Preparatory Studies for Ecodesign Requirements of EuPs (III)

ENER Lot 21 – Central heating products that use hot air to distribute heat
Task 1: Definition

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Table of Contents

List of Tables

List of Figures

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Introduction

The Ecodesign Directive

This report documents the preparatory study of air-based central heating systems (the "ENER Lot 21 study") on behalf of the European Commission (DG ENER) in the context of **Directive 2005/32/EC on the Ecodesign of Energy-using Products**[1]. This framework Directive does not introduce binding requirements for specific products directly, but defines conditions and criteria for setting requirements, through subsequent implementing measures, regarding environmentally relevant product characteristics.

According to the Directive, implementing measures can be proposed for product categories, which meet the following criteria:

- Significant volume of products placed on the EU market
- Significant environmental impact
- Significant potential for improvement

The implementing measures are to be based on an environmental assessment taking into account product characteristics and functionality. Technologies available on the market should be taken as a reference.

The first step, in considering whether and which Ecodesign requirements should be set for a particular product group, is a preparatory study recommending ways to improve the environmental performance of the product.

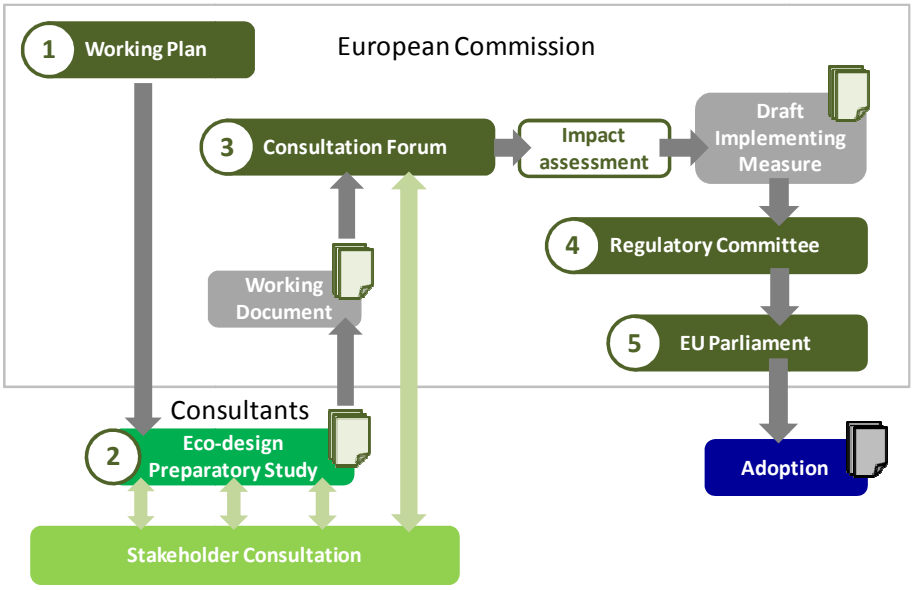

Figure 1: The Ecodesign process: based on a working plan (1) preparatory studies (2) are launched to establish the evidence base before any implementing measures are proposed

[1] Recasted in 2009: Directive 2009/125/EC on the Ecodesign of Energy-related Products

The preparatory study will provide the necessary information to prepare for the next phases in the policy process (carried out by the Commission) and in particular the impact assessment, the consultation forum, and the possible draft implementing measures laying down Ecodesign requirements for ErPs (see Figure 1).

As in all Ecodesign preparatory studies, a common and coherent methodology (MEEuP)[2] is used for analysing the environmental impacts and improvement potential of the products and Ecodesign options are analysed from a life cycle cost perspective. This methodology consists of eight main tasks which will be conducted in an iterative manner (see Figure 2):

- Task 1: Definition
- Task 2: Economic and market analysis
- Task 3: Consumer behaviour and local infrastructure
- Task 4: Technical analysis of existing products
- Task 5: Base-Cases
- Task 6: Technical analysis of BAT (Best Available Technology) and BNAT (Best Not yet Available Technology)
- Task 7: Improvement potential
- Task 8: Final analysis: scenario, policy, impact, and sensitivity analysis

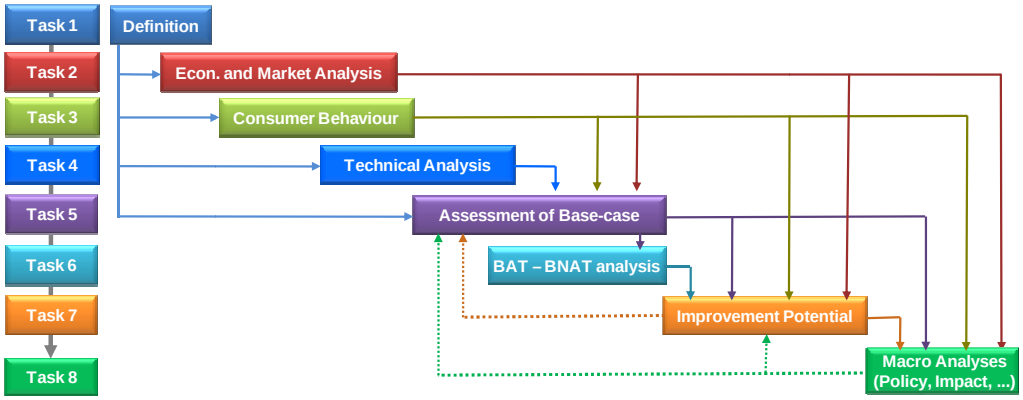

Figure 2: The task structure of the MEEuP methodology and the interrelationships between tasks

The latest version of this and other task reports can be found on: www.ecoheater.org/lot21/

[2] VHK (2005) Methodology for Eco-design of Energy-using Products (MEEuP),Final Report. Study commissioned by the European Commission - DG ENTR. Available at: ec.europa.eu/enterprise/eco_design/finalreport1.pdf

Task 1: Definition

The objective of this task is to discuss definition and scope issues related to the Ecodesign preparatory study for **central heating products that use hot air to distribute heat (other than CHP)**: ENER Lot 21[3]. It consists of categorisation of products; descriptions of product definitions; identification of key parameters for the selection of relevant products to perform detailed analysis and assessment during the next steps of the study; and, scope definition.

Further, existing harmonised test standards and sector-specific procedures for product testing will be identified and discussed, covering the test protocols for:

- Primary and secondary functional performance parameters (functional unit)
- Energy use during product life
- Safety (electricity, electromagnetic compatibility, stability of the product, etc.)
- Other product specific test procedures.

Finally, this task will identify and analyse existing legislation, voluntary agreements, and labelling initiatives at the EU level, in the Member States (MS), and in countries outside the EU.

1.1 Product category and performance assessment

The main objective of this subtask is to set a solid foundation for the ENER Lot 21 preparatory study by defining the product scope for central heating systems that use hot air; and, to understand these products from a functional, technical, environmental, and economic point of view. This subtask will also propose a structure for appropriate product groups.

1.1.1 Wider context of central heating appliances

The principle of central heating by hot air dates back to the ancient Romans, where hot flue gases from a furnace room below ground were conveyed via ducts under the floor and flues in the walls, to emerge at various points about the building. Today, air-based central heating systems are mainly used in the service sector in the EU, such as for heating retail stores, supermarkets, commercial kitchens, gymnasiums, warehouses, etc. Although common in North America, hot air heating is currently rarely found in residential houses in Europe, where hydronic central heating systems are by far more common. However, the development of heat pumps for central heating is starting to change that trend, especially in newly built residences.

[3] Preparatory studies are being managed both by DG ENER and DG ENTR. In order to differentiate between the different lots, the prefix «ENER» is used here.

Among the advantages of hot air heating over other forms of heating is the fact that they are able to heat up a space rapidly and that the associated ventilation of such systems prevents condensation and renews the indoor atmosphere, removing lingering odours and microbes. Air-based central heating systems can also be used to provide cooling to the building. However, large airflow rates are required to meet the heat demands of a space. Fan power is proportional to the cube of the volume of air moved. The result is high running costs and energy consumption for air distribution systems. Ductwork and associated insulation is also expensive and demands significant space requirements, which may be prohibitive where cooling is not required. There are however some technologies in the market which have less space requirements and lower running costs, such as mini-duct systems.

Furthermore, if the central heating system is poorly designed the diffusion of warm air can be ineffective and cause irritating draughts. The noise from the circulating fans and distributors can also sometimes be disturbing to the building's occupants.

Heating systems can be classified[4] according to *the means of generating heat* (i.e. the heat generator and energy source), *the means of distributing the heat* around the building (i.e. the distribution medium), *the means of delivering the heat* into the space to be heated (i.e. the heat emitter) and *the principle by which heat is delivered* to the space (i.e. convection or radiation). This study is focused on air (as opposed to water and steam) as the means for distributing heat. These types of systems are sometimes also called "hot air/warm air/forced-air/ducted heating systems".

Space heating is the largest component of household energy use in the European Union (EU) and is already identified as a priority by the European Commission as it also represents significant energy efficiency potential[5]. Several studies under the Ecodesign Directive on space heating related products have already been initiated. These are:

- TREN/ENER[6] Lot 1 – Central heating boilers (www.ecoboiler.org)
- TREN/ENER Lot 2 – Water heaters (www.ecohotwater.org)
- ENTR Lot 4 - Industrial and laboratory furnaces and ovens (www.eco-furnace.org)
- ENTR Lot 6 – Air-conditioning and ventilation systems (www.ecohvac.eu)
- TREN/ENER Lot 10 – Room air conditioning appliances (www.ecoaircon.eu)
- TREN/ENER Lot 15 – Solid fuel small combustion installations (www.ecosolidfuel.org)
- ENER Lot 20 – Local room heating products (www.ecoheater.org)

[4] Oughton & Hodkinson (2008) Faber & Kell's Heating and Air-Conditioning of Buildings. Tenth edition. UK: Elsevier Ltd.

[5] European Environment Agency (2008). Energy and environmental report No. 6/2008

[6] The different use of abbreviations are due to the first preparatory studies were launched under DG Transport and Energy (TREN). Since 2010 DG Energy (ENER) was split from DG Mobility and Transport.

- ENER Lot 22 – Domestic and commercial ovens (www.ecocooking.org)
- ENER Lot 23 – Domestic and commercial hobs and grills (www.ecocooking.org)

Whilst this study will not repeat work already done in other preparatory studies, it aims not to leave any loopholes. Therefore, before analysing the specificities of the products covered by this study, it is important to establish clear links and interfaces between product groups.

Central heating systems can be defined as appliances that provide heat to indoor spaces by generating heat at one central place, such as a boiler room in a house or a mechanical room[7] in a large building. This heat then gets distributed, typically by forced-air through ductwork, by water circulating through pipes, or by steam fed through pipes. Local room heating products (ENER Lot 20) on the other hand imply that heat is provided by distributing it directly in the same room in which it is generated. Central heating products are also covered in ENER Lot 1 for hydronic (using water to distribute heat) systems. The ENER Lot 21 appliances also rely on the same heating principles and are alternative solutions used for meeting the same functional needs, i.e. indoor space heating. Some ducted heating systems have boilers as heat generators and use heat exchangers to transfer heat to air that is then circulated around the building. All types of boilers are covered in ENER Lot 1 no matter how the heat is emitted into the building.

This study acknowledges the functional similarities and the eventual similarity or divergence in environmental impacts (especially during the use phase) and energy efficiency for products covered in other lots. The energy efficiency depends to a great extent on the type of fuel used and on the combustion or the electricity use efficiency. For example small solid fuel combustion installations (< 500 kW) which are investigated in ENER Lot 15, cover some types of hot air central heating furnaces. See Figure 1.1.

ENER Lot 10 includes air-conditioning appliances that besides cooling are also capable of providing heat (reversible air-conditioners). Likewise ENTR Lot 6 is currently covering non-domestic air-conditioning and ventilation systems, but several of the products considered in the study also have heating capabilities.

Together with this study, the above mentioned lots share many of the same components, e.g. motor, fans, heat exchangers, etc. Some of these components have already been investigated in ENER Lot 11 (e.g. motors, fans, circulators, etc.). The scope of this study is therefore very closely related to other heat, ventilation and air-conditioning (HVAC) products covered in ENER Lot 10, 11 and 20 as well as the ENTR Lot 6. Furthermore, a preparatory study (ENER Lot 31) focused on compressors is expected to be launched during 2012.

Some cooking appliances double as space heaters, but these have been covered in ENER Lot 22 as their primary function is cooking. Similarly ENTR Lot 4 investigates industrial and laboratory furnaces and ovens, but like cooking appliances these products have a specific primary functionality which is not space heating. Finally drying cabinets, which were considered in ENER

[7] A mechanical room is the term used for the room of space housing the centralised heat, ventilation and air-conditioning (HVAC) equipment.

Lot 16 (laundry dryers), could be classified as heaters, but again their primary function is to remove moisture from clothes and not to heat space.

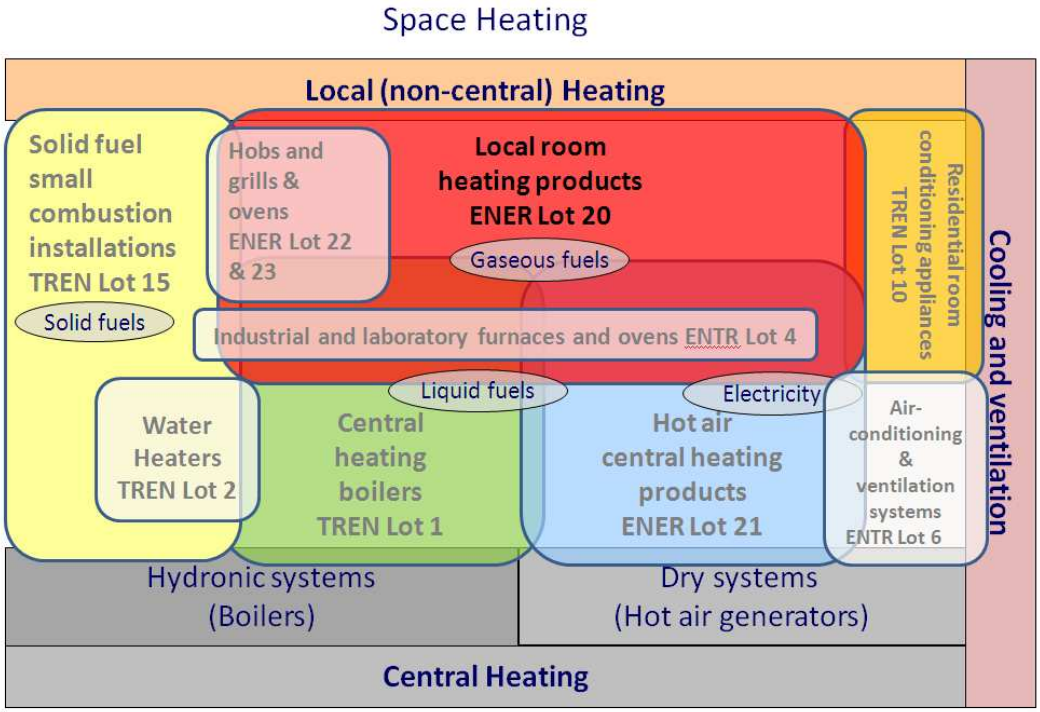

Figure 1.1: The interfaces and differences in scope of the Ecodesign preparatory studies compared to central heating products studied under ENER Lot 21

The work in the other preparatory studies is followed closely throughout this study. In close collaboration with DG ENER and DG ENTR, stakeholders and the other partners performing preparatory studies, the overlapping products will be defined and coordinated among lots to ensure no products are overlooked.

1.1.2 Definitions

An overview of the existing product categories commonly used to classify central heating systems covered by the ENER Lot 21 study will be the first step for elaborating the relevant product definitions. Possible definitions are derived from market statistics (Eurostat/PRODCOM[8]), technical standards (EN/ISO/IEC), and labelling schemes (Energy Star, etc.) and are compiled for a comparative analysis that will serve as a reference.

The second step is an assessment of additional criteria (technical, functional, design, market based criteria, etc.) which allows the scope of this preparatory study to be defined in a precise manner and complements the elaboration of the product definitions for the purpose of this study. The analysis of the technical and functional parameters and expected environmental impacts of typical products provides the input for determining the functional unit.

[8] PRODCOM Classification: List of PRODucts of the European COMmunity

Finally, an assessment of the product-system interactions from a broader perspective will identify whether key parameters of the system can influence the environmental impacts and improvement potential of the products.

1.1.3 Criteria for defining the scope

Central heating products that use hot air to distribute heat encompass a range of products, which can be broadly categorised according to their fuel type, end-user, and the functions they perform:

- Functions: heating only, or heating and ventilation, which may be combined with filtering and/or humidification of the air
- Means of heat generation and source of energy: electricity, gas, oil, solid fuels, or fuel mixture
- End-user: domestic, commercial or industrial

Other considerations, which may be important in the classification include:

- Power output capacity and equipment size
- The PRODCOM classification of the appliances
- Classifications employed by standard organisations (such as EN or ISO standards)

Each parameter taken individually may not provide enough information on the appliances to develop a relevant classification. For instance, the source of energy used is a key parameter for determining the environmental impacts of the combustion appliance, but it cannot be the only parameter used to classify appliances as one given appliance can be fed by different types of fuels and as the functionally of appliances fed by the same fuel can be very different. Consequently, paying attention to all relevant parameters will be of key importance for the next tasks in this study, in particular for defining the Base-Cases.

1.1.3.1 Functionality

Air-based central heating products are distinguished as indirect heating appliances that produce warm air at a central location and then distribute it throughout the building. This means that these products are actually a system of connected products such as furnaces, heat pumps, air handling units, fan coils, humidifiers, air filters, ducts and vents. A furnace is an appliance that provides heated air through ductwork to the space being heated. It is equipped with a blower to circulate air through the duct distribution system. A typical gas or oiled-fired furnace has the following basic components: cabinet or casing, heat exchanger(s), combustion system including burners and controls, forced draft blower or draft hood, and air filter and other accessories.

Figure 1.2 shows an example of how these products might work together (the configuration and installation of these systems may vary). These products may be integrated or "packaged" in one unit (a so-called air handling unit) or be individual components (e.g. heat exchangers, ventilator fans, filters, etc.) that are installed together.

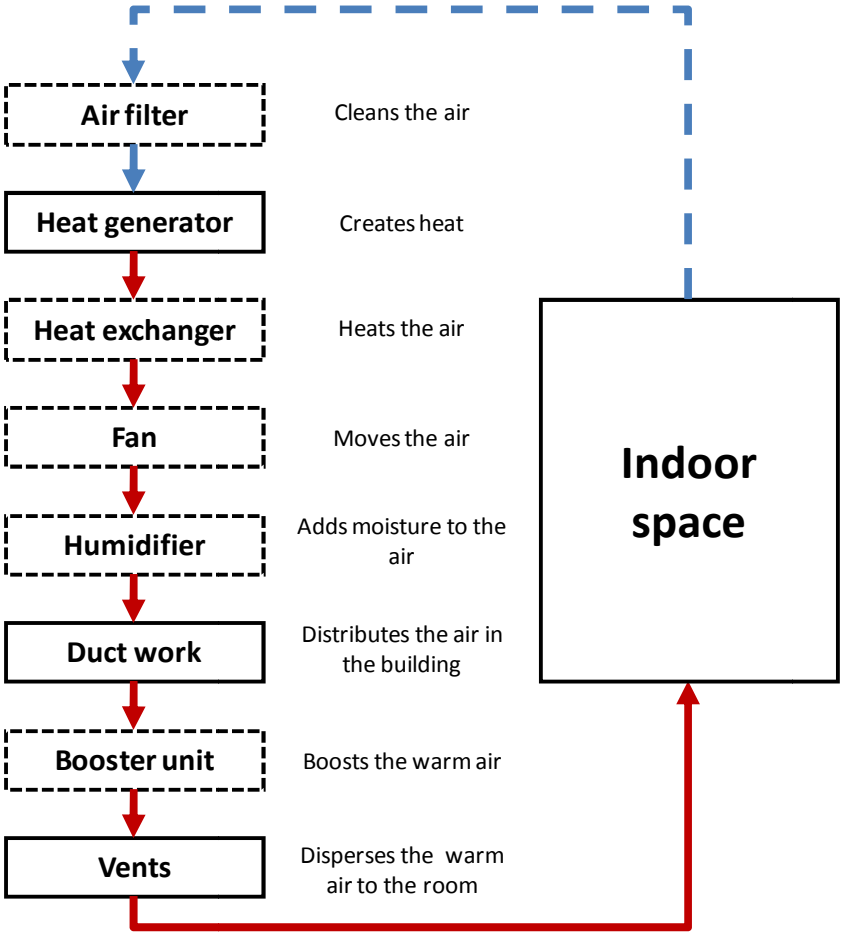

Figure 1.2: A simplified functional schematic of an air-based central heating system (the dashed lines indicate optional functional units)

This system also allows cooling and ventilation appliances to be connected in order to provide cooling capacity and/or additional ventilation. Heat pumps for instance are already capable of providing both heat and cooling. Air-based central heating products can also be combined with water heaters (e.g. the furnace or heat pump also heats up water) and hydronic systems (e.g. steam or hot water pipes are used in coils to heat the air (fan coils)), but these types of systems are considered out of scope as they do not use air to distribute heat.

