Policies to Limit European Air Conditioning Energy Consumption

Ownership of air conditioning in Europe has steadily increased over a number of decades and this trend looks set to continue (**Figure 1**). [1] Other things being equal, energy consumption will also increase. What could we do to constrain this increase?

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This article asks:

- Where are the biggest opportunities for reducing air conditioning energy consumption?
- Do we have policy frameworks that address these opportunities?
- Are there important gaps? If so, do we know how to address them?

Where are the savings and how quickly could they be achieved?

The Intelligent Energy Europe Harmonac project and other studies have shown that there is significant potential for savings in three areas:

- Reduction of cooling loads
- Improved efficiency of systems and equipment
- More effective operation and maintenance

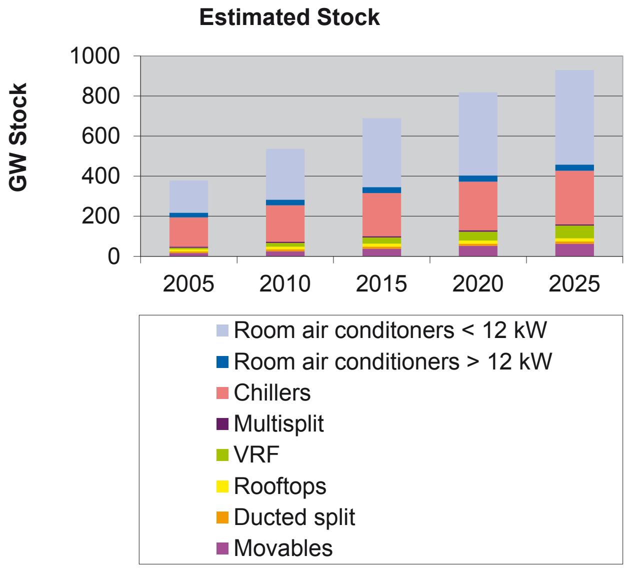

Figure 1. Air conditioning installed stock estimates. [1]

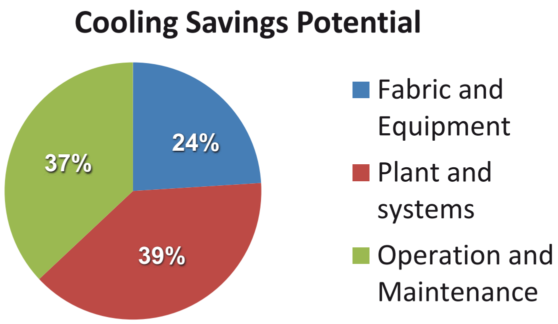

Figure 2. Relative air conditioning energy savings potential. [5]

Realising this potential is not straightforward. In particular, the relatively long operational life – typically of the order of 10 to 30 years - of air conditioning products and systems, and the equally long interval between building refurbishments are strong constraints on the rate at which energy-saving measures can be implemented.

This article considers "realisable 10-year potential savings" relative to a business as usual base case that could be achieved over a ten year period by applying measures and technologies that are already available in the market place. It summarises key results from a larger study [2,3]. Savings include both energy used for cooling and also that used for mechanical air handling within air conditioning systems.

The article concentrates on the six cases that were identified as having the largest energy-saving potentials. Unsurprisingly, these relate to the widespread use of the most energy-efficient products and procedures currently available. These are not always financially attractive to end-users, in which case regulatory measures may be needed to ensure their use. We therefore also consider whether these measures can be enforced by existing regulatory frameworks.

How did we estimate the potential savings?

The potential savings were derived using information taken from a number of published sources, including:

- IEE projects: Auditac, Harmonac, KeepCool, KeepCool II
- EC-funded Preparatory Studies for Energy Related Products Directive
- Other sources: Eurovent Certification database, other published reports

These data were used in a highly disaggregated model of European air conditioning energy consumption. The model takes account of the structure of the current installed stock of air conditioning systems, and of future sales into new buildings, existing buildings and as replacement systems and products. In particular, it breaks the market into: 30 countries; 14 air conditioning system types; 6 buildings per country; new-build, existing buildings, component and replacement rates. More details can be found in [3].

What are the most significant measures?

The six most significant types of measure are shown in **Figure 3**. The largest potential savings amount to about 30% of the 10-year base case consumption. They are subject to many assumptions and should be seen primarily as standardised indicators rather than projections. The measures overlap and interact and the potential savings cannot be simply added together.

How can these measures be implemented?

Consider each case in turn:

Demanding Minimum Performance Requirements for chillers and packaged cooling systems

This measure has a direct impact on series-produced products and is already covered by the existing policy framework supporting the Energy-related Products Directive, and the Energy Labelling Directive. The performance requirements assumed for products up to 12 kW cooling capacity are somewhat more demanding than those currently on place, but are still within the range of products that are on the market. The performance levels assumed for larger products are similar to those recently suggested by Preparatory Studies for the Ecodesign Directives. Our savings estimates are larger than those in the Preparatory Study as we have made the simplifying assumption that all policies could be implemented immediately. Realistically, the proposed levels of minimum performance would require many products to be taken off the market, which would require a phased implementation.

