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## Executive Summary

The European Union (EU) has embarked on a journey to establish a decarbonized cooling sector that aligns with the climate of the 21st century. Through initiatives like the COOLING DOWN project, the EU aims to unlock the potential of renewable cooling technologies and reduce greenhouse gas (GHG) emissions. This report provides a comprehensive analysis of the key results, lessons learned, and recommendations for the future, drawing upon three key deliverables of the COOLING DOWN project.

### **Sensitivity Analysis on the Impact of Energy and GHG Savings at the EU Scale**

This deliverable presents a macro-scale modeling approach to evaluate the potential of renewable cooling technologies in reducing GHG emissions across Europe. The study utilizes advanced tools and frameworks, such as UrbanEnergyPro and pyGreta, to estimate cooling demand, assess renewable energy potentials, and optimize the European energy system. The findings reveal a significant potential for emission reduction through the adoption of renewable cooling technologies, driven by increased CO<sub>2</sub> prices and the shift towards a more renewable energy mix.

### **Economic and Technical Analysis of Renewable Cooling Technologies**

This deliverable focuses on the economic and technical feasibility of geothermal and solar cooling technologies, comparing them with traditional options. The analysis includes a cost-benefit analysis, taking into account externalities such as productivity losses and mortality associated with heat waves. The results demonstrate the long-term economic benefits of renewable cooling solutions, particularly in mitigating the negative impacts of urban heat islands and improving health and well-being.

### **Good Practice Guide for Renewable Cooling**

This deliverable provides an overview of best practices and recommendations for mainstreaming renewable cooling, drawing upon EU legislation and national guidelines. The analysis includes a review of key aspects of the current European regulatory and policy framework, as well as national legislation and best practices in Spain, France, Italy, Germany, and Romania. The recommendations emphasize the need for stronger policies and incentives to promote the adoption of renewable cooling technologies and to ensure a sustainable and affordable energy future for Europe.

# Chapter 1: Sensitivity Analysis on the Impact of Energy and GHG Savings at the EU Scale

## 1.1 Introduction

The increasing global demand for cooling solutions, driven by rising temperatures and the growing frequency of extreme weather events, presents a significant challenge for energy systems worldwide. Macro-scale energy system modelling is crucial for understanding and mitigating the environmental impacts of this growing cooling demand, particularly in the residential sector. This chapter delves into the intricacies of macro-scale modelling of the European energy system, where high-resolution data and advanced modelling techniques are employed to analyse cooling load profiles and renewable energy potential on a large scale.

## 1.2 The Importance of Macro-Scale Energy System Modelling

Energy system modelling at a macro scale is essential for several reasons. Firstly, it provides a comprehensive understanding of CO<sub>2</sub> emissions across vast geographical areas, enabling policymakers to develop targeted strategies for emission reduction. By examining the interactions between different energy sectors, such as electricity, heating, and cooling, modelling helps identify the most effective measures to curb emissions. Secondly, it highlights the spatial and temporal variations in energy demand, which are influenced by climatic conditions and building characteristics. This granular insight is vital for designing efficient and sustainable energy systems that can adapt to changing environmental conditions.

## 1.3 Methodology

The sensitivity analysis presented in this chapter utilizes a combination of advanced tools and frameworks to estimate cooling demand, evaluate renewable energy potentials, and optimize the European energy system.

### Estimating Cooling Demand

The UrbanHeatPro tool, enhanced with the UrbanColdPro component, is used to estimate the cooling demand of typical residential buildings for each country of the European Union. This tool incorporates a grey-box model, which simplifies and represents various building components using resistances (R) and capacitances (C), similar to an electrical network. The model considers factors such as building envelope elements, ventilation losses, solar gains, and user behaviour to accurately estimate cooling loads.

