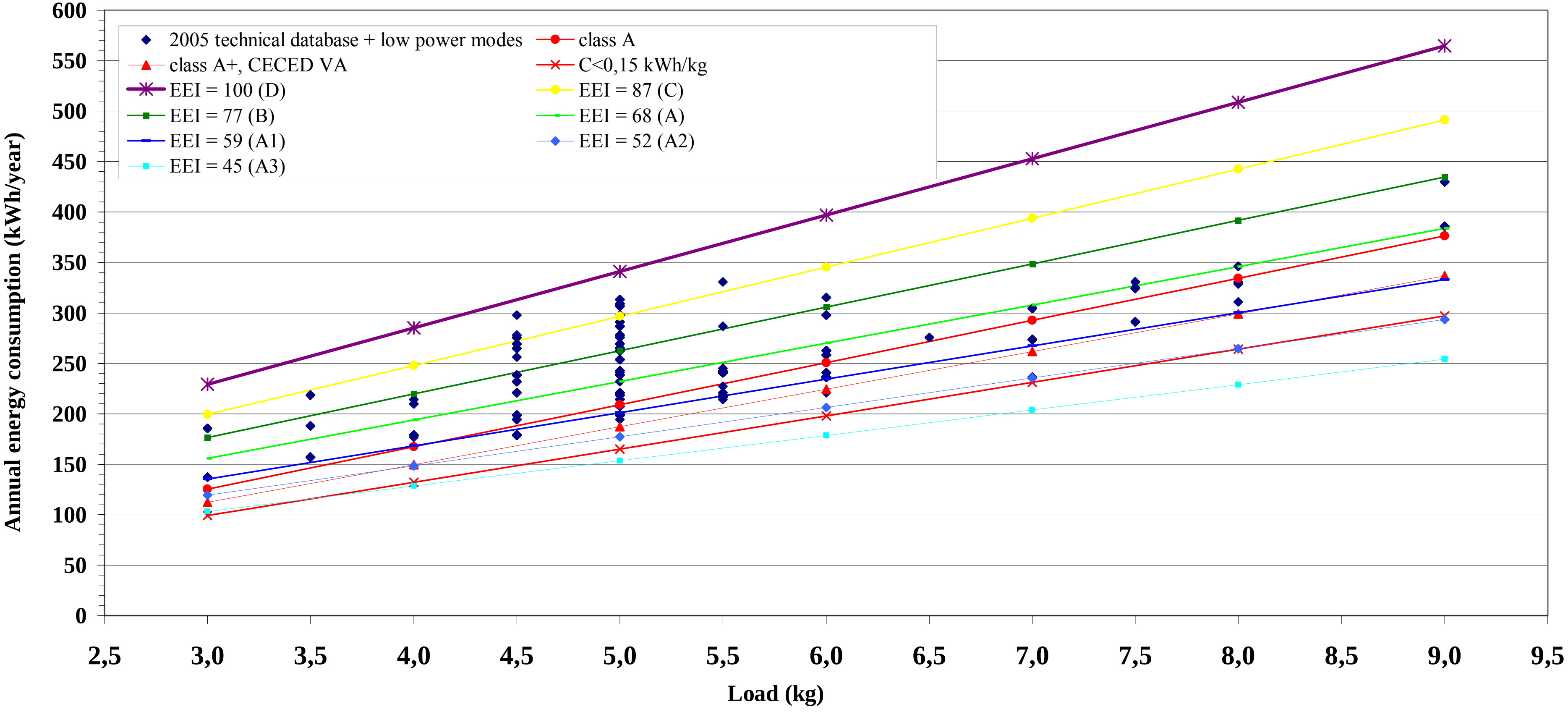


Figure 7.51: Straight lines for annual energy consumption including low power modes and 2005 CECED technical database (hypothesis of the 4,5-6,5kg 1997 cluster reference)



e) Water Efficiency Classes and Rinsing Performance for the 60°C cotton programme

At present the water consumption of a washing machine is only partially addressed by the EU policy measures, since only the indication of the water consumption per cycle has to be indicated in the label.

e.1) Rinsing Performance

There is a strong link is between water consumption and rinsing performance. In fact, in today's machine, water consumption in the (warm) washing phase is already at the minimum due to the associated energy consumption, therefore the water savings can be done only in the rinsing phase or better in the non-warm washing phases.

Most of the machines on the EU market have already the possibility of (one or more) extra rinses, recommended for people with a high sensitive skin or for babies and young children. Although it should be evaluated if the possibility of extra rinse(s) is an actual need (due to a poor rinsing performance known by the manufacturers, which might cause problems is specific social categories) or just a way for product differentiation through an appealing - but basically useless - extra feature (although rinse performance might be improved by increasing the rinse number).

At present in the EU the washing machine rinsing performance is driven by the market (manufacturers and consumers) judgement and - in general - it satisfies the consumer expectations in washing. This does not necessarily mean that the textiles are really "well" rinsed, but no major problems are detected or perceived by consumers.

Latest 2007 data from Australia[40], show that there is a very little influence of the spinning performance (in terms of residual moisture content) - and therefore broadly of the spinning speed - on the washing machine rinsing performance.

Australia has chosen the PBIS tracer retention method (see Task 1) because two detergents are available in the country and therefore the detection of the surfactant (LAS system) cannot be used, while the alkalinity system is still under investigation. The results of the tests on 8 top loader machines and 5 front loader machines, a representative cross section of the product available in 2004 in the Australian market, including a wide range of water efficiencies are presented in Figure 7.52[41], where the mass of retained PBIS is plotted against the water efficiency (l/kg load). For each data series (front loading machines in blue and washer-dryers in light blue in one series and top loading impeller machines in red and agitator machines in magenta in the other series) an exponential trend line has been fitted. In all cases the fit was good. The trend lines show a clear relationship between water efficiency and rinse performance whereby an increase in water efficiency will result in a decrease in rinse performance. However, for a given water efficiency some significant variation in rinse performance between different models was found.

One of the alternative systems, the LAS system, is based on the detection trough UV spectrophotometry of the surfactant component of the detergents. The alkalinity method, under preparation for the IEC 60456 5th edition, is still not completely satisfactory – due to a too large variation of the results.

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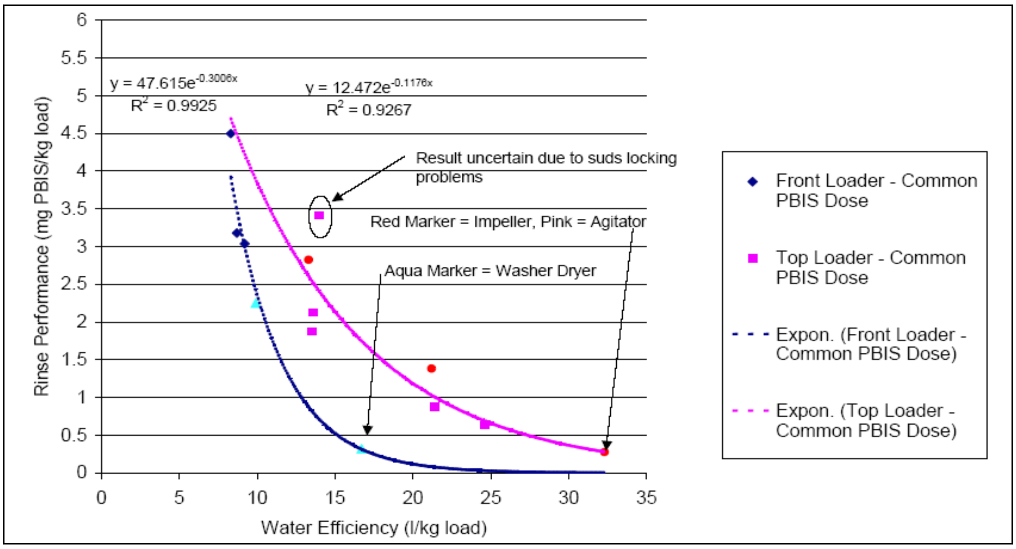
[40] Presentation of the Australian expert at the meeting of the IEC SC59D/WG20 held in Milton Keynes (UK), March 2007.

[41] Source: Energy Efficient Strategies, Method for the Determination of Rinse Performance in Clothes Washers, Summary Report, Report for The Department of Environment and Heritage – Australian Federal Government, June 2005

Figure 7.52: Rinse performance (PBIS) vs. water efficiency for a representative sample of washing machines in the Australian market in 2004



e.2) Water Efficiency Classes

Staring from the WEC and W_c values a rating system for water consumption can be hypothesised in term of WEI, based on the annual consumption or the consumption per cycle or per kg of load. However, any attempt to label the water consumption without addressing the rinsing efficiency might result in a reduction of the rinse quality and therefore having a negative impact on consumers.

e.3) Conclusions

Although very likely challenging for suppliers, water (efficiency or consumption) labelling should not be introduced in the EU if rinsing performance labelling or specific requirements are not contemporarily enforced, due to the strong relation between water consumption and rinsing performance (proven in Australia, where the introduction of a rinse performance requirement facilitated the introduction of mandatory water efficiency rating and labelling). Without a policy measure addressing the rinse performance in the EU, higher water efficiency rating could be achieved by reducing rinse quality that may not meet the needs of washing machine users. A specific requirement, addressing a maximum of water consumption per cycle will be proposed.

7.6.3.3 Dishwashers

a) Elements to be updated in the present labelling scheme for dishwashers

The main element of the present labelling scheme that should be updated in a revised scheme for dishwashers is the Energy Efficiency (Index) calculation algorithm: to be amended to include low power modes and to consider the machine annual energy consumption.

b) The Energy Efficiency (Index) algorithms for dishwashers

The opportunity of amending the algorithms in directive 97/12/EC will be discussed. The possible alternative is to calculate a new Energy Efficiency Index (EEI) based on the annual energy consumption (in kWh); the EEI is given by the ratio between the energy consumption per cycle of any given appliance and the reference energy consumption of the same appliance.

The current energy labelling scheme for dishwashers includes the calculation of energy efficiency index (E_I) as the ratio between the actual model energy consumption (C) and the energy consumption of the reference model (C_R) according to the following formulae:

$C_R = 1{,}35 + 0{,}025 \times S$ if $S \geq 10$
$C_R = 0{,}45 + 0{,}09 \times S$ if $S \leq 9$
$E_I = C/C_R$

To evaluate the average energy consumption of a machine per year, the energy consumption per cycle should be multiplied for an agreed number of washing cycles per year. The average number of washing cycles per year used in Task 6 is 280 for washing machines.

The overall annual energy consumption including 'low power modes' can be calculated, as shown in Table 7.45, as:

- including *off-mode* and *left-on mode* each working for half of the residual time after 280 washing cycles per year;
- in case a 'power management system' is implemented and *left-on mode* reverts to *off mode* within, lets say, about 1 hour, resulting in the hours in left-on mode hypothesised equal to the number of the annual washing cycles plus the time in off mode.

The contribution of the low power modes to the annual energy consumption is modest, as clearly shown in Table 7.46.

Table 7.46: Methods to calculate the machine energy consumption including low power modes, with and without a power management system for dishwashers

		Energy consumption	Et (cycle duration)	C (number of annual cycles)	off-mode power consumption with safety functions	t1 (oof mode duration)	left-on mode power consumption	t2 (left on duration)	Total annual energy consumption	t2 measured duration	Overall energy consumption per cycle	load capacity	Energy consumption of the reference model	Energy efficiency index
		Wh/cycle	min	cycle/year	W	min	W	min	kWh/y	min	kWh/cycle	ps	kWh/cycle	(dir. 97/17/EC)
without power management		1050	110	280	1	247400	2	247400						
	Wh	294000			4123,3		8246,7		525600					
	kWh	294			4,1		8,2		306,37		1,09417857	12	1,6500	0,6631
with power management		1050	110	280	1	478000	3	16800	525600	60				
	Wh	294000			7966,7		840		302,8066667		1,08145238	12	1,6500	0,6554
	kWh	294			8,0		0,84							

The formula to calculate the overall AE_c (when the power management is not enforced) is:

$$AE_c = E_t \times C + \left\{ P_s \times [525\,600 - (T_c \times C)]/2 + P_l \times [525\,600 - (T_c \times C)]/2 \right\} / (60 \times 1000)$$

where:

- AE_c = annual energy consumption (in kWh)
- E_t = the cycle energy consumption in kWh
- C = is the defined number of cycles per year, 280 for dishwashers
- P_l = the measured power (in W) in the "left-on mode"
- P_s = measured power in "off-mode" (W)
- T_c = washing cycle time (in minutes).
- 525 600 = total number of minutes in a year (= 60 min/h × 24 h/day × 365 days/year).

When a power management is enforced, the formula should be modified to take into consideration the effective duration of the "off-mode" and the "left-on mode" as:

$$AE_c = E_c \times C + \left\{(P_l \times T_{Pl} \times C) + P_s \times [525\,600 - (T_c \times C) - (T_{Pl} \times C)]\right\} / (60 \times 1\,000)$$

where T_{Pl} is the measured time in “left-on mode” (in minutes). In addition, the overall low power modes power is considered 100% the time in “off mode” where the “end of cycle” mode is not present (when products automatically revert to “off” after the end of cycle).

When 280 cycles per year are considered, the SEC (standard energy consumption) formulae are derived from C_R according to the place settings number:

$SEC_{\geq 10} = 7 \times ps + 378$ for $ps \geq 10$, where ps is the number of place settings, and

$SEC_{\leq 9} = 25{,}2 \times ps + 126$ for $ps \leq 9$, where ps is the number of place settings.

c) Energy Efficiency Classes: definition and thresholds

c.1) Upgrading of the current labelling scheme, with or without A-G rescaling

The energy efficiency/washing performance/drying performance classes are defined in directive 97/17/EC as:

Class	Energy efficiency	Washing performance	Drying performance
A	$E_I < 0{,}64$	$P_C > 1{,}12$	$P_D > 1{,}08$
B	$0{,}64 \leq E_I < 0{,}76$	$1{,}12 \geq P_C > 1{,}00$	$1{,}08 \geq P_D > 0{,}93$
C	$0{,}76 \leq E_I < 0{,}88$	$1{,}00 \geq P_C > 0{,}88$	$0{,}93 \geq P_D > 0{,}78$
D	$0{,}88 \leq E_I < 1{,}00$	$0{,}88 \geq P_C > 0{,}76$	$0{,}78 \geq P_D > 0{,}63$
E	$1{,}00 \leq E_I < 1{,}12$	$0{,}76 \geq P_C > 0{,}64$	$0{,}63 \geq P_D > 0{,}48$
F	$1{,}12 \leq E_I < 1{,}24$	$0{,}64 \geq P_C > 0{,}52$	$0{,}48 \geq P_D > 0{,}33$
G	$E_I \geq 1{,}24$	$0{,}52 \geq P_C$	$0{,}33 \geq P_D$

A new set of energy efficiency classes going from class G to class A3 (or as alternative from class 1 to class 10) can be created (Labelling Scheme Option 1), based on E_I (and corresponding energy consumption in kWh/cycle) thresholds with just a little modification of the current thresholds. As alternative, it is possible to define a shorter classification from G to A (Labelling Scheme Option 2), as described in Table 7.47. The new classes have been created with an almost constant improvement (i.e. technological effort) between two classes.

Table 7.47: Comparison of directive 97/17/EC and the updated labelling scheme based on E_I for 12ps dishwashers

Directive 97/17/EC				**Revised labelling scheme**					
Energy Efficiency Index	EE classes	improvement		New Energy Efficiency Index	improvement		EE classes		
							Option 1		**Option 2**
(E_I)	(class)	(units)	(%)	(E_I)	(units)	(%)	(class)		(class)
				$E_I < 50$	--	--	A3	10	A
				$50 \leq E_I < 56$	6	10,7	A2	9	B
				$56 \leq E_I < 63$	7	11,1	A1	8	C
$E_I < 0{,}64$	A	--	--	$63 \leq E_I < 71$	8	11,3	A	7	D
$0{,}64 \leq E_I < 0{,}76$	B	12	15,8	$71 \leq E_I < 80$	9	11,3	B	6	E
$0{,}76 \leq E_I < 0{,}88$	C	12	13,6	$80 \leq E_I < 90$	10	11,1	C	5	F
$0{,}88 \leq E_I < 1{,}00$	D	12	12,0	$90 \leq E_I < 100$	10	10,0	D	4	G
$1{,}00 \leq E_I < 1{,}12$	E	12	10,7	$100 \leq E_I < 112$	12	10,7	E	3	
$1{,}12 \leq E_I < 1{,}24$	F	12	9,7	$112 \leq E_I < 124$	12	9,7	F	2	
$E_I \geq 1{,}24$	G	--	--	$E_I \geq 124$	--	--	G	1	

c.2) New categorical scheme based on annual energy consumption with low power modes

Based on the new scale of E_I in the fourth column of Table 7.46, where $E_I = 100$ corresponds to an energy consumption per cycle of 1,650 kWh for 12 dishwashers (representative of machines ≥10ps) and 1,260 kWh for 9ps dishwashers (representative of machines ≤9ps) the before identified SEC straight lines for 280 washing cycles per year:

$$SEC_{\geq 10} = 7 \times ps + 378 \qquad \text{for } ps \geq 10$$
$$SEC_{\leq 9} = 25{,}2 \times ps + 126 \qquad \text{for } ps \leq 9$$

can be considered as reference lines with $E_I = 100$ and thresholds between Classes D and E (Tables 7.47 and 7.48).

For a 12ps machine, the first formula results in (7 × 12 + 378) = 462 kWh/year; for a 9ps machine the second formula results in (25,2 × 9 + 126) = 428,4 kWh/year. When other specific energy consumption values are considered, the values of the annual energy consumption and EEI shown in Table 7.47 are calculated. The SEC formulae do not take into consideration the low power modes consumption. For example, an annual consumption of 12,4 kWh can be calculated from Table 7.45 when off-mode power consumption is 1W and left-on mode power consumption is 2 W and should be added to the on-mode annual consumption.

The EEI of a dishwasher, under this new approach, is calculated as the ratio of the overall annual energy consumption (energy consumption for 280 cycles/year plus the low power modes consumption) with the standard energy consumption (calculated for each place setting category with the relevant SEC formula which does not includes the low power modes).

The effects of the new labelling system on the models in the CECED 2005 technical database is shown in Figure 7.53: for each mode, the energy consumption per cycle has been multiplied by 280 and then 16,kWh have been added. For sake of comparison, the line representing the current class A is also shown in the Figure. Classes B and C are common to the current and the new labelling scheme.

Similarly to the washing machines, in Tables 7.48 and 7.49 a set of energy efficiency classes are proposed: Labelling Scheme Option 3 foresees a rating system from class G to class A3 (or as alternative from class 1 to class 10), while Labelling Scheme Option 4 foresees a scale from class G to class A.

d) Water efficiency classes

Water consumption is only partially addressed in directive 97/17/EC, since only the indication of the water consumption per cycle has to be indicated in the label.

Starting from the WEC and W_c values a rating system for water consumption could be hypothesised in term of WEI, based on the annual consumption. However, since the water consumption per cycle is already modest for dishwashers, going from 20 litres to 9 litres per cycle for a 12ps machine (with an average of 15,2 litre/cycle) and the washing performance might be affected by a further reduction in the water use, the introduction of a water label should be carefully evaluated in terms of effective benefits and potential negative impact on consumers.

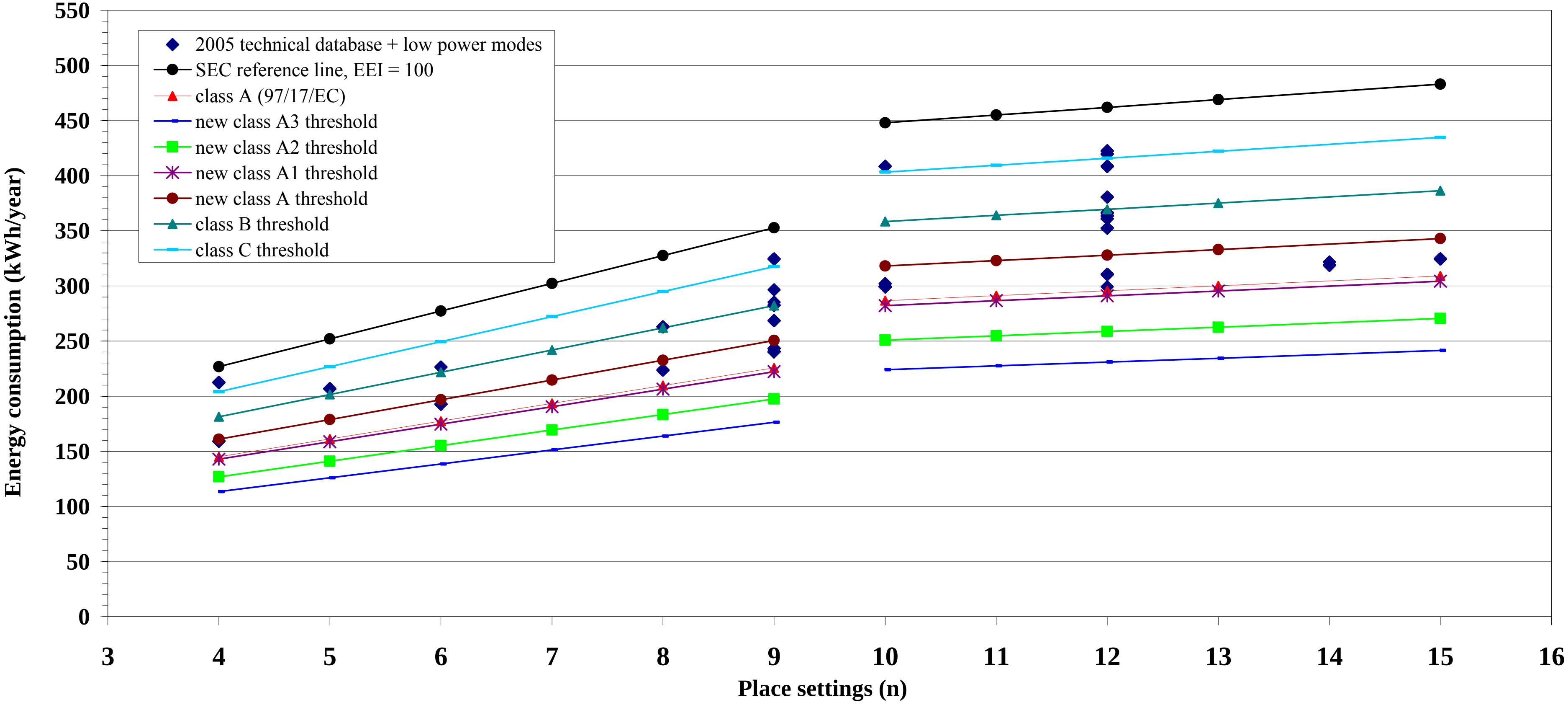
Table 7.48: Comparison of directive 97/17/EC and the updated labelling scheme based on annual energy consumption including low power modes for 12ps dishwashers

E_I directive 97/17/EC		Difference		E_I, new		Difference		Energy consumption		Annual energy consumption		New labelling scheme Energy Efficiency classes		
												Option 3		**Option 4**
(%)	(%)	(n)	(%)	(%)	(%)	(n)	(%)	(kWh/cycle)		(kWh/year)		(class)		(class)
				<50		--	--	< 0,825		< 231		A3	10	A
				50	56	6	10,7	0,825	0,924	231	259	A2	9	B
				56	63	7	11,1	0,924	1,040	259	291	A1	8	C
<64		--	--	63	71	8	11,3	1,040	1,172	291	328	A	7	D
64	76	12	15,8	71	80	9	11,3	1,172	1,320	328	370	B	6	E
76	88	12	13,6	80	90	10	11,1	1,320	1,485	370	416	C	5	F
88	100	12	12,0	90	**100**	10	10,0	1,485	**1,650**	416	**462**	D	4	G
100	112	12	10,7	**100**	112	12	10,7	**1,650**	1,848	**462**	517	E	3	
112	124	12	9,7	112	124	12	9,7	1,848	2,046	517	573	F	2	
>124		--	--	>124		--	--	>2,046		> 573		G	1	

Table 7.49: Comparison of directive 97/17/EC and the updated labelling scheme based on annual energy consumption including low power modes for 9ps dishwashers

E_I directive 97/17/EC		Difference		E_I, new		Difference		Energy consumption		Annual energy consumption		New labelling scheme Energy Efficiency classes		
												Option 3		**Option 4**
(%)	(%)	(n)	(%)	(%)	(%)	(n)	(%)	(kWh/cycle)		(kWh/year)		(class)		(class)
				<50		--	--	< 0,630		< 176		A3	10	A
				50	56	6	10,7	0,630	0,706	176	198	A2	9	B
				56	63	7	11,1	0,706	0,794	198	222	A1	8	C
<64		--	--	63	71	8	11,3	0,794	0,895	222	250	A	7	D
64	76	12	15,8	71	80	9	11,3	0,895	1,008	250	282	B	6	E
76	88	12	13,6	80	90	10	11,1	1,008	1,134	282	318	C	5	F
88	100	12	12,0	90	**100**	10	10,0	1,134	1,260	318	353	D	4	G
100	112	12	10,7	**100**	112	12	10,7	**1,260**	1,411	**353**	395	E	3	
112	124	12	9,7	112	124	12	9,7	1,411	1,562	395	437	F	2	
>124		--	--	>124		--	--	>1,562		> 437		G	1	

Figure 7.53: Energy consumption of dishwashers in 2005 CECED technical database



7.6.4 Specific requirements

The main question when proposing specific requirements for energy (and water) efficiency or consumption is whether the elements included in CECED Industry Commitments should be at the basis of the requirements or if a different system should be put in place.

