D4.3. Recommendations for enhanced and integrated strategies, policies and schemes relevant for space cooling

Cool LIFE

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List of Acronyms

CAs	Comprehensive Assessments
CBA	Cost-Benefit Analysis
EBC	Energy in Buildings and Communities Programme
EED	Energy Efficiency Directive
EPBD	Energy Performance of Buildings Directive
ESPR	Ecodesign for Sustainable Products Regulation
IEA	International Energy Agency
LTRS	Long-Term Renovation Strategies
MS	Member State
NAS	National Adaptation Strategies
NAP	National Adaptation Plans
NECP	National Energy and Climate Plans
RED	Renewable Energy Directive

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Keywords list

- Space cooling policies
- Comprehensive assessment on heating and cooling
- Building regulations
- Building renovation
- Ecodesign Directive
- Policy recommendations

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Executive summary

This report aims at summarizing the main lessons learned along the CoolLIFE project about the context and policies relevant to space cooling, and at suggesting recommendations for further developments to promote sustainable solutions in an integrated way. These recommendations build on all the previous work in the project, including literature reviews, syntheses and assessments about space cooling technologies and measures, thermal comfort, behavioural interventions, energy demand for space cooling, effectiveness and impacts of measures, EU policy framework, Member States' policies and financing schemes relevant to space cooling. They are also based on discussions with experts during the national workshops done in Italy, Greece (April 2025) and France (July 2025), lessons learnt from analysing a selection of national schemes and experiences, and conclusions and recommendations from other European or international projects.

For each category of recommendations, their presentation starts with summarizing key issues identified and lessons gathered during the project, before describing the suggested recommendations to further disseminate or complement good practices. Overall structure of the suggested recommendations:

Main category	Axis
Starting from the needs, anticipating changes	Starting from the building occupants – citizen
	What solutions for what conditions: considering operating limits and risks
	Linking mitigation and adaptation
	Planning to avoid ineffective and expensive actions in a hurry
	Sustainable space cooling for all: addressing summer energy poverty
A multilevel approach to provide whole-year comfort in a sustainable way	Towards efficient and climate-resilient buildings
	Promoting broader markets of sustainable space cooling solutions linked to adaptation and resilience strategies
	Ensuring an effective enforcement of regulations applicable to cooling systems, from design to disposal
Considering space cooling in the overall energy and climate framework	Assessing the main issues raised by space cooling in the country
	Coordinating the way space cooling is addressed in national planning
	Providing support for local authorities to develop solutions relevant to their territories

Improving the way space cooling is addressed in the comprehensive assessments	Overcoming the data issue
	Using sensitivity analysis to anticipate upcoming challenges
	What the Energy Efficiency First principle means for comprehensive assessments: considering a broader scope of options
	Discussing the coordination between the national and local level

1. Introduction

1.1. Increasing importance of space cooling while still hidden behind space heating in the heating and cooling policy framework

The European Environment Agency (Quefelec 2023) stressed that final energy consumption for space cooling in residential buildings tripled between 2010 and 2019 in the 19 euro-area countries (based Eurostat data), while households' equipment rate in air conditioning in Europe rose from 14% in 2010 to about 20% in 2019 (based on ODYSSEE data). This shows a **strong increasing trend**.

Cooling was previously estimated to account for around 4% of EU final energy consumption in 2016, with 106 TWh/year for space cooling (i.e. 1.9% of EU final energy consumption) and about 110 TWh/year for process cooling complemented by 0.6 TWh/year for district cooling (Gerard et al. 2021). As space cooling is mostly generated from electricity, its share is primary energy consumption is larger. But it remains **much less than space heating** in most Member States. This explains the focus on space heating in most policies dealing with energy consumption in buildings.

Giussani et al. (2024) provides a complementary assessment of the useful energy demand[1] for space cooling in buildings as of 2021, showing that (1) **tertiary buildings** would represent **about 78% of the useful energy demand** for space cooling in EU27. And that **four countries** would represent **79% of the useful energy demand** for space cooling in EU27 (Spain: 33.4%; Italy: 24.1%; France: 15.8%; Greece: 5.7%). Moreover, some countries may represent a small share of energy demand in EU27 due to their size, whereas space cooling represents a significant share of their useful energy demand and final energy consumption (e.g. Cyprus and Malta). This explains why space cooling is addressed to **various extents among Member States**. This not only reflects differences in needs for space cooling (e.g. in terms of cooling degree days), but also in terms of equipment rates. Giussani et al. also highlights difficulties encountered when assessing energy demand for space cooling, especially in terms of **data availability**. Complementary assessments at national level are thus useful to improve the evidence base for policymaking.

More frequent and intense heat waves accelerate the trend towards increasing energy demand for space cooling, and contribute to **peak loads** in summertime, and even power cuts such as in Italy in summer 2023. Likewise, warmer summers and heat waves represent a **major risk for health**, with over 70,000 excess deaths in Europe in 2003, and more than 60,000 in 2022 (Ballester et al. 2023). Heatwaves would cause about 90% of fatalities related to climate-related extreme events (Quefelec 2023). Summer comfort is thus a **major challenge for both mitigation and adaptation policies**.

[1] Useful energy demand for space cooling represents the net heat extracted from the space area that is cooled. This is different from the final energy consumption that represents the energy input to the cooling generators. The conversion factor between useful energy demand and final energy consumption depends on the cooling technology. Most space cooling is delivered by electrically driven cooling equipment that have an energy efficiency ratio greater than 1. Therefore, final energy consumption for space cooling is significantly lower than its useful energy demand.

1.2. CoolLIFE objectives and scope

The CoolLIFE project (November 2022-October 2025) aims to address the need for sustainable solutions to the EU's rising demand for space cooling in buildings. The main objectives of the project are to:

- Develop an open-source tool for mapping and simulating space cooling demand at multiple spatial scales and time horizons.
- Create a publicly accessible knowledge repository on space cooling technologies, user practices, policies, and financing mechanisms.
- Promote passive and nature-based space cooling solutions through scenario modelling and policy recommendations.
- Engage stakeholders involved in the planning, design and implementation of sustainable solutions for space cooling, and related policies.

This report aims at summarizing the main lessons learned about the context and policies relevant to space cooling, and at suggesting recommendations for further developments to promote sustainable solutions in an integrated way.

It is primarily meant for policy makers, officers and analysts, as well as experts and researchers dealing with space cooling and related policies and regulations. Especially these involved in the preparation of National Energy and Climate Plans, comprehensive assessments on heating and cooling, building regulations and national building renovation plans (formerly long-term renovation strategies). But more generally, it can of interest for any stakeholder involved or interested in the field of sustainable solutions for space cooling.

1.3. Main conclusions from the policy review

Two previous reports reviewed the current EU policy framework and national policies relevant to sustainable space cooling (Broc et al. 2024), and available financing schemes (Conforto 2024). This section summarises the main conclusions from both reports.

The EU framework covers the **dominant space cooling technologies** (vapour compression systems) with regulations to remove the least efficient devices from the market, inform consumers about the efficiency and consumption of the devices, and plan the phase out from fluorinated gases (due to their very high GWP). Updates of these regulations should soon be adopted to strengthen the requirements and stimulate the developments of more efficient and climate-friendly alternatives. However, the review of space cooling technologies done in CoolLIFE (Duplessis et al. 2024) showed that these alternatives are rarely ready to be massively deployed. Policy measures to complement the regulations may therefore be needed.

At **building level**, while space cooling is assumed to be included in the energy performance calculations and requirements due to the EPBD (Energy Performance of Buildings Directive), the way it is addressed in national building regulations may vary among countries. The EPBD recast adopted in 2024 emphasises the need to consider summer comfort. Its transposition could be an opportunity to enhance the requirements to minimise cooling needs in new buildings, and to ensure that major renovations do not worsen the conditions for summer comfort. The development of climate-resilient building regulations could help to address these issues.

At **urban level**, the EED (Energy Efficiency Directive) promotes the development of district cooling which remains rare so far. Going beyond the building level is also relevant to address urban heat islands, and more generally to adapt urban planning and make use of nature-based solutions. Ensuring summer comfort and other cooling needs in a sustainable way indeed implies the consideration of current and future changes in local climate conditions, and therefore an integrated approach from both the mitigation and adaptation sides. This should start with minimising cooling needs through urban planning and building design or renovation, and enabling occupants to meet their comfort expectations in simple and efficient ways.

Relevant **financing schemes** include various types of incentives for building refurbishment, promotion of renewable energy technologies, and assistance for vulnerable households. The mapping of financing schemes identified the following issues or needs in this field:

- Clarifying the scope of solutions and approaches for sustainable space cooling.
- Analysing how financing schemes can be designed or adapted, considering the differences in needs according to the segments of the building stock and the profiles of building owners or occupants.
- Defining criteria or requirements to ensure that renovation schemes are also relevant to space cooling/summer comfort.
- Considering multiple impacts (e.g. health, peak load, productivity) can be strategic reasons for motivating investments in solutions for sustainable space cooling, with a higher weight on decision-making than energy costs alone.
- Analysing the interactions and possible linkages between mitigation and adaptation measures, and how integrated approaches can be developed.

