Count on Cooling: A five-step approach to deliver sustainable cooling

A white paper prepared by EPEE

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Executive Summary

This White Paper examines the crucial role of cooling in the 21st Century. Cooling includes comfort cooling for people (in their homes, offices, shopping centers, etc.) as well as cooling of products (production, transport and storage of food, medicines, leisure applications such as ice rinks, etc.).

There is expected to be massive growth in the use of cooling carried out throughout the world, especially in developing countries. This growth will deliver substantial benefits in many respects including human health and productivity and it will contribute towards reduction of food loss and better supply of heat sensitive medicines. A number of these benefits align closely with the UN's Sustainable Development Goals.

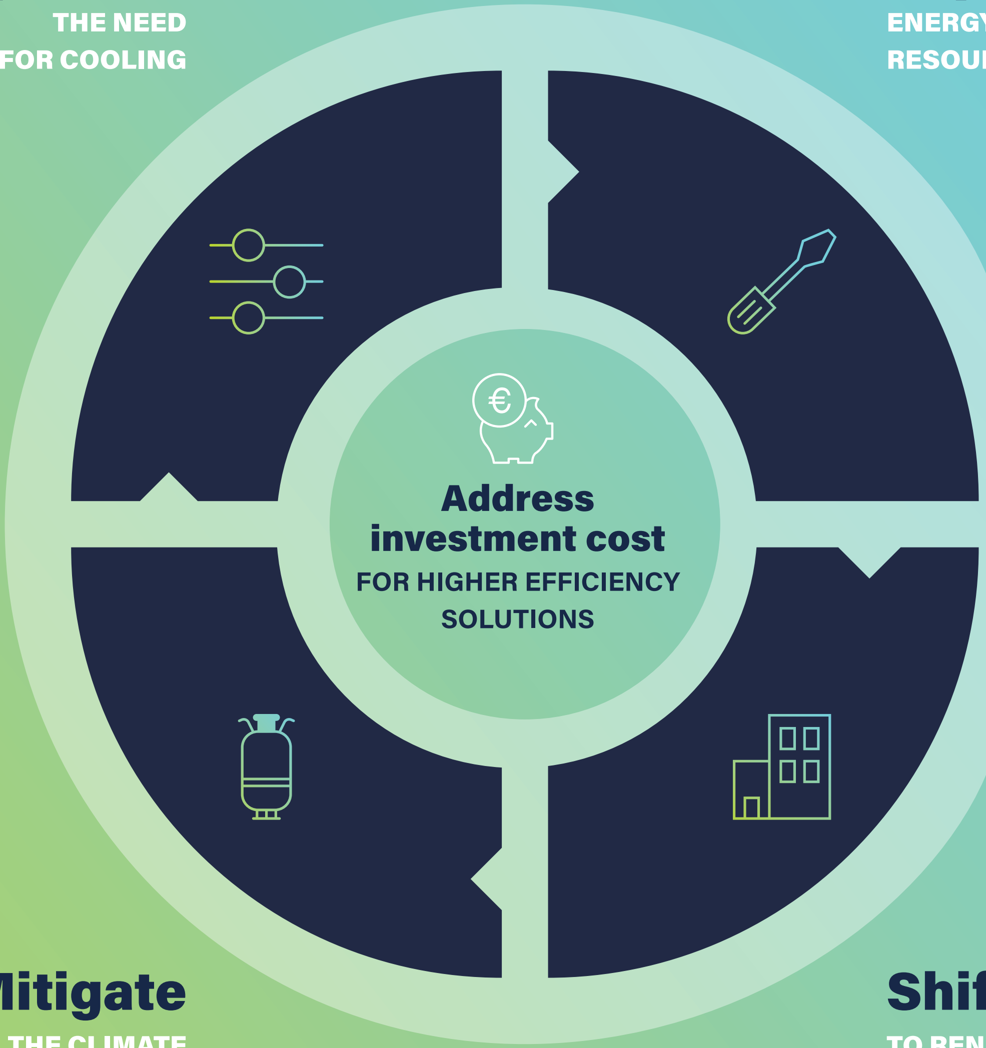
However, growth in the use of cooling could also lead to increased energy consumption associated with greenhouse gas emissions and place significant burdens of peak demand on electricity generation systems. These negative impacts can be addressed through the implementation of sustainable cooling – maximising the benefits of cooling whilst creating the smallest possible footprint in terms of greenhouse gas emissions and electrical peak demand.

