About Nordic Ecolabelled

Heat pumps

Revision proposal for version 3.0,

Background to requirement for ecolabelling

12 November 2012

Nordic Ecolabelling

Nordic Ecolabelled Heat pumps – Background to ecolabelling

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1 Summary

Nordic Ecolabelling has since the 15th June 1998 had criteria for heat pumps, and version 2 was approved on 14 March 2007 and applies to 31 March 2014 (version 2.3). These criteria are now revised by the Nordic Ecolabelling organisations, and a proposal for new criteria is sent out for review from 12th November to 14 January 2013. This document describes the background for ecolabelling of heat pumps, and the level of the individual requirements set. The market situation for heat pumps, and other existing labelling systems are also described.

The motivation for ecolabelling of heat pumps is primarily to help consumers in the moment of purchase. Heat pumps are today well-developed and mature technology, but it still has considerable development potential in terms of more climate-friendly refrigerants and reduced emissions of these, increased energy efficiency and greater reliability. Nordic Ecolabelling has had a strong focus on life-cycle thinking when the criteria are made. A heat pump helps reducing energy consumption for heating buildings and hot water, but the greatest environmental impact will nevertheless be in the user phase for the heat pump in terms of the energy used there. It is therefore important that the electricity is used as efficiently as possible. Heat pumps also have negative environmental impact in other life cycle phases, such as during material extraction, production and abolition. This is why the proposal has more requirements for the production process and the use of materials in addition to requirements for energy efficiency than the current version. Other important requirements are low noise level, extended warranty periode and good information to the customer and installer. The product definition is from version 2.3 to 3.0 more clearly defined, but also restricted in terms that heat pump systems (heat pumps paired with other energy sources) can no longer be ecolabelled. Only single aggregates can now be Swan labelled.

The heat pump market uses environmental claims to a large extent during sales of heat pumps, but it is not always these allegations are just as easy to deal with for a consumer. It is advertised for example that a heat pump does not contain ozone-depleting refrigerants, which has been illegal to sell for several years. Unfortunately, the use of refrigerants with low climate effect (low GWP, Global warming potential) is not very common yet. It has therefore not been possible to tighten this requirement particularly, but Nordic Ecolabelling wishes to encourage this development and therefore imposes slightly stricter requirements for energy efficiency for heat pumps with refrigerants with has a GWP value of more than 150 in the draft proposal. There are Nordic differences to what extent heat pumps are taken into use. Sweden has approximately 900 000 heat pumps installed in 2011 with a yearly heat production of 23 TWh/year, of which approximately 15 TWh (2/3) are retrieved from the environment. Finland has 372 000 heat pumps installed, divided between 300 000 air/air heat pumps, 17 000 exhaust heat pumps, 50 000 geo thermal heat pumps, and 50 000 air/water heat pumps. Norway has somewhat more installed heat pumps than Finland, while Denmark has traditionally been a bit skeptical due to the large share of coal-based electricity production. This is about to be changed because of increased production of wind power.

EU Ecodesign and Energy Labelling Directive regulate the market towards more energy efficient products and better information to consumers. Nordic Ecolabelling

requires that air/water and brine/water heat pumps should be 1 to 2 classes better than the EU minimum requirements depending on how low climate impact the refrigerant has. For air/air heat pumps it requires 2 to 3 classes better than the EU minimum requirements depending on how low climate impact the refrigerant has. Test parameters of the EU Ecodesign and Energy Labelling Directive relate to "Average" which refers to the climate in Strasbourg. Nordic Ecolabelling also requires that the pump meets a certain level of requirement in climate zone C, "colder", which refers to the climate in Helsinki. Heat pumps are also regulated by the government through the Machinery Directive, Ozone Regulation, F-gas Regulation, REACH Regulation, WEEE Directive, RoHS 2 Directive, different standards and national building regulations.

There are also a lot of other labelling systems for heat pumps, for example the ecolabels EU Ecolabel and Blue Angel. The European heat pump industry's umbrella organization, EHPA (European Heat Pump Association), has developed a quality label for heat pumps, in Denmark there is a "positive list" for heat pumps at Danish Technological Institute and the U.S. Energy Star has criteria for heat pumps.

2 General facts about the criteria

2.1 Products that can be labelled

Product group definition

The criteria make it possible for series manufactured electric heat pumps for space heating, with or without the option of heating hot water for household use, to use the Nordic Ecolabel.

Heat pumps bearing the Nordic Ecolabel are individual units of the following types:

1. For heating water up to 70 kW
    a. air-water heat pumps (heat source: outdoor air)
    b. exhaust air heat pumps (heat source: indoor air)
    c. liquid-water heat pumps (heat source: geothermal heat, lake water/fresh water or waste heat from e.g. greywater)
2. For heating of air up to 12 kW:
    d. air-air heat pumps (heat source: outdoor air)

There is no lower output limit for Nordic Ecolabelling of heat pumps. The criteria document makes continuous reference to the heat pump type definitions used in European work on the Ecodesign Directive. LOT 1[1] (product categories of the Ecodesign Directive) contains a suggested Ecodesign and Energy Labelling Regulation for air-water heat pumps and liquid-water heat pumps. The Ecodesign Regulation, (206/2012/EU), and the Energy Labelling Regulation, (626/2011/EU), outline requirements for heat pumps with air-air heat pumps.

These heat pumps cannot be assigned the Nordic Ecolabel:

[1] product categories of the Ecodesign Directive, at the end of the document is a list of various abbreviations

- Units with an output greater than 70 kW / 12 kW for heating air
- Units used solely for cooling;
- Gas powered heat pumps
- Heat pumps intended solely for drying
- Heat pumps covered by LOT 2 and ENER LOT 21.

Basic information on heat pumps can be found in Annex 1. Annex 2 provides a brief description of the most common terms used to indicate energy efficiency and climate impact for heat pumps, such as COP, SCOP, ETA (η), SEER, EER, SPF, PEF and TEWI; while Annex 3 lists standards and test methods of relevance.

2.2 Reasons for Nordic Ecolabelling

Background

There has been a lot of attention paid to heat pumps over the last few years as a way of promoting more eco-friendly heating. The advantage of heat pumps is that for every kWh of electricity consumed, several kWh will be produced as heat energy (up to 5 times as much). The principles of how heat pumps work are described in Annex 1. This energy can be used to heat buildings or hot water. Nordic Ecolabelling has opted to define criteria for application of the Nordic Ecolabel so that the most efficient, most eco-friendly heat pump are clearly apparent to ecologically aware customers/buyers. These heat pumps are adapted to suit needs and the climate in which they are used. Faults in heat pumps and incorrect use of heat pumps do not bring about the anticipated environmental benefits.

ELnet in Denmark has undertaken a survey[2] using a future scenario based on increased wind energy, electric cars and heat pumps. In this survey, it is worked out that energy consumption could be reduced significantly if, for example, much of our energy consumption outside of the district heating area were to be covered by heat pumps. However, it is also underlined that the choice of technology for household heat pumps is crucial. The desired effect will not be achieved using air-to-air heat pumps, although it can be using hydronic heat pump systems such as geothermal heat pumps.

Whether heat pumps are an eco-friendly alternative to other heating is largely dependent on their output. According to a survey carried out by the Swedish Society for Nature Conservation, the output of a heat pump is dependent on the following[3]:

- The heat pump has to be efficient, with a high COP (coefficient of performance) and SPF (Seasonal Performance Factor). (These factors are described in Annex 2)
- It has to suit the distribution system in place
- It has to be correctly dimensioned in respect of the heating requirement
- It has to work well in the climate zone in which you live. (See Section 4.4 for climate zones.)
- Competent fitters must undertake installation and adjustment

[2] Elnet 2009, "Effektiv andvendelse af vindkraftbasert el i Danmark".
[3] Roger Nordman: Undersökning av Värmepumpars miljöpåverkan, Swedish Society for Nature Conservation 2007, ISBN 91-85533-57-2, available from http://www.naturskyddsforeningen.se/upload/varmepumpars_miljopaverkan.pdf (visited on 26.02.2012)

Therefore, it is very important to take these factors into account when developing criteria for heat pumps. Other factors such as heat uptake effect from the heat source and efficient distribution of the heat are important, but it will not be possible for Nordic Ecolabelling to have direct control over planning/system construction.

Nordic Ecolabelling´s criteria are life cycle-based. This means that the environmental impact of all phases of the life of the product are included in the considerations of the criteria for the product in question, but it is not possible for the Nordic Ecolabelling to control all these factors; and hence a number of requirements have no absolute limits. Nordic Ecolabelling does not create its own life cycle assessments (LCAs), but it does use LCA studies carried out previously and also carries out minor product screening.

Life cycle analyses

There are not many LCA studies for heat pumps: the last one found is an LCA study dating back to 2005[4] which compares various types of heating for single-family homes. Moreover, the Swedish Society for Nature Conservation – as noted previously – has worked in cooperation with the Swedish Consumer Agency to carry out a survey in 2007 into the environmental impact of heat pumps[5]. This indicates that economic factors that will determine the choice of heat sources are:

- Energy prices for the various competing alternatives
- Grants, subsidised loans or similar
- Investment costs
- Do developers have a vested interest in reducing operating costs, or are then most concerned about the investment costs? What chances do users have to influence operating costs?

Life cycle screening can identify the phases of the life cycle at which the greatest environmental impact occurs from a given product. Moreover, it is necessary for us to decide whether the environmental factors found are relevant, whether there is any potential for improvement, and whether there is any element of controllability. The life cycle phases will be reviewed in brief below:

Phases in the life cycle of a heat pump:

- *Extraction of raw materials*
- *Production phase*
- *Usage phase*
- *Disposal phase*
- *Transport phase*

The life cycle phases are viewed below in context with RPS (relevance, potential and steerability). Nordic Ecolabelling uses RPS as a tool for finding out whether the environmental problems are relevant, whether there is any potential for improvement, and whether a possible licensee will have steerability in order to utilise this potential for environmental improvements.

[4] Livscykelanalys av Villauppvärmning, Hans Bengtsson, thesis (20 HEC), Chemical Environmental Science, Chalmers University of Technology, Gothenburg, May 2005.
[5] Same as footnote 2.

Materials in heat pumps

A heat pump comprises of a number of different materials. An inventory from the report "Undersökning av Värmepumpars miljöpåverkan" by the Swedish Society for Nature Conservation and SP, dated 2007[6], indicates that the vast majority of materials in a geothermal heat pump are metals. The metals listed are specified as percentages by weight: steel (57.4 %), stainless steel (8.5 %), cast iron (10.6 %), aluminium (0.9 %), copper (8.4 %), brass (0.9 %). It also includes insulation (4.7 %), dye powder (epoxy, polyester, 3.0 %), plastic (PE, PVC in cables, HDPE in electronics, 1.5 %), ester oil (0.6 %), refrigerant (such as hydro fluorocarbons, 0.6 %), cardboard (for transportation, 1.0 %), wood (pallet for transportation, 3 %).

In the EU's preparatory study for Ecodesign requirements, the reports for Task 4, "Technical analysis of existing products", normally provide a bill of materials. This has not been found in the reports for LOT 1 and LOT 10 (see Section 2.5 Regulatory requirements), which are applicable for heat pumps that will be included in Nordic Swan criteria. However, the Task 4 report for ENER LOT 21[7] (Central heating products that use hot air to distribute heat) provides the following materials composition for a "single split heat pump" weighing 128 kg: steel 45.0 %, other metals (non-ferrous metals) 30.5 %, plastic 13.5 %, electronics 9.5 % and other materials, approx. 1.5 %. The packaging weighs 11.5 kg and is made up of cardboard (60.5 % by weight), wood (21.5 %) and plastic (17.5 %).

The report for Task 5, which is minuted at the last meeting (final stakeholder meeting, 17 April 2012) in the work with ENER LOT 21[8], shows that the materials included in air-to-air heat pumps (single split heat pumps), in relation to the other life cycle phases, have the greatest environmental impact linked with process water, waste, volatile organic compounds (VOCs), persistent organic pollutants (POPs), heavy metals, polycyclic aromatic hydrocarbons (PAHs), particulate emissions and eutrophication. The production of materials contributes more than 20 % of the total environmental impact for three of the 17 environment categories assessed.

For the production of metals, plastics and electronics, there are relevant environmental problems where there is potential for improvement. These materials may include components made of cast iron, stainless steel and piping made of aluminium and copper. Different alloys may be used to reduce weight or prevent corrosion. The covers of heat pumps may be made from coated sheet steel. Heat pumps are made of parts such as pumps, condensers, evaporators, expansion valves, pipe fittings and electronics.

In earlier versions of the criteria, besides the regulatory requirements of the RoHS directive, specific requirements have only been laid down for plastics (flame retardants and plasticisers) and to refrigerants and secondary refrigerant. One

[6] Roger Nordman: Undersökning av Värmepumpars miljöpåverkan, Swedish Society for Nature Conservation 2007, ISBN 91-85533-57-2, available from http://www.naturskyddsforeningen.se/upload/varmepumpars_miljopaverkan.pdf (visited on 26.02.2012)

[7] Preparatory Studies for Ecodesign Requirements of EuPs (III), ENER LOT 21 – Central heating products that use hot air to distribute heat – Task 4: Technical analysis of existing products – March 5, 2012, page 55. Available from: http://www.ecoheater.org/lot21/documents.php (visited on 2 May 2012)

[8] Ecodesign Preparatory Studies, LOT 21: Central heating products that use hot air to distribute heat (other than CHP) Final Stakeholder Meeting Brussels Presentation – 17 April 2012. Available from: http://www.ecoheater.org/lot21/documents.php (visited on 2 May 2012)

restriction when it comes to laying down requirements concerning for metals is that the production chain may be long, with a lack of traceability in the chain. In the case of metals, it is usual to check the material quality, but not the origin all the way back to the extraction of the raw materials for the materials. Manufacturers of heat pumps which compile various components may experience difficulties in making demands with regard to the production of the metals or plastics included in these components. Nordic Ecolabelling is of the opinion that the manufacturers of heat pumps should have more opportunity to make demands in terms of surface coatings of – for example – the metal in the heat pump cover, additives in plastics and chemicals used when assembling the heat pump.

Chemicals used when assembling the heat pump and for surface treatments can include lubricants; cleaning products for the metals (degreasing agents); chemicals for galvanisation, nickel plating, chrome plating and lacquering; adhesives; sealants; putties, etc. There is potential for environmental optimisation here, and it is important for Nordic Ecolabelling to specify requirements which restrict or prevent the use of chemicals hazardous to the environment or to human health wherever possible. It is reasonable to assume that manufacturers can influence the surface coating of the metal used for covers, etc. and the chemical products used during assembly.

Energy consumption during the production phase
The production phase will, for example, include energy consumption, but this will be marginal in relation to the usage phase for a heat pump. Nordic Ecolabelling is working with energy/energy consumption, as well as associated environmental effects such as global warming, acidification, eutrophication, etc. Life cycle studies performed, as previously noted (Section 2.2), have revealed that most environmental impact takes place while the device is being used. This is also confirmed in the information provided at the last meeting when working on LOT 21[9], in which it states that the environmental impact of the production phase is negligible from a life cycle perspective, compared with the other phases. However, because manufacturers use many different subcontractors, it is very difficult for licensees to produce energy data for the various materials and semi-finished products.

Usage phase
An air-to-air and an air-to-water heat pump's average service life were deemed to be 8-10 years in 1998. 15-25 years for liquid-to-water. However, it is necessary to be aware that some components (mainly the compressor) may need to be replaced earlier[10]. Heat pumps often run on electricity, so it is during the usage phase that the heat pump will have the greatest environmental impact, viewed from a life cycle perspective.

For the types of heat pump estimated to have a service life of 8-10 years, the environmental impact in the material, production and disposal phases will of course be greater than for the type expected to have a service life of up to 25 years. But regardless of type, it can be found from the studies to which the project team had access that most of environmental impact comes from the usage phase, i.e. the

[9] The same as above.
[10] Roger Nordman: Undersökning av Värmepumpars miljöpåverkan, Swedish Society for Nature Conservation 2007, ISBN 91-85533-57-2, available from:
http://www.naturskyddsforeningen.se/upload/varmepumpars_miljopaverkan.pdf (visited on 26.02.2012)

consumption of electricity. Maintenance and other consumption, such as filters, are negligible by comparison[11]. The environmental impact of electricity consumption will be dependent on where the electricity is produced. The survey from the Swedish Society for Nature Conservation, among others, makes it clear that there is a very big difference between EU mix, Sweden mix or marginal electricity. "Marginal electricity" means the additional energy production which starts or stops at short notice when demand changes. In the Nordic region, many people think this refers to coal-fired power, but researchers in the Nordic region do not agree on which technology (-ies) are marginal in terms of electricity, and so this value cannot be determined without ambiguity. Moreover, the output of heat pumps is dependent on them being dimensioned correctly for the purposes required, as well as being installed correctly and maintained during the usage phase. There is also a risk of leaking refrigerants, which are often potent greenhouse gases. Thus it is relevant to make demands of low energy consumption and efficient energy utilisation during the usage phase. Noise pollution from heat pumps is rarely assessed in environmental studies, but nevertheless this is an important factor in the usage phase which ought to be restricted. Many houses are built nowadays without basements, so liquid-to-water heat pumps end up being positioned closer to living rooms and bedrooms.

Moreover, it will be relevant to ensure that the heat pump is suitable for the purpose for which it is intended, and installed correctly. There is potential here, as Nordic Ecolabelled heat pumps will make it easier for consumers to select the products which are most eco-friendly and energy-efficient. It is typically very difficult to ensure steerability during the usage phase and Nordic Ecolabelling has no way of making sure that the product is used correctly. However, requirements can be specified which make correct usage more likely. Correct usage can be made more likely by ensuring that a good installation and user guide are provided and by laying down requirements for the heat pump to be installed by a qualified fitter.

Disposal phase

As stated previously, most of a heat pump is made up of various materials that can be reused. It also has insulation, dye, plastics, oil, refrigerant, cardboard and wood. It will largely be relevant to make demands in terms of disposal of the heat pump: there is major potential in ensuring that the various materials can be reused and that the refrigerant is disposed of properly. According to Task 5[12] in the ecodesign study for ENER LOT 21, in which air-to-air heat pumps are assessed, it is apparent that the waste phase results in environmental impact in respect of waste, greenhouse gases and particulate emissions. Leakages of refrigerants during the usage phase are added to the waste phase. According to the report, there are major disagreements on how great these leakages are. In a report from the DEFRA[13], the UK Department for Environment, Food and Rural Affairs, an annual leakage factor of 0.3 % is stated. The Task 5 report for ENER LOT 21 indicates that emissions of the refrigerant results in

[11] Ecodesign Preparatory Studies, LOT 21: Central heating products that use hot air to distribute heat (other than CHP) Task 5 Definition of Base-Cases, 26 March 2012. Available from: http://www.ecoheater.org/lot21/documents.php (visited on 2 May 2012)

[12] Ecodesign Preparatory Studies, LOT 21: Central heating products that use hot air to distribute heat (other than CHP) Task 5 Definition of Base-Cases, 26th March 2012. Available from: http://www.ecoheater.org/lot21/documents.php (visited on 2 May 2012)

[13] 2011 Guidelines to Defra / DECC's GHG, Conversion Factors for Company Reporting: Methodology Paper for Emission Factors, August 2011. Available from: http://www.defra.gov.uk/publications/files/pb13625-emission-factor-methodology-paper-110905.pdf (visited on 2 May 2012)

less than one-sixth of the greenhouse gas emissions, compared with greenhouse gas emissions from the production of electricity used. One of the intentions of the F -Gas Regulation (842/2006/EC) is to ensure reduced emissions of hydro fluorocarbons from cooling and heat pump systems by way of requirements for certification of personnel and companies, accounting for gas consumption, leakage controls and clear labelling of systems[14]: for more information on the F-Gas Regulation, see also Section 2.5.

However, there is not much steerability for the Nordic Ecolabel criteria in the disposal phase, but in order to make correct disposal possible the criteria should stipulate requirements making it easy to disassemble the heat pump and sort out the various materials. Requirements can also be laid down concerning the contents of an instruction manual which can indicate how the product should be disposed of.

Over the past five years, heat pumps worth NOK 3.75 billion have been imported to Norway according to RENAS, an EE return company in Norway, in a press release in January 2012[15]. In 2010, the company received more than 570 tonnes of old heat pumps containing both environmental toxins and greenhouse gases. They are of the opinion that many heat pumps are now ready to be replaced, and between 2008 and 2010 the number of discarded heat pumps rose by a factor of 50 %.

Transport phase
This phase is relevant, and there is also plenty of potential for environmental improvements, but there is only very little steerability and it is difficult to specify requirements for transport in the criteria for the Nordic Ecolabel. However, requirements can be specified regarding the materials used in connection with transportation (cardboard, plastics, wooden pallets).

Sale of heat pumps
Heat pumps dealers may include individual chains, wholesalers, HVAC or electrical stores/chains or department stores. Air-to-air heat pumps are more commonly sold directly to consumers than air-to-water and liquid-to-water heat pumps, which are often procured via wholesalers or from individual chain stores accessible only by professionals. Heat pump users include homeowners, housing cooperatives, owners/constructors of commercial buildings, etc. Preventing the leakage of refrigerants and coolants is challenging. For products sold directly from HVAC or electrical stores/chains or department stores, there will be greater uncertainty as to whether installers are qualified as stores themselves are unable to influence who installs the products. The Nordic Ecolabel may help to reduce the problem by laying down requirements for design, installation and removal. The Nordic Ecolabel may also help to ensure that customers receive reliable information on annual efficiency and output in given climate zones, by means of quality assurance of calculations and guidelines, thereby helping to ensure that heat pumps are dimensioned correctly. However, the Nordic Ecolabel has no way of controlling whether this information is used correctly. Requirements for standardised rates for fitters may help to ensure that heat pumps bearing the Nordic Ecolabel are fitted correctly. The positioning of heat

[14] Climate and Pollution Agency of Norway, "Sertifisering av verksemder som handterer fluorhaldige klimagassar". Available from: http://www.klif.no/no/Aktuelt/Nyheter/2011/April-2011/Sertifisering-av-virksomheter-som-handterer-fluorholdige-klimagasser/?cid=3292 (visited on 26.02.2012)
[15] http://www.renas.no/Varmepumper-blir-miljotrussel

pumps with regard to noise is something which the Nordic Ecolabel can only help with by providing recommendations to customers through guidelines from manufacturers regarding installation; but if installed and used correctly, noise requirements applicable to heat pumps themselves will restrict inconvenience to residents and others.

2.3 Version and validity of criteria

The first version of the criteria for heat pumps was valid from 15 June 1998 to 31 March 2008. Version 2 was approved on 14 March 2007 and will remain valid until June 2013 (version 2.1). These criteria are now being revised for version 3.

2.4 The market

Globally

According to the IEA, the International Energy Agency, the market for heat pumps in the Nordic region should be viewed in context with the market in Europe, where outdoor air and the bedrock are dominant heat sources for heat pumps used in the housing sector. Exhaust air is used as a heat source in low-energy construction with mechanical ventilation systems, particularly in low-energy buildings in which mechanical ventilation is installed. Air-to-air heat pumps are very common in both Japan and the USA. In Japan, multi-split systems for heating and cooling are used for the most part, while central systems are used in the USA[16]. Multi-split systems are systems which have several indoor units for every outdoor unit.