Other products that are functionally related to air-based central heating products:

- **Heat pumps (Reversible air-conditioners)**

These products are capable of providing both cold and heat, which makes them versatile for providing thermal comfort indoors. Heat pumps below 12 kW cooling power are covered in ENER Lot 10 (Room air conditioning appliances). Heat pumps can be classified according to the heat source (e.g. air, water, and ground) and to the medium which they transfer heat to (e.g. air, water, and brine). Heat pumps that heat water are considered in ENER Lot 1 (Boilers) and Lot 2 (Water heaters). Large heat pumps (above 12 kW cooling capacity) are covered in the ENTR Lot 6 study on "Air-conditioning and ventilation systems" from a cooling perspective, but they will also be considered in this study from a heating perspective (see Table 1.1).

Table 1.1: Overview of air-based heating and cooling appliances covered in other studies

Preparatory study	Heat pumps	Air handling units
ENER Lot 1 (Boilers)	Air/Brine/Ground-source/Water–to–Water	Not considered
ENER Lot 10 (Room air conditioning appliances)	Air–to–Air ≤ 12 kW cooling capacity	Residential fans for: decentralised mechanical ventilation (electric power < 125 W) centralised ventilation (electric power > 125 W)
ENER Lot 11 (Fans for ventilation in non-residential buildings)	Not considered (fans used in heat pumps are affected)	Non-residential ventilation fans (125 W < electric power < 500 kW (ventilation only)
ENTR Lot 6 (Air conditioning and ventilations systems)	Air-to-Air, Air–to–Water, Water–to–Air, Water–to–Water > 12 kW cooling capacity from a cooling and heating perspective	AHU from ventilation perspective
ENER Lot 20 (Local room heating products)	Not covered	Industrial unit heaters that heat large single spaces
ENER Lot 21 (Central heating products that use hot air)	Air/Brine/Water/Ground-source–to–Air from a heating perspective > 12kW cooling capacity	AHU as part of warm air distribution system

- **Boilers for hydronic central heating systems and water heaters**

Boilers are heating products but use water to distribute heat. These products were studied in the lots: ENER Lot 1 and ENER Lot 2. Heat pumps that first transfer heat to water and then warm up air are considered hydronic systems. However, the 'systems approach'[9] taken in the preparatory studies to analyse water-based central heating products are very relevant to this study.

[9] A 'system approach' relates to the technical analysis done in the preparatory studies where the products are modelled and analysed from a systems perspective in order to understand where the greatest energy efficiency improvement potentials are. Only after the technical analysis is performed, will a decision be made on whether any Implementing Measures will focus on individual products or systems.

- **Ventilation systems**

As can be seen in Figure 1.2, ventilator fans are a part of most air-based central heating systems (i.e. fan-forced systems) in order to move the hot air. Ventilator fans for residential and industrial uses have already been covered in ENER Lot 10 and 11. Ventilation systems, such as air handling units (AHU) are not part of the scope of this study, but can be used as part of the warm air distribution systems. The ENTR Lot 6 study on air-conditioning and ventilation systems will consider the ventilation function of AHU.

- **Air-based or (fan-assisted) convection local room heating products**

These decentralised products are covered in ENER Lot 20 as they provide direct heating to space. Unlike central heating products they do not require ducts to distribute hot air to several different locations in a building (decentralised heating). Large industrial convective unit heaters are considered in ENER Lot 20 even though they can be connected to a duct system or make use of short ducts, e.g. to connect an outdoor unit to the inside of a building. Industrial unit heaters are in this way similar to the warm air heaters considered in this study, the difference being their application to heat single (large) spaces (ENER Lot 20) or multiple spaces (ENER Lot 21).

- **Solid fuel central heating systems**

Air-based central heating systems can also be powered by solid fuels, such as wood, coal, pellets, corn, etc., but as furnaces and stoves up to 500 kW were covered in ENER Lot 15 (Small combustion installations) these are not considered in this lot. Solid fuel furnaces beyond 500 kW are not common for air-based central heating as they are primary used for industrial purposes.

- **Industrial furnaces and ovens**

Industrial furnaces and ovens are investigated in the ENTR Lot 4 preparatory study. Although they are heating products their primary function is not to heat space, but to provide heat for industrial processes. However in commercial buildings and industrial plants exhaust air from heat producing equipment (such as ovens and furnaces) can be used as a heat source for central heating systems using heat recovery heat exchangers or heat pumps.

- **Combined heat and power (CHP)**

CHP is the simultaneous generation of usable heat and power (usually electricity) in a single process. CHP systems can vary in size ranging from large power plants to micro (5 kW) CHP systems for single households. Larger CHP systems primarily produce electricity with heat as a by-product, whilst smaller systems for houses and larger buildings are used primarily for their heat, and the extra electricity produced that is not used can be sold back to the electricity grid. According to the terms of reference for this study, CHP systems are outside the scope.

Besides the above mentioned functionalities, air-based central heating products can also provide secondary functionalities, such as air purifying, dehumidification, humidification, and exist as individual components or products:

- **Air purifiers** (also known as air filters or air cleaners) are devices that remove contaminants, often solid particulates such as dust, pollen, mould, and bacteria from the air. Although they do not have a heating function, they can be an

important part of air-based central heating systems in ensuring a healthy indoor climate.

- **Dehumidifiers** draw moisture from the air by condensing it over a refrigerated coil and then returning reheated dry air. They are used in domestic households, construction sites and for industrial purposes first and foremost to reduce the level of humidity in the air. Dehumidifiers have a slight space heating effect, but heating is not their primary function.
- **Steam humidifiers** or vaporisers boil water and releases warm steam into the room to add moisture to the air. Again, although they possess a space heating function, it is not their primary function.

Air purifiers, humidifiers and dehumidifiers for residential use were considered in the ENER Lot 10 study regarding room conditioning appliances but subsequently delimited from the preparatory study. These functions should be considered in the performance parameters for the products in this study, but as products on their own do not legitimate their own specific categories. Table 1.2 below characterises the functionalities of the central heating appliances considered in this study.

Table 1.2: Central heating appliances, primary, secondary and additional functionalities

Heat distribution	Gravity	Fan-forced				
Function	Warm air heater	Direct-fired warm air heater	Indirect-fired warm air heater	Air handling unit	Electric warm air heater	Heat pump
To provide heat indoors	P	P	P	S	P	P
To provide cooling indoors				S		P
To increase humidity indoors	A	S	A	A	A	A
To decrease humidity indoors	A	A	A	A	A	A
To provide ventilation	A	S	S	P	S	S
To filter the air indoors	A	A	A	A	A	A
To provide hot air directly to indoor space (without ductwork)	S	S	S		S	P & S

P = primary function, S = secondary function, A = additional function

1.1.3.2 *Energy source*

Central heating products use a variety of energy sources to produce heat. Some heating products are able to use multiple fuels, but most products are defined by their primary energy source. The preparatory study for ENER Lot 15 (Solid fuel small combustion installations) covers all the solid fuels such as traditional mineral fuels (coal of various ranks, lignite), manufactured solid mineral fuels (coke, manufactured mineral fuel briquettes or ovoids), peat and biomass (woods, straw,

charcoal, other solid biomass) for appliances up to heating capacity of 500 kW. Although solid fuel warm air heaters for space heating do exist in North America, they are not common in Europe, and certainly not beyond 500 kW. Solid fuel heating products are therefore not considered any further in this study.

This study will cover the remaining energy sources relevant to air-based central heating products. These are:

- **Gas** (e.g., natural gas, propane, propane/liquid petroleum gas (LPG), biogas etc.)
- **Liquid fuels** (e.g., heating oil, diesel, paraffin/kerosene,)
- **Electric** (e.g., mains or household power (230 V) or three-phase electricity (400 V))

Gas and liquid fuel generate heat from combustion, whilst electrical appliances convert electrical energy into heat. Heat pumps are also electric but use (outside or exhaust) air, water or the ground as a heat source.

1.1.3.3 Application area

Although common in homes in North America, air-based central heating products are predominantly used in large commercial and public buildings in Europe. Air-based central heating systems are however also used for industrial and agricultural purposes. As air-based heating systems are able to heat up large spaces quickly they are suitable for indoor spaces that do not need to be heated all the time.

In Europe, air-based central heating systems are used in public places such as sport halls, malls, supermarkets and Do-It-Yourself (DIY) markets. In the industrial sector air-based central heating systems are used in garages, workshops, paint shops, production facilities and warehouses as these systems can provide a decent indoor climate ensuring fresh air, ventilation, air purification, humidification or dehumidification. Air-based central heating systems are also used in greenhouses and for drying crops. Many manufacturers in North America classify air-based central heating products on the basis of residential, commercial and industrial applications. The US Department of Energy (DoE) classifies furnaces for residential use as the ones having a heat input rate of less than 225,000 BTU/h (66 kW), but furnaces of this size can however also be used for commercial applications.

In general central heating products that use hot air to distribute heat can be used to:

- Provide comfortable heat to human beings and/or animals
- Keep objects and indoor spaces warm and dry
- Provide both above functionalities

The hot air can also be used as an air door or air curtain to create an air seal that separates different climatic environments, e.g. store entrances. While allowing unhindered and unobstructed passage through openings, air doors help preserve the indoor temperature by forming a barrier to resist the ingress of cold air. Although air doors do contribute to the heating

of space, their primary function is a thermal replacement for a door. Air curtains can be stand alone products (like local room heaters they generate heat in the same place as it is delivered), or they can be connected to the central heating system in commercial buildings. Air doors/curtains are specifically addressed in ENER Lot 20.

1.1.3.4 *Heating capacity*

Air-based central heating products can be classified according to their heating capacity, which is the ability of the appliance to add heat to an indoor space. Air heated central heating products generally range in heating capacity between 10 kW (≈35,000 BTU/h) to 300 kW (≈1,000,000 BTU/h), but some heat generators included within air handling units are producing up to 1200 kW heat. The capacity ranges shown in Figure 1.3 are indicative and the boundaries are not always absolute. In general, lower capacity appliances are mostly used in the residential sector. The middle capacity range of warm air heaters can be found in commercial, larger residential and institutional buildings. The upper range is largely used in the industry sector.

In the case of heat pumps, in the residential sector the capacities installed are usually below 12 kW. In the commercial and services sectors systems may combine several modules and reach up to 400 kW.

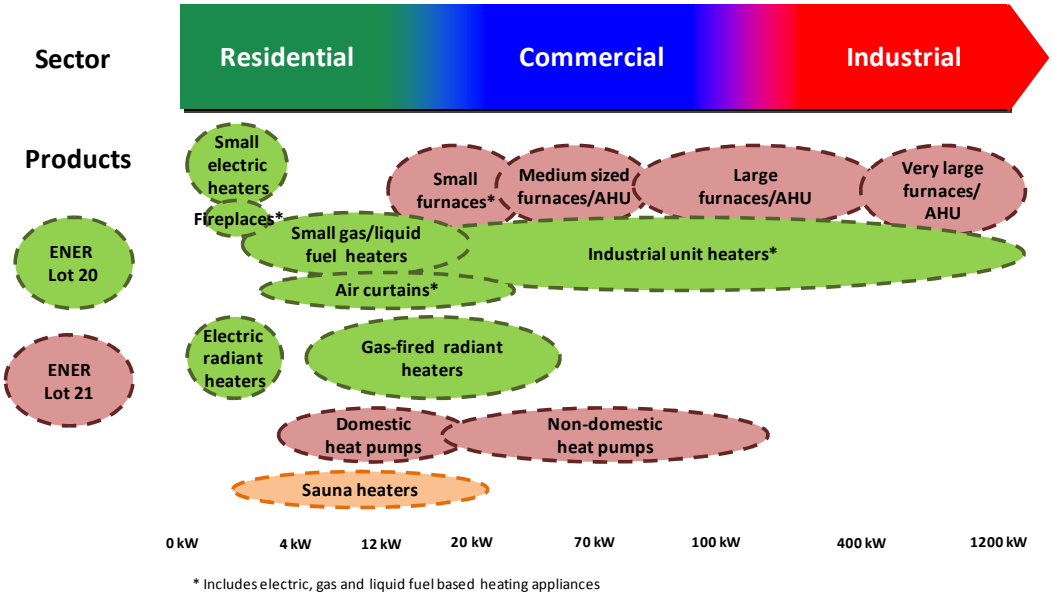

Figure 1.3: Range of uses and sizes of ENER Lot 21 and ENER Lot 20 appliances

The energy input required heating an indoor space or building depends on a variety of parameters such as:

- The local climate
- Size, shape, and orientation of the building
- Insulation levels
- Window area, location, and type

- Air infiltration rates
- The number and ages of occupants
- Occupant comfort preferences
- The types and efficiencies of lights and major energy using equipment

There are various modelling and calculation methods available to determine the heat loss (difference in temperature inside and out, ventilation, building insulation, etc.) or heat gain (solar heat, people, equipment use, etc.) for buildings. Often manufacturers or contractors will configure and design the heating system to fit the individual needs of the building and its users. For air-conditioning and ventilation systems the cooling capacity and the air flow rate are the key parameters for sizing a system for a building.

1.1.3.5 *Types of heating systems*

There are three general types of HVAC systems based on their configuration where outdoor installations are termed "weatherized", whilst indoor installations are called "non-weatherized" in the USA:

- **Split systems** have an indoor unit and outdoor unit connected only by a pipe system that transfers the heat or cooling by means of a refrigerant fluid in a closed loop. The indoor unit includes the evaporator and a fan, while the outdoor unit has a compressor and a condenser. Split systems can be ducted or non-ducted.

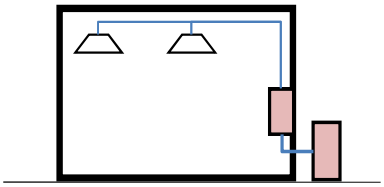

Figure 1.4: Simplified schematic of a split system

- **Packaged systems** are self-contained units that host both the heating-cooling and ventilation units. Packaged systems range from small units for single residential houses (3 kW) to huge installations either placed on the roof or ground outside (300 kW). Small packaged units can be duct free, but otherwise they are connected to ductwork to distribute warm (or cold) air around the building.

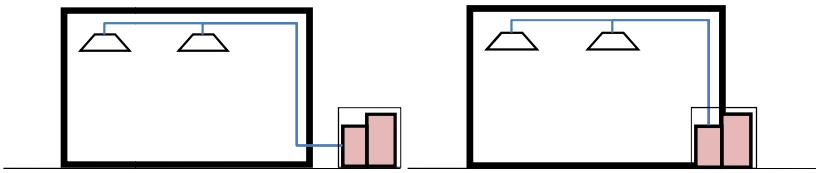

Figure 1.5: Schematics of packaged systems: the entire unit is placed outside (left) and through the wall (right)

- **Hybrid systems** are systems where a heat pump and a warm air heater are connected to support each other in cold weather as both appliances are capable of providing heat. This type of system is more energy efficient as the heat pump and warm air heater can complement each other throughout a range of different heat loads. Hybrid systems can be split or packaged.

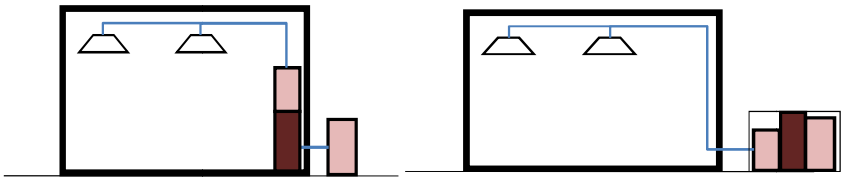

Figure 1.6: Schematics of hybrid systems with a heat pump and warm air heater working together: a split hybrid system (left) and a packaged hybrid system (right)

1.1.3.6 Types of heat distribution

Hot air for central heating can be distributed through two main types of systems:

- **Gravity systems**

  Some (usually older) systems circulate hot air passively, by gravity, using the convection currents, whereby the hot air rises and is carried through the system. Gravity central heating is however no longer common. Most systems today use fans to force the flow of air throughout the building.

- **Forced-air heating systems**

  Forced-air heating is the most common form of central heating used in domestic houses in North America, but it is much less common in houses in Europe. It is however often used to heat offices, industrial buildings, commercial centres, etc. in cold and temperate climates all over the world. In forced-air heating systems a blower or fan draws cold air in and pushes it through the system. Ductwork carries the air (from the outside or from return vents inside the building) to a heat generator (i.e. warm air heater, heat pump, heat exchanger, etc.), where the air is heated and then blown back through ducts to the rest of the building (see Figure 1.7).

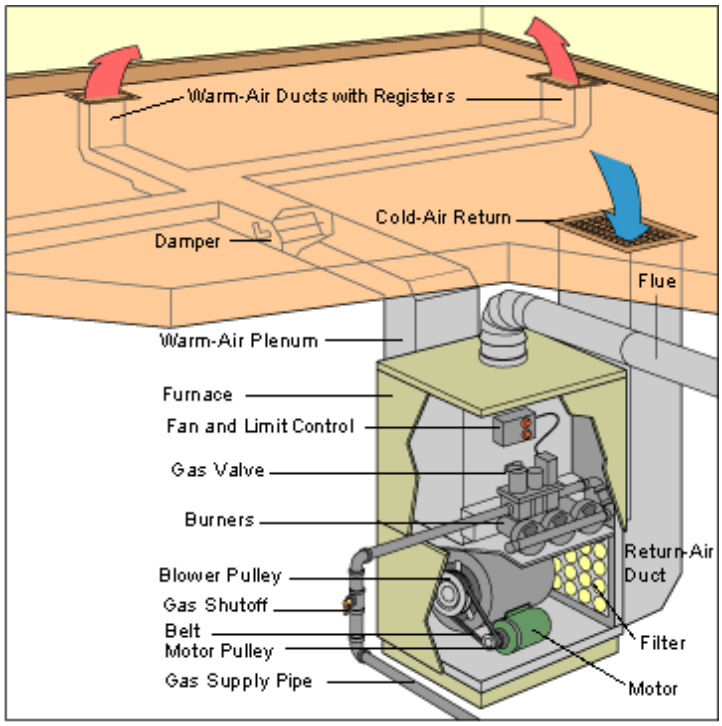

Figure 1.7: Typical forced-air central heating system[10]

Alternatively to the systems described above, which rely entirely on hot air to distribute heat, some combined systems may be used. For example, a central heating boiler (e.g. wood, coal, fuel, gas) heats hot water, which is then passed through a heat exchanger (i.e. heat coils) to heat air in an air handling unit. The hot air is then distributed throughout the building. However, such heat distribution systems do not fall within the scope of this study, given their reliance on a hydronic system for distributing heat (which is covered in ENER Lot 1).

1.1.3.7 *Types of warm air central heating products*

There are several types of air heating equipment that can be used for central heating: warm air furnaces based on combustion (direct-fired or indirect-fired); electric air heaters or furnaces; and, heat pumps (electric or gas-fired). Often these products are combined with other ventilation and air conditioning components to form air handling units (AHU). A general description of these types of central heating products are provided in the following. Although out of scope of this study combined heat and power (CHP) systems are also briefly mentioned.

- **Direct-fired warm air heating**

In direct-fired warm air heaters, combustion occurs directly in the inlet ventilation air stream, resulting in 100% combustion efficiency (net calorific value). Direct-fired warm air heating discharges the products of combustion, including flue gases, into the surrounding space. Although the combustion products in the airflow are safe for indoor use, the air tends to be damp and is therefore only possible in situations where there is good ventilation. Direct-fired heaters are often used for heating up supply air (make up air) from the outside to indoors areas that need

[10] Clean Air Ducts Inc. Our home page. Available at : http://www.clean-air-ducts.com

frequent air change, such as commercial kitchens, factories, paint booths, etc. Direct-fired heating equipment burns natural gas or propane directly in the fresh air stream (Figure 1.8) resulting in the most efficient method of heat transfer. Direct-fired heaters generate the lowest cost per kW of heating when compared to indirect-fired and electric strip heaters.