This paper describes important steps that can be undertaken to deliver sustainable cooling, including examples of how the EU policy framework has already taken steps forward and an analysis of the remaining challenges.

A 5-step approach is proposed to (1) optimise the need for cooling, (2) improve the energy and resource efficiency of cooling equipment, (3) mitigate the climate impact of refrigerants, (4) address the investment cost for higher efficiency solutions, (5) shift to renewable energy sources with an integrated approach to cooling and heating of individual buildings or whole cities.

Optimise
THE NEED FOR COOLING

Improve
ENERGY & RESOURCE EFFICIENCY



Enable carbon neutrality
WITH AN INTEGRATED APPROACH ON COOLING AND HEATING

Mitigate
THE CLIMATE IMPACT OF REFRIGERANTS

Shift
TO RENEWABLE ENERGIES

The growing use of cooling

A number of studies show a clear trend to a rapid increase in global cooling demand over the next 30 years.

In developed countries, such as those in the European Union, one of the key drivers for the increasing use of cooling is the changing climate. The growing number of heat waves in the EU has stimulated a significant increase in the number of air-conditioning systems being purchased. For example, in a business as usual scenario, the European Commission's Heating and Cooling Strategy expects **the number of residential air-conditioners and refrigerators in Europe to more than double by 2030 compared to today**[1].

Another important area of growth relates to digitalisation. In 2020, data centres are projected to use 4% of the total energy consumed in the EU, which is double the use of 2007. **On average, around 40% of energy use in data centres is for cooling**[2].

In many developing countries the growth of cooling demand is much higher than in the EU. As levels of financial prosperity grow, the purchase of air-conditioning and refrigeration equipment are very high on the list of "must haves". A significant proportion of the population of developing countries live in hot climates, where the need for cooling is most crucial.

[1] Heating and cooling strategy, EC 2016

[2] ESPAS report on global trends, 2019; Trends in data centre energy consumption under the European Code of Conduct for Data Centre Energy Efficiency, JRC 2017

On average, around 40% of energy use in data centres is for cooling

The number of residential air-conditoners is expected to more than double by 2030

The benefits of cooling

There are numerous benefits of cooling, many of which align with the UN's Sustainable Development Goals (SDGs). Even in relatively moderate climates, such as in most of the EU, it would be impossible to support a modern urban economy without cooling systems. Some of the benefits include:

Health and well-being in the built environment: Europeans spend **90% of their time indoors and 80% will live in urban areas by 2050**[3]

Work force productivity: **cooling can improve productivity by 15%**[4]

Reduced food loss and food waste: A robust cold chain can significantly reduce the loss of food caused by spoilage between food production and food retail. In developing countries, more widespread use of residential refrigeration can significantly reduce the waste of food at the point of use. **Current levels of food loss and waste are estimated to be around 20% of all food produced**[5]. This creates significant GHG emissions which can be avoided by improving the food cold chain.

Improved healthcare: **Around 50% of medicines are heat sensitive** and require a robust cold chain to avoid wastage and dangerous degradation of products[6]. Many types of sophisticated medical equipment (such as scanners) require cooling and cooling is crucial for blood and tissue storage.

Affordable and sustainable energy: The **increased use of renewable energy sources** comes with challenges to balance the electricity supply and demand. Cooling, as well as heating by heat pumps can provide solutions to optimise the balance, for example by demand shifting controls as well as storing energy (cold and hot storage, also called "thermal" storage batteries).

[3] Healthy Homes Barometer 2018 and Standard Eurobarometer; Healthy Homes Barometer 2018
[4] Healthy Homes Barometer 2018, [5] The fight against food waste, Fusions, [6] IIR Heat sensitive health products

