Air conditioning products, ENTR Lot 6, Tasks 1-5

Executive Summary

Introduction

This is the draft executive summary for tasks 1-5 on Air-Conditioning products, as part of the preparatory study on Air-Conditioning and Ventilation Systems in the context of the Ecodesign Directive: '**ENTR Lot 6 – Air Conditioning and Ventilation Systems'.**

This study is being carried out for the European Commission (DG ENTR). The consortium responsible for the study is Armines (lead contractor), BRE and VHK. Subcontractors for the report on air-conditioning products are Armines and BRE.

Scope

The products covered in this study are products related to air conditioning systems in human occupied buildings to ensure comfort air conditioning. Although air conditioning systems are often made of a large number of components, the number of products covered in this study has been limited to the following list :

1. Air conditioners > 12 kW and air conditioning condensing units
    - Package (including rooftop units) air conditioners > 12 kW
    - Split systems (non-ducted single split, ducted single split and multisplit systems) [air-to-air > 12 kW, water-to-air, evaporatively cooled] and positive temperature air condensing units [air-cooled, water-cooled, evaporatively-cooled]
    - VRF systems (centralized air conditioning systems with refrigerant fluid as the main media to circulate and extract heat from the building) [air-to-air and water-to-air].
      The distinction with multisplit systems might be drawn on the basis of the expansion of the refrigerant fluid : locally in each indoor unit of the system, rather than centrally in the outdoor unit.

2. Chillers for air conditioning comfort applications [air-to-water, water-to-water, evaporatively-cooled], with no lower or upper limit in terms of cooling capacity.

3. Terminal units to extract heat from the space to be conditioned
    - Fan-coil units

4. Heat rejection units means from the cooling system
    - Cooling towers
    - Dry coolers

The cooling function of reversible split systems and VRF systems is assessed as a primary function. Their heating function is assessed as a secondary function, in order to provide a comparison basis with its assessment as a primary function in ENER Lot 21 preparatory study. This includes air conditioners included in air handling units.

For the time being, the heating function of reversible chillers that falls under the scope of ENTR Lot 6 is not studied, since it is already covered in the ENER Lot 1 study. However, the study team has technical data on these products in order to further assess the compatibility of the cooling/heating requirements.

Both cooling and heating functions of reversible fan-coil units are fully addressed in ENTR Lot 6 study, as the electricity consumption of the fan that transfers heat from the ambient air to the water distribution system or supply heat in the reverse way.

Specific renewable solutions with limited applicability such as earth pipes or seawater cooling are not included. Desiccant, evaporative and solar cooling solutions are not included but their applicability as potential design options is discussed.

Air Handling Units included in all air systems, so-called CAV (Constant Air Volume) and VAV (Variable Air Volume) systems are not treated in ENTR Lot 6. A specific briefing on AHUs explains why in more details. The main reason behind is that the cooling and heating in these systems is mainly supplied by cooling/heating generators, already included in the study.

Control systems are not considered as ENTR Lot 6 products. However, they are of interest regarding the impact they can have on the energy consumption of air conditioning systems and so the products these systems are made of. Better control strategies are improvement options to be considered per ENTR Lot 6 product in the final tasks of the study.

Preliminary key findings

The quantitative assessments in Task 4 confirm that all the products included in the scope should be eligible for Ecodesign measures, all the more since the stock of air conditioning products used for comfort applications is expanding at a significant rate.

Market analysis

Projections of sales and stock of products reported in Task 2 show indeed that :

- The installed stock of air conditioning chillers might increase from around 180 GW in 2010 to around 240 GW in 2020 and 270 GW in 2025. Because chillers have long lifetimes greater than 20 years for medium and large capacity products, 75% of the 2025 stock should be composed of pre-2020 products, which products will be impacted by future Ecodesign measures. Projected figures also show that there should be a continuous growth in sales of chillers, with a slow decline in first-time installation sales and an increase in replacement sales.

- Since sales of chillers are projected to increase significantly, so should also do sales of water-cooled chillers and therefore sales of heat rejection units.

- Sales of fan-coil units seem to have been slightly declining from 2007 on, but at a slow rate and partly because of the economic downturn. The stock of fan-coil units should continue to increase at a rate close to the growth rate of the chillers stock and so be composed in 2020 of post-2010 products, to a large extent.

- The installed stock of VRF systems might increase from around 18 GW in 2010 to around 45 GW in 2020 and 63 GW in 2025. The study team has estimated that future sales of split systems will progressively decline to the benefit of sales of VRF systems.

- The installed stock of split systems and rooftops might increase by about 10% from 2010 to 2020. Although this is a less important figure than for chillers and VRF systems, these products have short lifetimes of around 15 years, meaning that a significant part of future sales from 2010 to 2020 will correspond to the replacement of old units. A majority of the 2020 stock will therefore be composed of products sold after 2010, which products will be impacted by Ecodesign measures.

Current EU-27 figures

Task 4 results show that the stock of ENTR Lot 6 air conditioning products might consume at least 74 TWh in 2010, knowing that the electricity consumption related to the heating function of reversible chillers has not been included in this figure and should be around 15 TWh.