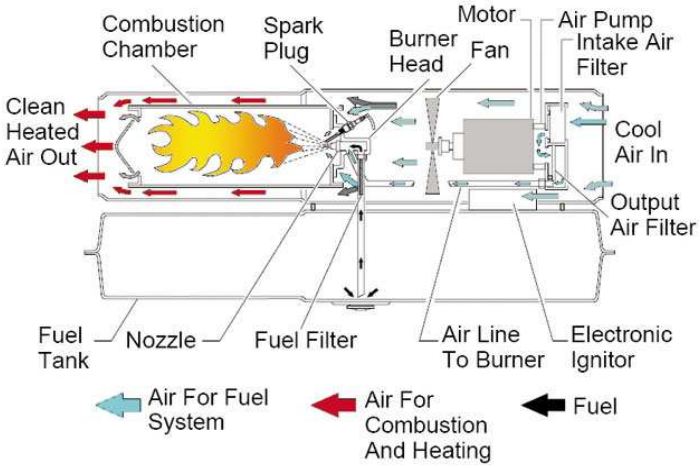

Figure 1.8: Schematic of a typical direct-fired hot air heating appliance

Some of the major benefits for using direct-fired heating include energy efficiency, heating flexibility, and durability. Direct-fired heating is over 90% efficient as a heating process (compared to indirect-fired heating equipments which are typically 70% thermally efficient) and a flue is not required. Intelligent flame monitoring equipment can ensure that the airflow through the burner and gas flow to the burner are optimised to produce the most efficient and clean combustion process. Direct-fired systems tend to have a long life compared to indirect-fired systems that use a heat exchanger that can break down and needs to be replaced over time. Direct-fired systems are easy to maintain and therefore operate well for many years.

- **Indirect-fired warm air heating**

Indirect-fired warm air heaters have a sealed combustion chamber in which all products of combustion are discharged through a flue to the outside. The heat from the combustion is transferred to the circulating air through a heat exchanger. This means that there are two entirely separate air flows: the combustion path supplies air to the burner and to the draft hood and carries hot combustion gases through the burner, heat exchanger and flue pipe to the vent and out of the house; the heat distribution and cold air return path circulates and heats the air inside the building –either directly from the unit or ducted into the rooms. Both floor standing and suspended units are available.

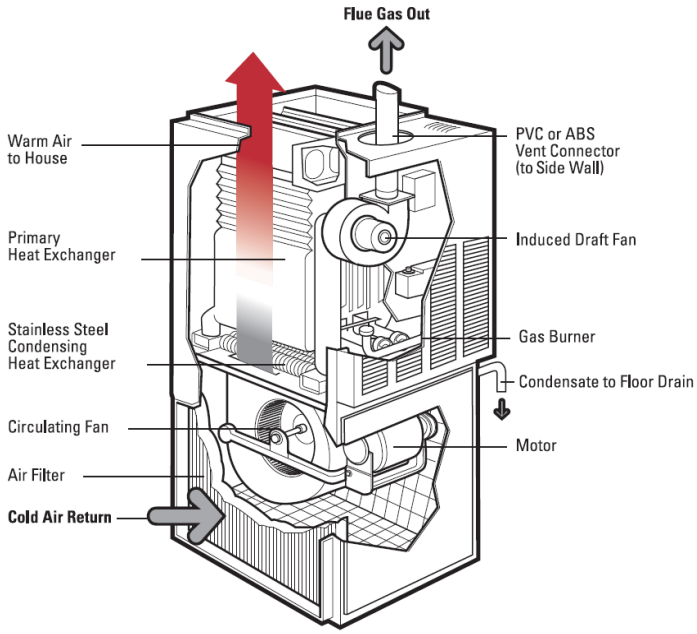

Figure 1.9: A indirect fired gas warm air heater where the combustion gases pass through a heat exchanger before being discharged through a the flue pipe[11]

Indirect-fired warm air heaters can be fuelled by natural gas, propane (LPG), oil, coal, wood or a mix of these energy sources. Today, most indirect-fired warm air heaters are condensing, i.e. they condense the water vapour in the combustion gases in order to recover the heat that would otherwise be lost and use it for space heating. Condensing warm air heaters are more energy efficient than non-condensing warm air heaters (see Table 1.3).

Table 1.3: Condensing and non-condensing warm air heater types

Condensing warm air heater	Non-condensing warm air heater
Recovers more heat from the combustion products by condensing the water vapour	Flue temperature is higher than the water dew point and the latent heat is lost in the flue
Additional plastic through-the-wall venting systems typically used in conjunction with regular chimney	Vented through roof or wall

- Gas and liquid fuel indirect-fired heating appliances

  A conventional natural-gas-fired, forced-air heating system is shown in Figure 1.10, and is similar in principle to oil or propane heaters. This system consists of a heater with a naturally aspirating gas burner.

[11] Natural Resources Canada's Office of Energy Efficiency (2004) EnerGuide, Heating With Gas. Available at : oee.rncan.gc.ca/publications/infosource/pub/home/Heating_With_Gas.pdf

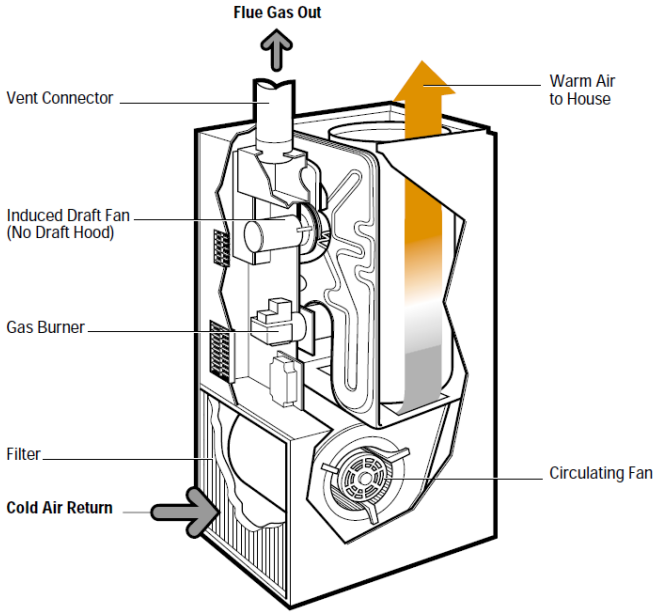

Figure 1.10: Typical gas indirect-fired, warm-air heater[12]

The combustion gases pass through the warm air heater, where they pass heat across a heat exchanger and are exhausted to the outside through a flue pipe and vent. A draft hood serves to isolate the burner from outside pressure fluctuations at the vent exit by pulling varying quantities of heated house air into the exhaust as required. A circulating fan passes cooled house air from the return ducts over the warm air heater heat exchanger, where the air is warmed up and passed into the ductwork that distributes the heated air around the house. The efficiency of the system can be improved in several ways, for instance by adding a vent damper in the flue exhaust. This enables to close the vent during the off-cycle and prevents some of the warm household air from being drawn up the chimney and lost to the outdoors.

- Solid fuel indirect-fired heating appliances

The traditional wood or coal indirect-fired warm air heater burns wood or coal in a sealed firebox to heat a heat exchanger (Figure 1.11). The basic components of this type of appliances include the cabinet or jacket, firebox, blower, access doors for stoking and cleaning, and a small blower to fan the fire when more heat is needed. Accessories for a wood warm air heater can include: electronic air cleaner, high performance media filter, humidifier, evaporator coil for central air, and a coil to make domestic hot water. Sometimes a condensate pump will be used to dispose of the water produced by the dehumidifying action of the air conditioning. Due to high temperatures in the supply plenum, extra precautions must be taken with regard to air conditioning, evaporator coils, as well as ductwork clearance from combustibles. Proper sizing of a wood warm air heater and air distribution are very important for comfort and performance, therefore power output and blower size should be assessed. Complete automatic start and stop blower systems are now available, as well as automatic draft systems with high limit control and filter systems.

[12] Natural Resources Canada's Office of Energy Efficiency (2004) EnerGuide, Heating With Gas. Available at : oee.rncan.gc.ca/publications/infosource/pub/home/Heating_With_Gas.pdf

Figure 1.11: Solid fuel indirect-fired warm air central heating appliance [United States Stove Company]

- Indirect-fired multi-fuel air heating appliances

  Two separate burners – one for wood or coal and one for oil – enable one to choose between burning oil as the primary fuel or setting up the system to burn oil only as a backup, in case the fire burns out. The oil burner fires into a separate combustion chamber, so that the oil nozzle will not clog from the soot from wood or coal fires.

Figure 1.12: Multi-fuel indirect-fired warm air central heating appliance [Yukon Eagle]

As mentioned earlier, solid fuel combustion furnaces less than 500 kW have already been investigated in ENER Lot 15.

- **Electrical warm air heaters**

An electrical warm air heater generates heat through an array of electric resistance coils, each of which are typically rated at 5 kW. Electricity flowing through the coils generates heat that is distributed throughout the building by a fan or blower which forces air through the elements, and directs the heated air into the ductwork (Figure 1.13). The warm air heater's heating elements activate in stages to avoid overloading the building's electrical system. A built-in thermostat called a limit controller prevents overheating. This limit controller may shut the warm air heater off if the blower fails or if a dirty filter is blocking the airflow.

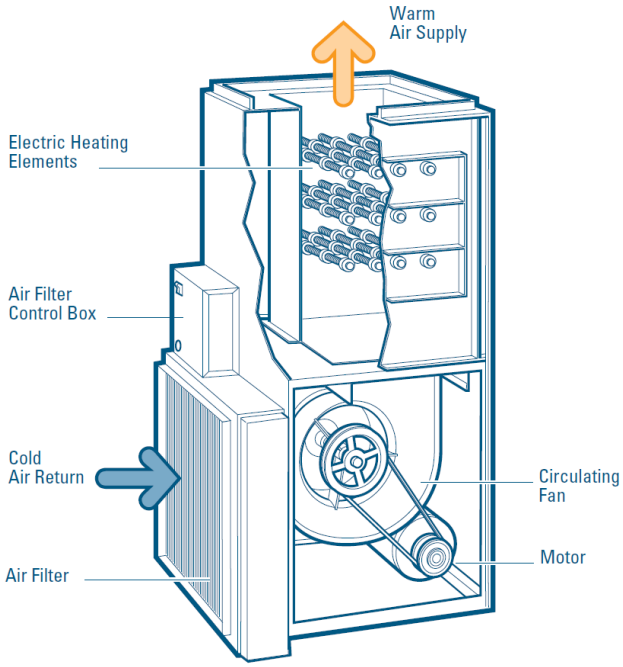

Figure 1.13: A typical electric indirect-fired force-air heating appliance[13]

Electric resistance heating converts nearly 100% of the electrical energy in to heat. However, electric forced-air heating appliances are less efficient to operate than other electric resistance systems because of their duct heat losses (through radiation and convection from the duct's surface) and the extra energy required to distribute the heated air throughout the building.

Electric forced-air systems can be coupled with air-to-air heat pumps or central air-conditioners to provide thermal comfort all year round. Electric hot air plenums can also be added to forced-air systems to boost capacity or create dual-energy systems. The plenum heater, consisting of one or more heating coils, is placed in the hot air plenum of the heating system (the plenum is that part of the ductwork immediately downstream from the warm air heater). Finally, wood or oil warm air heaters can also be fitted with electric heating elements to form combined wood-electric or oil-electric combination warm air heaters.

- **Heat pumps**

Air-to-air heat pumps extract heat from the air and transfer that heat to either the inside or outside of the building, depending on the needs of the indoor space. Heat pumps therefore can supply both heating and cooling. They use a refrigerant that is pumped in a closed circuit of outdoor and indoor units to transfer heat (Figure 1.14). First, the liquid refrigerant passes through the expansion device, changing to a low-pressure liquid/vapour mixture. It then goes to the outdoor coil, which acts as the evaporator coil. The liquid refrigerant absorbs heat from the outdoor air and boils, becoming a low-temperature vapour. This vapour passes through the reversing valve to the accumulator, which collects any remaining liquid before the vapour enters the compressor. The vapour is then compressed, reducing its volume and causing it to heat up. Finally, the reversing valve sends the gas, which is now hot, to the indoor coil, which is the

[13] Natural Resources, Canada's Office of Energy Efficiency (2004) EnerGuide, Heating With Electricity. Available at : http://oee.rncan.gc.ca/publications/infosource/pub/home/Heating_With_Electricity.pdf

condenser. The heat from the hot gas is transferred to the indoor air, causing the refrigerant to condense into a liquid. This liquid returns to the expansion device and the cycle is repeated. The indoor coil is located in the ductwork, or close to the warm air heater, if it is a hybrid system.

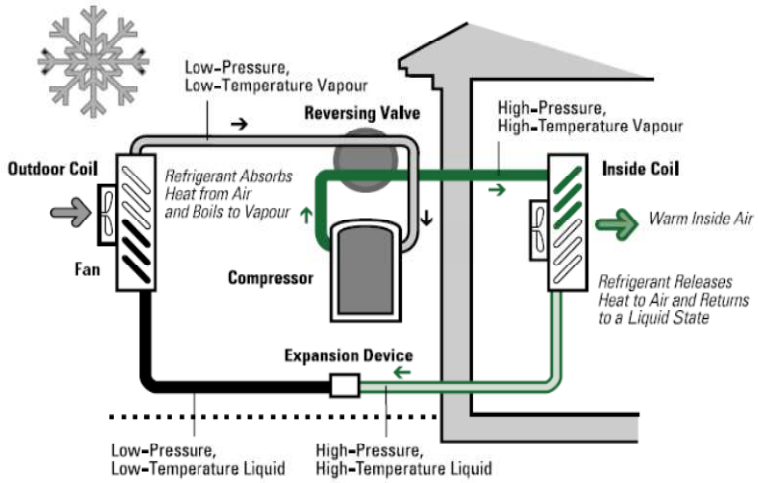

Figure 1.14: Components of an air-to-air heat pump[14]

Heat pumps are defined by their heat source and can use ambient air, water (also known as water-to-air, water-loop or water-source heat pumps), brine or the ground as a heat source. Air-to-air heat pumps can be add-on, all-electric or bivalent. Add-on heat pumps are designed to be used with another source of supplementary heat, such as an oil, gas or electric heater. All-electric air-to-air heat pumps come equipped with their own supplementary heating system in the form of electric-resistance heaters. Bivalent heat pumps are a special type, developed in Canada, that use a gas or propane fired burner to increase the temperature of the air entering the outdoor coil. This allows these units to operate at lower outdoor temperatures.

When the heat pump is operating in the heating mode without any supplementary heat, the air delivered inside will be cooler than air heated by a normal furnace. Warm air heaters generally deliver air to the living space at between 55°C and 60°C. Heat pumps provide air in larger quantities at about 25°C to 45°C and tend to operate for longer periods. The ability of the heat pump to transfer heat from the outside air to the house depends on the outdoor temperature. As this temperature drops, the ability of the heat pump to absorb heat from this cooler air also drops. The coefficient of performance (COP) of heat pumps is a measure of energy efficiency. It is says how many kW of heat is transferred for every kW of electricity (or gas) supplied to the heat pump. The COP depends on the input and output temperature, configuration and efficiency of the product, refrigerant used, etc. The COP, however, is a performance parameter measured at "one point", whereas the seasonal efficiency (SEER, SCOP, etc.) is more accurate to measure the performance of heat pumps in real working conditions. The energy costs of the heat provided by a heat pump can be lower than those of other heating systems, particularly electric or oil heating systems. By running a heat pump, less gas or oil will be used, but more electricity.

[14] Natural Resources, Canada's Office of Energy Efficiency (2004) EnerGuide, Heating and Cooling With a Heat Pump. Available at : http://oee.nrcan.gc.ca/publications/infosource/pub/home/heating-heat-pump/booklet.pdf

Heat pumps can also be driven by a gas engine instead of an electric motor. In this case, the gas engine is used to run the refrigerant compressor. The heat generated by the gas engine can also be recovered for indoor heating purposes.

Depending on the configuration of the heat pump, different types of heat pumps can be defined:

- **Packaged/rooftop**: a single body contains the evaporator and the condenser, as well as the compressor and the rest of the accessories needed for the functioning of the heat pump. It is usually installed in the outer part of a wall and can be connected to ducts in order to distribute the warm air in the indoor space.
- **Single split**: the evaporator and the condenser are installed separately in one indoor unit and one outdoor unit connected by one circuit of refrigerant pipes. The compressor, expansion valve, liquid receiver, etc., are usually contained within the outdoor unit.
- **Multi split**: several indoor units are connected to one or more outdoor units by refrigerant pipes. As in the case of single split, the indoor units and the outdoor units contain heat exchangers and fans. The compressor, expansion valves and other components are installed within the outdoor units.
- **Variable Refrigerant Flow (VRF)**: several indoor units connected to one or more outdoor unit(s) by refrigerant pipes. Unlike in the case of multi split heat pumps, each indoor unit can be operated independently, either in cooling or heating mode. As a result, VRF heat pumps have a more complex construction and several additional components.

Air Handling Units (AHU)

Air handling unit (AHU) is a general term used to describe factory made encased assemblies of HVAC equipment that provide ventilation to indoor spaces[15]. The typical main functions of an AHU include air supply, air filtration, heat recovery and exhaust air. Figure 1.15 shows an example of a basic AHU. Additionally an AHU can be equipped to perform secondary functions such as heating, cooling, circulation, humidification, dehumidification, etc. Warm air furnaces or heat pumps, such as those mentioned above, can be integrated into AHUs to provide warm air.

It is common for AHUs to provide heating or cooling as secondary function, not directly by the unit itself, but from a generator, integrated or independent of the product. Therefore, as the primary function of an AHU is to provide ventilation, this type of product will not be covered in this study. AHU's are covered by the ENTR Lot 6 study on air-conditioning and ventilation systems.

[15] ARMINES, VHK & BRE (2010) Preparatory study, Lot 6 (Air-conditioning and ventilation systems), Draft report of Task 1. Study commissioned by the European Commission - DG ENTR.

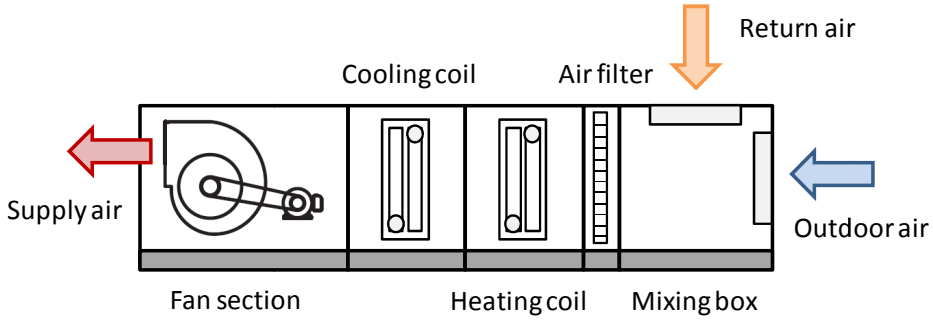

Figure 1.15: An example of a configuration of an air handling unit

- **Combined Heat and Power**

Combined heat and power (CHP) systems generate both electricity and heating for buildings. CHPs can be based on several different technologies, e.g. internal combustion engines, Stirling engines, micro-turbines, fuel cells, etc. Some types of CHP systems can be connected to air-based central heating systems where the heat from the power generator is transferred via a heat exchanger to the forced-air system. Although CHP products are beyond the scope of this study, they are mentioned here to clarify the interface with this product type, but they will not be investigated in detail as with the other product types.

Figure 1.16: A warm-air micro combined heat and power system [Honda]

Table 1.6 provides a full overview of central heating products that use hot air to distribute heat, which have been identified in this study.

1.1.3.8 Control systems

Control systems are one of the most important components of central heating systems. The better the controls, the less wear and tear on the heating system. Most central heating systems are equipped with additional control functions, such as time switches, zone controlling, programmers or room thermostats.

- A time switch (clock) allows to switch the whole central heating system on or off as required.