European market

Figure 1 shows figures from the European Heat Pump Association, indicating the total number of heat pump systems sold per year in the following European countries: Finland, France, Italy, Norway, the United Kingdom, Switzerland, Sweden, Germany and Austria) between 2003 and 2009[17]. Between 2008 and 2009, there was a decline of approx. 10 % in sales compared to 2008 due to the credit crunch. Although the market in many countries has been dominated by air-to-air heat pumps, a significant number of systems supply heat to hydronic heating systems, i.e. liquid-to-water and air-to-water heat pumps.

[16] IEA Final report Annex 32 part 1 Summary, March 2011.
[17] European Heat Pump Association (EHPA). Outlook 2010. The statistics are available from http://www.ehpa.org/heat-pump-statistics/2009/

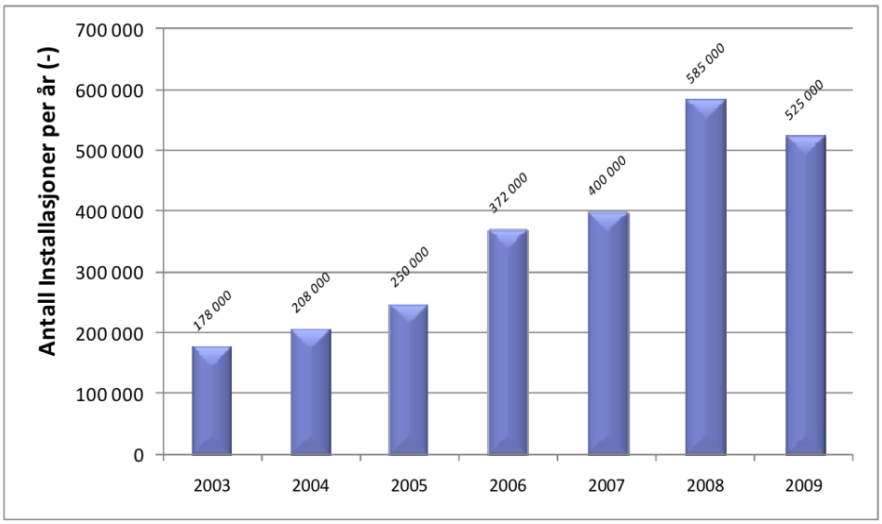


Figure 1: Total number of heat pumps installed per year in Europe between 2003 and 2009 (EHPA-1, 2010).

At present (winter 2012), it is estimated that there are 2.5 to 3.0 million heat pumps operational in Europe. It is estimated that the heat pumps installed between 2003 and 2009 contribute a net energy saving of approx. 30 TWh/year, equivalent to utilised renewable heat from the surroundings[18,19].

Nordic countries

According to a Norwegian report from Energy21[20], it is estimated that there were 450 000 heat pumps operational in Norway in 2010. Approx. 90 % of installations over the past eight years are air-to-air heat pumps. For 2010, annual heat production and annual energy saving in Norway are estimate to amount to 8-9 TWh and 5-6 TWh respectively. The same report states that Sweden has 900 000 heat pumps with an annual heat production of approx. 23 TWh/year, approx. 15 TWh (two-thirds) being taken from the surroundings[21]. The Royal Swedish Academy of Sciences has stated that by 2050, 25 % of the heat requirement in Sweden could be covered by heat pumps[22]. According to recent information from the Swedish Heat Pump Association (SVEP), there is good growth in sales for larger properties. Not only are heat pump installations becoming more common, but they are also growing in size (a 30 % increase).

In Denmark, use of heat pumps is restricted due to widespread usage of coal-fired combined heat and power plants in combination with district heating. However, Danish authorities are now seeing major opportunities to reduce their greenhouse gas emissions by combining electricity from an increasing number of Danish windmills to run heat pumps connected to hydronic heat systems[23]. The people of Denmark have traditionally been sceptical about heat pumps in that their electricity is largely based

[18] European Heat Pump Association (EHPA). Outlook 2010. The statistics are available from http://www.ehpa.org/heat-pump-statistics/2009/
[19] Energy21, established by the Norwegian Ministry of Petroleum and Energy in 2008 – Nasjonal strategi for forskning, utvikling, demonstrasjon og kommersialisering av ny energiteknologi. Initiative team report "IG-rapport Fornybar Termisk Energi – Distribuert varme og kuldesystemer – med veikart" (2010). Available from: http://www.energi21.no/prognett-energi21/Strategidokumenter/1253955410657 (visited on
[20] As footnote 18 – IG-rapport Fornybar Termisk Energy … – page 7
[21] As footnote 18 – IG-rapport Fornybar Termisk Energy … – page 8 (Swedish Energy Agency, 2007).
[22] As footnote 18 – IG-rapport Fornybar Termisk Energy … – page 8
[23] Danish authorities (Energinet, 2009).

on coal power. Therefore, the environmental benefits of heat pumps have not been as easy to defend as alternative heat sources which have not been dependent on electricity to the same degree, such as biofuel and solar energy. In Finland, 372 000 heat pumps have been installed: 300 000 air-to-air heat pumps, 50 000 geothermal heat pumps, 17 000 exhaust heat pumps and 50 000 water-to-air heat pumps[24].

Manufacturers

Examples of manufacturers supplying to the Nordic market in 2011 include: Alpha-InnoTec, Carrier, CTC Ferrofil, Daikin, Ecowell, Foma, Fujitsu, Gebwell, Geopro, General, Høiax, IVT, Lämpöässä, LG Electronics, Mitsubishi Electric, Nibe, Ochsner, Oilon, Panasonic, Polar Kulde, Sanyo, Toshiba, Thermia, Vaillant and Wilfa.

Air-to-air heat pumps account for approx. 80% of the market in the Nordic region. The Swedish Heat Pump Association stated in the spring of 2011 that in Sweden, IVT and Nibe had the highest market shares for geothermal heat pumps, followed by Thermia and CTC. For air-to-water heat pumps, CTC is the most important, followed by Nibe, IVT and Thermia; but for air-to-air heat pumps, IVT is probably the most important manufacturer, followed by the majority of manufacturers such as Toshiba, Panasonic and Daikin, which is the biggest on the market. On the Finnish market, the biggest manufacturers/importers are IVT, NIBE and Thermia, accounting for approx. 60 % of the market, followed by LämpöÄssä, Oilon Geopro and Gebwell.

Nordic Ecolabel licences

There is currently one licensee (Bosch Thermoteknik AB, formerly IVT Industrier AB) with seven heat pump models branded as IVT Heat Pumps. There are a number of different sizes among the individual models. Five of these are liquid-to-water heat pumps, and two are air-to-air heat pumps. IVT holds a significant market share and is the biggest supplier of geothermal heat pumps. It's customers are mostly homeowners, but they also sell to larger projects such as terraced houses.

2.5 Regulatory requirements, environmental labels and other labelling schemes

The industry's environmental work takes place via regulatory requirements and various voluntary tools such as environmental management, environmental declarations, environmental labelling and quality labelling.

Regulatory requirements

Below is a summary of EU directives and regulations relating specifically to heat pumps. For heat pumps, this is slightly more complex than for many other product types as different heat pumps are covered by different parts of the regulations.

Ecodesign Directive (2005/32/EU)

This directive specifies environmental requirements for energy-related products, and among other things involves the setting of minimum requirements for energy efficiency for energy-related products to be sold on the EU market. The EU is constantly working on the Ecodesign Directive for the various product categories,

[24] SULPU Finnish Heat Pump Association

known as LOTs (LOT = category). Work with each individual LOT involves a product study which examines market data and technological status and makes recommendations to the EU Commission. These recommendations will result in environmental requirements which will be made mandatory (Ecodesign Regulation) for products to be sold on the European market. The LOT recommendations also provide a basis for energy labelling (Energy Labelling Regulation) for the product group. Various stakeholders can participate in LOT work.

The following LOTs relate to heat pumps bearing the Nordic Ecolabel :

- LOT 1 – Boilers and combi-boilers (gas/oil/electric) (http://www.eceee.org/Eco_design/products/boilers)
  The aim of LOT 1 work is to result in ecodesign and energy labelling regulations for boilers, including heat pumps for hydronic heat and hot water up to 400 kW. Final proposals for ecodesign requirements and requirements to energy labelling were issued in February 2012[25], and it is anticipated that the minimum environmental requirements and requirements for energy labelling will be adopted before the summer. In early October 2012, these are not complete.
- TREN LOT 10 – Room conditioning appliances, local air coolers and comfort fans (http://www.eceee.org/Eco_design/products/domestic_ventilation).
  Work on LOT 10 is complete, and the Ecodesign Regulation (206/2012 EU) came into force on 6 March 2012, followed by the Energy Labelling Regulation (626/2011 EU), which came into force on 26 July 2011. These regulations are applicable to air conditioning and air-to-air heat pumps up to 12 kW.

The following LOTs are not considered to affect heat pumps bearing the Nordic Ecolabel which are related to the product group definition provided in Section 2.1

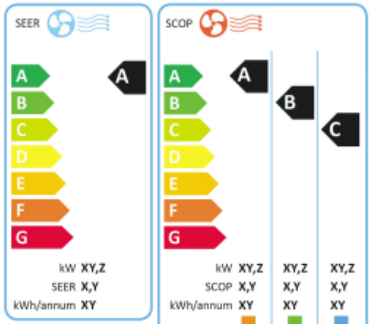
- LOT 2 – Water heaters and hot water storage tanks. This category is applicable to water heaters and water heaters with energy sources (www.ecohotwater.org). Proposals for ecodesign and requirements for energy labelling were issued in February 2012. Water heaters based on heat pumps – air-to-water and liquid-to-water – are covered by LOT 2. There are also combinations with solar heating.
- ENTR LOT 6 – Tertiary air conditioning and ventilation systems (www.ecohvac.eu). This category only covers cooling and systems above 12 kW, and will therefore be of no relevance in terms of Nordic Ecolabel criteria.
- ENER LOT 21 – Central heating products using hot air to distribute heat. (other than Combined Heat and Power boiler) (www.ecoheater.org). This category covers central heating systems with heat distribution via air, beyond power-to-heat products. Liquid-to-air and air-to-air heat pumps larger than 12 kW heat output, which are used in ventilation systems and for airborne heating, are also included in the study – the cooling element is covered by

[25] http://www.eceee.org/Eco_design/products/boilers

LOT 21. Energy labelling criteria are not planned for products included in LOT 21[26].

Energy Labelling Directive

Work on the Energy Labelling Directive is resulting in regulations for a number of product types. For heat pumps, a regulation relating to the energy labelling of climate systems (air conditioning systems with cooling output or air-to-air heat pumps with heat output of less than 12 kW, regulation (626/2011 EU[27]) has been adopted in October 2012. This scheme is based on self-declarations. It is also anticipated that a regulation for heat pumps for hydronic heat and hot water up to 400 kW will be complete before the summer of 2012: see LOT 1 above. A regulation for water heaters based on heat pumps is also being prepared: see LOT 2 above.



Climate zones, etc. are described in greater detail in Section 4.4 Energy requirements.

Ozone Regulation (1005/2009 EU)

This regulation restricts the use of substances degradable to the ozone layer, and means that importing HCFCs to the EU and Norway is prohibited. This regulation also specifies requirements for non-mobile equipment with a refrigerant content exceeding 3 kg must be inspected for leakage every year.

F-Gas Regulation (842/2006 EU)

According to the F-Gas Regulation, personnel handling the greenhouse gases HFC, PFC and SF6, which contain fluorine, must be certified. Companies also have to be certified in the refrigeration industry and if they work with fire extinguishing systems. The intention is to prevent emissions of greenhouse gases.

Note: GWP=150, which is used as a limit for energy efficiency in R11, is equivalent to the EU's upper limit for GWP for refrigerant for use in AC systems in vehicles.

Renewable Energy Directive (2009/28 EU)

The EU has established what is known as a 20-20-20 target in the new Renewable Energy Directive. The EU has to reduce its CO_2 emissions by 20 %, cut 20 % of its energy consumption and increase the amount of renewable energy use from 8.5 % to 20 % by 2020. This directive defines as renewable energy both shallow geothermal heat and the heat sources air and water used in heat pumps. But the energy produced by heat pump systems is only deemed to be renewable energy if heat production from the heat pumps exceeds the amount of energy input by 15 %. Furthermore, only part of these heat pumps' heat production is deemed to be renewable energy, the energy consumed by the heat pump is deducted. The EU Commission will be preparing standard calculation methods for renewable energy from heat pumps by January 2013 [EU Renewable Energy Directive, Annex VII].

[26] Ecodesign Preparatory Studies, LOT 21: Central heating products that use hot air to distribute heat (other than CHP) Final Stakeholder Meeting Brussels Presentation – 17 April 2012. Available from: http://www.ecoheater.org/lot21/documents.php (visited on 2 May 2012)
[27] Regulation 626/2011 EC

Article 13. 6 Administrative procedures, regulations and codes, states: In the case of heat pumps, Member States shall promote those that fulfil the minimum requirements of eco-labelling established in Commission Decision 2007/742/EC of 9 November 2007 establishing the ecological criteria for the award of the Community eco-label to electrically driven, gas driven or gas absorption heat pumps.

Article 14. 3 Information and training, states: Member States shall ensure that certification schemes or equivalent qualification schemes become or are available by31 December 2012 for installers of small-scale biomass boilers and stoves, solar photovoltaic and solar thermal systems, shallow geothermal systems and heat pumps. Those schemes may take into account existing schemes and structures as appropriate, and shall be based on the criteria laid down in Annex IV. Each Member State shall recognise certification awarded by other Member States in accordance with those criteria.

CE labelling

The CE label is manufacturers' way of notifying the supervisory authorities that they have met the basic safety requirements in the regulations applicable to their products in Europe. This means that the manufacturer declares that these requirements are met and that documentation can be produced which verifies this. The CE label provides no information on the quality aspects of product. Minimum requirements in the Ecodesign Directive must be met if so defined for the product group.

WEEE (Waste Electronical and Electronic Equipment) Directive 2012/19/EU

The purpose of this directive is to prevent the occurrence of waste made up of or containing electrical or electronic products (WEEE) and to ensure that such waste is reused, materials are recycled and other forms of recycling are applied in order to reduce the disposal of waste.

The directive is applied to the electrical and electronic products covered by categories listed in annexes to the directive: According to Annex IV, Non-exhaustive list of EEE which falls within the categories listed in Annex III
Category 1. Temperature exchange equipment
Refrigerators, Freezers, Equipment which automatically delivers cold products, Air conditioning equipment, Dehumidifying equipment, Heat pumps, Radiators containing oil and other temperature exchange equipment using fluids other than water for the temperature exchange.

The Member States are obliged to encourage manufacturers to design and manufacture electrical and electronic products in a manner which takes into account and facilitates dismantling and recycling, in particular reuse and recycling of WEEE, its components and materials.

Manufacturers (or third parties acting on behalf of manufacturers) must create systems for recycling. Reuse of whole appliances must be given priority. In the case of products covered by category 1 (large household appliances), requirements are specified for recycling on treatment, in accordance with article 7, paragraph 2 a):

- the rate of recovery shall be increased to a minimum of 80 % by an average weight per appliance, and
- component, material and substance reuse and recycling shall be increased to a minimum of 75 % by an average weight per appliance.

The Member States must keep records on the mass of WEEE, their components, materials or substances when entering (input) and leaving (output) the treatment facility and/or when entering (input) the recovery or recycling facility.

The producer/manufacturer is responsible for ensuring that users of electrical and electronic products in private households are given access to all necessary information on the obligation to dispose of WEEE separately, which systems are available for returning and collection of such products, the role of the user in the system, potential effects on the environment and health, and the meaning of the symbol which is to be included on such products. As a minimum, the following substances, preparations and components must be removed from all separately collected WEEE (and which are often deemed to include large household appliances):

- Polychlorinated biphenyls (PCB) containing capacitors
- mercury containing components, such as switches or backlighting lamps
- Batteries
- Printed circuit boards if the surface of the printed circuit board is greater than 10 square centimetres,
- Plastic containing brominated flame retardants
- Asbestos waste and components which contain asbestos
- Freons, hydro chlorofluorocarbons (HCFC), hydro fluorocarbons (HFC) and hydrocarbons (HC)
- External electrical cables
- Components containing refractory ceramic fibres

A Norwegian survey carried out by the Climate and Pollution Agency in Norway (Klif) indicates that inspection of compliance with the WEEE Directive is not satisfactory, and that improvement of collection stations for dealing with EE waste is required.

RoHS 2 (Restriction on Hazardous Substances)

One of the prime objectives of RoHS 2 is to address concerns related to the increasing volume of waste electrical and electronic equipment (WEEE) arising in the EU. The purpose of RoHS is to reduce the occurrence of hazardous substances in waste from electrical and electronic products by restricting the use of hazardous substances in electrical and electronic products and helping to protect human health and ensure eco-friendly recycling and disposal of waste comprising or including electrical or electronic products. RoHS includes the same products as those listed in the WEEE Directive: in this instance, category 1, Large household appliances, according to the above list from WEEE is applicable to white goods.

As of 1 July 2006, the Member States must ensure that new electrical and electronic products released to the market do not contain:

- Lead
- Mercury

- Cadmium
- Hexavalent chromium
- PBB and/or PBDE

The limits for the hazardous substances listed above are 0.1 % by weight in homogeneous material; except for cadmium, for which 0.01 % by weight in homogeneous material is applicable.

The directive is regularly evaluated and revised in order to adapt the requirements to scientific and technical development, as well as controlling consultation with manufacturers of electrical and electronic products, material recycling companies, treatment companies, environmental organisations and consumer organisations. Exceptions to the use of prohibited substances can be found in the annex to the WEEE Directive. This is applicable to special applications where remuneration is not available at present and is taken into account in the formulation of the requirements for the Nordic Ecolabel . For more details regarding RoHS 2, see requirement R5, Section 4.3.

REACH ordinance

The REACH ordinance (Registration, Evaluation, Authorisation and Restriction of Chemicals) (1907/2006/EC) with reference to the ECHA (European Chemical Agency) candidate list, Annex 1 (http://echa.europa.eu/chem_data/candidate_list_en.asp), includes a list of hazardous substances according to the definition "Substances of Very High Concern (SVHC)". The candidate list is published by ECHA, and the substances on the list will be covered by the official regulatory requirement when the EU Commission has confirmed the substances on the list. Once the substances have been confirmed by the Commission, the Nordic Ecolabelling will pay particular attention to the substances.

RoHS and REACH are two different acts with different scopes and objectives. RoHS 2 is a sector specific directive laying down rules on the restriction of certain hazardous substances in EEE, while REACH is a general act regulating registration, evaluation, authorization and restriction of chemical substances.
RoHS 2 and REACH apply in parallel. REACH also contains rules on restriction of substances in various applications, but in principle there should be no overlaps, as restrictions of the specific use of substances in EEE should not be addressed by REACH.[28]

National regulatory requirements

In Denmark, the building regulation, BR10, specifies requirements for the normalised power factor of liquid-to-water heat pumps and air-to-water heat pumps (BR10 – 8.6.4 Heat pumps and cooling systems)[29].

In Norway, the building regulations, TEK 10 – § 14-7, state that for buildings greater than 500 m^2, a minimum of 60 % of the net heat requirement for heated floor space must be provided with an energy supply other than direct-acting electricity or fossil fuels in the case of end users. For buildings up to 500 m^2, the corresponding

[28] RoHS 2 FAQ 15 June 2012 – Q1.5
[29] http://www.ebst.dk/bygningsreglementet.dk/br10_02_id171/0/42

requirement is 40 %. To gain support for air-to-water heat pumps from Enova in Norway, the overall system must meet the requirements laid down in standard NS-EN 14511-4 with user documentation in a Scandinavian language and have documentation which verifies the output of the total system. See Annex 3 for more information on EN 14511-4 under standards and test methods.

In Sweden, the building regulations, BBR 19, state that if the building's floor area A_{temp} exceeds 60 m^2, the building must be provided with facilities for heat recycling from the ventilation air or with a heat pump. Furthermore, they state that ventilation heat exchangers which transfer heat from exhaust air to supply air with a minimum thermal efficiency of 70 % or a heat pump providing an equivalent saving. In addition, the need for comfort cooling in the building must be kept to a minimum.

Ecolabels

Products bearing ecolabels are approved according to specific environmental requirements developed according to the standard ISO 14024, and these products are certified by an independent third party. The system excludes products which fail to meet these requirements and hence showcase the products on the market which are most expedient in respect of the environment. Alongside the Nordic Ecolabel, there are criteria for heat pumps in schemes such as Ecologo in Canada, Der Blaue Engel in Germany and the EU's Ecolabel. The Canadian ecolabel has no licences for the criteria "Energy Efficient Heating/Cooling Systems for Building(s)", appears to be rather general and also includes district heating systems. See also the table in Annex 4 for the stances of various schemes concerning different parameters for energy calculation.

EU Ecolabel

Existing EU Ecolabel criteria for heat pumps powered by electricity, gas or gas absorption (2007/742/EC) are valid until 31 March 2013. These criteria are being reviewed (EU Ecolabel for hydronic central heating generators). The new criteria are expected to be complete in late 2012[30], and they will include several types of heat source for hydronic heating such as gas boiler, biomass boiler, gas-powered hydronic heat pump, electric hydronic heat pump and CHP.

Der Blaue Engel

Der Blaue Engel – the Blue Angel – has criteria for both gas and electric heat pumps, but there were no licences as at 31 March 2011. The criteria for electric heat pumps are titled "Energy-Efficient Heat Pumps using an Electrically Powered Compressor, RAL-UZ 121" and date back to July 2011. Requirements are specified for TEWI (Total Equivalent Warming Impact). TEWI is used as a basis for calculation of total global climate impact. There are no material requirements beyond this, but there are requirements for instruction manuals.

[30] Presentations_GPP_workshop 17 Jan 2012

Other labelling schemes

EHPA European Heat Pump Association

EHPA is a quality mark for heat pumps from the European Heat Pump Association[31]. This label was derived originally from heat pump associations in Austria, Germany and Switzerland in order to ensure the quality of products and services in respect of heat pumps. The concept has been further developed by the EHPA, and a number of countries are about to join the scheme. The quality label was introduced in Sweden in 2007, Finland in 2008, and Belgium and France in 2010. Trade associations in Norway and Denmark are also members of the EHPA. To qualify for the EHPA's quality label, the heat pump must be compliant with the EHPA's Heat Pump test criteria and the distributor must provide a defined service level. As at 14.09.2011, a total of 365 heat pump models within the member countries bear the EHPA label.

Positive list of the Danish Technological Institute

The Danish Technological Institute provides system approval for heat pumps and air conditioning systems, and this voluntary approval includes requirements for safety, design and system structure (including assessment of service life), as well as for declaration and installation. The list is applicable only to air-to-air heat pumps and residential ventilation/consumer water-to-heat pumps and was updated in February 2012[32].