In the EU framework, the main requirements applicable to space cooling have mostly been focused on cooling devices, district cooling and developing the share of RES in heating and cooling. This **technical focus** did not favour the development of integrated approaches. The changes from the fit-for-55 package may improve this, for example with the EPBD recast emphasising more the importance of summer comfort, and the EED recast introducing an official EU definition of energy poverty, clarifying that adequate cooling is part of the basic levels and decent standards of living and health.

The shift in the governance at EU level to an integrated reporting of all the dimensions of the Energy Union means that the main national planning document reported in the EU context (NECP – National Energy and Climate Plans) does not enter into the details of each and every topic, and particularly of topics such as space cooling that, despite its growth, represents a small share of most Member States' final energy consumption, and is already almost fully electrified (so not a major direct challenge for decarbonisation, apart from that of electricity production itself). Still, space cooling is already an important issue for security of electricity supply in a few countries (e.g. Greece, Italy and Spain) already facing significant increases in summer peak loads. National adaptation strategies and plans also often raise increasing summer temperatures and heat waves as major changes to anticipate, emphasising the impacts on health as well as economic activity (e.g. tourism). The analysis of the EU framework showed that space cooling is a topic that illustrates well the need to consider **more integrated approaches**, beyond siloed technical solutions, and addressing jointly mitigation and adaptation.

1.4. Methodology for preparing the recommendations

The recommendations are one of the final results of the CoolLIFE project. They build on all the previous work, including:

- The literature review and taxonomy of space cooling technologies and measures (Duplessis et al. 2023)

- The literature review and survey about thermal comfort and occupant-centric space cooling (Hurtado-Verazaín et al. 2023*)*
- The literature review and analysis of behavioral interventions (Gelesz et al. 2023)
- The assessment of energy demand for space cooling in European countries (Giussani et al. 2024)
- The assessment of the effectiveness of measures to reduce energy consumption and GHG-emissions for meeting cooling needs (Malla et al. 2024)
- The assessment of multiple, socioeconomic impacts of sustainable space cooling (Gelesz et al. 2024)
- The review of the EU policy framework and Member States' policies relevant to space cooling (Broc et al. 2024)
- The review of financing schemes relevant to space cooling, at the EU and national levels (Conforto 2024)

The recommendations are also based on:

- discussions with experts during the national workshops done in Italy, Greece (April 2025) and France (July 2025) (see minutes in the Annexes)
- lessons learnt from analysing a selection of national schemes and experiences (see good practices factsheets in the Annexes)
- conclusions and recommendations from sister LIFE projects also dealing with space cooling, notably CoolToRise (about summer energy poverty) and CoolingDown (about RES for cooling).

The presentation of the recommendations in the following sections reflects the process starting from the knowledge gained along the project:

1. **The issue(s)**: based on the literature and exchanges with stakeholders and experts, we identify key problems, questions or challenges that should be address when developing a strategy and policies for sustainable space cooling.

2. **Lessons learned / knowledge available**: based on the literature, and experience with existing policies or schemes (e.g. from the good practices factsheets), a short summary about key points highlighted by experts and that can guide stakeholders' practices and policy design.

3. **Possible ways forward / recommendations**: our suggestions about how the experience and knowledge available could be used to enhance practices and policies.

2. Starting from the needs, anticipating changes

Space cooling or maintaining the indoor temperature within certain boundaries is not an objective in itself. It is a means to meet needs, for example in terms of health or working conditions and comfort for building occupants. Strategies for sustainable space cooling and related standards should be based on a **detailed analysis of the needs**, considering the multiple factors that can influence thermal comfort and differences among individuals.

This should also consider **how the needs can be affected by future changes**, notably climate changes. Investments made today in technical systems (e.g. air conditioning systems) have a lifetime until 2040 or beyond. Investments in new buildings or retrofitting of existing building envelopes set the features of these buildings until 2050, and very likely beyond. Anticipating upcoming climate conditions is thus essential.

This chapter deals with the **upstream part of policies and strategies**, looking at how recent developments in research and experience from stakeholders could inform policymaking at design and planning stages.

The suggested recommendations are therefore focused on **transferring these inputs to the policymaking process**, as well as **fostering knowledge sharing** between researchers, policymakers, building professionals and citizen.

We structured these recommendations according to key issues identified from the literature and stakeholders' experience:

- The need to switch from a techno/building-centric approach to an **occupant-centric** approach (section 2.1)
- The concepts of **operating limits and risks** to guide the selection of the most suitable solutions in the context of climate change (section 2.2)
- The **strong interactions between mitigation and adaptation** when dealing with space cooling and resilience to extreme heat events (section 2.3)
- The need for planning and **considering different timescales**, despite cooling needs surging only on short periods, compared to heating season (section 2.4)
- The need of **specific support for the most vulnerable persons** who are usually the most impacted by summer discomfort and heat-related health risks (section 2.5)

2.1. Starting from the building occupants – citizen

The issue(s):

Key points raised in (Lizana et al. 2022):

- Until the invention of vapour-compression refrigeration in the early XXth century, human beings have developed various solutions and practices (behaviours, architectural design, choice of materials, etc.) to adapt to hot weather conditions.

- The development of air-conditioning systems went together with increasingly considering buildings a purely technical system, to be optimised according to technical criteria (i.e. setpoint temperature), independently of the differences in the needs of building occupants or users. This resulted in the dominance of building-centric instead of occupant-centric approach of meeting cooling needs.
- This is one of the reasons why policies and strategies for space cooling tend to be too focused on cooling technologies, overlooking solutions to avoid, or at least minimize, cooling needs while ensuring summer comfort.
- More generally, energy efficiency policies have been focused on energy performance requirements mostly related to technical features of buildings (see e.g. building codes or Energy Performance Certificates) or equipment (see e.g. energy labelling or ecodesign regulations).

Lessons learned / knowledge available:

Findings from the **literature review done in CoolLIFE** (Hurtado-Verazaín et al. 2023):

- The standardized approach towards thermal comfort has been first developed based on the psychrometry chart, that was meant for determining the physical states of the air within air-conditioned areas. The current standard indices for determining satisfaction with the indoor thermal environments are similar all around the globe and have been developed based on Fanger's model from the 1970's.
- This standard methodology meant for air-conditioned areas considers the following factors: air temperature, mean radiant temperature, humidity, air velocity, clothing insulation, and metabolic rate. The standards also incorporate methods for assessing the effect of increased air velocity, which represent the use of fans.
- In practice, air-conditioning might still be designed and operated considering mostly temperature rather than other thermal comfort parameters. Reciprocally, the development in the use of air conditioning systems reinforces temperature as the main comfort criteria.
- For space without air conditioning, standards include adaptive thermal comfort calculation methods based on the outdoor running mean temperatures. However, the adaptation of comfort criteria to different groups or locations is missing.
- Information on space cooling preferred setpoints for residential buildings is very limited as opposed to literature regarding heating setpoints or space cooling in commercial buildings.
- Occupant's behaviour in using active space cooling is different than what is seen for heating: preferred summer temperatures cannot be taken as realistic setpoints, and are heterogenous.
- Likewise, limited information is available on to what extend and how active space cooling devices are used to reach this targeted value.
- A number of simplifications in the standard methodologies cannot address the complexity of the thermal sensation of each individual, and can have limitations regarding space types in their application.
- Thermal comfort is indeed first and foremost a socially constructed phenomenon, with a dynamically evolving nature as a function of time, space, and context.
- Dynamic feedback loop between space cooling expectations and space cooling infrastructure: the higher the equipment rate of air conditioning systems, the more expectation of lower optimal indoor temperature during summer, which in turn feeds back into the deployment and availability of space cooling technologies.
- At the opposite, persons living in warmer regions tend to feel comfortable in warmer indoor environments.

- A failure to properly specify the parameters of the feedback loop between thermal comfort and air conditioning availability might severely mislead predictions of future space cooling demand.
- People's perception of thermal comfort depends on both internal and external factors.
- Internal factors include inherent physiological variables (such as gender, age, metabolism, among others), psychological experiences (personal relations, perception of control), behavioral variables (level of activity, clothing), or personal preferences.
- External factors include the surrounding physical environment (design, materials, colors, textures) and the heavy influence of society and culture in behaviors and choices (e.g. social norms). Contextual determinants of thermal comfort for example include the financial incentives and the social environment when one decides on their clothing choices, activity levels, and social behaviors.
- Considering these factors is fundamental to a relevant design and operation of buildings and their technical systems. For example, a perfectly calibrated building model designed for Scandinavian citizens might have limited applicability for a Mediterranean market.
- The current meaning of summer thermal comfort is strongly associated with the use of air conditioning from building occupants' perspective. But this is not set in stone: it has evolved throughout time and could keep evolving, in order to support the adaptation capacities of individuals. Therefore, the design of solutions to reduce space cooling demand should be greatly informed by the social, physiological, spatial, and cultural dimensions of thermal comfort.
- Studies have highlighted the lack of adaptive environments with operable windows, movable shadings, integrated fans or personalised cooling alternatives, partially because of cultural and building-centric frameworks focused on centralised indoor temperature control.
- Taking a socially constructed view of human behaviour in the context of space cooling opens up a lot of possibilities for meetings occupants' needs in a sustainable way, including how energy demand can be reduced given the right changes in the social environment where individuals are embedded.