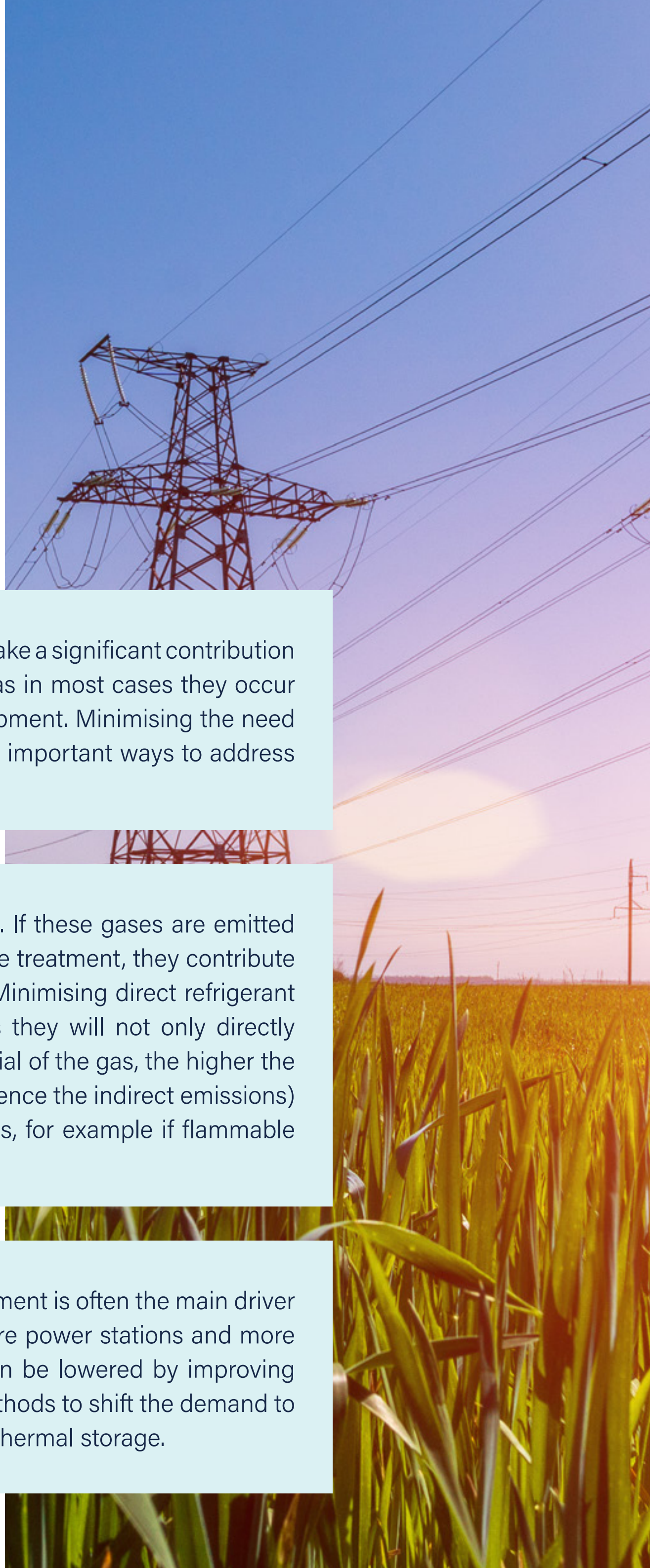
Current levels of food loss and waste are estimated to be around 20% of all food produced

Europeans spend 90% of their time indoors and 80% will live in urban areas by 2050

Cooling can improve productivity by 15%

The risks which can be avoided with sustainable cooling

The need for more cooling and the many benefits delivered are clear. Cooling demand will grow in response to climate change, and to increasing urbanisation and prosperity in developing countries. However, it is also clear that increased cooling must be done in a sustainable way. If design and operation of cooling are not properly addressed, there are potentially three important negative impacts:



Indirect emissions: Growing electricity demand for cooling could make a significant contribution to emissions of CO_2. These emissions are referred to as “indirect” as in most cases they occur at power stations that are at a different location to the cooling equipment. Minimising the need for electricity and shifting to low carbon electricity generation are 2 important ways to address this problem.

Direct emissions: Cooling systems make use of refrigerant gases. If these gases are emitted into the atmosphere, for example due to leakages or improper waste treatment, they contribute to global warming. These emissions are called “direct” emissions. Minimising direct refrigerant emissions – independent of the type of gas used – is crucial, as they will not only directly contribute to global warming (the higher the global warming potential of the gas, the higher the direct impact) but will also increase the energy consumption (and hence the indirect emissions) of the cooling equipment. Emissions can also pose safety concerns, for example if flammable refrigerants are used.

Peak electricity demand: In warm and hot climates, cooling equipment is often the main driver for peak electrical demand. Growing use of cooling will require more power stations and more electricity transmission infrastructure. Peak electricity demands can be lowered by improving the energy efficiency of systems at peak load conditions, and by methods to shift the demand to off-peak times (peak shaving), for example by demand control and thermal storage.