- In a central air-based heating system, zone controlling involves placing dampers in duct passages and hence regulating the temperatures of individual rooms using separate thermostats in different areas of the house. For heat pumps, Variable Refrigerant Flow (VRF) systems can provide different heating (or cooling) loads to several indoor units with only one outdoor unit. Some VRF systems can even transfer heat from one area of a building to another and in this way provide both heating and cooling in a building at the same time.
- A programmer can be used to switch one, two or even three different circuits on or off at different times or even on different days. The programmer sends a signal to the cylinder and room thermostats and they then keep everything at the desired temperatures.
- Room thermostats are an integral part of all central air heating systems. Their primary function is to shut the heating circuit off, allowing the air heater (or heat pump) and system to be turned down once the space being heated has reached the desired temperature. As the air starts to cool slightly, the room thermostat switches on the heating again to maintain the set temperature.

Inverters in heat pumps use controls to monitor and match the speed of the compressors to vary according to the precise heat requirements. The heat pumps are then called VRF (Variable Refrigerant Flow) heat pumps and can be either electricity or gas-driven. Conventional heat pumps operate their compressors at a fixed speed and therefore deliver a fixed amount of heat/cooling power. As a result the compressor must continually stop and start to maintain temperature required in the room. Although more expensive to purchase, inverter heat pumps can provide heat quicker than a conventional heat pump and is also more energy efficient. In the above sections various categorisations of air-based central heating products were presented. This helps in forming an appropriate classification scheme for the Ecodesign preparatory study at hand, but before a scope and classification scheme for this study is suggested, categorisations used in international statistics and standards will be considered.

1.1.3.9 Product versus system approach

Central heating products only constitute a part of a building's heating system. To begin with air heaters, heat pumps and air handling units work together with a duct/pipe system, dampers, controls and vents. These again form a part of a building, comprising insulation, ventilation, room size, etc. Furthermore the whole heating system in the building should be adapted to the heat demand and the local climatic conditions. In order to understand the efficiency improvement potentials the whole heating system –including heat generator, distribution system, controls, internal load, building shell and climate – must be taken into consideration (see Figure 1.17). The efficiency of the individual products does not always reflect the overall efficiency of the system. This is particularly apparent when comparing test conditions with real life situations.

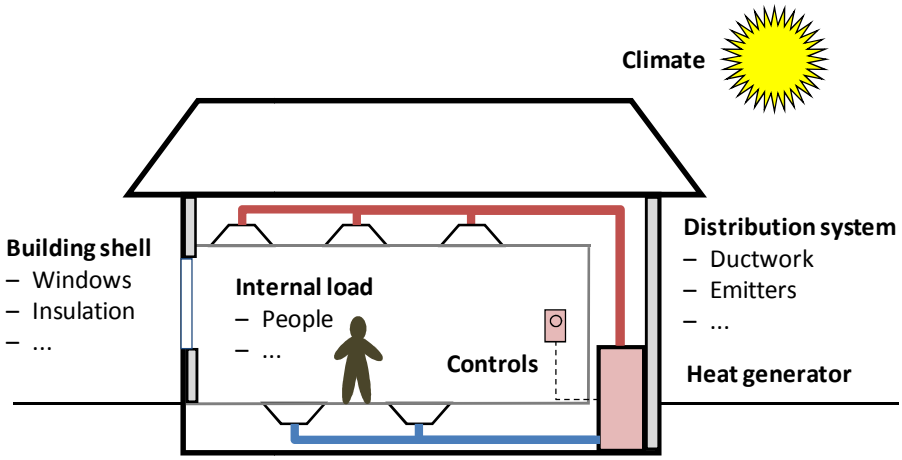

Figure 1.17: The overall heating system is more than just the heat generator

Space heating and cooling of buildings is generally assumed to be one of the most climate sensitive end-uses of energy. For example, central space heating is very strongly influenced by ambient conditions (temperature and draughts) which in turn are dependent on the user behaviour, e.g. the duration and frequency of the use of heating, the temperature at which the room is set (depending on the user's temperature preference) and the location of the room to be heated with respect to the air heater (central heating source) and exposure to ambient conditions. Most often, central space heating furnaces such as the ones based on solid and liquid fuels are indirect-fired and must be properly ventilated.

Although many of the aspects at a system level are beyond the influence of a heating appliance manufacturer, it is important to ensure that the interfaces between the appliance and the system are well designed and fit for purpose, so that they can contribute to minimising the overall environmental impacts. Following ENER Lot 1 and ENTR lot 6, the same 'extended product approach' will be used for the technical analysis of this study. Improvement potentials will be identified in relation to the efficiency of the heating systems on the whole so that results from the various central HVAC preparatory studies can be compared and combined.

It should however be noted that this system perspective does not necessarily mean that any resulting proposals for implementing measures will also be based on the entire heating system. The discussion on whether implementing measures should focus on individual products or systems will only be taken after the technical analysis has been completed.

1.1.3.10 *PRODCOM classification*

Central heating products that use hot air may fall under various PRODCOM[16] categories referring to heating appliances (Table 1.4): in NACE 27.51 *Manufacture of electric domestic appliances* (although these appear to rather cover local heating products), NACE 27.52 *Manufacture of non-electric domestic appliances*, NACE 28.21 *Manufacture of ovens, furnaces and furnace burners* but also NACE 28.25 *Manufacture of non-domestic cooling and ventilation equipment*. However, none of these cover central-heating products explicitly, and many seem to rather refer to local heating products (ENER Lot 20).

[16] PRODCOM Classification: List of PRODucts of the European COMmunity

Table 1.4: PRODCOM classification relevant for hot air central heating products

PRODCOM code	PRODCOM category
27.51.26.90	Other electric space heaters
27.52.12.33	Iron or steel gas domestic appliances with an exhaust outlet (including heaters, grates, fires and braziers, for both gas and other fuels; excluding cooking appliances and plate warmers)
27.52.12.35	Iron/steel gas domestic appliances (including heaters, grates, fires and braziers, for both gas and other fuels radiators; excluding cooking appliances and plate warmers, those with an exhaust outlet)
28.21.11.30	Furnace burners for liquid fuel
28.21.11.50	Furnace burners for solid fuel or gas (including combination burners)
28.25.12.70	Air conditioning machines not containing a refrigeration unit; central station air handling units; vav boxes and terminals, constant volume units and fan coil units
27.52.13.00	Air heaters or hot air distributors n.e.c., of iron or steel, non-electric

1.1.3.1 EN-, ISO- and other classifications used by standardisation bodies

International and European standards cover some air-based central heating products. The International Classification of Standards (ICS) classifies installation in buildings under ICS 91.140 and burners under ICS 27.060. Table 1.5 shows the ICS codes covering ENER Lot 21 products. A search under this classification did not provide any more categorisation relevant to this study. See Section 1.2.3. for more information on international standards.

Table 1.5: ICS standards for ENER Lot 21 products[17]

ICS	Field
27.060.01	Burners and boilers in general
27.060.10	Liquid and solid fuel burners
27.060.20	Gas fuel burners
27.080	Heat pumps
91.140.10	Central heating appliances including burners
91.140.30	Ventilation and air-conditioning systems
97.100.01	Heating appliances in general
97.100.10	Electric heaters
97.100.20	Gas heaters
97.100.40	Liquid fuel heaters

[17] International Organization for Standardization. ISO standards catalogue. www.iso.org/iso/iso_catalogue/catalogue_ics.htm

European standards

A number of standards at European level deal with air-based central heating products. As can be seen in Table 1.7, air-based heating products are differentiated in EN standards based on the energy source, the type of draught and heat distribution, the type of combustion, or the heating capacity.

Table 1.6 European standards relevant to ENER Lot 21 products

Type of central heating appliance	Standards
Warm air heaters: Gas-fired	EN 298 Automatic gas burner control systems for gas burners and gas burning appliances with or without fans
	EN 525: Gas-fired air heaters without heat exchangers with forced convection for heating non-domestic rooms, nominal heat input not exceeding 300 kW
	EN 613 Independent gas-fired convection heaters
	EN 621: Non-domestic gas-fired forced convection air heaters for space heating not exceeding a net heat input of 300 kW, without a fan to assist transportation of combustion air and/or combustion products
	EN 676 Automatic forced draught burners for gaseous fuels
	EN 778 Domestic gas-fired forced convection air heaters for space heating not exceeding a net heat input of 70 kW, without a fan to assist transportation of combustion air and/or combustion products
	EN 1020 Non-domestic forced convection gas-fired air heaters for space heating not exceeding a net heat input of 300 kW, incorporating a fan to assist transportation of combustion air or combustion products
	EN 1196 Gas-fired air heaters for domestic and non-domestic use - Additional requirements for condensing air heaters
	EN 1319 Domestic gas-fired forced convection air heaters for space heating, with fan-assisted burners not exceeding a net heat input of 70 kW
Warm air heaters: Oil-fired	EN 225 Atomizing oil burners. Oil burner pumps and oil burner motor. Connecting dimensions.
	EN 267 Automatic burner with blower for liquid fuels standard specifies requirements for testing, terminology, construction and operation
	EN 13842 Oil-fired air heaters. Fixed and transportable for room heating
	EN 1596 Specification for dedicated liquefied petroleum gas appliances - Mobile and portable non-domestic forced convection direct fired air heaters

Type of central heating appliance	Standards
Heat pumps	EN 378 Refrigerating systems and heat pumps – safety and environmental requirements
	EN 12102 Air conditioners, liquid chilling packages, heat pumps and dehumidifiers with electrically driven compressors for space heating and cooling - Measurement of airborne noise - Determination of the sound power level.
	EN 12309 Gas-fired absorption and adsorption air-conditioning and/or heat pump appliances with a net heat input not exceeding 70 kW
	EN 13253 Ducted air-conditioners and air-to-air heat pumps – Testing and rating for performance
	EN 14276 Pressure equipment for refrigerating systems and heat pumps - Part 1: vessels - General requirements - Part 2: piping - General requirements
	EN 14511 Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling. Part 1: Terms and definitions Part 2: Test conditions
	prEN 14825 Air conditioners, liquid chilling packages and heat pumps, with electrically compressors, for space heating and cooling- Testing and rating at part load conditions and calculation of seasonal performance
	prEN 16084 Refrigerating systems and heat pumps. Qualification of tightness of components and joints
	EN/IEC 60335-2-40 Household and similar electrical appliances - safety - Particular requirements for electrical heat pumps, air conditioners and dehumidifiers
Electric heating appliances	IEC/EN 60704-2-2 Test code for the determination of airborne acoustical noise emitted by household and similar electrical appliances. Part 2: particular requirements for forced draught convection heaters

- **EUROVENT**

The European Committee of Air Handling and Refrigeration Equipment Manufacturers, EUROVENT[18], has a certification programme that provides a categorisation of some of the products, which are covered in the scope of the air-based central heating system studied in ENER lot 21:

- Comfort air-conditioners 12 kW to 45 kW (EN 14511 and EN ISO 3741)
- Comfort air-conditioners 45 kW to 100 kW (EN 14511 and EN ISO 3741)
- Ducted fan coil units
- Air handling units (prEN 1886 and prEN13053)
- Air to air plate heat exchangers (EN 308)
- Air to air rotary heat exchangers (EN 308 and ARI 1060-2001)
- Rooftop unit (EN 14511)
- Fan coil units (FCU)

- **International Mechanical Code**

The International Mechanical Code, produced by the United States based International Code Council (ICC), distinguish between the following types of appliances that might be included in this study:

- Duct furnaces
- Forced warm-air furnaces
- Unit heaters (covered in ENER Lot 20)

For gas based central heating, a number of standards specify different types of furnaces (see Section 1.2.2. for more information). In European Standard EN 1596:1998 space heating appliances are defined as "*appliances whose air delivery temperature does not exceed the ambient temperature by more than 80°C*".

Most standards classify devices according to the fuel type then define them according to whether they are direct-fired or indirect-fired. Sometimes the nominal heat input is also specified.

- **US Department of Energy**

In the US Code of Federal Regulations (CFR) the Department of Energy (DOE) use the following definitions are given for the products covered in this study:

- Furnace means a product, which utilizes only single-phase electric current, or single-phase electric current or DC current in conjunction with natural gas, propane, or home heating oil, and which is designed to be the principal heating source for the living space of a residence.

[18] EUROVENT Association. Eurovent Certification. www.eurovent-certification.com

- Warm air furnace means a self-contained oil-fired or gas-fired furnace designed to supply heated air through ducts to spaces that require it and includes combination warm air furnace/electric air conditioning units but does not include unit heaters and duct furnaces.
- Gravity central furnace means a gas fuelled furnace which depends primarily on natural convection for circulation of heated air and which is designed to be used in conjunction with a system of ducts.
- Forced air central furnace means a gas or oil burning furnace designed to supply heat through a system of ducts with air as the heating medium. The heat generated by combustion of gas or oil is transferred to the air within a casing by conduction through heat exchange surfaces and is circulated through the duct system by means of a fan or blower.
- Electric central furnace means a furnace designed to supply heat through a system of ducts with air as the heating medium, in which heat is generated by one or more electric resistance heating elements and the heated air is circulated by means of a fan or blower.
- Heat pump means a product, other than a packaged terminal heat pump, which consists of one or more assemblies, powered by single phase electric current, rated below 65,000 BTU/h (19 kW), utilizing an indoor conditioning coil, compressor, and refrigerant-to-outdoor air heat exchanger to provide air heating, and may also provide air cooling, dehumidifying, humidifying circulating, and air cleaning.
- Mobile home furnace means a direct vent furnace that is designed for use only in mobile homes.
- Weatherized warm air furnace means a furnace designed for installation outdoors, approved for resistance to wind, rain, and snow, and supplied with its own venting system.
- Commercial warm air furnace means a warm air furnace that is industrial equipment, and that has a capacity (rated maximum input) of 225,000 BTU/h (66 kW) or more.
- Commercial package air-conditioning and heating equipment means air-cooled, water-cooled, evaporation-cooled, or water source (not including ground water source) electrically operated, unitary central air conditioners and central air-conditioning heat pumps for commercial application.
- Small commercial package air-conditioning and heating equipment means commercial package air-conditioning and heating equipment that is rated below 135,000 BTU/h (40 kW) (cooling capacity).
- Large commercial package air-conditioning and heating equipment means commercial package air-conditioning and heating equipment that is rated at or above 135,000 BTU/h (40 kW); and below 240,000 BTU/h (70 kW) (cooling capacity).

- Very large commercial package air-conditioning and heating equipment means commercial package air-conditioning and heating equipment that is rated at or above 240,000 BTU/h (70 kW); and below 760,000 BTU/h (222 kW) (cooling capacity).

As can be seen in the above, heat pumps and reversible air-conditioners are typically defined by their cooling capacity.

The US Department of Energy considered in its Advance Notice of Proposed Rulemaking (ANOPR) in 2004 to establish energy conservation standards for residential furnaces and boilers (10 CFR Part 430[19]) based on the following product classes:

- Gas furnaces
  - Non-weatherized (for indoor installation)
  - Weatherized (for outdoor installation)
- Oil-fired furnaces
  - Non-weatherized (for indoor installation)
  - Weatherized (for outdoor installation)
- Mobile home furnaces (smaller furnaces that also provide direct hot air heating)
  - Gas
  - Oil
- Electric resistance furnaces

- **Standards AUSTRALIA**

The Australian Standard AS 3814-2005 (AG-011) – Industrial and Commercial Gas-Fired Appliances lists the following types of gas furnaces for air-based heating:

- High input gas-fired appliances
- Direct-fired air heaters and curtains
- Multi-fuel firing systems
- Air-gas mixing blowers
- Manually operated Bunsen type burner
- Atmospheric burners (not fitted in a combustion chamber)

- **American National Standards Institute (ANSI)**

Similarly, the American National Standards Institute (ANSI) specifies safety standards according to the following categories of appliances (see section 1.2.3.):

- Direct-Vent Central Furnaces (ANSI/AGA Z21.64.90)

[19] Code of Federal Regulations, Energy Conservation Program for Consumer Products

- Automatic Vent Damper Devices for Use with Gas-Fired Appliances (ANSI/AGA Z21.66.88)

- **Natural Resources Canada**

Furthermore, Canada's Energy Efficiency Act establishes energy efficiency standards for a wide range of furnaces and heat pumps. Test standards and Annual Fuel Utilisation Efficiency (AFUE) ratings are given for the following:

- Automatic operating gas-fired central forced-air furnaces that use propane or natural gas and have an input of not more than 117.23 kW (400,000 BTU/h), but does not include furnaces for mobile homes or recreational vehicles.
- Oil-fired warm-air furnaces, other than furnaces for mobile homes or recreational vehicles, that have an input rate of less than or equal to 66 kW (225,000 BTU/h)
- Ground- or water-source heat pumps that are factory-built single packages or split-system matching assemblies that have a cooling or heating capacity of less than 40 kW (135,000 BTU/h) and are intended for application in open- or closed-loop ground- or water-source systems.
- Water-source heat pumps that are factory-built single packages or split system matching assemblies that are intended for installation in internal water-loop systems and do not exceed 40 kW (135,000 BTU/h) in cooling or heating capacity.
- Factory-assembled commercial and industrial unitary air conditioners, heat pumps and air-conditioning condensing units that have a cooling or heating capacity of more than 19.0 kW (65,000 BTU/h) but less than 70.0 kW (240,000 BTU/h)
- Factory-assembled packaged terminal air conditioners and heat pumps (PTAC/HP) with a wall sleeve and a separate unencased combination of heating and cooling assemblies intended for mounting through the wall.
- Permanently installed air-source air-conditioner and heat pumps that are single package and split system, single and three-phase, with rated capacity of less than 19 kW (65,000 BTU/h)

Table 1.6: Air-based central space heating product categorisation

Type of central heating appliance	Energy source	Typical power output range (in kW)	Relevant standards
Direct-gas-fired warm air heater	Natural gas (NG) /propane/butane (LPG)	< 19 (r) 19 – 1,200 (c)	EN 525 EN 621 EN 676 EN 1020 EN 298
Indirect-gas-fired warm air heater	Natural gas (NG) /propane/butane (LPG)	< 19 (r) 19 – 900 (c)	EN 525 EN 621 EN 676 EN 1020 EN 298
Liquid fuel-fired warm air heater	Fuel oil/diesel/ kerosene	15 – 45 (r) 35 – 400 (c)	EN 267 EN 13842
Electrical warm air heater	Electricity	15 – 50	EN/IEC 60335-1
Multi fuel-fired warm air heater	Wood/coal and fuel oil	<50 (r) 50 - 500 (c)	
Heat pump	Air/water/ ground	< 12 (r) 12 – 100 (c)	EN 225 EN 378 EN 14511
Air handling unit (AHU)	Electricity/gas/oil	20 – 1,200 (c)	prEN 1886 prEN13053 EN 1020 EN 525
(r): residential, (c): commercial or industrial			

1.1.4 Summary subtask 1.1

As shown above, several products can be considered as central heating products that use hot air to distribute heat. In order to perform a thorough evaluation of the products, it is necessary to clearly define the scope of this study in terms of products to be analysed and those to be excluded.

- **Functional unit**

The functional unit of a central heating product that uses hot air to distribute heat is to generate a certain heating capacity (measured in kW), which is distributed by air to warm several indoor spaces.

Scope of study

Based on the considerations presented here in subtask 1.1, it is proposed to follow an extended product approach for the analysis in this ENER Lot 21 study similar to ENER Lot 1 and ENTR Lot 6. The scope of heat generation appliances that use hot air to distribute heat includes oil, gas, electric and multi-fuel warm air heaters and air-based heat pumps (reversible air conditioners with air, ground or water as heat sources). The heating capacities for air-based central heating systems range from small buildings to very large facilities, but this study did not identify any products with heating capacities beyond 1,200 kW[20] (most warm air heaters, even commercial ones, have much lower heating capacities). For high heating requirements, large systems configured with several units are used. In the case of heat pumps, most of the appliances are in the range below 200 kW of heating capacity. Higher capacities are obtained by combining multiple outdoor units.

In this study central heating products that use hot air to distribute heat are defined as appliances that convert electricity, gaseous or liquid fuels into heat (up to 1,200 kW), or extract the heat from a medium, and then distribute the hot air via ducts to one or several indoor spaces in a building.

The following types of products are preliminarily considered to be within the scope of this study:

- Warm air heaters
  - Gas heaters
  - Liquid-fuel heaters
  - Multi-fuel heaters
  - Electric heaters
- Heat pumps (above 12 kW cooling capacity)
  - All-electric heat pumps
  - Gas-engine heat pumps

The products that also are able to provide cooling or merely ventilation will be covered in the ENTR Lot 6 study on air-conditioning and ventilation systems.