Energy Star in the USA

Energy Star is a joint programme for the Environmental Protection Agency and the Department of Energy aiming to save the environment through energy-efficient products and behaviour. They have criteria for geothermal heat pumps and for air-to-air and air-to-water heat pumps[33].

[31] http://www.ehpa.org/ehpa-quality-label/
[32] http://www.varmepumpeinfo.dk/8333
[33] http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=HP

3 About the revision

Purpose of the revision

Environmentally friendly heat pumps are energy-efficient, silent and contain a minimal amount of environmentally problematic chemicals. Installation, usage and maintenance are important environmental parameters for achieving intentional environmental gains in which the Nordic Ecolabel can make a positive contribution.

About this criteria revision

Most of the work on creating new criteria and a new background document was carried out in the autumn of 2011 and the winter of 2012. Project participants for the Nordic Ecolabelling were:

- Project manager: Ola Rise
- Manager, Denmark: Thomas Christensen
- Manager, Finland: Harri Houtalainen
- Manager, Norway: Ola Rise
- Manager, Sweden: Sara Bergman
- Area coordinator: Elisabeth Magnus

4 Requirement motivation

Section 4 provides motivation for the requirements laid down by the Nordic Ecolabelling in the criteria for heat pumps. These requirements are based on the motive for Nordic Ecolabelling in Section 2.2 and the evaluation of current requirements which has been carried out. Unlike other labelling arrangements, an assessment has also been carried out in order to identify eco-friendly requirements which may work in the Nordic market. This means that these requirements focus on the energy efficiency measures achieved by using heat pumps, but also on relevant environmental and health problems associated with the production, use and waste phase until the products are assessed. When references are made to an annex in the requirement text or documentation requirements, this annex in the criteria document is referred to.

4.1 Products which can carry the Nordic Ecolabel

Requirement suggestion

The criteria make is possible to Nordic Ecolabel series manufactured, electrically operated heat pumps for space heating, with or without the option of heating water for household use.

Nordic Ecolabelled heat pumps are individual units of the following types:

1) For heating water up to 70 kW:
   a) air-water heat pumps (heat source: outdoor air)
   b) exhaust air heat pump (heat source: indoor air)
   c) liquid-water heat pumps (heat source: geothermal heat, lake water/fresh water or waste heat from e.g. grey water)
2) For heating of air up to 12 kW:
   d) air-air heat pumps (heat source: outdoor air)

There is no lower output limit for Nordic Ecolabelling of heat pumps. The criteria document makes continuous reference to the heat pump type definitions used in European work on the Ecodesign Directive. LOT 1 (product categories of the Ecodesign Directive) contains a suggested Ecodesign and Energy Labelling Regulation for air-water heat pumps and liquid-water heat pumps. The Ecodesign Regulation, (206/2012/EU), and the Energy Labelling Regulation, (626/2011/EU), outline requirements for heat pumps with air-air heat pumps.

The following heat pumps cannot be Nordic Ecolabelled:

- Units with an output greater than 70 kW for heating water and greater than 12 kW for heating air.
- Units used solely for cooling.
- Gas powered heat pumps.
- Heat pumps intended solely for drying.
- Heat pumps covered by LOT 2 or ENER LOT 21.

Background to the requirement

When the criteria were evaluated in the spring of 2011, it emerged that the product group definition is unclear and that there has been uncertainty in a number of areas regarding what can bear the Nordic Ecolabel. Therefore, the product group definitions have been amended in version 3. The biggest change from version 2 is that heating systems can no longer bear the Nordic Ecolabel. This is due to a lack of steerability for the licensee and because systems are supplied complete ex works only in exceptional cases, but are adapted to the individual buildings in which they are to be used. Which individual heat pumps can bear the Nordic Ecolabel is specified in greater detail than before.

General information on applications for heat pumps
In general, heat pumps can be used for space heating, heat ventilation air, heat hot water and for drying and cooling in residential buildings and commercial or industrial buildings. They can also be used in district heating and district cooling systems and be included in energy-intensive industrial processes. The capacity of the various facilities varies from a couple of kW to many tens of MW. More information on applications can be found in Annex 1.

Products not covered by these criteria:
Heat pumps over 70 kW for liquid-to-water and air-to-water heat pumps and 12 kW for air-to-air heat pumps. The product group definition corresponds to how the products are defined in the draft for ecodesign and energy labelling in LOT 1 for liquid-to-water and air-to-water heat pumps, and the Ecodesign Regulation (206/2012/EC) and the Energy Labelling Regulation (626/2011/EC) for air-to-air heat pumps. The limit of 70 kW for liquid-to-water heat pumps and air-to-water heat pumps is not set to 400 kW as described in the LOT 1 proposal. Nordic Ecolabel intends to cover the large market in this way as series-manufactured heat pumps are generally below 70 kW and because the organisation does not have the capacity to retain criteria for large heat pumps this time. Nor does the LOT 1 proposal describe acoustic requirements for heat pumps larger than 70 kW.

Gas-powered heat pumps: (Gas heat pumps and gas absorption.) Nordic Ecolabelling is of the opinion that it should not be possible to apply the Nordic Ecolabel to gas heat pumps and gas absorption as a transition to fossil energy sources is not wanted. Biogas can be used, but environmental labelling has no control over whether this is done.

Heat pumps designed only for drying: Tumble dryers with heat pumps can bear the Nordic Ecolabel due to criteria for white goods. Heat pumps for drying processes are not covered by these criteria as the market for such products is mainly Business-to-Business (B2B), and delineation is necessary in order to limit the internal use of resources at Nordic Ecolabelling.

Categories (LOTs) not covered by the criteria: ENER LOT 21 covers liquid-to-air and air-to-air heat pumps larger than 12 kW heat output which are used in ventilation systems and for airborne heating. Only the heating element of the heat pump is covered by the study: the cooling element is covered by ENER LOT 6. ENER LOT 6 covers cooling only. ENER LOT 6 and ENER LOT 21 are of no relevance to heat pumps bearing the Nordic Ecolabel as LOT 6 covers only cooling and the market for heat pumps under ENER LOT 21 is limited. Water heaters based on heat pumps – air-to-water and liquid-to-water – are covered by LOT 2. There are also combinations with solar heating. LOT 2 will be of no relevance to heat pumps bearing the Nordic Ecolabel as the market for such heat pumps is small.

4.2 Requirements for production and materials

R1 Description and list of materials

Requirement suggestion

R1 Description of manufacturing processes and materials

The manufacturing process for the Nordic Ecolabelled heat pump is to be described.

The description must, as a minimum, contain the following details:

- A summary of all the parts in the heat pump, stating the type and materials. The weight of plastic parts must be stated (see R6).
- A description of the manufacturing process for the heat pump, stating the different stages of the process. The production technology and environmental purification schemes for surface treatment and metal plating of parts is to be stated.
- Name and location of:
  - factory/factories for final assembly of the heat pump.
  - subcontractors producing core components (e.g. compressor unit, heat exchangers, accumulator tank if applicable and pipework, frame, etc.). Provide information on what the relevant subcontractors supply.
  - subcontractors for surface treatment and metal plating
- Copy of environmental licence/permit or control reports/documents from environmental authorities for final assembly, if applicable.

Final assembly of heat pumps relates to assembly of core components (such as compressor unit, heat exchanger, accumulator tank if applicable, pipework, frame and cabinet) into a finished heat pump unit. Final assembly does not refer to production of inputs such as metals, insulation materials, plastic parts, electro technology or electronics.

✉ A material description of the heat pump's parts, a description of the heat pump's manufacturing process and subcontractors, plus a copy of the environmental licence/permit in line with the requirement.

Background to the requirement

This is a new requirement. Manufacturers of heat pumps have found over the past few years that competition has increased on existing markets. This has resulted in mergers and takeovers of competitors, but also in transfers of the actual manufacturing process to European and Asiatic manufacturers for the most part. Heat pumps under undergo final assembly by main manufacturers using semi-finished products from various subcontractors in Europe and Asia (e.g. Japan and China). Other manufacturers carry out more of the partial production process within their own organisation. Production is spread over a number of subcontractors in many instances.

Surface treatment and metal plating are carried out at separate plants or by any subcontractors. Nordic Ecolabelling wants to know who is doing this work so that it has the opportunity to check it. To provide a better overview of subcontractors used, it is desirable to specify subcontractors for primary components such as compressor unit, heat exchanger, any accumulator tank and pipe system, plus a description of what the subcontractor in question produces. This requirement gives Nordic Ecolabelling the opportunity to understand where the parts come from and who is responsible for the various operations. Information will also be useful in order to see what opportunities the manufacturer has to influence the various processes. Information may also be useful for Nordic Ecolabelling for the next revision in order to specify the correct requirements viewed from a life cycle perspective. Nordic Ecolabelling requires a description of the manufacturing process on final assembly which covers the entire production flow. Further documentation may include production diagrams which show the individual production process during final assembly.

Requirements have also been laid down for information on the environmental concessions of manufacturers for final manufacture/assembly of heat pumps (by end manufacturers) or inspection reports from environmental authorities and emissions of various substances in accordance with an environmental licence. This is the kind of information which Nordic Ecolabelling wishes to collect so that it can assess prior to the next revision what requirements may be relevant to the production of heat pumps.

R2 Classification of chemical products

Requirement suggestion

R2 Chemical products, classification

The manufacturer must compile a list of the chemicals used in final assembly of heat pumps and in surface treatment. The safety data sheet for the chemical products is to be submitted.

Chemical products, such as cleaning products, paints, lacquers, adhesives and sealants that are used in the final manufacture of heat pumps and for surface treatment of parts must not be classified in line with the risk phrases in Table 1 below.

An exemption to the requirement applies to metal plating of parts. The terms of requirement in R4 must be met when metal plating of parts.

Table 1: Classification of chemical products. Note that for lacquers and paints there is also a ban on classification of environmental toxicity risk phase R51/53.

Classification	EU classification to 1 December 2010*	EU classification after 1 December 2010*
Toxic to the environment, paints	N with R50, R50/53, R51/53, R52/53 or R59	Aquatic 1 with H400 Chronic 1/2/3 with H410, H411, H412, EUH 059.
Toxic to the environment, other chemical products	N with R50, R50/53, R52/53 or R59	Aquatic 1 with H400 Chronic 1/3 with H410, H412, EUH 059.
Very toxic	T x (T+ in Norway) with R26, R27, R28, R39	Acute Tox. 1/2 with H330, H310, H300, STOT SE 1 with H370
Toxic	T with R23, R24, R25, R39, R48	Acute Tox 2/3 with H331, H330, H301 STOT SE 1 with H370 STOT RE 1 with H372
Allergens	Xn with R42, Xi with R43	Resp.sens 1 with H334 or Skin sens 1 with H317
Carcinogens	Xn with R40 or T with R45, R49	Carc 1A/1B/2 with H350, H350i and/or H351
Mutagens	T with R46 or Xn R68	Mut 1B/2 with H340 and/or H341
Toxic for reproduction	T with R60 and/or R61. Or Xn with R62 and/or R63	Repr 1A/1B/2 with H360F, H360D, H361f, H361d, H360FD, H361fd, H360Fd, H360Df Lact with H362

**The classification applies under Directive 67/548/EEC and Directive 1999/45/EC (until 1 December 2010 and during transition period 2010-2015) or Regulation 1272/2008/EC (from 1 December 2010). The requirement also covers combinations of the above risk phrases, e.g. T+ R26/27/28.*

✉ List of chemical products used in final assembly of heat pumps and surface treatment.

Safety data sheet/product data sheet in line with prevailing legislation in the country of application, e.g. Annex II to REACH (Regulation 1907/2006/EEC) for each product.

Background to the requirement

This is a new requirement, and it is presented in such a manner as to make it clear that Nordic Ecolabelling is focusing on the properties of the chemicals/chemical products used. This requirement is applicable to classification of the chemical products used. Substances may be included which have the same classification but which occur in such small quantities that the chemical product is therefore not classified. This requirement is not particularly strict due to the fact that this is the first time such as requirement is being laid down in accordance with the criteria for heat pumps. In the case of surface treatment of heat pumps, a surface coating is used which is classified as environmentally hazardous N with R52/53 and with the following risk phrases: "Harmful to aquatic organisms", may cause long-term adverse effects in the aquatic environment. Products with this classification must not be prohibited in accordance with these criteria.

During final assembly and surface treatment of heat pumps, chemicals can currently be used which are classified as environmentally hazardous with the following risk phrases (R50/53, R51/53, R 52/53).

Chemical products such as adhesives, sealants (silicone, putty), detergents for the sheet metal (degreasing agents) and soldering chemicals (flux) may be used during final assembly. Adhesives containing naphtha and zinc oxide (R50/53) can be classified with R51/53 and R52/53, sealants containing naphtha have classification R51/53, and sealants (without silicone) containing zinc oxide have classification R50/53, cleaning products containing naphtha have classification R51/53, soldering chemicals without classes harmful to health or the environment, lubricants with naphtha have classification R51/53. Varnishing does not normally take place during final assembly: instead the metal parts purchased are varnished by the supplier (see below). To encourage companies not to use varnishes unnecessarily which are hazardous to the environment (or hazardous to health), Nordic Ecolabelling specifies requirements indicating that adhesives, sealants, detergents (degreasing agents) for sheet metals, lubricants and soldering chemicals must not be classified as R50/53 or R52/53. This requirement would require the manufacturer to find alternative adhesives and sealants without R50/53 and R52/53. That said, in this version of the criteria we do not demand that naphtha is replaced by non-R51/53 substances.

Paints and varnishes are used for surface treatment. In many instances, powder paints are used instead of standard wet paints which contain solvents. Thus in the case of powder paints, the quantity of solvent is limited, which means a reduction in VOC (Volatile Organic Compound) emissions. In a typical powder painting facility, the goods are transported through the process on a "convair". First, the parts enter a rinse tunnel where the metal surface is pretreated. This may involve anything from a single wash process to several stages involving chemical conversion of the surface. From here, the parts move into a drying oven which dries the surfaces before they enter the powder painting cabinet where the paint is actually applied. During injection, tiny grains of powder receive a powerful electrostatic charge and are loaded into the guns. The powder attaches itself to the surface due to the electrostatic charge between the part and the grains of powder. When the powder enters the curing oven, it melts and flows together, hardening to form a hardwearing layer. There are different types of powder paint. Polyester paints, epoxy paints and combinations of the two are often used. Pre-treatment with regard to chemicals takes place during powder painting. Wet paints and lacquers containing naphtha have classification R51/53, while powder

paints can be classified with R52/53. However, there are also powder paints which receive no classification in terms of environmental hazard (they include only small quantities of substances hazardous to the environment).

This requirement is restricted to the final assembly of heat pumps and on surface treatment due to the fact that it may be difficult for heat pump manufacturers to acquire information from all subcontractors (e.g. approximately 20 suppliers) on which individual substances are used in raw material production. Manufacturers of heat pumps can control their own production. The requirement relating to substances can be specified for end manufacturers of heat pumps. This requirement is applicable, for example, to chemicals such as adhesives, sealants (silicone, putty), detergents/cleaning products (such as degreasing agents) for heat pumps, paints and varnishes. The requirement is not applicable to the production of raw materials for heat pumps, such as steel. Manufacturers of heat pumps have not previously needed to produce safety data sheets for chemicals, and information and training may be needed.

R3 Hazardous substances in chemical products

Requirement suggestion

R3 Chemical products, hazardous substances

The following substances must not be actively added* to chemical products, for example, cleaning products, paints, lacquers, adhesives or sealants used in final assembly of heat pumps and surface treatment:

- lead (Pb), mercury (Hg), hexavalent chromium (Cr^{VI}), cadmium (Cd) and their compounds
- halogenated organic compounds
- alkylphenols, alkylphenol ethoxylates or other substances which may form alkylphenols or alkylphenol ethoxylates
- phthalates, listed in R8
- volatile aromatic compounds (VAH) at more than 1% by weight.
- volatile organic compounds (VOC**) at more than 5% by weight in surface treatment agents
- nano particles (from nanomaterial***)

An exemption to the requirement applies to metal plating of parts. The terms of requirement in R4 must be met when metal plating of parts.

** Substances that are not actively added by the chemical manufacturer or its subcontractors and that appear in quantities of less than 100 ppm are excluded from the requirement.*

***VOCs are defined as organic compounds that at 293.15 K have a steam pressure of 0.01 kPa or more.*

**** The definition of a nano material follows the European Commission's definition of nano materials from 18 October 2011, with the exception of the limit for particle size distribution, which is reduced to 1%: A nano material is a natural, incidental or purposely manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for at least 1% of the particles in the number size distribution, one or more external dimensions is in the size range 1-100 nm. This definition applies to the whole material, including particles exceeding the interval of 1-100 nm, as long as 1% of the material is particles of 1-100 nm. The definition applies to nano particles both in an unbound and in a bound state.*

✉ Declaration or other equivalent certification (documentation) from the chemical manufacturer/supplier. Appendix 2 may be used.

Background to the requirement

This is a new requirement.

Heavy metals and their compounds:
The substances in question are lead, mercury, hexavalent chromium and cadmium. Heavy metals are vital components which allow animals and plants to live and function normally. Often, only small quantities are required. However, at the same time heavy metals can be very harmful, and their toxicity is dependent entirely on their volume and concentration. Lead, mercury, hexavalent chromium and cadmium are some of the most harmful heavy metals.

Halogenated organic compounds:
Halogenated organic compounds are organic compounds containing halogenated compounds such as chlorine, bromine, fluorine or iodine. Halogenated organic compounds include many substances which are hazardous to health and the environment, which are very toxic to aquatic organisms and which are also carcinogenic or hazardous to health in other respects. It is very difficult to degrade halogenated organic compounds, which increases the risk of harmful effects from such substances. The requirements state – among other things – that halogenated flame retardants, high chlorinated paraffins, perfluoroalkyl compounds (such as PFOA and PFOS) and halogenated organic solvents must not be added.

Alkylphenol ethoxylates (APEOs) and alkylphenol derivatives:
This means that substances which give off alkyl phenols when they degrade must not be used. APEOs may be present in detergents, binders, dispersants, thickeners, driers, defoamers, pigment pastes, waxes, etc. APEOs have a number of problematic properties which are hazardous to health and the environment. APEOs are not readily degradable in accordance with applicable standardised tests. They have a tendency to bio accumulate, they have been found in high concentrations in wastewater sludge, degradation products from APEOs, alkyl phenol and APEOs with one and two ethoxy groups. They are very toxic to aquatic organisms, and some alkyl phenols are suspected of having hormone disrupting effects – alkylphenols and bisphenol-A are some of the more potent substances among the oestrogenic chemicals which can occur in wastewater.

Raw materials containing APEOs can be replaced with APEO-free raw materials, which are based on three groups of tensides: alkyl sulphates, alkylether sulphates and alcohol ethoxylates. These three groups of tensides are readily degradable under both oxygen-rich and oxygen-poor conditions and the tensides are toxic or very toxic to aquatic organisms. The alkyl sulphates and alkylether sulphates are not considered to be bio accumulative, while independent alcohol ethoxylates (in long chains with few ethoxylate units) have the potential to bio accumulate. Although the substitution tensides are toxic or very toxic to aquatic organisms, it is environmentally beneficial to use these for replacement as they degrade quickly. Moreover, the degradation product nonyl phenol is avoided, which can disrupt the hormones by replacing APEOs.

Phthalates:
The group of substances known as phthalates consists of many different substances, e.g. diethyl hexyl phthalate (DEHP), dibutyl phthalate (DBP), butyl benzyl phthalate (BBP), diisodecyl phthalate (DIDP), diisononyl phthalate (DINP) and diisobutyl phthalate (DIBP). Some phthalates are classified as toxic to the reproduction, while some are also classified as being hazardous to the environment. Phthalates occur in many placed in the environment, including in freshwater, saltwater, wastewater, air and organisms, e.g. mussels and fish. Phthalates are used mainly as softeners in plastic, particularly in PVC, but they also occur in other products such as sealants, adhesives, paints and varnishes. For more information on phthalates, see requirement R8.

Volatile aromatic compounds (VAH) and volatile organic compounds (VOC):
Volatile organic substances which include one or more benzene rings are known as volatile aromatic compounds and are very stable. The term 'aromatic compounds' refers to – among other things – benzene, toluene, mixed xylenes, orthoxylene, paraxylene and methaxylene (also known as BTX). Benzene is used mainly for the production of styrene, cumene and cyclohexane. Toluene is used mainly for the production of benzene, phenol and toluene diisocyanate. "Organic solvents can be absorbed through the lungs and skin and damage a number of organs. This damage may be acute or chronic. Acute injuries following inhalation of vapour include headache, fatigue, etc. Organic solvents can also cause irritation to the mucous membranes of the eyes, nose and throat. Organic solvents degrease the skin and may cause eczema. Long-term exposure to organic solvents may cause chronic damage to the brain and nervous system. Some organic solvents also add to the greenhouse effect. Some solvents contribute to the formation of photochemical ozone, while others contribute to the degradation the ozone layer.

The use of products containing high levels of VOCs is controlled mainly by two ordinances: VOC Ordinance no. 350 dated 29 May 2002, which is based on EU directive 13/1999 and VOC Product Ordinance no. 1049 dated 27 October 2005, which is based on EU directive 2004/42/EC. VOC Ordinance no. 350 regulates emissions from 20 different types of facility where the annual VOC consumption exceeds the stated threshold values. This directive is a minimum directive, which means that EU Member States can specify more stringent requirements by specifying, for example, a higher level of protection for the country's environment than the level prescribed in the directive. The VOC Ordinance prescribes (surface treatment of metal) the use of max. 5 tonnes of solvents per year. This means that in particular, major manufacturers of heat pumps have to use different methods for recycling/incineration of VOCs in order to meet the requirements laid down in law. National work environment laws also prescribe the use of VOC-based chemicals. Nordic Ecolabel wishes to limit quantities of VOCs to the minimum level of 5 % by weight in surface treatment agents.

Nanotechnology
Nanotechnology, which also includes nanoparticles, is being used ever more extensively in the construction and furniture industry. One major concern is the use of nanoparticles which can be released, affecting health and the environment. For instance, nanoparticles can penetrate healthy cells, where they can harm the cell or its DNA at the nucleus.

Particles at nano level have special properties and are being used more and more extensively in various consumer products in order to provide new, improved functions for products, including chemical products such as paints and coatings. Nanoparticles may also constitute an unwanted risk to health and the environment. The particle form makes it possible, for example, to reach parts of the body and the environment that are otherwise protected[34].

Furthermore, their size can lead to increased reactivity, where small structures in relative terms will have a much larger available area compared with larger particles. Research into the risks involved with the use of nano materials have focused mainly on effects on health, and has been proven in some cases involving injury[35.] For example, it has been demonstrated that nanoparticles can penetrate cells and damage them[36.] This does not mean that all nanoparticles will cause damage. There is currently a lack of knowledge on the effects of nanoparticles on health and the environment, particularly in respect of long-term effects and environmental effects[37.] The Nordic Ecolabelling utilises the precautionary principle as regards the use of nanomaterial.

R4 Metal plating on parts

Requirement suggestion

R4 Metal plating of parts

Metal parts may not be coated with cadmium, hexavalent chromium, nickel, zinc or their compounds.