To avoid any potential confusion, it is proposed that the new energy efficiency requirements are set in terms of maximum Energy Efficiency Index value, which indirectly defines a maximum annual energy consumption. This approach allows us:

- to set an univocal energy index and corresponding consumption value for a given model,
- to phase out an energy efficiency class (of the labelling scheme) when setting a minimum efficiency requirement (should the phase-out EEI value corresponding to a labelling class threshold, which is a recommended choice); the market control will be facilitated because no residual models in a labelling class will be present on the market,
- to put in place a ‘dynamic’ approach for the phase-out of less efficient products, implicitly given by the sequence of the labelling energy efficiency classes, and
- to reinforce the synergy – and therefore the effectiveness – between the labelling system and the eco-design energy efficiency/consumption requirements.

The main criterion for setting a specific requirement is that the product classification and the energy efficiency calculation algorithms are the same as the new labelling scheme.

7.6.4.1 Washing machines (for the 60°C cotton programme)

a) Washing performance

Minimum washing performance B (or even A). This requirement is set more to avoid that tightening the energy consumption efficiency classes might result in a decrease of the washing performance.

b) Water consumption

Maximum water consumption $W_{c,max}$ per cycle given by the formula:

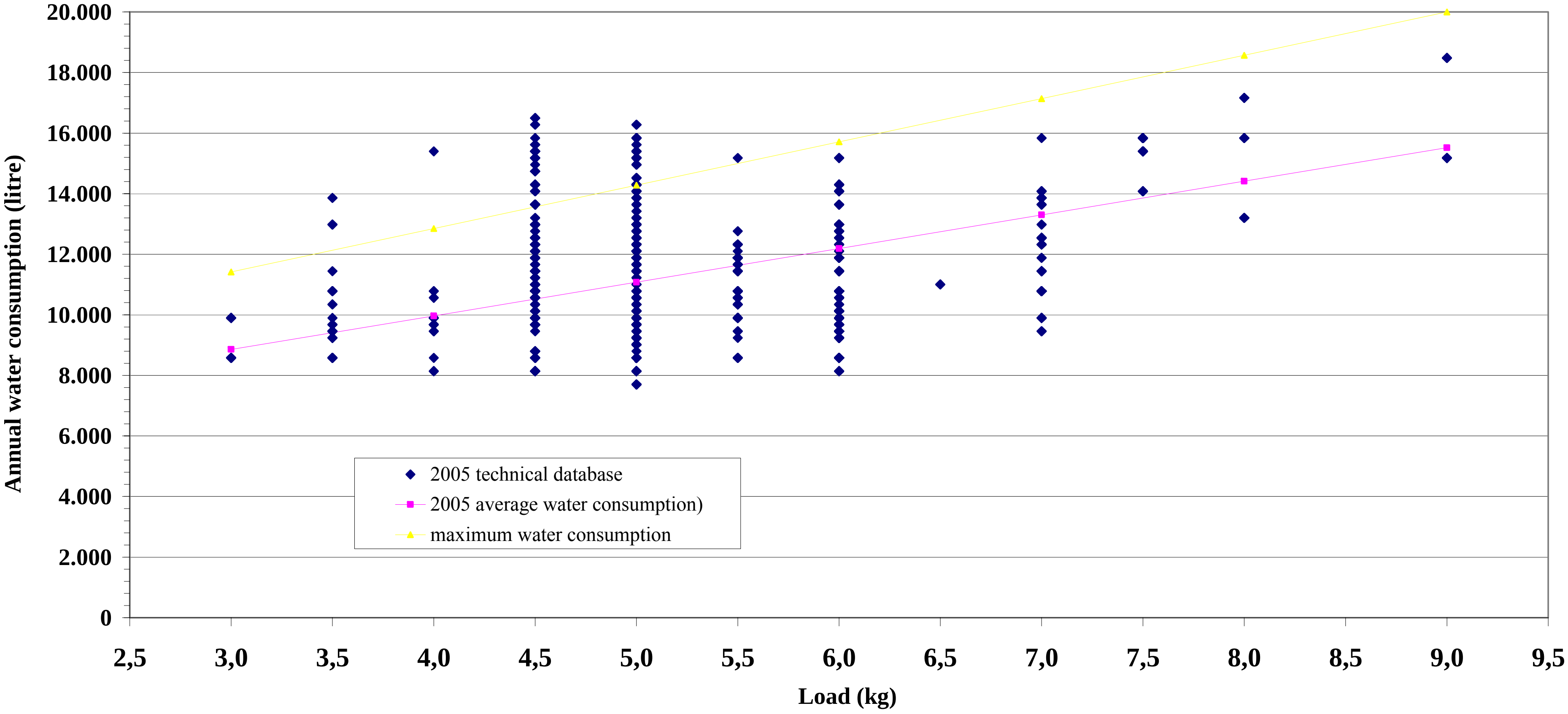
$$W_{c,\max} \leq 6{,}5 \times c + 32{,}4$$

Where c is the machine load capacity. The limit corresponds to a 65 litre consumption per cycle for a 5kg washing machine. A preliminary analysis showed that 299 models, essential belonging to energy efficiency class C will be phased-out, corresponding to about 5% of the 2005 CECED technical database (Figure 7.54).

c) Energy consumption

If the new labelling system based on the overall annual energy consumption (including the low power modes) is implemented, the pulling effect of the new label should be sufficient to drive the market. However, if considered necessary, the phase out of the class C models from 01.01.2009 can be considered: about 560 models (of the 2005 technical database) will be involved.

Figure 7.54: Maximum and average annual water consumption per washing machine load capacity



If the current labelling scheme is updated by adding some classes on top (Labelling Scheme Options 1 and 2), then a maximum energy consumption of 0,19 kWh/kg is proposed, with a possible exemption for machines with a load capacity ≤ 3kg. This means that the models belonging to the present class B (532 models) will be phased out starting 01.01.2009.

d) Spinning speed

As analysed in details in Task 6, due to the strong dependence of the energy consumption of the 'washing + drying' system on the laundry residual moisture content and contemporarily on the dryer ownership and use any specific requirement addressing minimum spinning speed or maximum residual moisture content has been found a sub-optimal solution. No specific requirement is therefore proposed.

7.6.4.2 Dishwashers

a) Washing performance

Minimum washing performance B. This requirement is set to avoid that tightening the energy efficiency classes might result in a decrease of the present washing performance.

b) Drying performance

Minimum drying performance C. This requirement is set to avoid that tightening the energy efficiency classes might result in a decrease of the drying performance. [*alternative*: minimum drying performance B: only 242 models (or 5,7%) in the 2005 database will be phased-out].

c) Energy consumption

If the new labelling system based on the annual energy consumption including the low power modes (Energy Labelling Options 3 and 4) is implemented the pulling effect of the new label is considered sufficient to drive the market. However, if necessary the phase-out of class B models can be considered (resulting in the phase-out of 335 models for ≥10ps machines and 121 ≤9ps machines from the 2005 technical database).

If on the contrary the present labelling scheme is updated by adding some classes on top (Energy Labelling Options 1 and 2), then a requirement of E_I ≥0,63 starting 01.01.2009 for the ≥10ps machines and E_I ≥0,71 starting 01.01.2009 for the ≤9ps machines. This means that the models belonging to the present class B (≥10ps) or C (≤9ps) will be phased out. In total, it is expected that more than one hundred models of the 2005 database will be phased out only for the energy efficiency parameter.

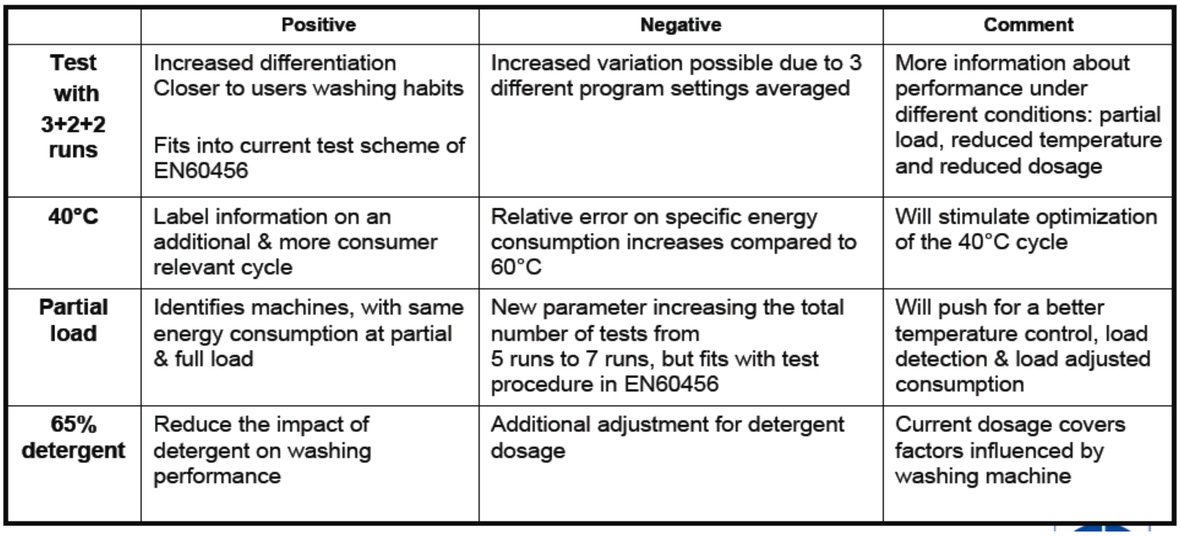
d) Noise

Although noise is an important element for the consumer comfort, and to allow washing cycles during the night, the decrease from 50 dB(A) to 41 dB(A) will increase the dishwasher energy consumption of about 125 Wh/cycle for a 9ps machine and of about 150 Wh/cycle for a 12ps machine and as discussed in Task 6. Therefore the setting of a maximum noise level should be carefully evaluated against the increase in the energy consumption and the possible savings when washing tableware during night off-peak hours.

7.6.5 *Policy measure for washing cycles at temperature different from 60°C and partial load*

7.6.5.1 The energy consumption and energy efficiency

In 2007 CECED proposed a new approach to determine the energy consumption of washing machines, which takes into account the needs of a new test procedure closer to consumer behaviour. This method foreseen a series of 7 test runs: 3 runs at 60°C plus 2 runs at 60°C and partial load plus other 2 runs at 40°C and partial load (with a reduced detergent dosage). CECED identified also pros and cons of this new method:



	Positive	Negative	Comment
Test with 3+2+2 runs	Increased differentiation Closer to users washing habits Fits into current test scheme of EN60456	Increased variation possible due to 3 different program settings averaged	More information about performance under different conditions: partial load, reduced temperature and reduced dosage
40°C	Label information on an additional & more consumer relevant cycle	Relative error on specific energy consumption increases compared to 60°C	Will stimulate optimization of the 40°C cycle
Partial load	Identifies machines, with same energy consumption at partial & full load	New parameter increasing the total number of tests from 5 runs to 7 runs, but fits with test procedure in EN60456	Will push for a better temperature control, load detection & load adjusted consumption
65% detergent	Reduce the impact of detergent on washing performance	Additional adjustment for detergent dosage	Current dosage covers factors influenced by washing machine

Three test conditions (different temperatures, different loads and different detergent amounts) instead of one will give a significant increase of information about the performance of the machines with a consequent better product differentiation and machines tested closer to real consumer behaviour. In addition, under the assumption of equal reproducibility in the three test conditions no precision is lost when going from testing procedure of current standard (1 treatment, 5 runs) to proposed method (3 treatments, 7 runs).

Following this approach, the energy consumption (in kWh) per cycle of the washing machine models is calculated through the formula:

$$E_c = (3 \times E_{c,60} + 2 \times E_{c,60½} + 2 \times E_{c,40½})/7$$

where:
- $E_{c,60}$ = energy consumption of the 60°C cotton full load cycle
- $E_{c,60½}$ = energy consumption of the 60°C cotton half load cycle
- $E_{c,40½}$ = energy consumption of the 40°C cotton half load cycle.

CECED asked also the Commission to issue a mandate to CENELEC to prepare the new standard on basis of the proposed 3+2+2 test procedure in parallel to the procedure for the implementation of the new IEC 60456 5th Ed (under preparation by IEC, seek Task 1).

In the transition period it would be possible to calculate the energy consumption of the washing machines models on the basis of the consumption of the 60°C cotton cycle at full load according to the following equation:

$$E_c = [3 \times E_{c,60} + 2 \times (a \times E_{c,60}) + 2 \times(b \times E_{c,60})]/7$$

where the multiplying factors *a* and *b* can be initially set at a = 0,80 (or 80% of the energy consumption at 60°C cotton cycle) and b = 0,64 (or 80% of the consumption at 40°C). These values were assumed taking into consideration the few known energy consumption values for the different washing cycles (40°C cotton programme and half load for the 60°C cotton) presented in Task 3.

The previous formula will allow to put in place a new labelling system based on the new proposed 3 treatments and 7 runs approach while waiting for the new standard be defined.

When considering the annual energy consumption (AE_c), it is calculated considering 220 washing cycles per year:

$$AE_c = E_c \times n$$

or, when considering the contribution of the low power modes (when the power management is not enforced), as:

$$AE_c = E_c \times C + \{P_s \times [525\,600 - (T_c \times C)]/2 + P_l \times [525\,600 - (T_c \times C)]/2\} / (60 \times 1\,000)$$

where :

- AE_c = annual energy consumption (in kWh)
- E_c = calculated washing cycle energy consumption in kWh
- C = defined number of cycles per year, 220 for washing machines
- P_l = measured power (in W) in the "left-on mode"
- P_s = measured power in "off-mode" (W)
- T_c = washing cycle time (in minutes).
- 525.600 = total number of minutes in a year (= 60 min/h × 24 h/day × 365 days/year).

The average washing time T_c for the 3 treatments and 5 runs is given by :

$$T_c = (3 \times T_{c,60} + 2 \times T_{c,60½} + 2 \times T_{c,40½})/7$$

where:

- $T_{c,60}$ = washing cycle time of the 60°C cotton full load cycle (in minutes)
- $T_{c,60½}$ = washing cycle time of the 60°C cotton half load cycle (in minutes)
- $T_{c,40½}$ = washing cycle time of the 40°C cotton half load cycle (in minutes)

an in the interim period could be considered equal to the washing time of the 60°C cotton full load cycle: $T_c = T_{c,60}$; P_l and P_s are the same for all the washing temperatures and loads.

When a power management is enforced the formula should be modified to take into consideration the effective duration of the "off-mode" and the "left-on mode" as:

$$AE_c = E_c \times C + \{(P_l \times T_{Pl} \times C) + P_s \times [525\,600 - (T_c \times C) - (T_{Pl} \times C)]\} / (60 \times 1\,000)$$

where T_{Pl} is the measured time in "left-on mode" (in minutes) which is considered same for all the washing temperatures and loads.

Once AE_c - including low power modes - is known, the Energy Efficiency Index (EEI) is then calculated for each washing machine model as the ratio between the annual energy consumption and the standard energy consumption (EEI = AE_c/SEC) of that model, where the SEC can be any agreed reference line as in three hypothesis previously defined for the 60°C cotton cycle. The new three straight lines can be derived from the three lines for the 60°C washing cycle by calculating new m_1 and q_1 values from the previous m and q values as:

$m_1 = [3 \times m_{60} + 2 \times (a \times m_{60}) + 2 \times (b \times m_{60})]/7 = [3 \times m_{60} + 2 \times (0{,}8 \times m_{60}) + 2 \times (0{,}64 \times m_{60})]/7$
$q_1 = [3 \times q_{60} + 2 \times (a \times q_{60}) + 2 \times (b \times q_{60})]/7 = [3 \times q_{60} + 2 \times (0{,}8 \times q_{60}) + 2 \times (0{,}64 \times q_{60})]/7$

The resulting straight lines formulae are:

- Hypothesis one: the SEC line is derived from the 4,5-6kg machine cluster of the 2005 CECED technical database:

  (1) $SEC_{year} = 28{,}3 \times c + 144{,}8$ where c is the machine load capacity in kg.

- Hypothesis two: the SEC line is derived from the 4,5-7kg machine cluster of the 2005 CECED technical database:

  (2) $SEC_{year} = 34{,}7 \times c + 112{,}9$ where c is the machine load capacity in kg.

- Hypothesis three: the SEC line is derived from the 4,5-6,5kg machine cluster of the 1997 CECED technical database:

  (3) $SEC_{year} = 47{,}0 \times c + 51{,}7$ where c is the machine load capacity in kg.

The position of the three SEC lines compared to the models in the 2005 CECED technical database is presented in Figure 7.55. The energy consumption of the 60°C cotton full load washing cycle of 2005 washing machines has been recalculated following the formula:

$E_c = [3 \times E_{c,60} + 2 \times (0{,}8 \times E_{c,60}) + 2 \times (0{,}64 \times E_{c,60})]/7$

to evaluate the impact of the new '3+2+2 approach'. The present class C threshold (recalculated following the same approach) has been added for comparison.

In Table 7.50 a proposal is presented for a new labelling scheme based on EEI and overall annual energy consumption of the combination of 60°C and 40°C washing cycles. Also for this scheme a set of energy efficiency classes are proposed in the same Table: Labelling Scheme Option 3 foreseen a rating system from class G to class A3 (or as alternative from class 1 to class 10) while Labelling Scheme Option 4 foreseen a scale from G to A.

The impact of the adoption of the three SEC lines is presented in Figures 7.56-7.58.