Not included in the scope of this study are: boilers (ENER Lot 1), water heaters (ENER Lot 2), hydronic heat pumps (ENER Lot 1), combined heat and power systems, heat pumps with less than 12 kW cooling capacity (ENER Lot 10), ventilator fans (ENER Lot 10 & 11), solid fuel heaters (ENER Lot 15), air doors and curtains, decentralised industrial unit heaters (ENER Lot 20) and industrial heating process equipment (ENTR Lot 4). Some of these products are however very similar to, or at least share many of the same components as, the products considered in this study.

In relation to the energy efficiency of air-based central heating products, it is worthwhile noting that apart from the heat generation efficiency, the efficiency of the hot air distribution is an

[20] The 400 kW power limit is the same as for ENER Lot 1 Boilers (a hydronic central heating product), but the choice here is not correlated with the study

important factor for achieving energy savings. Here system perspectives come to play as room insulation, ventilation, ductwork, installation/placement of heater and interaction with other HVAC components are important parameters.

This is a preliminary scope definition and will be evaluated further against three key criteria defined in the Ecodesign Directive, viz. large sales volumes, significant environmental impacts and significant improvement potential. These issues will be dealt with later on in the Task 2, 5, and 7.

1.2 Test standards

This subtask gives an overview of existing test standards for the products to be covered by ENER Lot 21 study and to identify needs and requirements for standards to be developed.

A "test standard" is a standard that sets out a test method, but that does not indicate what result is required when performing that test. Therefore, strictly speaking, a test standard is different from a "technical standard". Namely, in technical use, a standard is a concrete example of an item or a specification against which all others may be measured or tested. Often it indicates the required performance. In addition to official standards, there may be other sector specific procedures for product testing, which could be considered as standards as they are broadly recognised. Those procedures are discussed later in this chapter.

Following the EU's 'New Approach', any product-oriented legislation should preferably refer to harmonised (EN) test standards in order to verify the compliance with set measures. The referenced test standard should be accurate, reproducible and cost-effective, and model as well as possible the real-life performance. If no suitable test standard exists, they need to be developed (possibly based on existing sector specific procedures) for the relevant parameters in the view of implementing measures. Hence, this sub-task identifies and describes the harmonised test standards, and where relevant, additional national or sector-specific directions or methods for product-testing, particularly regarding test procedures for functional performance parameters such as energy efficiency.

1.2.1 Definitions of performance parameters for energy efficiency

In order to explain the test standards relevant for this study, the following provides a short description of the most commonly used energy efficiency performance metrics.

The energy conversion efficiency of appliances that generate heat from combustion is determined by the ratio between the useful output heat provided for a defined time period and purpose and the energy used (input heat: electricity and fuel). This can be measured in several different ways:

- **Gas and oil-fired warm air heaters**

The energy conversion efficiency of appliances that generate heat from combustion is determined by the ratio of the useful output heat and the energy (electricity and fuel) used. This can be measured in several different ways:

- **Combustion Efficiency** is a measure of the warm air heater burner's ability to burn fuel. It is determined by measuring the amount of unburned fuel and excess air in the exhaust. Well designed burners firing gaseous and liquid fuels operate at excess air levels of 15% and result in negligible unburned fuel. By operating at only 15% excess air, less heat from the combustion process is being used to heat excess air, which increases the available heat for the load. Combustion efficiency is also dependent on the type of fuel.
- **Thermal Efficiency (TE)** is the energy conversion efficiency of warm air heaters under steady-state peak conditions. It is determined by the ability of the heat exchanger in indirect-fired systems to transfer heat from the combustion process to the warm-air used for space heating. TE is often specified as net or gross depending on whether the net or gross calorific value of fuel is used. The net calorific value of a fuel excludes the latent heat of water vapour in the exhaust, and so is lower than the gross calorific value. Efficiency test results and European standards normally use net calorific values. As TE does not include efficiency at part load operation, it is not a realistic indicator of actual efficiency.
- **Annual Fuel Utilization Efficiency (AFUE)** is used in the US as an indicator for energy efficiency. AFUE takes into account the cyclic on/off operation and associated energy losses due to changes in loads during the heating season. Test standards, such as ASHRAE 103-2007 (residential warm air heaters and boilers), specify a method and test conditions for determining the AFUE of furnaces.

- **Heat pumps**

As heat pumps can both provide heating and cooling, the performance in each mode is determined separately. For cooling EER (Energy Efficiency Ratio) and SEER (Seasonal Energy Efficiency Ratio) are used. Here only the energy efficiency performance for heat pumps in heating mode is considered.

- **Co-efficient of Performance (COP)** of a heat pump is the ratio of the heat delivered by the heat pump and the energy (electricity if an electric heat pump) supplied to the compressor under steady state conditions and at a given set of temperature conditions for the heat source and the heat sink.
- **Reference Seasonal Co-efficient of Performance (SCOP)** is the seasonal efficiency of a unit calculated for the reference annual heating demand. For the calculation of the SCOP, the reference annual heating demand is divided by the annual electricity consumption of a unit, including the power consumption during all working modes and additional back up heaters, if needed.
- **Reference SCOPon** is the seasonal efficiency of a unit in active heating mode, determined from mandatory conditions given in the standard prEN 14825.

- **Reference SCOPnet** is the seasonal efficiency of a unit in active heating mode without supplementary electric heaters, and is determined from mandatory conditions given in the standard prEN 14825.
- **Application SCOP/SCOPon/SCOPnet** are seasonal efficiency factors that take into account the specific application and location of the unit. The heating bin, loads and hours used for the calculation are specific for the location of the building.
- **Seasonal Performance Factor (SPF)** or Seasonal COP is calculated as the ratio of the total heating output during the normal heating season and the total electricity consumed during the same period.
- **Heating Seasonal Performance Factor (HSPF)** As it is mostly used in North America, HSPF has the units BTU/Wh (heat output given in BTU and electrical energy supplied given in watts-hour). HSPF can be converted to a seasonally averaged COP by converting both the BTU heat input and the electrical input to Joules (or any common energy unit). AHRI test standards specify methods to determine the HSPF of heat pumps.

Air handling units

The overall efficiency of air handling units is usually determined by the energy it takes to move a given quantity of air against the system. However, the Eurovent Certification programme combines the velocity of air with the pressure losses of the heat recovery system and the active power of fans to determine the efficiency of the unit.

The efficiency of central heating products that use hot air at system level –according to the approach proposed for the ENER Lot 21 preparatory study, should also include insulation factors, energy losses, and interaction of the product, the heating demand and the user. Existing legislation and standards such as **EN 15316-2-1:** "Heating systems in buildings – Method of calculation of system energy requirements and system efficiencies" already include energy efficiency from a system perspective.

1.2.2 Test standards at European Union level

A summary of the standards most relevant to ENER Lot 21 is provided in Table 1.7. These standards are explained in detail in the following paragraphs, and where applicable the relevance of these standards to the central heating appliances is indicated.

At present there are standards (in place and under development) that specify methods for calculating the energy requirements of space heating systems to determine their energy efficiency performance, e.g. EN ISO 13790 and EN 15316. These standards are very relevant for this study in that a system approach that takes into account the building and climate will be used to analyse the energy performance of ENER Lot 21 products. These standards also rely on data that is determined from particular product standards. This shows the importance of the links between all these standards.

Besides energy efficiency, a number of European standards related to safety issues and airborne acoustical noise have been identified as also relevant for this study. These standards fall under EU directives that include the Directive (2001/95/EC) on general product safety, the Directive (2009/142/EEC21) on appliances burning gaseous fuels (GAD), Directive (89/106/EEC) for construction products and the low voltage (LVD) Directive (2006/95/EC).

Many EN standards on appliances covered by this preparatory study also correspond to international standards, in particular the International Electrotechnical Commission (IEC). Nevertheless, product specified European standards are rather limited in relation to ENER Lot 21 products. At this stage, European standards have been identified for gas, LPG and oil-fired burner systems. Certain standards relative to air-conditioner units and heat pumps (some of these were covered in the ENER Lot 10 study) also apply to hot air central heaters. These standards are only briefly mentioned.

1.2.2.1 Test standards on energy and environment requirements

1.2.2.1.1 *Heating systems in buildings*

- **EN ISO 13790:** Thermal performance of buildings - Calculation of energy use for space heating and cooling

The standard provides calculation methods for assessing the annual energy use for space heating and cooling of buildings. The method includes the calculation of:

- the heat transfer by transmission and ventilation of the building zone when heated or cooled to constant internal temperature;
- the contribution of internal and solar heat gains to the building heat balance;
- the annual energy needs for heating and cooling, to maintain the specified set-point temperatures in the building – latent heat not included;
- the annual energy use for heating and cooling of the building.

EN ISO 13790 also provides an alternative simple hourly based calculation method, using hourly user schedules (such as temperature set-points, ventilation modes, or operation schedules of movable solar shading).

- **prEN 15316:** Heating systems in buildings – Method for calculation of system energy requirements and system efficiencies

This standard, which is still under development, was initiated under the mandate of the European Commission to support the requirements of the EU Directive on the Energy Performance of Buildings (EPBD) regarding harmonisation of the methodology for calculation of the energy

[21] To undertake a codification of this directive, the Commission has made a proposal for a Directive of the European Parliament and of the Council relating to appliances burning gaseous fuels (Codified version), COM(2007) 633 - COD 2007/0225

performance of buildings. The calculation method for the system energy losses of the heating system (i.e. heat generation, storage, distribution, emission and control) is based on:

- the building energy need for space heating (building thermal properties and the indoor and outdoor climate);
- non-uniform internal temperature distribution in each conditioned zone;
- heat emitters embedded in the building structure towards the outside or unheated spaces;
- control of the operative temperature;
- auxiliary energy consumption.
- The calculation of the system thermal losses takes into account:
- energy interaction between type of heat emitters (radiator, convector, floor/wall/ceiling heating systems) and space;
- type of room/zone thermal control strategy and equipment (thermostatic valve, P, PI, PID control etc.) and their capability to reduce the temperature variations and drift;
- position and characteristics of heat emitters.

Based on these data, the following output data can be derived:

- system thermal losses;
- auxiliary energy consumption;
- recoverable system thermal losses.

Two recommended calculation methods are proposed: one using efficiencies (adapted from German regulation DIN 18599-6), and the other using equivalent increase in internal temperature (adapted from the French regulation RT2005).

1.2.2.1.2 *Warm air heaters*

- **EN 621:** Non-domestic gas-fired forced convection air heaters for space heating not exceeding a net heat input of 300 kW, without a fan to assist transportation of combustion air and/or combustion products
- **EN 778:** Domestic gas-fired forced convection air heaters for space heating not exceeding a net heat input of 70 kW, without a fan to assist transportation of combustion air and/or combustion products. This standard covers domestic gas-fired air heaters with (an) atmospheric burner(s) and without a fan to assist the transportation of combustion air and/or flue gases. The standard only applies to heaters with an input not exceeding 70 kW (net caloric value basis), intended primarily for use in single unit residential dwellings. Provision of the heated air may be by means of ducting. This standard does not regard appliances:

- of condensing type,
- intended for outdoor installation,
- for dual purpose air conditioning (heating and cooling),
- where the air is heated by an intermediate fluid,
- forced draught burners,
- with manual or automatic adjustment of combustion air supply and of the evacuation of combustion products (including flue dampers),
- portable or transportable forced convection appliances,
- having multiple heating units with a single draught diverter,
- fitted with more than one flue outlet,
- designed for continuous condensation within the flue system under normal operating conditions,
- Products Of Combustion Evacuation Ducts (POCED), that are non-metallic.

- **EN 1020:** Non-domestic forced convection gas-fired air heaters for space heating not exceeding a net heat input of 300 kW incorporating a fan to assist transportation of combustion air or combustion products. EN 1020 is an European Standard which specifies the requirements and test methods for the safety and efficiency of nondomestic gas-fired air heaters having a fan to assist the transportation of combustion air and/or flue gases, hereafter referred to as "appliances". This includes appliances having forced draught burners
- **EN 13842:** Oil-fired air heaters. Fixed and transportable for room heating. This standard specifies the requirements and test methods for the safety and efficiency of oil-fired air heaters using only forced draught oil burners. This European Standard applies to stationary and portable appliances. It also applies to appliances intended for outdoor installation. Provision of the heated air may be by means of ducting or may be directly into the heated space.
- **EN 1196:** Gas-fired air heaters for domestic and non-domestic use - Additional requirements for condensing air heaters. This European Standard specifies the additional requirements and test methods for gas-fired air heaters which are designed so that water vapour condenses from combustion products. On this subject, it extends the European Standards EN 778 and EN 1319 for domestic air heaters, and EN 1020 for non-domestic air heaters. This European Standard applies to gas-fired air heaters (with or without a fan in the combustion circuit) in one of the following construction categories:
  - integral air heater with at least one condensing heat exchanger;
  - non-condensing air heater with an integrated additional condensing heat exchanger;

- non-condensing air heater, with an integrated additional condensing heat exchanger for the recovery of heat from combustion products and from ventilation air if appropriate.

- **EN 1319:** Domestic gas-fired forced convection air heaters for space heating, with fan-assisted burners not exceeding a net heat input of 70 kW. .This standard covers gas-fired air heaters for domestic use with a fan to assist transportation of combustion air and/or combustion products. It refers to appliances designed for a maximum heat input (based on the calorific value) of 70 kW and primarily used for single home dwellings. The standard specifies the requirements and test methods for the safety and efficiency of domestic gas-fired air heaters.

Note: In the UK the national Building Regulation requires system controls to be based on time and temperature for at least two separate zones.

1.2.2.1.3 *Heat Pumps*

- **EN 12102: Air conditioners, liquid chilling packages, heat pumps and dehumidifiers with electrically driven compressors for space heating and cooling. Measurement of airborne noise. Determination of the sound power level**

This standard specifies the conditions for determining the noise level of heat pumps.

- **ISO 13253: Ducted air conditioners and heat pumps -- Testing and rating for performance**

The procedure applies to heat pumps of any capacity and type provided they are ducted with a static pressure superior to 25 Pa. Variables required to be measured, determined or declared are climate classification types, total cooling capacities, EER, heating capacity COP, rated voltages and frequencies, cooling power consumption, refrigerant designation and refrigerant mass charge.

- **EN 14511: Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling**

This standard specifies the rating conditions and test requirements for determining efficiency at full load conditions. This standard also provides requirements for safety, and is harmonised for the Energy Labelling Directive for air conditioners and heat pumps below 12kW.

- **prEN 14825: Air conditioners, liquid chilling packages and heat pumps, with electrically compressors, for space heating and cooling- Testing and rating at part load conditions and calculation of seasonal performance**

This standard (under development) specifies the rating conditions and test requirements for determining seasonal efficiency at part load conditions.

- **prEN 16048: Refrigerating systems and heat pumps. qualification of tightness of components and joints**

This standard specifies the requirements to determine the level of tightness of components. This is important for the control of refrigerant leakages.

1.2.2.1.4 *Electric Heating Appliances*

- **IEC/EN 60704: Determination of acoustical noise emitted by household and similar electrical appliances**

Appliances: This part of EN/IEC 60704 applies to electric appliances (including their accessories or components) for household and similar use, supplied from mains or from batteries. By similar use is understood the use in similar conditions as in households, for example in inns, coffee-houses, tea-rooms, hotels, barber or hairdresser shops, launderettes, etc.

Energy supply: Electrical power supply

Devices Classifications: All electric appliances (including their accessories or components) for household and similar use, supplied from mains or from batteries.

1.2.2.2 Test standards on safety

1.2.2.2.1 *Gas Heating Appliances*

- **EN 525: Non-domestic direct gas-fired forced convection air heaters for space heating**

Appliances: This standard applies to non-domestic gas direct-fired forced convection air heaters having fully automatic control systems, with heat input based on the net calorific value of 300 kW or less, fitted with integral burners, intended for use other than in residential dwellings. It also applies to appliances designed for outdoor installation. For indoor appliances the heated air may be provided by ducting or directly into the heated space. This standard does not apply to:

- Appliances intended for use in residential dwellings
- Portable or transportable forced convection appliances
- Appliances fitted with gas boosters
- Appliances fitted with air/gas ratio controls
- Appliances which incorporate a main burner having more than one section under a common burner control, of which one or more sections may be extinguished whilst another section remains in operation.

Fuels: Propane and propane-butane mixture

- **EN 613: Independent gas-fired convection heaters**

Appliances: This standard applies to independent gas-fired convection heating appliances which:

- Incorporate a natural draught burner
- Connected directly to an open flue or to a device to evacuate the products of combustion (open-flued appliances, balanced-flued appliances)
- Are wall mounted, free-standing or built-in
- Have a nominal heat input not exceeding 20 kW (based on the net calorific value).

In addition, this standard is applicable to live fuel effect appliances, such as gas stoves and fireplaces.

Fuels: Propane, propane-butane mixture, butane and natural gas family H, L and E[22]

- **EN 778: Domestic gas-fired forced convection air heaters for space heating not exceeding a net heat input of 70 kW**

See section 1.2.2.1.2.

- **EN 1020: Gas-fired air heaters with enhanced convection space heating for non-domestic use not exceeding nominal heat input over 300 kW**

Appliances: This standard applies to non-domestic gas-fired air heaters having a fan to assist the transportation of combustion air and/or flue gases which includes appliances having forced draught burners.

Fuels: Propane, propane-butane mixture and natural gas family H, L and E

- **EN 1319: Domestic gas-fired forced convection air heaters for space heating**

See section 1.2.2.1.2.

1.2.2.2.2 *Liquid Fuel Heating Appliances*

- **EN 267: Forced draught oil burners**

Appliances: This standard covers forced draught oil burners supplied with a fuel having a viscosity at the burner inlet in the range of 1.6-6 mm^2/s at 20°C. It specifies the general requirements for the construction and operation of these burners.

This standard also applies to the oil function of dual fuel burners designed to operate on liquid and gaseous fuels in which case the requirements of EN 676 will also apply in respect of the gaseous fuel function.

Fuels: Light fuel oil

1.2.2.2.3 *Electric Heating Appliances*

- **IEC/EN 60335: Household and similar electrical appliances heaters – particular requirements for gas, oil and solid-fuel burning appliances having electrical connections**

Appliances: This standard deals with the safety of electrical appliances for household and similar purposes, their rated voltage being not more than 250 V for single-phase appliances and 480 V for other appliances.

[22] The natural gas family H, L and E refer to a characteristic composition of natural gas (e.g. Natural gas family H has a percentage composition by volume as: CH_4-82, C_2H_6-3.3, C_3H_8-0.6, C_4H_{10}-0.3, N_2-12.6, CO_2-1.2)

Appliances not intended for normal household use but which nevertheless may be a source of danger to the public, such as appliances intended to be used by laymen in shops, in light industry and on farms, are within the scope of this standard.

As far as is possible, this standard deals with the common hazards presented by appliances that are encountered by all persons in and around the home. However, in general, it does not take into account:

- Persons whose physical, sensory or mental capabilities; or lack of experience and knowledge prevent them from using the appliance safely without supervision or instruction (children included)
- Children playing with the appliance

1.2.2.2.4 *Heat Pumps*

- **EN 378: Specification for refrigerating systems and heat pumps. Safety and environmental requirements. Basic requirements, definitions, classification and selection criteria**

Harmonised standard that specifies the safety requirements with relation to machinery and Pressure Equipment Directive.

- **EN 14276: Pressure equipment for refrigerating systems and heat pumps**

Appliances: This standard applies to the heat pumps and refrigerating systems and covers the requirements for their construction, manufacturing, material, testing and documentation for fixed pressure tanks.

- **EN 60335-2-40: Household and similar electrical**

A**ppliances:** Harmonised standards that specify the electric safety requirements, as well as restrictions for the use of flammable refrigerants.

1.2.3 Third country test standards

- **International level**

The International Organization for Standardization (ISO) is the leading international standardisation body. It manages the International Classification for Standards (ICS) which was used to identify relevant standards for ENER Lot 21. The ICS codes listed in EN-, ISO- and other classifications used by standardisation bodies were investigated. Among the current standards only those related to gas and oil burners and heat pumps were identified as relevant to this study. Most of these standards related to safety and control devices but some international test standards exist for performance rating of heat pumps (see Table 1.8).

