The efficiency of HVAC products goes beyond EU stipulations

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Introduction

To achieve the ambitious energy-efficiency goals that it had set, the EU Commission made a number of efforts, including preparing bodies of directives to assure more efficient operation of HVAC facilities and, in turn, of the buildings in which they are installed. A number of these stipulations that apply to HVAC technology are being prepared at this very moment. The purpose of these bodies of rules is to provide manufacturers with a context for the design of efficient solutions. It does not always suffice, however, to build products merely in accordance with these rules. The present article shows where manufacturers' solutions can complement upcoming EU requirements, and how they can even go beyond. It also outlines what planners, investors, and operators should consider to promote optimal climate protection and lower operating costs.

Slow down climate change with efficient HVAC technology

It is undisputed that buildings in Europe are among the greatest energy consumers. In Germany, for example, space heating and hot water make up almost one-third of the total energy use. In the sector classified as "trade, commerce, and services" – which also includes shops and office buildings – around 45 % of the required energy is used for heating and hot water alone [1]. Around two-thirds of all commercial buildings and half of public buildings additionally use mechanical ventilation to ensure the required room-air quality in modern buildings with their insulated façades [2]. The tendency is upward here.

To achieve the goal of slowing down global warming, respectively to achieve a maximum increase of 2°C of the earth's temperature above the level of the preindustrial age, buildings must become more efficient. It is particularly also in residential and commercial construction where a potential of making a valuable contribution to reaching the 20-20-20 goals[1] of the EU can be allocated. By 2050, the objective is even to reduce emissions to a level of one-fifth of the reference value of 1990. It is not feasible to achieve this ambitious goal without progress in building services engineering.

Contribution from industry and trade associations

To provide constructive and effective support to the complex and dynamic process of preparing the above-stated bodies of rules by the EU Commission, the Eurovent Association has set up a dedicated task force. This task force, which consists of industrial experts from all relevant product areas, plays an active role in the regulation-preparation process. While also integrating the Eurovent Product Groups and the national member associations, the Eurovent Association proposes suggestions for detailed preparation of the bodies of rules, with the objective of enhancing the energy efficiency of the products and solutions in scope.

1 These goals for 2020 call for the following: 20 % less greenhouse gas than in 1990, renewable energy with a share of 20% of the energy mix, and an energy efficiency 20% greater than in 1990.

EU stipulations for HVAC products

The new EU stipulations currently being discussed for HVAC products are primarily aimed at achieving more energy efficiency and of preventing emission of fluorinated greenhouse gases (F-gases). The power consumption of air treatment and air conditioning facilities – with consideration taken of the respective energy-mix for power generation – directly correlates with CO_2 emissions. This means that each kilowatt-hour that can be saved in the transport and treatment of air will benefit the environment. This is particularly reflected in the discussion under Eco-design Energy-related-products ErP "Ventilation Systems, ENTR Lot 6" [2], which includes facilities with fans over 125 W that are typical for commercial applications.

The air handling units discussed in [2] – see **Figure 2** – for full or partial HVAC systems, as they are used for example in commercial facilities – serve for transport, filtering, pre-heating, cooling, and/or emission of exhaust air. They are classified as equipment for air transport, and as energy-related products (ErP), since they can contain heat exchangers for temperature control of supply air or for energy recuperation. Owing to their own power consumption, air handling units are subject, among others, to the regulations in Directive EC/640/2009 (which calls for the introduction of increasingly more efficient motors, presently at least at the level of IE2 motors), as well as the stipulations in Directive EU/327/2011 (which regulates fans driven by motors between 125 and 500 kW).