7.6.5.2 The washing performance and the water extraction efficiency

The **water extraction efficiency** depends mainly from the amount of water used in the rinsing phases, the number of intermediate spinning phases and the spinning speed of the final spinning. It

Figure 7.55: Recalculated annual energy consumption per washing machine load capacity for the models in 2005 CECED technical database and comparison with the three hypothesised SEC lines

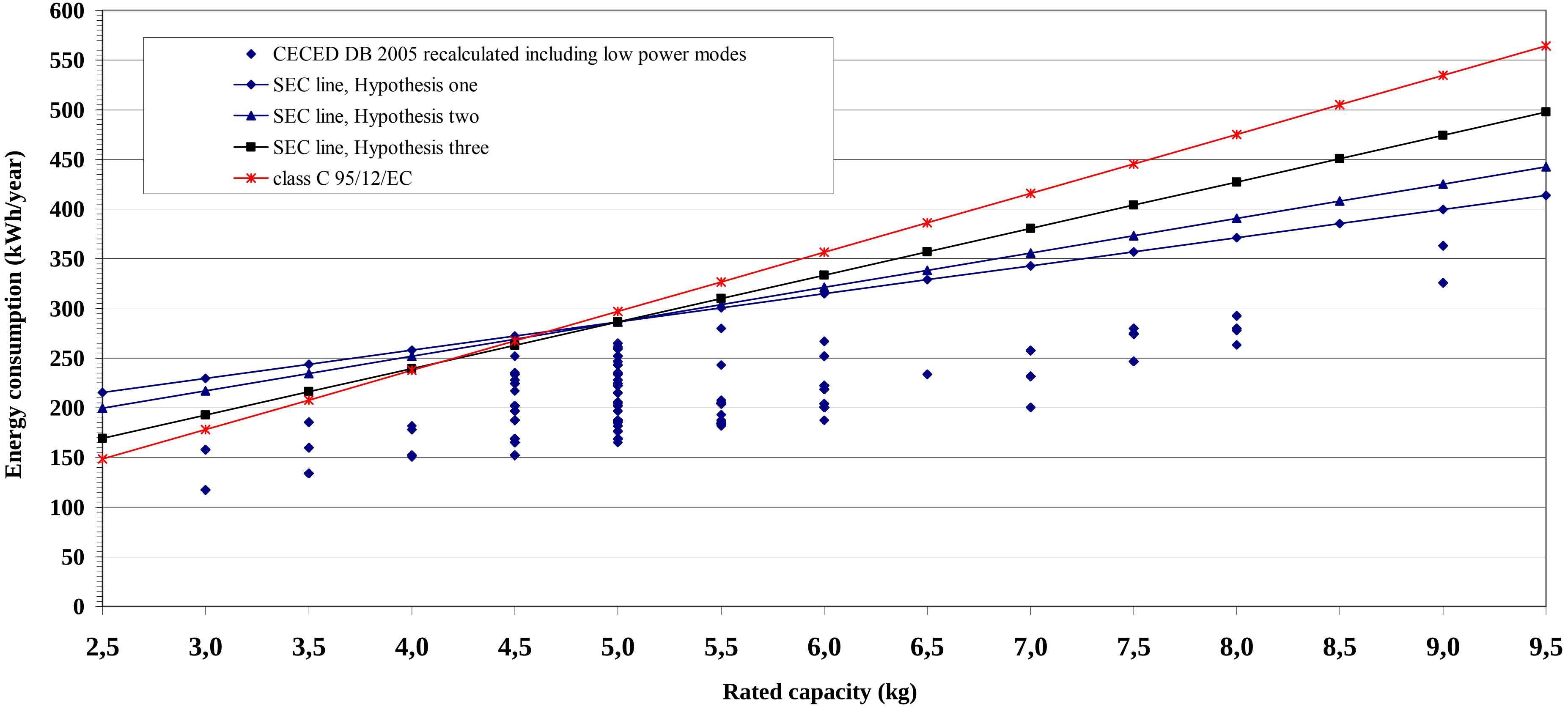


Table 7.50: Proposed labelling scheme based on EEI and overall annual energy consumption for a 5kg washing machine and a combination of 60°C and 40°C cotton cycles

Annual energy consumption		Energy consumption		difference		Specific energy consumption		**Energy efficiency index**		difference		EE classes		
(kWh/year)		(kWh/cycle)		(%)	(kWh/cycle)	(kWh/kg)		(EEI)		(%)	(n)	**Option 3** (class)		**Option 4** (class)
<129		<0,586		--	--	< 0,117		< 45		--	--	A3	10	A
129	149	0,586	0,678	13,5	0,091	0,117	0,136	45	52	13,5	7	A2	9	B
149	169	0,678	0,769	11,9	0,091	0,136	0,154	52	59	11,9	7	A1	8	C
169	195	0,769	0,886	13,2	0,117	0,154	0,177	59	68	13,2	9	A	7	D
195	221	0,886	1,003	11,7	0,117	0,177	0,201	68	77	11,7	9	B	6	E
221	249	1,003	1,134	11,5	0,130	0,201	0,227	77	87	11,5	10	C	5	F
249	287	1,134	1,303	13,0	0,169	0,227	0,261	87	**100**	13,0	13	D	4	G
287	324	1,303	1,473	11,5	0,169	0,261	0,295	**100**	113	11,5	13	E	3	
324	361	1,473	1,642	10,3	0,091	0,295	0,328	113	126	10,3	13	F	2	
>361		>1,642		--	--	> 0,328		>126		--	--	G	1	

Figure 7.56: Recalculated annual energy consumption per load capacity for the models in 2005 CECED technical database and comparison with the EEI and SEC lines (hypothesis one)

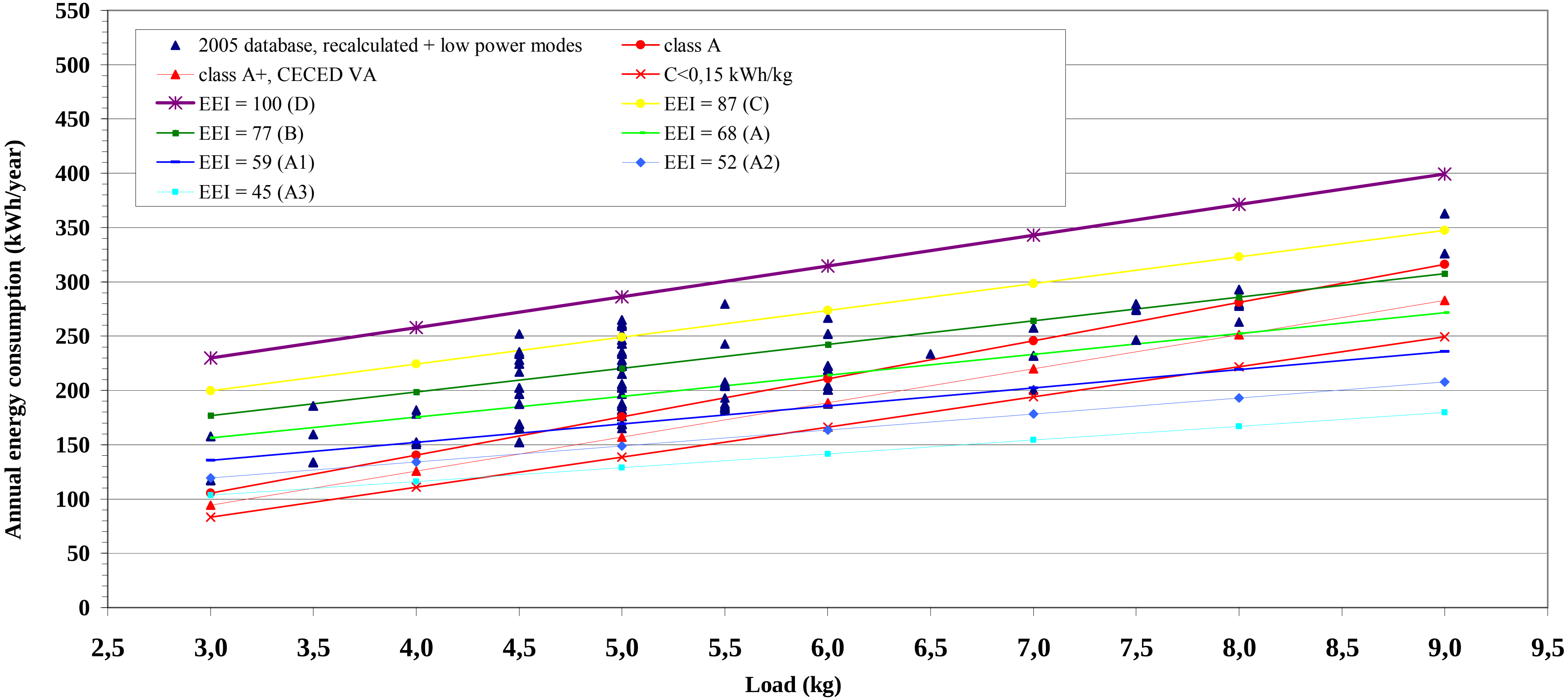


Figure 7.57: Recalculated annual energy consumption per load capacity for the models in 2005 CECED technical database and comparison with the EEI and SEC lines (hypothesis two)

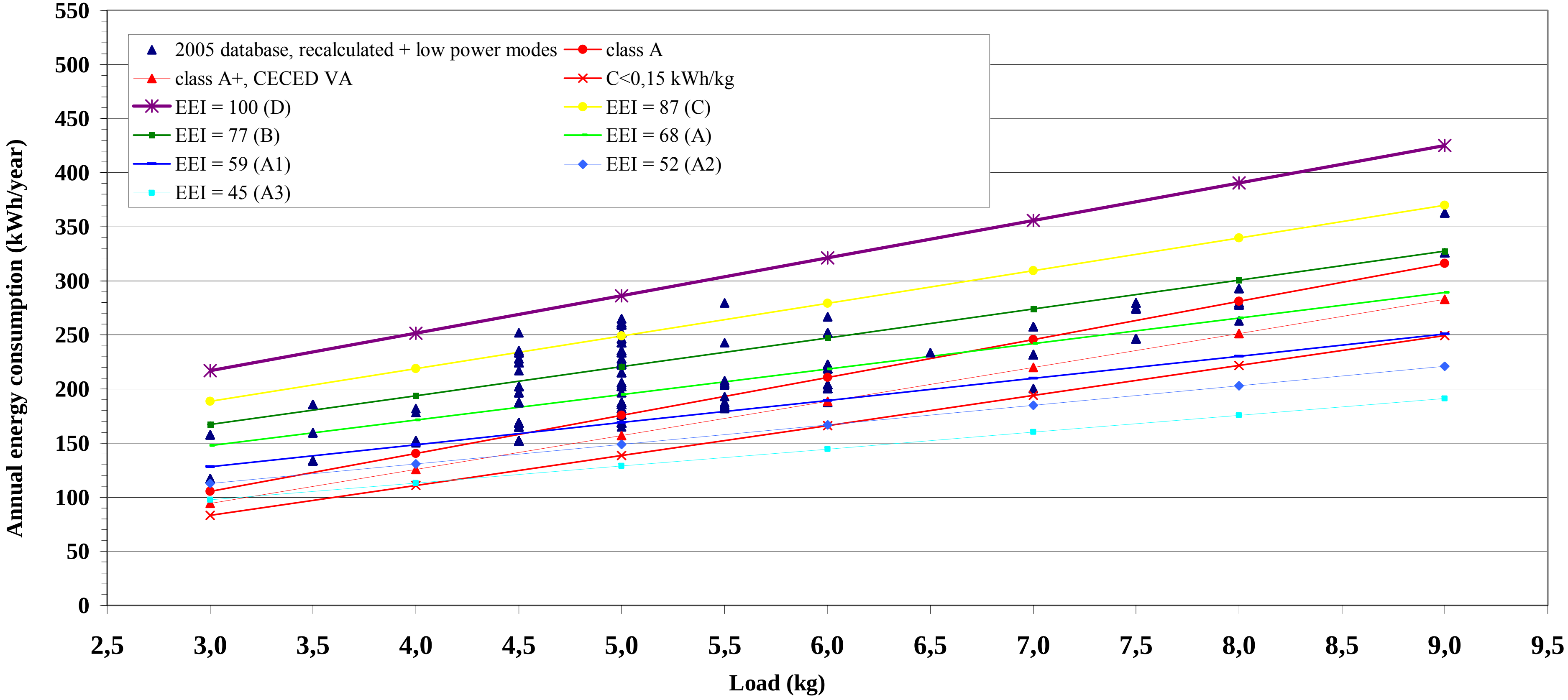
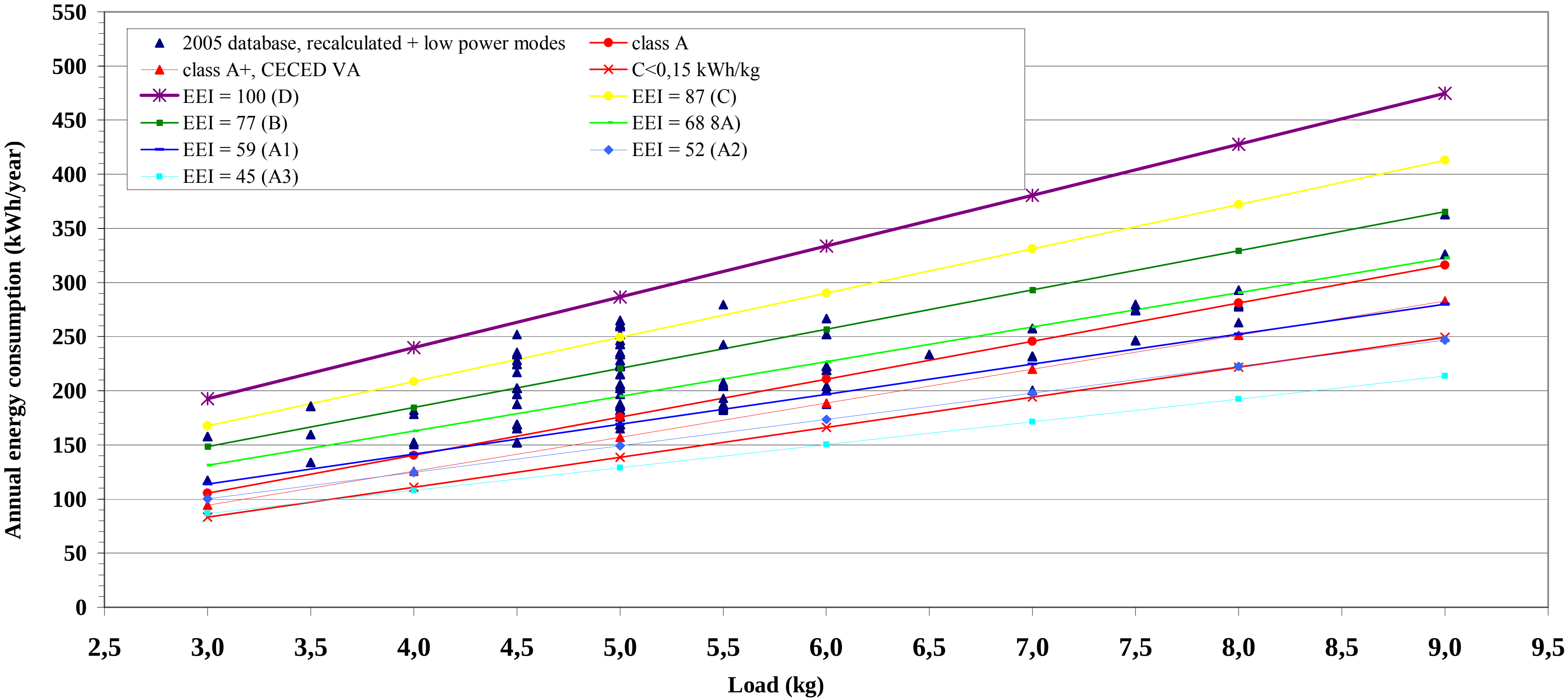


Figure 7.58: Recalculated annual energy consumption per load capacity for the models in 2005 CECED technical database and comparison with the EEI and SEC lines (hypothesis three)



is mostly independent from the washing temperature. Therefore the thresholds of the spinning efficiency classes in directive 95/12/EC:

CLASS (95/12/EC)	WATER EXTRACTION EFFICIENCY
A	$D < 45\%$
B	$45\% \leq D < 54\%$
C	$54\% \leq D < 63\%$
D	$63\% \leq D < 72\%$
E	$72\% \leq D < 81\%$
F	$81\% \leq D < 90\%$
G	$90\% \leq D$

do not need any upgrading or recalculation when the '3+2+2 approach' is followed. The overall residual moisture content "D_c" of the laundry can be calculated as the weighted average of the 7 runs:

$$D_c = (3 \times D_{60} + 2 \times D_{60½} + 2 \times D_{40½})/7$$

where:

- D_{60} = residual moisture content of the 60°C cotton full load cycle (in percentage)
- $D_{60½}$ = residual moisture content of the 60°C cotton half load cycle (in percentage)
- $D_{40½}$ = residual moisture content of the 40°C cotton half load cycle (in percentage)

In the transition period the D_{60} value can be can be considered. This will force manufacturers to achieve the same water extraction efficiency at lower temperature and partial load.

The same is proposed for the **washing performance**. Again there are no reasons to modify the satisfactory values of the "P" parameter in directive 95/12/EC:

CLASS (95/12/EC)	WASHING PERFORMANCE
A	$P > 1{,}03$
B	$1{,}03 \geq P > 1{,}00$
C	$1{,}00 \geq P > 0{,}97$
D	$0{,}97 \geq P > 0{,}94$
E	$0{,}94 \geq P > 0{,}91$
F	$0{,}91 \geq P > 0{,}88$
G	$0{,}88 \geq P$

The overall washing performance "P_c" can be calculated as the weighted average of the 7 runs:

$$P_c = (3 \times P_{60} + 2 \times P_{60½} + 2 \times P_{40½})/7$$

where:

- P_{60} = washing performance of the 60°C cotton full load cycle (in percentage)
- $P_{60½}$ = washing performance of the 60°C cotton half load cycle (in percentage)
- $P_{40½}$ = washing performance of the 40°C cotton half load cycle (in percentage)

In the transition period the P_{60} value can be can be considered. This will force manufacturers to achieve the same good washing performance at lower temperature and partial load.

The name of the washing performance and the water extraction efficiency classes should be adapted to the new classification adopted for the energy efficiency classes.

7.6.5.3 Specific requirements

a) Washing performance

Minimum washing performance B (or even A). This requirement is set more to avoid that tightening the energy consumption efficiency classes might result in a decrease of the washing performance.

b) Water consumption

For the 60°C cotton full load cycle a maximum water consumption $W_{c,max}$ per cycle given by the formula:

$$W_{c,\max,60} \leq 6{,}5 \times c + 32{,}4$$

has been proposed, where *c* is the machine load capacity. The limit corresponds to a 65 litre consumption per cycle for a 5kg washing machine and the 60°C cotton full load cycle. The same value is proposed **for each of the three considered cycles** also for the '3+2+2 approach', at least for the transitional period, since very poor information is available on the water consumption at lower washing temperature and partial load.

c) Energy consumption

If the new labelling system based on the overall annual energy consumption (including the low power modes) is implemented, the pulling effect of the new label should be sufficient to drive the market. However, if considered necessary, the phase out of the class C models from 01.01.2009 can be considered: about 500-550 models (of the recalculated 2005 technical database) will be involved, the exact number depending on the selected SEC line and the low power modes energy consumption.

d) Spinning speed

As analysed in details in Task 6, due to the strong dependence of the energy consumption of the 'washing + drying' system on the laundry residual moisture content and contemporarily on the dryer ownership and use any specific requirement addressing minimum spinning speed or maximum residual moisture content has been found a sub-optimal solution. No specific requirement is therefore proposed.

7.6.6 Generic requirements

Some possible requirements are described, along with considerations about positive and negative aspects of their implementation:

- dishwashers and washing machines: clear indication of the programme(s) used for the energy labelling on the machine and default setting of this programme for a 'normal' cycle (dishwashers) and for the cotton 60°C cycle (washing machines). For washing machines, when a combination of programmes is applied (60°C and 40°C cycles) this indication should be given for all used programmes;

- prevention of the detergent over-dosage: mainly for washing machines. The optimum detergent dosage depends mainly on the used detergent formulation (for example. liquid, pearls, tabs, compact powder or traditional powder) and chemical composition, the water hardness, the user selected washing temperature, the amount of laundry and the amount of soil on it. Some instructions for the consumer on detergent dosing are shown on the detergent package but there is a common understanding that consumers tend to overdose the detergent thinking to achieve a better washing performance. Although hardly the washing machine is involved in the final used decision about dosage, some help might be given by indicating (for example with a line) some volumes of the dispenser;
- mandatory presence of a hard switch: although this requirement could apparently solve the issue of the consumption in the so called standby mode (when the machine is disconnected from the mains there is no energy consumption) some consideration about the real effectiveness of this requirement should be highlighted:
  - real use of the hard-switch by the consumer: if the machine is not switched-off then the hard switch is useless;
  - need of maintaining basic safety functions, which are deactivated when the appliance is switched-off through the hard switch;
  - consistency with the presence of a power management system: under the assumption that the power consumption in the left-on-mode is higher than in off-mode, if power management is taking care of the left-on-mode consumption (automatically reverting the machine to the off-mode after a certain period) the importance of the hard switch is lower the lower is the off-mode power consumption.

    A brief analysis for the washing machine standard base case shows that the annual energy savings, under the conservative hypothesis that (i) the hard switch is actually used 50% of the time the machine is in low power modes, and (ii) the power consumption in low power modes is as indicated by stakeholders in EuP Lot 6 (Table 7.51), is in the range of 8,9-11,2 kWh/year (Table 7.52) when Consumer Organisations data are considered and of 4,4-5,5 kWh/year when CECED date are instead used. This savings has to be considered against the measurement tolerance of the on-mode energy consumption (about 22 kWh/year following the before discussed proposal).

    The effectiveness of this requirement should be also considered in respect with the proposed new energy efficiency algorithm considering the annual energy consumption including low power modes.

Table 7.51: Low-power mode power consumptions for washing machines and dishwashers

Modes (definition)	**Average real life power consumption**	
	CECED (W)	Consumer Organisations (W)
delay-start	2,5	4,3
left-on mode[1]	1,6	3,3
off mode[2] with functions	1	2
off-mode[3] no functions	0,5	0,6

[1] considered equal to the end-of-cycle mode power consumption

[2] Lot 14 estimates

[3] as defined in EuP Lot 6 study, i.e. without (safety) functions.

- mandatory presence of a power management: basically the appliance is automatically reverted from the left on-mode to the lowest possible power (off-mode) after a certain time. To be checked for inconsistency with the use of a hard switch. From Table 7.52 the difference in savings with or without a power management system (in addition to the hard switch) is estimated in 1,1-2,3 kWh/year depending on the input values of power consumption.

Also the effectiveness of this requirement should be also considered in respect with the proposed new energy efficiency algorithm considering the annual energy consumption including low power modes.

Table 7.52: Estimated annual energy savings in low power modes for washing machines and dishwashers when a hard switch is used 50% of the time

	min/h	W	Wh	kWh	%
measurement tolerance (energy consumption)					10
on-mode energy consumption per cycle			0,998		
on-mode energy consumption per year				219,6	
minutes in on mode	19.800				
minutes in a year	525.600				
hours in low power modes (no power management)	8.430				
hours in left-on-mode (3 hours per cycle)	660				
power consumption in left-on mode		3,3			
hours in off mode	7.770				
power consumption in off-mode		2			
percentage of time the machine is "hard switched"					50
annual energy consumption in low power modes (no power management)			22.340	22,3	
annual saved energy consumption in low power modes (no power management)				**11,2**	
annual energy consumption in low power modes (with power management)			17.718	17,7	
annual saved energy consumption in low power modes (with power management)				**8,9**	

7.6.7 Compliance assessment and verification procedures for wash appliances

7.6.7.1 The possible sources of appliance non compliance

According to a recently pamphlet by Alan Maier, Senior Executive Editor, and published by the US Home Energy Magazine Online[42], several unrelated matters related to compliance with energy efficiency regulations. These incidents illustrate that compliance - or failure to comply - with a regulation is not always objective. Indeed, one could say that there is a spectrum of "compliance." An insidious, new form of non-compliance has recently emerged. Thanks to microprocessor controls, some appliances now recognize when they are being tested and switch into a low-energy mode. According to Consumer Reports, this appears to be the case with a new refrigerator from a large Asian manufacturer, which inexplicably switches-off some operations when the ambient temperature approaches the testing temperature and when doors haven't been opened for a while. These measures cut enough electricity use to qualify the unit for Energy Star endorsement and sales-enhancing utility rebate programs. But it is not alone; other refrigerator manufacturers became so adept at circumventing the test that actual electricity use of refrigerators in a country was typically twice as high as the labels claimed; the government changed the test procedure to make it harder to circumvent. Many appliance manufacturers (and importers) might poised to adopt the same approach. The competent Authorities should be on the alert.
A more subtle form of non-compliance occurs when manufacturers misrepresent the capacity of their products and efficiency, which is described in terms of energy use per unit of capacity, might thus overstated.
Finally, there are cases where the energy-saving claims are partly true for example, under certain conditions. The motor controllers did save electricity when motors were oversized or the voltage delivered was unnecessarily high. Here the problem is agreeing on appropriate test conditions. Reasonable people may disagree on these conditions, so compliance is less clear-cut.

These stories show that compliance is not a simple yes-no decision. It begins with clear regulations. But it must be followed by vigilance, intelligence, and, occasionally, Solomon-like decisions.

7.6.7.2 The verification limits and verification tolerance

In a recently published MTP document[43], it is stated that when tested, an individual cold appliance sample is permitted by the standard to be 15% worse on energy consumption, while the eco-labelling directive, which adopts the same EN 153 standard as the energy labelling directive in fact does not permit any 15% tolerance.