Table 1.7: International standards relevant for ENER Lot 21 products

Standard	Title
ISO 13253	Ducted air-conditioners and air-to-air heat pumps - Testing and rating for performance
ISO 13256-1	Water-source heat pumps -- Testing and rating for performance - Part 1: Water-to-air and brine-to-air heat pumps
ISO 23550	Safety and control devices for gas burners and gas-burning appliances - General requirements
ISO 23551-1	Safety and control devices for gas burners and gas-burning appliances – Particular requirements – Part 1: Automatic valves
ISO 23551-2	Safety and control devices for gas burners and gas-burning appliances – Particular requirements – Part 2: Pressure regulators
ISO 23551-3	Safety and control devices for gas burners and gas-burning appliances – Particular requirements – Part 3: Gas/air ratio controls, pneumatic type
ISO 23551-3	Safety and control devices for gas burners and gas-burning appliances – Particular requirements – Part 4: Valve-proving systems for automatic shut-off valves
ISO 23552-1	Safety and control devices for gas and/or oil burners and gas and/or oil appliances – Particular requirements – Part 1: Fuel/air ratio controls, electronic type
ISO 23553-1	Safety and control devices for gas and/or oil burners and gas and/or oil appliances – Particular requirements – Part 1: Shut-off devices for oil burners
ISO 5149	Mechanical refrigerating systems used for cooling and heating -- Safety requirements
IEC 60335-2-40	Household and similar electrical appliances –Safety
ISO 817	Refrigerants -- Designation system

Also identified were international standards relevant for this study that currently are under development (see Table 1.8). These specify test methods for determining the energy and environmental performance of heat pumps.

Table 1.8: International standards under development that are relevant for ENER Lot 21 products

Standard	Title
ISO/DIS 5149	Refrigerating systems and heat pumps – Safety and environmental requirements
ISO/NP 13261-3	Sound power rating of air-conditioning and air-source heat pump equipment – Part 3: Ducted equipment
ISO/NP 13612	Heating and cooling systems in buildings – Method for calculation of the system performance and system design – Heat pump systems
ISO/NP 15042	Multiple split-system air conditioners and air-to-air heat pumps – Testing and rating for performance
ISO/CD 16358-2	Air-cooled air conditioners and air-to-air heat pumps – Testing and calculating methods for seasonal performance factors – Part 2: Heating seasonal performance factor HSPF
ISO/CD 16358-3	Air-cooled air conditioners and air-to-air heat pumps – Testing and calculating methods for seasonal performance factors – Part 3: Annual performance factor APF
ISO/NP TR 16491	Guide to the estimation of uncertainty of measurement in air conditioner and heat pump cooling and heating capacity tests
ISO/CD 14903	Refrigerating systems and heat pumps - Qualification of tightness of components and joints

- **USA**

The most recognised standards for HVAC (Heating, Ventilation, and Air Conditioning) products under which central-heating products fall, is based on data from ASHRAE, the American Society of Heating, Refrigerating and Air-Conditioning Engineers. In addition, the AHRI, the Air-Conditioning, Heating, and Refrigeration Institute, is the American trade association representing manufacturers of air conditioning, heating, and commercial refrigeration equipment. It also develops industry standards and voluntary certification programmes (AHRI performance certification programs[23]) for central heating products. The standards from ASHRAE and AHRI are often developed in collaboration with the American National Standards Institute (ANSI), which develops national standards for performance testing.

ASHRAE provides uniform test methods that measure the energy consumption of furnaces. This includes test methods for cyclic and part load performance, methods for interpolating and extrapolating test data and calculation procedures for establishing seasonal performance, which result in the commonly used energy efficiency metric, Annual Fuel Utilization Efficiency (AFUE). The ASHRAE 103-2007 standard specifies a method and test conditions for determining the AFUE of residential central warm air heaters and boilers.

AHRI specifies test standards for determining the energy efficiency performance of heat pumps. Test standard AHRI 210/240 specifies the method to determine the HSPF of unitary air-conditioning and air-source heat pump equipment, whilst AHRI 340/360 and AHRI 390 specify

[23] AHRI, Air-Conditioning, Heating and Refrigeration Institute. Directory of Certified Product Performance. Website: www.ahridirectory.org/

how to determine the COP for commercial and industrial heat pumps and single package vertical heat pumps, respectively.

- **Canada**

The Canadian Standards Association shares many of the same test standards as the US, but also establishes its own methods and minimum efficiency levels for certain central heating products. CAN/CGA-2.3 M86 is a test method for AFUE rating for Gas-Fired Gravity and Forced Air Central Furnaces (used in accordance with CAN/CSA-P.2-07). CAN/CSA-B 212-00 specifies the methods for determining AFUE for oil-fired furnaces having an input of up to and including 225,000 BTU/h (66 kW), and boilers having an input of up to and including 300,000 BTU/h (88 kW). These products are:

- Intended for installation with the base of the appliance placed on the floor
- Intended to be used with pipes or ducts for the distribution of the heated air
- Employing forced circulation of the heated air

The tests contained in this standard are not intended to represent actual efficiencies realised in the field, but aim to provide a standardised method of comparing relative unit performance.

- **Australia**

The main objective of AS 3814-2005 for Industrial and Gas Fired Appliances is to provide uniform minimum requirements for the safe operation of gas-fired industrial or commercial appliances. It takes into account the design, construction and safe operation aspects of appliances that use town gas, natural gas, simulated natural gas, liquefied petroleum gas, tempered liquefied petroleum gas or any combination of these gases either together or with other fuels.
Table 1.9 provides a summary of third country test standards relevant for this study.

Table 1.9: Third country test standards for ENER Lot 21 products

Standard	Country	Title
AG 501/ AS 3814	Australia	Industrial gas-fired appliances
ANSI Z21.47 / CSA 2.3 / DOE 10 CFR Part 430	USA / Canada	Gas-fired central furnaces
ANSI Z83.8 / CSA 2.6	USA / Canada	Gas unit heaters (input rate ≤ 10,000,000 BTU/h (≈ 2,930 kW)), gas packaged heaters, gas utility heaters and gas-fired duct furnaces (input rate ≤ 400,000 BTU/h (≈117 kW))
ANSI Z21.40.1-1996 / CGA 2.91-M96	USA / Canada	Gas-fired, heat activated air conditioning and heat pump appliances
ANSI Z21.40.2-1996 / CGA 2.91-M96	USA / Canada	Gas-fired, work activated air conditioning and heat pump appliances (Internal Combustion)

Standard	Country	Title
ANSI Z21.40.4-1996 / CGA 2.94-M9	USA / Canada	Performance testing and rating of gas-fired, air conditioning and heat pump appliances
ANSI/ASHRAE 103-2007	USA	Method for testing Annual Fuel Utilization Efficiency (AFUE) of residential central furnaces and boilers (furnaces with input rating < 250,000 BTU/h (≈66 kW))
ANSI/AHRI 210/240-2008	USA	Performance rating of unitary air-conditioning and air-source heat pump equipment
ANSI/AHRI 310/380-2004 / CSA-C744-04	USA / Canada	Standard for packaged terminal air-conditioners and heat pumps
ANSI/AHRI 340/360-2007	USA	Performance rating of commercial and industrial unitary air-conditioning and heat pump equipment
ANSI/AHRI 390-2003	USA	Performance rating of single package vertical air-conditioners and heat pumps
ANSI/AHRI 870	USA	Performance rating of Direct GeoExchange heat pumps
CAN/CSA-B140.4-04	Canada	Oil-fired warm air furnaces
CAN/CSA-B212-00	Canada	Seasonal energy utilisation efficiencies of oil-fired furnaces and boilers
CAN/CSA C273.5-1980	Canada	Installation requirements for air-to-air heat pumps
CAN/CSA-P.2-07	Canada	Testing method for measuring the annual fuel utilization efficiency of residential gas-fired furnaces (input rate < 65.9 kW (225,000 Btu/h) and boilers
CGA 3.2	Canada	Industrial and commercial gas-fired package furnaces (400,000 BTU/h (≈117 kW) < input rating ≤ 10,000,000 BTU/h (≈2,930 kW)))
CGA 3.4	Canada	Industrial and commercial gas-fired conversion burners (400,000 BTU/h (≈117 kW) < input rating ≤ 10,000,000 BTU/h (≈2,930 kW)))
UL 727	USA	Oil-fired central furnaces

1.2.4 Summary subtask 1.2

The standards at the European level (EN) presented in this subtask classify the air-based central heating appliances covered in ENER Lot 21 study on the following basis:

- Type of fuel used (e.g. natural gas, oil, electricity, etc.)
- Net heat input (e.g. up to 66 kW or up to 300 kW)
- Flue-gas system (e.g. without a fan, fan assisted forced convection, etc.)
- Type of application (e.g. domestic, commercial, industrial, etc.)

This classification of the ENER Lot 21 products is in coherence with the criteria proposed to define the scope of this study in section 1.1. Most of the important standards relevant to warm air heaters and heat pumps were discussed, however these product test standards are of course not

the only relevant standards and the collection of these standards could be extended to include also the standards referenced in the context of overall design of the central heating systems.

1.3 Existing legislation

The main aim of this subtask is to give an overview of existing legislation and voluntary programs for central heating products included in the ENER Lot 21 study. Further, this subtask includes a comparative analysis of such legislation in the context of possible future Ecodesign implementing measures.

1.3.1 Legislation and agreements at European Union level

Several EU directives addressing safety, energy and environmental issues apply to the products in the scope of ENER Lot 21. The most relevant legislation applicable to this study is presented in Table 1.10.

Table 1.10: Relevant European legislations identified for this study

Scope	Legislation
Energy efficiency related	
Entire product	Besides the Ecodesign Directive 2009/125/EC no other European legislation on energy efficiency for central heating air appliances has been identified.
System	Energy Performance of Buildings Directive (EPBD) 2010/31/EU
	Construction Products Directive 89/106/EEC
Boiler	Boiler Efficiency Directive 92/42/EEC
Motors	Commission Regulation (EC) No 640/2009 on Motors
Fans	Commission Regulation (EU) No 327/2011 on Fans
Environmental legislation	
Entire product	Ecodesign Directive 2009/125/EC
	Waste Electrical and Electronic Equipment Directive 2002/96/EC
	Packaging and Packaging Waste Directive 94/62/EC
	Restriction of the use of certain Hazardous Substances in electric and electronic equipment Directive 2002/95/EC
	Directive 89/106/EEC on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products
Liquid refrigerant	Ozone depleting substances regulation 2037/2000
	Fluorinated greenhouse gases regulation 842/2006
Energy	Directive 2009/28/EC on the promotion of the use of energy from renewable sources
	Directive 2006/32/EC on energy end-use efficiency and energy services.
Safety related	
Entire product	Machinery Directive 2006/42/EC
	Gas Appliance Directive 90/396/EEC
	General product safety Directive 2001/95/EC
	Low Voltage equipment Directive 2006/95/EC
	Electromagnetic Compatibility Directive 2004/108/EC
	Directive 89/106/EEC on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products
	Pressure Equipment Directive 97/23/EC

1.3.1.1 *Energy efficiency and related legislations*

Besides the Ecodesign Directive of which this preparatory study has been launched under, there is no specific legislation currently in place regarding the environmental or energy performance of central heating hot air appliances in Europe. The European Directive on the energy performance of buildings (EPBD) does however concern ENER Lot 21 products as it aims to increase the energy performance of public, commercial and private buildings in all Member States (MS). Although it does not specifically mention central heating hot air appliances, energy performance in the Directive is described as "the amount of energy actually consumed or estimated to meet the different needs associated with a standardised use of the building, which may include, inter alia, heating, hot water heating, cooling, ventilation and lighting[24]".

- **Ecodesign Directive 2009/125/EC (recast of 2005/32/EC)**

This Directive applies to different categories of energy-using and energy-related products. It establishes a framework for setting Ecodesign requirements (such as energy efficiency requirements) for all energy-using and energy-related products in residential, tertiary, and industrial sectors.

The Ecodesign preparatory study ENER Lot 11 analysed electric motors and fans. The European Commission put into force implementing measures following the preparatory study by adopting the following Regulations:

- Commission Regulation (EC) No 640/2009 on Motors of 22nd of June 2009

The Regulation covers electric motors with an input power of 0.750 to 375 kW. It establishes minimum efficiency requirements for electric motors. The scope will be progressively extended to cover a larger range of motors, in June 2011, January 2015 and January 2017, respectively. The regulation does not apply to motors designed to operate immersed in a liquid, motors completely integrated into a product, brake motors and motors designed to operate at extreme conditions of altitude, temperature, or in explosive atmospheres.

- Commission Regulation (EU) No 327/2011 on Fans of 30th of March 2011

The Regulation covers fans driven by motors with an input power of 0.125 to 500 kW. Fans integrated in other products are also covered by this regulation. Therefore, Lot 21 products equipped with fans can be considered covered by these requirements.

The requirements will enter into force in two steps, 2013 and 2015 respectively. The regulation does not apply to fans used in industrial applications with non-gaseous fluids, fans designed to be used temporarily under emergency conditions with a safety purpose, with optimum energy efficiency at 8,000 rotations per minute or a specific ratio over 1.11.

[24] European Parliament. Directive 2002/91/EC of 16 December 2002 on the Energy Performance of Buildings. Official Journal L 001, 04/01/2003. Available at : http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0091:EN:HTML

- **Directive 2010/31/EU on Energy Performance of Buildings Directive (EPBD) (Recast of 2002/91/EC)**

The EPBD aims to set minimum efficiency standards for residential and commercial buildings. The Directive proposes a general framework for a methodology for calculating the integrated energy performance for buildings (Article 3) which includes HVAC and hot water systems, lighting, building shell, outdoor climate, etc. Each Member State must apply a calculation methodology as well as establish minimum requirements concerning the energy performance of new and existing buildings. The EPBD also stipulates that a certification system of the energy performance of buildings is put in place together with regular inspection of HVAC systems. Whilst the Ecodesign Directive regulates what products may be placed on the market, the EPBD aims to ensure proper installation and optimal energy use of technical building systems.

- **Directive 89/106/EEC on Construction Products**

The purpose of the Construction Products Directive is to ensure the free movement of all construction products within the EU by harmonising national laws with respect to the essential requirements applicable to these products in terms of health and safety. It applies to construction products, i.e. any products produced with a view to their incorporation in a permanent manner in construction works.

The Directive also contributes to energy efficiency as "the construction works and its heating, cooling and ventilation installations must be designed and built in such a way that the amount of energy required in use shall be low, having regard to the climatic conditions of the location and the occupants"[25]. Products covered by the Construction Products Directive obtain the CE marking only if they comply with technical specifications described in Europe-wide standards.

- **Directive 92/42/EEC on Boiler Efficiency (BED)**
  - Type of assessment: Self declaration + Technical file
  - Scope: Energy efficiency of domestic boilers

This Directive regulates minimum efficiency requirements for boilers and sets a voluntary labelling system, which is now superseded by the Ecodesign Directive. Although boilers are part of central heating systems, this Directive is not relevant to air-based central heating products. This directive is limited to 400 kW power output.

1.3.1.2 Environmental legislation

- **Directive 2002/96/EC on Waste electrical and electronic equipment(WEEE)**

The Directive implements the principle of "extended producer responsibility" where electrical and electronic product manufacturers are responsible for the costs of collection, treatment, recovery and disposal of their own products and hence preventing such products from entering municipal waste collection systems. Starting from 31st December 2006 this Directive requires 80% of large household appliances to enter a separate WEEE stream, and 75% of this waste by

[25] European Commission, DG Enterprise and Industry. Interpretative document No. 6: Energy economy and heat retention, relating to Council Directive 89/106/EEC of 21 December 1988. Available at : http://ec.europa.eu/enterprise/sectors/construction/documents/legislation/interpretative-documents/doc6_en.htm

weight should be reused (components) or recycled (materials and substances). With regard to the products studied in ENER Lot 21, the WEEE Directive applies primarily to industrial unit heaters and heat pumps running on electricity. Other ENER Lot 21 appliances not using electricity as a primary fuel are also covered by WEEE Directive as they use electricity for secondary purpose (e.g. electric ignition, control systems etc.).

- **Directive 94/62/EC on Packaging and Packaging Waste**

The aim of this Directive is to harmonise measures in different Member States which aim to reduce and prevent harmful impacts on the environment from packaging and packaging waste. The aim is to provide a high level of environmental protection as well as ensure a good functioning of the market within the EU. In relation to Lot 21 the Directive applies to all packaging placed on the market, thus all packaging for heating appliances as well as packaging for system products (controls, thermostats etc.).

- **Directive 2002/95/EC on Restrictions of the use of certain hazardous substances in electric and electronic equipment (RoHS)**

The purpose of the RoHS Directive is to restrict the use of hazardous substances in electro-technical products and the protection of human health.

As from 1 July 2006, lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs) in electrotechnical products must be replaced by other substances.

Essentially the RoHS Directive covers the same products as the WEEE Directive, even though at the time of writing some of the categories are excluded (Cat. 8 and Cat. 9. The recast version of the Directive will include them). The control-systems and printed circuit-boards covered by this Directive needs to be accounted for in ENER Lot 21 study.

- **Directive 2000/2037/EC on Ozone depleting substances regulation**

This Regulation "in the context of Montreal Protocol" covers appliances related to the production, importation, exportation, placing on the market, use, recovery, recycling and destruction of chlorofluorocarbons, other fully halogenated chlorofluorocarbons (CFC), halons, carbon tetrachloride, 1,1,1-trichloroethane, methyl bromide hydrobromofluorocarbons and hydrochlorofluorocarbons (HCFC). The heat pumps covered in the ENER Lot 21 study fall under the scope of this Directive.

- **Directive 2006/842/EC on the Regulation of fluorinated greenhouse gases**

The objective of this Regulation is to "contain, prevent and thereby reduce emissions of the fluorinates greenhouse gases covered by the Kyoto Protocol". Some of the appliances studied in ENER Lot 21 like heat pumps are covered by this Directive.
This Regulation addresses:

- Labelling and disposal of products and equipment containing those gases
- Introducing on the market prohibitions of certain products and equipment
- Containment, use, recovery and destruction of fluorinated greenhouse gases
- Training and certification of personnel and companies involved in activities provided for by this regulation

- **Directive 2001/81/EC** on national emission ceilings for certain atmospheric pollutants

This Directive sets national emission ceilings for several pollutants (sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia) emitted by combustion installations, among others, space heating installations.

- **Directive 2008/50/EC** on ambient air quality and cleaner air for Europe

This Directive sets limit values for air quality. Even though the limits do not affect directly to the products in the scope of ENER Lot 21, some of these contribute to outdoor air pollution, due to the emissions of combustion processes.

1.3.1.3 Legislation related to safety

- **Directive 2006/42/EC on Machinery**
  - Type of assessment: Third party verification or self declaration
  - Scope: Safety of machinery

The Directive applies to machinery and lays down the essential health and safety requirements for them. Machinery that conforms to all relevant requirements can then carry the CE[26] mark, showing compliance with the Essential Health and Safety Requirements (EHSR) of the Machinery Directive and all other relevant Directives.

Regarding the ENER Lot 21 study, air handling units and central heating appliances must be designed to avoid potential hazards, thus complying with the Directive in order to obtain the CE mark, for example.

- **Directive 2001/95/EC on General product safety**

This Directive covers all the products "which are intended for consumers or likely, under reasonable foreseeable conditions". The Directive requires producers to place only safe products on the market, and to inform about risks. A safe product is defined as one which, "under normal or reasonably foreseeable conditions of use including duration does not present any risk or only the minimum risk compatible with the product's use, considered to be acceptable and consistent with a high level of protection for the safety and health of persons". It obliges Member States to survey products on the market.

- **Directive 2006/95/EC on Low voltage equipment**
  - Type of assessment: Self declaration + Technical file
  - Scope: Safety of electrical equipment

This Directive is applicable to all electrical equipment designed for use with a voltage rating[27] 50–1000V AC and 75–1500V DC. It requires products to have protection against hazards that could arise from within the product itself or from external influences. All risks arising from the use of

[26] The CE mark certifies that a product has met European harmonised safety, health and environmental requirements

[27] Voltage ratings refer to the voltage of the electrical input or output, not to voltages, which may appear inside the equipment.

electrical equipment, including mechanical, chemical, and all other risks. Noise and vibration, and ergonomic aspects, which could cause hazards, are also within the scope of the Directive.

- **Directive 2009/142/EEC on Gas appliances**
  - Type of assessment: Third party verification
  - Scope: Safety, emissions and efficiency of gas appliances

The Gas Appliance Directive (GAD) covers appliances used for cooking, lighting, washing (including ironing), refrigeration, forced draught burners and heating bodies to be equipped with such burners, space heating for thermal comfort and hot water production (having, where applicable, a normal water temperature not exceeding 105°C.