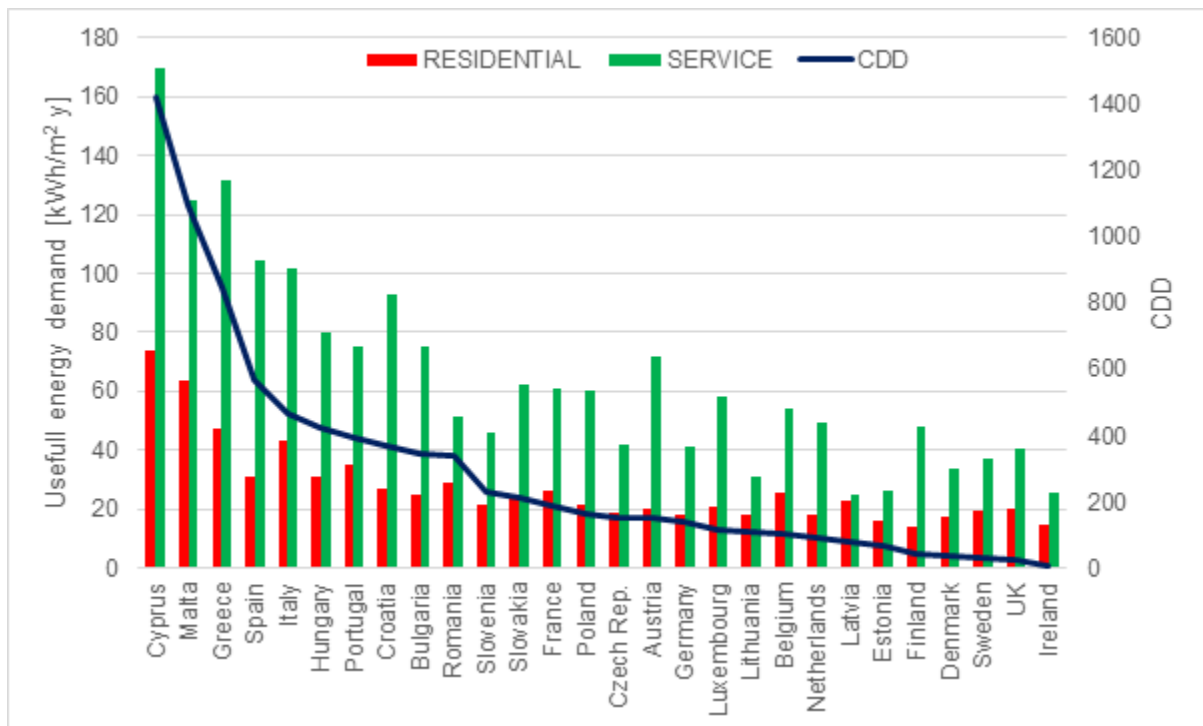


Figure 1: Specific cooling demand for each country. [Source: D2.1 Cooling Down](#)

### Evaluating Renewable Energy Sources

Renewable energy potentials for solar, wind, and geothermal sources are assessed using the pyGreta tool and existing methodologies. The pyGreta tool generates high-resolution potential maps and time series data for solar photovoltaic (PV) and wind power, considering factors such as land availability, historical weather data, and technical specifications of renewable technologies. For geothermal potential, the existing tool G.POT is utilized, which is based on an established methodology for assessing shallow geothermal potential.

### Optimizing the European Energy System

The optimization of the European energy system, including cooling, electricity, and heating sectors, is conducted using the urbs framework. This open-source linear optimization framework creates linear programming optimization models for capacity expansion planning and unit commitment within distributed energy systems. The optimization process considers various scenarios, including different CO<sub>2</sub> price projections, to identify cost-optimal solutions and assess the role of GSHP in meeting cooling demands.

## 1.4 Results

The sensitivity analysis reveals several key findings regarding the impact of renewable cooling technologies on energy and GHG savings at the EU scale.

### ➤ **Significant Emission Reduction**

The study indicates a significant reduction in emissions from 2022 to 2050, primarily driven by increased CO<sub>2</sub> prices and the subsequent shift from fossil-fuel-based power plants to a more renewable energy mix. This finding underscores the importance of policy measures, such as carbon pricing, in promoting the adoption of renewable energy sources and achieving emission reduction targets.

### ➤ **Minor Impact of Cooling Sector on CO<sub>2</sub> Emissions**

The analysis highlights the relatively small impact of the cooling sector on CO<sub>2</sub> emissions compared to the electricity sector. This suggests that the decarbonization of electricity will inherently decarbonize cooling, as most cooling technologies are powered by electricity.

### ➤ **Minor Contribution of Residential Cooling Demand to Total Electricity Demand**

The cooling demand of residential buildings, particularly when using efficient technologies, represents only a minor portion of total electricity demand. This finding emphasizes the importance of promoting energy efficiency in cooling technologies to minimize the impact of cooling demand on the electricity grid.

# Chapter 2: Economic and Technical Analysis of Renewable Cooling Technologies

## 2.1 Introduction

Renewable cooling technologies, such as geothermal and solar cooling, offer a sustainable and environmentally friendly alternative to traditional cooling systems. This chapter delves into the economic and technical aspects of these technologies, comparing them with traditional options and highlighting their potential to mitigate the negative externalities associated with conventional cooling systems.