Eco-design Directive 2009/125/EC

- EU's most important legal instrument to improve the environmental performance of **energy-related products** (ErP)
  - Extension of scope of former Eco-design Directive 2005/32/EC (energy-using products, EuP)
- **Framework Directive**
  - ➡ The requirements are introduced on a product-by-product basis via:
    - **Implementing measures** (IM) to be adopted by the Commission, or
    - **Voluntary agreements**
- Implementing measures only for products with:
  - Significant environmental aspects
  - Significant potential for improvement
  - Significant trade and sales volume (indicative threshold: 200 000 units per year)

Product Scope of Eco-design Directive 2009/125/EC

- Product scope defined in workplan 2009-2011 COM(2008) 660 (study on amended workplan ongoing)
  - Air-conditioning and ventilation systems
  - Electric and fossil-fuelled heating equipment
  - Food-preparing equipment
  - Industrial and laboratory furnaces and ovens
  - Machine tools
  - Network, data processing and data storing equipment
  - Refrigerating and freezing equipment
  - Sound and imaging equipment
  - Transformers
  - Water-using equipment

Proceedings Eco-design

- **Preparatory studies**: Technical, environmental and economic assessment of product groups done via consultants with input from stakeholders requested
- **Consultation Forum**: Discussion of suggestions for Eco-design requirements (Commission)
- **Impact assessment and interservice consultation**
- **WTO notification** (Technical Barrier to Trade agreement)
- Vote in **Regulatory Committee** (EU Member States)
- **Scrutiny** of the European Parliament and Council
- Regulations directly applicable in EU Member States

Preparatory Study → Consultation Forum → Draft Regulation → Approval Process → Publication Regulation

Sources: European Commission

Figure 1. Overview Eco-design – European HVACR policies.

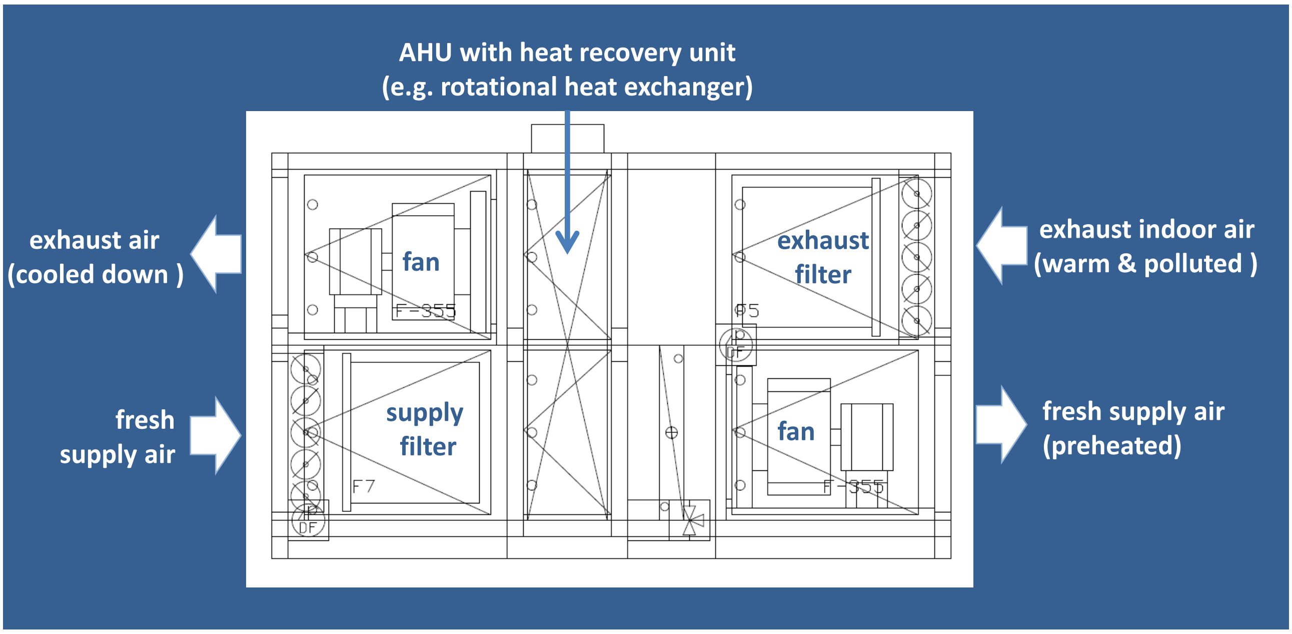

Figure 2. Air handling units (AHUs), as described in "Ventilation Systems, ENTR Lot 6". [2]

Energy-efficiency classes for orientation

The EU-requirements become applicable in a "compact" form in the various energy-efficiency classes for air handling units (AHUs), as set forth by Eurovent Certification. There, classification takes place on five levels, based on the criteria of air speed in the system cross section, power consumption of the fans, and efficiency of heat recovery. These classifications provide orientation for planners and investors. High-quality fans, as stipulated by EC/640/2009, as well as efficient heat recovery, lead to a more favorable classification on a scale from A-E. The Eurovent classification furthermore provides certainty to investors that manufacturers have observed the performance stipulations, since the Eurovent Certification actually tests sample equipment units to verify the performance claims of the equipment producers. At present, Class A is the best, but discussion has already begun at Eurovent Certification for addition of a Class A+.