The Directive also covers safety devices, controlling devices or regulating devices and sub-assemblies separately marked for trade use and designed to be incorporated into an appliance burning gaseous fuel or assembled to constitute such an appliance. This Directive covers various European harmonised standards (CE) for the air space heating appliances falling under the scope of ENER Lot 21 study (as described in subtask 1.2).

- **Directive 2004/108/EC on Electromagnetic Compatibility**
  - Type of assessment: Self declaration + Technical file. Verification through a competent body.
  - Scope: Emissions and immunity of electrical/electronic/technical equipment

This Directive regulates the electromagnetic compatibility of equipment. It aims to ensure the functioning of the internal market by requiring equipment to comply with an adequate level of electromagnetic compatibility.

The products studied under this study have to comply with restrictions for safety on the emissions of electromagnetic radiation and the immunity against electromagnetic radiation set by this Directive. Countries outside the EU have similar regulations although the detailed requirements differ.

- **Directive 97/23/EC on Pressure Equipment**
  - Type of assessment: Third party verification
  - Scope: pressure equipment with a maximum allowable pressure PS greater than 0.5 bars

This Directive, effective since 29/11/1999, applies to the design, manufacture and conformity assessment of pressure equipment and assemblies with a maximum allowable pressure PS greater than 0.5 bars. This Directive establishes that the pressure equipment and the assemblies under the scope may be placed on the market and put into serve only if, when properly installed and maintained and used for their intended purpose, they do not endanger the health and safety of persons. The Directive also establishes technical requirements for equipment, listed in Annex I of the Directive. The compliment of the Directive is certified by the CE Marking.

1.3.1.4 *European voluntary programmes*

- **EU Ecolabel**

The European Ecolabel is awarded on the basis of an environmental impact assessment of a category of products throughout its entire life cycle. The Ecolabelled products are inspected by independent bodies to ensure that they comply with the environmental performance criteria.

The Ecolabel programme provides criteria for ecolabelling of heat pumps. It can be awarded to electrically driven, gas driven or gas absorption heat pumps with the purpose of space heating or the opposite process space cooling, with a maximum heating capacity of 100 kW. The definitions and requirements provided by this labelling programme can work as a precursor for heat pumps regarding the requirements for energy efficiency and refrigerants.

The scope of this labelling programme relevant to present study includes the following product categories:

- Single heat pump units, and
- Heat pump systems for indoor air heating

The key criteria for the award of this Ecolabel to the heat pumps are presented in Table 1.11 below:

Table 1.11: Criteria for the award of European Ecolabel[28]

Life cycle stage	Criteria	Requirements
Manufacturing	Safety of product	The heat pump system shall not contain: Cd, Pb, Hg, Cr VI, or the flame retardants as listed in RoHS Directive 2002/95/EC
Use	User instructions for correct environmental use	A comprehensive manual for installation, maintenance, and for operating the heat pump Suitable training for installers in Member States where the product is marketed shall be ensured.
Use	Performance	The sound power level(s) shall be tested and stated in dB (A) on the information fiche. The efficiency of the heat pump unit shall exceed the minimum requirements of the coefficient of performance (COP) and the primary energy ratio (PER) as defined in Commission Decision 2007/742/EC
Use	Limitation on the use of substances harmful to the environment	Global Warming Potential (GWP) for the refrigerant: GWP ≤ 2000 (100 yrs). If GWP < 150 (100 yrs), then the COP and the PER in heating mode and the EER in cooling mode shall be reduced by 15%. The secondary refrigerant, brine or additives must not be substances classified as environmentally hazardous or constituting a health hazard as defined in the Dangerous Substances Directive 67/548/EEC and its amendments.
End of life	Durability	The availability of spare parts shall be ensured for a period of 10 years from the date of sale.

The efficiency of the heat pump shall exceed the following minimum COP values requirements in the heating mode as presented in Table 1.12 below:

Table 1.12: Minimum COP requirements for award of EU Ecolabel for heat pumps

Type of heat pump: (heat source / heat sink)	Outdoor unit [°C]	Indoor unit [°C]	Min COP	
			Electric heat pump	Gas heat pump
Air/air	Inlet dry bulb: 2 Inlet wet bulb: 1	Inlet dry bulb: 20 Inlet wet bulb: 15 max	2.9	1.27
Brine/air	Inlet temp.: 0 Outlet temp.: – 3	Inlet dry bulb: 20 Inlet wet bulb: 15 max	3.4	1.49
Water/air	Inlet temp: 15 Outlet temp: 12	Inlet dry bulb: 20 Inlet wet bulb: 15 max	4.7	2.07

[28] European Commission. The European eco-label for heat pumps, Green Store. www.ec.europa.eu/environment/ecolabel/brochures/producers/en/heat_pumps_en.pdf

EUROVENT

The EUROVENT certification programme[29] certifies the performance ratings of AHU and heat pumps according to existing European and international standards[30]. By participating in the Eurovent Certification scheme and allowing their products to be independently tested, manufacturers are also allowed to use the Eurovent Certification label.

AHUs are tested according to EN 1886 for mechanical performance and for thermal performance. The velocity of air (measured in the area of the filter section) is combined to the efficiency and the pressure losses of the heat recovery system, and the active power of fans, to define the efficiency of the unit, and a corresponding voluntary classification was issued in 2009. AHUs are grouped in following three categories:

- AHUs connected to outdoor air with a design temperature (winter time) below 9°C
- AHUs with 100% circulation air and units connected to outdoor air with a design temperature (winter time) above 9°C
- Stand-alone extract air handling units

Following characteristics of AHUs are certified by the Eurovent certification programme:

- Mechanical characteristics
  - Casing strength
  - Casing air leakage
  - Filter bypass leakage
  - Thermal transmittance of the casing
  - Thermal bridging factor
  - Acoustical insulation of casing
- Performance characteristics
  - Air flow - Available static pressure - power input
  - Octave band in-duct sound power level
  - Airborne sound power level
  - Heating capacity*
  - Cooling capacity*
  - Heat recovery*
  - Pressure loss on water side*

** If standard features of the product range*

[29] Eurovent Association. Eurovent certification. http://www.eurovent-certification.com

[30] Other product types certified by Eurovent relevant to this study were listed in section 1.1.3.1

Heat pumps are certified following tests according to the EN 14511 standard: *"Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling"*. The Acoustic testing has to follow the standard EN ISO 3741*: "Determination of sound power levels of noise sources using sound pressure. Precision methods for reverberation rooms"* considering the frequency range of interest between 100 Hz and 10 kHz. Heat pumps are grouped within the Eurovent Certification programme in the following three categories:

- Comfort Air Conditioners from 12 to 45 kW (AC 2)
- Comfort Air Conditioners from 45 to 100 kW (AC 3)
- Rooftops

The following characteristics are certified by the Eurovent Certification programme:

- Comfort Air Conditioners:
  - Total cooling capacity
  - Heating capacity for reverse cycle units
  - Energy efficiency ratio (Cooling mode)
  - Coefficient of performance (Heating mode)
  - A-weighted sound power indoor side (non ducted units)
  - A-weighted sound power outdoor side (non ducted units)
  - A-weighted sound power radiated from the duct (ducted units)
- Rooftops:
  - Net Cooling capacity
  - Net Heating capacity
  - Total Unit Power Input
  - Net Energy efficiency ratio
  - Net Coefficient of performance
  - Condenser water pressure drop (only for water cooled rooftops)
  - A-weighted Sound Power Level outside
  - A-weighted Sound Power Level in supply duct.

- **European Heat Pump association**

In order to qualify for the EHPA quality label, the heat pump in question must comply with EHPA heat pump test criteria and the distributor must provide a defined level of service. The key requirements are (list not exhaustive):

- Conformity of all main components and compliance with the national rules and regulation (CE marking)
- Minimum efficiency values defined as follows (operating points - required COP), tested in labs accredited to ISO 17025 to perform heat pump test according to EN 14511:
  - Brine to water B0/W35 - 4.30
  - Water to water W10/W35 - 5.10
  - Air to water A2/W35 - 3.10
  - Direct exchange ground coupled to water E4/W35 - 4.30
  - hot water heat pump (currently under revision)
- Declaration of sound power level.
- Existence of sales & distribution, planning, service and operating documents in the local language of the country where the heat pump is distributed.
- Existence of a functioning customer service network in the sales area that allows for a 24h reaction time to consumer complaints.
- A two year full warranty which shall include a declaration stating that the heat pump spare parts inventory will be available for at least ten years.

1.3.2 Standards and agreements at Member state level

Essentially most of the central heating appliances covered in the ENER Lot 21 study are bound by European Directives at the national levels within EU-27. However, it is useful to identify existing standards and labelling programmes which are applicable at national level in the concerned Member States.

1.3.2.1 Energy efficiency standards at Member State level

Specific standards for individual ENER Lot 21 products have only been identified in Germany. Otherwise with the implementation of the EPBD several Member States have adopted their own minimum energy efficiency standards for buildings. An overview of these is provided in the following table.

Table 1.13: Standards for energy efficiency of ENER Lot 21 products in EU Member States

Member State	Standard	Title
Denmark	DS 2187	Oil burning, fan-assisted air heaters
Germany	DIN V 4701-10	Energy efficiency of heating and ventilation systems in buildings Part 10: Heating, domestic hot water, ventilation
	DIN 33830	Heat pumps, complete absorption pump units, concepts requirements, testing, marking
	DVGW VP 120	Gas-fired adsorption heat pump
Netherlands	NEN 5128;2004, NEN 2168;2004	Minimum energy efficiency for new buildings and large renovations (sets minimum Energy Performance Coefficient (EPC) criteria)
UK	BS 5410	Code of practice for oil firing. Installations up to 45 kW output capacity for space heating and hot water supply purposes
	BS 5864	Installation and maintenance of gas-fired ducted air-heaters of rated input not exceeding 70 kW
	BS 7977	Specification for safety and rational use of energy of domestic gas appliances. Radiant/convectors.
	OFS A102	Oil Firing Appliance Standard – Room heaters with Atomising or Vaporising Burners with or without Boilers, heat outputs up to 25 kW
	OFS A103	Oil Firing Appliance Standard – Used Lubricating Oil Burners for Space and Water Heating Appliances, heat outputs up to 400 kW
	Building Regulations 2010	Domestic Building Services Compliance Guide Non-domestic Building Services Compliance Guide

DVGW: Deutscher Verein des Gas- und Wasserfaches e.V. - Technisch-wissenschaftlicher Verein (German Technical and Scientific Association for Gas and Water), www.dvgw.de
OFTEC: Oil Firing Technical Association, www.oftec.org

For non-domestic buildings heating efficiency credits may be awarded if additional measures, such as additional controls that raise the energy efficiency of the system beyond the recommended minimum standards, are also part of the heating system. For gas and oil-fired warm air heaters features such as 'optimised shut down'; 'Hi/Lo burners'; and 'modulating burners' increase the effective heat generator efficiency with 1%, 2% and 3%, respectively. For heat pumps 'appropriate sizing', 'optimised stop', 'full zone control', and 'monitoring and targeting' each raise the effective heat generator efficiency with 2%.

Table 1.14: Overview of recommended minimum standards for efficiency for ENER Lot 21 products in the UK

Type of building	Type of appliance	Relevant standard	Performance criteria
Domestic buildings	Gas-fired warm air heating	EN 778, EN 1319	-
Non-domestic buildings	Gas-fired forced convection	EN 621 (without a fan for combustion air and/or products), EN 1020 (with a fan for combustion air and/or products)	≥ 91% Net Thermal Efficiency*
	Direct gas-fired forced convection	EN 525	100% Net Thermal Efficiency*
	Oil-fired forced convection	EN 13842	≥ 91% Net Thermal Efficiency*
	Heat pumps (except absorption heat pumps and gas-engine heat pumps) for space heating	ISO 13256-1 (Ground-to-Air), EN 14511 (Water-to-Air & Air-to-Air)	≥ 2.2 COP when operating at the rating conditions given by EN 14511
	Absorption heat pumps	EN 14511	≥ 0.5 COP
	Gas-engine heat pumps	EN 14511	≥ 1.0 COP

*Efficiency is heat output divided by the calorific value of the fuel. The net calorific value of a fuel excludes the latent heat of water vapour in the exhaust, and so is lower than the gross calorific value. Efficiency test results and European standards normally use net calorific values.

1.3.2.2 *Voluntary programmes at Member State level*

- **Nordic region**
  - The Nordic Swan[31]

The Nordic Swan was introduced by the Nordic Council of Ministers. It is a common ecolabelling system for Sweden, Norway, Denmark, Iceland and Finland. It provides criteria for single heat pump units and heat pump systems. The heat pump systems include air heat pumps with a heat distribution through air ducts. The heat pump must be tested for efficiency and noise. The heating efficiency of the heat pump is tested in accordance with standard EN 14511 whereas noise is tested as per standard EN 12102. The basic criteria for the awarding of this label are:

[31] Nordic Ecolabelling (2008) Swann labelling of heat pumps, version 2.0. Available at: http://www.svanen.nu/sismabmodules/criteria/getfile.aspx?fileid=92735001

- The materials used in the heat pump must fulfil the requirements of the RoHS Directive (2002/95/EC)
- Halogenated flame retardants are acceptable only if they are necessary for electrical or fire safety, in accordance with the low voltage Directive (72/23/EEC)[32] and the standard EN 60335-1
- The refrigerant and its constituents must not have a Global Warming potential (GWP) value >2000 over a period of 100 years
- The refrigerant must be classified in accordance with EU Dangerous Substances Directive (67/548/EEC)[33] or Dangerous Preparations Directive (1999/45/EC) with respect to assessing environmental and health hazards

The performance criteria for the award of this label is the average efficiency, calculated as the produced useful heat per electricity consumption in kWh, as an average over a defined period of time, mainly during a year. The heat pump shall provide an A level as defined by the EU Energy Label for air-to-air heat pumps.

The annual average efficiency[34] for heat production shall reach at least 2.0 in the relevant climate zone. If the refrigerant in the heat pump unit is a HFC refrigerant, the Annual Average Efficiency (AAF) for heat production shall reach at least:

- GWP < 1,000, AAF = 2.25
- GWP < 2,000, AAF = 2.30

The heat pump shall be classified for use in one or more climate zones. Climate zones are defined according to the following temperature ranges:

- Climate zone 1: Annual average temperature below and up to 5°C
- Climate zone 2: Between 6 -10°C
- Climate zone 3: Between 11-15°C

Germany

The Blue Angel

The Blue Angel environmental label is sponsored and administered by the German Federal Environmental Agency and awarded by the quality assurance and product labelling institute "RAL – Deutsches Institut für Gütesicherung und Kennzeichnung". Criteria for the label are proposed by the Federal Environment Agency and decided by an independent jury.

The Blue Angel provides criteria for following:

- Electric powered heat pumps (RAL – UZ 121)[35] (for hydronic systems)

[32] The requisite is referred to Directive 72/23/EEC, which was amended by Directive 2006/95/EC.

[33] The requisite is referred to Directive 67/548/EEC, which was amended by Regulation (EC) 1272/2008

[34] Annual average efficiency = annual electricity consumption / annual produced useful heat

- **Scope:** Maximum power output of 70 kW at 40° C
- **Compliance:** Standard DIN EN 225, DVGW VP 120, DIN 33831

- Heat pumps gas operated (RAL – UZ 118)[36] **(**for hydronic systems)
  - **Scope:** Maximum power output of 100 kW at 45° C
  - **Compliance:** Standard DIN EN 12309/EN 14511

Table 1.15: Blue Angel requirements absorption and adsorption gas-driven compressors

Requirements	Standard	Criteria
Refrigerants		< 15 GWP_{100}
Emissions	Gas-fired heat pumps (0% of O_2)	NO_X ≤ 60 mg/kWh CO ≤ 50 mg/kWh
	Gas engine-driven heat pumps (5% of O_2)	NO_X ≤ 250 mg/kWh CO ≤ 300 mg/kWh
	Other combustion engine-driven heat pumps (O_2 content according to 1st BImSchV)	NO_X ≤ 250 mg/kWh CO ≤ 300 mg/kWh Total dust content ≤ 150 mg/kWh
	Heat pumps fired by other fuels (O_2 content according to 1st BImSchV)	NO_X ≤ 250 mg/kWh CO ≤ 300 mg/kWh
Energy efficiency	Energy Efficiency Ratio, DIN 4702 T8	≥ 120% (at 75/60 °C)

- **United Kingdom (UK)**
  - Energy Saving Recommended scheme[37]

The Energy Saving Recommended scheme (UK) is operated by the Energy Saving Trust. It awards labels on products that meet energy efficiency requirements. The Energy Saving Recommended scheme operates by identifying the top 20% of products in terms of their energy efficiency. Samples are tested to verify performance before being approved to display the Energy

[35] RAL: German Institute for Quality Assurance and Certification (2003) Basic Criteria for Award of the Blue Angel Environmental Label - Energy-Efficient Heat Pumps using an Electrically Powered Compressor (RAL-UZ 121). Available at: http://www.blauer-engel.de/_downloads/vergabegrundlagen_en/e-UZ-121.zip

[36] RAL: German Institute for Quality Assurance and Certification (2005) Basic Criteria for Award of the Blue Angel Environmental Label – Energy-Efficient Heat Pumps using Absorption and absorption technology or operating by use of Combustion engine-Driven compressors (RAL-UZ 118). Available at: http://www.blauer-engel.de/_downloads/vergabegrundlagen_en/e-UZ-118.pdf

[37] Energy Saving Trust. Heating and hot water. Website: www.energysavingtrust.org.uk/Home-improvements/Heating-and-hot-water/Heating-controls

Saving Recommended label. The standards are revised annually to reflect improvements in the average energy efficiency of products. DEFRA (UK Department for Environment, Food and Rural Affairs), provides the main financial support for the Energy Saving Recommended scheme. Within the ENER Lot 21 context, this program concerns heating controls (settings to determine when the heating is on, how warm it is, and where heat should be directed) which must confirm the basic recommendations in the central heating system specification (2005). Heating controls are often used to regulate hot air central heaters.

- Enhanced Capital Allowances (ECA)[38]

The Enhanced Capital Allowance (ECA) scheme is a key part of UK's government programme to manage climate change. The ECA scheme provides businesses with 100% first year tax relief on their qualifying capital expenditure. This means that businesses can write off the whole cost of the equipment against taxable profits in the year of purchase. This can provide a cash flow boost and an incentive to invest in energy saving equipment which normally carries a price premium when compared to less efficient alternatives.

For a product to appear on the Energy Technology Product List (ETPL), and therefore qualify for an ECA claim, it must meet a set of energy-saving criteria. The indirect-fired central heating products covered by the ETPL are at least 9% more efficient than a standard product whereas the direct-fired ETPL products provides minimum 10% fuel savings when compared to a standard product.

The ECA scheme applies to the following appliances covered in the ENER Lot 21 study:

- Warm Air Heating Equipment (gas or oil fired)[39]
  - Indirect-fired packaged warm air heater units
  - Indirect-fired packaged air heater modules (within an AHU)
  - Direct fired packaged warm air heaters
  - Optimising controllers for warm air heating systems
- Heat pumps
  - Air source: Split and multi-split including VRF
  - Air source: Gas-engine-driven split and multi-split including VRF
  - Air source: Packaged heat pumps
  - Water source: Split and multi-split including VRF heat pumps

The eligibility criteria for the warm air heating products is provided in the following table:

[38] Department of Energy and Climate Change, Energy technology List, ECA Scheme. Website:.www.eca.gov.uk/etl

[39] Also considered in ENER Lot 20 as non-ducted direct heating industrial unit heaters

Table 1.16: Enhanced Capital Allowance eligibility criteria

Type of warm air heating product	Requirements
Direct-fired	Incorporate a microprocessor-based controller that monitors product's outlet air temperature, and adjusts the product's operation to maintain pre-set temperature(s). Use modulating burners with a turn down ratio that is greater than, or equal to, 10:1. Be fitted with a variable speed fan controller, or a variable air volume control system, that can vary the fresh air flow through the product by a factor of at least two to one.
Indirect-fired	Net thermal efficiency ≥ 91.0%
Optimising controllers	Incorporate a microprocessor based controller that is pre-programmed to: Automatically control the air temperature in one or more zones within a building in an energy efficient manner that reflects predefined zone occupation schedules. Automatically switch warm air heating equipment on and off in accordance with the predefined occupation schedule for each of the zones being controlled. Incorporate the following automatic control mechanisms: A frost protection mechanism that monitors internal air temperature, and switches on the warm air heaters to prevent equipment and/or pipework from freezing up. A building fabric protection mechanism that monitors external or internal temperatures and switches heating on to prevent condensation from occurring. An anti-tampering mechanism that prevents the product's control strategy from being modified, and the specified automatic control mechanisms from being disabled, except during commissioning, maintenance or testing. Provide facilities that enable building managers to: Define the normal occupation times for the building and for each zone controlled (in intervals of five minutes or less), for each day of the week, including at least two periods of occupation per day (i.e. at least 14 different occupation period per week). Define the temperature set-points for each zone to +/- 1 degree centigrade. Provide facilities that enable building users to "temporarily override" the pre-set times when the warm air heating is scheduled to be switched off within an individual zone. Conform with the requirements of the EU EMC Directive

For heat pumps covered by the ECA scheme the criteria are:

Table 1.17: Criteria for the allotment of ECA to heat pumps

Type of heat pump		Efficiency criteria in heating mode
Air-to-air	Split and multi-split including Variable Refrigerant Flow (VRF) heat pumps	Heating mode COP > 3.20 (for VRF: COP > 3.70)
	Gas-engine-driven split and multi-split including VRF heat pumps	Heating mode COP > 1.30
	Packaged heat pumps	Heating mode COP > 3.20
Water-to-air	Split and multi-split including VRF heat pumps	Heating mode COP > 3.70 (for VRF: COP > 4.10)

COP: Coefficient of Performance across the range of connected capacities and including 100% (full) load in heating mode.