## 2.2 The Need for Renewable Cooling

The growing demand for cooling solutions, driven by rising global temperatures and the increasing frequency of extreme weather events, presents a significant challenge for energy systems worldwide. Traditional cooling systems, often reliant on fossil fuels, contribute to greenhouse gas emissions and exacerbate the urban heat island effect, leading to negative impacts on health, well-being, and the environment. Renewable cooling technologies offer a sustainable and environmentally friendly alternative, providing cooling solutions without relying on fossil fuels and mitigating the negative externalities associated with conventional cooling systems.

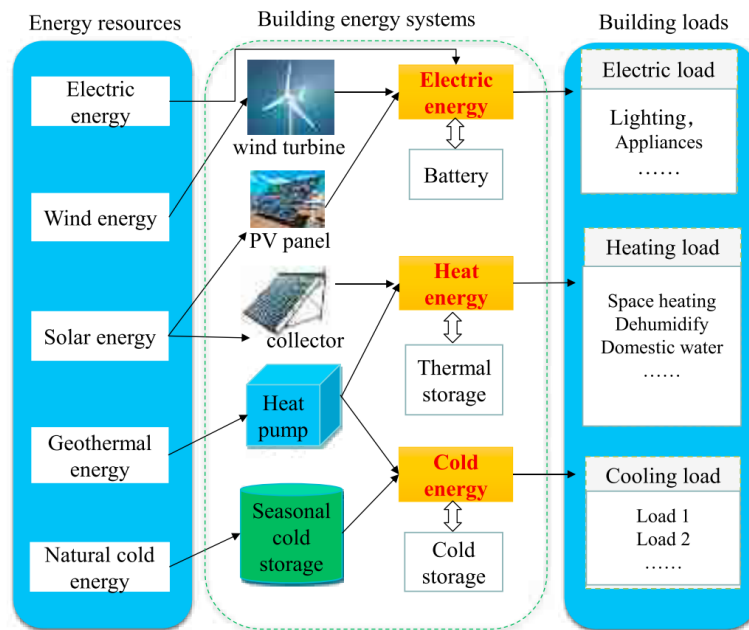


Figure 2: Schematic of the hybrid renewable energy system. Source: D2.1 Cooling Down

## 2.3 Geothermal Cooling



Geothermal cooling utilizes the relatively constant temperature of the Earth's subsurface to provide cooling solutions. Geothermal heat pumps (GHPs) can extract heat from buildings and transfer it to the ground, providing efficient and sustainable cooling. This technology offers several advantages, including:

- **Energy Efficiency:** GHPs can achieve high energy efficiency ratios (EERs), reducing energy consumption and operating costs.
- **Environmental Friendliness:** Geothermal cooling does not rely on fossil fuels, reducing greenhouse gas emissions and mitigating the urban heat island effect.
- **Health and Well-being:** Geothermal cooling can improve indoor air quality and thermal comfort, contributing to a healthier and more comfortable living environment.

## 2.4 Solar Cooling



Solar cooling utilizes solar energy to provide cooling solutions. Solar thermal collectors can be used to generate hot water, which can then be used to drive absorption chillers or desiccant cooling systems. Solar photovoltaic (PV) systems can also be

used to power conventional cooling systems, providing a renewable energy source for cooling. Solar cooling offers several advantages, including:

- **Renewable Energy Source:** Solar cooling utilizes a clean and renewable energy source, reducing reliance on fossil fuels and greenhouse gas emissions.
- **Cost-Effectiveness:** Solar cooling can reduce energy costs in the long term, particularly in regions with high solar irradiance.
- **Environmental Sustainability:** Solar cooling contributes to a more sustainable and environmentally friendly built environment.

## 2.5 Economic and Technical Analysis

The economic and technical feasibility of geothermal and solar cooling technologies depends on various factors, including the local climate, building characteristics, and energy prices.



### Geothermal Cooling

The upfront costs of geothermal cooling systems can be higher than those of traditional cooling systems, but the long-term operating costs are typically lower due to higher energy efficiency. The payback period for geothermal cooling systems can vary depending on the specific project, but it is generally within a reasonable timeframe.



### Solar Cooling

The upfront costs of solar cooling systems can also be higher than those of traditional cooling systems, but the long-term operating costs are typically lower due to the use of free solar energy. The payback period for solar cooling systems can also vary depending on the specific project and local conditions.