Energy recovery

Further CO_2-emitters include heating plants fired by fossil fuels (see EuP 2005/32/EC, Lot 1 for Space Heating) and equipment for heating of sanitary water (see EuP 2005/32/EC, Lot 2, Sanitary Water). The use of energy recovery in central and decentral ventilation systems is a very effective measure for keeping consumption for heating as low as possible. As a result, heat recovery is classified as regenerative energy (also see EU Directive 2009/28/EG). With the installation of rotary heat exchangers, the degree of heat recovery achieves a level in practice of up to 70% (optimal level up to approx. 90%). This measure cuts approx. two-thirds of heating costs arising from air exchange.

Energy recovery can also apply for cooling

At the same time, however, neither the EU bodies of regulations nor energy efficiency classes for AHUs explicitly mention the recovery of cooling – although this matter is by all means of significance, for example, for southern European countries. The use of sorption rotary heat exchangers enables saving up to 40% of the energy used to cool supply air. Even though this aspect is not considered in EU regulations, investors and planners should take it into account for system design.

Control systems for enhancement of efficiency

AHUs are optimally operated when a control system regulates the volume of air according to demand: e.g., during working hours or other times of occupation, or as a function of the number of persons present in the ventilated rooms. In such cases, the AHU will bring the required air volume to moderate temperatures, such as 22°C during summer and 18°C during winter time. The temperature control of individual rooms takes place in the rooms themselves, which decouples air-volume demand from heating or cooling demand. This decoupling prevents the transport of air amounts that exceed those required for the fresh-air demand by persons present in the rooms. To achieve this beneficial decoupling, control technology is necessary that goes beyond satisfaction of the currently discussed EU rules for such equipment. Such systems would require CO_2 sensors, volume-flow controllers, a high-level building management system, and/or other components.

As with ventilation and heating, these matters involve the provision of air-conditioning cooling (with chillers/direct expansion). Here as well, control systems enhance efficiency by regulating the entire system, consisting of regulation of ventilation and heating (or air conditioning cooling) from a higher and more all-inclusive level, in accordance with demand.

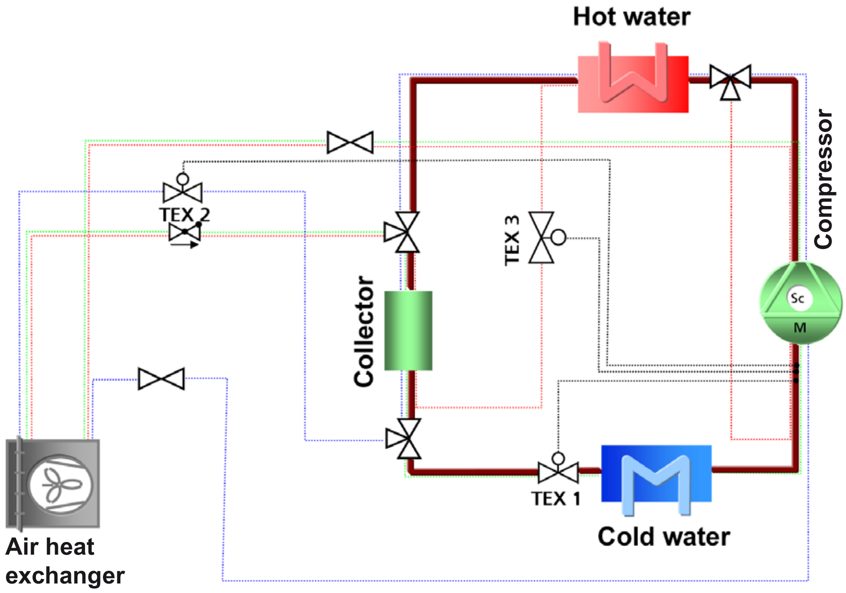

Figure 3. Combination of a chiller and a heat pump for simultaneous heating and cooling.