This is the most common misunderstanding that has originated the never ending discussion about a (too large) permitted tolerance in the EU legislation. In fact, a general confusion has always been made between the compliance of the declared values of a model with the regulation(s) criteria (in general threshold values or lines) and the compliance assessment in the verification procedure.

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[42] Source: Alan Meier, http://www.homeenergy.org/blog.php?id=18&blog_title=January/February_2007_Editorial-Compliance:_Following_the_Letter_(and_the_Spirit)_of_the_Law. The document has been adapted to better 'comply' with the spirit of this EuP study by omitting manufacturers and Countries names.

[43] Source: BNC07: Domestic cold appliance EC Energy Label revision, Version 1.5, 05 October 2007, downloadable from http://www.mtprog.org .

A clarification is needed. The EU legislation about household appliances (both energy labelling schemes and efficiency requirements, where existing) **does not permit any declaration tolerance; i.e. all units of a same model shall comply with the set criteria**. An example of 'declaration tolerance' can be found for example in the Australian standard for cold appliances, which specifies an allowable tolerance of 3% on the measurement of the volume (note that the precise rule depends on the compartment volume).

The EU legislation is more stringent than for example the mentioned Australian regulations, since for cold appliance minimum requirements the latter requires, at 90% confidence, that the mean (of all the units of a same model) does not exceed the requirements level and mean energy.

A different issue is the **verification tolerance** or **verification limit**, that is the maximum permitted variation between the supplier's declared value and the measured value resulting from a test developed in a Laboratory under a verification procedure. This 'verification tolerance or verification limit' should not be interpreted as an allowed tolerance on the original declaration used to support the compliance with a regulation. More in detail:

- a '**verification limit**' (usually larger than a verification tolerance) includes allowances for elements such as production variability, measurement accuracy and uncertainties;
- a '**verification tolerance**' is intended to take care only of the known margin of error or uncertainty in the measurement procedure for a particular test method (no production variability is considered).

Only when Government certified laboratories are used for the compliance assessment both the verification limit and the verification tolerance can be kept at a real minimum (2-3% for the latter, but higher in the specific case of the energy consumption of cold appliances) because the laboratory error is known and under strict control.

Following the above definitions, in the EU legislation a verification limit (which includes production variability) of 15% is assumed on a single sample and a 10% on a sample of 3 units of the same model.

The application of verification limits or verification tolerance means that the models a consumer buys is not necessarily as the declared one, but at a lower extent when a lower verification tolerance is used. The solution proposed by the before mentioned MTP document that, the laboratories' own measurement tolerance aside, a 'zero tolerance' (in our discussion a zero production variability) Energy Label is possible, but the claimed benefit for consumers as the Energy Label scheme that a B-energy consuming appliances would be B-declared is unfortunately unattainable, since there will be always "border line" appliances that will comply with a different (worse) energy efficiency class when tested.

The benefit of adopting a lower verification tolerance is that the difference of between the declared and the measured energy consumption will be at maximum as great as the verification tolerance. But on the other side a lower verification tolerance can be applied only under the condition that the margin of error or uncertainty in the measurement procedure (the reproducibility of the measurement method including the laboratory error) for the testing Laboratories is kept under strict control. This is possible only under if a system of certified Laboratories is put in place.

As far as the claim that the EU eco-label does not permit any 15% tolerance, again a major misunderstanding occurred. The eco-label Decisions related to household appliances describe only the procedure for the declaration of the measured values: the reports of at least three measurements of energy consumption made according to EN 153 and the test guidelines as detailed in CECED's

Operational Code shall be presented; the arithmetic mean of these measurements shall be less or equal to the energy efficiency ecolabel requirement; the value declared on the energy label shall not be lower than this mean value, and the energy efficiency class indicated on the energy label shall correspond to this mean value. In simpler words this means that 3 units of a same models are tested, and the average of the three measured values is declared on the energy label, while at present the energy labelling schemes foreseen that only one unit of a model is tested.

The before mentioned MTP document stated also that "when challenged by the Trading Standards Office, manufacturers will sometime declare a fault on the appliance 'that one is not functioning as designed' or state that model is no longer available". Although a fault of a model may always happen, the misuse of this loop-hole can be avoided by imposing (as already in force in Australia) that the onus is on the manufacturer/importer to provide evidence that a defect capable of affecting the test results does exist; furthermore, it must be demonstrated that the "defect" is peculiar to the test unit alone and not common to other samples of the stock of the appliance. But this has nothing to share with the setting of a larger/stricter verification limits or verification tolerance.

7.6.7.3 The verification error sources

Very little information is generally available on the different factors that impact on the verification process. In addition, the way of explaining the differences in test results may also somehow differ.

According to the latest Australian experience[44], typically, differences in the test results represent the outcome of several different types of factors that can be classified into two general categories: (i) random errors, and (ii) systematic errors:

- **Random Errors**: random errors are the kinds of errors that are caused by natural variations in materials, human factors, fluctuations in power input etc. Such errors may cause measurements of appliance energy consumption or performance to deviate from the true or "design" level. A key feature of random errors is that they are just as likely to be positive as they are to be negative and over many measurements they average out to be zero. The main sources of random error in the verification process are:

    - Production Variability: all production processes are subject to random fluctuations as a result of manufacturing tolerances, variations in input materials, power fluctuations, human factors etc. These variations in the production process may cause different units of the same model to have slightly different average energy consumption or performance levels. This random error describes the differences in the average energy consumption and/or performance values of different units of the same model due to production variability;
    - Performance Variability: in addition, the same individual unit may perform differently on different occasions under test; e.g. a pressure switch may terminate fill volume to a different amount each time, even under identical test conditions. Performance variability is often related to the quality of components used in an appliance but it can also be a reflection of the complexity of the process being tested and of the test assessment (e.g. hand soiling of dishes and the subsequent visual assessment of washing performance of a dishwasher). This type of error affects a test's repeatability.
    - Random Measurement Error: if the performance of a single unit is tested twice, in the same laboratory, and using exactly the same equipment and the same staff, then, in addition to the

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[44] Source: NAEEEC, Statistical Basis for the Determination of Check testing Validity Criteria, Report prepared by: Professor R. Bartels, University of Sydney, L. Harrington, Energy Efficient Strategies, original Report: January 1999, updated and corrected: February 2004, downloadable from http://www.energyrating.gov.au.

performance variability, there will be some variability in the test results due to random variations in testing equipment, measurement procedure, human factors, etc. This type of error also affects a test's repeatability.

It is difficult to separate out the error due to performance variability from the random measurement error. Hence the joint impact of these two errors (out of the three identified random errors) is referred to as the '***test repeatability error***'. In conclusion it can be affirmed that the random error is given by the sum of 'production variability' and 'test repeatability error'.

- **Systematic Errors (measurement errors)**: systematic errors are not completely random. These errors may have some pattern in them: for example, a bias in a series of measurements leading to an overstatement (or understatement) of the true measure. Such errors can be caused by differences in measuring equipment, calibration errors, differences in procedures between laboratories etc. For the verification process purposes, the sources of systematic error can be classified into two categories:

    - Calibration Errors: equipment that is not properly calibrated can lead to systematic errors in the measurement of energy consumption or performance levels. Calibration errors cannot be detected in the verification testing procedure since they are confounded with laboratory-specific factors, such as types of metering equipment, different operating procedures etc. For the verification procedure purposes, it can be assumed that calibration errors are adequately addressed by a laboratory Accreditation Procedure. For electrical energy consumption, the calibration error is usually less than 2% (typically 1% or better). However, for products such as washing machines, much of the energy is embodied in hot water drawn into the machine, which means that calibration errors in water temperature measurement and water volume will also contribute to energy errors. For other products such as refrigerators and air conditioners, calibration errors in air temperature measurement can have a large effect on the measurement of energy consumption and performance actually delivered;
    - Inter-Laboratory Variability: performance measurements taken in one laboratory can differ systematically from those taken in another laboratory due to differences in equipment, operating procedures and staff. An estimate of the size of the errors introduced due to inter-laboratory variability can be obtained through a program of Round Robin Tests in which two or more laboratories all carry out tests on the same unit. Estimates of inter-laboratory variability, if established through round robin tests, will include any calibration errors present.

A summary of the different errors occurring during a verification procedure is shown in Figure 7.59.

Only limited information is available on the relative sizes of the errors introduced in the verification measurements due to production variability or test repeatability. More data are available on the combined variability caused by production variability and test repeatability. Table 7.53 summarises some of the available information in relation to the energy consumption of a number of products in the energy labelling program in Australia and New Zealand. These data have been derived from energy labelling applications where 3 different units of the same model are tested in the same laboratory.

A somehow different description on how to express uncertainty in standardisation is presented in Annex A.

Figure 7.59: Possible errors affecting the verification procedure of energy consumption and performance values

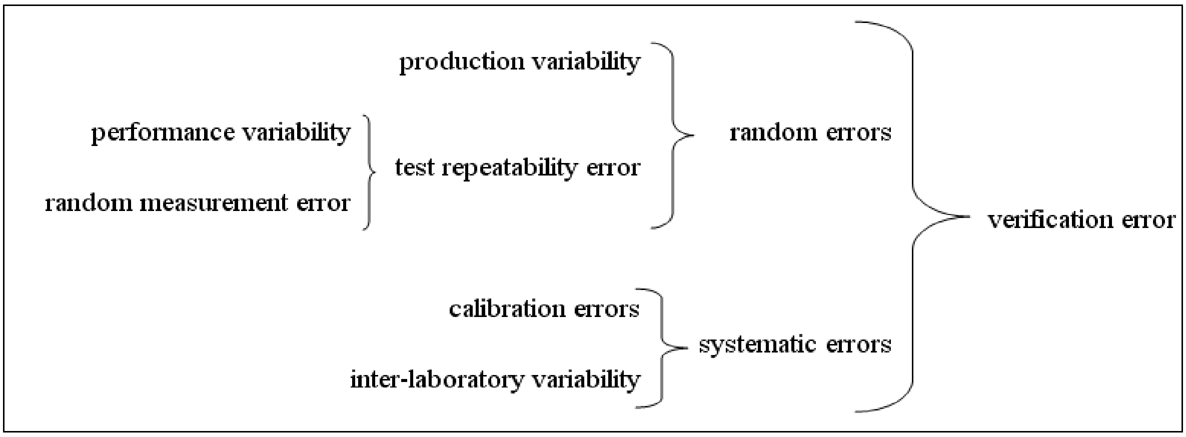
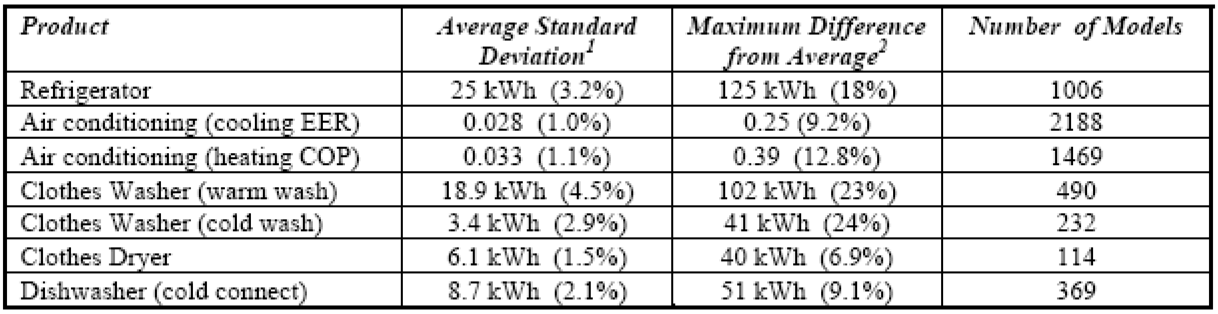


Table 7.53: Variability in the measurement of the energy consumption for selected household appliances in Australia



Product	*Average Standard Deviation*[1]	*Maximum Difference from Average*[2]	*Number of Models*
Refrigerator	25 kWh (3.2%)	125 kWh (18%)	1006
Air conditioning (cooling EER)	0.028 (1.0%)	0.25 (9.2%)	2188
Air conditioning (heating COP)	0.033 (1.1%)	0.39 (12.8%)	1469
Clothes Washer (warm wash)	18.9 kWh (4.5%)	102 kWh (23%)	490
Clothes Washer (cold wash)	3.4 kWh (2.9%)	41 kWh (24%)	232
Clothes Dryer	6.1 kWh (1.5%)	40 kWh (6.9%)	114
Dishwasher (cold connect)	8.7 kWh (2.1%)	51 kWh (9.1%)	369

Notes:

1. sample standard deviation of 3 units is used to calculate this value. The standard deviations are also measured as a percentage of the sample mean. This is also known as the 'coefficient of variation'. Measuring standard deviations as percentages allows one to make comparisons across different models and different appliance types. The numbers shown are the average of these absolute and relative sample standard deviations across the different models for which 3 measurements were available for 3 different units of the same model.
2. The maximum difference is calculated as the absolute difference between the most extreme unit in the sample of three from the mean of the three. In most of these cases (which are generally very unrepresentative) it appears that 3 very different units were tested (or in some cases 1 unit was very different from the other 2). Specific investigations would be required to ascertain why such large variations were produced in these isolated cases. The minimum difference between all 3 units was zero for all products.

7.6.7.4 A possible verification procedure for wash appliance

In Table 7.54 the measurement errors identified in the previous paragraph are listed according to their source. Taking into consideration the pragmatic Australian experience, although the test method followed in the country is sometimes non comparable with the European standards, the measurement variability can be divided into three components:

- variability due to the production, which is in charge of the manufacturers and can be controlled and possibly reduced adopting better manufacturing processes, quality control systems, etc;
- variability of the test method, which can not be modified once the standard in defined, but that might be reduced through the improvement of the test method by the standardisation bodies;
- variability due to the testing Laboratories errors, which can be controlled and kept to the minimum in qualified laboratories.

Table 7.54: Verification errors and relevant sources

error source error type	MANUFACTURERS	TEST METHOD	TESTING LABORATORIES
production variability	**X**		
performance variability		**X**	
random measurement error		**X**	
calibration error			**X**
inter-laboratory variability			**X**

The present 15% tolerance allowed in the verification procedure for the energy consumption can be therefore broadly divided into three 5% components: 5% due to the manufacturing process, 5% due to the test method and finally another 5% due to the Laboratory errors.

Manufacturers have the full control of the first 5% only, but not on the other two, which represent the reproducibility of the measurement method and the variability of the testing laboratories.

The quality of the production process, which in turn is reflected in a more stable – or less variable – performance characteristics (including the energy consumption) of the produced units of the same model, should be considered part of the overall appliance 'performance' and should be taken into consideration when setting policy measures. The measurement method reproducibility and Laboratory error should be included in the verification tolerance.

Taking into consideration the discussed allocation of verification errors, a double approach is proposed, according to whether the verification involves a qualified or in a non-qualified testing Laboratory: As example of this new approach, for the energy consumption it is proposed that:

- when the verification in done **in a non-qualified laboratory**: the value measured on one randomly selected wash appliance shall not be greater than the rated value by more than 10%. If the result of the test carried out on the first refrigerating appliance is greater than the rated value plus 10% the test shall be carried out on a further three randomly selected refrigerating appliances. The arithmetic mean of the three refrigerating appliances shall be equal to or less than the rated value plus 10%
- when the verification in done **in a qualified laboratory**: the tolerance value can be different (lower) than the value for non-qualified laboratories provided that technical evidence is given on the laboratory ability to reduce such value.

The verification tolerance values for the other measured parameters for both dishwashers (cleaning performance, drying performance and cycle time) and washing machines (washing performance, spin extraction, programme duration, spin speed should be modified following the same approach.

This approach (i) internalises in any case the appliances production variability in the measured energy/water consumption and (ii) sets a different value for the verification tolerance depending if the appliances are tested in qualified or non-qualified laboratories.

No different specific verification scheme is deemed necessary for the verification of the specific requirements compared to the labelling scheme declarations.

It is recommended that the verification tolerances are verified and if necessary modified according to the results of specific Round Robin Test(s) that the Commission should promote and fund either within the existing EU programmes or through the delivering of mandates to the relevant standardisation bodies.

In addition, a system of qualified laboratories should be put in place by the Commission, taking into account the experience achieved at European and other countries level, such as the Australian one. It is also suggested that a further mandate is given to the standardisation bodies to define the criteria and the procedure for the laboratories qualification since this is a critical issue to assure that the lowest possible verification tolerance is pursued.

For the selection criteria for the verification of appliance models two approaches are possible:

- the ‘random type selection’: a certain number of appliances are randomly selected from the market and tested. The resulting failure rate gives the almost exact picture of the investigated market, but the resources to be used are maximised;
- the ‘maximum failure selection’: the selection criteria are set as to maximise the failure rate (i.e. the non complying models). The outcome is not representative of the market situation, but the use of the available resources is optimised.

7.6.8 The Effect of the Proposed Policy Measures on Wash Appliances in 2005

7.6.8.1 Washing machines

a) Policies for the 60°C cotton full load cycle

The effect of the application of Labelling Scheme Option 1, which implies the rescaling of the present scheme based on the specific energy consumption (in kWh/kg) and the reduction of the verification tolerance of 5%. The latter effect is simulated in the worse case scenario by increasing the energy consumption of 5% (i.e. under the hypothesis that for all the models in the technical database the relevant manufacturers had used part of the verification tolerance to declare a better energy efficiency). The major outcome of the analysis of the 2005 models distribution in the energy efficiency classes (Table 7.55) is that the present and the rescaled schemes are practically identical. In the new energy labelling two empty classes are created on top. If specific requirements encompassing the phase out of class B are considered, 532 washing machines models are involved.

When the new approach, based on the calculation of the overall annual energy consumption including the low power modes and the creation of a Energy Efficiency Index system, is applied, the effect on the models of the 2005 CECED technical database is presented in Table 7.56. The three hypotheses about the SEC reference line are presented. When only the overall annual energy consumption is considered, the models disaggregation in the new energy efficiency classes is not dramatically different from the rescaling of the present labelling scheme since about one thousand models are still in class A1 (and more than one hundred in class A2) and no models belonging to the present class A are downgraded. When hypothesis two and three are considered more than two thousand models are classified as A1, but very few models belong to class A2. When the addition of low power modes consumption and the effect of a 5% reduction of the verification tolerance are considered the number of the higher efficiency models decreases, more dramatically under hypothesis three, but few models are downgraded below class A.

The impact on each load capacity is analysed in Tables 7.57-7.59 for the same three hypothesis. Hypothesis one has the strongest impact on high load capacity washing machines, which are less favoured compared to the present labelling system, while hypothesis three has the lowest impact on such machines.

Table 7.55: Effects of the combined proposed policy measures (energy labelling Option 1 + specific requirements) on washing machine models in 2005 CECED technical database (60°C cotton full load cycle)

Labelling scheme 95/12/EC			New labelling scheme		EE class threshold rescaling		Rescaling and 5% verification tolerance reduction	
(class)	(n)	(%)	(class)	(class)	(n)	(%)	(n)	(%)
--	--	--	**A3**	**10**	0	0	0	0
--	--	--	**A2**	**9**	3	0,1	2	0,04
(A+)	1 953	37,6	**A1**	**8**	2 006	38,6	1 951	37,6
A	2 704	52,1	**A**	**7**	2 690	51,8	2 707	52,1
B	323	6,2	**B**	**6**	309	6,0	314	6,0
C	211	4,1	**C**	**5**	183	3,5	94	1,8
D	1	0,0	**D**	**4**	1	0,02	124	2,4
E	0	0	**E**	**3**	0	0	0	0
F	0	0	**F**	**2**	0	0	0	0
G	0	0	**G**	**1**	0	0	0	0
Total	5 192	100	Total		5 192	100	5 192	100

Table 7.56: Effects of the combined proposed policy measures (energy labelling Option 3, using the reference line in hypothesis one, two and three) on washing machine models in 2005 CECED technical database (60°C cotton full load cycle)

New labelling scheme		Hypothesis 1 (4,5-6kg reference line)						Hypothesis 2 (4,5-7 kg reference line)						Hypothesis 3 (4,5-6,5 kg 1997 ref. line)					
EE Classes		Annual energy consumption		+ low power modes consumption		& 5% verification tolerance reduction		Annual energy consumption		+ low power modes consumption		& 5% verification tolerance reduction		Annual energy consumption		+ low power modes consumption		& 5% verification tolerance reduction	
(class)	(class)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
A3	**10**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	**9**	115	2,2	8	0,2	0	0	8	0,2	0	0	0	0	2	0,04	0	0	0	0
A1	**8**	976	18,8	748	14,4	115	2,2	2 104	40,5	722	13,9	117	2,3	2 064	39,8	741	14,3	3	0,1
A	**7**	3 535	68,1	3 362	64,8	3 660	70,5	2 500	48,2	3 431	66,1	3.805	73,3	2 629	50,6	3 902	75,2	3 945	76,0
B	**6**	360	6,9	684	13,2	851	16,4	380	7,3	658	12,7	789	15,2	294	5,7	171	3,3	754	14,5
C	**5**	164	3,2	311	6,0	406	7,8	162	3,1	306	5,9	323	6,2	166	3,2	253	4,9	316	6,1
D	**4**	42	0,8	79	1,5	160	3,1	38	0,7	75	1,4	158	3,0	37	0,7	125	2,4	174	3,4
E	**3**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F	**2**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		5 192	100	5 192	100	5 192	100	5 192	100	5 192	100	5 192	100	5 192	100	5 192	100	5 192	100

Table 7.57: Effects of the policy measures (energy labelling Option 3, hypothesis one) by load capacity on washing machine models in 2005 CECED technical database

Labelling scheme EE Classes		Load capacity (kg)												Total models	
		3,0	**3,5**	**4,0**	**4,5**	**5,0**	**5,5**	**6,0**	**6,5**	**7,0**	**7,5**	**8,0**	**9,0**		
(class)	(class)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(%)
Annual energy consumption (60°C cotton full load cycle)															
A3	**10**													0	0
A2	**9**									2				2	0,0
A1	**8**	8	37	34	84	623	70	1 031		154	22	1		2 064	39,8
A	**7**				247	1 670	178	430	2	26	57	13	6	2 629	50,6
B	**6**	9	7	3	82	178	1	10					4	294	5,7
C	**5**		8		67	90	1							166	3,2
D	**4**				1	36								37	0,7
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Annual energy consumption + low power modes consumption (60°C cotton full load cycle)															
A3	**10**													0	0
A2	**9**	8												8	0,2
A1	**8**		37	34	70	604		1		2				748	14,4
A	**7**	9	7		247	1.668	247	1.030		154				3.362	64,8
B	**6**		8	3	96	36	1	430	2	26	73	9		684	13,2
C	**5**				67	216	1	10			6	5	6	311	6,0
D	**4**				1	73	1						4	79	1,5
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Annual energy consumption + low power modes consumption & 5% verification tolerance reduction (60°C cotton full load cycle)															
A3	**10**													0	0
A2	**9**													0	0
A1	**8**	8	37		70									115	2,2
A	**7**		7	34	247	2 269	70	1 031		2				3 660	70,5
B	**6**	9		3	28	24	178	430	2	154	22	1		851	16,4
C	**5**		8		81	206	1	8		26	57	13	6	406	7,8
D	**4**				55	98	1	2					4	160	3,1
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Total		**17**	**52**	**37**	**481**	**2 597**	**250**	**1 471**	**2**	**182**	**79**	**14**	**10**	**5 192**	**100**