## 2.6 Externalities

Renewable cooling technologies offer significant benefits in mitigating the negative externalities associated with traditional cooling systems.

### Urban Heat Island Effect

Traditional cooling systems, particularly those that reject heat into the atmosphere, contribute to the urban heat island effect, leading to increased temperatures in urban areas. Renewable cooling technologies, such as geothermal and solar cooling, can reduce or eliminate this effect

by rejecting heat into the ground or utilizing solar energy, which does not contribute to urban heat island formation.

### Health and Well-being

The urban heat island effect can have negative impacts on health and well-being, leading to increased heat stress, respiratory problems, and mortality. Renewable cooling technologies can mitigate these impacts by reducing urban temperatures and improving indoor air quality.

### Productivity

Heat stress can also lead to reduced productivity, particularly in workplaces that require physical labour or mental concentration. Renewable cooling technologies can improve thermal comfort in workplaces, leading to increased productivity and reduced absenteeism.

## 2.7 Case Studies

The COOLING DOWN project includes several case studies that demonstrate the economic and technical feasibility of renewable cooling technologies in different contexts.

### ➤ District Heating and Cooling (DHC) Systems

DHC systems can efficiently distribute heating and cooling to multiple buildings, reducing energy consumption and emissions compared to individual building systems. Renewable energy sources, such as geothermal and solar thermal, can be integrated into DHC systems to provide sustainable heating and cooling solutions.

### ➤ Data Centres

Data centres require significant amounts of energy for cooling, making them ideal candidates for renewable cooling technologies. Geothermal cooling and free cooling, which utilizes cool ambient air or water, can significantly reduce energy consumption and emissions in data centres.

## Chapter 3. Business Model: Initial-aid cashback model for renewable cooling financing

In the context of the Cooling Down project, **three innovative business models** were developed and evaluated to support the implementation of renewable cooling systems. These models respond to the growing demand for cooling in buildings while addressing the financial, social, and institutional barriers that hinder the implementation of renewable and low-carbon cooling technologies.

The three models examined in the project are:

- **Initial-Aid Cashback (IAC) Model (new)**
- **Energy Service Company (ESCO) Model**
- **Community Cooling Hubs**

Other than ESCO and Community Cooling Hubs, the Initial-Aid Cashback (IAC) model is a novel and particularly promising approach. It was developed to provide a decentralized, socially inclusive financing mechanism that enables energy operators to implement cooling systems without bearing the upfront investment costs. The following summary outlines the functionalities and evaluation of all three models, but the main focus lies on the IAC model.

### 3.1 The Challenge of Financing Renewable Cooling

Traditional financing structures are often not well-suited to the deployment of renewable cooling technologies, which usually require substantial initial investments but deliver long-term economic and environmental benefits. Many building owners, especially in residential or small commercial settings, lack the liquidity or risk appetite for such investments, despite a clear need for thermal comfort during hotter summers caused by climate change.

The Cooling Down project therefore aimed to explore models that are not only **technically and financially viable** but also **fair, participatory, and scalable** across different socio-economic and institutional settings. Giving energy consumers the chance to participate actively and benefit from the clean energy transition is one of the main goals of the Initial-aid cashback model.

### 3.2 Initial-Aid Cashback (IAC) Model: Concept and Functionality

The Initial-Aid Cashback model addresses the central obstacle of upfront capital by introducing a third-party financing actor, the investor which is also consumer. This investor can be an individual, a community group, a private company, or even a local foundation that provides the necessary funding to install a renewable cooling energy system.

The functionality of the model is structured as follows:

### **Pre-Financing and Implementation phase**

The cooling system is financed by a group of consumers that become investors at that point. These investors cover 100% of the initial capital expenditure. The system is installed by the operator which is the owner of the technology.

### **Cashback Mechanism**

In return for their investment, the consumers that invested in the first phase receive compensation for a pre-defined amount of energy by reduced energy prices. This is why it is important that investors are consumers. Consumers that didn't invest in the first place receive their energy, paying the standard energy price.

### **End of Contract Period**

After the repayment, the operator and owner of the cooling device keep selling cold, receiving the standard price payment from all consumers. This makes the model interesting for operators, as the investments are made by the consumers, but it has a high rentability from the very beginning.

## **3.3 Comparison with Other Models**

To place the IAC model in context, two other business models were developed and analysed as part of the project.

### **Energy Service Company (ESCO) Model**

This well-established model involves a professional third party (an ESCO) that installs and operates energy systems but does not own them as the ownership is kept on consumer side. While the ESCO model is technically mature and risk-reducing for users, it is often limited to large-scale commercial projects due to its administrative and contractual complexity.