Coordinated efforts between policy makers, end users, equipment producers, finance institutions and power providers are needed to ensure broad deployment of sustainable cooling

Many technology solutions already exist to avoid these impacts, but market imperfections still lead to widespread inefficient use of cooling equipment and a lack of system integration. The minimisation or elimination of these negative impacts can only be achieved by coordinated efforts between policy makers, end users, equipment producers, finance institutions and power providers.

The role of Governments and international support organisations as well as close cooperation and coordination between public and private stakeholders is crucial if there is to be wider access to sustainable cooling.

A simplistic approach would be to concentrate exclusively on using ultra-low Global Warming Potential (GWP) refrigerants and to use zero carbon electricity. That eliminates the direct emissions caused by high GWP refrigerants being released into the atmosphere and indirect greenhouse gas emissions due to fossil fuel-based energy generation. However, if insufficient effort is made to ensure maximum energy efficiency and optimised cooling system integration, there will be unnecessarily high electricity use and electricity peak demand. This would result in massive extra costs for both the power providers (who would have to build more power stations) and to end users (who would use more electricity and who would ultimately pay for the extra supply capacity required to meet their peak demand). It would also not be a sustainable approach from an environmental viewpoint as it would require more use of natural resources (metal, copper, aluminum, water, refrigerants, etc.) to build power stations and produce equipment.

A far better approach is to encourage or mandate an integrated and sustainable cooling approach where systems need to be designed and applied to provide the required benefits whilst minimising or eliminating the negative impacts at an affordable cost.

Such an approach needs to properly take into account **(a) the costs to the end user** (initial capital investment and on-going electricity costs), **(b) the costs to the power provider** (to provide sufficient infrastructure to meet peak demand) and **(c) the costs to the environment**, in terms of greenhouse gas emissions and use of natural resources.

A 5-Step approach to sustainable cooling

To provide sustainable cooling and minimise the aforementioned risks in the most cost-effective way, it is helpful to consider five distinct steps in the design and use of cooling systems. If these steps are fully implemented, the cooling systems will have minimum cooling demand, be highly efficient and be well integrated with the power generation system.

STEP 1
OPTIMISE THE NEED FOR COOLING

Optimising the cooling demand should always be the first step – in many cases it will lead to a smaller system being required and a significant reduction in energy use. Savings of 30% to 60% are often possible. There are numerous ways in which this can be achieved, for example:

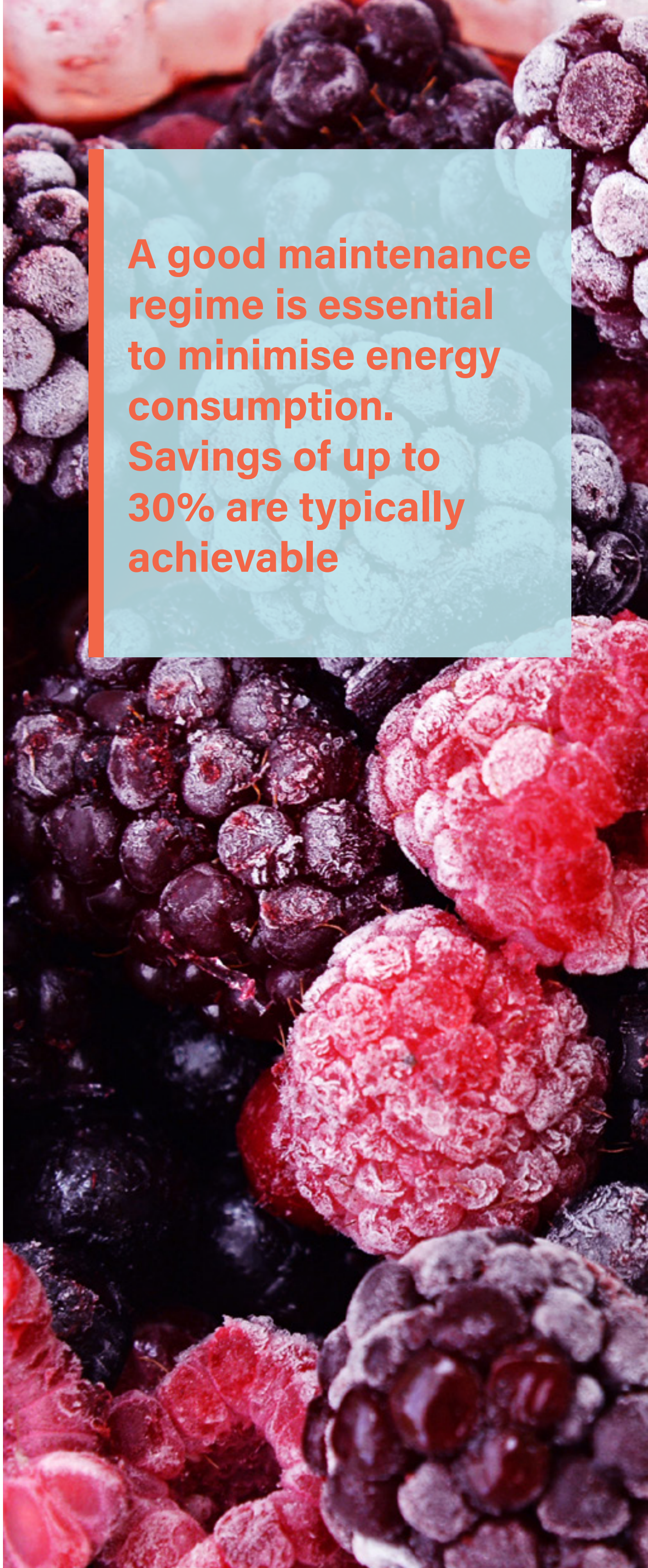
- Building design measures to reduce the thermal load, such as shading (savings up to 54%[7]), high performance glazing (savings up to 29%[8]) and improved insulation (savings up to 90%[9]).