Table 7.58: Effects of the policy measures (energy labelling Option 3, hypothesis two) by load capacity on washing machine models in 2005 CECED technical database

Labelling scheme EE Classes		Load capacity (kg)												Total models	
		3,0	**3,5**	**4,0**	**4,5**	**5,0**	**5,5**	**6,0**	**6,5**	**7,0**	**7,5**	**8,0**	**9,0**		
(class)	(class)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(%)
Annual energy consumption (60°C cotton full load cycle)															
A3	**10**													0	0
A2	**9**	8												8	0,2
A1	**8**		37	34	317	623	69	1 022		2				2 104	40,5
A	**7**	9	7	3	14	1 670	179	439	2	154	22	1		2 500	48,2
B	**6**		8		83	178	1	8		26	57	13	6	380	7,3
C	**5**				66	90		2					4	162	3,1
D	**4**				1	36	1							38	0,7
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Annual energy consumption + low power modes consumption (60°C cotton full load cycle)															
A3	**10**													0	0
A2	**9**													0	0
A1	**8**	8	37		70	604		1		2				722	13,9
A	**7**		7	34	247	1 668	248	1 050		154	22	1		3 431	66,1
B	**6**	9		3	96	36		410	2	26	57	13	6	658	12,7
C	**5**		8		67	216	1	10					4	306	5,9
D	**4**				1	73	1							75	1,4
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Annual energy consumption + low power modes consumption & 5% verification tolerance reduction (60°C cotton full load cycle)															
A3	**10**													0	0
A2	**9**													0	0
A1	**8**	8	37		70					2				117	2,3
A	**7**			34	247	2 269	70	1 031		154				3 805	73,3
B	**6**	9	7	3	28	24	178	430	2	26	73	9		789	15,2
C	**5**		8		81	206	1	10			6	5	6	323	6,2
D	**4**				55	98	1						4	158	3,0
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Total		**17**	**52**	**37**	**481**	**2 597**	**250**	**1 471**	**2**	**182**	**79**	**14**	**10**	**5 192**	**100**

Table 7.59: Effects of the policy measures (energy labelling Option 3, hypothesis three) by load capacity on washing machine models in 2005 CECED technical database

Labelling scheme EE Classes		Load capacity (kg)												Total models	
		3,0	**3,5**	**4,0**	**4,5**	**5,0**	**5,5**	**6,0**	**6,5**	**7,0**	**7,5**	**8,0**	**9,0**		
(class)	(class)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(%)
Annual energy consumption (60°C cotton full load cycle)															
A3	**10**													0	0
A2	**9**									2				2	0,04
A1	**8**	8	37	34	84	623	70	1 031		154	22	1		2 064	39,8
A	**7**				247	1 670	178	430	2	26	57	13	6	2 629	50,6
B	**6**	9	7	3	82	178	1	10					4	294	5,7
C	**5**		8		67	90	1							166	3,2
D	**4**				1	36								37	0,7
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Annual energy consumption + low power modes consumption (60°C cotton full load cycle)															
A3	**10**													0	0
A2	**9**													0	0
A1	**8**				70	604	64	1		2				741	14,3
A	**7**	8	37	34	247	1 668	184	1 460	2	180	73	9		3 902	75,2
B	**6**		7	3	96	36		8			6	5	10	171	3,3
C	**5**	9	8		17	216	1	2						253	4,9
D	**4**				51	73	1							125	2,4
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Annual energy consumption + low power modes consumption & 5% verification tolerance reduction (60°C cotton full load cycle)															
A3	**10**													0	0
A2	**9**													0	0
A1	**8**							1		2				3	0,1
A	**7**	8	37	34	317	2 269	70	1 030		154	22	4		3 945	76,0
B	**6**		7		14	24	178	430	2	26	57	10	6	754	14,5
C	**5**	9		3	83	206	1	10					4	316	6,1
D	**4**		8		67	98	1							174	3,4
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Total		**17**	**52**	**37**	**481**	**2 597**	**250**	**1 471**	**2**	**182**	**79**	**14**	**10**	**5 192**	**100**

b) Policies for lower washing temperatures and partial load

When the ‘3+2+2 approach’ is selected, the overall effect of the three SEC line hypotheses is shown in Table 7.60. As expected, the outcome is the same as when only the 60°C cotton full load cycle is considered, because the simulation is based on the energy consumption of the 60°C cotton cycle and the low power models consumption has been considered the same for all models.

The effect on each load capacity is analysed in Tables 7.61-7.63 for the three SEC hypotheses. It should be highlighted that when evaluation the energy efficiency class of each model the relevant EEI has not been rounded to the closest integer. Therefore the models classification could be (slightly) modified by the rounding rules, which shall be defined in the implementing measure.

7.6.8.2 Dishwashers

The effect of the combined proposed policy measures (Energy Labelling Option 3 + specific requirements) on dishwasher models in 2005 CECED technical database is presented in Table 7.64. When the low power modes consumption is added and the 5% decrease of the verification tolerance is taken into consideration the 2005 models disaggregation in the new energy efficiency classes is similar with the present labelling scheme for the first 7 classes and three new and empty classes are on top.

7.6.9 The Effect of Other measures

The effect of other measures: early replacement, subsidies and incentives to manufacturers, studied or run in EU and non-European countries are briefly summarised to evaluate the possible benefits for a EU-wide application within the eco-design framework.

7.6.9.1 Early replacement

It has been proved that replacement of old appliances with new efficient ones would represent a good answer to the efforts of the EU towards reducing CO_2 emissions. Therefore, CECED invites authorities to set up policies encouraging earlier and better replacement of our appliances, to promote the penetration of existing energy efficiency appliances.

Today’s products have very low running costs compared to old generation ones, and consumers could make significant saving by replacing a ten year old appliance with a state-of-the-art one. Yet, despite this and despite our efforts as an industry to promote this message, the transformation is not taking place, and consumers are not accelerating the replacement of the old products. Some 188 million obsolete and energy inefficient appliances are still used in European households. 22 millions tonnes of CO_2 emissions could be avoided by replacing them with new efficient products. Therefore, there is need that governments push for the early replacement of inefficient appliances and educate consumer to buy only most efficient ones. Initiatives in this direction can provide more significant results than chasing the residual energy efficiency improvement.

In 2005 the German Öko-Institut analysed the environmental and economic impact of the accelerated replacement of domestic appliances. The goal of the study, commissioned by CECED was to compare the impact of the substitution of installed appliances of different age with the purchase (and use) of new models on the market in 2005, considering both environmental and

Table 7.60: Effects of the combined proposed policy measures (energy labelling Option 3, using the reference line in hypothesis one, two and three) on washing machine models in 2005 CECED technical database (3+2+2 approach)

New labelling scheme		Hypothesis 1 (4,5-6kg reference line)						Hypothesis 2 (4,5-7 kg reference line)						Hypothesis 3 (4,5-6,5 kg 1997 ref. line)					
EE Classes		Annual energy consumption		+ low power modes consumption		& 5% verification tolerance reduction		Annual energy consumption		+ low power modes consumption		& 5% verification tolerance reduction		Annual energy consumption		+ low power modes consumption		& 5% verification tolerance reduction	
(class)	(class)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
A3	**10**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	**9**	115	2,2	0	0	0	0	8	0,15	0	0	0	0	2	0,04	0	0	0	0
A1	**8**	976	18,8	115	2,2	8	0,15	2 104	40,5	117	2,3	8	0,15	2 064	39,8	3	0,06	2	0,04
A	**7**	3 535	68,1	3 660	70,5	1 083	20,9	2 500	48,2	3 805	73,3	2 104	40,5	2 629	50,6	4 142	79,8	2 031	39,1
B	**6**	360	6,9	919	17,7	3 512	67,6	380	7,3	789	15,2	2 481	47,8	294	5,7	559	10,8	2 654	51,1
C	**5**	164	3,2	342	6,6	382	7,4	162	3,1	323	6,2	398	7,7	166	3,2	314	6,0	293	5,6
D	**4**	42	0,81	156	3,0	200	3,9	38	0,73	158	3,0	195	3,8	37	0,71	174	3,4	206	4,0
E	**3**	0	0	0	0	7	0,13	0	0	0	0	6	0,12	0	0	0	0	6	0,12
F	**2**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		5 192	100	5 192	100	5 192	100	5 192	100	5 192	100	5 192	100	5 192	100	5 192	100	5 192	100

Table 7.61: Effects of the policy measures (energy labelling Option 3, hypothesis one) by load capacity on washing machine models in 2005 CECED technical database

Labelling scheme EE Classes		Load capacity (kg)												Total models	
		3,0	**3,5**	**4,0**	**4,5**	**5,0**	**5,5**	**6,0**	**6,5**	**7,0**	**7,5**	**8,0**	**9,0**		
(class)	(class)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(%)
Annual energy consumption (3+2+2 approach)															
A3	**10**													0	0
A2	**9**	8	37		70									115	2,2
A1	**8**			34	247	623	69	1		2				976	18,8
A	**7**	9	7	3	28	1 670	179	1 460	2	154	22	1		3 535	68,1
B	**6**		8		69	178	1	8		26	57	13		360	6,9
C	**5**				66	90		2					6	164	3,2
D	**4**				1	36	1						4	42	0,81
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Annual energy consumption + low power modes consumption (3+2+2 approach)															
A3	**10**													0	0
A2	**9**													0	0
A1	**8**	8	37		70									115	2,2
A	**7**		7	34	247	2 269	70	1.031		2				3 660	70,5
B	**6**	9		3	96	24	178	430	2	154	22	1		919	17,7
C	**5**		8		17	206	1	8		26	57	13	6	342	6,6
D	**4**				51	98	1	2					4	156	3,0
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Annual energy consumption + low power modes consumption & 5% verification tolerance reduction (3+2+2 approach)															
A3	**10**													0	0
A2	**9**													0	0
A1	**8**	8												8	0,15
A	**7**		37	34	317	623	69	1		2				1 083	20,9
B	**6**	9	7	3	14	1 661	179	1 460	2	154	22	1		3 512	67,6
C	**5**		8		83	187		8		26	57	13		382	7,4
D	**4**				66	121	1	2					10	200	3,9
E	**3**				1	5	1							7	0,13
F	**2**													0	0
G	**1**													0	0
Total		**17**	**52**	**37**	**481**	**2 597**	**250**	**1 471**	**2**	**182**	**79**	**14**	**10**	**5 192**	**100**

Table 7.62: Effects of the policy measures (energy labelling Option 3, hypothesis two) by load capacity on washing machine models in 2005 CECED technical database

Labelling scheme EE Classes		Load capacity (kg)												Total models	
		3,0	**3,5**	**4,0**	**4,5**	**5,0**	**5,5**	**6,0**	**6,5**	**7,0**	**7,5**	**8,0**	**9,0**		
(class)	(class)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(%)
Annual energy consumption (3+2+2 approach)															
A3	**10**													0	0
A2	**9**	8												8	0,15
A1	**8**		37	34	317	623	69	1 022		2				2 104	40,5
A	**7**	9	7	3	14	1 670	179	439	2	154	22	1		2 500	48,2
B	**6**		8		83	178	1	8		26	57	13	6	380	7,3
C	**5**				66	90		2					4	162	3,1
D	**4**				1	36	1							38	0,73
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Annual energy consumption + low power modes consumption (3+2+2 approach)															
A3	**10**													0	0
A2	**9**													0	0
A1	**8**	8	37		70					2				117	2,3
A	**7**			34	247	2 269	70	1 031		154				3 805	73,3
B	**6**	9	7	3	28	24	178	430	2	26	73	9		789	15,2
C	**5**		8		81	206	1	10			6	5	6	323	6,2
D	**4**				55	98	1						4	158	3,0
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Annual energy consumption + low power modes consumption & 5% verification tolerance reduction (3+2+2 approach)															
A3	**10**													0	0
A2	**9**													0	0
A1	**8**	8												8	0,15
A	**7**		37	34	317	623	69	1 022		2				2 104	40,5
B	**6**		7	2	14	1 661	179	439	2	154	22	1		2 481	47,8
C	**5**	9	8	1	82	187	1	8		26	57	13	6	398	7,7
D	**4**				67	121	1	2					4	195	3,8
E	**3**				1	5								6	0,12
F	**2**													0	0
G	**1**													0	0
Total		**17**	**52**	**37**	**481**	**2 597**	**250**	**1 471**	**2**	**182**	**79**	**14**	**10**	**5 192**	**100**

Table 7.63: Effects of the policy measures (energy labelling Option 3, hypothesis three) by load capacity on washing machine models in 2005 CECED technical database

Labelling scheme EE Classes		Load capacity (kg)												Total models	
		3,0	**3,5**	**4,0**	**4,5**	**5,0**	**5,5**	**6,0**	**6,5**	**7,0**	**7,5**	**8,0**	**9,0**		
(class)	(class)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(n)	(%)
Annual energy consumption (3+2+2 approach)															
A3	**10**													0	0
A2	**9**									2				2	0,04
A1	**8**	8	37	34	84	623	70	1 031		154	22	1		2 064	39,8
A	**7**				247	1 670	178	430	2	26	57	13	6	2 629	50,6
B	**6**	9	7	3	82	178	1	10					4	294	5,7
C	**5**		8		67	90	1							166	3,2
D	**4**				1	36								37	0,71
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Annual energy consumption + low power modes consumption (3+2+2 approach)															
A3	**10**													0	0
A2	**9**													0	0
A1	**8**							1		2				3	0,06
A	**7**	8	37	34	317	2 269	240	1 050	2	154	22	9		4 142	79,8
B	**6**		7	2	14	24	8	410		26	57	5	6	559	10,8
C	**5**	9		1	83	206	1	10					4	314	6,0
D	**4**		8		67	98	1							174	3,4
E	**3**													0	0
F	**2**													0	0
G	**1**													0	0
Annual energy consumption + low power modes consumption & 5% verification tolerance reduction (3+2+2 approach)															
A3	**10**													0	0
A2	**9**													0	0
A1	**8**									2				2	0,04
A	**7**	8	37	1	84	623	70	1 031		154	22	1		2 031	39,1
B	**6**			33	247	1 662	178	430	2	26	57	13	6	2 654	51,1
C	**5**		7	3	82	186	1	10					4	293	5,6
D	**4**	9	8		67	121	1							206	4,0
E	**3**				1	5								6	0,12
F	**2**													0	0
G	**1**													0	0
Total		**17**	**52**	**37**	**481**	**2 597**	**250**	**1 471**	**2**	**182**	**79**	**14**	**10**	**5 192**	**100**

Table 7.64: Effects of the combined proposed policy measures (energy labelling Option 3 + specific requirements) on dishwasher models in 2005 CECED technical database

Energy efficiency classes		Dishwasher scenarios																	
		Annual energy consumption						+ low power modes consumption						& 5% verification tolerance reduction					
		all dishwashers		≤9ps		≥10ps		all dishwashers		≤9ps		≥10ps		all dishwashers		≤9ps		≥10ps	
(class)	(class)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
A3	**10**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	**9**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	**8**	489	11,3	437	73,1	52	1,4	0	0	0	0	0	0	0	0	0	0	0	0
A	**7**	3 433	79,1	76	12,7	3.357	89,7	3 898	89,8	489	81,8	3 409	91,1	3 886	89,5	477	79,8	3 409	91,1
B	**6**	314	7,2	46	7,7	268	7,2	331	7,6	68	11,4	263	7,0	65	1,5	36	6,0	29	0,8
C	**5**	106	2,4	39	6,5	67	1,8	67	1,5	2	0,3	65	1,7	285	6,6	46	7,7	239	6,4
D	**4**	0	0	0	0	0	0	46	1,1	39	6,5	7	0,2	106	2,4	39	6,5	67	1,8
E	**3**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F	**2**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total		4 342	100	598	100	3 744	100	4 342	100	598	100	3 744	100	4 342	100	598	100	3 744	100

economic aspects[45]. The goal of the study was to consider whether it makes sense to further use an old washing machine or is it better to buy a new one.

According to GfK the average useful life of installed washing machine in Germany was 12,9 years in 2003. More than 16% of the washing machines in stock were older than 13 years and even washing machines older than 25 years can be found in households. The age distribution of the washing machines in EU9 and selected countries in 2003 is presented in Table 7.65[46].

Table 7.65: Age of the washing machines in Europe and selected countries in 2003

Countries	after 2002 (%)	2002 (%)	1998-2001 (%)	1993-1997 (%)	1992 and older (%)
EU9	6	8	34	27	25
Germany	2	33	21	16	28
Great Britain	6	11	43	24	16
France	8	9	36	26	21
Italy	1	7	31	28	33
Spain	6	10	33	26	25
The Netherlands	5	8	36	29	22
Sweden	7	7	29	25	32
Austria	4	8	30	28	30

This questions had been tackled in a very simplified way in a previous study developed by the same institute, to get a first impression on the issue of accelerated replacement. At that time it was assumed that the new washing machine was bought in 2004 and thus all environmental impacts through production and the acquisition costs occur at once in 2004. For all washing machines (installed and the new models) it was assumed that they would not break within the next ten years (the time period which was regarded). Thus it was investigated, if and when the environmental impacts through production and the purchasing price of a new washing machine are paid back through the lower energy and water consumptions. The consumption values from 1985 to 1991 were taken from Stiftung Warentest (average figures for the 90°C cotton program) and the values from 1996 were taken from CECED database (average figures for the 60°C cotton program). The values for 1995 were interpolated, the values for the other washing programs were calculated according to a fix ratio. No modification of the initial performance due machine ageing or system changes (such as detergents formulation) was considered. The use of driers was included in the calculations, assuming that driers were used during the whole year for 80% of the annual laundry. The influence of inclusion/exclusion of drier was then analysed as sensitivity (use for only half percent of the year or no use at all).

In the second study, some new elements were added: the costs were discounted, failure rates of installed washing machines were considered through the environmental impacts and costs for repairs or through substitution of older washing machines within the regarded time period.

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[45] Source: I. Rüdenauer, C. Gensch,, Eco-Efficiency Analysis of Washing machines. Refinement of Task 4: Further use versus substitution of washing machines in stock. Final report commissioned by: European Committee of Domestic Equipment Manufacturers (CECED), Öko-Institut e.V., Freiburg, 18 March 2005.

[46] Source: Per un uso razionale dell'energia, Apparecchi Elettrodomestici, February 2006, pp. 94-96

Although the authors clearly stated that the study results are valid under the assumptions made and only for Germany, due to the different parameters that strongly depend on the country or climatic conditions such as:

- use of electric tumble driers: the use of driers might not be necessary in countries with other climatic conditions
- electricity supply: the primary energy sources are different in most countries
- consumer behaviour, washing habits,

some useful general indications can be drawn. The answer to the previous question depends on the individual evaluation of the time span, which is acceptable for the environmental and economic payback time. In the study a 5 period is considered acceptable to justify the substitution for both the environmental and the economic payback.

In practice the decision to substitute the washing machine is probably determined by other reasons like the break-down of the existing machine, which would make a repair necessary, or the move to another accommodation. Against the defined payback period of 5 years the following conclusion can be drawn:

- considering the Cumulated Energy Demand, the substitution of washing machines of the years 1985, 1990 and 1995 with a new model is justified. The payback time is approximately 2, 3 and 5 years respectively;
- considering the Global Warming Potential, only the substitution of washing machines of 1985 and 1990 with a new model is justified. The payback time is approximately 3 and 5 years respectively. Washing machines of 1995 have a payback time of approximately 8 years;
- considering the total environmental burden (expressed in environmental points calculated with EcoGrade), only the substitution of washing machines of 1985 is justified, with a payback period of approximately 4 years. Washing machines of 1995 and 2000 present a payback time longer than 10 years;
- considering the economic aspect, for all of the considered washing machines the payback time is longer than the accepted 5 years. Even in case of the 19-year-old washing machine it takes up to 6 years before the savings equal the additional purchasing price.

7.6.9.2 Subsidies

Economic incentives in the form of rebate schemes or tax deduction have been enforced in The Netherlands[47,48]. From the beginning the energy label in the Netherlands had a strong relation with the following energy policy instruments: the MAP (Environmental Action Plan from 1991 to 2000) and the EPR (Energy Premium Regulation from 2000 to 2003). Only a MAP or EPR subsidy could be received when the appliance had an A class label. The EPR started in 2000 and aimed to stimulate households to take energy saving measures and to buy energy efficient appliances. Until October 2003, consumers could get an EPR subsidy for appliances with an energy efficiency class A. For some appliances additional conditions where set to receive the subsidy.

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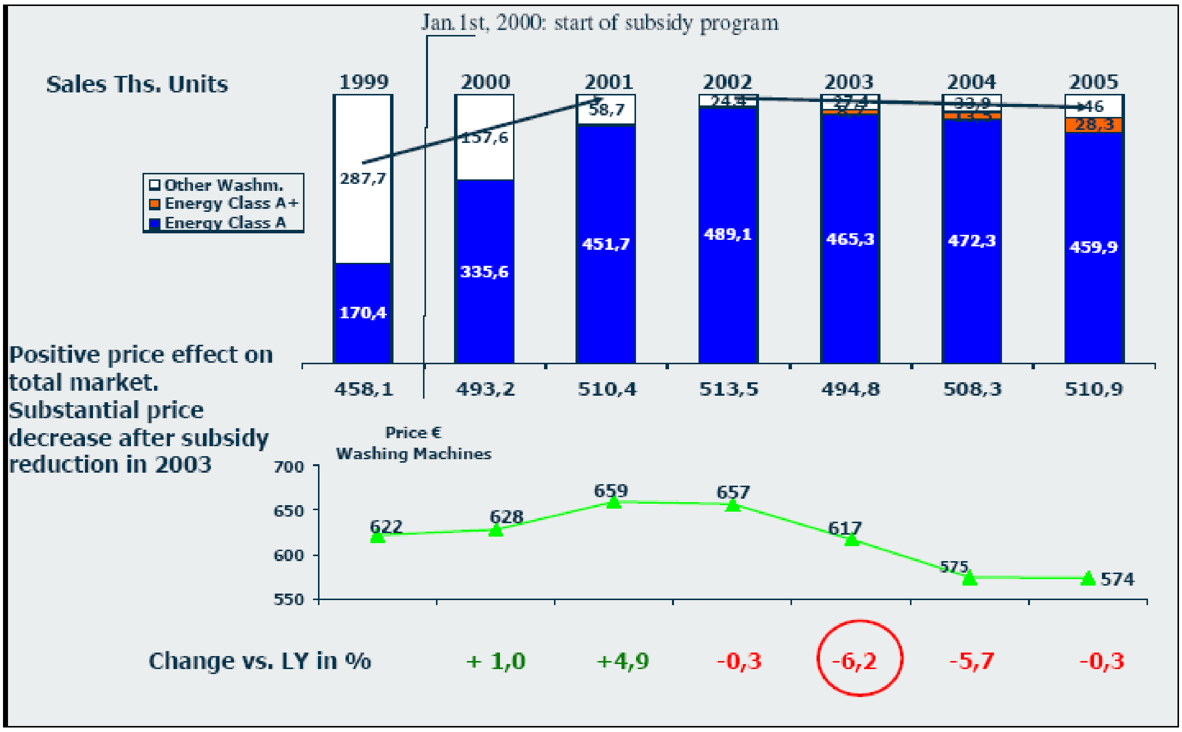
[47] Source: Maxim Luttmer, Evaluation of Labelling of Appliances in the Netherlands, Case Study executed within the framework of the AID-EE project, FINAL DRAFT, contract number EIE-2003-114, April 2006.