### **Community Cooling Hubs**

This model is based on shared infrastructure and cooperative investment. A central cooling system (e.g., district cooling or shared geothermal systems) serves multiple users in a neighbourhood. Financing is typically organized through local private persons. While this model has high environmental potential and promotes local governance, it requires significant coordination, institutional stability, and upfront planning.

Compared to these models, the IAC model offers greater flexibility and accessibility. It is suited to smaller- scale projects, easier to initiate, and can be adapted to individual users or small communities without requiring complex organizational structures.

### 3.4 Evaluation and Stakeholder Validation

The IAC model was evaluated through a combination of expert reviews, stakeholder workshops, and participatory feedback formats.

Key **strengths** identified by stakeholders included:

- The ability to mobilize private capital at the local level
- High social acceptability due to its fairness and transparency
- Low administrative burden compared to ESCO contracts
- Potential for hybrid financing models (e.g., public-private or crowdfunded)
- Opportunity of participation on CET by private investors

However, several **challenges** were also highlighted:

- Legal uncertainty around contracts between investors and users
- Need for trust and clear accountability mechanisms
- Potential risk for investors if energy savings are lower than expected

Despite these challenges, the model was seen as highly promising, especially when combined with supportive policy instruments, such as municipal guarantees, subsidies, or tax incentives.

Furthermore, Figure 3 shows the profitability of the model for operators (Calculations were based on the case study of Romania from the Cooling Down project).

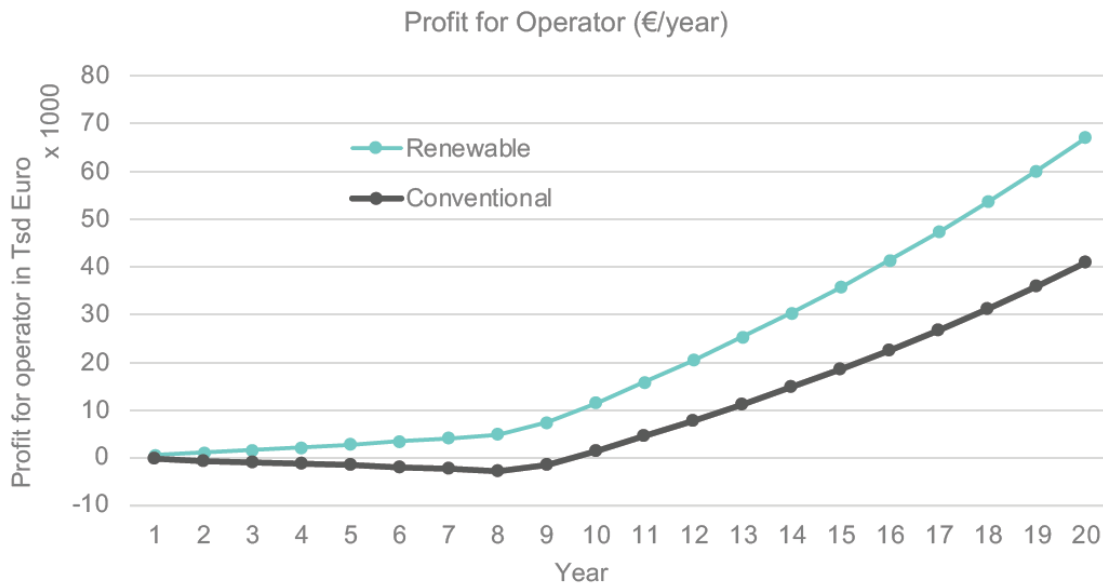


Figure 3: Profit for operator in Tsd. Euro per year

### 3.5 Future Outlook

The **Initial-Aid Cashback (IAC) model** offers a promising and innovative approach for financing renewable cooling. By involving consumers as investors, it overcomes the common barrier of upfront costs while ensuring fair returns through reduced energy prices. Most importantly, consumers – especially private person – can thereby be involved actively into the clean energy transition and benefit from it, which increases its acceptance. Compared to ESCOs and Community Cooling Hubs, the IAC model is more flexible, socially inclusive, and easier to implement on a smaller scale.

To fully realize its potential, legal clarity, trust-building, and supportive policies are essential. With targeted pilot projects and integration into local climate strategies, the IAC model can become a highly supporting tool for accelerating the transition to renewable and just cooling solutions.