- Improved control systems to avoid poor consumer habits such as "over-cooling". For example, using a higher temperature set point for an air-conditioned building has the dual benefit of reducing the number of hours when cooling is needed and improving the equipment efficiency at times when cooling is required. Just a 1 degree C increase in set point can save 5% of energy use. Control systems also help to avoid cooling when no people are present in the room.

- Doors on chilled retail displays can reduce the cooling demand significantly.

- Designing data centres to operate at a higher temperature to reduce the energy needed for cooling.

[7] Solar shading saves energy. [8] Glazing Potential. [9] Keep cool stay warm. [10] Optimising the energy use of technical building systems – unleashing the power of the EPBD's Article 8, Ecofys 2017. [11] Inspection Methodology – Air Conditioning Maintenance Tasks - Identifying Energy Savings, iSERV, Intelligent Energy – Europe (IEE) SAVE Project, 2012



A good maintenance regime is essential to minimise energy consumption. Savings of up to 30% are typically achievable

STEP 2
IMPROVE THE ENERGY AND RESOURCE EFFICIENCY OF COOLING EQUIPMENT

There can be massive differences between the energy consumption of different cooling systems used for the same application. There are many potential reasons for poor performance, falling into 5 main areas:

- **Design**: A state of the art design might use half the energy of an older design. Technologies such as variable speed compressors and optimised heat exchanger designs can deliver significant efficiency improvements. **Savings of 30% to 50% are often possible**.
- **Sizing**: Cooling equipment is often found to be oversized due to inadequate cooling load calculations, leading to inefficient operation of the equipment and increased energy use.
- **Control and operation**: Modern control systems can ensure that the use of a cooling system is minimised and that the correct control settings are always used. Many inefficient systems have poor controls or the controls are not well optimised. **Good controls are relatively inexpensive and might save 20% to 50% of energy use**[10].
- **Maintenance**: Over a period of time the performance of a cooling system can deteriorate due to a range of maintenance issues, such as fouled heat exchangers or refrigerant leakage. **A good maintenance regime is essential to minimise energy consumption. Savings of up to 30% are typically achievable**[11].
- **Monitoring performance**: It is common to find that end users are unaware their cooling systems are operating inefficiently. Good instrumentation helps generate the savings possible through improved control, operation and regular maintenance.

A sustainable cooling approach requires responsible use of the natural resources used to produce the cooling equipment (for example copper, aluminium, steel, refrigerants, etc...). This includes the need to reduce, recover and reuse these materials, contributing to a Circular Economy approach. Heating and cooling products are subject to different Regulations (e.g. in the EU: Ecodesign, RoHS, WEEE), and therefore contribute to Circular Economy across their whole lifecycle, for example:

- **End of life**: Heating and cooling products are not allowed to be disposed of by consumers directly, but only by professionals and installers that ensure proper handling of all materials.
- **Extended Producer Responsibility (EPR)**: Significantly improved end-of-life recycling techniques that enhance material recovery.