[48] Source: "Evaluation of the Netherlands energy efficiency subsidy scheme EPR", Tax Office/Centre for process- and product development, 21 June 2002. English summary by VHK, René Kemna, 8 October 2002. Original title "Rapportage van Onderzoeksbevindingen in Het Kader van de Evaluatie van de Energiepremieregeling, Belastingdienst/Centrum voor proces- en productont-wikkeling, 21 juni 2002

The introduction of the EPR has led to an enormous growth of the supply of A labelled appliances. The market share of A class washing machines grew from 40 to 71% over the 1999-2000 period and 26% to 55% for refrigerators. This increase is most likely due to the EPR and has led to a situation where retailers very often advice their customers to buy an A class appliance as the best on offer.

The effect of the subsidy scheme for washing machines has been specifically studied by GfK[49]. The EPR scheme positively affected the increase the share of the higher efficiency machines and an increase of the average machine price (see the increase in the sales and price of the A and A+ washing machines in Figure 7.60) in the period 1999-2002, followed by a decrease in 2003 when the subsidy ended.

Figure 7.60: The effect of the Dutch subsidy scheme for washing machines in 1999-2005



In Figure 7.61, a comparison between the Dutch and the German market for washing machines in 2001 and 2002 is presented, where the effect of the subsidy can be appreciated from the difference in the units sold per 1000 households in the two countries.

Savings on CO_2 emissions were calculated for each EPR-item, using reference situations proposed by the Energie Onderzoek Centrum Nederland (ECN). The total calculated emission saving over 2000 and 2001 amounted to 210 333 ton (the total CO_2 saving over the lifetime of the appliances that were bought with an EPR-subsidy was not calculated), due to insulation-measures 30%, glazing 18%, PV systems 18% and condensing CH boilers 15%. Refrigerators/freezers plus washing machines contributed for 15%, although they took up 46% of funds. The savings did not lead to a general decrease of residential energy consumption: between 1999 and 2000 the average electricity consumption per household rose from 3 165 kWh to 3 197 kWh.

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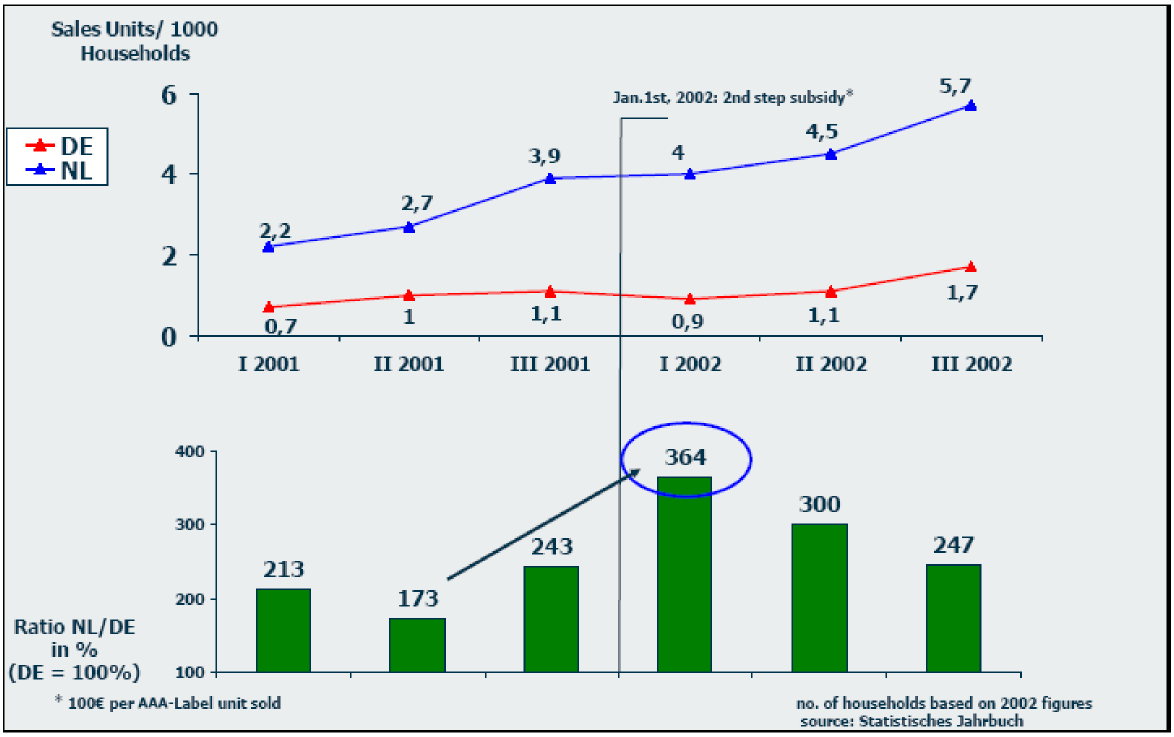
[49] Source: Source: Friedemann Stoeckle, Trends of major domestic appliances sales in the various phases of energy efficiency legislation in Europe, EEDAL 06, London, June 2006.

Figure 7.61: Comparison between the Dutch and the German market for washing machines in 2001 and 2002



Savings on CO_2 emissions were calculated for each EPR-item, using reference situations proposed by the Energie Onderzoek Centrum Nederland (ECN). The total calculated emission saving over 2000 and 2001 amounted to 210 333 ton (the total CO_2 saving over the lifetime of the appliances that were bought with an EPR-subsidy was not calculated), due to insulation-measures 30%, glazing 18%, PV systems 18% and condensing CH boilers 15%. Refrigerators/freezers plus washing machines contributed for 15%, although they took up 46% of funds. The savings did not lead to a general decrease of residential energy consumption: between 1999 and 2000 the average electricity consumption per household rose from 3 165 kWh to 3 197 kWh.

A further example of subsidy scheme comes from, UK. In the UK the more efficient white goods products - cold appliances, washing machines and dishwashers - have been subsidised by power supply firms which are required to promote energy efficient products to consumers by the Energy Efficiency Commitment (EEC) as part of a range of activities to reduce energy consumption. The promotion of products has taken several forms, including subsidising products at point of sale to consumers and replacing old products in some low income homes. The scheme is administered by Ofgem[50], but is a Defra[51] initiative. The EEC scheme has run in two phases - 2002 to 2005 and 2005 to 2008. In 2008 it will be replaced by the Carbon Emissions Reduction Target, but it likely to continue to promote some white goods.

7.6.9.3 Tax incentives to manufacturers

Direct manufacturer subsidies to cover the incremental costs of producing more-efficient appliances have not been tried in Europe to date, but they are implemented in the USA (see Task 1).

Were it possible to introduce a similar tax subsidy in the EU, it could produce substantial positive

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[50] For information see: http://www.ofgem.gov.uk/Sustainability/Environmnt/EnergyEff/Pages/EnergyEff.aspx .
[51] For information see: http://www.defra.gov.uk/environment/climatechange/uk/household/eec/index.htm

improvements in the average efficiency of new appliances and far higher efficiency levels could reasonably be requested without any fear of serious negative impacts for industry or consumers. The existence of a mark-up factor between manufacturing cost and final price suggests it is more cost-effective to deliver subsidies directly to manufacturers (assemblers and component suppliers alike) than to deliver them in the form of rebates; however, there are some complications:

- the legality of direct tax credits has to be established as they contravene state aid regulations. Unfortunately the recent guidelines on state aid for the environment makes it clear that investments for products (as opposed to processes) that bring about energy and environmental benefits in their use, are still not included in state aid[52]. This rules out manufacturing tax credit for the time being;
- production of wash appliances in the EU occurs mainly in some countries and yet the products are consumed throughout the EU and beyond. Unless the main producer Member States were to offer unilateral subsidies for the production of higher-efficiency products, an agreement between net producer and net importer Member States may be needed regarding an equitable funding mechanism. The benefits of production tax grants, which may include price reductions or increased marketing go to all the consumer Member States; however, any increase in profits would come home to the producing companies in the producer Member States.

A recent study promoted by CECED addressed the issue[53], but for a different product - cold appliances - although the validity of the overall study outcome can be extended to major household appliances. This study showed how it was necessary to consider all of the three major players involved: producers, consumers and Member State governments in analyzing public incentive policy. The situation examined is that of a consumer who decides to purchase an energy efficiency class A++ refrigerator-freezer instead of a class A model as the result of the marketing campaign associated with production tax credits. In order to capture the substitution effects, a dual production facility (for both class A++ and class A production) is modelled using the E-GRIM method, utilized in several studies for CECED and the European Commission.

Compared to the business as usual base case, the production tax credit resulted in increased discounted cash flows for the manufacturer, zero or neutral cash flows for the government and positive discounted cash flows for the consumer. Surprisingly, for the government, even including the loss in electricity taxes due to energy savings, the cost of the tax credits were almost fully compensated by increased value added taxes and increased corporate income taxes, due the production shift to the more costly and profitable class A++ model. Thus, the production tax credit can result in essentially positive cash flows for all three major stakeholders.

A comparison was made with the traditional policy of rebate. Under assumptions quite favourable to rebates, it was found that government cash flows are significantly negative and consumer benefits disproportionately high, due to the fact that rebate schemes cannot identify and eliminate free riders, those who would have purchased in any case the higher efficiency model.

In general production tax credits are more cost effective for governments with respect to rebates and lower value added taxes. The production tax credits are based upon tax credits for *only those units produced above an established historic level of production and sales*, which is the level associated with those that would have purchased the improved model anyway. Thus it eliminates free riders,

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[52] Source: “State aid: guidelines on state aid for the environment– frequently asked questions”, Europe Press Releases, MEMO/08/31, 23/01/2008.

[53] Also see, “New Policy Instruments for Energy Efficient Home Appliances In Europe: Production Tax Credits”, 9th IAEE European Energy Conference: Energy Markets and Sustainability in a Larger Europe, June 12, 2007, Florence, Italy

which is very important for promoting a product that already has an initial market share. Also if the government is not successful in the incentive policy it pays nothing. Instead in the rebate scheme, it pays everyone even though the historic sales may not have been reached.

The second reason tax grants can be more effective is that if the grant is used to lower prices at the production stage this has a greater impact on retail prices because of the high distributor/retailer mark-up, typical of the household goods sector. One hundred Euro less in terms of production prices implies two to three hundred Euro less at consumer prices.

The entire program of Energy Using Products is hindered if the EU financial policy can only address energy process improvement. Other major trading nations such as the United States do not suffer such limitations.

7.7 Subtask 7.7: EU Policy Scenarios and Targets

An attempt to model the policy measures (a mix of specific requirements and a revised energy labelling scheme) described in Subtask 7.6 is here developed, aimed at evaluating the overall energy impact at EU level[54]. To this end, the analysis of the possible market penetration trends of the energy efficiency classes in the Business as Usual (BaU) scenario developed in Subtask 7.3 is used as reference. The new energy efficiency classes hypothesised for the revised labelling scheme are evaluated and the resulting energy efficiency potential when compared to the BaU scenario are discussed.

7.7.1 Summary of the Policy Scenarios

In Subtask 7.6 a comprehensive policy measures portfolio has been discussed and, among the different alternatives, a new labelling scheme to substitute and improve the existing one has been suggested and analysed. Moreover possible complementary policy measures addressing resource consumption at washing temperature different from 60°C has been presented, taking into account the constraints deriving from an insufficient standardisation. Finally a proposal to introduce the standby and low power mode consumption in the formulation of the new energy policies has been brought forward.

In the mentioned revised labelling scheme, the new energy efficiency classes could be named either through letters (from G to A3) or numbers (from 1 to 10). Just for sake of a better comparison with the current situation, energy efficiency classes will be indicated only with letters in the followings. This should not be interpreted as preference or commitment towards this specific option. The final layout of a possible revised labelling scheme will be defined by the Regulatory Committee managing the EU energy labelling scheme.

7.7.1.1 Washing machines

For washing machines, the Energy Efficiency Indexes and the average energy consumption values defined for the revised labelling scheme presented in Table 7.45 are considered. The evolution of the market penetration of the new energy efficiency classes of the Revised Labelling scheme Scenario is shown in Table 7.66 and Figure 7.62. In the upper rows of Table 7.66 the new

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[54] In this modelling exercise the absorption refrigerators are not taken into account.

hypothesises energy efficiency classes are presented, while in the lower part of the Table the corresponding Energy Efficiency Index and the average energy consumption per kg, per cycle and year for each energy efficiency class are given. As in the BaU also in this scenario the average annual energy consumption includes the standby consumption, hypothesised in 11,8 kWh/year. It is worth noting that in general the standby consumption accounts for about 6% of washing machines average annual energy consumption for laundry washing.

Table 7.66: Energy efficiency class trend in the Revised Labelling scheme Scenario for washing machines

New labelling classes	**A3**	**A2**	**A1**	**A**	**B**	**C**	Tot.
Year	(%)	(%)	(%)	(%)	(%)	(%)	(%)
2005	--	--	40	51	6	4	100
2009	--	10	65	25	0	0	100
2014	1	25	69	5	0	0	100
2019	10	65	25	0	0	0	100
2025	20	70	10	0	0	0	100
2030	40	58	10	0	0	0	100
EEI	<45	<52	<59	<68	<77	<87	--
Energy consumption (kWh/kg)	0,14	0,16	0,17	0,19	0,23	0,26	
Energy consumption (kWh/cycle)	0,75	0,86	0,91	1,02	1,21	1,40	
Energy consumption (kWh/y)	164	190	201	224	265	307	
Energy consumption including stand-by (kWh/y)	176	202	213	235	277	319	

Figure 7.62: Energy efficiency class trend in the Revised Labelling scheme Scenario for washing machines

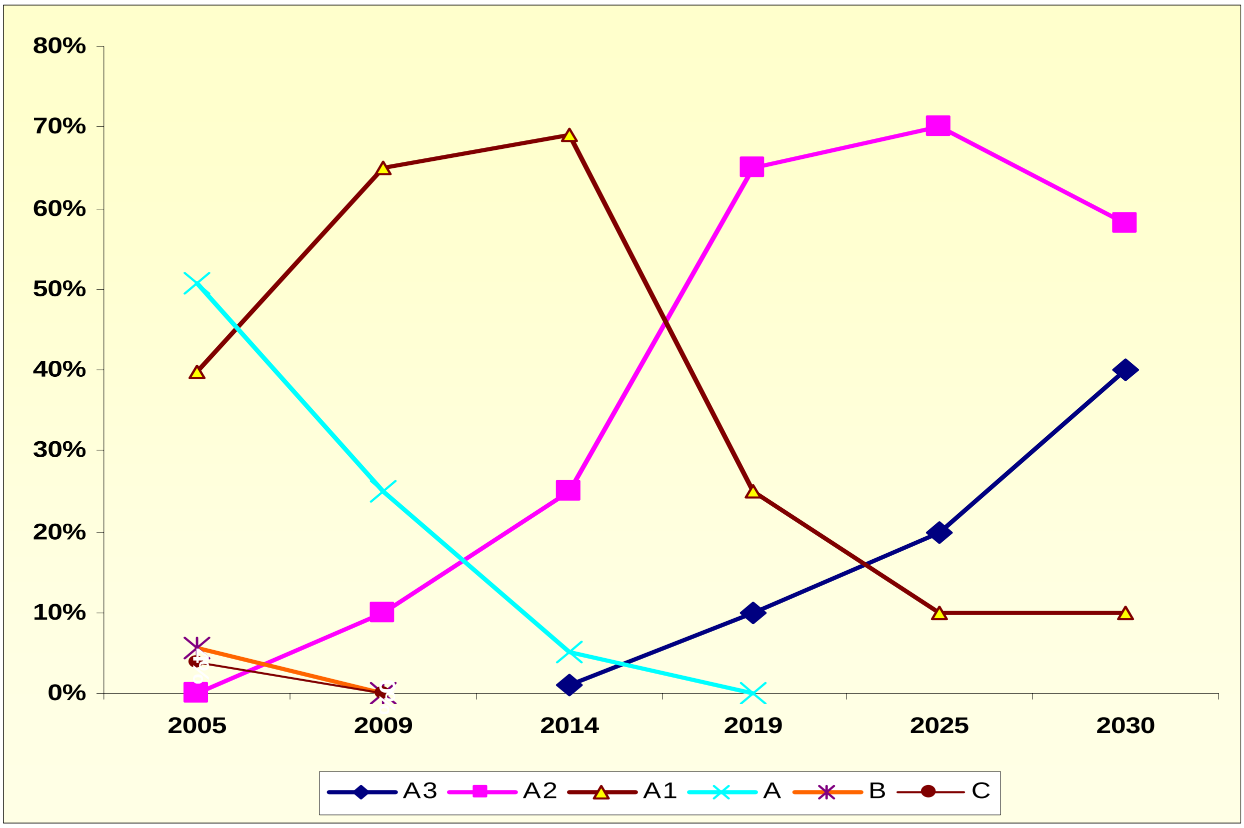


Table 7.67 and Figure 7.63 show the stock energy consumption trends for EU25, EU15 and EU10 countries in this Scenario. The shape of the energy consumption curves is very similar than in the BaU Scenario (see Subtask 7.3) even if here the introduction on the market of the more energy efficient models seems to better counterbalance the energy consumption increase due to the raise of the washing machines stock. This effect is better highlighted in Table 7.68 and Figure 7.64, where it is shown the unitary consumption. In this case the slope corresponding to the years 2005-2030 decreases more rapidly than that of the BaU scenario.

Table 7.69 shows the comparison of the energy consumption trend under the Revised Labelling scheme Scenario and under the hypothesis the washing cycles are carried out at lower temperature and partial load, considering a series of 7 test runs: 3 runs at 60°C plus 2 runs at 60°C and partial load plus other 2 runs at 40°C and partial load (with a reduced detergent dosage). It is worth noting in this case the significant savings achieved at lower temperature (and partial load) washing.

Table 7.67: Stock energy consumption for washing machines under the Revised Labelling scheme Scenario

Year	**Stock energy consumption** (GWh)		
	EU25	EU15	EU10
1990	52 092	46 527	5 565
1995	54 857	48 368	6 489
2000	52 400	45 465	6 935
2005	47 704	40 553	7 151
2009	45 283	38 283	7 000
2014	43 695	37 019	6 676
2019	43 121	36 724	6 397
2025	43 152	36 947	6 205
2030	43 692	37 548	6 145

Figure 7.63: Stock energy consumption for washing machines under the Revised Labelling scheme Scenario

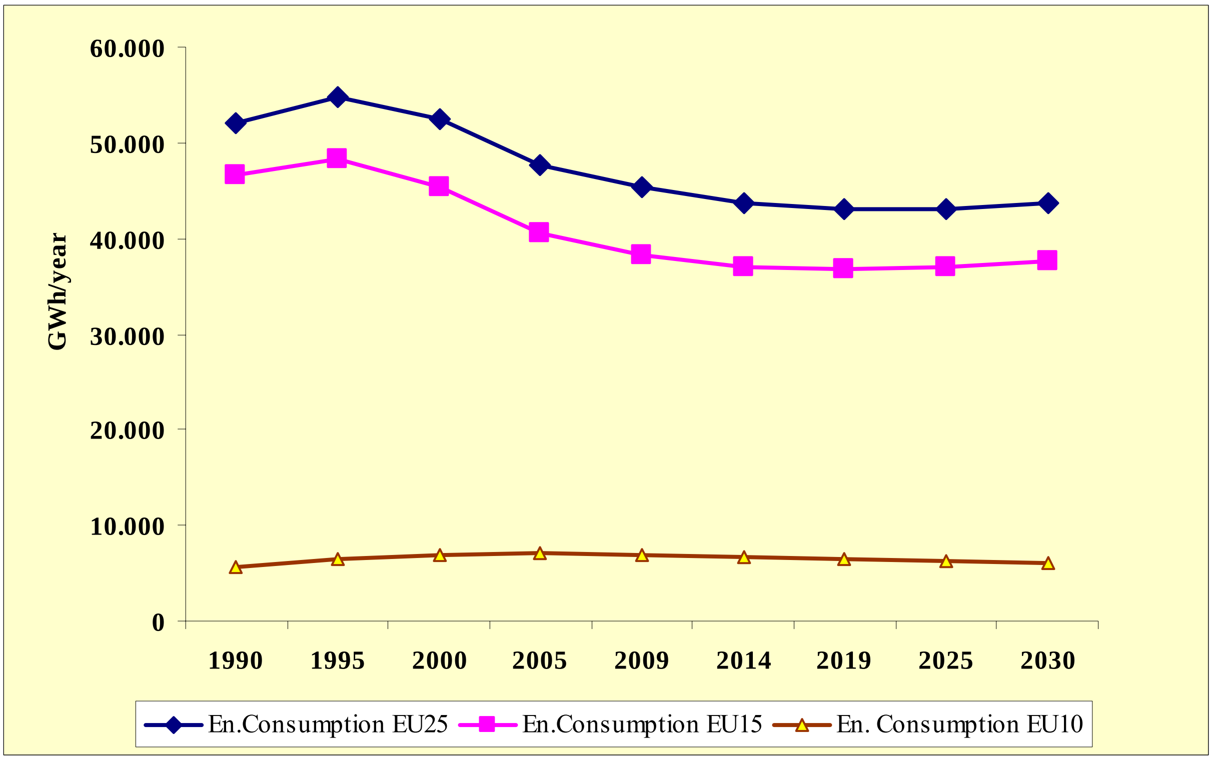


Table 7.68: Average unitary annual energy consumption for washing machines under the Revised Labelling scheme Scenario

Year	**Average annual energy consumption** (kWh/year unit)		
	EU 25	EU 15	EU 10
2005	285	283	296
2009	255	253	266
2014	232	231	240
2019	219	218	224
2025	207	207	210
2030	201	201	203

Figure 7.64: Average unitary annual energy consumption for washing machines under the Revised Labelling scheme Scenarios

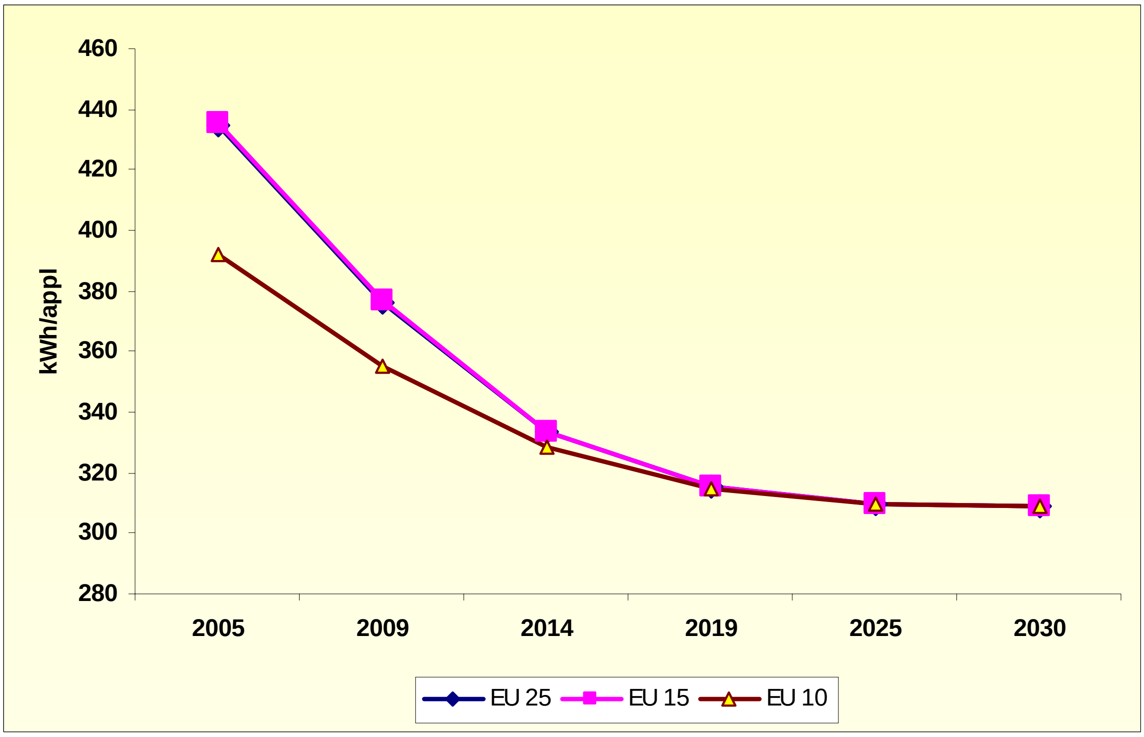


Table 7.69: Energy consumption for washing machines under the Revised Labelling scheme Scenario and the low temperature/partial load conditions for EU25

Year	**Stock energy consumption** (GWh)		
	Revised Labelling Scenario	Low temperature/partial load	Difference
2005	47 704	47 241	463
2009	45 283	42 842	2 441
2014	43 695	39 067	4 628
2019	43 121	37 143	5 978
2025	43 152	36 767	6 385
2030	43 692	37 265	6 428

7.7.1.2 Dishwashers

As in the case of washing machines, also for dishwashers the market penetration trend and the corresponding impact on the energy consumption have been calculated for the Revised Labelling scheme Scenario.