# Chapter 4: Good Practice Guide for Renewable Cooling

## 4.1 Introduction

Renewable cooling technologies play a crucial role in achieving the European Union's ambitious climate goals. This chapter provides a comprehensive guide to best practices and recommendations for mainstreaming renewable cooling, drawing upon EU legislation and national guidelines. The analysis includes a review of key aspects of the current European regulatory and policy framework, as well as national legislation and best practices in Spain, France, Italy, Germany, and Romania.

## 4.2 EU Policies on Climate & Energy

The EU has implemented various directives and initiatives to promote renewable energy and energy efficiency, including the Renewable Energy Directive (RED), the Energy Efficiency Directive (EED), and the Energy Performance of Buildings Directive (EPBD).<sup>1</sup> These policies provide a framework for the adoption of renewable cooling technologies, but there are challenges in achieving the ambitious targets set for renewable heating and cooling.



### Renewable Energy Directive (RED)

The RED sets targets for the share of renewable energy in gross final energy consumption, including a binding target of 42.5% renewable energy by 2030. The directive also includes provisions for promoting renewable heating and cooling, such as the requirement for Member States to assess their potential for renewable energy in heating and cooling and to implement measures to promote its use.



### Energy Efficiency Directive (EED)

The EED promotes energy efficiency measures, including in heating and cooling systems. The directive requires Member States to develop national energy efficiency action plans and to implement energy efficiency obligation schemes. The EED also includes provisions for promoting efficient district heating and cooling (DHC) systems and for improving the energy efficiency of data centres.



### Energy Performance of Buildings Directive (EPBD)

The EPBD sets minimum energy performance requirements for buildings, including new and existing buildings. The directive also promotes the use of renewable energy in buildings and requires Member States to develop long-term renovation strategies to decarbonize their building stock.

## 4.3 National Legislation and Best Practices

The analysis of national legislation and best practices in Spain, France, Italy, Germany, and Romania reveals varying levels of support for renewable cooling technologies.

### Spain

Spain has several laws and initiatives that indirectly support the development of renewable cooling technologies, such as the Royal Decree 56/2016 on energy audits and the Long-Term Strategy for the Energy Rehabilitation of Buildings (ERESEE). However, there is no comprehensive national regulation focused exclusively on heating and cooling.

### France

France has implemented the RE2020 environmental regulation, which aims to improve the energy performance of new buildings and reduce their carbon footprint. The regulation includes a new indicator, the "degree-hour," which measures the cumulative time during which building occupants are exposed to temperatures above a predefined comfort threshold. This indicator encourages the design of buildings that are more comfortable during the summer months and promotes the use of renewable cooling technologies.

### Italy

Italy has the DM 26/6/15 "Minimum Energy Performance Requirements," which sets minimum energy performance requirements for buildings, including cooling systems. The legislation promotes the use of high-efficiency cooling technologies, the integration of renewable energy sources, and passive design and natural cooling strategies.

### Germany

Germany has a comprehensive legislative framework for promoting renewable energy and energy efficiency, including the Renewable Energy Sources Act (EEG), the Energy Efficiency Act (EEffG), and the Building Energy Act (GEG). These laws encourage the adoption of



renewable cooling technologies, such as solar thermal and geothermal systems, and promote the use of waste heat and renewable energy in cooling systems.

### Romania

Romania has several programs and initiatives that indirectly encourage energy efficiency and sustainability, which may include cooling systems. However, renewable cooling systems are not widely promoted or supported through specific legislative measures.

## 4.4 Best Practice Examples

The COOLING DOWN project includes several best practice examples that demonstrate the successful implementation of renewable cooling technologies in different contexts.

### District Heating and Cooling (DHC) System in Mieres, Spain

The DHC system in Mieres, Spain, utilizes geothermal energy from mine water to provide heating and cooling to various buildings, including a hospital, a university campus, and residential buildings. This project demonstrates the potential of geothermal energy to provide sustainable and efficient heating and cooling solutions, even in areas with limited access to traditional renewable energy sources.



*Figure 4: Geothermal District Heating and Cooling in Mieres, Spain*

### Renewable Cooling in the Euronext Data Centre in Bergamo, Italy

The Euronext data centre in Bergamo, Italy, utilizes geothermal energy and dynamic free cooling to meet its significant cooling demands. This project showcases the feasibility of renewable cooling technologies in meeting the high cooling requirements of data centres, reducing energy consumption and emissions.



*Figure 5: Euronex Data Centre in Bergamo, Italy*

## 4.5 Recommendations

Based on the analysis of EU policies, national legislation, and best practice examples, the COOLING DOWN project proposes several recommendations for mainstreaming renewable cooling.