Parts may only be coated with trivalent chromium, nickel or compounds of these where this is necessary on the grounds of chemical or mechanical wear or on the grounds of another specific technical need.

Any chrome plating and nickel plating processes must be carried out with the help of purification technology/waste water treatment technology such as ion replacement membrane technology or similar technology in order to ensure the greatest possible recovery of the metals. The process water shall be captured for recycling or destruction. The system must be closed.

✉ Specification of any need for metal plating from the heat pump manufacturer. Declaration from the manufacturer that the metal plating requirement is fulfilled. Including a statement as to what cleaning technology has been used, if applicable. Appendix 3 may be used.

[34] Teknologirådet, 2008: Nanomaterialer, risiko and regulering, report 2008
[35] Teknologirådet, 2008: Nanomaterialer, risiko and regulering, report 2008
[36] Janne K. Folkmann, Lotte Risom, Nicklas R. Jacobsen, Håkan Wallin, Steffen Loft, Peter Møller; Oxidatively Damaged DNA in Rats Exposed by Oral Gavage to C60 Fullerenes and Single-Walled Carbon Nanotubes, Environ. Health Persp, 117(5), 2009
[37] Janne K. Folkmann, Lotte Risom, Nicklas R. Jacobsen, Håkan Wallin, Steffen Loft, Peter Møller; Oxidatively Damaged DNA in Rats Exposed by Oral Gavage to C60 Fullerenes and Single-Walled Carbon Nanotubes, Environ. Health Persp, 117(5), 2009

Background to the requirement

This is a new requirement. The plating of metal has an environmental impact (relevance). Substances which are harmful to health and the environment are used in some metal platings, e.g. chrome plating. The environmental impact of metal plating may vary depending on which process is applied and which substances are used for surface treatment (potential). In exceptional cases, smaller parts and areas can be plated with trivalent chromium or nickel if so required due to chemical or mechanical wear or for some other special technical requirement.

For the introduction of future criteria, the Nordic Ecolabel proposes that lead, mercury, cadmium, hexavalent chromium or nickel should not be allowed to be added for metal plating as these substances are classified as hazardous in accordance with the requirement in Section 4.2.2 Chemical products used during manufacture – classification.

In exceptional cases, parts can be plated with trivalent chromium or nickel if so required due to chemical or mechanical wear or for some other special technical requirement. The chrome plating process must then be based on trivalent chromium, and hexavalent chromium must not occur in the plating. These chrome plating and nickel plating processes must take place using purification technology/waste water treatment such as ion exchange technology, membrane technology or similar technologies in order to ensure the greatest possible recovery of the metals. The process water shall be captured for recycling or destruction. The system must be closed.

Therefore, we are introducing requirements here concerning special types of purification plant among subcontractors to manufacturers of heat pumps bearing the Nordic Ecolabel. Annex 2 to the criteria document has been created to help manufacturers to document this requirement.

4.3 Material requirements

R5 and R6 General requirements

Requirement suggestion

R5 RoHS Directive

All materials in the heat pump must meet the requirements of the RoHS Directive (2011/65/EU).

✉ Heat pump manufacturer's declaration, see Appendix 8.

R6 Marking of plastic parts

Plastic parts that weight 25 grams or more must be marked in accordance with ISO 11469.

Cables or rubber parts are excluded from the requirement. Plastic parts with a smooth surface of less than 200 mm^2 are also excluded from the requirement.

✉ Declaration from the heat pump manufacturer that the requirements are met or that the smooth surface on plastic parts is smaller than 200 mm^2.

Background to requirement R5

Version 2.2 of the criteria document starts off with a requirement stating that materials in heat pumps must meet the requirements of the RoHS Directive[38]. This European directive prohibits the use of mercury, cadmium, hexavalent chromium and flame retardants PBB and PBDE in new electronic devices sold after 1 July 2006. RoHS2 (2011/65/EC), which will come into force on 2 January 2013 in all Member States, including Norway, has an open field of application. Certain product groups are excepted from RoHS2. Two of the exceptions stated in article 2 (4) relate to combinations of electrical and electronic products in a professional context, i.e. "large-scale stationary industrial tools" (article 2 (4) (d)) and "large-scale fixed installations" (article 2 (4) (e)). Both terms are explained in the definitions (articles 3 (3) and 3 (4)), but no explanation is given of what "large" means. An attempt is made to describe this in the draft FAQ issued for comment in September 2012[39]. The following text is provided here:
Examples for large-scale fixed installations (benefiting from an exclusion): …..
Larger fixed installed cooling, air conditioning and refrigerating systems of more than 12 kW nominal cooling capacity, or heating systems with a nominal capacity higher than 70 kW, or ventilating systems with a power input above 125 W, insofar as they are not intended for domestic use.[40] This means that all heat pumps included in version 3 of the criteria must meet the requirements laid down in RoHS2. The RoHS Directive must be interpreted as referring to the entire product, not just the electrical parts[41]. Requirement R6 has been formulated in order to capture this.

Background to requirement R6

Version 2.2 of the criteria document requires labelling of plastic parts weighing 50 grams or more. In the new criteria, it is proposed that corresponding requirements should remain in place but that the weight limit is reduced to 25 grams, which is the same as for other electric and electronic product groups bearing the Nordic Ecolabel. Some products are difficult to label, partly on account of their size. This is why cables, parts made of rubber and plastic parts with a smooth surface smaller than 200 mm^2 are an exemption from this requirement. Annex 4 to the criteria document has been created to help manufacturers to document this requirement.

[38] The RoHS Directive, which came into force on 13 February 2003 (2002/95/EC), has been replaced by a new directive (RoHS II 2011/65/EC)
[39] http://www.klif.no/no/Aktuelt/Horinger-og-kunngjoringer/2012/RoHS-2-FAQ-dokument/
[40] http://ec.europa.eu/environment/waste/rohs_eee/events_rohs3_en.htm
[41] Sara Bergman, personal communication with Göran Gabling, Swedish Chemicals Agency, 27 October 2011

R7 Flame retardants

Requirement suggestion

R7 Flame retardants in plastic and rubber parts

a) Hexabromocyclodecane (HBCDD), tetrabromobisphenol A (TBBP-A) and highly chlorinated short-chain and medium-chain chloroparaffins must not be added.

b) Other halogenated organic flame retardants and flame retardants that have been given one or several of the following risk phrases must not be added.
- R45 (H350) (may cause cancer)
- R46 (H340) (may cause inherited genetic harm)
- R60 (H360F) (may impair fertility)
- R61 (H360D) (may cause harm to the unborn child).

An exemption from requirement b) may be given for halogenated flame retardants:
- In cases where these are required for electrical or fire safety reasons under the Low Voltage Directive 73/23/EEC or standard EN 60335-1
- Printed circuit boards, PCBs
- Plastic and rubber parts weighing < 25 grams that are integral to electronic parts

The exemption does not apply to the flame retardants governed by a) that are prohibited under the RoHS Directive (2011/65/EU).

✉ Duly completed declaration from the manufacturer/supplier of the plastic and rubber parts, see Appendix 4.

Background to the requirement

All electrical and electronic products involve a risk of fire. Various flame retardants are used to minimise this risk. The choice of flame retardants is controlled by a number of factors such as which material is to be flame proofed, fire protection requirements and price. Nor may the flame retardant impair the intended technical functions of the product.

The intention of flame retardants is to provide protection throughout a products use phase. This is why they are deliberately manufactured so as not to degrade readily, which means that these substances can be difficult to degrade when they emerge into the environment. Most attention has been paid to *brominated* flame retardants, partly because their presence has been detected in breast milk and blood. Of non-brominated flame retardants, the most common are metal compounds, organic phosphorus and nitrogen compounds and inorganic salts.

There are approximately 70 brominated flame retardants on the market, and knowledge of their properties as hazardous to health and the environment varies. The five brominated flame retardants which have been used most and for which a lot of knowledge exists are[42]:
- pentabromodiphenyl ether
- octabromodiphenyl ether

[42] Information from the Swedish Chemicals Agency website, sww.kemi.se

- decabromodiphenyl ether
- hexabromocyclododecane (HBCDD)
- tetrabromobisphenol-A (TBBP-A)

The first three form part of the group of polybrominated diphenyl ethers (PBDEs). Due to the EU Directive Restriction of Hazardous Substances (RoHS), polybrominated diphenyl ethers and polybrominated biphenyls (PBB) have been prohibited in new electrical and electronic devices since July 2006.

The Commission decided in October 2005 that the flame retardant decaBDE[43] would generally be excepted from the prohibition laid down in the RoHS Directive. On 1 April 2008, the EC Court decided that decisions of the Commission on such exceptions are not valid. Consequently, decaBDE is also prohibited in electrical and electronic products as of 1 July 2008.

Now that the RoHS Directive has been revised (came into force in June 2011), no new substances have been prohibited. The flame retardants which the Commission was tasked with incorporating into the RoHS Directive were the brominated flame retardants HBCDD and TBBPA.

Sweden reported on the risk assessment of HBCDD within the EC's Existing substance programme. The conclusions of the report are that this substance is persistent, bio accumulative and very toxic to aquatic organisms and may cause harmful long-term effects in the aquatic environment. In animal experiments, HBCDD has proven to affect the liver and thyroid and to be reprotoxic. The risk assessment of HBCDD is complete within the EU. HBCDD has been identified as a particularly hazardous substance, SVHC (Substance of Very High Concern), and it is included in the candidate list (REACH). HBCDD is also included in the authorisation list, Annex XIV, in REACH.

TBBP-A has also undergone risk assessment within the EU's Existing substance programme. This substance is classified as very toxic to aquatic organisms and may cause harmful long-term effects in the aquatic environment. TBBP-A is considered to be poorly degradable and bio accumulative. Alternatives to TBBP-A with flame retardant effect have been developed and are being used more widely.

TBBP-A is the most widely used brominated flame retardant in the world. It is used mostly in printed circuit boards. As it is chemically bound to the material in the printed circuit board and hence is not spread so readily to the surrounding environment, the EU has deemed that it does not pose a risk to human health in this application.

Chloroparaffins, which can also be used as flame retardants, are stable, poorly degradable compounds which may bio accumulate in the environment. Highly chlorinated short-chain and medium-chain chloroparaffins are very toxic to aquatic organisms and may cause harmful long-term effects in the aquatic environment.

[43] Pentabromodiphenyl, octabromodiphenyl and decabromodiphenyl ethers belong to the same chemical substances, polybrominated diphenyl ethers (abbreviated PBDE). These have different numbers of bromine atoms in their structures. All three are poorly degradable, persistent substances, while their bioaccumulation and toxicity differ.

Highly chlorinates short-chain chloroparaffins have been identified as particularly hazardous substances, SVHC, in REACH and are included on the candidate list.

Flame retardant	**Regulations**	**Risk assessment**	**Nordic Swan stance for heat pumps**
Polybrominated biphenyls (PBB)	Prohibited in new electrical and electronic products in accordance with the RoHS Directive since July 2006	PBB was the first brominated flame retardant found to be hazardous. The substance has now been investigated thoroughly, and as far as we know PBB is no longer manufactured.	Must not be used
Polybrominated diphenyl ethers (PBDE)	Prohibited in new electrical and electronic products in accordance with RoHS Directive since July 2006 (since July 2008 for decaBDE).	pentaBDE: persistent, hazardous to the environment, harmful to health. POP substance (UNEP) octaBDE: reprotoxic, persistent and bioaccumulative. POP substance decaBDE: suspected hazard but risk assessment not complete.	Must not be used
Hexabromocyclo dodecane (HBCDD)	Use permitted	Classified as SVHC. Included in the candidate list.	Criteria version 2.2: No requirements Revised criteria: Must not be used
Tetrabromobisph enol A (TBBPA)	Use permitted	Very toxic to aquatic organisms. May cause harmful long-term effects in the aquatic environment.	Criteria version 2.2: No requirements Revised criteria: Must not be used
Short-chain chloroparaffins	Use permitted	Classified as SVHC. Included in the candidate list.	Must not be used
Medium-chain chloroparaffins	Use permitted	Very toxic to aquatic organisms. May cause harmful long-term effects in the aquatic environment.	Criteria version 2.2: No requirements Criteria version 3.0: Must not be used

Table b1: List of flame retardants, their risks and usage restrictions.

It is estimated that a heat pump is made up of 4 kg[44] of electronics which may require flame proofing. PVC for electric cables amounts to a further approx. 0.5 kg, but PVC is flame retardant in itself and does not normally require the addition of flame retardants. The plastic-based insulating materials cellular rubber and expanded polystyrene (EPS) may contain brominated flame retardants. However, alternatives without brominated flame retardants are available on the market. The insulation in a heat pump is normally made up of foam rubber (polyurethane cellular plastic).

[44] Volume data from the report Livscykelanalys av villauppvärmning – en studie av fjärrvärme, pelletspanna, oljepanna, elpanna och värmepump, thesis, Chemical Environmental Science, Chalmers 2005

Polymer	Contents (%)	Substance/s
Polystyrene foam	0.8-4	HBCDD
High-impact polystyrene	11-15	decaBDE, brominated polystyrene
Epoxy resin	0-0.1	TBBPA
Polyamides	13-16	decaBDE, brominated polystyrene
Polyolefins	5-8	decaBDE, propylene dibromostyrene
Polyurethanes	n/a	no brominated flame retardants available*
Polyethylene terephthalate (PET)	8-11	brominated polystyrene
Unsaturated polyesters	13-28	TBBPA
Polycarbonate	4-6	brominated polystyrene
Styrene copolymers	12-15	brominated polystyrene

Table b2: List of which brominated flame retardants are used in various common polymers, dated 2001[45].

* Nordic Ecolabelling has experienced in 2012 use of brominated flame retardants in polyurethane foam.

However, exceptions can never be allowed for substances regulated by the RoHS Directive, including decaBDE, or for highly chlorinated short-chain chloroparaffins.

Against this background, primarily the thorough risk assessment, the following are proposed:

1. Continued prohibition of polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE) in that the requirements in RoHS must be met. As RoHS now includes decaBDE as well, requirement R13 in version 2.2 of the criteria document does not need to be passed on.
2. Continued prohibition of highly chlorinated short-chain chloroparaffins and also of highly chlorinated medium-chain chloroparaffins.
3. Prohibition of hexabromocyclodecane (HBCDD) and tetrabromobisphenol-A (TBBP-A).
4. Prohibition of other halogenated organic flame retardants, that have been given one or several of the following risk phrases: R45, R46, R60 and and R61, but that exceptions may be accepted when this is necessary for electrical and fire safety reasons with reference to the Low Voltage Directive **73**/23/EC (note: written incorrectly in version 2.2 of the criteria) and to standard EN 603 35-1.

This requirement has the same structure as in version 2.2, but more brominated flame retardants have been added.

All flame retardant-related requirements are to include plastic and rubber components weighing 25 grams or more. Printed circuit boards are excepted from these

[45] Pedro Arias, Brominated flame retardants –an overview. 2:nd International Workshop on BFR, Stockholm, 2001

requirements. However, neither of these is permitted to contain PBB, PBDE, HBCDD, TBBPA or highly chlorinated short-chain and medium-chain chloroparaffins in concentrations in excess of 0.1 % by weight in homogeneous materials (contamination limit). There may be a need to except cables entirely from the requirements.

For information: The Blaue Engel label has no requirements concerning additives to materials. The EU Ecolabel specifies requirements which are identical to the level in applicable EU legislation/RoHS.

R8 Phthalates

Requirement suggestion

R8 Phthalates

The following phthalates must not be added to plastics or rubbers:

- Di(2-ethylhexyl) phthalate (DEHP)
- Dibutyl phthalate (DBP)
- Butyl benzyl phthalate (BBP)
- Dicyclohexyl phthalate (DCHP)
- Diisobutyl phthalate (DIBP)
- Diisooctyl phthalate (DIOP)
- Diisononyl phthalate(DINP)
- Diisodecyl phthalate (DIDP)
- Di-n-octyl phthalate (DNOP)
- Diethyl butyl phthalate (DEBP)
- Di-n-hexyl phthalate (DnHP)
- Di-n-decyl phthalate (DnDP)

Printed circuit boards and plastic and rubber parts weighing < 25 g that are integral to electronic parts are exempt from the requirement.

✉ Duly completed declaration from the manufacturer/supplier of the plastic and rubber parts, see Appendix 4.

Background to the requirement

Phthalates are used mainly as softeners in plastic and rubber, and the phthalate content can be up to 40 % of the finished product. Particular attention is paid to the use of DEHP (di(2-ethylhexyl) phthalate) as a softener in PVC plastic. Softeners are not firmly bound to the PVC polymer, and so phthalates are secreted from plastic products throughout their entire service life. Phthalates can be found almost everywhere in the environment because of this diffuse spreading[46].

Diethylhexyl phthalate (DEHP), dibutyl phthalate (DBP) and butyl benzyl phthalate (BBP) are classified as toxic and reprotoxic, i.e. they may impair fertility and cause harm to the unborn child. DBP is also classified as environmentally hazardous and very toxic to aquatic organisms. These three most hazardous phthalates (DEHP, DBP and BBP) are completely prohibited[47] in toys and childcare items. For the three less

[46] Swedish Chemicals Agency, http://www.kemi.see/templates/Page____3283.aspx
[47] If the content in the product exceeds 0.1 %.

hazardous substances diisononyl phthalate (DINP), diisodecyl phthalate (DIDP) and di-n-octyl phthalate (DNOP), this ban relates to toys and childcare articles which children may put in their mouths.

The Nordic Ecolabel 's criteria for heat pumps, version 2.2, prohibit the addition of a range of softeners to plastic, including the above but also including other softeners such as dicyclohexyl phthalate (DCHP) and diisobutyl phthalate (DIBP).

It should be noted that only a small element of any heat pump is made up of plastic; let along *softened* plastic. For example, a geothermal heat pump[48] consists of approximately 3.5 kg of plastics, of which approximately 0.5 kg is PVC plastic for the electric cable and approximately 10 kg is foam rubber insulation (probably polyurethane foam).

The revised criteria will continue to apply a ban on the phthalates which present or probably present a hazard. This means that they comprise straight medium, straight long or branched carbon chains.

Besides the phthalates listed in R12 in version 2.2 of the criteria document, the following phthalates will also be banned:

- Di-n-octyl phthalate (DNOP)
- Diethyl butyl phthalate (DEBP)
- Di-n-hexyl phthalate (DnHP)
- Di-n-decyl phthalate (DnDP)

All phthalate-related requirements are to include plastic and rubber components weighing 25 grams or more. Printed circuit boards are excepted. There may be a need to except cables as well. Nordic Ecolabelling hope that the consultation will provide responses on which softeners are used in PVC cables and whether alternatives to phthalates can be used.

R9 Foaming agents in insulation materials

Requirement suggestion

R9 Foaming agents

Foaming agents used in insulation must have an ozone depletion potential (ODP value) equal to 0 and a global warming potential (GWP100 value) < 15 (calculated in CO_2 equivalents over a period of 100 years).

The foaming agent may not contain halogenated organic compounds.

✉ List of foaming agents used plus declaration from producer/supplier of the foaming agents showing that the requirement is fulfilled. Use Appendix 5.

[48] Volume data from the report Livscykelanalys av villauppvärmning – en studie av fjärrvärme, pelletspanna, oljepanna, elpanna och värmepump, thesis, Chemical Environmental Science, Chalmers 2005

Background to the requirement

Foaming of insulation material is possible using – for example – water or pentane, which environmentally are expedient. CFCs (chlorofluorocarbons) and HCFCs (hydrochlorofluorocarbons) are often known as freons and have been used for foaming of insulation material. These help to deplete the ozone layer. The international agreement, the Montreal Protocol, has been entered into concerning termination of their use. The newer substitute HFC (hydrofluorocarbon) now represents almost the entire use of this type of substance. It is used in refrigeration systems, for foaming plastic, in fire extinguishing agents and for cleaning[49].

In accordance with Norwegian regulations relating and EU rules, use of ozone-depleting HCFCs was prohibited for all foam production as of 1 January 2004. Back in 2002, a number of Norwegian manufacturers of insulation foam had switched to production processes that do not release ozone-depleting substances[50].

Properties of alternative foaming agents:
Ideal foam expansion agents should present the following properties[51]:

- Low thermal conductivity of steam
- Non-flammable
- Liquid at room temperature (boiling point above 25 °C)
- Low toxicity
- Zero ODP (ozone depletion potential)
- Low GWP (global warming potential)
- Chemical/thermal stability
- Soluble in formulation
- Low diffusion
- Financial feasibility

The fourth generation of foaming agents (known as the AFA series) includes both liquid and gas alternatives with low GWP (<15) and insignificant ozone-depleting effects[52]. This is hydrofluoro olefins (HFO), and even though they have a low GWP it is of concern that they contain fluorine and that their long term effects are unknown[53]. Due to the precautionary principle these compounds are banned. Table b3 summarises the properties for the fourth-generation foaming agent and other foaming agents such as cyclopentane, HFC-134a, HFC-245fa and HCFC-141b.

[49] http://www.kemi.se/sv/Innehall/Statistik/Kortstatistik/Kortstatistik-over-amnen-och-amnesgrupper/CFC-HCFC-och-HFC-freoner/
[50] http://www.klif.no/no/Aktuelt/Nyheter/2003/April/Redusert-bruk-av-ozonreduserende-stoffer/
[51] www.ecomatesystems.com
[52] http://www.appliancemagazine.com/editorial.php?article=2149&zone=1&first=1
[53] "New Blowing Agent Addresses Climate Impact of Foam Insulation", from the American web page: GreenBuildingAdvisor.com. Available from: http://www.greenbuildingadvisor.com/blogs/dept/energy-solutions/new-blowing-agent-addresses-climate-impact-foam-insulation (visited 7 November 2012)

	Lambda (mw/m-°K) 10°C 25°C		ODP	GWP
AFA-G1	**11**	**12**	**0**	**<15**
AFA-G2	**12**	**13**	**0**	**<15**
AFA-L1	**9**	**10**	**0**	**<15**
AFA-L2	**9**	**10**	**0**	**<15**
Pentane cC5	**11**	**13**	**0**	**11**
Pentane iC5	**14**	**?**	**0**	**11**
Pentane nC5	**14**	**?**	**0**	**11**
F 134a	**12**	**14**	**0**	**1300**
F 245fa	**13**	**13**	**0**	**950**
F 141b	**9**	**10**	**00:11**	**700**

Table b3: Excerpt from properties for AFA molecules.

R10 Refrigerants

Requirement suggestion

R10 Refrigerants, greenhouse gas effect

The GPW_{100} value of the refrigerant and its contents may not be > 2,000.

If a refrigerant with a GWP_{100} value >100 has been used, the unit shall be constructed in a way that prevents leakage. One such construction is system units that have undergone factory pressure testing.

The types of refrigerant and the filling quantity (kg) shall also be stated in connection with or on the nameplate pursuant to EN 14511-4. See R14

The refrigerant and its contents shall be classified and labelled pursuant to EU Directive 67/548/EC and EN 1999/45/EC, or alternatively pursuant to European Regulation CLP (EC) 1272/2008.

If refrigerants with a GWP_{100} value <150 are used, a lower energy efficiency level may be acceptable, see R11.

✉ Nameplate copy. Information about the refrigerant used with GWP100 value, see Appendix 6.