Because of no existing statistical data, a proper installation and maintenance of the modelled products have been supposed, although this is not a realistic assumption, as explained in Task 3. As well, the impact of the main technical failures quoted in Task 3 has not been modelled, since there is no sufficient information to do so.

Similarly, other impacts that are all but negligible in reality could not be taken into account. This applies among other to improper centralized control methods that lack flexibility, to poor occupant behaviour and knowledge of a proper use of air conditioning products, as well as to the impact of the heat island effect on the cooling loads to be handled and the efficiency of the cooling generators. The heat island effect increases the outdoor air temperature in densely populated urban areas where an important part of the stock of ENTR Lot 6 products is supposed to be installed. Higher cooling loads must be handled, and cooling generators are operating at higher sink temperatures, which lead to lower efficiencies.

Back to the results, the electricity consumption during the use phase constitutes the greatest part of the environmental impact of air conditioning products. Refrigerant emissions due to the use of cooling generators functioning on the basis of electrically driven vapour compression cycles is the second main cause of environmental impacts.

The 74 TWh of electricity consumption correspond to annual equivalent emissions of 34 Mt of CO_2. Between 4 and 15 Mt of annual equivalent CO_2 emissions correspond to losses of refrigerant directly dumped into the atmosphere. Refrigerant emissions are related to the use of R-22 (HCFC) in old stock products and R-134a, R-410A and R-407C (HFC) in more recent products. There is a large uncertainty on the refrigerant impact figure because no data is available at the EU level regarding refrigerant losses by product category.

The electricity consumption estimate matches pretty well preliminary estimates done in Task 1 (90 TWh of cooling + heating electricity consumption). Amongst the 4 product groups, the contribution of terminal units and heat rejection units is relatively low though not negligible, with 2 TWh of electricity consumption for fan-coil units and 1 TWh of electricity consumption for heat rejection units.

Modelling methodology

To estimate the current electricity consumption of ENTR Lot 6 products, the study team has developed a specific numerical methodology :

- 8 typical buildings representative of different building sectors have been modelled under 3 typical climates (Helsinki, Strasbourg, Athens). Typical cooling and heating loads have been deduced over a year.
- Several typical air conditioning systems that include base-case Lot 6 products representative of the current sales and stock in the EU have been selected in cooling and heating mode.
- The technical characteristics of the base-cases have been derived from the analysis of market data from Task 2, existing product database, manufacturers' technical documentations and scientific algorithms.
- The calculated building cooling and heating loads have been used as inputs in air conditioning systems modelling programs, which have been fully developed and coded by the study team.
- The electricity consumption of the base-case products have been outputted from these simulations, per typical building and typical climate.
- Market and building sector repartitions respectively from Task 2 of this study and Task 3 of the Lot 6 Ventilation study, cooling/heating degree days calculated per EU country in Task 3 and other technical assumptions have been combined with the results of the systems simulations to derive an equivalent representative annual electricity consumption per base-case product.

To estimate the environmental impact of refrigerant losses related to cooling generators :

- Information from several reference studies has been summarized and compared in Task 4, to get lower and upper limits.
- 2 refrigerant losses scenarios called “low estimate” and “high estimate” have been defined, the first one taking only into account losses intrinsic to the products, whereas the second one encompasses also possible accidents, technical failures, poor maintenance practices or refrigerant discharge at the end-of-life.

Best Available Technologies and Best Non Available Technologies

Air conditioners and chillers have still a large potential for improvement by using the best available technologies, which encompass better individual component like EC motors for fans, larger heat exchangers, better part load control and optimized part load designs. To maximize the potential benefits, the efficiency is to be judged on a seasonal performance standard, which is almost ready (prEN14825) for air conditioning products in this study. However, full load performance should not be forgotten as the externality linked to the management of the peak demand may be important in some EU countries. The potential alternative refrigerants have been screened. Regarding air conditioners, there is no perfect alternative for split and VRF air conditioners. Regarding chillers the choice is larger as they are operating as indirect systems. The identified alternative refrigerants will be considered as improvement options in the LCC analysis in Task 6.

Although they represent only a small part of the total energy consumption of air conditioning products, fan coils have a large potential for improvement which mainly coincides with the introduction of EC motors. The industry is proposing a seasonal based metrics which could help to foster the development of fan coils with EC motors and VSD controls.

Regarding heat rejection units, the gains that can be hoped first come from the choice of the heat rejection unit. The completion of the air conditioner/chiller standard should help the designers to make the best choices. In addition, and even if their own energy consumption is estimated to be low, heat rejection units may consume less energy by introducing more efficient EC motors and VSD control, as fan coils.

The overall potential for improvement could be much higher if comparing not only air cooled units amongst themselves but comparing the chilled water cooling plant as an extended product, together with its heat rejection means. This implies however a certain complexity which is thought to be at least a step forward as compared to the present situation.

Alternative cooling technologies have been described. Motor driven and heat driven absorption machines are available. They are of specific use, e.g. when waste heat is available or when supplying electricity ot the zone is too costly. The medium term development of solar and waste heat driven cooling system seems feasible. It may start with hybrid products, close to the present product architectures, with supplementary desiccant cooling or dehumidification. On the longer terms, thermo-acoustic and magnetic cooling still appear as possible alternative to the standard electric vapor compression cycles.