### Policy Recommendations

- Strengthen EU targets and policies for renewable heating and cooling.
- Promote the integration of renewable cooling technologies into the broader energy system.
- Encourage the development and implementation of national and local policies that support renewable cooling.
- Provide financial incentives and support mechanisms for the adoption of renewable cooling technologies.
- Raise awareness among stakeholders and the public about the benefits of renewable cooling.

### Technical Recommendations

- Promote the use of high-efficiency cooling technologies and the integration of renewable energy sources.
- Encourage the adoption of passive cooling strategies and building design optimization.
- Support the development and implementation of DHC systems that utilize renewable energy sources.
- Promote the use of renewable cooling technologies in data centres and other energy-intensive applications.

#### 4.5.1 Recommended Measures for the Integration of Renewable Cooling in SECAPs

In a Sustainable Energy and Climate Action Plan (SECAP), various recommendations can be incorporated that directly or indirectly impact the efficiency of renewable cooling systems. Incorporating measures that enhance the efficiency of climate control systems (heating and cooling) in a SECAP is fundamental for reducing greenhouse gas emissions and energy costs, as these systems represent a significant portion of energy expenditure in buildings.

These measures can be technical, regulatory, educational, or adaptive and should be approached from the perspective of building efficiency and urban planning. By applying these strategies, municipalities can make significant progress in the transition toward more sustainable and resilient cities in the face of climate change.

Outlined below are several categories of recommendations that can be included in a SECAP:

**1. Building Efficiency for Climate Control** Efficient climate control depends largely on the overall building efficiency, as energy losses can significantly increase heating or cooling demands. Some of the most important measures include:

- Improving insulation of facades, roofs, and floors can reduce heat loss in winter and keep interiors cool in summer, thus reducing the workload on climate control systems.
- Installing double or triple glazed windows with thermal breaks and using efficient doors and frames to minimize air leakage.
- Promoting the construction of new buildings under efficiency standards like Passivhaus, which minimize energy demands for climate control.

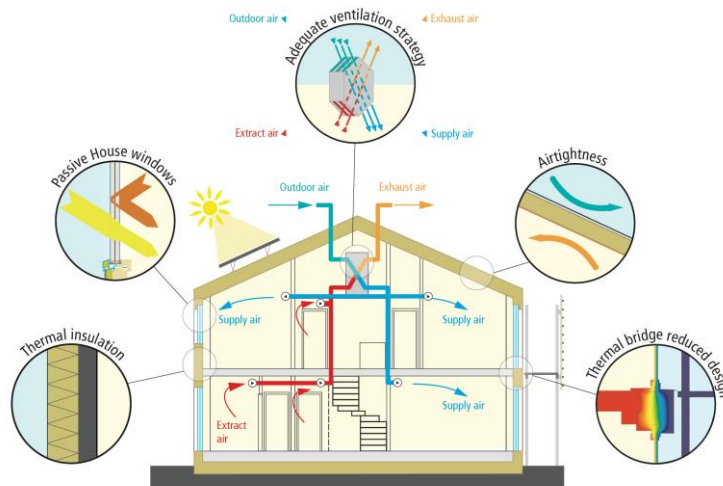


Figure 6: Passivhaus energy efficiency standards. Source:

**2. Modernization and Improvement of Climate Control Systems** Measures that directly address the modernization and improvement of climate control systems are crucial for enhancing their efficiency. These include:

- Encouraging the installation of heat pumps for both heating and cooling, which are much more efficient compared to traditional fossil fuel systems.
- Replacing old boilers with natural gas condensing boilers, which are more efficient in utilizing heat.
- Installing centralized climate control systems in buildings or neighbourhoods (District Heating/Cooling) with optimized temperature control and heat recovery.
- Using solar energy for hot water production and heating.
- Utilizing geothermal systems that leverage the stable thermal properties of the subsurface for climate control, thereby reducing energy demand.

**3. Automation and Intelligent Control** Automation technologies can significantly improve the efficiency of climate control systems by adapting them more precisely to actual needs.

- Automatic control systems and smart thermostats that adjust climate control based on building occupancy, weather conditions, and specific energy needs.
- Implementing Building Energy Management Systems (BEMS) to optimize energy usage, control climate equipment, and adjust energy consumption in real-time.
- Using sensors and monitoring systems for the energy consumption of climate control systems to detect inefficiencies and adjust usage.