The market penetration rates of the new energy efficiency classes are shown in Table 7.70 and Figure 7.65. In the upper rows of the Table, the new classes are illustrated along with the corresponding Energy Efficiency Indexes. As in the BaU Scenario the average annual energy consumption includes the standby consumption, hypothesised to be 12,4 kWh/year. In general, also for dishwashers, the standby consumption accounts for about 4% of the annual energy consumption for dish washing.

Table 7.70: Energy efficiency class trend in the Revised Labelling scheme Scenario for dishwashers

New labelling classes	**A3**	**A2**	**A1**	**A**	**B**	**C**	Tot.
Year	(%)	(%)	(%)	(%)	(%)	(%)	(%)
2005	--	--	11	79	7	2	100
2009	--	15	70	15	0	0	100
2014	1	39	55	5	0	0	100
2019	3	46	50	1	0	0	100
2025	6	69	25	0	0	0	100
2030	15	80	5	0	0	0	100
EEI	<50	<56	<63	<71	<80	<90	--
Energy consumption (kWh/cycle)	0,83	0,93	1,04	1,17	1,32	1,49	--
Energy consumption (kWh/y)	231	259	292	329	370	416	--
Energy consumption including stand by (kWh/y)	244	272	304	341	383	429	

Figure 7.65: Energy efficiency class trend in the Revised Labelling scheme Scenario for dishwashers

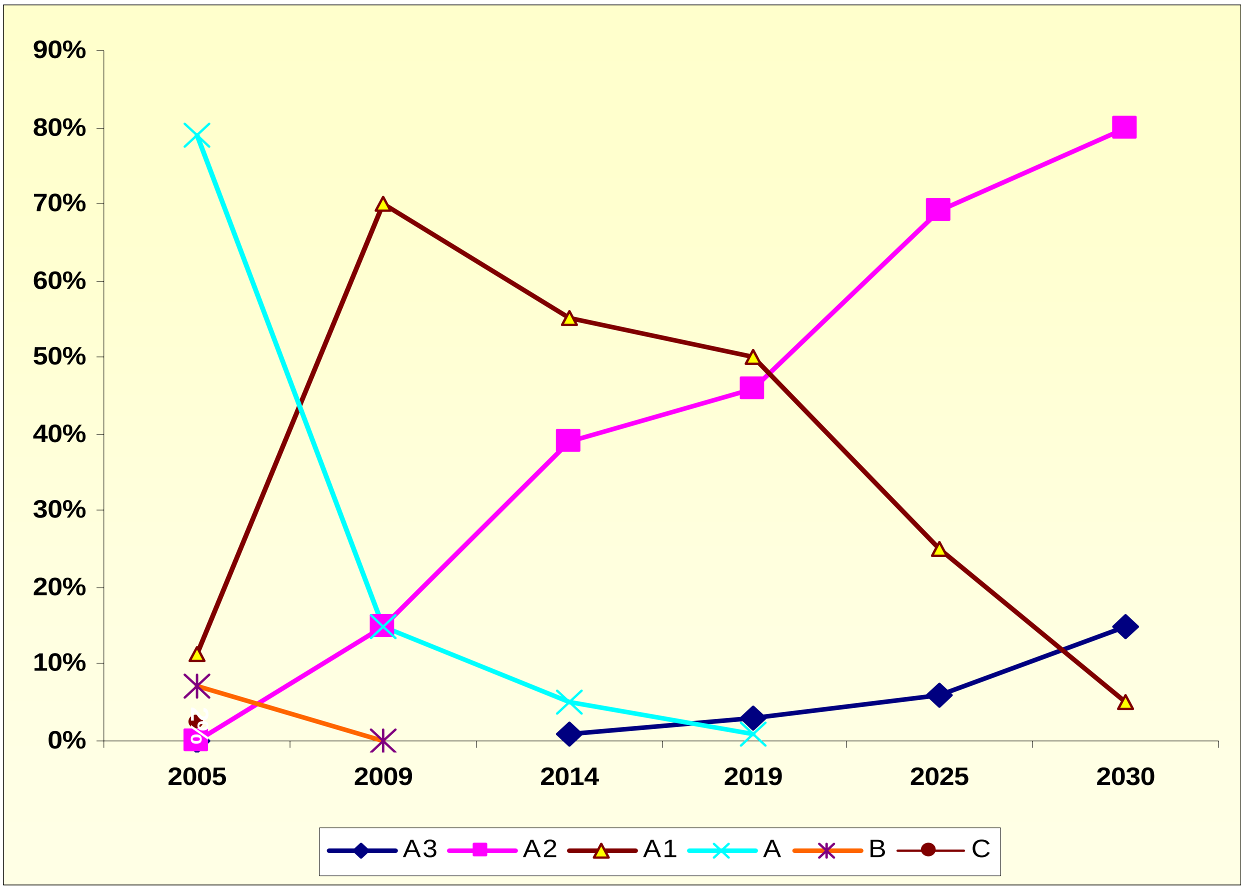


Table 7.71 and Figure 7.66 show the stock energy consumption trends of the EU25, EU15 and EU10 countries under the Revised labelling scheme Scenario. The shape of the energy consumption curves is similar than in the BaU Scenario, even if also for dishwashers the introduction in the market of the more energy efficient models does not prevent the increase of the overall energy consumption, due to the contemporary steadily raise of the dishwashers stock starting from 2014 (see Subtask 7.3).

Nonetheless the slope of the average annual energy consumption curve (see Table 7.72 and Figure 7.67) decrease steadily after 2014 (which presents an asymptotic trend under the BaU Scenario). Unfortunately, the improvement in energy efficiency is not sufficient to counterbalance the contemporary raise in the dishwashers stock. Finally it is worth noting that the average annual energy consumptions for EU15 and EU10 converge to a common value.

Table 7.71: Stock energy consumption for dishwashers under the Revised Labelling scheme Scenario

Years	**Stock energy consumption** (GWh)		
	EU25	EU15	EU10
1990	23 190	23 190	--
1995	27 456	27 390	67
2000	29 678	29 436	242
2005	29 907	29 407	500
2009	30 297	29 551	746
2014	31 342	30 237	1 105
2019	33 710	32 179	1 531
2025	38 001	35 837	2 163
2030	42 221	39 449	2 772

Figure 7.66: Stock energy consumption for dishwashers under the Revised Labelling scheme Scenario

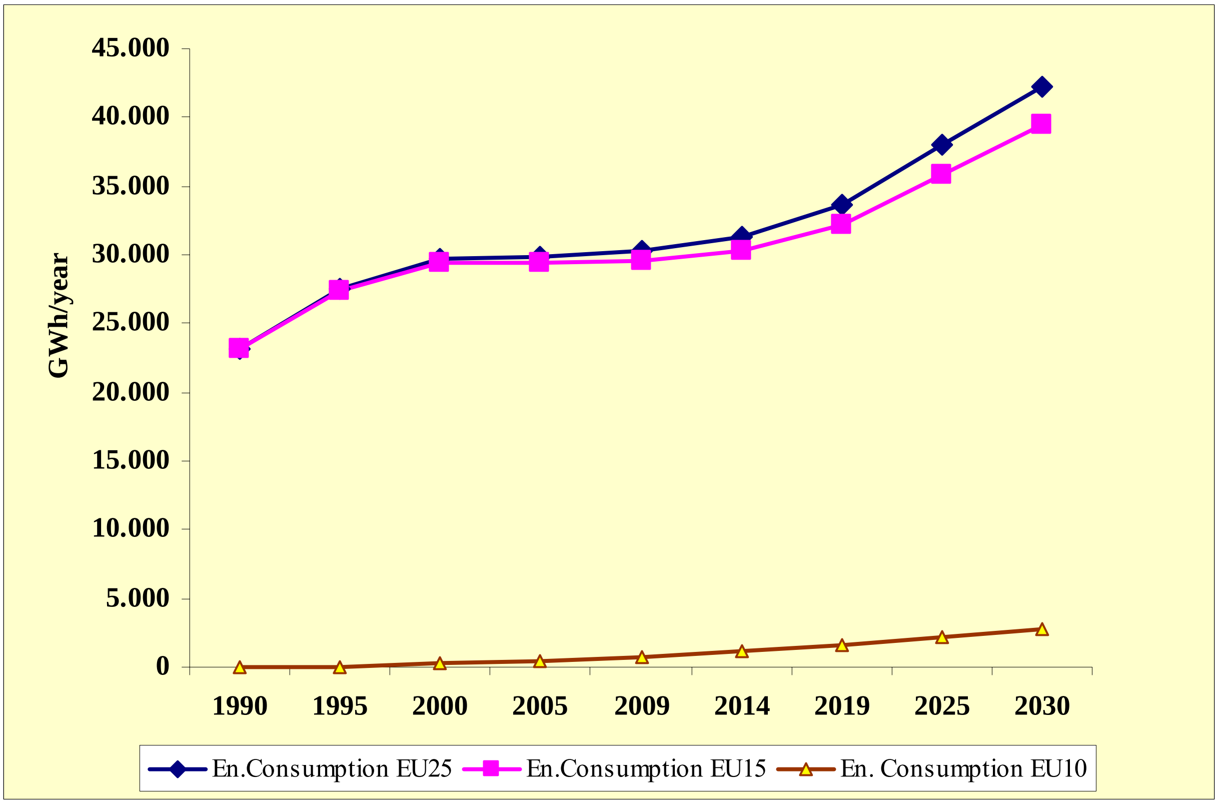
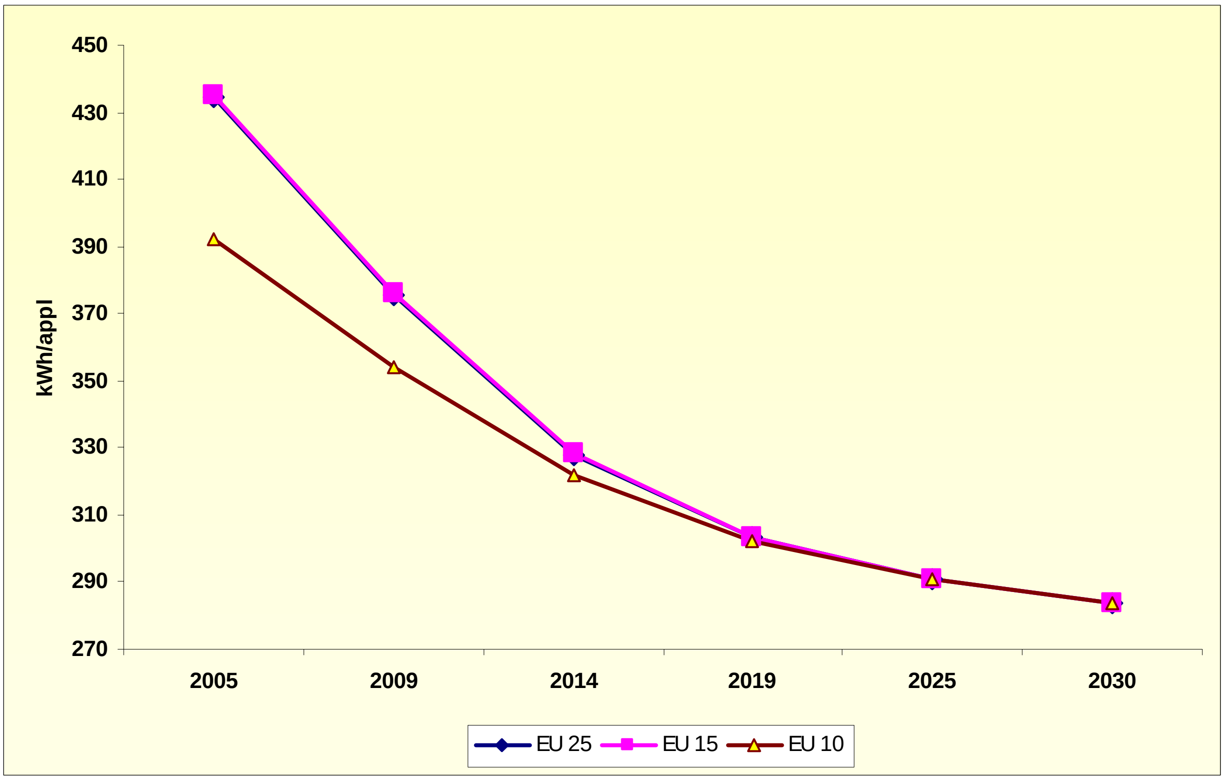


Table 7.72: Average annual energy consumption for dishwashers under the Revised Labelling scheme Scenario

Year	**Average annual energy consumption** (kWh/year unit)		
	EU25	EU15	EU10
2005	434	435	392
2009	376	376	354
2014	328	328	322
2019	304	304	302
2025	291	291	291
2030	283	283	283

Figure 7.67: Average annual energy consumption for dishwashers under the Revised Labelling scheme Scenario



7.7.2 The impact of Policy Scenarios on the EU wash appliance energy consumption

Table 7.73 and Figure 7.68 show the energy consumption forecast of the BaU and Revised Labelling scheme Scenarios for washing machines in EU25 countries. The same data are presented in Table 7.74 and Figure 7.69 for dishwashers. For both products, the impact of the policy Scenarios - compared to the BaU – show a steadily decrease of the stock energy consumption after 2014 due to the introduction of more performing models in the European market.

The energy savings potential of the Revised Labelling scheme Scenario, compared to the BaU, is highlighted and compared for both products in Table 7.75. The achievable savings are in the order of about 2,6% (or 1 140 GWh) for washing machines and about 3,7% (or 1 283 GWh) for dishwashers in 2019, to reach at a maximum of about 6% and 8% (or 2 810 GWh and 3 759 GWh) respectively in 2030, when the best performing (and still not available in the market) washing technologies are expected to dominate the market.

Table 7.73: Comparison of the stock energy consumption by the BaU and the Revised Labelling scheme Scenarios for washing machines in EU25 countries

Year	**Stock energy consumption** (GWh/year)		
	BaU Scenario	Revised Labelling Scenario	Difference
2005	47 704	47 704	0
2009	45 356	45 283	73
2014	44 188	43 695	493
2019	44 261	43 121	1 140
2025	45 120	43 152	1 968
2030	46 502	43 692	2 810

Figure 7.68: Comparison of the stock energy consumption by the BaU and the Revised Labelling scheme Scenarios for washing machines in EU25 countries

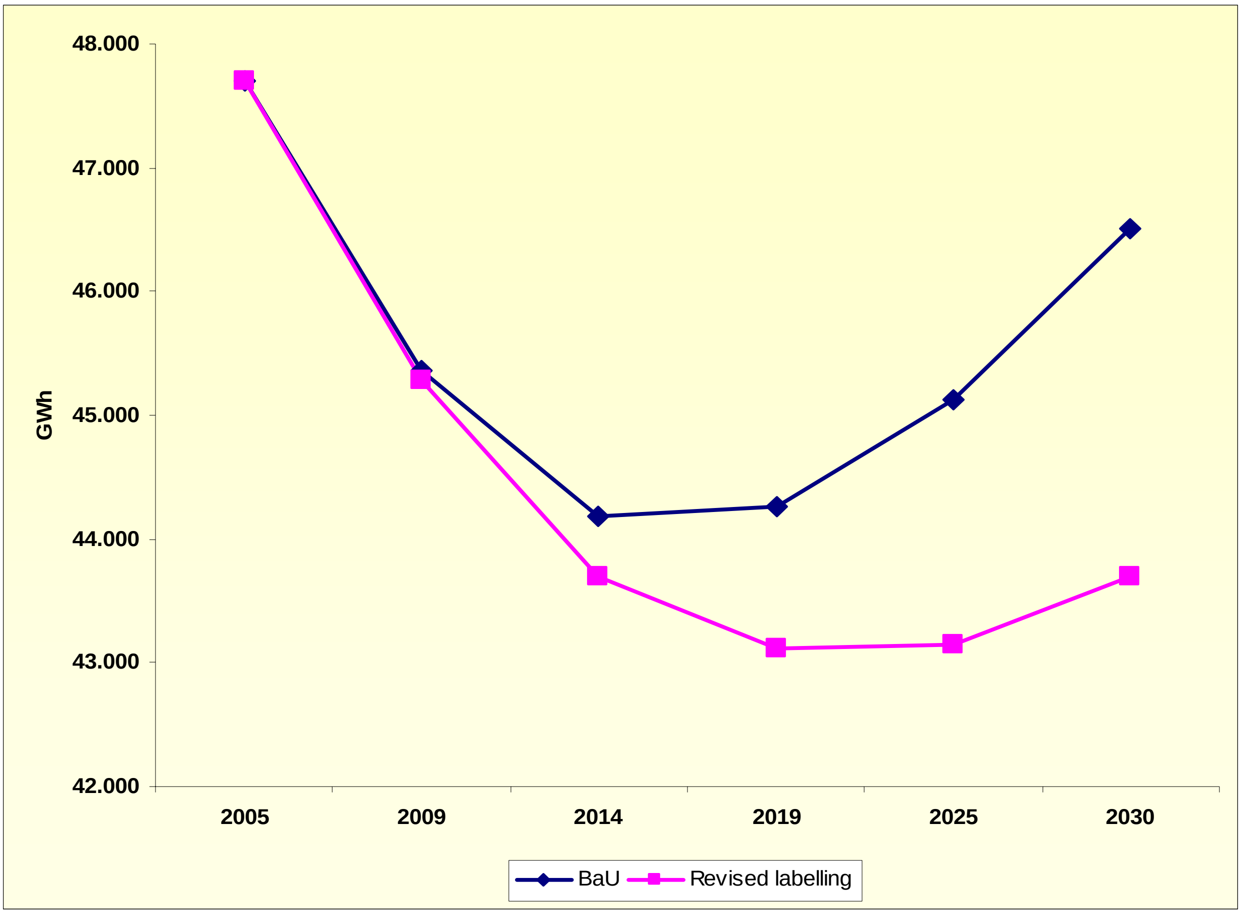


Table 7.74: Comparison of the stock energy consumption by the BaU and the Revised Labelling scheme Scenarios for dishwashers in EU25 countries

Year	**Stock energy consumption** (GWh/year)		
	BaU Scenario	Revised Labelling Scenario	Difference
2005	29 907	29 907	0
2009	30 372	30 297	75
2014	31 865	31 342	522
2019	34 993	33 710	1 283
2025	40 421	38 001	2 420
2030	45 81	42 221	3 759

Figure 7.69: Comparison of the stock energy consumption by the BaU and the Revised Labelling scheme Scenarios for dishwashers in EU25 countries

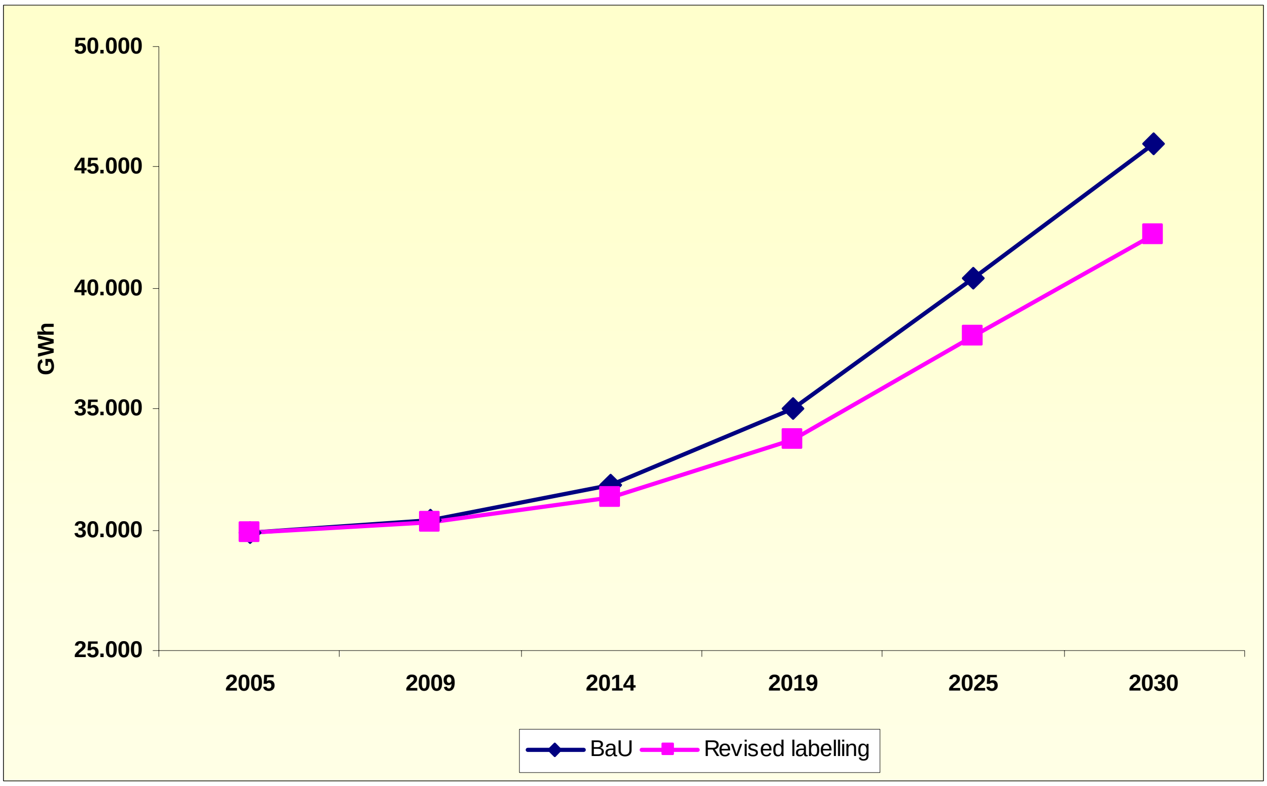


Table 7.75: Energy savings potential for washing machines and dishwashers in EU25 countries

Year	Energy savings potential			
	WASHING MACHINES		**DISHWASHERS**	
	(GWh)	(%)	(GWh)	(%)
2005	0	0,0	0	0,0
2009	73	0,2	75	0,2
2014	493	1,1	522	1,6
2019	1.140	2,6	1.283	3,7
2025	1.968	4,4	2.420	6,0
2030	2.810	6,0	3.759	8,2

Finally in Table 7.77 and Figures 7.70 (for washing machines) and 7.71 (for dishwashers) show the average annual energy consumption trends for the two wash appliances in EU25 countries. In particular, the average annual energy consumption per unit:

- for washing machines: in 2005 is close to the average consumption of the current class B, to decrease in 2019 to the average value of the current class A, and to target in 2030 a value slightly lower the current class A+ average consumption;

- for dishwashers: in 2005 is slightly lower than the current class C threshold, to decrease in 2019 to a value that is between the current classes A and B, and to target in 2030 a value close to the current A+ class average consumption.