Performance requirements for air handling subsystems

This complements the previous case by extending minimum energy performance requirements to parts of larger air conditioning systems. Specifically, it covers requirements for duct and air handling unit leakage and for specific fan power. As air handling subsystems are tailored to different buildings, such requirements need to be implemented at national level through building energy regulations or codes. Although not explicitly required by the Energy Performance of Buildings Directive (EPBD), several European countries already implement such measures. The potential savings shown result from application of the same requirements across the rest of Europe. Current ERPD (Eco design of Energy Related Products Directive) proposals for requirements for air handling units have a narrower scope and would have a smaller impact. This case has a relatively small

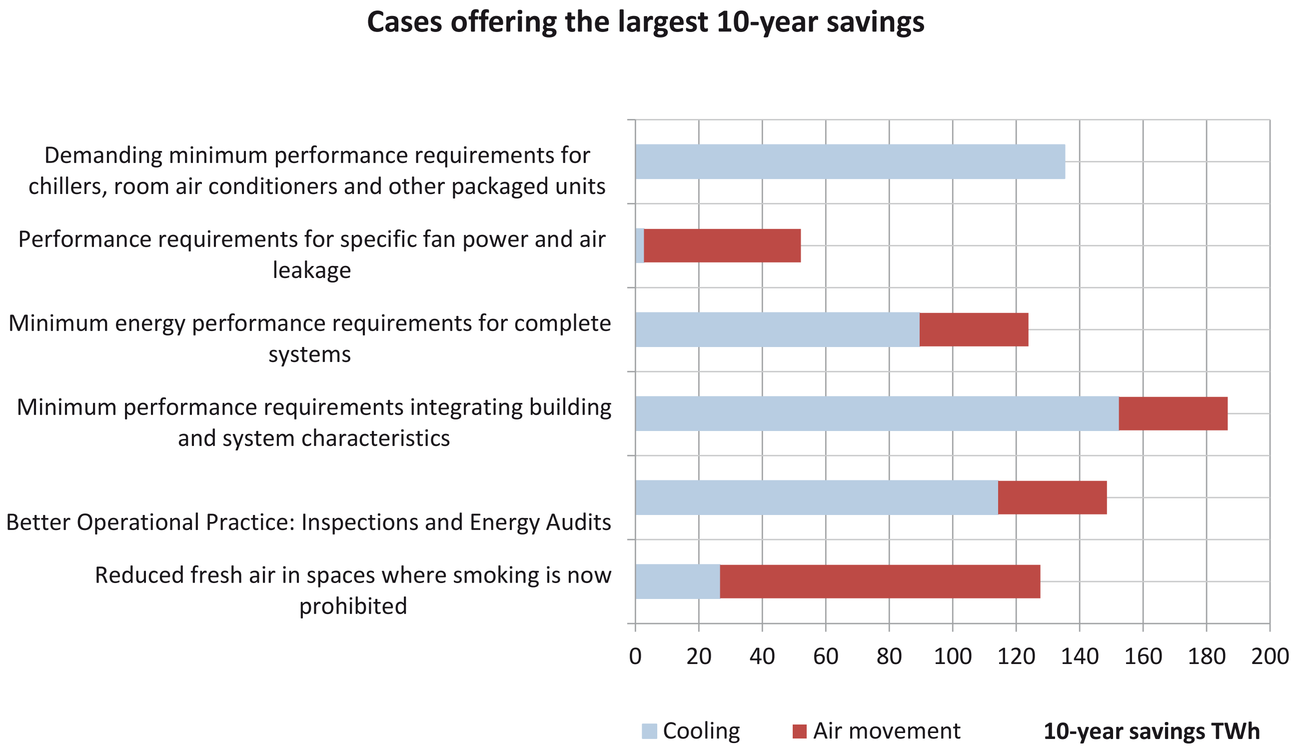

Figure 3. Largest opportunities for 10-year energy savings related to air-conditioning.

impact, but would be relatively easy to implement and provides a complement to requirements placed on series-produced products. The energy savings reported do not include the substantial additional savings that would result from applying the same requirements to mechanical ventilation systems that do not provide cooling.

Demanding Whole-system Minimum Energy Performance Requirements

Efficient components do not guarantee efficient systems and so a performance requirement placed on the system as a whole is a logical concept. A whole-system performance indicator is, in fact, required by the Recast EPBD. Since larger systems are specific to buildings, a requirement of this type would have to be implemented at national level. Modelling shows that this approach offers large 10-year potential savings. However, many of these savings overlap with those more easily achieved through performance requirements placed on products and air handling sub-systems.

There are also several practical implementation problems. The most fundamental of these is the need to agree a performance metric for systems that typically provide both cooling and heating, and often ventilation services. This might take the form of an integrated metric covering all three services (plus perhaps humidity control and air filtration). Alternatively it might consist of separate requirements for each service – in which case the apportionment of energy for components serving more than one service (notably fans) needs to be agreed. System performance cannot be measured on site, so agreement would also be needed on calculation methods and boundary conditions. Finally, there is the question of who is responsible for the calculation and for enforcement: the installation of an air conditioning system in an existing building does not always require building consent.