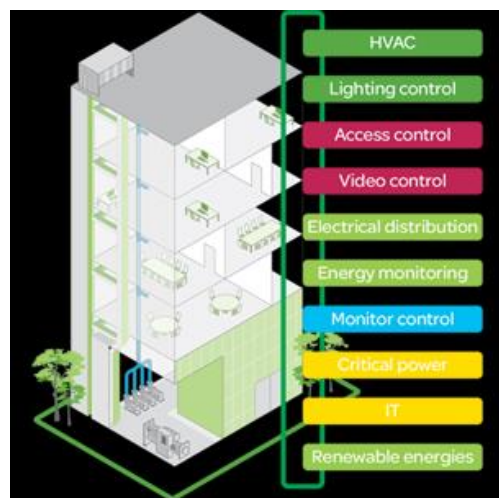


Figure 7: Building Energy Management Systems (BEMS). Source:

**4. Incentivizing Renewal of Old Equipment** Encouraging the replacement of old appliances with more efficient ones is key to improving climate control efficiency. Citizens should be incentivized to replace obsolete climate control devices with those that have a higher energy rating (A+++, A++).

**5. Reducing the Need for Mechanical Climate Control Through Architectural and Urban Strategies** Another effective measure to improve efficiency is reducing the need for mechanical climate control.

- Implementing architectural designs that allow natural ventilation during the summer to reduce the need for air conditioning.
- Promoting the use of awnings, pergolas, vegetation, and other solutions to reduce solar radiation exposure during hot periods, thereby decreasing cooling needs.
- Encouraging the installation of green roofs or wall vegetation to enhance insulation and thermal efficiency.



Figure 8: Example of green roofs. Source:

**6. Promoting Urban Climate Networks and Energy Districts** Creating urban climate networks and energy districts can provide a more efficient solution for climate control across multiple buildings.

- Implementing district heating systems that use renewable energies or low emission energy sources like biomass, geothermal, or waste heat from industrial processes.
- In warmer areas, creating district cooling systems that optimize efficiency at scale and reduce the use of individual air conditioning units.

**7. Education and Awareness for Efficient Climate Control** Beyond technical measures, it is essential to raise awareness among citizens and users of municipal facilities about the efficient use of climate control systems.

- Launching awareness campaigns to promote rational use of climate control systems, establishing appropriate temperature settings (avoiding excessive heating in winter and cooling in summer).
- Providing training to municipal technicians, building maintenance personnel, and users on efficiently managing climate control systems.

**8. Adaptation Measures in Response to Increasing Cooling Demand Due to Climate Change** Climate change is increasing the frequency of extreme weather events, such as heatwaves, which in turn increase cooling demands. Incorporating climate adaptation measures in SECAPs is crucial to improve climate control efficiency.

- Promoting the creation of green areas, parks, and shaded areas in cities to reduce urban heat islands that increase temperature and air conditioning demand.
- Developing plans to efficiently manage cooling demand during heatwaves, minimising excessive air conditioner use and ensuring the protection of vulnerable populations.

## Chapter 5: Conclusions

The findings of the LIFE project Cooling Down underscore the pivotal role that macro-scale energy system modelling and renewable cooling technologies can play in addressing the growing challenges associated with increasing cooling demand across Europe.

The sensitivity analysis conducted highlights the complex interplay between cooling demand, energy supply, and greenhouse gas emissions, revealing that tailored, high-resolution energy modelling is indispensable for formulating effective climate and energy policies. By leveraging advanced tools such as UrbanHeatPro, pyGreta, and urbs, the Cooling Down project produced invaluable insights into optimizing energy systems for renewable cooling, emphasizing the importance of integrating energy sources like solar, wind, and geothermal into the energy mix.

Furthermore, the economic and technical assessments of renewable cooling technologies, specifically geothermal and solar cooling, demonstrate their significant potential to mitigate environmental and health-related externalities associated with conventional cooling systems. While these technologies may present higher initial costs, their long-term operational benefits—coupled with the ability to reduce greenhouse gas emissions and enhance urban thermal comfort—make them a compelling alternative to traditional cooling methods.

The integration of these systems not only promises substantial reductions in energy consumption but also contributes to healthier living environments and improved productivity, aligning with broader sustainability and climate adaptation goals.

As the demand for cooling solutions continues to rise, the transition toward renewable and energy-efficient cooling technologies will be essential in meeting Europe's energy and climate targets. The technical and policy recommendations outlined in this report, driven by data-informed insights, serve as a foundation for future policy development and investment in innovative energy solutions.



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