Background to the requirement

Refrigerant is the working medium which circulates inside the heat pump and transfers heat. First of all, a refrigerant must have good properties for increasing the temperature within the temperature range of the heat pump. Good transport properties (low viscosity) and good heat transfer properties are also important.

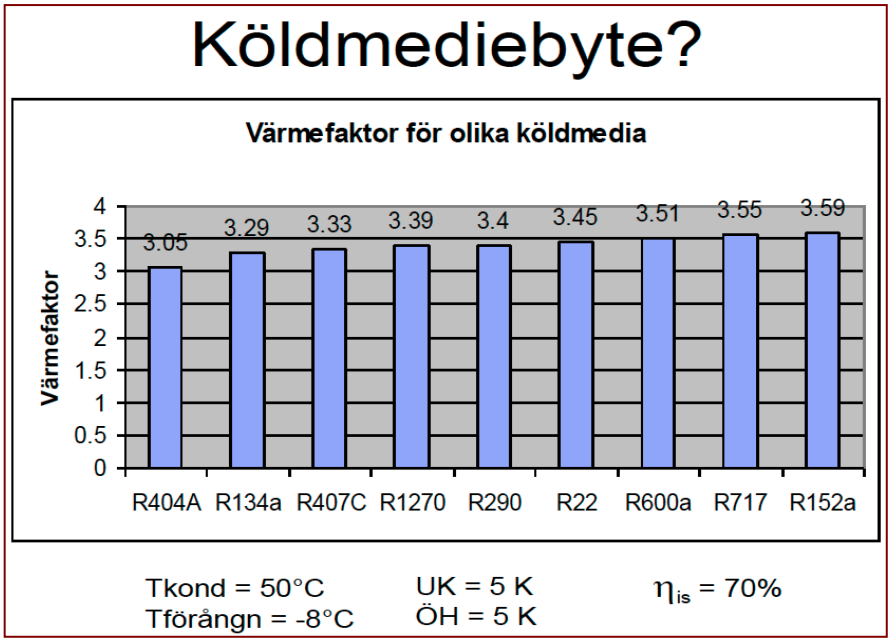


Figure 1: To what extent can the heat pump be improved? Source: Jan-Erik Nowacki, Royal Institute of Technology, Swedish Heat Pump Association, etc.

The Ordinance on substances that deplete the ozone layer (1005/2009/EC) has controlled the phasing-out of ozone-depleting substances. This ordinance was formerly known as 2037/2000/EC. The Ordinance on certain fluorinated greenhouse gases (842/2006/EC) regulates refrigerants in the group of HFCs and PFCs (perfluorinated compounds). National laws and regulations, which in many instances are more stringent, complement the European regulations.

Ozone-depleting refrigerants (the CFC and HCFC groups) have been removed entirely from new heat pumps for many years now. They have largely been replaced by fluorinated gases with no chlorine content; HFC gases. HFC refrigerants do not deplete the ozone layer, but they are potent greenhouse gases. Factors which affect the greenhouse effect of refrigerants are:

- good materials and good connections which minimise the risk of leaks
- as little refrigerant as possible required for filling
- refrigerant with as low a GWP factor[54] as possible.

Geothermal heat pumps have a typical fill volume of 1-2.5 kg of refrigerant. R407C is by far the most commonly used refrigerant, although R134a and R404A are also used in a number of products.

In air-to-air heat pumps, R410A is almost the sole refrigerant used, with a fill volume of approximately 0.7-1.5 kg. The difference in fill volume is due to whether or not one is forced to lay extra long connecting pipes between the outdoor unit and the indoor unit for the air-to-air heat pump

[54] The GWP_{100} value indicates how strong the greenhouse effect of the substance is compared with carbon dioxide over a period of 100 years.

Refrigerant	Category	Upper temperature limit*, °C	toxic/flammable	Residence time in the atmosphere, years	Greenhouse effect, GWP100 factor
R134a (HFC)	Synthetic	<60°C (70-90°C)[2]	N/N	14	1300
R407C (HFC)	Synthetic	<50°C (65°C)[1]	N/N	36	1530
R410A (HFC)	Synthetic	<50°C (60°C)[1]	N/N	36	1730
R404A (HFC)	Synthetic	<50°C (60°C)[1]	N/N	55	3260
R507 (HFC)	Synthetic	-	N/N	-	3800
R717 Ammonia	Natural	<50 (70-90)[2]	J/J (partial)	-	0
R600 (Butane)	Natural		J/J	-	4
R600a (Isobutane)	Natural		J/J	-	4
R290 (Propane)	Natural	60	N/J	<1	3
R744 (Carbon dioxide)	Natural	65-70	N/N	-	1

Table b4: Data on refrigerants used in heat pumps[55].

** This means the upper temperature to which the heat pump can produce its heating output.*

1) High-pressure compressor

2) Two-stage system, pressure class dependent on the medium and temperature.

Alternative refrigerants with little greenhouse effect

As can be seen from table b4, there are refrigerants with considerably less impact than HFC on the greenhouse effect. These natural refrigerants, as they are known, are:

Ammonia (NH_3)

Ammonia can be used for certain large industrial facilities where trained personnel work. The disadvantage of ammonia is that it is very toxic and can cause fatal accidents if it escapes. Therefore, this substance will probably not be an option for use in densely populated areas.

Carbon dioxide (CO_2)

Carbon dioxide is currently used as a coolant in certain special applications, with good results. The introduction of transcritical[56] heat pumps using carbon dioxide as a refrigerant has gone slowly. A heat pump of this kind is a good solution thanks to its low GWP_{100} factor. Unfortunately, this technology presents a number of challenges. Heat pumps using carbon dioxide as a refrigerant require five to ten times as much pressure as traditional pumps containing HFCs. Carbon dioxide has a critical temperature of 31°C and a critical pressure of 73.8 bar. Carbon dioxide works well as a refrigerant in commercial refrigerators and freezers. In Japan, carbon dioxide is a relatively common refrigerant in heat pumps designed to heat hot water for household use. In our rugged Nordic climate, on the other hand, where heat pumps are largely used to heat homes, it is not an appropriate refrigerant. Quite simply, the coefficient of performance is too poor. Carbon dioxide is not flammable and is not regarded as toxic at these concentrations. The high pressures required do not appear to be a

[55] www.cbs.grundfors.com

[56] Wikipedia: A transcritical process is a circuit process where the working medium (refrigerant) has states both above and below the critical point. CO_2 has a critical temperature of 31 ^{o}C

problem, either. Therefore, carbon dioxide could be a good refrigerant in heat pumps designed only for the heating of hot tap water[57].

Hydrocarbons (HCs)
Propane, butane and isobutane are all examples of hydrocarbons which can be used. These substances are flammable and/or explosive. As most compressors are not approved for these refrigerants, they are limited to a fill volume of a maximum of 150 grams[58]. This is supported by the safety standard EN 60335-2-24 or draft 60335-2-89 IEC.

It should be noted that this limit is not legally binding. It is perfectly possible to create installations using larger hydrocarbon fill volumes than 150 grams, but these installations are more complex and require other precautionary measures and materials in order to minimise the risks of fire explosion[59].

The applications in which hydrocarbons replace HFCs satisfactorily are currently small units such as household refrigerators and household freezers. Hydrocarbons are also becoming ever more common in refrigerator and freezer gondolas ("plug-in" refrigerators) in shops and kiosks.

How much damage could be done if we have full discharge of refrigerant from a heat pump? The table below assumes 1.6 kilos of refrigerant and that the production of electricity supplied to the heat pump has an emission of 380 grams of CO_2 per kWh (EU mix).On conversion, 2.632 kWh per kilo of CO_2 emissions is used.

	Greenhouse effect, GWP_{100} factor	**Kilos in machine**	**GWP or CO_2 equivalents in machine**	**kWh/kg CO_2**	**kWh**
R134a (HFC)	1300	1.6	2080	2.632	5474
R407C (HFC)	1530	1.6	2448	2.632	6442
R410A (HFC)	**1730**	**1.6**	**2768**	**2.632**	**7284**
R404A (HFC)	3260	1.6	5216	2.632	13726
R507 (HFC)	3800	1.6	6080	2.632	16000
R717 Ammonia	0	1.6	0	2.632	0
R744 (Carbon dioxide)	1	1.6	1.6	2.632	4
R600a (Isobutane)	4	1.6	6.4	2.632	17
R290 (Propane)	3	1.6	4.8	2.632	13

Table b5: Number of kWh required to "make up for" full discharge of refrigerant.

The table above shows that the refrigerants with the highest GWP will require several years of operation for a full discharge to be "made up".

[57] Discussion with Björn Palm, Professor of Energy Technology at the School of Industrial Engineering, Royal Institute of Technology.
[58] Through a statement made by ASERCOM, a federation of European manufacturers of components for the heating, ventilation, AC and refrigeration industry (www.asercom.org)
[59] Mats Blomqvist, Head of Technology at KYLMA-Sverige's leading refrigeration wholesaler, personal communication, 28 November 2011

In version 2 of the criteria document for heat pumps (requirement R16), the refrigerant must not have a GWP value >2000 over a period of 100 years. When refrigerants with GWP>100 are used, the device must be designed to prevent leaks (unit pressure-tested at the factory). There are also requirements for higher efficiency when using refrigerants with GWP>1000.

Moreover, requirement R17 in version 2 of the criteria document demands that the refrigerant should not be classified using risk phrases in respect of hazard to health or environmental hazard (this is also applicable to the substances included in the medium) as it may come into contact with water, soil or rock. A requirement relating to the environmental hazard and hazard to health posed by refrigerants has been evaluated during review of the criteria. There are no risk phrases relating to hazard to health or environmental hazard for the refrigerants in question. The risk of such refrigerants coming into contact with water, soil or rock is not deemed to be serious and requirements for health hazards or environmental hazards are derför removed.

EU and the development of new refrigerants
It should be noted that the EU recently expressed a desire to reduce emissions of fluorinated greenhouse gases by two-thirds[60]. As legislation to date has been successful in the field, it is stated that emissions must be reduced by – among other things – prohibiting the use of certain products and through agreements with industry. The EU's new F Gas Directive lays down requirements for GWP<150 in new vehicles as of 1 January 2011. The transition from 134a to a different refrigerant with GWP<150 in new vehicles as of 1 January 2011 is the field which, in isolation, will help to bring about the greatest reduction in emissions of F gases in the long term, according to the Commission. The refrigerant used in this case is 2.3.3.3-Tetrafluoro-propene, HFO-1234yf (sometimes also known as R1234yf) and has a GWP_{100} factor of 4. This refrigerant is so new that it has not been fully tested for applications other than air conditioning in vehicles. There are questions relating to the stability of the substance which must be answered.

Given the fact that it may be difficult, as things stand at present, to find replacements for HFC refrigerants with low climate impact which are safe and reliable and which can operate without severely impairing the efficiency of the heat pump, it is proposed that the revised requirements for refrigerants should remain unchanged. On the other hand, it should definitely be possible in future to implement considerably more stringent requirements in the Nordic Ecolabel criteria than is currently the case.

For information: The Blaue Engel label has no requirements concerning refrigerants and secondary refrigerants. Earlier EU Ecolabel requirements (2007) had requirements for refrigerants and secondary refrigerants similar to the Nordic Ecolabel requirements in version 2.

Facts box – Phasing-out of ozone-depleting substances
The Montreal Protocol, which came into force in 1987, has affected the concentrations of ozone-depleting substances in the atmosphere. The total volume of ozone remains 3.5 % below the ozone levels prior to introduction of ozone-depleting substances. The thinning of the ozone layer has remained constant between 2002 and

[60] News item from Miljörapporten Direkt, 27 September 2011.

2005, which indicates that ozone levels have stopped falling. According to forecasts from the WMO/UNEP, it will be possible to observe a turning point in the thinning of the ozone layer by around 2020. This means that we have passed the minimum ozone layer thickness and that we can then expect to see recovery of the ozone layer. However, the results of the forecast assume that work under the Montreal Protocol will continue to be successful and be able to deal with the alarming increase in the consumption of HCFCs worldwide.

The phasing-out of ozone-depleting substances is a success in industrialised countries. The new supply of CFC products to the European market has long been phased out entirely. At present, there are CFCs present only in products released to the market before the ban on CFCs came into force. Nor is it permitted to install new heat pumps containing HCFCs.

New systems can use hydrocarbons, ammonia, carbon dioxide or HFC compounds, all of which are easy on the ozone layer. However, HFC compounds have a negative impact on climate. Moreover, it has been found that climate change affects the development of the ozone layer due to the changes in global circulation, chemical composition and temperature of the atmosphere resulting from a change in climate. Conversely, changes in the ozone layer also affect the climate.

The effects of a change in climate on the thinning of the ozone layer have been studied intensively, but there is still no clear consensus on whether these effects will delay or accelerate the recovery of the ozone layer. This shows how the issue of the phasing-out of ozone-depleting substances is linked with the greenhouse problem. Note that the criteria do not specifically prohibit the use of refrigerants containing ozone-depleting properties in heat pumps bearing the Nordic Ecolabel. This is regarded as unnecessary as it is banned by the authorities.

4.4 Operation of heat pumps bearing the Nordic Ecolabel

R11 Energy efficiency

Requirement suggestion

R11 Energy efficiency

The heat pump's energy efficiency classification shall, at least, correspond to the requirements pursuant to energy classes in Table 2 that refer to the EU's Energy Labelling Regulation (626/2011/EU) for air-air heat pumps and suggestions for the Energy Labelling Regulation for air/liquid-water heat pumps in LOT 1. Note that the heat pump must meet requirements for both climate zone A and C.

Table. 2 Energy class requirements

	Climate zone A, "Average", refers to climate in Strasbourg			Climate zone C, "Colder", refers to climate in Helsinki		
Type of heat pump	air/liquid-to-water*	air/liquid-to-water* low temperature	air-to-air	air/liquid-to-water*	air/liquid-to-water* low temperature	air-to-air
Refrigerants $GWP_{100} > 150$	A++	A+++	A+	A+	A++	A
Refrigerants $GWP_{100} \leq 150$	A+	A++	A	A	A+	B

** Energy labelling requirements for liquid-to-water and air-to-water heat pumps are expected to be decided upon in 2012. Until further notice, there is also a proposal for energy labelling requirements under LOT 1.*

Heat pump efficiency must be tested and calculated in accordance with EN 14511 and EN 14825. Laboratories which carry out testing and calibration must be accredited to EN ISO/IEC 17025.

Heat pump manufacturers must also provide a minimum level of technical data in an installation manual and technical information, see R14.

✉ Certificate from an accredited laboratory in accordance with Annex 1, which indicates the applicable SCOP value (Seasonal coefficient of performance) and energy label in accordance with the Energy Labelling Regulation (626/2011/EC) for air-to-air heat pumps for climate zones A and C. Or the η_s value (seasonal space heating energy efficiency) and energy label in accordance with proposals for an Energy Labelling Regulation in LOT 1 for climate zones A and C.

Background for energy efficiency requirements

Annex 2 provides a brief described and supported of the most common terms used to specify heat pump energy efficiency and climate impact, such as COP, SCOP, ETA (η_s), SEER, EER, SPFPEF and TEWI.

These requirements are approximately 15 % to 20 % lower for heat pumps with refrigerants with a GWP value of 150 or lower over a period of 100 years. GWP=150, which is used as a limit for energy efficiency, is equivalent to the EU's upper limit for GWP for refrigerant for use in AC systems in vehicles. This is the same rebate given in the ecodesign requirements for air-to-air heat pumps (206/2012/EC).

The EU's ecodesign requirement work means that energy-related products must have certain levels of energy efficiency and resource efficiency in order to be used within the EU. These can be viewed as legislation for minimum requirements. Energy labelling requirements supplement information and make it clear to consumers how energy-efficient the product is and allows customers to make active choices.

In LOT 1, which covers liquid-to-water and air-to-water heat pumps, there is differentiation between low temperature and other heat pumps, including heat pumps which can also supply heat for hot water: "Low temperature heat pump" means a heat pump for space heating which is specially designed for low temperatures, and it is unable to supply hot water with a supply temperature of 52 °C at a dry (wet) cooling temperature of -7 °C (-8 °C) under the reference/design conditions for average climate.[61]

According to LOT 1, standard assessment criteria for heat pumps state that low temperature heat pumps must be tested with a flow temperature of 35 °C and a return temperature of 30 °C. For other heat pumps, the test conditions will involve a flow temperature of 55 °C and a return temperature of 47 °C. Depending on whether the outdoor source is air, liquid or water, the requirements for these temperatures will also be specified in the proposal from LOT 1.

The energy efficiency requirement proposed by EU Ecolabel[62] is defined as seasonal space heating efficiency, abbreviated η_s and pronounced "eta-s". Eta-s is defined as η= SCOP/primary energy factor 2.5. The limit proposed in these criteria is η= 90 %, which is viewed by the Nordic industry as a very low ambition level for heat pumps.

The energy class limits in these criteria have been established on the basis of an assessment of the efficiency of some of the best heat pumps on the market and an average of these.

Nordic Ecolabelling's summary of how energy-efficient heat pumps on the market are forms the basis of the following assessment:

- the market should be able to handle a limit corresponding to two energy (label) classes better than the legislation, i.e. than prescribed in the Ecodesign Regulation. This is applicable to air-to-water heat pumps and air-to-air heat pumps.
- that the market should be able to handle three energy (label) classes better than the legislation for liquid-to-water heat pumps.

In 2012, the EU Commission has proposed an Ecodesign Regulation and an Energy Labelling Regulation for boilers (LOT 1) which includes liquid-to-water heat pumps and air-to-water heat pumps, see table b6 and b7. In these regulations, energy efficiency is expressed as efficiency (η_s). Table b6 below also states what the equivalent of this is in terms of seasonal coefficient of performance, SCOP, calculated in accordance with η_s = SCOP/ 2.5.

[61] http://www.eceee.org/Eco_design/products/ LOT 1 boilers.... ANNEX I Definitions related to heaters: (50) Translated into Norwegian)
[62] In work on developing "Criteria for Hydronic Central Heating Generators" LOT 1

LOT 1, Heat pumps, with the exception of low temperature heat pumps.		
2 years after coming into force	4 years after coming into force	
SCOP= 2.25 / η_s = 90 (class A or better)	SCOP= 2.50 / η_s = 100 (class A+ or better)	
LOT 1, Low temperature heat pumps.		
2 years after coming into force	4 years after coming into force	
SCOP= 2.87 / η_s = 115 (class A or better)	SCOP= 3.125 / η_s = 125 (class A or better)	
EU's Ecodesign Regulation (206/2012 EC) for air-to-air heat pumps, single or double duct air conditioners As of 1 January 2013		
	Double duct air conditioners, COP_{rated}	Single duct air conditioners, COP_{rated}
If refrigerant GWP > 150	2.36 (class D or better)	1.80 (class C or better)
If refrigerant GWP < 150	2.12	1.62
EU's Ecodesign Regulation (206/2012 EC) for air-to-air heat pumps, except for single or double duct air conditioners, As of 1 January 2013		
	Seasonal coefficient of performance (SCOP) (average heating season)	
If refrigerant GWP > 150	3.40 (class B or better)	
If refrigerant GWP < 150	3.06	

Table b6: SCOP/ ETA (η_s)* requirements in accordance with the latest Ecodesign proposal in LOT 1[63]. And SCOP requirements in accordance with the latest Ecodesign Regulation (206/2012 EC).

*Calculated value of Seasonal space heating energy efficiency (η_s) "eta" in accordance with η_s = SCOP/ 2.5.

	"Seasonal space heating energy efficiency classes of heaters, with the exception of low temperature heat pumps and heat pump space heaters in low temperature application"	"Seasonal space heating energy efficiency classes of low temperature heat pumps and heat pump space heaters in low temperature application"
A+++	η_s >= 150 / SCOP>= 3.25	η_s >= 175 / SCOP>=3.875
A++	125<= η_s <150 / 3.25<=SCOP<2.85	150<= η_s <175 / 3.875<=SCOP<3.475
A+	98<= η_s <125 / 2.85<= SCOP<2.45	123<= η_s <150 / 3.475<=SCOP<3.075
A	90<= η_s <98 / 2.45<= SCOP<2.25	115<= η_s <123 / 3.075<=SCOP<2.675
B	82<= η_s <90 / 2.25<= SCOP<2.05	107<= η_s <115 / 2.675<=SCOP<2.5
The table continues to energy class G in the regulation, but this is not relevant.		

Table b7: "Seasonal space heating energy efficiency" (Ƞs) requirements in accordance with the latest proposal for Energy labelling in LOT 1[64].

The EU Commission has also adopted the regulation for ecodesign and energy labelling of air conditioning and air-to-air heat pumps. The EU Commission published its Energy Labelling Regulation in its Official Journal in May 2011 and the Ecodesign Regulation in March 2012. These regulations will be applicable as of these dates, which mean – for example – that manufacturers can already use the new, updated energy labelling on their products.

[63] http://www.eceee.org/Eco_design/products/ LOT 1 boilers....Draft 2012
[64] http://www.eceee.org/ energy labeling/products/ LOT 1 boilers....Draft 2012, ANNEX II Energy efficiency classes

The Energy Labelling Regulation (626/2011/EC), which came into force on 26 July 2011, defines energy-efficient air-to-air heat pumps in accordance with the limits specified in Table b8.

Energy Efficiency Class	SEER	SCOP
A+++	SEER ≥ _8.50	SCOP ≥ _5.10
A++	6.10 ≤ _SEER < 8.50	4.60 ≤ _SCOP < 5.10
A+	5.60 ≤ _SEER < 6.10	4.00 ≤ _SCOP < 4.60
A	5.10 ≤ _SEER < 5.60	3.40 ≤ _SCOP < 4.00
B	4.60 ≤ _SEER < 5.10	3.10 ≤ _SCOP < 3.40
C	4.10 ≤ _SEER < 4.60	2.80 ≤ _SCOP < 3.10
D	3.60 ≤ _SEER < 4.10	2.50 ≤ _SCOP < 2.80
E	3.10 ≤ _SEER < 3.60	2.20 ≤ _SCOP < 2.50
F	2.60 ≤ _SEER < 3.10	1.90 ≤ _SCOP < 2.20
G	SEER < 2.60	SCOP < 1.90

Table b8: Energy efficiency classes for air conditioners, except double ducts and single ducts.

The ecodesign requirements for air conditioning systems and air-to-air heat pumps (206/2012/EC) are applicable as of 1 January 2013 and involve the setting of minimum requirements for energy efficiency[65] over two stages.