This last point was also emphasised by Lizana et al. (2022): "*Cooling design combining all comfort parameters through centralised and individualised systems can harness a larger comfort range in which people feel comfortable, downsizing the cooling system capacity and decreasing operating and environmental costs*". They illustrated this with the example of introducing air velocity to increase the upper threshold at which people start feeling discomfort.

Complementary **lessons learned from the examples** of Italy's National Adaptation Plan (PNACC) and Greece's National Heatwave Plan & Athens' Chief Heat Officer (see more details in the annexes):

- Technical measures should go together with practical information or training of occupants. For example, night-time ventilation protocols are as important as physical upgrades. Occupant practices (shading use, night ventilation) are essential.
- Participatory processes involving citizen, stakeholders and experts, are useful to raise awareness, discuss the implications of extreme heat events and solutions to mitigate them. This can increase the legitimacy of the strategies adopted, and the involvement of citizen and stakeholders.
- More generally, two-way communication is essential, to inform citizen and stakeholders about why action is needed, what can be done, and to collect feedback and suggestions from citizen and stakeholders, so that strategies can be tailored to local specificities.

Suggested recommendations:

- **Promoting studies to improve knowledge and data availability about space cooling-related behaviours**

Surveys or field studies about space cooling-related behaviours can bring detailed knowledge and data (see e.g. Hurtado-Verazaín et al. 2023; Durand-Daubin et al. 2024). These results are valuable inputs to identify trends, gaps in the information of building occupants and owners, missing enabling conditions for efficient behaviours, or to compare with assumptions made in standards and models.

They grow the evidence base for specifying standards and designing policies taking into account occupants' needs and practices.

The literature review showed that the number of studies and related data about space cooling-related behaviours in European countries remain limited compared to other similar topics (e.g. space heating-related behaviours). A metareview could identify knowledge and data gaps more in detail, as a basis to prioritize a European programme that could coordinate surveys and studies to fill these gaps.

This programme could either be specific to space cooling & summer comfort, or could look at thermal comfort for the whole year, which could inform more integrated approaches.

- **Facilitating multidisciplinary exchanges and knowledge gathering**

The literature reviews done in CoolLIFE show the diversity of knowledge and experience on space cooling, from various fields and perspectives. Researchers, experts, policymakers and other stakeholders could benefit from opportunities for cross-cutting exchanges and initiatives to gather knowledge and experience, such as the Annex 80 of IEA EBC (Energy in Buildings and Communities) programme.

Such initiatives may already be organised per type of stakeholder (e.g. association of HVAC engineers, network of energy agencies). This could be complemented with opportunities for cross-cutting exchanges among various types of stakeholders (e.g. ad-hoc working groups, dedicated seminars). This would help confront research, policymaking, professional experience and feedback from building owners and occupants.

- **Revising standards in line with current knowledge and allowing adaptation to specificities**

International and national standards (e.g. ASHRAE Standard 55, EN 16798) play a major in the specifications of regulations, reference manuals, and for the professional practices. The process and working groups defining these standards may however be dominated by a limited number of fields of expertise or stakeholder types. A cross-cutting approach could help align the revisions of standards with multidisciplinary knowledge, and experience from technical experts and practitioners, researchers, policy officers and representatives from organisations of owners and tenants.

Ahead of major revision cycles, public bodies could commission studies to update independent state of the art.

More detailed considerations for revising standards related to thermal comfort include:

- Investigating how more factors proven to be important for defining or assessing thermal comfort (e.g. physiological variables, behavioral variables, cultural differences) could be integrated in standards related to thermal comfort.
- Allowing flexibility in international standards for adaptations to national specificities.
- Considering adaptative comfort for air-conditioned areas (not only for areas without air conditioning)
- Considering a broader range of activity type

- **Specifying enabling conditions for efficient and adaptative behaviours**

Building occupants and operators can have a major influence on the effectiveness of the space cooling solutions, and ultimately on the indoor comfort. However, they can adopt efficient and adaptative behaviours only if enabling conditions are met. These conditions are not limited to technical conditions (e.g. possibility to open windows). They may include social norms (e.g. about clothing at work), information and awareness, among others.

Specifying enabling conditions per type of solution could make related information more systematically available to professionals, and thereby to building occupants and owners. Such documentation could be updated regularly, considering the development in space cooling solutions and feedback from their use.

- **Involving citizen and building occupants in the process to define strategies for sustainable space cooling**

Citizen and building occupants know best their needs. When discussing decisions that will impact their living or working conditions, their experience with the building, urban environment, etc. should be considered, for example:

- by architects and building engineers when preparing a construction or renovation project
- by local governments and agencies when preparing a local adaptation plan or projects to improve neighbourhoods
- by national governments and agencies when preparing the national adaptation or heatwave plan, or when revising building regulations or renovation schemes

While obvious, this is not yet a systematic practice. For example, various studies reported cases where building automation and control systems have been designed and implemented according to a theoretical use of the building diverging significantly from the actual practices and expectations of building occupants.

2.2. What solutions for what conditions: considering operating limits and risks

The issue(s):

Key points raised in (Alessandrini et al. 2019) and (Zhang et al. 2021):

- There is a broad range of solutions to improve / maintain summer comfort in buildings. They can be evaluated in many ways, for example considering energy performance, thermal comfort, air quality, capital expenditure and applicability in different climate zones.
- In practice, each solution has operating limits: when certain conditions are exceeded (e.g. max outdoor temperature, humidity rate), they can no longer maintain comfort (or even minimum health requirements). This can be illustrated through the case of ceiling fans and night ventilation that can be very effective solutions until certain temperatures and humidity rates, but are not enough (or are no longer possible) when these conditions are exceeded.
- The risk of operating limits to be exceeded is strongly related to the extreme heat risks (cf. long-duration heatwaves and prevailing warm annual conditions) that are increasing due to climate change.
- This results in higher heat-related health risks, with a situation worsen by ageing populations and increasing share of the population living in dense urban areas.
- Heat-related health risks depend on various factors that can be described with five main categories: environmental factors (e.g., lack of vegetation, urban heat island, building construction quality), socio-demographic factors (e.g., age, gender), health factors (e.g., obesity, pre-existing diseases), social factors (e.g., poverty and social isolation), and behavioural factors (e.g., inadequate clothing, reduced mobility)
- Cooling strategies that work well today might not remain effective under long-term climate change, or in extreme events such as a heatwave or power failure.

Lessons learned / knowledge available:

From the literature:

- The efficiency of passive measures to refresh dwellings depends strongly on the local climate, building characteristics (e.g. dynamic thermal response to indoor and outdoor stresses) and occupant behaviour. This means that there cannot be a generic answer about the ability of a system to avoid heat-related health risks. (Alessandrini et al. 2019)
- A gap is observed in temperature ranges between the legitimate domain of thermal comfort ("moderate thermal environment") set in the ISO 7730 standard, and the thresholds about "heat stress" proposed in the ISO 7243 standard. This gap can be explained by the discrepancies between the standard experimental conditions used for the assessments. Further investigation is required to better identify the threshold values between thermal comfort and heat-related health risks. (Alessandrini et al. 2019).
- Using typical weather or historical weather files for the assessment of cooling demand and effectiveness of cooling strategies can create a bias for building design, or selection of options for building retrofits or technical systems of buildings. While future typical weather files are widespread, methodologies to reproduce future extreme conditions and consider climate uncertainties are scarcer, partly due to the lack of data accessibility. (Machard et al. 2020). The IEA EBC Annex 80 "Resilient Cooling for Buildings" developed datasets of current

and future projected weather files for building simulations in 15 major cities distributed across 10 climate zones worldwide (Machard et al. 2024).