Combination solutions with chillers and heat pumps

Whereas cooling-only chillers and heat pumps as well as reversible chillers (with alternative operation as chillers or heat pumps) are covered by 2009/28/EC and other stipulations, and are recognized (according to function) as regenerative solutions, there is an equipment class on the market for which no EU directives or efficiency labels exist until now. These are hybrid solutions for bivalent heating and cooling: systems that combine chillers and heat pumps into one system (see **Figure 3**). Such systems can be efficiently employed when both heating and air-conditioning cooling are simultaneously required throughout relatively longer periods of the year: e.g., in office buildings with their own server rooms or in hospitals. Hotels also often simultaneously require cooling and heating during the summer: heating, for example, for pre-heating of hot water and for heating of swimming pools. Such systems, with employment of electrical energy or, for example, via water circuits, can deliver surplus heat to the areas in the hotel where heat is required. If the demand for heating and cooling does not exactly coincide, however, there is the possibility of exchanging the energy differential with the environment (air, soil, ground water). Although there is not even correlation of these systems to the coefficient of power (COP) or to the European Seasonal Energy Efficiency Ratio (ESEER), they exceed – during bivalent operational mode – the performance of the most efficient combination of heat pump and chiller. It would be highly advisable if these systems as well would be considered within the context of work with standards and EU rules.

Efficient use of perceived cooling

Fan coil units also offer potential savings when employed for individual room temperature control. EU stipulations and, for example, Eurovent efficiency labels promote the production of larger units (in favor of lower air resistance values) with better drive systems (i.e., more efficient motors). In addition – and in the same manner as for AHUs – heat exchangers with fewer tube rows lead to lower pressure drops and lower power consumption. Already within the next few years, it is planned to expand the energy classification applied for these systems at Eurovent Certification by adding the classes A+ and A++. It is planned in turn to delete the classes F and G.

Whereas the significance of performance characteristics is obvious to the investor, some underestimate the perceived cooling effect. In southern Europe, for example, where hot and moist conditions regularly prevail throughout a large part of the year, dehumidification already provides a more comfortable room climate under conditions of water supply and return temperatures, for example, of 7/12°C. As a result, the room temperature can be acceptable at levels a few degrees higher than without dehumidification.

A comprehensive consideration is indispensable

The above-stated examples show that the EU stipulations will indeed fulfil their purpose: e.g., the exclusion of technologies that are inefficient and no longer up to date. These rules, however, cannot serve as guides to best practice. It is within the capability of planners, investors, and/or building operators to compose the optimal solution for each individual project. At the same time, however, their attention should not be entirely focused on the efficiency of individual devices – but likewise on the overall efficiency of the entire equipment plant and for the operation that is required. The example of the mode of bivalent heating and cooling vividly shows that solutions not discussed in the EU set of rules yet can indeed provide an additional contribution to energy savings.

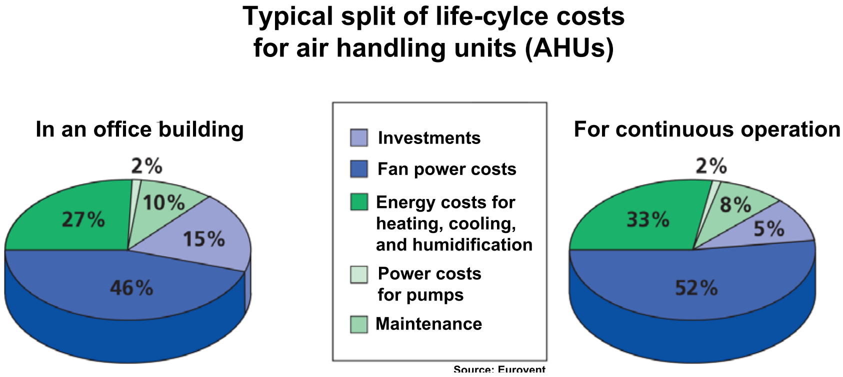

Figure 4. Life-cycle costs of an AHU (source: Eurovent).