As of 1 January 2013, the following are applicable:

	Seasonal coefficient of performance (SCOP)
Refrigerants with GWP > 150	3.40
Refrigerants with GWP ≤ 150	3.06

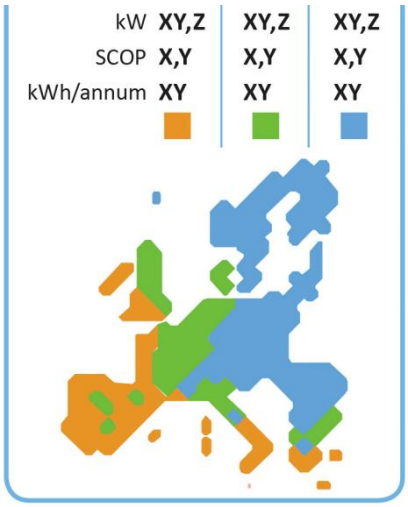
One year later, as of 1 January 2014, this must correspond as a minimum to:

	Seasonal coefficient of performance (SCOP)
Refrigerants with GWP > 150	3.80
Refrigerants with GWP ≤ 150	3.42

Background to the requirement, climate zones

The Energy Labelling Regulation specifies requirements for testing heat pump energy efficiency within 3 climate zones in Europe, but a minimum for class A "Average". The requirement levels in the Energy Labelling Regulation and the Ecodesign Regulation are also linked to climate zone A. Nordic Ecolabel requires that the heat pump also fulfils climate zone C, which is a very relevant climate zone in the Nordic region. Climate zones are defined in accordance with the following annual average temperatures:

- Climate zone "C": below and up to 5 ºC "Colder" refers to the climate in Helsinki



[65] The Ecodesign Regulation also lays down requirements for maximum power consumption when switched off and in standby mode.

- Climate zone "A": between 6–10 ºC "Average" refers to the climate in Strasbourg
- Climate zone "W": between 11–15 ºC "Warmer" refers to the climate in Athens

Denmark has a climate very similar to that in Strasbourg. The Nordic region, except for Denmark, is situated in climate zone "C" (the blue zone in the map). The fact that large parts of the Nordic region are situated in a climate zone does not give consumers plenty of opportunity for energy assessment of the potential of heat pumps. Nordic Ecolabel is of the opinion that energy efficiency requirements and information for consumers, dealers and installers through R11, R14 and R15 could help them to choose correctly dimensioned heat pumps. See R14 – R15.

In version 2.2 of the Nordic Ecolabel criteria for heat pumps it requires that heat pumps should be classified for use in one or more climate zones as defined in an annex:
"Heat pumps must be classified for use in one or more climate zones.
Climate zone 1: annual average temperatures below and up to 5 ºC
Climate zone 2: between 6 -10 ºC
Climate zone 3: between 11-15 ºC
(a map of climate zones can be found in Annex 9 in version 2.2 of the criteria):"

Annual average temperature:
WMO-defined normal period 1961-1990.
In Sweden, a map is supplied by the Swedish Meteorological and Hydrological Institute showing climate zones for the entire country at:
http://www.smhi.se/klimatdata/meteorologi/temperatur/1.3973
In Denmark, the annual average temperature for the entire country is approx. 7.7 °C (normal 1961-90), varying from 7.4 °C in the middle of Jutland to 8.4 °C in some coastal areas:
http://www.dmi.dk/dmi/index/klima/klimaet_indtil_nu/temperaturen_i_danmark.htm
For Norway, a map of climate zones does not work well as this is a very hilly country with major local variations. In R14 Installation manual, there is a requirement to provide information on how annual average temperatures are calculated in the inhabited area. In Norway, for example, it is possible to use www.eklima.no, where you can create a user and find a precise annual average temperature (normal 1961-90), for the place where you live, or
senorge.no/mappage.aspx > Normal annual temperature (1971-2000) if you want to use more recent figures. It may be appropriate to use more recent figures as we know that the average temperature has increased slightly over the past few years.

R12 Noise

Requirement suggestion

R12 Noise

The sound power level for air/air, liquid/water and air/water heat pumps may not exceed the values stated in Tables 3 and 4.

Table 3: Requirement for air/air heat pump maximum sound power level (LWA)

Output < 6 kW		**6 < output < 12 kW**	
Sound power level Indoor element, dB(A)	Sound power level Outdoor element, dB(A)	Sound power level Indoor element, dB(A)	Sound power level Outdoor element, dB(A)
55	60	60	65

Table 4: Requirement for liquid/water and air/water heat pump maximum sound power level (LWA)

Output ≤ 6 kW		**Output > 6 kW and ≤ 12 kW**		**Output > 12 kW and ≤ 30 kW**		**Output > 30 kW and ≤ 70 kW**	
Indoor element, dB(A)	Outdoor element, dB(A)	Indoor element, dB(A)	Outdoor element, dB(A)	Indoor element, dB(A)	Outdoor element, dB(A)	Indoor element, dB(A)	Outdoor element, dB(A)
55	60	60	65	65	70	75	80

✉ The sound power level shall be tested and reported to Nordic Ecolabelling. The sound power level shall be tested when the heat pump is operating at maximum air flow. Test pursuant to EN 12-102. Further test requirements are stated in Appendix 1.

Background to the requirement

The sound level from a heat pump with an outdoor air unit (air-to-air or air-to-water) can be significant. The precise amount of noise output by heat pumps differs from product to product, but a preliminary statement from the Danish Energy Agency[66] showing noise data from manufacturers shows a spread of approx. 60 to 40 decibels. The Danish Energy Agency has just started work on a project which will indicate noise from air-to-water heat pumps, including preparation of a noise calculation model and a guide on how noise pollution can be avoided or kept to a minimum. Grontmij-Acoustica is responsible for this project, which is expected to be completed in the spring of 2012. Provisional data collection from manufacturers indicates major variation in the information given on noise in user manuals. Of a provisional number of 31 manufacturers, the following information has been given: 14 usable sets of noise data (i.e. minimum sound pressure level linked to a measuring distance), 7 specify a noise level, and 10 provide no information on noise[67].

Installation of a heat pump is an individual undertaking, and many factors influence the noise level on a local basis (location, building shielding (corners), ground level, shielding, distance to boundaries, etc.). Likewise, noise has a major part to play if the heat pump is located in a densely populated area, compared with a sparsely populated area.

[66] www.ens.dk
[67] Discussion with Jørgen Heiden, Grontmij project manager, December 2012

Legislation and the Ecodesign Regulation (206/2012 EC)

The Environmental Protection Act in Denmark (paragraph 42) specifies a noise limit of 35 dB(A) at the boundary of residential areas. If this limit is exceeded, an order to move the heat pump may be issued.

Noise requirements in Ecodesign are expressed as *sound power levels*. The sound power level is the "basic unit" for calculation of the noise level (sound pressure) at a given distance. The sound power level is established by first measuring the sound pressure and then converting this figure, including several flat areas and local acoustic conditions (= acoustic work). When the whole thing has been corrected for local measurement conditions, we get a "universal" unit which is independent of how the heat pump is set up. When a project is in progress, these local conditions are input (via a calculation model) and the sound pressure is determined at an adjacent terrace, for example. All official noise limits are related to a *sound pressure level*. The Ecodesign Regulation (206/2012 EC), which came into force on 6 March 2012, sets these requirements for the maximum sound power level:

Nominal capacity ≤ _6 kW		6 < Nominal capacity ≤ _12 kW	
Sound power level indoors in dB(A)	**Sound power level outdoors in dB(A)**	**Sound power level indoors in dB(A)**	**Sound power level outdoors in dB(A)**
60	**65**	**65**	**70**

Table b9

Noise requirements in other labelling schemes

The latest draft for the new EU Ecolabel criteria for heating systems (European Ecolabel Criteria for Hydronic Central Heating Generators, 2nd draft) includes an absolute noise requirement for air-to-water heat pumps (outdoor element) of 60/65 dB(A) for < 6kW capacity and 65/70 dB(A) for > 6 kW capacity respectively. This is the same level as Ecodesign. Noise testing must be carried out in accordance with ENV-12 102.

Heating generator technology	Ecodesign implementing measures	EU Ecolabel	Blauer Engel	Nordic Ecolabel, version 2	Austrian Ecolabel	GGP
Gas-driven or electrically driven hydronic heat pump	**60/65 dB(A), for <6 kW rated capacity** **65/70 dB(A), for >6 – ≤ 12 kW rated capacity**	**No limit**	**No limit**	**Noise must be tested and reported. Test standard ENV-12 102**	**N/A**	**No limit**

Table b10: Comparison of noise limits in various labelling schemes[68].

Nordic Swan requirements in version 2.2:

The noise level must be tested and reported to Nordic Ecolabel.
Information on noise levels measured must be included in the installation manual. For units designed as split units, information must be provided on both indoor and outdoor noise levels. Noise is tested in accordance with ENV-12-102

[68] 2nd Technical Background report - for the development of ecological criteria for hydronic central heating generators

R13 Warranty

Requirement suggestion

R13 Warranty

A warranty of at least five years, for normal use, shall be issued for the heat pump. A further seven-year warranty shall be issued for the compressor, but shall not necessarily cover the cost of work associated with compressor changes.

✉ The warranty period shall be stated in the operation and maintenance instructions.

Background to the requirement

If quality is poor, the heat pump's electricity consumption may be affected or quite simply stop. Requirements are specified concerning the durability of the heat pump. A warranty covering at least 5 years of normal use must be provided for the heat pump, and 7 years for the compressor. The contents of the warranty and the number of years must be specified in R13 operation/maintenance instructions.

The warranty could include a prerequisite stating that the heat pump must be installed by a specialist: a survey carried out by If Skadeforsikring in Norway in 2012 shows that one in ten heat pumps is fitted by an amateur. In their opinion, incorrect installation is a common cause of heat pump failure. They are also of the opinion that there is much to suggest that people are avoiding mail order purchases of such equipment to a greater extent than previously. Information and good advice are probably reaching out to an ever wider range of people. Nor should we ignore the fact that there are fewer scammers in the market nowadays, says Trond Anfinsen of insurance company If.

4.5 Customer information

R14 and R15 Installation manual, Operation and Maintenance Instructions

Requirement suggestion

R14 Installation manual and technical information

The installation manual and/or available technical information must include the information below, and as a minimum this must be readily accessible on the website(s) of manufacturers and/or dealers.

Information stating:

- that liquid-to-water heat pumps and air-to-water heat pumps are also appropriate for heating of hot water for household use in accordance with the Energy Labelling Regulation proposal in LOT 1
- the type of hydronic heating system for which liquid-to-water heat pumps and air-to-water heat pumps are designed (floor/wall or radiator) in accordance with the definition for low temperature heat pumps in the Energy Labelling Regulation proposal in LOT 1
- annual energy consumption in kWh, nominal heating capacity, limit temperature for operation (T_{ol}) and (SCOP) in respect of air-to-air heat pumps which are categorised in the Ecodesign Regulation (206/2012/EC)
- annual energy consumption in kWh and weighted heat release (rated heat output, P_{ratedh}) in kW for liquid-to-water heat pumps and air-to-water heat pumps, along with information on the climate zone for which the heat pump is designed
- how to find annual average temperatures in the location in which you live or for the nearest relevant weather station with an equivalent climate to the place where you live
- what refrigerant the heat pump contains and the filling quantity (kg) This information shall also be stated on the nameplate according to EN 14511-4
- the importance of competent personnel carrying out installation in the proper manner, and that design/project planning should be carried out in accordance with EN 15450
- indoor and outdoor sound power level in dB(A)
- good positioning of the outdoor air element in respect of noise, cleaning and deicing
- that air-to-air heat pumps with an indoor element require open spaces or open plan solutions and open stairwells between floors so as to help with the heating of the entire building
- that contact should be made with local supervisory authorities if the pump is to be installed in rock, soil or water

✉ A copy of the nameplate, the installation manual with technical information or the installation manual and technical information.

R15 Operation and maintenance instructions

The manufacturer must ensure that operation and maintenance instructions are supplied with the heat pump, specifying the following:

- information on the need for regular cleaning and deicing
- what the warranty covers and its validity period (number of years). The warranty must meet the requirements laid down in R13
- which refrigerant is present in the heat pump and the fill volume (kg).

The manufacturer must notify dealers of the importance of giving customers access to the installation manual and operation and maintenance instructions.

✉ A copy of the operation and maintenance instructions.

Background for requirements

In operation, clean heat absorption system surfaces are important. This may pose challenges in the case of seawater heat pumps and sewer heat pumps, but pollen and ice can also cause reduced heat pump efficiency in outdoor air elements. Dust collecting on the air filter of the indoor air element reduces the through flow of air to the indoor element, forcing the heat pump to work harder. Removal of accumulated dust considerably improves efficiency. Air filters on the indoor element should be cleaned once a fortnight[69].

Inspection requirements in accordance with the F-Gas Regulation
The F-Gas Regulation (842/2006(EC) with subregulations EC no. 303/2008 and EC no. 1497/2007 requires all EU countries to carry out annual leakage inspections of all systems containing more than 3 kg of HFC and applications containing more than 6 kg of HFC which are hermetically sealed and labelled as such. The inspection must also be carried out by certified personal as described in R16 Skills requirements. If the system contains between 30 and 300 kg of HFC, the inspection is increased to four times a year, and if it contains more than 300 kg, monthly leakage inspections must be carried out and a leak detection system is required.

Climate zones
Information on how to find annual average temperatures in the location where you live is important to help you choose the correct heat pump and the right heat pump size. In Norway, which is a hilly country, there are major local variations in annual average temperatures. See Section 4.4 for more information on climate zones.

What should you do in the cold?
For an air-to-air heat pump, it may be a good idea to set your heat pump to 16 degrees when the temperature is below -15 degrees outdoors. The heat pump is subject to major wear and tear when the weather is so cold, and this is not good for the service life of the heat pump, according to the Norwegian Heat Pump Association.

[69] Heat pump researcher Helge Lunde at Thermoconsult in Norway, http://www.vg.no/dinepenger/artikkel.php?artid=10075667

4.6 Information for retailers and fitters

R16 Skills requirements

Requirement suggestion

R16 Fitter/geo driller expertise

The manufacturer/retailer should inform the buyer of the need to select:

- a fitter with certified expertise
- a geo driller with certified expertise

✉ Declaration that the requirement is fulfilled.

Background to the requirement

Skills requirements and certification for fitters of heat pumps

The European directive on the promotion of the use of energy from renewable sources, the RES Directive (2009/28/EC)[70], requires fitters of heat pumps to have sufficient knowledge to:

- Meet the customer's need for performance and reliability
- Apply qualified professional knowledge
- Operate in compliance with applicable laws and regulations

The directive also requires:

- Accredited training
- Personal certification, with successful completion of examinations which include both theory and practice
- Time-limited validity

The requirements for skills and certification are applicable to all heat pumps fitters. According to the RES Directive, all Member States have to have built up functioning training and certification systems by 31 December 2012 at the latest.

Since 2004, EUCERT[71] has been producing a collective training course for heat pump fitters within the EU and a certification procedure for these. At least ten countries are currently represented. The European Heat Pump Association, EHPA, is responsible for the training committee, which is responsible for the quality of the training and training material. National certification bodies then arrange certification in accordance with ISO 17024 in the respective countries. In Sweden, Incert AB is the certification body. The requirements for certification are the same in all EU countries.

In Sweden, these courses are provided in cooperation with the trade organisation SVEP (the Swedish Heat Pump Association) and also meet the theoretical requirements laid down by SVEP for membership of the organisation – i.e. to become a "SVEP fitter". To become a SVEP fitter, it is currently necessary to demonstrate that the skills requirements are met, but personal certification is not required.

[70] See Article 14 and Annex IV.
[71] European Certified Heat Pump Installer

*Certification requirements in accordance with the F-Gas Regulation (*842/2006/EC[72]*)*
The F-Gas Regulation (EC 842/2006) with subregulation (303/2008/EC) requires all EU countries to train certified personnel for the fitting and inspection of heat pumps. There are various skills requirements for these systems according to how much HFC they contain. The fitter must have *personal certification,* and the company represented by the fitter must hold *corporate certification.* This certification is entirely separate from the certification covered by the RES Directive or by EHPA.

In Sweden, Installations Certifiering i Stockholm AB (Incert AB) certifies personnel and companies in respect of refrigeration[73], i.e. the same certification body which carries out skills certification of heat pump fitters. No temporarily issued certificates (transitional rules) have been valid since 4 July 2011.

In Norway, KLIF has appointed Isovator as the certification body for personnel and companies working with HFC and PFC (perfluorinated compound) gases. As implementation is delayed in Norway, the certification bodies will ensure that pragmatic solutions are put in place until the certification bodies are fully operational (in approximately two years' time), according to KLIF[74].

According to the law, an installation is[75]:
"the combination of two or more items of equipment or circuits which contain or are designed to contain refrigerants containing fluorinated greenhouse gases, the assembly of a system in the location in which it is to be used, including the operation through which conductors of refrigerants in a system are connected together in order to form a complete circuit with refrigerants, without taking into account the fact that the system may need to be topped up after being assembled".

In practice, this means that certification is required in accordance with the F-Gas Regulation for all air-to-air heat pumps and for *some* air-to-water heat pumps. *However, for the vast majority of heat pumps, this is not required as installation there does not involve working on the refrigerant circuit.*

In general, heat pumps also have to be clearly indelibly marked with approved industry nomenclature, stating the content of fluorinated greenhouse gases covered by the Kyoto Protocol and the volume of greenhouse gas. Hermetically sealed systems must be labelled as such.

Certification of well drillers
Well drillers can be certified at two levels, responsible well driller (AB) and well driller (B). This certificate is issued for a period of five years. For certification, well drillers need to have passed theory and practical tests, have confirmed experience, passed a welding test and have course certificates from the courses "Hot work" and "Work on the road".

[72] http://eur-lex.europa.eu/sv/index.htm EU regulation (EC) no. 2037/2000 on substances that deplete the ozone layer have been amended several times in essential regards, and therefore it has been revised as (EC) no. 1005/2009.
[73] Swedish Environmental Protection Agency, www.naturvardsverket.se
[74] http://www.klif.no/no/Aktuelt/Nyheter/2011/April-2011/Sertifisering-av-virksomheter-som-handterer-fluorholdige-klimagasser/?cid=3292
[75] Swedish Environmental Protection Agency, www.naturvardsverket.se

To summarise: Nordic Ecolabelling requirements aim to increase demand for certified well drillers, which is crucial for systems involving voluntary certification.

R17 Dimensioning and design of the heating system

Requirement suggestion

R17 Dimensioning and design of the heating system

The manufacturer shall ensure that the fitter has access to data on approved heat transfer fluids, relevant calculation programmes and other relevant information required for meeting the Nordic Ecolabelling requirements.

✉ Declaration that the requirement is fulfilled.

4.7 Quality and environmental management requirements and regulatory requirements

R18 – R26

Requirement suggestion

R18 Laws and regulations (regulatory requirements)

The licensee shall ensure compliance with all applicable local laws and provisions at all production facilities for the Nordic Ecolabelled product, e.g. with regard to safety, working environment, environmental legislation and site specific requirements/concessions.

✉ Declaration from the licensee that the requirement is fulfilled, plus a report to the regulatory authority, see Appendix 7.

R19 Licence administrators

The company shall appoint an individual responsible for ensuring the fulfilment of Nordic Ecolabel requirements, and a contact person for communications with Nordic Ecolabelling.

✉ Organisational chart showing who is responsible for the above.

R20 Documentation

The licensee must be able to present a copy of the application and factual and calculation data supporting the documents submitted with the application (including test reports, documents from suppliers and suchlike).

☺ On-site inspection.

R21 Heat pump quality

The licensee must guarantee that the quality of the Nordic Ecolabelled heat pump is maintained throughout the validity period of the licence.

✉ Procedures for collating and, where necessary, dealing with claims and complaints regarding the quality of the Nordic Ecolabelled heat pump.

R22 Planned changes

Planned product changes and commercial changes which affect Nordic Swan requirements must be reported in writing to Nordic Ecolabel.

✉ Procedures which show how planned product changes and commercial changes are handled.

R23 Unforeseen non-conformances

Unforeseen non-conformances which affect Nordic Swan requirements must be reported in writing to Nordic Ecolabel and be logged.

✉ Procedures which indicate how unforeseen non-conformances are handled.

R24 Traceability

The licensee must implement traceability for the heat pump bearing the Nordic Ecolabel during production.

✉ Description/procedures indicating how the requirement are met.

R25 Return systems

There must be compliance with relevant national rules, laws and/or industry agreements relating to return systems for products and packaging in the Nordic countries in which the heat pump bearing the Nordic Ecolabel is marketed.

✉ Certificates from applicants concerning adherence to existing agreements on recycling/treatment.

R26 Marketing

Marketing of the heat pump bearing the Nordic Ecolabel must take place in accordance with "Rules for Nordic environmental labelling of products", 22 June 2011 or later versions.

✉ Completed Annex 9.

Background to requirement R18- R26

To ensure that the Nordic Ecolabels requirements are meet, shall different routines be implemented so that the production follows the authorities' laws and regulations and the production quality is maintained. These requirements are general for many of Nordic Ecolabels criteria documents.

The laws and regulations of the local authorities must always be followed, wherever in the world the manufacturer or the subcontractors are based. The company shall appoint an individual responsible for ensuring the fulfilment of Nordic Ecolabel requirements. Once a manufacturer has a licence for the production of Nordic Ecolabelled heat pumps, guarantees are to be given that the requirements will be met for the whole of the licence period and that a traceability system for the Nordic Ecolabelled heat pumps in the production. Planned changes and unforeseen non-conformities must be reported to Nordic Ecolabelling. The Nordic Ecolabel is a very well-known and well-reputed trademark in the Nordic region. Nordic Ecolabelled heat

pumps may be marketed using the Nordic Ecolabel so long as the associated licence is valid.

4.8 Appendices to the criteria document

The criteria document has 9 appendices to help document the requirements in the document. The appendices must be completed by the license applicant or relevant subcontractor. The appendices in the criteria document are:

1 Testing and laboratory requirements
2 Dangerous substances in chemical products declaration
3 Parts metal plating declaration
4 Declaration on flame retardants and phthalates in plastic and rubber parts
5 Declaration on foaming and blowing agents in insulation materials
6 Refrigerant declaration
7 Declaration of compliance with applicable laws and provisions in production
8 RoHS Directive compliance declaration
9 Marketing Nordic Ecolabelled heat pumps

5 Abbreviations

ODP	Ozone Depletion Potential. The ability of substances to deplete the ozone layer in the stratosphere is expressed by means of an ODP value. CFC, chlorofluorocarbons (often referred to as freons or R12) serve as a reference, and by definition these have an ODP value of 1.0.
GWP	Global Warming Potential. The contribution to global warming is indicated by a GWP value in a similar way. Typical periods published by the IPCC are 20, 100 and 500 years, and 100 years is most commonly presented as GWP_{100}. Here, R744 (CO_2, carbon dioxide) serves as a reference, and by definition this has a GWP=1.0.
TEWI	Total Equivalent Warming Impact. Used as a basis for calculation of total global climate impact.
COP	Coefficient of Performance. Ratio of emitted heat to input electricity in a heat pump.
SPF	Seasonal Performance Factor. COP average over one year.
EU	European Union
LCA	Life Cycle Analysis
LOT	Product category in the Ecodesign Directive
SCOP	Seasonal coefficient of performance
VOC	Volatile Organic Compound
VAH	Volatile Aromatic Hydrocarbon
CHP	Combined Heat and Power, also known as cogeneration
CLP	Classification, Labelling and Packaging

Annex 1 What is a heat pump?