- Combining weather files about typical weather years ad heatwave events enable to assess in a more comprehensive way the resilience of buildings to overheating in future climate conditions. Similarly, sensitivity analysis considering multiple types of future weather files, climate models or scenarios help addressing uncertainties in climate projections. (Machard et al. 2020)
- The assessment of the potential of passive measures is also strongly depending on the assumptions about the occupant scenarios and the hot periods to cope with. Building designers, owners and occupants should therefore be involved in these choices to consider realistic occupant behaviours, and to discuss how occupants can adapt their behaviours during heatwaves. (Alessandrini et al. 2019)
- More generally, resilience capacities of cooling strategies at building level depend on various parameters: the function of cooling strategies (reducing heat gains, removing sensible/latent heat, or enhancing personal comfort), the driven forces (passive or active), design feature, and control and operation of the cooling system. This makes that a single solution will rarely provide all resilience capacities, and that a combination of cooling strategies will be more effective (Zhang et al. 2021)
- Studies already raise the issue that even ambitious adaptation strategies might not be enough to entirely avoid air conditioning during extreme heat events, with different time horizons according to the countries (e.g. by the end of the century in France, according to Viguié et al. 2020). Nevertheless, implementing passive measures and adaptation actions can significantly reduce energy consumption of air conditioning (by 60% in the French case study of Viguié et al.). This also points out that usage efficiency can be the most effective measure, ahead of policies on insulation, reflective materials and urban greening.
- Methods can already be used to assess the resilience of buildings to both, current heat waves and their recurrence in the future under the impact of climate change. Such studies can provide building owners and asset managers with reliable information to assess heat-related health risks for occupants and what actions can mitigate these risks. Assessing the probability of risk occurrence provide a documented basis for a cost-benefit balance and to decide about adaptation pathways. (Roccamena et al. 2024)
- Such methods can help classify buildings into categories, considering the extent to which faultless performance criteria or operating limits are exceeded. This can help prioritize interventions and select relevant solutions. Such assessment should also consider variations according to building occupants, according to their acclimatisation level and their sensitivity to heat. (Roccamena et al. 2024)
- These issues are no longer limited to Southern Europe. Research showed that while new buildings in Finland should cope with future climate conditions, this is already no longer the case for part of the existing buildings. Passive solutions could effectively reduce their indoor temperatures during typical summers, but active cooling systems would likely be needed during hot summers (Velashjerdi Farahani et al. 2024).

Complementary **lessons learned from the examples** of Italy's National Adaptation Plan (PNACC) and Hambourg green roof strategy (see more details in the annexes):

- Italy's National Adaptation Plan (PNACC) encourages municipalities to contribute to monitoring campaigns of indoor temperature (with low-cost dataloggers in a sample of dwellings to build an evidence base) and report to the National Adaptation Observatory.
- Italian pilots part of the PNACC reported 2–4 °C drop during 2023 heat-wave events in retrofitted flats, that passive cooling measures can lower annual cooling electricity by up to 50 % when insulation and shading

are combined, and that 84 % of surveyed households reported “notable improvement” in summer comfort after installing shutters and practicing night ventilation.

- Design responses differ according to local climate and building types. Guidance must be both archetype-based and location-specific. Harmonised taxonomies and open archetype libraries can help streamline modelling and evaluation.
- In the meantime, “rule-of-thumbs” communication as a first layer of advice for households (e.g., external shade before noon, night ventilation after 22:00, fans to extend comfort by about 2–3 °C operative temperature) can be co-designed with behavioural experts and help for short-term impacts.
- Downscaling future climate projections to building-level metrics (e.g., hours above comfort thresholds) is non-trivial. Staged pilots across climate archetypes with randomised inspections can help calibrate thresholds, costs, and user guidance before national roll-out
- Acoustic and security requirements may limit night-time ventilation in urban areas.
- Local programmes can be opportunities for experimenting innovative solutions and design in real conditions, as part of scientific research, then providing science-based evidence to improve and promote these solutions.
- Monitoring real buildings through low-cost temperature loggers and short post-occupancy surveys can be key to iterative improvements.
- Evidence-based standardisation is pivotal: pattern books with replicable details (e.g. over-window awnings, shutters) and minimum performance descriptors (e.g. solar-factor ranges, ventilation rates) reduce design and permitting frictions.

Suggested recommendations:

- **Linking implementation, monitoring and research to grow science-based evidence**

Actual impacts of space cooling solutions are still a field of investigation. Programmes promoting these solutions can provide samples of real cases for monitoring their impacts as part of scientific research. The resulting science-based evidence can guide further revisions of the programme, and provide sound information to professionals, building occupants and owners.

Monitored data (e.g. measurements, surveys) can be used to verify the relevance of underlying assumptions used in model-based assessments (e.g. assumed range of operating conditions).

- **Maintaining future weather files including typical weather years ad heatwave events**

Anticipating the impacts of climate change on cooling needs is essential. The knowledge in this field is evolving rapidly. Maintaining official future weather files at national level can help disseminate and harmonize the practices, taking into account the different climate zones in the country.

These weather files should consider both, future typical weather years and expected heatwave events, to provide key input data for heat-resilience assessments.

- **Providing methodologies to streamline sensitivity analysis**

Climate projections include significant uncertainties, especially when considering long-term horizon in line with the expected lifetime of buildings. This calls for sensitivity analysis that can help assess the risks related to these uncertainties, and these risks are mitigated depending on the mix of solutions implemented.

However, sensitivity analysis might be complex to implement and to interpret. Providing methodologies and guidelines could help a more systematic and comparable practice.

- **Promoting heat-resilience assessments to anticipate overheating risks and prioritize asset managers' actions**

Heat-resilience assessments can help asset managers anticipate overheating risks in their building stock, categorize the buildings according to their level of risks, and prioritize their actions and investments accordingly.

Such assessment can be specific, or part of a broader resilience or adaptation assessment, in line with the approach promoted by national or local adaptation plans.

- **Categorizing typical situations, operating limits and mix of solutions**

A simplified approach can be developed to assess the national, regional or local building stock. This can be useful to inform individual building owners or to guide the design of policies to promote packages of solutions per type of building, for example. This can also provide a benchmark for more detailed assessments.

Identifying relevant mix of solutions per type of situation can then help verify that these solutions are well covered by regulatory models (e.g. models used to implement building regulations or to prepare Energy Performance Certificates), to avoid bias in the models that would make that these solutions would be disregarded in practice.

A categorization of typical situations can also be used to assess where and when air conditioning systems may become necessary to mitigate overheating risks.

- **Involving building designers, owners and occupants in the definition of scenarios and analysis of results**

Assessments at building level can be tailored to consider the building's specificities, and should also consider realistic occupant behaviours. Which implies discussions between building designers, owners and occupants, when defining the scenarios to be assessed and when analysing the results.

Guidelines and case studies could help disseminate and harmonize participatory practices.

2.3. Linking mitigation and adaptation

The issue(s):

- Thermal comfort in summer, space cooling and the use of air-conditioning systems are closely related to both, mitigation and adaptation to climate change. Increasing temperatures and heat waves is the main driver for increases in the equipment rate and use of cooling systems, resulting in increases in electricity consumption and in GHG emissions (indirectly from electricity generation, and directly from the leakages of refrigerants). Moreover, an uncontrolled development of air conditioning in urban areas could worsen urban heat islands, which in turn increases the cooling needs (Quefelec 2023).
- Another link is that the fast-growing use of air-conditioning systems combined with more frequent, intense and longer heatwaves increases the pressure on the electricity system (cf. summer peak loads). Which may result in power outages, thereby stopping air-conditioning systems (if no backup supply) at critical times, with possible serious implications up to increased morbidity and mortality. (Baniassadi and Sailor 2018)
- Strategies for energy efficiency in buildings are not always consistent with cooling strategies, notably about improving resilience to extreme heat: there can be a trade-off between both objectives. Notably because energy efficiency strategies might be focused on reducing space heating consumption during winter. Whereas high insulation, air-tightness and radiation loads (e.g. due to large south facing windows) can have adverse effects for summer comfort (Baniassadi and Sailor 2018).
- Energy efficiency measures and strategies for housing and services rarely consider actions beyond the building level, apart from district heating and cooling. Adaptation strategies usually cover better the local / urban level (e.g. to address urban heat island effects), with a major role devolved to local authorities.
- Different administrations or agencies, or different units with the same institution, may be in charge of energy efficiency measures and adaptation measures respectively. This can be seen in the planning, implementation and reporting of both groups of policies, and may result in inconsistencies or lost opportunities of synergies.

Lessons learned / knowledge available:

- At building level, the implication of energy efficiency strategies on building resiliency to heat depends strongly on building characteristics and underlying climate. For example, increasing the insulation and airtightness were found to be beneficial to passive survivability in warmer climate, unlike similar studies in colder climate. (Baniassadi and Sailor 2018).
- Definitions of thermal resiliency metrics can have a major influence on the interpretation of the results of simulations (Baniassadi and Sailor 2018).
- At urban level, recent developments in Urban Building Energy Modelling (UBEM) can contribute to assess indoor overheating risks in urban settings (e.g. due to urban heat islands). UBEM was primarily focused on energy simulation rather than indoor thermal comfort, and was often using a generic approach, modelling a limited set of archetype buildings. These simplifications can result in suboptimal climate adaptation and mitigation strategies. However, UBEM is increasingly incorporating microclimate data and climate change scenarios, also considering new thermal comfort metrics in line with addressing climate change, among other developments. Still, further endeavours are needed so that enhanced assessments of urban-level indoor overheating can support better-informed urban planning and building design strategies, to provide resilience against overheating (Morales et al. 2025).