STEP 3
MITIGATE THE CLIMATE IMPACT OF REFRIGERANTS

The direct impact of refrigerants can be minimised by a combination of various factors, such as:

- The GWP of refrigerants: When new equipment is being purchased the "traditional" high GWP HFC refrigerants should be avoided. In the EU, the F-Gas Regulation has already led to the availability of lower GWP alternatives in almost all parts of the refrigeration, air-conditioning and heat pumps market. The Kigali Amendment of the Montreal Protocol will lead to rapid uptake of lower GWP alternatives throughout the world[12].
- Proper installation, maintenance and servicing, by working with qualified installers
- Set up of refrigerant recovery and recycling schemes to avoid that refrigerants are emitted into the atmosphere during servicing or at end-of-life.

[12] UNEP Ozone Action

STEP 4

ADDRESS THE INVESTMENT COST FOR HIGHER EFFICIENCY SOLUTIONS

In most countries there is little or no interaction between decisions made to purchase cooling equipment and decisions affecting the supply of electricity. If end users continue to select inefficient cooling appliances, for example because they have the lowest capital cost, there will be unnecessarily high peak electrical demands created. These must be met by building extra power stations and by creating larger electricity transmission and distribution networks. Working in this way leads to:

- Unnecessarily high electricity use and cost to the end user.
- Further extra cost, as the price of electricity will need to reflect the excessive peak demands created by the widespread use of inefficient appliances. Ultimately these extra costs must also be paid by end users.

To overcome this issue, there needs to be close cooperation between the parties involved, to create a more integrated approach to the delivery of more cooling and to optimise the balance of capital investment between new cooling equipment and power generation. By encouraging end users to only use the most efficient equipment, the overall cost to the country or region can be minimised. This type of integration can be considered in a number of different ways:

- By ensuring that cooling appliances meet high standards of efficiency, for example by using Minimum Energy Performance Standards (MEPS).
- By informing users about the energy efficiency differences between products offered on the market, for example by Energy Labels.
- By supporting buyers to overcome the financial challenge of a higher investment cost, for example by offering different types of financing schemes or incentives.
- By incentivizing power supply companies to support investments in high efficiency cooling.
- By facilitating it for end users to “sell” the waste heat from their cooling equipment to other users that require heating. For example, supermarkets could sell their rejected heat to a district heating system.

To address the upfront cost for higher efficiency solutions, it is crucial to optimise the balance between capital investment for new cooling equipment and power generation.

STEP 5
SHIFT TO RENEWABLE ENERGY SOURCES WITH AN INTEGRATED APPROACH TO COOLING AND HEATING OF INDIVIDUAL BUILDINGS OR WHOLE CITIES

To maximise the cost-effective uptake of renewable energy it is important to integrate the design of energy supply systems (supply side) with the design of energy using systems (demand side). This means, for example, that buildings need to be considered as a key element of the energy infrastructure with heating and cooling demand being at the core of long-term planning.

An important opportunity is to ensure optimal use of energy between different categories of users (residential/commercial/industrial), by coordinating building clusters at local and at city level. Such an approach enables the provision of minimal energy input, without sacrificing the functionality of the system (whether dedicated to comfort, manufacturing processes, or other functions).