These hurdles are not insurmountable but do raise the question of whether the energy savings – over and above those achievable from existing policy frameworks – justify the effort to overcome them.

Demanding Integrated Minimum Energy Performance Requirements for Buildings and Systems

This case represents a tightening of the current EPBD minimum energy performance requirements in a number of countries, notably those in warmer climates with large numbers of air conditioning systems. Implementation is at a national level within the framework of the EPBD. In addition to incentivising the use of more efficient systems, the scope of the requirements includes the impact of load reduction measures from better building design and more efficient lighting systems, especially for new buildings and those undergoing major refurbishment. This case has the largest potential 10-year savings of the six that are described. However, the estimated savings are subject to the additional uncertainty associated with assumptions about the relative savings from air conditioning and other energy-using services.

Since the calculation of energy performance covers both the building and its "technical building systems", implementation of this case shares some of the challenges faced by whole-system requirements. However, these are reduced by the absence of a need for an explicit system performance metric and the existence of an established implementation infrastructure.

Better operational practice

There are substantial potential 10-year energy savings from better operational practice. Most such energy savings do not need substantial investments or new equipment. In principle, they can therefore be implemented quickly – and can disappear just as quickly. The estimated savings for this case are "demanding" in the sense that they assume that the majority of potential savings are identified and actions are taken to address them.

Existing policy instruments include the EPBD requirements for regular inspections of air conditioning systems larger than 12 kW cooling capacity (or the provision of advice in a way that can be shown to be equally effective) and more general advice campaigns including energy benchmarking. Energy Ratings based on measured consumption are also intended to impact on operational practice. Experience has shown that all of these have a limited impact. The Harmonac study showed that, while most of the savings potential identified by inspections was operational savings, most operational savings potential was not identified. [4, 5]

There is therefore a significant gap in effective policy measures. Remote energy monitoring combined with feedback that is building-specific has been shown to be capable of producing significant operational savings at economic costs (see for example the iSERV project [6, 7] and is a possible way forwards. This approach also allows the identification of high-consumption systems that could benefit most from inspection and provides diagnostic information to make inspections more effective. Building managers have proved to be somewhat reluctant to adopt the approach and implementation may require regulatory incentives such as less frequent inspections for low consumption systems.

Reduction of outdoor air supply

The final case is one that tends to be overlooked. Many existing air conditioning (and ventilation) systems were designed to deal with tobacco smoke, but smoking is often now prohibited in buildings or parts of buildings. There is scope for reducing outdoor air supply rates in new systems and, providing that issues of control and balancing can be handled, in some existing systems too. Most of the savings come from reduced fan energy use but, in hot climates, there are also cooling energy savings.

Policies to implementation these savings in new buildings would need to address design practice (the required air supply rates for smoking and non-smoking spaces are already defined by standards). For existing buildings, the same (rather weak) measures that are in place for operation savings seem to be the most appropriate option.

As information on the prohibition of smoking and the extent to which this opportunity has already been recognised is fairly sparse, the exact size of the opportunity is relatively uncertain.

Summary

- There is substantial energy savings potential through improved technical efficiency which could be achieved through the ERPD and EPBD. Extension of EPBD to include air handling subsystems looks desirable.
- Additional savings through the reduction of cooling loads is achievable through the EPBD, though implementation rate will be slow in existing buildings – but further saving in this are will accrue after the end of the 10-year period considered here. Further cooling demand savings are available from the impact of the ERPD on lighting and appliances.
- There is substantial energy savings potential through better operation and maintenance, but the impact of current policy instruments is weak.

As **Table 1** shows, existing policy frameworks mainly impact on system and product efficiency and, to a lesser extent, on load reduction. Policy measures addressing operational practice are few (and as we have seen weak).

The cases highlighted overlap and interact and we would suggest that the following combination of measures offers a reasonably balanced portfolio:

For new-build and major refurbishment: Integrated building plus system performance requirements in the form required by the EPBD.

Table 1. Summary of impacts and implementation routes.

Case	Impacts on: Cooling load	System efficiency	Operation	Implementation route
Demanding minimum performance requirements for chillers, room air conditioners and other packaged units		XXX		Ecodesign
Performance requirements for specific fan power and air leakage	X	XXX		National codes (under EPBD)
Minimum energy performance requirements for complete systems		XXX		National codes (under EPBD)
Minimum performance requirements integrating building and system characteristics	XXX	XXX	XXX	National codes (under EPBD)
Better operational practice	XX	XX		National programmes (under EPBD)
Reduced fresh air in spaces where smoking is prohibited	XXX	XX		National design codes and audits

For installations in existing buildings: performance requirements for new products, packaged systems, and air handling subsystems, implemented by the ErPD and an extension of the EPBD.

For existing systems: there is a need for policy instruments that incentivise better operation. It not clear what form these should take, although remote metering and diagnostics looks a promising option. ■

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