- At national level, while most National Energy and Climate Plans and comprehensive assessments on heating and cooling include limited information about adaptation measures, the National Adaptation Plans or Strategies increasingly make the link between mitigation and adaptation measures, when dealing with buildings or addressing extreme heat events.
- National Adaptation Plans and Strategies and National Heatwave Plans (e.g. in France and Greece) may then be the drivers for more integrated strategies for sustainable space cooling.

Suggested recommendations:

- **Mapping possible synergies and adverse effects of mitigation and adaptation measures**

Research and experience gains from pilots or local schemes document risks of adverse effects (e.g. maladaptation) and benefits that mitigation measures can have for adaptation purposes, and reciprocally.

A systematic mapping could help update guidelines for integrated approaches, that can be prepared for building design, building renovation and urban planning.

- **Ensuring consistency among mitigation and adaptation policies**

The preparation and validation process of new policies or revisions of policies should include a consistency check to avoid inconsistencies in the purposes or provisions of mitigation and adaptation policies dealing with the same object (e.g. buildings, urban environment).

This consistency check could build on the mapping of synergies and adverse effects and include coordination between relevant administrations or departments (see also section 4.2).

For example, renovation schemes should be aligned with plans about heat-related health risks. Reciprocally, national adaptation plans should consider passive measures among the actions for climate-resilient buildings (see also section 3.1).

- **Valuing co-benefits through co-funding**

When solutions have well-documented co-benefits, their promotion may be supported from several policies. This could help address funding issues through co-funding or increase outreach through multiple communication channels and messaging.

For example, green roofs and façades can be incentivised through the reduction in wastewater fee splits, as they retain rainwater (see Hambourg Green Roof Strategy in the annexes).

2.4. Planning to avoid ineffective and expensive actions in a hurry

The issue(s):

- When not anticipated, heatwaves can generate severe impacts (e.g., excess deaths, blackouts).
- Many Member States have prepared national heatwave plans or alike to mitigate these impacts, inform citizens and organize the adaptation of public services and economic activities when needed.
- However, not all plans include a more structural approach with actions on medium and long term.
- In the meantime, heatwaves often trigger peaks in sales of air-conditioning devices (Dolques and Dépoues 2024), that might have low efficiency, be installed or used in bad conditions, etc.
- More generally, market trends show significant increases in sales of air-conditioning systems over the years. Whereas passive measures might be disregarded (e.g. due to lack of information).

Lessons learned / knowledge available:

Key results from the assessment done in the CoolLIFE project (Malla et al. 2024):

- Integrating high-efficiency passive measures alongside technological advancements could significantly reduce cooling energy demands in the EU27 by up to 55% by 2030 and almost 80% by 2050 compared to a baseline scenario.
- These strategies are particularly effective in non-residential sectors due to higher baseline energy demands. Moreover, the study highlights the importance of sector-specific approaches, given the varying characteristics and requirements across different regions.
- GDP of the EU27 region could be increased by close to 6 billion euros annually until 2050 in the scenario reducing cooling energy demands compared to the baseline scenario. This can be translated to an additional employment of an average 124 000 to 300 000 full-time employment years in each year at the EU27 level, together with avoiding 36 600 lost working days.
- The environmental implications of unmitigated increases in cooling demand could significantly worsen energy consumption and associated greenhouse gas emissions. Our environmental impact scenarios projected that without substantial efficiency improvements and widespread adoption of passive measures, CO2 and NOx emissions would rise steeply. However, these emissions could be considerably mitigated through the combined application of advanced technological deployments and passive cooling measures. To align with the EU's ambitious net-zero emissions target by 2050, it is imperative to actively enhance the performance and adoption rates of low-emission cooling technologies

Suggested recommendations:

- **Setting clear and measurable targets with regular monitoring**

National and local plans should define clear directions for action and regularly monitor progress. This could avoid episodic policy debates raised by extreme heat events, and decisions based on reactions to emergency situations.

- **Structuring action plans from short-term to long-term**

Policy interventions need to address emergency situations (e.g. in case of extreme heat events) up to long-term impacts of climate change. Action plans should be structured accordingly, considering priorities, time and budget needed for implementation.

- **Providing stability and visibility about funding**

Feedback from almost all renovation schemes or adaptation plans raises the major issue of stability and visibility about funding. This is essential to engage stakeholders in the development of the products and services needed to implement the expected mitigation and adaptation measures. This is also needed for the confidence of building owners and other investors.

2.5. Sustainable space cooling for all: addressing summer energy poverty

Summer energy poverty was not directly in the scope of CoolLIFE. However, this is an important and growing issue. Therefore, we summarize here main conclusions and recommendations from the sister project CoolToRise that was specifically focused on summer energy poverty. More details can be found in (Gayoso Heredia et al., 2023).

The issue(s):

- Energy poverty was officially defined at the European level for the first time in the EED recast (EU)2023/1791 adopted in September 2023, in Article 2(52):
  "*a household's lack of access to essential energy services, where such services provide basic levels and decent standards of living and health, including adequate heating, hot water, cooling, lighting, and energy to power appliances, in the relevant national context, existing national social policy and other relevant national policies, caused by a combination of factors, including at least non-affordability, insufficient disposable income, high energy expenditure and poor energy efficiency of homes*".
- Energy poverty has a multidimensional nature, driven by factors such as low income, low energy efficiency of dwellings, limited availability of energy sources, skyrocketing energy prices, etc.
- While the winter situation is well-documented, obtaining a comprehensive picture for the summer is more challenging.
- The SILC survey done in 2012 found that 19% of Europeans were unable to keep their homes adequately cool in summer (Eurostat data). This figure provides an initial glimpse into the extent of summer energy poverty across the EU. For comparison, the SILC survey done in 2013 found that 11% of the population declared an inability to keep their homes adequately warm.
- These statistics support the hypothesis that more households struggle to maintain comfort in summer compared to winter (Sanz Fernndez et al., 2024).

- While in winter people can use clothes and blankets to reduce their heating needs, passive options are limited during hot summer days, when the occupants cannot invest in or install solutions such as sun shading or ceiling fans, or when the dwelling does not enable efficient practices (e.g., no shutters, or limited possibility for night ventilation). Without air conditioning, people might then be left with either relying on mobile fans or leaving their houses looking for a climate shelter (Sanz Fernandez et al., 2024).
- With growing inequities and more frequent extreme heat events, the current situation is likely even more severe.
- Data for 2022 is available for a few countries only, and some of them indeed show a worsening trend. For example, in Portugal, 38.3% of the population reported living in dwellings that are not adequately cool in the summer, compared to 35.7% in 2012.
- The summer of 2022, marked by record-breaking heat, witnessed over 61,000 deaths across Europe (Ballester et al., 2023). Women were more affected than men, and southern countries such as Italy, Greece, Spain, and Portugal experienced higher heat-related mortality rates.
- Additionally, heat can adversely impact pregnant women, potentially leading to premature births. Vulnerable groups include not only the elderly and individuals with preexisting medical conditions but also children and outdoor workers (Tobìas et al., 2014).

Lessons learned / knowledge available:

- Given that a portion of summer mortality can be linked to the urban heat island (Iungman et al., 2023), addressing this phenomenon should be prioritized as part of adaptation and heat mitigation strategies.
- Five key actions were found when it comes to improving neighbourhoods' adaptation to heat and thus alleviating summer energy poverty (Pérez Rodrìguez et al., 2024):
    - incorporation of vegetation and green spaces,
    - humidification and presence of water,
    - shading and ventilation improvements,
    - enhanced routes and walkaways, and
    - community activities in spaces that serve as climate shelters.
- Public spaces can be essential for the vulnerable groups. It is thus vital to increase and protect existing trees near the neighbourhood; install pergolas with deciduous vegetation around the neighbourhood to create cool areas and corridors in summer that also allow sunlight in winter; promote native and drought-resistant species in public and private spaces; increase the presence of trees and green areas in playgrounds and schoolyards to promote safe and stimulating outdoor activities for children; and replace impermeable pavements with vegetated areas, natural soils, and permeable surfaces (Pérez Rodrìguez et al., 2024).
- Proper water management needs to be promoted; permeable pavements are to be used to facilitate water infiltration and retention in the ground or be captured and stored in subsurface layers for later reuse or drainage. The presence and evaporation of water in the neighbourhood contributes to surface cooling (Pérez Rodrìguez et al., 2024).
- Critical areas most exposed to solar radiation that require more shading need to be identified. Additionally, pergolas, awnings, and shading structures need to be incorporated in places such as courtyards, squares, and parks within or near the neighbourhood, inviting social interaction and permanence along with urban furniture (Pérez Rodrìguez et al., 2024).
- Awareness programs indicating at what time it is appropriate to leave home should be delivered, in addition to promoting good habits that enhance well-being when going out (Pérez Rodrìguez et al., 2024).
- Spaces such as libraries, museums, senior centers, cultural centers, health centers, and social centers have to be designated and adapted to become free-access climate shelters, adjusting their hours to

promote their use by the public. Sitting areas in shopping centers, not linked to consumption, need to be equipped to relieve visitors from the heat (Pérez Rodrìguez et al., 2024).