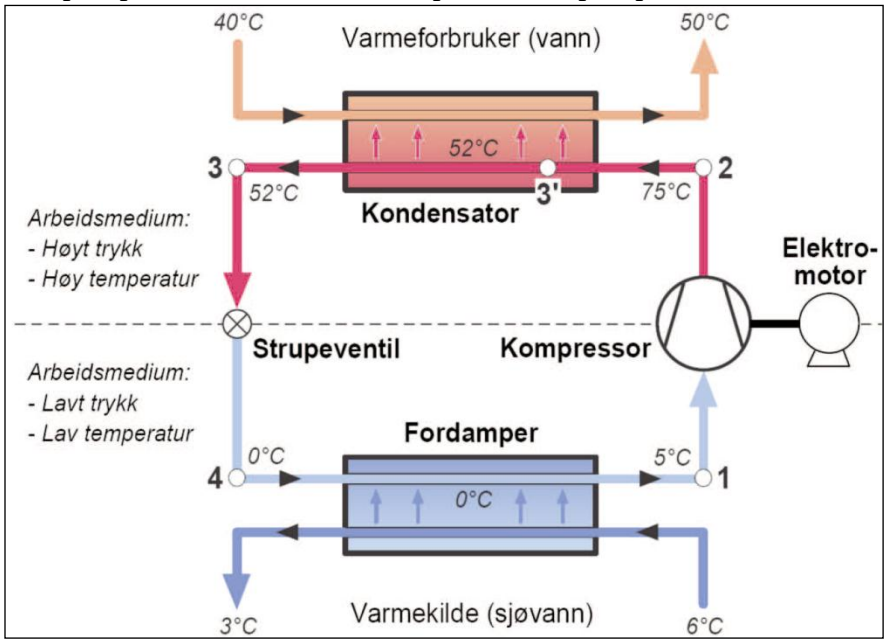
Heat pumps represent a technology in which heat can be moved from a lower temperature level to a higher temperature level. This process is known as heat pumping. Heat pumps utilise heat from air, soil, rock, sea or freshwater/groundwater. These types of low temperature source can use electricity to give off heat which can be used to heat air or water. This air or water in turn can be used for direct space heating, heating of ventilation air or heating of water.

A short history

The heat pump process is a closed thermodynamic cycle. This refers to the Carnot cycle, which is a theoretical description of the combustion efficiency of a given fuel, described by Nicolas Léonard Sadi Carnot in 1824 and further developed by Benoit Paul Émile Clapeyrons in the 1830s and 1840s.

Heat pump operation

Figure B1 shows the principle for a seawater heat pump. The structure is more or less the same for all compressor-operated heat pumps. Compression/absorption heat pumps and gas heat pumps, and gas absorption in contrast to compressor-operated heat pumps are described under Special heat pumps later on in this annex.



Figur B12: Simplified sketch of a heat pump based on seawater, supplying hydronic heat distribution.

This system consists of separate circuits linked to one another by means of heat exchangers. These circuits are:

- The heat source circuit, which transports the energy from the heat source to the heat pump's refrigerant circuit. (refrigerant = working medium)
- The refrigerant circuit, which uses evaporation, compression, condensing and expansion to give off heat to the hot water circuit.
- The hot water circuit (heat distribution) which feeds the heating and domestic hot water for the hot water tank.

The essential difference between the heat pumps described above is that the heat exchangers "radiates" on the hot and cold sides of the system. These heat exchangers are designated condenser and evaporator. The condenser (the hot "radiator" in a heat pump) supplies heat to the building. The type of medium (air, water or liquid) which circulates on the outside of both the condenser and the evaporator is what determines what we call the heat pump, "air-to-air", etc. The refrigerant circulates between the condenser or evaporator. An "air-to-air" heat pump will, for example, have an evaporator outdoors which exchanges heat with the outdoor air and a condenser indoors where heat exchange takes place between the refrigerant and the indoor air. An "air-to-air" heat pump is what is known as a "split system" in which the indoor element is equipped with a condenser and fan, and the outdoor element has an evaporator, fan, compressor and flow control valve. In another example, the evaporator can carry out heat exchange using glycol, which circulates down into a borehole in the rock below the building and gives off heat to water indoors. This is then a liquid-to-water heat pump.

A refrigerant has a special property whereby the temperature increases significantly when the refrigerant is pressurised. It is this special property which is used in a heat pump in order to increase the temperature from a lower to a higher level. Traditionally, refrigerants have been chlorofluorocarbon compounds (CFCs) , but these are now banned and gases with smaller chlorine atoms, such as HCFCs, are used instead. Some of these chlorine atoms have been replaced with hydrogen or fluorine.

In a heat pump, the working medium is pressurised at between 25 and 37 bar. A nail gun, by comparison, has a pressure of 8 bar. An uncontrolled blowout at the inside element, with a gas maintaining a temperature in excess of 70 °C, can therefore have serious consequences. The most common consequence of self-installation is not injury, but the installation of a system which does not operate as intended and in which the anticipated energy saving is not achieved. One common fault is the leakage of working medium, and the heat pump will lose its output and offer a poorer coefficient of performance in the event of even small leaks. When people install heat pumps themselves, there is little chance of checking small leakages which require special instruments[76].

In addition to electric heat pumps, there are gas and gas absorption heat pumps which run on gas instead of electricity. Such heat pumps are more commonly used in Southern Europe.

Various types of heat pumps

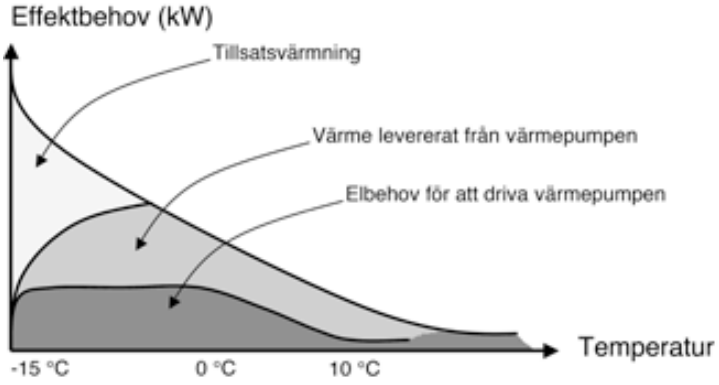
Heat pumps utilise heat from air, soil, rock, sea or freshwater/groundwater. Basically, common commercially available heat pumps are divided into three types; air-to-air, air-to-water and liquid-to-water heat pumps.

[76] Source: http://www.viivilla.no/novap-advarer-mot-selvmontering-av-varmepumper.aspx

Air-to-air heat pumps are the most common type. An air-to-air heat pump can also be reversed and supply cold air to the room on a hot summer's day (air conditioning system).	
Common air-to-air heat pumps	Air-to-air heat pumps positioned in a balanced ventilation system. Balanced ventilation involves ventilation systems which supply both fresh supply air and remove "used" air. However, it is most common for balanced ventilation units to be fitted with a heat recovery system.

Table B1: Air-to-air heat pumps

Air-to-air heat pumps take heat out of the air (often the outdoor air) and give off heat to the indoor air. Air-to-air heat pumps will not help on the coldest days of the year, i.e. at design outdoor temperature. The applicable requirements as at November 2011 (BBR16 in Sweden) set limits for installed output, among other things. This excludes heat pumps based on outdoor air for new buildings[77].



Figur B2: General characteristics for air-to-air heat pumps. Source: SP Technical Research Institute of Sweden.

Air-to-air heat pumps can also give off heat to a front panel as well as giving off heat directly to the indoor air. The front panel will then act as a radiator. Daikin's Nexura is a heat pump of this type.

Air-to-water heat pumps are available in common commercially available variants:	
Heat pumps which take heat out of the outdoor air.	Heat pumps which take heat out of used ventilation air in exhaust ducts (exhaust heat pumps). Exhaust heat pumps can provide an alternative to balanced ventilation with energy recovery as they use heat in used ventilation air.

Table B2: Air-to-water heat pumps

In contrast to air-to-air heat pumps, heat is given off indoors by means of hydronic heat in ceilings, walls, floors, skirting or radiators. In general, hydronic heat provides an opportunity to cover a greater proportion of the heat requirement. Major costs are linked with the installation of distribution systems for hydronic heat. Air-to-water heat pumps can also give off heat to for hot tap water.

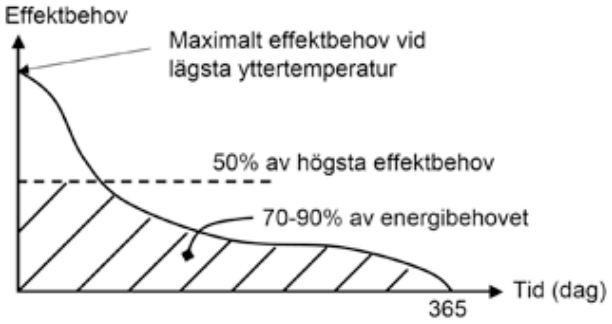
[77] norskvvs.no/apps/pbcs.dll/article?AID=/20111128/NYHETER/111129989&NL=1

Liquid-to-water heat pumps can again be divided into four commercially available types:			
Geothermal heat pumps, which take energy from a borehole in the ground*	Shallow geothermal heat pumps, which take energy from hoses buried in the ground (geothermal energy)	Sea heat pumps, which take energy from hoses submerged in the sea (hydrothermal energy). These are rarely used for single-occupancy homes.	Ground heat pumps, which take energy from groundwater (hydrothermal energy)

Table B3: Liquid-to-water heat pumps

*The necessary well depth for a geothermal heat pump will be in the order of 80-200 m, depending on the rock type and quartz content, fracturing, catchment size and slope of the terrain, among other things. The annual energy output will vary from 100 to 250 kWh per metre of borehole[78]. In liquid-to-water heat pumps, a liquid such as glycol is used to take heat from soil, rock or water.

Besides these liquid-to-water heat pumps, there are also liquid-to-water heat pumps which take energy from the heat in sewage treatment systems or other waste heat. These are generally large.



Figur B3: Eeneral characteristics for a heat pump with a constant heat source temperature. Power requirement and design output. Most of the days in the year cover 50 % of the maximum power requirement. Source: Swedish Heat Pump Association.

Exhaust air from ventilation systems, which can also be referred to as waste heat, is at high temperature in the heating season if there is a weak heat recovery unit in the system. This can be recovered using a heat pump.

Advantages:

- Ventilation air normally stays at 18-25 °C all year round.
- Relatively low investment costs.

Disadvantages:

- Limits on how much energy can be taken from this source.
- Requires constant ventilation all year round.

Exhaust heat pumps alone cannot replace ventilation systems with heat recovery without further ado in accordance with regulatory requirements for efficient energy consumption in the Nordic region as at the end of 2011.

[78] www.ivt.ntnu.no/igb/forskning/oppgaver/2002_gr1_geotermiske_varmepumper.pdf

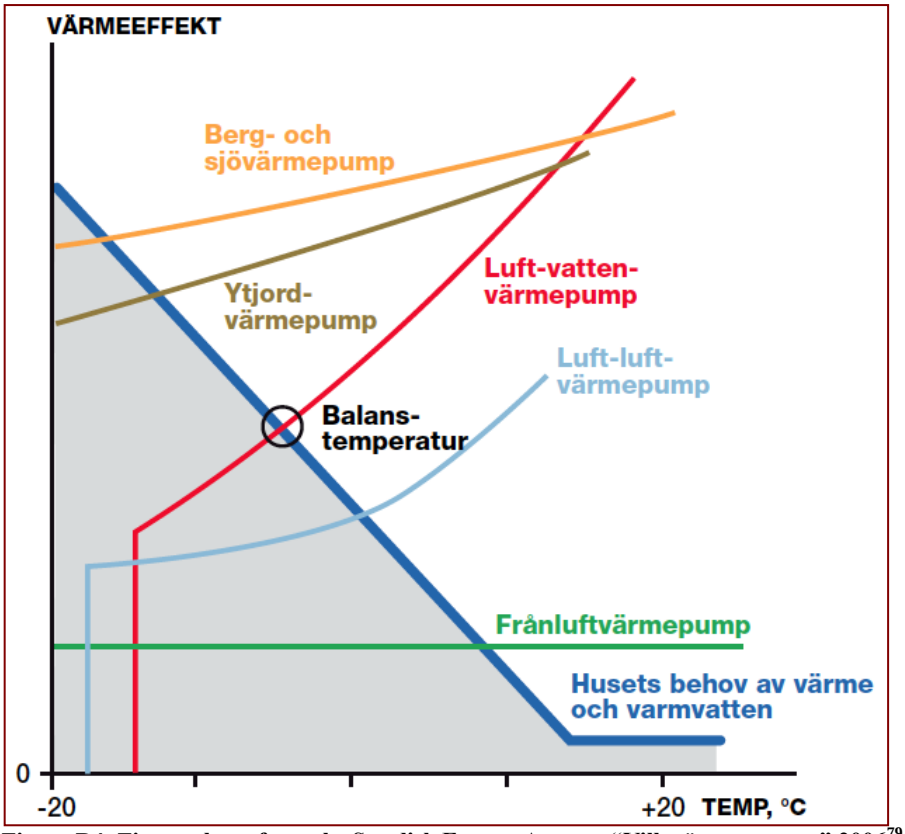


Figure B4: Figure above from the Swedish Energy Agency. "Villavärmepumpar" 2006[79] shows how the energy efficiencies of various types of heat pump relate to one another.

Geothermal, sea and shallow geothermal heat pumps are less susceptible to low outdoor temperatures. These will therefore normally cover the heat requirement over a year to a greater extent. In addition, they do not need to be shut down at low outdoor temperatures in the same way that heat pumps with an outdoor air element may have to be. Exhaust heat pumps work under constant conditions and so can help to provide constant heat output. What can also be seen from the diagram is that the greater the output we decide a heat pump is to supply, the greater the proportion of unusable energy. This is particularly true of heat pumps with outdoor air elements. Heat pumps which are too large could therefore result in poorer heating system economy.

Air-to-water heat pumps based on CO_2 (carbon dioxide) for indoor heating and heating of hot water:

> Such CO_2 air-to-water heat pumps, eco-friendly from the outset, are linked to special water heaters and heat up buildings via radiators or underfloor heating.
>
> For these to be able to provide the required output and greater energy savings than ordinary pumps, the average return water temperature in the heating system must be low, well below 30 °C. This is why this type of heat pump is very suitable for use in large buildings where a lot of hot water is used, such as sports halls, hotels and spas. As far as residential buildings are concerned, John Stene at COWI Norway will only recommend such heat pumps for combined indoor heating and water heating in new low energy and passive buildings with low

79

213.115.22.116/System/TemplateView.aspx?p=Energimyndigheten&view=default&cat=/Broschyrer&id=83faa2bcf27d405093f1d63c9d33fb52

temperature heating systems, and where the heat requirement for heating of tap water constitutes 50 to 80 % of the total annual heat requirement. Stene. His conclusions coincide with measurements carried out at the Royal Institute of Technology in Sweden in 2008[80].

Distribution systems and supplementary heat sources

Version 2 of the criteria do not specify requirements for the system beyond the fact that any supplementary heat source must have "no environmental impact" and that any solar collectors must meet the requirements laid down in the standard EN 12 975. In the new criteria, it is not possible to apply the Nordic Ecolabel to systems or heat pumps in combination with other heat sources. This is because we have not found any appropriate standards for energy calculation or measurement methods for systems.

A little information on heat pump systems:

Combination of an exhaust heat pump and a liquid-to-water heat pump: In this system solution, the exhaust air will heat the coolant which comes from the borehole, sea or ground loop (or heat it before it goes to the borehole, sea or ground loop). This will lead to the heat pump being able to work at a higher evaporation temperature compared with the situation if the heat in the exhaust air had not been recovered. This, in turn, will lead to higher efficiency, COP (Coefficient Of Performance), for the heat pump and hence lower electricity consumption for the same heat requirement. Moreover, this should make it possible to make the borehole or the ground loop shorter. When there is no heat requirement and the heat pump (compressor) is not operational, the exhaust air heats up the land around the borehole or the ground loop. However, the additional heat exchange leads to extra electricity being drawn by the exhaust fan and the coolant pump. Good control of the coolant pump is important in order to maintain a high COP for this system solution. As it would be possible for a system of this kind to handle higher efficiency and stricter requirements, a description is given in the section entitled "Heat pump systems" in the same way as for heat pump systems using alternative heat sources as described below.

Special heat pumps

Compression/absorption heat pump (hybrid heat pump):

If pure ammonia is the working medium in a heat pump, a traditional heat pump can be used to heat water to around 50 °C. A hybrid heat pump with a 50 % mix of ammonia and water can heat water to temperatures in excess of 100 °C using equipment from the same pressure class. This means that the system can cover completely different temperature ranges to traditional heat pumps, and this is of particular interest in industrial processes.

Gas heat pumps and gas absorption:

With the current criteria, only electric heat pumps are included in the product group definition. The criteria for the EU Flower label and the Blaue Engel cover both electric or gas heat pumps and gas absorption. See Section 2.5 for more information on these environmental labels. Nordic Ecolabel is of the opinion that it should not be possible to apply the Nordic Ecolabel to gas heat pumps and gas absorption as a

[80] Article entitles "Egner seg ikke for vanlige boliger" by Rolf Nordberg in Avisen Glomdalen, Monday, 7 March 2011, Interview with Jørn Stene Førsteamanuensis II, NTNU, who now works at COWI.

transition to fossil energy sources is not wanted. Biogas can be used, but environmental labelling has no control over whether this is done.

Gas is used here instead of electricity, and these are used mostly in Southern Europe. En gas absorption heat pump uses the gas absorption principle as a source of renewable energy. The gas flame heats up water, which absorbs ammonia. When the mixing ratio of H2O to NH3 reaches a critical value, an exothermic reaction[81] starts and heat is generated. NH3 gas rises in the column, is pumped across to the condenser, condenses and gives off heat before the expander and is then cooled sharply. This is then fed to the evaporator, where it collects new energy from either the outdoor air, energy wells or another energy source. It is then pumped back to the generator and the gas flame and starts on a new cycle. This exothermic reaction is what generates heat, resulting in the renewable energy.

Heat pumps for drying processes

Heat pumps for e.g. tumble dryers and washing machines are not included in the product group definition. If requirements for a heat pump to bear the Nordic Ecolabel were to be assessed for use in white goods bearing the Nordic Ecolabel , this would lead to too high a degree of technology management. Heat pumps for use in drying processes are not included in the criteria for heat pumps. However, heat pumps could certainly be included in dryers to make them energy-efficient.

Various factors which should influence the choice of a heat pump as a heat source.

Ventilation air:

If the building has a balanced ventilation system, a heat pump can heat fresh air by adding heat to the air entering the building. If the hot air is also to be hot enough to cover the heat loss for the entire building in the middle of winter, the supply air temperature in individual instances could be 30-40 °C. Heating up space via ventilation air is not considered to be optimal in terms of health in homes or offices where there is a high heating requirement. Therefore, this is not common at present, but it is possible that this could become more common in low-energy buildings and passive buildings. In grocery shops and some other commercial buildings, it is nevertheless entirely common to handle heating of the premises via ventilation air. Nordic Ecolabel cannot maintain control over where all heat pumps are used, and as the market for such heat pumps is limited as at 2012, Nordic Ecolabel will not be giving priority to the inclusion of heat pumps for positioning in ventilation systems in this version. Heat pumps for positioning in ventilation systems are covered by LOT 21, which is not expected to lead to an Ecodesign Regulation or Energy Labelling Regulation initially[82]

[81] Wikipedia: An exothermic reaction is a chemical reaction which "releases" energy by converting potential energy into kinetic energy. One example is the reaction between oxygen and carbon when coal burns. An exothermic reaction will normally take place spontaneously when it first gets going, but it needs a certain amount of energy to start. Unlike its opposite – the endothermic reaction, which takes place during the absorption of heat energy – an exothermic reaction gives off heat energy and results in an increase in temperature. The enthalpy change in an exothermic reaction is always negative.

[82] Ola Rise during a telephone conversation with Kristine Fagerlund at the Norwegian Water Resources and Energy Directorate, May 2012.

Distribution systems:[83]

It is important here to be aware that COP decreases as temperature lift increases. A heat pump which takes heat at 10 °C and supplies it to underfloor heating at 40 °C will have a coefficient of performance[84] of around 6.8. If the heat pump had supplied it to radiators at 65 °C, the coefficient of performance would have been almost halved, to approx. 3.5 Thus a heat pump will be more suitable for distribution by means of underfloor heating than with small radiator surfaces. Today's heat pumps for heating buildings have a relatively moderate upper limit with regard to the maximum temperature at which heat can be supplied, 55-75 ^{o}C depending on the technical solution and refrigerant. If there is no interaction between hydronic heat and the heat pump, the temperature back to the heat pump may at times be so high that the maximum is exceeded and the heat pump has to stop. This is not an uncommon incident, and of course it leads to a reduction in energy savings. Nordic Ecolabel cannot control how a distribution system is structured or constructed. However, we can specify requirements for good information to fitters and customers. See Section 4.5 Information/details for customers.

Supplementary heating sources

Different heat sources have different outputs depending on the time of year, and the choice of heat source is also dependent on a large range of external factors. We have attempted to summarise this in the following list:

Spring, summer and autumn:

- Solar collectors and solar cells are most efficient in spring, summer and autumn. Of course, the seasons vary according to latitude, weather conditions and any barriers which obscure the sun.
- Air-to-air heat pumps are also most efficient in spring/summer and autumn. The outdoor temperature is what determines this.

Autumn, winter and spring:

- Heaters and boilers based on biofuel
- Heaters and boilers based on fossil oil or gas
- District heating or local heating
- Gas-powered heat pumps

All year round:

- Heat recovery from hot greywater
- Windmills
- Electric radiators, bulbs
- Liquid-to-water heat pumps.
- Exhaust heat pumps
- Systems for preheating of intake air via the ground. (Can also assist with cooling in summer)

Supplementing geothermal or air-to-water heat pumps with solar collectors can be beneficial for the following reasons[85]:

[83] Klimadokument Kulde, Klimatiltak med relasjon til kuldeanlegg og varmepumper. Oslo 2008

[84] The coefficient of performance is a figure which describes how much heat a heat pump gives in relation to the amount of electricity supplied. That is to say, with a coefficient of performance of 6.8, you will get 6.8 kWh of heat by inputting 1 kWh of electricity. Or, if you prefer, you will get 5.8 kWh of free energy for every kWh you pay for.

[85] www.byggahus.se from 20 September 2010.

- The solar collector assists with the heating of hot water for household use and reduces the electricity consumption of the heat pump.
- The performance of the heat pump is improved, so it supplies more heat and requires less additional energy from the immersion heater.
- The operating time of the heat pump is reduced, which means less wear and tear and a longer service life for the compressor.
  In a building with direct-acting electricity, an air-to-air heat pump can reduce electricity consumption, while at the same time a solar collector can relieve the load on the immersion heater for production of hot tap water.

A dissertation from Lund University[86] shows that solar heat is best utilised in combination with a geothermal heating system. In this instance, the excess heat of the solar collector can recharge the borehole. The solar heat helps to increase the heat pump's seasonal performance factor, but it can also improve heat extraction in underdimensioned boreholes and reduce any impact from nearby geothermal heat wells.