Suitable instruments exist to promote comprehensive, overall thinking approaches from the side of operators and investors. These instruments include the Energy Performance of Buildings Directive, 2010/31/EU (EPBD) as well as national implementations: e.g., the 'Energie-Einspar-Verordnung' in Germany, the 'Réglementation Thermique' in France, the 'Bouwbesluit' in the Netherlands, the 'Boverkets Byggregler' in Sweden, and Building Regulations (in greater detail in Part L) in Great Britain. Here as well, more stringent basic characteristic values will ensure that, in the future, the best available technology (BAT) will enter the bodies of legislation (i.e., the best next available technology, or BNAT, from today's standpoint).

Since energy and operation costs exceed investment costs by several times – for example, with regard to AHUs –, it pays to exactly consider the requirements regarding air quality and setpoint temperatures – and to select a solution in accordance with these factors, and with low life-cycle costs. As a rule, low operational costs go hand-in-hand with low consumption of resources. Rising prices for power and gas will further increase the ratio of operation costs to investment, with the result that investments in energy efficiency will pay off even more in the future.

Case-by-case consideration of refrigerants

From case to case, it likewise pays to determine whether the replacement of conventional refrigerants by alternative natural products is always goal-oriented in every individual case. Without doubt turning away from hydrofluorocarbons (which have a global warming potential (GWP) that is significantly greater than that of CO_2) will minimize the danger to the ozone layer from incorrect handling and leakages in refrigerant circuits. Total elimination of conventional refrigerants, however, is not advisable in every single case. Although natural refrigerants such as ammonia and CO_2 are already widely used today in plants with great levels of efficiency, they cannot be used in all cases in reversible systems. Indeed: reversible chillers, which also support heat-pump operation, cannot easily be manufactured for use with natural refrigerants – or cannot operate with equivalent efficiency. If refrigerants are properly handled, and if they are used to minimum degree in refrigeration cycles (which is the responsibility of the manufacturer), the use of conventional refrigerants cannot be negatively assessed in principle in all cases. If, for example, a reversible chiller contributes to prevention of CO_2 emissions, it can very well make a greater contribution to climate protection than a less versatile and less efficient plant with natural refrigerants.

In addition, it is necessary to remember that chlorinated hydrocarbons and hydrofluorocarbons – despite their great potential for depleting the ozone layer – are not the primary causes of the greenhouse effect. The most important greenhouse gases in the atmosphere, in the order of their relevance, are water vapor, CO_2, CH_4 (methane, the main constituent of natural gas),

N_2O, and O_3 (ozone), only then come chlorinated hydrocarbon and hydrofluorocarbon compounds. For this reason, approaches should also place high emphasis on minimization of the use of methane (natural gas). In addition to the CO_2 that results from combustion of natural gas, the following two processes contribute to environmental warming: the consumption of fuel required for transport and storage of fossil energy media, as well as leakage losses in the pipelines. Measurements made in the 1990s revealed, for example, that leakage in the Russian long-distance gas pipelines produced losses of around 1% of the total transported volume [3]. This seems inconsequential in regard to the thousands of kilometers covered by the pipelines; it must be considered, however, that methane – the main constituent of natural gas – has a global warming potential (GWP) around 24 times greater than that of CO_2.

Within this context, therefore, it is only logical to pose the following question: should one, in the case of reversible chillers, place priority on elimination of a refrigerant that can potentially destroy the ozone layer, or should the additional energy efficiency of such agents be favoured? The bodies of rules valid until now do not yet provide support in this matter, and must be adapted to the state of the art. Nevertheless, industry is attempting to develop solutions with climate-friendly refrigerants that at the same time offer a maximum of efficiency. In addition to EU stipulations, the responsibilities of individual companies and, not least, the wishes of investors, remain as the driving forces for these and further innovations in the sense of climate protection.

Sources

[1] "Energie in Deutschland" – *Trends und Hintergründe zur Energieversorgung in Deutschland*; April 2009; Bundesministerium für Wirtschaft und Technologie.

[2] Lot 6: Air-conditioning and ventilation systems, Draft Report Task 1; 2.5.2011; Van Holsteijn and Kemna, Center of Energy and Processes, Building Research Establishment.

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