Suggested recommendations:

- **Prioritizing decent living conditions over energy savings**

Actions tackling summer energy poverty may not generate energy savings on short term, as vulnerable households are rarely equipped with air conditioning systems. These actions are however essential to help vulnerable households cope with deteriorating living conditions due to warmer summers and heatwaves. They can also deliver collective benefits (e.g. reduced health expenses).

Energy efficiency or energy savings might not be a relevant primary objective for measures tackling summer energy poverty.

- **Identifying priority target groups**

Data is often missing at national or local level to assess the extent of summer energy poverty and identify who is affected the most. Better knowledge on summer energy poverty should be part of the objectives of surveys on living conditions (e.g. EU SILC) and of research on heat resilience.

- **Using targeted and dedicated measures**

Including provisions to prioritize vulnerable households within general schemes has shown limited results (see for example Greece’s renovation programme in the annexes). Dedicated measures including specific communication and outreach prove to be more effective.

3. A multilevel approach to provide whole-year comfort in a sustainable way

The current EU policy framework relevant to space cooling is primarily focused on technical systems (see Figure 1), i.e. equipment (cooling devices and fans) and buildings, and on cooling supply, through efficiency and RES (see Figure 2). This chapter looks at issues and policies related to the technical systems, and how they could be enhanced or complemented. Overall planning and cooling supply are addressed in the following chapters 4 and 5.

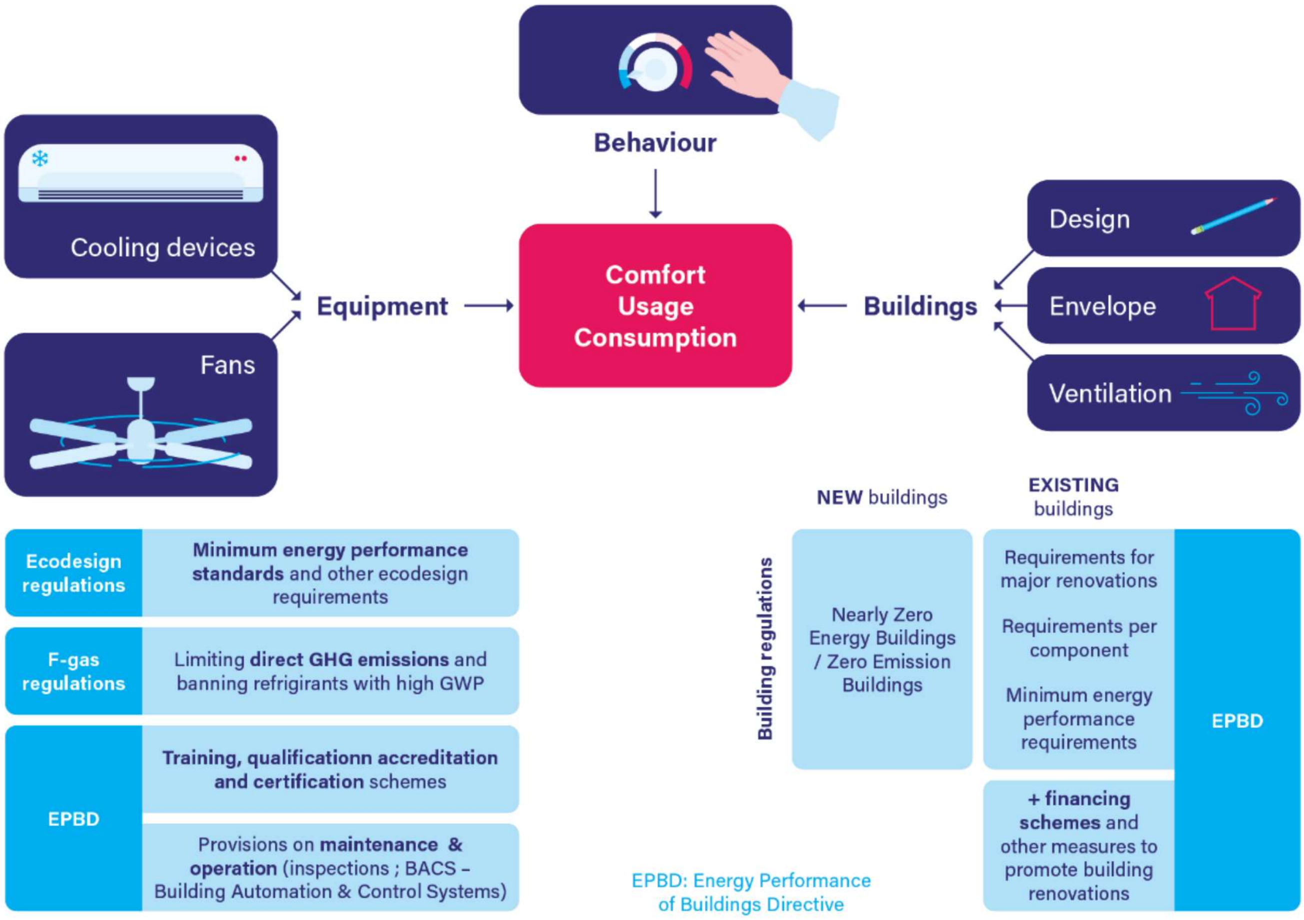

Figure 1. Coverage of the equipment and building level in the EU policy framework.

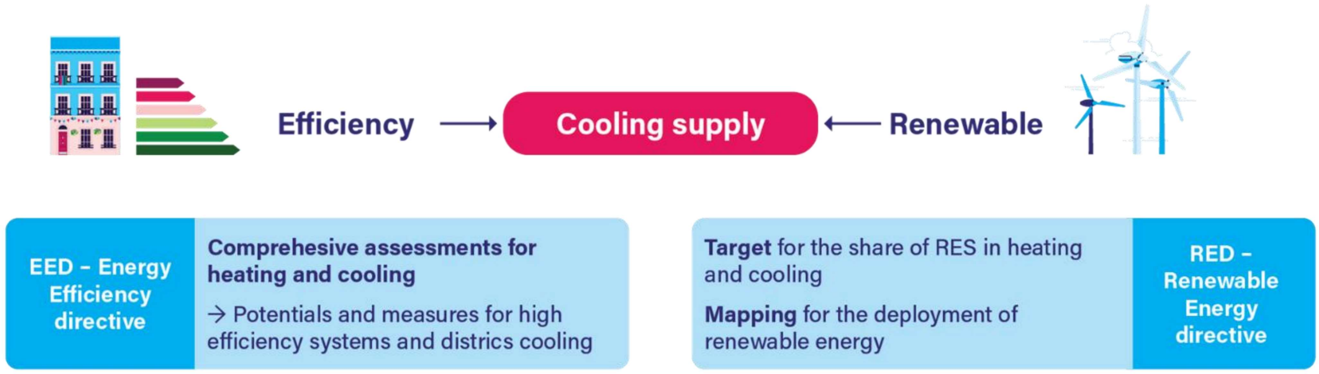

Figure 2. Coverage of cooling supply in the EU policy framework.

The previous analysis of the policy framework (Broc et al. 2024) has shown that provisions on space cooling are often secondary or hidden by the provisions on space heating, as space heating represents by far the largest share of energy consumption in buildings in most cases. Moreover, as highlighted in chapter 2, adverse effects can occur when space heating - comfort in winter and space cooling - comfort in summer are addressed separately. Providing the conditions for whole-year comfort therefore comes out as the umbrella objective.

Building on the literature, stakeholders' experience and the recommendations from the previous chapter, we structure our suggestions of recommendations to meet this objective according to three main topics:

- Integrated approaches for buildings, reconciling energy performance and climate-resilience (Section 3.1)
- Promoting the diversity of solutions to avoid that addressing space cooling be limited to air conditioning systems (Section 3.2)
- Considering the enforcement of current regulations for cooling systems (Section 3.3)

3.1. Towards efficient and climate-resilient buildings

The issue(s):

- In Europe, the priority challenge is to improve existing buildings, due to the low renewal rate with new buildings and that most existing buildings have not been designed to cope with current and future risks of overheating (and other risks due to climate change).
- Energy performance of buildings is mostly focused on reducing space heating consumption (as main share of buildings' energy consumption). Whereas some of the solutions to reduce space heating consumption might create adverse effects for comfort in summer (see also section 2.3).
- Building regulations may use a restrictive definition of comfort, with energy performance requirements mostly focused on meeting average indoor temperature (see also section 2.1)
- More generally, the growing risks due to extreme weather events related to climate change, especially about health impacts and property losses, raise the need to revise building codes and standards, in line with climate

adaptation policies (Hinge 2023). Among various aspects, this includes considering future weather data to better address changes in cooling needs (see also section 2.2).