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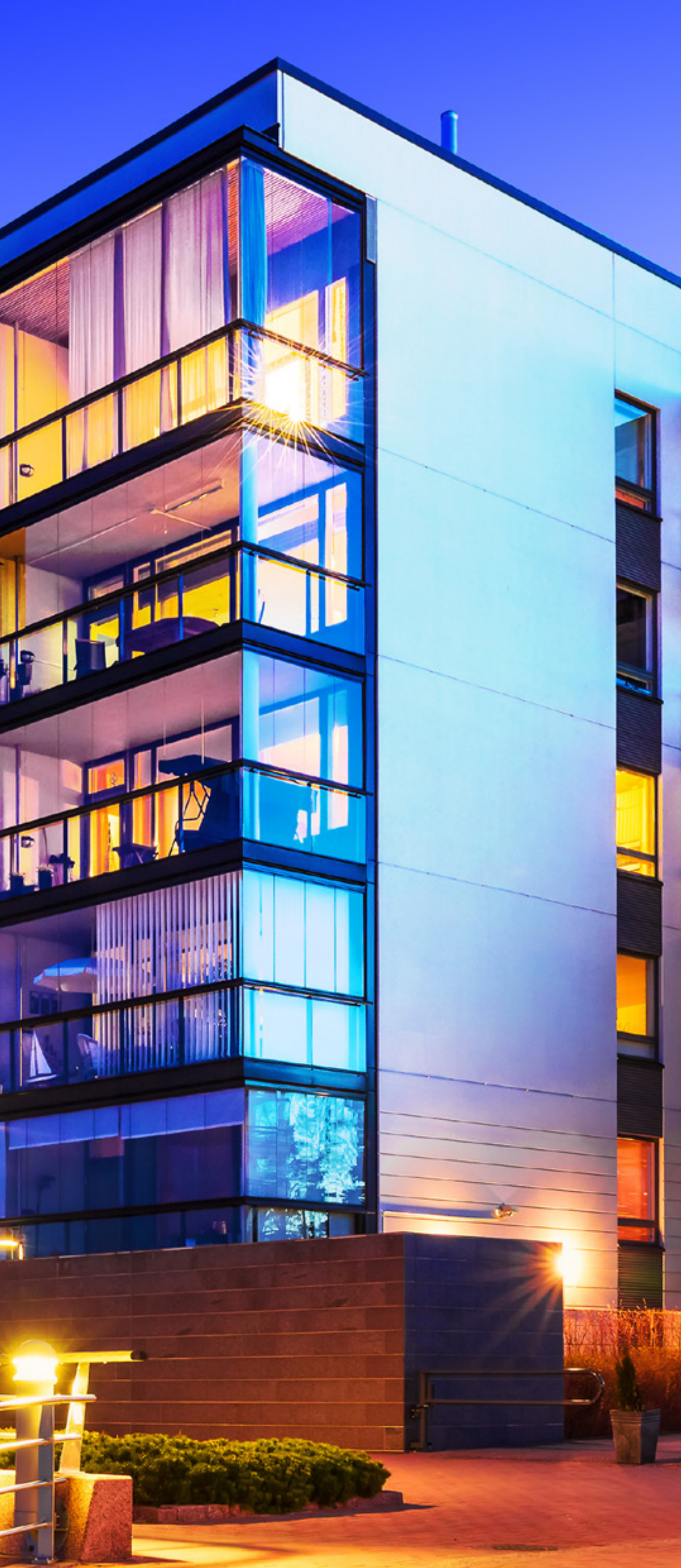

Examples for system integration include:

- District heating and cooling systems for individual large buildings, building clusters or whole cities, enabling the development of highly efficient cooling systems operated with low carbon energy and optimised with sophisticated technologies such as energy storage.
- Decentralised systems such as heat pumps or photovoltaics to relieve burden from the electricity infrastructure, while guaranteeing delivery of energy without interruption, thus increasing supply reliability.
- On-site energy storage where cold (and heat) are used as thermal energy batteries and demand response schemes, where heating and cooling systems provide flexibility to the grid and shift peak demand which is increasingly important with the transition to renewable energies.
- Integration of decentralized systems into thermal networks empowering consumers to help share cooling and heating capacities, be it on a local level or on the level of building clusters. Again, this can be a great opportunity to increase efficiency and flexibility while reducing investment in large central heating and cooling plants.
- Use of rejected heat from cooling systems to further enhance energy efficiency and system integration by supporting other heating needs (heat recovery).

Without coordinated actions by key decision-makers and stakeholders there is a danger that in many countries the new cooling equipment supplied will be sub-optimal in terms of efficiency, environmental impact and life cycle costs.

Implementing the 5-Step approach

The need for more cooling is well understood. However, **without coordinated actions by key decision-makers and stakeholders there is a danger that in many countries the new cooling equipment supplied will be sub-optimal in terms of efficiency, environmental impact and life cycle costs.** Barriers standing in the way of the 5-step approach proposed in this paper include:

- Low political awareness of the potential for improved efficiency and the significant benefits of the integrated approach – and therefore a lack of clear financial drivers.
- Limited end user awareness of the potential life cycle cost reductions of improved efficiency.
- A siloed approach, that makes it hard for all the key stakeholders to work together, especially in the relationship between the power supply sector and the users of cooling.
- Challenges to attract, retain and upskill professionals to meet the evolving needs of the industry. These professionals are vital to ensure proper sizing, installation and maintenance, deliver high efficiency designs, provide good monitoring of performance and address the complexities of large integrated systems.