- **Netherlands**
  - Milieukeur programme[40]

The Milieukeur programme is a voluntary environmental labelling programme for central heating appliances in the Netherlands, set up in 1992 by the Dutch Ministry of Housing, Physical Planning and Environment, and the Ministry of Economic Affairs. Stichting Milieukeur is the agency responsible for the implementation of this labelling programme.

  - Kwaliteitskeur warmtepompen[41]

Kwaliteitskeur warmtepompen labelling programme covers the heat pumps for heating purposes in Netherlands. The criteria that have to be fulfilled for the award of this label correspond to:

- No requirements concerning the power of the heat pump
- Performance requirements according to standard NEN/EN 225
- Minimum and maximum temperature levels
- A margin of 5%, which means that after testing, the result must be within 5% of the information given in the information manual.
- Noise-level requirements

[40] Collaborative Labelling and Appliance Standard Program. S&L around the world. www.clasponline.org/clasp.online.worldwide.php?programinfo=601

[41] IDEG, WP2 Heat Pump Systems. Available at: www.ideg.info/media/docs/upload/WP2%20Heat%20Pumps.pdf

- **Sweden**
  - The P-Mark[42]

The P-mark is a quality label for heat pumps which is awarded on the fulfilment of criteria on:

- Efficiency requirements (COP at certain operation points)
- The Swedish Refrigeration Code
- Noise levels according to the Swedish Building Regulations
- CE-marking, both for electricity and pressure vessels
- Information on the manuals and installation instructions
- Quality of the manufacturing; this is controlled by surveillance inspections

- **France**
  - Promotelec

Promotelec labelling program for heat pumps is managed by the Promotelec Association. For houses equipped with heat pump systems, the heat pump must have a minimum level of performance according to the type of heat pump. If the performances are certified by the EUROVENT Association, or are published in a testing report issued by an independent laboratory, retained values are those given by the manufacturers; if not, there is a degradation coefficient depending on the technology of the heat pump. An independent company gives the label to the house after a check.

1.3.3 Third country legislation

Most of the third country identified legislations are mandatory Minimum Energy Performance Standards (MEPS). The aim of MEPS is to remove the least efficient appliances from the market. Specific test standards for energy consumption measurement are sometimes imposed in these MEPS.

1.3.3.1 Third country mandatory programmes

- **USA**
  - Federal Energy Conservation Standards

The Energy Policy and Conservation Act established two programmes in which the Department of Energy (DOE) is responsible for testing, labelling and setting Federal energy efficiency standards[43]:

[42] Swedish Heat Pump Association (2005) Heat Pumps – Technology and environmental impact. Available at: http://ec.europa.eu/environment/ecolabel/about_ecolabel/reports/hp_tech_env_impact_aug2005.pdf

[43] U.S. Department of Energy. Energy Efficiency and Renewable Energy. Website: www.eere.energy.gov/

- the Energy Conservation Program for Consumer Products Other than Automobiles (10 CFR Part 430)
- the Energy Efficiency Program for Certain Commercial and Industrial Equipment (10 CFR Part 431)

ENER Lot 21 products covered by these programmes include warm air heaters and heat pumps. The efficiency standards proposed by DOE can be found in Table 1.18. The standards for commercial equipment have been based on the ASHRAE Standard 90.1-2007: Energy Standard for Buildings except Low-Rise Residential Buildings. For furnaces the energy efficiency levels have not changed, but design requirements have been introduced. These specify that furnaces must use an interrupted or intermittent ignition device, have jacket losses (losses to the surroundings from the furnace excluding flue losses) no greater than 0.75% of the input rating, and use a power vent or flue damper. The Energy Policy Act of 2005 (EPACT 2005) amended the DOE programmes to also include very large commercial package air conditioning and heating equipment rated at or above 240,000 BTU/h (70 kW) and below 750,000 BTU/h (220 kW) cooling capacities (see Table 1.19). The Energy Independence and Security Act of 2007 (EISA 2007) further amended the definitions of commercial package air-conditioning and heating equipment and their energy efficiency standards (see Table 1.20).

▷ Energy Guide Label

The Federal Trade Commission's Appliance Labeling Rule (16 CFR Part 305) requires manufacturers to state the estimated annual energy use for a variety of energy-using appliances. The so-called Energy Guide Label allows consumers to compare different models on the market and help them choose the most efficient. Currently central heating furnaces and heat pumps are covered by the Energy Guide Label.

Table 1.18: Proposed MEPS for warm air central heating products by the US DOE

Appliance	Type	Capacity	Test standard	Performance criteria
Furnace	Non-weatherized gas furnaces [a]	Input rating < 225,000 BTU/h (≈ 66 kW) (Residential furnaces)	DOE 10 CFR Part 430, ANSI Z21.47	≥ 80% AFUE
	Weatherized gas furnaces [a]			≥ 81% AFUE
	Mobile home gas furnaces [a]			≥ 80% AFUE
	Non-weatherized oil furnaces [a]		DOE 10 CFR Part 430, UL 727	≥ 82% AFUE
	Weatherized oil furnaces [a]			≥ 78% AFUE
	Mobile home oil furnaces [a]			≥ 75% AFUE
	Gas-fired commercial warm air furnaces [b]	Input rating ≥ 225,000 BTU/h (≈ 66 kW) (Commercial furnaces)	ANSI Z21.47	≥ 80% Thermal efficiency
	Oil-fired commercial warm air furnaces [b]		UL 727	≥ 81% Thermal efficiency
Heat Pump	Split system heat pumps [c]	Cooling capacity < 65,000 BTU/h (≈ 19 kW)	ARI 210/240	≥ 7.7 HSPF
	Single package heat pumps [c]			≥ 7.7 HSPF
	Small duct, high velocity systems			≥ 7.7 HSPF
	Through-the-wall air conditioners and heat pumps split system [c]	Cooling capacity ≤ 30,000 BTU/h (≈ 8.8 kW)		≥ 7.1 HSPF (≥ 7.4 HSPF from 23/01/2010)
	Through-the-wall air conditioners and heat pumps single package [c]			≥ 7.0 HSPF (≥ 7.4 HSPF from 23/01/2010)
	Space constrained products-heat pumps	Cooling capacity ≤ 30,000 BTU/h (≈ 8.8 kW)		≥ 7.4 HSPF

AFUE: Annual Fuel Utilisation Efficiency
TE: Thermal efficiency
HSPF: Heating Seasonal Performance Factor, the total heating output of a heat pump (including supplementary electric heat) during the normal heating season (in BTU) as compared to the total electricity consumed (in watt-hours) during the same period

[a] Effective 19 November 2015
[b] Effective 1 October 2008
[c] Effective 23 January 2006

Table 1.19: Minimum energy performance standards as stated in EPACT 2005 (effective from January 2010)

Appliance	Type	Capacity	Test standard	Performance criteria
Heat Pump	Small commercial package air conditioning and heating equipment	65,000 BTU/h (≈ 19 kW) ≤ cooling capacity < 135,000 BTU/h (≈ 40 kW)	ARI 340/360	≥ 3.3 COP
	Large commercial package air conditioning and heating equipment	135,000 BTU/h (≈ 40 kW) ≤ cooling capacity < 240,000 BTU/h (≈ 70 kW)		≥ 3.2 COP
	Very large commercial package air conditioning and heating equipment	240,000 BTU/h (≈ 70 kW) ≤ cooling capacity < 760,000 BTU/h (≈ 223 kW)		≥ 3.2 COP

COP: Coefficient of Performance at a high temperature rating of 47 °F (8.3 °C) dry-bulb.

Table 1.20: Prescribed standards for commercial heat pumps under EISA 2007 (effective from January 2010)

Appliance	Type	Capacity	Test standard	Performance criteria
Heat Pump	Single Package Vertical Air Conditioners and Single Package Vertical Heat Pumps	Cooling capacity < 65,000 BTU/h ≈ 19 kW	ARI 390	≥ 3.0 COP
		65,000 BTU/h (≈ 19 kW) ≤ Cooling capacity < 135,000 BTU/h (≈ 40 kW)		≥ 3.0 COP
		135,000 BTU/h (≈ 40 kW) ≤ Cooling capacity < 240,000 BTU/h (≈ 70 kW)		≥ 2.9 COP

COP: Coefficient of Performance at a high temperature rating of 47 °F (8.3 °C) dry-bulb.

- **Canada**
  - Energy Efficiency Regulations

Mandatory programmes for ENER Lot 21 products in Canada relate to MEPS for gas and oil fired central furnaces and heat pumps[44]. The standard for gas-fired furnaces applies to automatically operating gas-fired central furnaces for installation in residential, commercial, and industrial structures, including furnaces for direct vent (not including furnaces for mobile homes and recreational vehicles). These furnaces may include a cooling unit, hence providing both central heating and cooling. It applies to furnaces burning propane or natural gas and having an input rate not exceeding 225,000 BTU/h (66 kW). The minimum performance level, Annual Fuel Utilization Efficiency (AFUE), for gas-fired furnaces is 90% and for furnaces intended to be

[44] Natural Resources Canada. Office of Energy Efficiency. Website: www.oee.nrcan.gc.ca

installed outdoors it is 78% AFUE. The CSA P.2-07 test standard is used to determine the corresponding AFUE of the furnace. For oil-fired furnaces with the same input ratings the minimum AFUE is also 78%. The test standard for oil-fired furnaces is CSA B212-00.

For heat pumps there are a range of minimum energy efficiency standards in place according to the source and type of heat pump. An overview of existing MEPS in place for ENER Lot 21 products in Canada is provided in Table 1.21.

Table 1.21: Energy efficiency regulations for ENER Lot 21 products in Canada

Appliance	Type	Test standard	Performance indicator	Performance criteria
Furnace	Gas-fired (≤ 65.92 kW using single-phase electric current)	CAN / CGA P.2-07	AFUE	≥ 90% ≥ 78%a ≥ 78%b
	Gas-fired (≤ 65.92 kW using three-phase electric current)	CSA 2.3-01	AFUE	≥ 78%
			TE	≥ 80%
	Gas-fired (65.92 kW ≤ input rate ≤117.23 kW)	CSA 2.3-01	TE	≥ 80%
	Oil fired (input rate ≤ 66 kW)	CAN / CSA-B212-00	SEUE	≥ 78%
Heat Pump	Air source - Single packaged & split systems (≤ 19 kW)	CSAC656-05	HSPF	≥ 6.7 (Region V - Canada)
	Air source – small duct, high velocity (≤ 19 kW)	CSAC656-05	HSPF	≥ 5.9 (Region V - Canada)
	Ground or water source – closed loop (≤ 40 kW)	CAN / CSA 13256-1	COP	≥ 3.0
	Ground or water source – open loop (≤ 40 kW)	CAN / CSA 13256-1	COP	≥ 3.6
Heat Pump	Ground source – direct expansion (DX)	CAN / CSA 13256-1	COP	≥ 3.5
	Commercial and industrial (19 kW ≥ input rate ≤ 40 kW)	CAN / CSA-C746-98	COP	≥ 3.2 (COP at 8.3 oC) ≥ 2.2 (COP at -8.3 oC)
	Commercial and industrial (19 kW ≥ input rate ≤ 40 kW)	CAN / CSA-C746-98		≥ 3.1 (COP at 8.3 oC) ≥ 2.0 (COP at -8.3 oC)
	Packaged terminal air conditioners and heat pumps	CAN / CSA-C744-04	COP	≥ 3.2 (new construction) ≥ 2.9 (replacement)

TE: Thermal efficiency
SEUE: Seasonal energy utilisation efficiency
HSPF: Heating seasonal performance factor
[a] (outdoor units with an integrated cooling component)
[b] (through-the-wall units with an integrated cooling component (from 2013 ≥ 90%))

- EnerGuide label

In addition to the minimum energy performance standards, the mandatory EnerGuide labelling programme is another important energy efficiency initiative in Canada. EnerGuide allows consumers to compare the energy efficiency of the many different models of household appliances or heating and cooling products sold in Canada. Gas and propane fired furnaces and air-to-air heat pumps are ENER Lot 21 products which are included in the EnerGuide rating system.

- **Australia/New Zealand**
  - Gas appliance Star Rating Scheme

The Gas appliance Star Rating Scheme (est. 1980) is administered by the Australian Gas Association (AGA). In order for appliances to be approved for sale, technical information must be provided to the AGA. This information allows an assessment of energy efficiency that determines the appliances star rating (Energy (MJ/year), 1 to 6 stars). The rating system for ducted gas space heater uses Annual Energy Consumption (AEC) as the performance parameter for appliance labelling. The AEC of a heater is calculated based on 600 hours of heating operation per year at a heating load of 0.2 MJ/h/m^3 (55.6 W/m^3). The Star rating represents the seasonal operating efficiency of the appliance working at heavy and light loads, and takes account of the standby energy consumption. An appliance with a seasonal operating efficiency of 50% is allocated 1 Star, with each additional Star for a 10% increase in efficiency to 90%, which is allocated 5 Stars. A minimum thermal efficiency of 70% is required by the standard (AS 4556, AG 106).

  - Top Energy Saver Award Winner (TESAW) (2004)

Appliances are granted this award if they achieve the efficiency benchmark set by the government (usually the top 5-10% of models on the market). The TESAW label is an endorsement label - it is complementary to the normal star rating label. This enables consumers to recognise the most efficient models on the market instantly. Each year, government officials review the energy efficiency of all products on the market. In consultation with industry, they set minimum energy efficiency criteria (usually a minimum star rating) for TESAW awards for the coming year.

Table 1.22: TESAW award criteria in year 2006

Appliance	Fuel	Standard	Performance criteria
Indirect gas fired ducted	Natural gas	AS 4556-2000	≥ 5 Stars
Heat pump on heating mode	Electricity	AS/NZS 3823.2	≥ 4 Stars

1.3.3.2

1.3.3.3 *Third country voluntary programmes*

- **ENERGY STAR Labelling Program (USA)**

ENERGY STAR is a joint programme of Department of Energy (DOE) and the US Environmental Protection Agency (USEPA). It is an energy endorsement label which allows end-users to identify energy efficient products in line with the ENERGY STAR energy efficiency specifications for qualifying products as presented in Table 1.23.

Products that have earned the Energy Star designation prevent greenhouse gas emissions by meeting energy-efficiency specifications set by the government. Different ENERGY STAR programs exist which are relevant in the scope of ENER Lot 21:

- **Oil and Gas Furnaces:** These products are the most common residential heating system in the USA. ENERGY STAR labelled furnaces signifies that they are up to 15% more efficient than standard models.
- **Electric air-source heat pumps:** ENERGY STAR qualified heat pumps have a higher Seasonal Efficiency Rating (SEER) and Heating Seasonal Performance Factor (HSPF) than standard models, which makes them about 8% more efficient than standard new models and 20% more efficient then what you may have in your home. Typical residential systems are "split" with a separate indoor evaporator unit in the furnace ducting and an outdoor condenser unit. There are also "single package" systems that have the evaporator and condenser in one unit.

- **ENERGY STAR and ENERGUIDE Labelling Program (Canada)**

The ENERGY STAR energy efficiency label is also recognised in Canada. It follows the same performance criteria for furnaces, but takes the colder Canadian climate into consideration for heat pump heating efficiency.

Table 1.23: Key product criteria for award of ENERGY STAR label in USA (and Canada)

Appliance	Type	Test standard	Performance indicator	Performance criteria
Furnace (< 225,000 BTU/h ≈ 66 kW)	Gas fired forced air	ANSI / ASHRAE 103-1993	AFUE45	≥ 90 %
	Oil fired forced air	ANSI / ASHRAE 103-1993	AFUE	≥ 85 %
Heat Pump (< 65,000 BTU/h ≈ 19 kW)	Split systems	AHRI 210/240, CSAC656-05	HSPF	≥ 8.2 (Region IV - US) ≥ 7.1 (Region V - Canada)
	Single packaged units	AHRI 210/240, CSAC656-05	HSPF	≥ 8.0 (Region IV - US) ≥ 7.0 (Region V - Canada)
	Geothermal – closed loop water-to-air	ISO 13256-1	COP	≥ 3.3 (from 2011 ≥ 3.5) (from 2012 ≥ 3.6)
	Geothermal – open loop water-to-air	ISO 13256-1	COP	≥ 3.6 (from 2011 ≥ 3.8) (from 2012 ≥ 4.1)
	Direct Geoexchange (DGX) heat pump	AHRI 870	COP	≥ 3.5 (from 2011 ≥ 3.6)

1.3.4 Summary subtask 1.3

Subtask 1.3 briefly presented the existing legislation and labelling programs relevant to ENER Lot 21 products at EU-27 level including non-EU countries' legislations. At the European Union level, legislation covers the scope of ENER Lot 21 products, but most of them only require the central heating appliances to adhere to safe operation during use phase, impose binding environmental regulations for end of life disposal and also to avoid use of certain hazardous substances during manufacturing etc. The most relevant legislation at the European Union level covering the aspect of rational use of ENER Lot 21 products is EPBD 2010/31/EU on minimum energy performance requirements in buildings.

Voluntary labelling agreements for ENER Lot 21 were identified in Germany, Netherlands, UK, the Nordic countries, USA and Canada. MEPS programmes in other countries around the world already provide energy performance criteria for certain products covered in the ENER Lot 21 study, especially gas and oil fired warm air heaters and air-to-air heat pumps.

[45] AFUE does not include the heat losses of the duct system or piping, which can be as much as 35% of the energy for output of the furnace when ducts are located in the attic.

1.4 Conclusions Task 1

Task 1 presents an overview of the existing product categories of commonly used hot air-based appliances for central heating purposes. An elaboration of the considerations to define the scope of this ENER Lot 21 study justifies the proposal to limit this study to air-based central heating appliances having a power capacity of up to 200 kW in the case of heat pumps and 1,200 kW in the case of warm air heaters.

Central heating products that use hot air to distribute heat are defined as appliances that convert electricity, gaseous or liquid fuels into heat and then distribute the hot air via ducts around a large indoor space or building. The following types of products are preliminarily considered to be within the scope of this study:

- Warm air heaters
  - Gas heaters
  - Liquid-fuel
  - Multi-fuel
  - Electric
- Heat pumps (above 12 kW cooling capacity)
  - All-electric heat pumps
  - Gas-engine heat pumps

This selection and classification of the scope only serves as a preliminary basis for the following tasks of the preparatory study, and will be revised and adapted according to the conclusions of the different tasks.

Although it may be argued that heat pumps (even air-to-air heat pumps) are not air-based central heating products as fluid refrigerant is used to transfer heat, heat pumps (also called reversible air-conditioners) that provide hot air (above 12 kW cooling capacity) are considered to be part of this study. The cooling functionality of these products will be studied in the ENTR Lot 6 study on air-conditioning and ventilation systems. Heat pumps below 12 kW of cooling capacity were already studied in the ENER Lot 10 preparatory study on domestic air conditioners, which included both cooling and heating functions.

Most interpretations of the standards and legislation at European level studied in this task seem to limit their scope to safety and environmental criteria with very little or no information on energy efficiency. Some of the existing European standards that provide guidelines for testing energy efficiency are focused on steady state efficiency and do not include seasonal performance. International standards and labelling options that specify energy efficiency requirements do however exist. They will provide inspiration for testing conditions and measurement methods for later on in this study.

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