Lessons learned / knowledge available:

- The main approaches to make a building resilient against overheating can be grouped in four categories (when considering the building level): (1) Reducing heat loads to people and indoor environments, (2) Removing heat from indoor environments (production, emission and combined), (3) Increasing personal comfort apart from space cooling, and (4) Removing latent heat from indoor environments (Stern et al. 2024).
- The IEA EBC Annex 80 about "Resilient Cooling of Buildings" developed a structured approach to evaluate Key Performance Indicators for assessing the resilience of buildings across various technologies, grouping KPIs in four main categories: thermal comfort, heat stress, energy performance, HVAC ad grid (Holzer et al. 2024). Overall, this initiative provides a comprehensive overview of recent technical research about building cooling under extreme events, particularly with regard to the adaptability and resilience of cooling systems under extreme climatic conditions.
- Improving energy efficiency in buildings can support climate resilience and bring multiple resilience benefits (Ribiero et al. 2015, Hinge 2023).
- The role of ventilation is essential to avoid that increased insulation and airtightness create risks of overheating as less heat could be dissipated. Likewise, when buildings and their systems are improved focusing on temperature control only, further adverse effects may occur such as increased indoor air pollution, due to inadequate air renewal (e.g. when air conditioning systems do not include any fresh air supply) (Lizana et al. 2022).
- Sun shading and related solutions are essential to reduce heat inputs due to solar radiation and are often a no-regret option.
- Renovation schemes increasingly include passive measures for summer comfort (e.g. sun shading) as part of their eligible action types (see the examples of Greece's Residential Energy Renovation Programme and Italy's ecobonus in the annexes of this report).
- Recent revisions of building regulations tend to address more explicitly the conditions for comfort in summer and overheating risks: more comprehensive definitions of thermal comfort, definition of specific indicators (e.g. number of hours of discomfort in summer without air conditioning systems, maximum allowed cooling demand), specific requirements to avoid overheating (e.g. mandatory solar protection according to the share of glazing surface), revised weather files considering extreme heat events (Broc et al. 2024). Most of these requirements promote passive measures in priority, to improve passive survivability (i.e. considering the risk of power outage or air conditioning failure during heatwaves).
- In 2022, UK formally issued a new component (document O) of its building regulations to minimize building overheating, following a study that quantified the overheating risk in the UK domestic housing stock and the potential costs and benefits of policy measures to decrease the risk (Arup 2022; see also Hoggett et al. 2024). The new requirements can be met either through a simplified (but prescriptive) method or using dynamic thermal modelling (more flexibility in the solutions). The requirements give a clear preference to passive design measures (Hinge 2023).
- Similar national studies have been done in other countries (e.g. in France, see Peuportier et al. 2023). This provides a growing knowledge base to adapt building regulations and provide guidelines to professionals.
- The EU policy framework does not include yet a clear vision for a climate-resilient built environment. An EU strategy for climate-resilient built environment could help increase consistency between adaptation and buildings policies, building on the experience of pioneer regions and cities (BPIE, 2024). As first steps, the Renovation Wave communication includes a definition for climate-resilient buildings, DG CLIMA published EU-level technical guidance for adapting buildings to climate change (Ramboll and CE Delft 2023) and the

new EPBD adopted in 2024 mentions policies and measures to increase the climate resilience of buildings as part of the optional information to be included in National Building Renovation Plans.

- Building regulations can address thermal comfort and some aspects of passive survivability but need to be complemented with other policies (Hinge 2023), notably to address urban heat island effects (see section 4.3).
- The implementation of provisions addressing overheating risks and resilience is still recent. Research is needed to assess what measures may be most impactful and the various uncertainties due to climate change (Hinge 2023).

Suggested recommendations:

- **Ensuring renovation programmes are 'fit for cooling'**

Heat resilience assessment can be required for large renovation projects. Simplified checklists could be used for smaller projects, for example emphasising the importance of ventilation.

Eligible action types should include passive measures, and at least no-regret options (e.g. sun shading).

Measures for energy advice should provide building owners with information about whole-year comfort (not only about the heating season).

- **Favouring deep renovations and synergetic actions**

Studies show that single actions achieve limited impacts compared to renovation packages or deep renovations. This is true for both, winter and summer comfort, reducing space heating and space cooling consumption. Deep renovations should therefore be favoured, for example with higher grant rates.

The support to certain action types could also include conditions to favour synergies and avoid missed opportunities. For example:

  - an assessment of the feasibility of sun shading options could be required for projects of façade renovation.
  - the installation of solar PV panels could be required in case of installation or replacement of air conditioning systems (except when not technically possible)

- **Ensuring that building regulations address summer comfort and overheating risks**

Provisions in the building regulations should for example:

  - Include definition and assessment of comfort that is not limited to average indoor temperature

  - Include definition and assessment of criteria specific to the summer period (e.g. hours of discomfort without air conditioning)
  - Require the use of weather files that reflect future climate conditions in terms of typical year and extreme heat events

More generally, building regulations could consider integrating climate-resilient standards (covering other aspects than overheating risks).

- **Revising Energy Performance Certificates to include information about summer comfort**

Energy Performance Certificates are a key source of information for building owners and tenants. As they mostly deal with energy consumption and GHG emissions, the information they include on summer comfort is usually limited.

A revision of the Energy Performance Certificates could enhance the information about summer comfort, for example by identifying overheating risks and including more systematically actions about summer comfort in the recommendations.

3.2. Promoting broader markets of sustainable space cooling solutions linked to adaptation and resilience strategies

The issue(s):

- From a market perspective, space cooling might be perceived in a restricted view, considering mostly standard air-conditioning devices, with a focus on growing product sales. Moreover, the market has been dominated by product-based business models, where producers and retailers manage only a small part of the lifecycle of the cooling appliances (Lizana et al. 2022).
- In this product-based model, final customers may first look for the lowest initial investment cost, and then face defaults in installations, while maintenance might be inadequate. This can result in higher operating costs, refrigerant leaks and other failures (Lizana et al. 2022).
- The product-based model also favours obsolescence, as manufacturers may favour sales volumes over durability (Jensen et al. 2021).
- Considering a mix of solutions, instead of air-conditioning as a silver bullet, might imply to change the way the markets and offers are structured. A coordination role is needed, between the various trades that may be involved (e.g. building insulation, ventilation, cooling products, nature-based solutions).
- Information about passive measures and other alternatives to space cooling, and about risk factors for overheating in buildings might not be as disseminated and easily available as information about space heating and air conditioning systems.

- The relevance of solutions is highly dependent on the local conditions (e.g. local climate) and the type(s) of building use or segment of the building stock (e.g. housing, offices, healthcare). Information should therefore be available in a tailored way.

Lessons learned / knowledge available:

- Recent research provides updated review and taxonomy of space cooling measures (passive and active), showing a broad set of solutions (e.g. Zhang et al. 2021, Duplessis et al. 2024)
- Lizana et al. (2022) suggested an order to consider solutions for sustainable space cooling, to increase heat resilience of buildings, downsize cooling needs and systems, as shown in the figure below.