Systems for preheating of intake air via the ground: These are commercially available in two essentially different versions. One of them involves passing the air through ducts in the ground, and the other involves running an additional liquid circuit in the ground as a heat exchanger, with intake air before the ventilation unit. Both systems can also assist with cooling in summer[87]. Energy besides fan or pump energy can be regarded as free energy with these solutions. However, it must also be remembered here that there are environmental costs relating to production, transport and so forth.

New technologies improve efficiency

There are a number of ways to improve energy efficiency for a VP unit. For example, good electronic control systems and variable speed control for compressors, pumps and fans are all important elements. However, other measures are also being researched:

The Royal Institute of Technology has created an energy-efficient surface coating: This surface coating is not available on the market as yet. This is a porous coating of copper, applied by electrodeposition. It works by reducing bubble formation resistance, i.e. bubbles are formed in a large number of locations on the surface, even with small temperature differences[88]. For a little more information, see the website at www.microdeltatT.com

[86] Elisabeth Kjellsson, research engineer, Building Physics, Lund University
[87] Final_report_market_systems_IEA_HPP_Annex32
[88] Ola Rise, personal contact with Björn Palm at the Royal Institute of Technology on 27 September 2011 + www.klimatsmart.se/?page=news&id=11458

Annex 2 Common terms for energy efficiency and climate impact for heat pumps

Double duct air conditioner:
An air conditioner where the intake to the condenser (or the evaporator) during cooling or heating is taken from the outdoor environment to the unit via a duct and released to the outdoor environment via another duct, and which is positioned in its entirety in the space which is to be conditioned, close to a wall[89].



Single duct air conditioner
An air conditioner where the intake to the condenser (or the evaporator) during cooling or heating is taken from the space surrounding the unit and released into the environment outside this space[90].

Coefficient of Performance (COP)
The efficiency of a heat pump is measured in coefficient of performance, or COP. This indicates how much heat energy is generated from the input electricity. For example, from 1 kWh of electricity you get 4 kWh of heat energy at 0 ^{o}C outdoors and 35 ^{o}C indoors, so you have a coefficient of performance of 4 (COP 4)[91]. It could also be stated that with a coefficient of performance of COP = 4, 75 % of the energy we get is renewable, but this is also dependent on how the input electricity is produced.
Depicted in a diagram, this may appear as follows:
Input electricity at 0 ^{o}C outdoors = 1.0 kW
Heat gain to heating element 35 ^{o}C = 4.0 kW
The COP for the product in the example above is 4.0/1.0 = 4.0.
The COP is related to the supplied heat output at an operating point – instantaneous value (kW)

$$COP = \left(\frac{\dot{Q}_k}{W} \right)$$

Where:
Q_k = Heat output emitted from the heat pump (kW)
W = Input electricity to compressors and possibly also fans/pumps (kW)
Electricity for circulation pumps is not included.

Standard EN 14511 describes which temperatures are to be used when measuring the individual heat pump types.

[89] Ecodesign Regulation 206/2012
[90] Ecodesign Regulation 206/2012
[91] sv.wikipedia.org/wiki/Värmepump

Heat pump COP decreases as temperature lift increases. A relatively high and constant temperature for the heat source results in a high heat gain to the heating element over the year. At the same time, it is important to have clean surfaces on the heat absorption system (outdoor section) and the air indoor section. That is to say, at low outdoor temperatures and when an air-to-air heat pump has unclean surfaces, the gains are very small. COP is a useful value, but alone it does not provide a sufficiently good view of the energy efficiency of a heat pump. This is why SCOP is also used. This also takes into account various temperature lifts that would occur in reality over a normal year.

SCOP and ETA or η_s

The seasonal coefficient of performance (SCOP) means that you test/calculate COP at three partial loads as well as at full power. According to the Energy Labelling Regulation 626/2011 EC, which came into force on 26 July 2011, SCOP has to be specified on the energy label for all three climate zones in Europe. prEN 14825, which is described under Standards and testing methods in Annex 3, is used for calculation/testing of SCOP.

Seasonal space heating efficiency or η_s

(Seasonal space heating efficiency (ETA or η) is achieved via (SCOP) by correcting for a primary energy factor of 2.5 in order to convert to "ETA".)

The seasonal space heating energy efficiency ηs shall be calculated as the seasonal space heating energy efficiency in active mode ηson, corrected by contributions accounting for temperature controls, auxiliary electricity consumption, standby heat loss, ignition burner power consumption (if applicable), and for cogeneration space heaters the electrical efficiency multiplied by the conversion coefficient CC of 2.5; Ref: "Criteria for Hydronic Central Heating Generators" LOT 1,[92]

Seasonal space heating energy efficiency = SCOP / 2.5

Proposals for energy labelling and ecodesign requirements in LOT 1 (Boilers and combi-boilers, gas-oil-electric)
It is proposed that climate zones, output (kW) and ETA should be used as indicators of energy efficiency in energy labelling and ecodesign requirements for the following: heat pumps, except for low temperature heat pumps (55 oC) and low temperature heat pumps (35 oC)[93]. See above for calculation of SCOP from seasonal space heating energy efficiency.
The Ecodesign Regulation 206/2012 EC, which came into force on 6 March 2012, sets these minimum requirements for energy efficiency, SCOP.
Seasonal coefficient of performance (SCOP) (average heating season)

If refrigerant GWP > 150	3.40
If refrigerant GWP < 150	3.06

"Rated heat output" (Prated), "standard rating conditions" and "reference design condition"

[92] http://www.eceee.org/Eco_design/products/boilers 30 Mar 2011 WD_Ecodesign .... ANNEX III Measurements and calculations – 4f Translated to Norwegian)
[93] http://www.eceee.org/Eco_design/products/boilers 30 Mar 2011

Rated heat output (Prated) means the declared heat output from a heat source for space heating, and possibly for heating of tap water under standard conditions, expressed in kW. "Standard rating conditions" can be found in Annex VII, in the proposal for energy labelling requirements as shown in table B4 below. For heat pumps for space heating and combination heat pumps, the standard conditions for establishing nominal heat output mean reference design conditions in accordance with Annex VII, in the proposal for energy labelling requirements as shown below[94].

Heat source	Outdoor heat exchanger	Indoor heat exchanger			
	Inlet dry bulb (wet bulb) temperature	Heat pump space heaters and heat pump combination heaters, except low temperature heat pumps		Low temperature heat pumps	
		Inlet temperature	Outlet temperature	Inlet temperature	Outlet temperature
Outdoor air	+ 7 °C (+ 6 °C)	+ 47 °C	+ 55 °C	+ 30 °C	+ 35 °C
Exhaust air	+ 20 °C (+ 12 °C)				
	Inlet / outlet temperature				
Water	+ 10 °C / + 7 °C				
Brine	0 °C/- 3 °C				

Table B4: Standard rating conditions for heat pump space heaters and heat pump combination heaters.

Climate condition	Reference design temperature	Bivalent temperature	Operation limit temperature
	Tdesignh	T_{biv}	TOL
Average	- 10 (- 11) °C	maximum + 2 °C	maximum – 7 °C
Colder	- 22 (- 23) °C	maximum – 7 °C	maximum – 15 °C
Warmer	+ 2 (+ 1) °C	maximum + 7 °C	maximum + 2 °C

Table B5: Annex VII, Table 11 in the proposal for energy labelling requirements under LOT 1.

Annual energy consumption

Annual energy consumption in kWh/year or GJ/year, under "colder, average and warmer" climate conditions.

Seasonal Energy Efficiency Ratio (SEER) and (EER)

A measurement of efficiency in cooling mode, representing the ratio of total cooling capacity to electricity. For the purpose of this specification, EER will be calculated for closed loop and open loop systems in accordance with ISO 13256-1 or 13256-2. EER is calculated in accordance with standard AHRI 870. EER and SEER are of no relevance as they describe cooling and not heating.

Seasonal performance factor/SPF_h (SPF = Seasonal Performance Factor)

SPF_H or SPF_C indicates whether we are referring to heating or cooling. We will be referring only to heating below. COP at several different temperatures lifts forms the

[94] In work on developing "Criteria for Hydronic Central Heating Generators" LOT 1, http://www.eceee.org/Eco_design/products/boilers/

basis for the SPF_h value. The seasonal performance factor describes how efficiently the heating system works on average over a year. To achieve maximum efficiency, a heating system must be run at the output for which the system is designed. Systems are often designed for high efficiency when the system is being used to its fullest extent, while efficiency is lower in summer when the system is under low load. Therefore, the seasonal performance factor can be considerably lower than the COP indicated by the manufacturer of the heating system. To describe how much heat is produced in relation to how much electricity has to be supplied for the entire system throughout the entire heating season, we use an SPF_h factor (Seasonal Performance Factor, heating system)[95]. This is how SPF_h can be used:

Purchased electricity, kWh/year	SPF_h factor	Heat requirement, kWh/year
3560	2.8	15008

Table B6:

The seasonal performance factor relates to the system coefficient of performance, this is calculated in theory and shows the efficiency of the heat pump over an entire year. A heat pump with a seasonal performance factor of 3.0 gives off three times more heat energy than the electricity supplied to the air-to-air heat pump. The building's layout and furnishings have a major effect on the actual seasonal performance factor[96].

System boundaries for calculation of SPF_h.

The definition of system boundaries affects the results of SPF, depending on the effect of the various units in the system. This is why SPF has to be calculated in accordance with various system boundaries. Furthermore, the choice of system boundaries has a major impact on the required measuring equipment. The figures below show different system boundaries for heating mode.

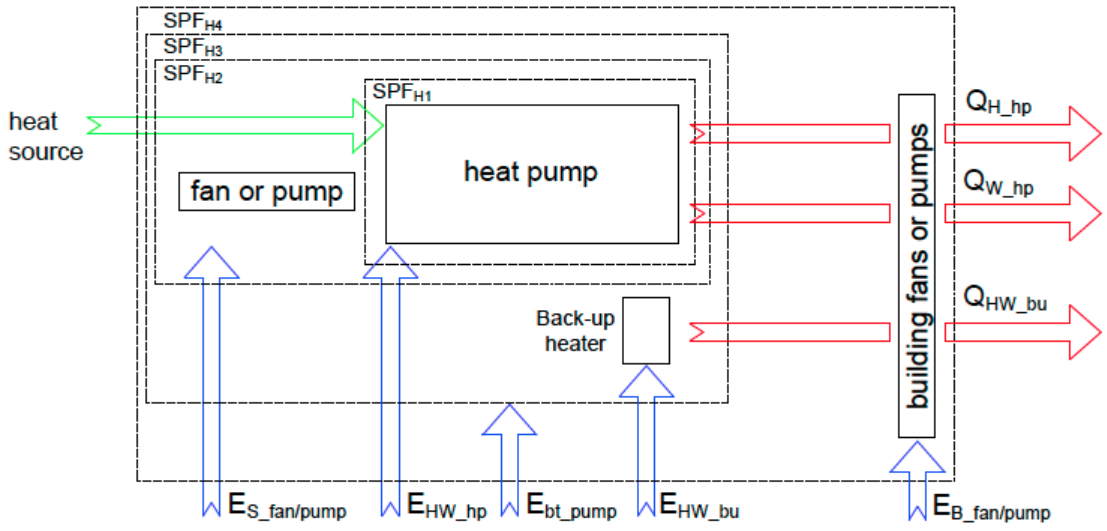


Figure B5: Energy flow for calculation of SPFH.

[95] http://www.effektiv.org/miljobel/forklaring.asp
[96] energimyndigheten.se/sv/Hushall/Testerresultat/Testresultat/Luftluftvarmepumpar/

The system boundary for SPF_{H2} is the one used in the energy labelling schemes, and it will also be the most useful for environmental labelling.

Primary energy factor (PEF)

The primary energy factor (PEF) is indicated by the following: COP × 0.40 (or COP/2.5) in the criteria for EU ecolabel (2007/742/EC).

TEWI

The term Total Equivalent Warming Impact could be used as a basis for calculation of the overall contribution to global warming. The equation includes CO_2 equivalents from input energy. Power produced from coal power will contribute more than power produced from gas power, for example. CO_2 equivalents from the type of refrigerant are included in the form of the associated GWP value. The refrigerant volume and percentage of leaks over the year will also be included. The service life of the product will also be included in the equation. If the machine runs under varying operating conditions, this will also have to be described[97]. It is easy to understand here that TEWI calculation for a series-manufactured heat pump would in itself have to include many template factors. This means that the figure calculated can easily vary widely from the figures actually measured. The TEWI factor is not used much by the industry itself, and is used mostly for research.

$$TEWI = GWP * (ER * n * m + \alpha V * m) + n * \beta * Q/SPF$$

Explanation of the abbreviations:

GWP:	Global warming potential	[-]
ER:	Emission rate	[%/a]
n:	Life of a system	[a]
m:	Filling quality of refrigerant	[kg]
α_v:	Disposal loss	[%]
β:	Conversion factor	[kg CO_2/kWh]
Q_h:	Heat demand	[kWh/a]
SPF:	Seasonal performance factor	[-]

Annual average temperature / normal values

A normal value is a comparative value or reference value which is used to characterise the climate in a location, and also to compare a current value with an average value calculated over a large number of years. Normal values are usually given for temperature, among other things.

[97] Spreadsheet for calculation of TEWI http://www.hfc-fri.dk/21596

Annex 3 Standards and testing methods

What space heating and hot water system would be best for my home?
Although this question appears to be basic, it is nevertheless not easy to answer as there are still no standardised characteristic figures relating to energy consumption – or standardised calculation methods for working out these figures – for comparison of heating systems, particularly on an international level. Despite this, there are at least standards which provide the opportunity to compare products in the same category. Here is a brief description of the most relevant standards in this regard:

ISO / IEC 17025:2005[98]
General requirements for skills at laboratories undertaking testing and calibration.

ISO / IEC 17025:2005 specifies general requirements for skills for carrying out tests and / or calibrations, including sampling. It covers testing and calibration carried out using standard methods, non-standard methods and laboratory-developed methods.

ISO / IEC 17025:2005 is applicable to all organisations carrying out tests and / or calibrations. These include, for example, first-party, second-party and third-party laboratories and laboratories where testing and / or calibration form part of inspection and product certification.

ISO / IEC 17025:2005 is applicable to all laboratories, irrespective of the number of personnel or the scope of testing and / or calibration activities. When a laboratory does not carry out one or more of the activities covered by ISO / IEC 17025:2005, such as the sampling and development of new methods, the requirements in these clauses are not applicable.

ISO / IEC 17025:2005 must be used by laboratories for development of their control systems for quality, administrative and technical operation. Laboratory customers, regulatory authorities and affiliated accreditation bodies can also use them to confirm or recognise the skills of the laboratories. ISO / IEC 17025:2005 is not intended to be used as a basis for certification of laboratories.

Compliance with the regulations and safety requirements for operating of the laboratories is not covered by ISO / IEC 17025:2005.

Examples of accredited European test laboratories (ISO/IEC 17025)[99]:

- Sweden: SP Technical Research Institute of Sweden (Borås)
- Germany: Institute of Air Handling and Refrigeration (Dresden)
- Austria: Arsenal Research (Vienna)
- Switzerland: Heat Pump Test Center WPZ (Buchs)

98
webstore.ansi.org/RecordDetail.aspx?sku=ISO%2fIEC+17025%3a2005&source=google&adgroup=iso9&keyword=ISO%2FIEC%2017025&gclid=CP_imeufga0CFe8umAodOCaI1Q
99 test.novap.no/sites/default/files/Arsvarmefaktor.pdf

EN 14511

This standard describes how to work out the COP for air conditioners, liquid chillers, air-to-air heat pumps, air-to-water heat pumps and liquid-to-water heat pumps. This European standard is not applicable to heat pumps for hot water, although certain definitions can be used for these[100].

EN14511 is calculated at the temperatures 0 °C from the ground and 45 °C out to the radiators for liquid-to-water heat pumps[101].

A complete test in accordance with standard EN 14511 involves testing of the heat pump's performance and function and carrying out a review of the heat pump's technical data and maintenance and installation instructions. Performance testing is carried out at a number of given testing points in accordance with EN 14511-3[102].

Function testing involves testing a number of different operations in accordance with EN 14511-4:

- Operating range of the heat pump. The heat pump is started up at the highest and lowest possible specified operating temperatures without being impeded by safety functions.
- Any ice formation is inspected. Ice must not accumulate on the evaporator, and water or ice must not blow out into the room.
- The defrosting function is checked
- To check safety functions, the heat medium flow is restricted on both the hot and the cold side for at least one hour and is then restored. The heat pump must be capable of being started after a stoppage of this type without it being damaged.
- Power cut.
- It must be possible to restart the heat pump after a power cut without it being damaged.

It should be observed that standard EN 255 was used previously, where heat pumps were tested at temperatures of 0 °C from the ground and 35 °C out to the radiators for liquid-to-water heat pumps. This results in a higher coefficient of performance, which makes tests in accordance with the various standards difficult to compare.

EN 14825

Standard EN 14825 is used for testing at reduced capacity or partial load testing under heating or cooling operation. This standard is applicable to testing and classification under partial load conditions and calculation methods for determination of seasonal energy efficiency and seasonal coefficient of performance. This standard is related to EN 14511 and is applicable to the same types of heat pumps: air conditioners, liquid chillers and heat pumps with electric compressors for space heating and cooling[103].

This standard can be used to calculate SCOP and Rated heat output as required in the Energy Labelling Regulation 626/2011 EC and the Ecodesign Regulation 206/2012 EC. The standard describes data for the three climate zones used in the Energy Labelling Regulation and the Ecodesign Regulation. "European reference heating season under average climate conditions for heat pump space heaters and heat pump combination heaters". In addition to "average climate conditions" which refers to

[100] DS/EN 14511-4:2012
webshop.ds.dk/product/M241487/dsen-14511-42012.aspx
[101] sv.wikipedia.org/wiki/Värmepump
[102] www.sp.se/sv/index/services/heatpump/standards_methods_heatpumps/Sidor/default.aspx
[103] www.standard.no/no/Sok-og-kjop/produktkatalogen/Produktpresentasjon/?ProductID=532827

Strasbourg climate, the other climate conditions are "Warmer and Colder", referring to Athens climate and Helsinki climate respectively.

Test temperatures:
For calculation of SCOP in accordance with EN 14825, the heat pump has to be tested at a series of temperatures corresponding to temperatures in EN 14511. For example, the table shows test temperatures on the cold side for an air-to-air heat pump and an air-to-water heat pump in the three climate zones in question.

Point	Average	Warmer	Colder
			-15/20 ˚C*
A	-7/20 ˚C		-7/20 ˚C
B	2/20 ˚C	2/20 ˚C	2/20 ˚C
C	7/20 ˚C	7/20 ˚C	7/20 ˚C
D	12/20 ˚C	12/20 ˚C	12/20 ˚C
Tbivalent	The temperature at which the heat pump exactly meets the heating demand*		
TOL	The heat pump's lower temperature limit***		

Table B7: Test temperatures for the outside part of air-to-to-water heat pumps .

* The test point for -15 ˚C only has to be performed if SCOP is calculated for climate zone Colder.
** Tbivalent is described in more detail in the next section. The manufacturer has to provide this value.
*** Temperature Operating Limit describes the lowest temperatures at which the heat pump can function.
Also to be provided by the manufacturer.

EN 378
Refrigerating systems and heat pumps – Safety and environmental requirements –
Part 1: Basic requirements, definitions, classification and selection criteria
Part 2: Design, construction, testing, marking and documentation
Part 3: Installation site and personal protection
Part 4: Operation, maintenance, repair and recovery[104]

EN 13313
Refrigerating systems and heat pumps – Competence of personnel

EN 15316-4-2
Heating systems in buildings – Method for calculation of system energy requirements and system efficiencies – Part 4-2: Space heating generation systems, heat pump systems.

EN 15450
Heating systems in buildings – Design of heat pump heating systems

[104] www.standard.no/no/Sok-og-kjop/produktkatalogen/Produktpresentasjon/?ProductID=532827

Annex 4 Various schemes and parameters for energy calculation

Tabell B8: The table show how individual schemes relate to various parameters for energy calculation.

	Validity	**Coefficient of Performance (COP)**	**Seasonal coef-ficient of performance SCOP and seasonal space heating efficien-cy ETA or η**	**Seasonal performance factor, SPF (heat)**	**Seasonal Energy Efficiency Ratio (SEER) and Energy Efficiency Ratio (EER)**	**Total Equivalent Warming Impact (TEWI)**	**Open to system solutions**	**Climate zones**
Quality-labelled EHPA	From 01.01.2011	Yes, various requirements for different solutions and dependent on GWP <150<	Not examined	No!	No!	No!	No!	No!
Energy Star in the USA		Yes, this has to be included in SPF	No!	Yes, without examining this more closely.	Yes, without examining this more closely.	Not examined	Not examined	Not examined
EU Flower criteria 2007/742/EC	From November 2007 to 31 March 2013	Yes, various requirements for different solutions	No, but requirements are specified for primary energy factor PEF	Applicant must offer a suitable tool/software to provide fitters with the opportunity to calculate SPF	Offer a suitable tool/software to provide fitters with the opportunity to calculate SEER and PEF. Various EER requirements for different solutions.	No!	No!	No! But applicant must offer a suitable tool/software to provide fitters with the opportunity to calculate SPF
EU Flower criteria and GPP criteria under revision (EU Ecolabel for hydroniccentral heating generators).	Relates to LOT 1; and the new criteria are expected to be complete in late 2012.	Not examined	Yes, min. 90% ETA	Not examined	Not examined	Yes, max. 180 g CO_2 equivalents per kWh of heating output	Not examined	Not examined

Der Blaue Engel	From May 2008	Yes, various requirements for different solutions	No!	Yes, various requirements for different solutions, and climate data for the town of Würzburg must be used for calculation.	No!	Yes, various requirements for different solutions	Not examined	No, climate data for the town of Würzburg must be used for calculation.
EC Regulation: 626/2011 for energy labelling of air conditioners and air-to-air heat pumps. Formerly LOT 10	4 May 2011, will come into force in January 2013, cooling or heating capacity of up to 12 kW	Yes, defines energy label using COP and differentiates between single duct and double duct conditioners	Yes, defines energy label using SCOP for heating	No!	Yes, defines energy label using SEER for cooling. Yes, defines energy label using EER and differentiates between single duct and double duct conditioners	No!	No!	Yes, 3 zones in Europe, with Finland, Norway and Sweden in the same zone
LOT 1 (Boilers and combi-boilers, gas-oil-electric) Not complete as at February 2012	Boilers; including heat pumps for hydronic heat and hot water from 4 to 400 kW.	Not examined	Suggested for use in energy labelling and ecodesign criteria.	Not examined	Not examined	Not examined	Not examined	Yes, 3 zones in Europe, with Finland, Norway and Sweden in the same zone
LOT 21: Central heating products using hot air to distribute heat (other than Combined heat and power (CHP)).	A finished report is expected in April 2012	Not examined	Not examined	Not examined	Not examined	Not examined	Not examined	Not examined
Nordic Swan requirements, version 2.2:	14 March 2007 – 30 June 2013	Yes, to calculate SPF	No!	Yes!	No!	No!	Yes, but no requirements specified for system efficiency	Yes, 3 zones in the Nordic region