EPEE's Call on policy makers

The various steps described in this paper create different levels of difficulty in terms of widespread implementation. Whilst a robust framework exists at EU level, there is still a major gap in terms of implementation at national level. To overcome the described barriers, EPEE calls on policy makers to:

Promote an integrated approach

Encourage synergies between heating and cooling such as heat recovery from cooling systems or the use of heat pumps that are able to provide heating and cooling.

Encourage demand side management and thermal storage via heating and cooling systems to provide flexibility for the grid.

Inform, empower and motivate consumers

Support the deployment of smart appliances by rewarding flexibility.

Strengthen tools to raise awareness on energy efficiency (Energy Labels for buildings and products, metering, etc.).

Upskill installers

Provide lifelong learning to keep up with technological developments.

Ensure the adaptation of the curriculum to match the industry's evolving needs.

Better reflect the sector's specificity in the NACE statistical classification.

Reward sustainable investments

Develop a framework to drive investments into sustainable solutions for consumers, business and investors.

Ensure sustainable public spending (taxation, electricity prices, subsidies) and put an end to subsidising fossil fuels.

Encourage the optimum balance of investment for efficiency improvements in the demand side and power infrastructure in the supply side.

Implement and enforce EU laws

Consolidate national heating and cooling plans, for example as part of the National Energy and Climate Plans (NECPs) and/or the national long-term strategies.

The national heating and cooling plans need to address both the full implementation and enforcement of existing legislation and the design of adequate drivers to encourage and/or mandate an integrated approach of sustainable heating and cooling.

EU Policy Framework

CLEAN ENERGY PACKAGE: TO PAVE THE WAY FOR A CARBON NEUTRAL EUROPE IN 2050

- Renewable Energies Directive: For more renewables in the energy mix
- Energy Performance of Buildings Directive: For more efficient buildings
- Ecodesign Directive and Energy Labelling Regulation: For more efficient products
- Energy Efficiency Directive: For energy savings obligations
- Governance of the Energy Union and Climate Action Regulation: For national energy and climate plans
- Electricity Market Design Regulations: For a modernised and stable grid

F-GAS REGULATION:

- To reduce emissions stemming from F-gases, so-called fluorinated greenhouse gases (such as HFCs), through a phase-down approach

MARKET SURVEILLANCE:

- To ensure that products on the EU market are compliant with legislation

WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE) DIRECTIVE AND RESTRICTION OF HARZARDOUS SUBSTANCES (ROHS) DIRECTIVE

- To provide for the creation of collection schemes to increase the recycling of WEEE and/or re-use and requiring heavy metals and flame retardants to be substituted by safer alternatives

Concluding Comments

There will be significant growth in the use of cooling over the next 30 years, delivering many benefits including better health and well-being in the built environment, improved healthcare, higher work force productivity, reduced food loss and food waste, responsible consumption and production, affordable and clean energy, reduced climate impact, etc. We need to ensure that this growth is delivered with sustainable cooling solutions for the sake of people, the environment and the EU economy and competitiveness on a global level. Many of the required technologies are already available, and the cooling industry is continuing to innovate and provide further improvements.

To get the maximum benefits in the most cost effective way it is essential that there are coordinated efforts at national and EU level, to bring together experts from the power sector and the cooling industry, as well as from the public and the private sector to address all the opportunities in the 5-step process described in this White Paper:

1. Optimise the need for cooling;
2. Improve the energy and resource efficiency of cooling equipment;
3. Mitigate the climate impact of refrigerants;
4. Address the investment cost for higher efficiency solutions;
5. Shift to renewable energy sources with an integrated approach to cooling and heating of individual buildings or whole cities.

About EPEE

The European Partnership for Energy and the Environment (EPEE) represents the refrigeration, air-conditioning and heat pump industry in Europe. Founded in the year 2000, EPEE's membership is composed of 48 member companies, national and international associations from three continents (Europe, North America, Asia).

EPEE member companies realize a turnover of over 30 billion Euros, employ more than 200,000 people in Europe and also create indirect employment through a vast network of small and medium-sized enterprises such as contractors who install, service and maintain equipment.

EPEE member companies have manufacturing sites and research and development facilities across the EU, which innovate for the global market.

As an expert association, EPEE is supporting safe, environmentally and economically viable technologies with the objective of promoting a better understanding of the sector in the EU and contributing to the development of effective European policies. Please see our website (www.epeeglobal.org) for further information.

CountOn
Cooling

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