Table 7.76: Average annual energy consumption by policy scenarios for washing machines and dishwashers in EU25 countries

Year	**Average annual energy consumption** (GWh/year unit)			
	WASHING MACHINES		**DISHWASHERS**	
	BaU Scenario	Revised Labelling Scenario	BaU Scenario	Revised Labelling Scenario
2005	285	285	285	285
2009	256	255	256	255
2014	235	232	235	232
2019	224	219	224	219
2025	217	207	217	207
2030	214	201	214	201

Figure 7.70: Average annual energy consumption by policy scenarios for washing machines in EU25 countries

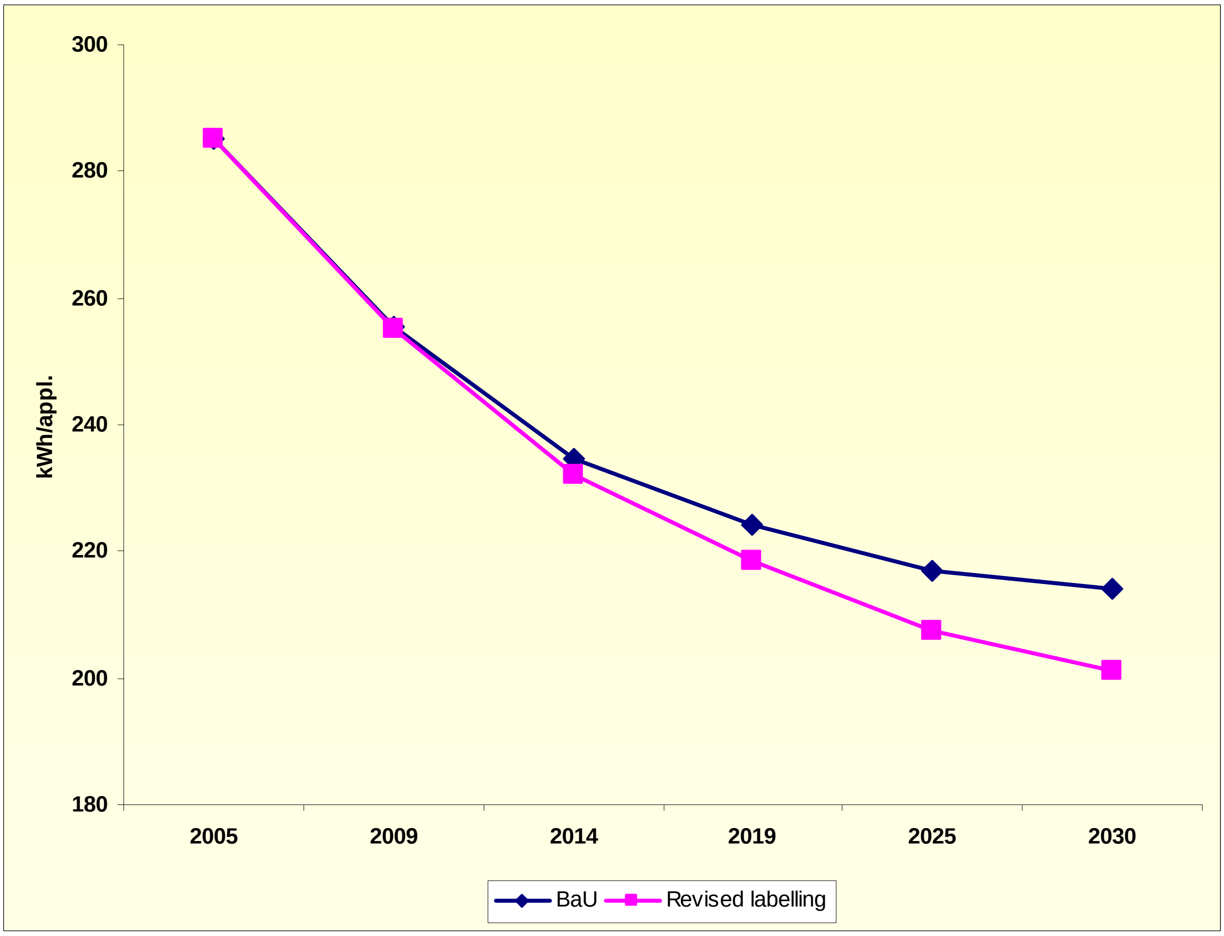
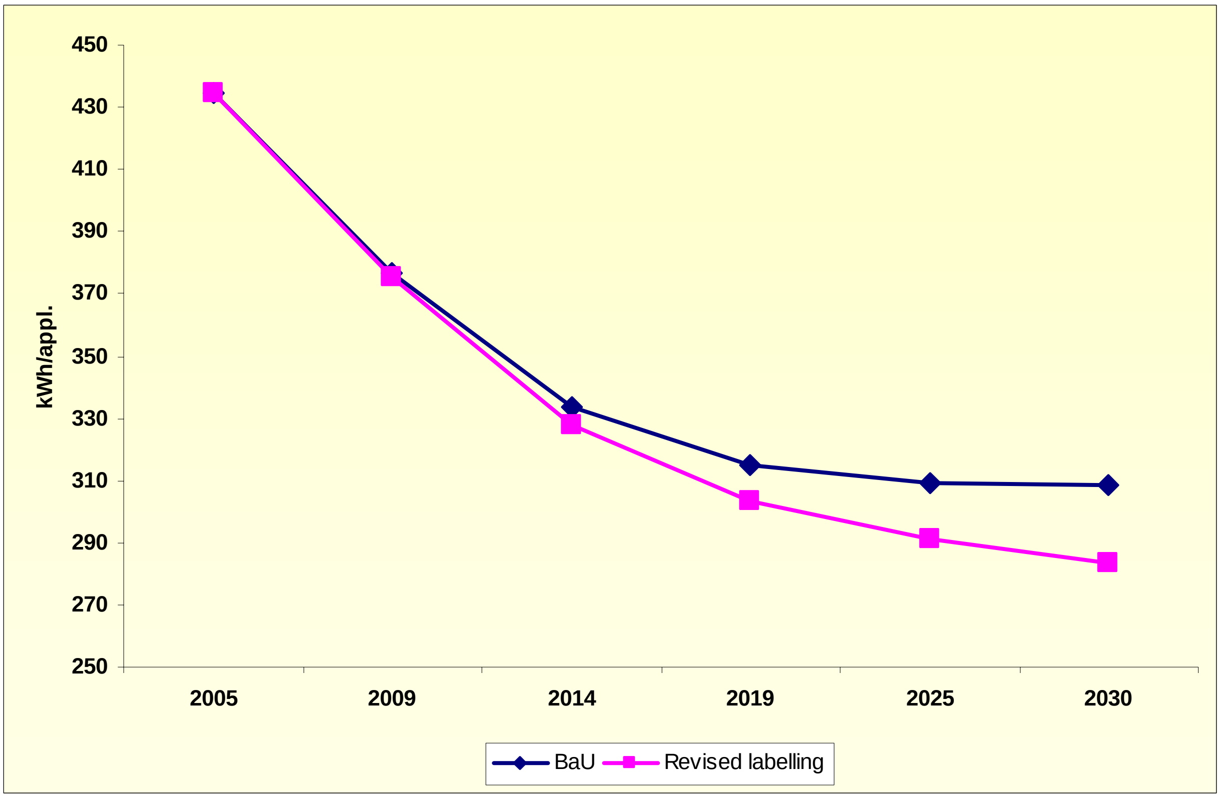


Figure 7.71: Average annual energy consumption by policy scenarios for dishwashers in EU25 countries



7.8 Annex A: Uncertainty in standardisation

7.8.1 The uncertainty in measurements

Uncertainty reporting is essential to ensure measured data are interpreted in a correct way. Especially when data of measurements are to be compared between laboratories or when normative requirements are set up, it is necessary to know the uncertainty with which data can be measured.

The current international view of how to express uncertainty in measurement is the “Guide to the Expression of Uncertainty in Measurement” (called in short GUM), Ed.1, prepared by BIPM/IEC/IFCC/ISO/IUPAC/IUPAP/OIML in 1995.

In general, the result of a measurement is only an approximation or estimate of the value of the specific quantity subject to measurement, that is, the *measurand*, and thus the result is complete only when accompanied by a quantitative statement of its uncertainty. The uncertainty of the result of a measurement generally consists of several components which, may be grouped into two categories according to the method used to estimate their numerical values:

A. those which are evaluated by statistical methods,
B. those that are evaluated by other means.

There is not always a simple correspondence between the classification of uncertainty components into categories A and B and the commonly used classification of uncertainty components as “random” and “systematic” (described in Subtask 7.6). The nature of an uncertainty component is conditioned by the use made of the corresponding quantity, that is, on how that quantity appears in the mathematical model that describes the measurement process. When the corresponding quantity is used in a different way, a “random” component may become a “systematic” component and vice-versa. Thus the terms “random uncertainty” and “systematic uncertainty” can be misleading when generally applied. An alternative nomenclature that might be used is:

component of uncertainty arising from a random effect
component of uncertainty arising from a systematic effect,

where a random effect is one that gives rise to a possible random error in the current measurement process and a systematic effect is one that gives rise to a possible systematic error in the current measurement process. In principle, an uncertainty component arising from a systematic effect may in some cases be evaluated by ‘method A’ while in other cases by ‘method B’, as may be an uncertainty component arising from a random effect.

The difference between *error* and *uncertainty* should always be borne in mind. For example, the result of a measurement after correction can unknowably be very close to the unknown value of the measurand, and thus have negligible error, even though it may have a large uncertainty.

Basic to the GUM approach is representing each component of uncertainty that contributes to the uncertainty of a measurement result by an estimated standard deviation, termed **standard uncertainty** with suggested symbol u_i, and equal to the positive square root of the estimated variance u^2_i.

It follows that an uncertainty component in 'category A' is represented by a statistically estimated standard deviation s_i, equal to the positive square root of the statistically estimated variance s^2_i, and the associated number of degrees of freedom n_i. For such a component the standard uncertainty is $u_i=s_i$.
The evaluation of uncertainty by the statistical analysis of series of observations is termed a **Type A evaluation (of uncertainty)**.

In a similar manner, an uncertainty component in 'category B' is represented by a quantity u_j, which may be considered an approximation to the corresponding standard deviation; it is equal to the positive square root of u^2_j, which may be considered an approximation to the corresponding variance and which is obtained from an assumed probability distribution based on all the available information. Since the quantity u^2_j is treated like a variance and u_j like a standard deviation, for such a component the standard uncertainty is simply u_j.

The evaluation of uncertainty by means other than the statistical analysis of series of observations is termed a **Type B evaluation (of uncertainty)**.

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data; a Type B evaluation of standard uncertainty is usually based on scientific judgment using all the relevant information available, which may include: previous measurement data, experience with, or general knowledge of, the behaviour and property of relevant materials and instruments, manufacturer's specifications, data provided in calibration and other reports, including uncertainties assigned to reference data taken from handbooks.

Convert a quoted uncertainty that is a stated multiple of an estimated standard deviation to a standard uncertainty by dividing the quoted uncertainty by the multiplier. Convert a quoted uncertainty that defines a "confidence interval" having a stated level of confidence (such as 95% or 99%) to a standard uncertainty by treating the quoted uncertainty as if a normal distribution had been used to calculate it and dividing it by the appropriate factor for such a distribution. These factors are 1,960 and 2,576 for the two levels of confidence given.

If the quantity in question is modelled by a normal distribution there are no finite limits that will contain 100% of its possible values. However, ±3 standard deviations about the mean of a normal distribution corresponds to 99,73% limits. Thus, if the limits a_- and a_+ of a normally distributed quantity with mean = $(a_+ + a_-)/2$ are considered to contain "almost all" of the possible values of the quantity, that is, approximately 99,73% of them, then $u_j = a/3$, where $a = (a_+ - a_-)/2$.

7.8.2 The combined standard uncertainty

The *combined standard uncertainty* of a measurement result, u_c, is taken to represent the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties u_i, whether arising from a Type A evaluation or a Type B evaluation, using the law of propagation of uncertainty (also known as "root-sum-of-squares" method) for combining standard deviations. It is assumed that a correction (or correction factor) is applied to compensate for each recognized systematic effect that significantly influences the measurement result and that every effort has been made to identify such effects.

In many practical measurement situations, the probability distribution characterized by the measurement result y and its combined standard uncertainty $u_c(y)$ is approximately normal (Gaussian). When this is the case and $u_c(y)$ itself has negligible uncertainty, $u_c(y)$ defines an interval

$y - u_c(y)$ to $y + u_c(y)$ about the measurement result y within which the value of the measurand Y estimated by y is believed to lie with a level of confidence of approximately 68%. That is, it is believed with an approximate level of confidence of 68% that $y - u_c(y) \leq Y \leq y+u_c(y)$, which is commonly written as $Y = y \pm u_c(y)$.

The term "confidence interval" has a specific definition in statistics and is only applicable to intervals based on u_c when certain conditions are met, including that all components of uncertainty that contribute to u_c be obtained from Type A evaluations. Thus, an interval based on u_c is viewed as encompassing a fraction p of the probability distribution characterized by the measurement result and its combined standard uncertainty, and p is the coverage probability or level of confidence of the interval.

Although the combined standard uncertainty u_c is used to express the uncertainty of many measurement results, for some commercial, industrial, and regulatory applications of such results, what is often required is a measure of uncertainty that defines an interval about the measurement result y within which the value of the measurand Y is confidently believed to lie. The measure of uncertainty intended to meet this requirement is termed **expanded uncertainty**, U, and is obtained by multiplying $u_c(y)$ by a **coverage factor** k. Thus $U = ku_c(y)$ and it is confidently believed that $y - U \leq Y \leq y + U$, which is commonly written as: $Y = y \pm U$.

In general, the value of the coverage factor k is chosen on the basis of the desired level of confidence to be associated with the interval defined by $U = ku_c$. Typically, k is in the range 2 to 3. When the normal distribution applies and u_c has negligible uncertainty, $U = 2u_c$ (i.e., k=2) defines an interval having a level of confidence of approximately 95% and $U = 3u_c$ (i.e., k=3) defines an interval having a level of confidence greater than 99%.

For a quantity z described by a normal distribution with expectation μ_z and standard deviation s, the interval $\mu_z \pm ks$ encompasses 68,27%, 90%, 95,45%, 99% and 99,73% of the distribution for k=1, k=1,645, k=2, k=2,576, and k=3, respectively.

Ideally, one would like to be able to choose a specific value of k that produces an interval corresponding to a well-defined level of confidence p, such as 95% or 99%; equivalently, for a given value of k, one would like to be able to state unequivocally the level of confidence associated with that interval. This is difficult to do in practice because it requires knowing in considerable detail the probability distribution of each quantity upon which the measurand depends and combining those distributions to obtain the distribution of the measurand.

The GUM gives an approximate solution to the problem of how the relation between k and p is to be established. Use expanded uncertainty U to report the results of all measurements other than those for which u_c has traditionally been employed. To be consistent with current international practice, the value of k to be used for calculating U is, by convention, k = 2. Values of k other than 2 are only to be used for specific applications dictated by established and documented requirements.

An example of the use of a value of k other than 2 is taking k equal to a t-factor obtained from the t-distribution when u_c has low degrees of freedom in order to meet the dictated requirement of providing a value of $U = ku_c$ that defines an interval having a level of confidence close to 95%.

7.8.3 Accuracy of a measurement method

The current international method for assessing the accuracy of a measurement method is the standard ISO 5725: *Accuracy (trueness and precision) of measurement methods and results*, Part 1-6, issued in issued 1994 – 1998.

Methods for measuring declared values for energy and other resources consumption must be of sufficient ***accuracy*** to provide confidence to governments, consumers and manufacturers. The term accuracy implies the total displacement of a result from a reference value due to random as well as systematic effects. The accuracy of a test method is expressed in terms of *trueness* and *precision*:

- ***trueness*** refers to the closeness of agreement between the arithmetic mean of a large number of test results and the true or accepted reference values. Trueness assess the various components of bias;
- ***precision*** refers to the closeness of the agreement between test results. Precision is the general term for variability between repeated measurements. The need to consider precision arises because tests performed on presumably identical materials or products in presumably identical circumstances do not, in general, yield identical results. This is attributed to unavoidable random errors inherent in every measurement procedure; the factors that influence the outcome of a measurement cannot all be completely controlled. For instance, the difference between a test result and some specified value may be within the scope of unavoidable random errors, in which case a real deviation from such a specified value has not been established

Accuracy data can be used in various practical situations:

- giving a standard method of calculating the repeatability limit, the reproducibility limit and other limits to be used in examining the test results obtained by a standard measurement method
- providing a way of checking the acceptability of test results obtained under repeatability or reproducibility conditions
- describing how to assess the stability of results within a laboratory over a period of time, and thus providing a method of "quality control" of the operations within a laboratory
- describing how to assess whether a given laboratory is able to use a given standard measurement method in a satisfactory way
- describing how to compare alternative measurement methods.

Two conditions of precision: ***repeatability*** and ***reproducibility*** have been found necessary and useful for describing the variability of a measurement method, where:

- *repeatability*: is precision under repeatability conditions, where independent test results are obtained with the same method, on identical test items, in the same laboratory, by the same operator, using the same equipment, within short intervals of time;
- *reproducibility*: is precision under reproducibility conditions, where test results are obtained with the same method, on identical test items, in different laboratories, with different operators, using different equipment.

The *repeatability* of a test method must be sufficiently accurate for comparative testing, while *reproducibility* must be sufficiently accurate for the determination of values, which are declared, and for checking the declared values.

Many different factors may contribute to the variability of results from a measurement method, including:

- the operator
- the equipment (instrumentation) used
- the calibration of the equipment
- the environmental conditions (temperature, humidity, etc.)

- the time elapsed between measurements.

The variability between measurements performed by different operators and/or different equipment will usually be greater than the variability between measurements carried out within a short interval of time by a single operator using the same equipment. Under repeatability conditions the listed factors are considered constant and do not contribute to the variability, while under reproducibility conditions they vary and do contribute to the variability of test results. Thus *repeatability* and *reproducibility* are the two extremes of precision, the first describing the minimum and the second the maximum variability in results.

The measure of precision usually is expressed in terms of "*imprecision*" and is computed as a standard deviation σ of the test results. Less precision is reflected by a larger standard deviation. However, in statistical practice, where the true value of a standard deviation is not known, it is replaced by an estimate based upon a sample, then the symbol σ is replaced by "s" to denote that it is an estimate. The square of the standard deviation is called the *variance* "S". According to ISO 5725:

- S_L^2 = *between-laboratory variance*; it includes the between operator and between equipment variability
- S_W^2 = *within-laboratory variance*, under repeatability conditions. **Note**: under IEC 61923:1997, within-laboratory variance is the square of the within-laboratory standard deviation indicated as $S_{L,i}$
- S_r^2 = *repeatability variance*; it is the arithmetic mean of the within laboratory variances S_W^2; this arithmetic mean is taken over all those laboratories taking part in the accuracy experiment which remain after outliers have been excluded
- $S_R^2 = (S_L^2 + S_r^2)$ = *reproducibility variance*

From variance values "S" the repeatability (s_r) and the reproducibility (s_R) of the measurement method are derived:

- s_r = repeatability of the test method, is the square root of the *repeatability variance*;
- s_R = reproducibility of the test method, is the square root of the *reproducibility variance*

The 'trueness' of a measurement method is of interest when it is possible to conceive a true value for the property being measured. Although for some measurement methods the true value cannot be known exactly, it may be possible to have an accepted reference value for the property being measured. The trueness of a measurement method can be investigated by comparing the accepted reference value with the level of the results given by the measurement method.

Trueness is normally expressed in term of *bias*. Bias is the difference between the expectation of test results and an accepted reference value. Bias is the total systematic error as contrasted to random error. There may be one or more systematic error components contributing to the bias:

- ***laboratory bias***: the difference between the expectation of the test results from a particular laboratory and an accepted reference value
- ***bias of the measurement method***: the difference between the expectation of test results obtained from all laboratories using that method and an accepted reference value
- ***laboratory component of bias***: the difference between the laboratory bias and the bias of the measurement method.

An accepted reference value is a value that serves as an agreed-upon reference for comparison, and which is derived as:

a) theoretical or established value, based on scientific principles

b) an assigned or certified value, based on experimental work of some national or international organisation
c) a consensus or certified value, based on collaborative experimental work under the auspices of a scientific or engineering group
d) when a), b) and c) are not available, the expectation of the (measurable) quantity, i.e. the mean of a specified population or measurements.