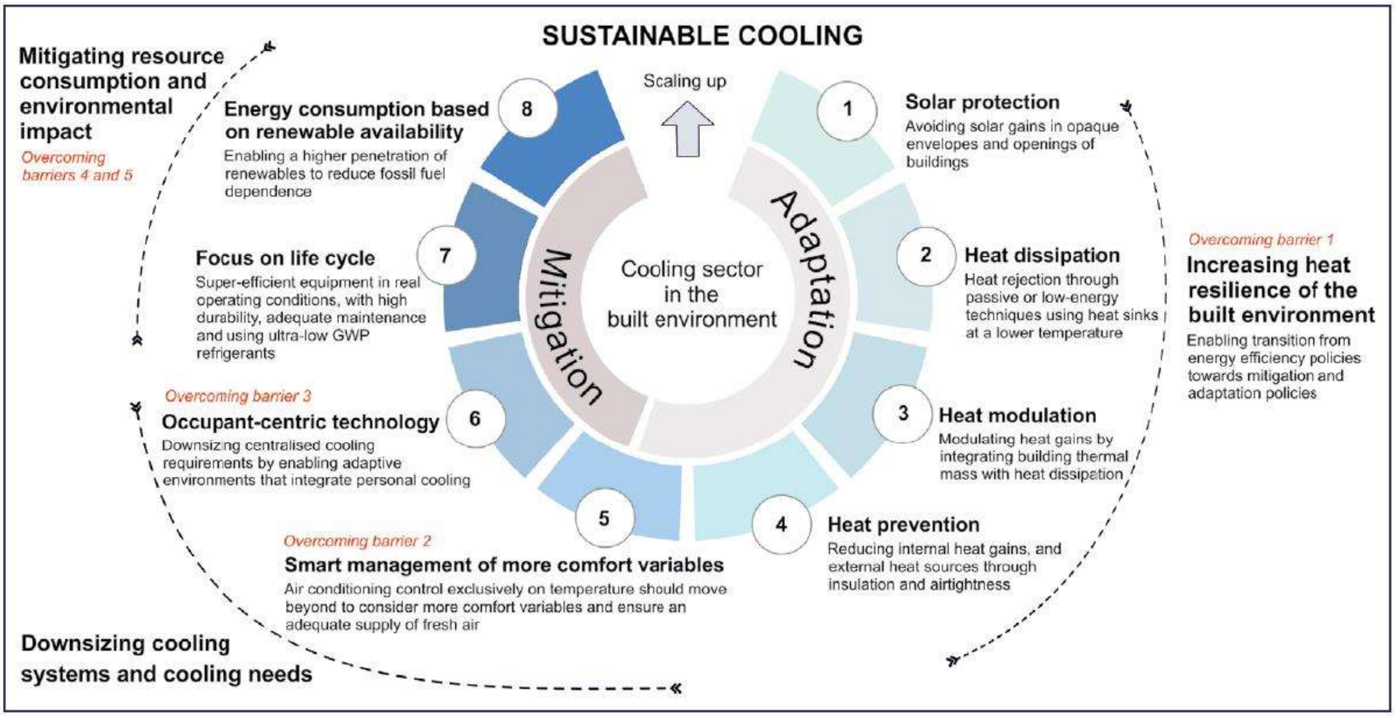

Figure 3. Recommended steps towards sustainable cooling in the built environment (figure 6 of Lizana et al. 2022)

- Overall, publicly available resources providing information and recommendations about sustainable solutions for space cooling (and beyond, for adapting buildings to climate change) are growing, for example:
  - The IEA EBC (Energy in Buildings and Communities Programme) Annex 80 about "Resilient Cooling of Buildings" produced detailed recommendations per technical solutions (Levinson et al. 2024), and results from a sample of field studies (Qi et al. 2024).
  - The European Commission (DG CLIMA) published technical guidance on adapting buildings to climate change (Ramboll and CE Delft 2023), with a focus on existing buildings, and covering heatwaves (in chapter 1) among other climate hazards. This includes a short description of typical solutions, and a discussion about stakeholder roles to promote and implement them.
  - OID (2024) provides a guide for the adaptation of tertiary buildings, with practical factsheets per action type, covering, among others, solutions relevant to sustainable space cooling.

- A few references have discussed the possibility to develop service-centric models or hybrid models (combining product sales and service options), with the long-term objective of cooling as a service (Lizana et al. 2022). Such models put an emphasis on the operating and end-of-life phases, creating an incentive for market players to promote higher system efficiency, avoid oversizing, ensure good quality installation and maintenance. However, further research is needed to overcome the barriers to this transformation.

Suggested recommendations:

- **Raising awareness about alternatives to air conditioning systems**

Various resources are available about alternatives to air conditioning systems. However, general awareness about them may still be limited.

A well-identified national public online resource about solutions for summer comfort could become the go-to source for information designed for a general audience. Communication campaigns could then promote this resource and key messages to raise awareness about alternatives to air conditioning systems, as well as about efficient use of air conditioning systems.

- **Providing professionals with set of technical recommendations**

Various resources also exist about technical information and guidance. However, professionals may have limited time to go beyond their initial field of expertise and consider other technics and solutions.

Technical recommendations officially promoted by well-established public agencies could help promote good practices, and enlarge the scope of solutions considered by professionals.

- **Including space cooling solutions in the plans about skills and supply chain for the buildings sector**

Shortage in trained installers and in the supply chain is a common challenge faced by renovation programmes. This is addressed with plans about skills and supply chain for the buildings sector. However, these plans do not necessarily cover the needs of the markets for sustainable space cooling solutions.

Including space cooling solutions in these plans could support the development of these markets.

- **Supporting innovation, demonstration and performance-based approaches**

Real estate stakeholders, architects, planners and building professionals need to be convinced with documented evidence that alternative or new solutions are effective and deliver outcomes as expected. Supporting innovation and demonstration is therefore essential to their development. This is also needed to demonstrate compliance with relevant regulations (e.g. fire safety) and how operational the solutions are (e.g. about maintenance).

Innovation is also needed in terms of services (e.g. to experiment the approach of cooling as a service).

3.3. Ensuring an effective enforcement of regulations applicable to cooling systems, from design to disposal

The issue(s):

- The dominant cooling technologies are already covered by the ecodesign, energy labelling and F-gas regulations, but the adoption of these regulations may not deliver the expected impacts if not effectively enforced. This was for example evidenced by the Effect project in the Nordic countries (Dragovic and Broc 2018), though not specifically about cooling products.
- Disposal of air-conditioning products will increase, due to the growth in sales observed since the early 2000's in certain countries. This might raise concerns about the collection of refrigerants that represent a high risk for climate change, due to their high GWP (Global Warming Potential).

Lessons learned / knowledge available:

- Market surveillance is essential and supported through the Concerted Action on Market Surveillance, including a work package dealing with cooling products[2].
- Member States may pool resources (e.g. for lab testing) and share information (e.g. about results of controls, products/retailers with higher risks), as done through Nordsyn in the Nordic countries (Dragovic and Broc 2018).

Suggested recommendations:

- **Strengthening cooperation in market surveillance**

Importance and effectiveness of market surveillance have been documented. However, the means dedicated to it rarely meet the needs. Strengthening cooperation among Member States could help address this.

- **Accompanying the transition to natural refrigerants**

The F-gas regulation set the roadmap to phase out refrigerants with high GWP. Achieving these targets may require further public interventions.

[2] https://eepliant.eu/index.php/new-products/air-conditioners/60-new-products/204-eepliant4-wp8-air-heating-and-cooling-products

- **Strengthening the measures dealing with AC systems' end of life**

The growth in the disposal of air-conditioning systems should be anticipated. For example, with measures:

  - To favour products with long-lifetime
  - To raise awareness of product owners about the risks and consequences of improper disposal
  - To increase recycling capacities
  - To increase capacities to collect old AC systems

4. Considering space cooling in the overall energy and climate framework

Space cooling is often hidden in the overall energy and climate framework, at EU or national level, due to its low share in the total energy balance. However, it is related to major issues, including risks for health, electricity system and economic activity (see section 4.1). Moreover, space cooling is related to various policy fields and stakeholders, calling for integrated approaches and coordination (see section 4.2). Multi-level coordination, notably between national and local levels, is also essential to the success of strategies for sustainable space cooling (see section 4.3).

4.1. Assessing the main issues raised by space cooling in the country

The issue(s):

- Space cooling and maintaining a minimum indoor comfort during summer period can be related to various impacts and risks (e.g. health, pressure on the electricity system or power outage, limitations in economic or social activities).
- Related assessments might be spread, possibly creating risks of adverse effects (e.g. maladaptation), and making it difficult to get a comprehensive picture when comparing or prioritizing strategies.

Lessons learned / knowledge available:

- National adaptation strategies and plans can be the focal point where various impacts and risks are considered together.
- National adaptation strategies and plans are also increasingly related to mitigation policies. This can for example be illustrated for the topic of space cooling through the linkage between the concepts and measures for climate-resilient buildings and building regulations, renovation programmes and other measures for energy efficiency in buildings.
- At the opposite, the link with adaptation in the National Energy and Climate Plans remains limited, even if recent or upcoming revisions of building regulations to address overheating risks or similar provisions are sometimes mentioned (Broc et al. 2024).

Suggested recommendations:

- **Mapping and quantifying the expected impacts of warmer summers and extreme heat events**

The preparation of National Adaptation Strategies and Plans can be the opportunity to assess the expected consequences of warmer summers and extreme heat events, identify the most critical ones and put figures on them. This is essential to get the issues recognised in the policy agenda and prioritize communication and action.

This is also an opportunity to put together studies and data from various stakeholders (health administration, environment administration, electricity network operators, insurance companies, etc.)

- **Ensuring up-to-date information of stakeholders**

Information from the assessments of expected impacts should be made easily available, so that stakeholders can take this into account in their own planning. This may require different types of summaries, according to target groups.

4.2. Coordinating the way space cooling is addressed in national and local planning

The issue(s):

- In theory, the national planning and reporting processes related to energy and climate are now integrated through the Governance Regulation of the Energy Union and Climate Action: the various assessments or plans required by the Energy Efficiency Directive (EED), Energy Performance of Buildings Directive (EPBD), the Climate Law and the Renewable Energy Directive shall all come together with the National Energy Climate Plans prepared for 10-year periods with mid-term updates (i.e. revision every 5 years), as shown in the figure below.

Figure 4. Integration of national planning and assessments relevant to space cooling (in the EU policy framework).

- In practice, these national planning and reporting processes include limited cross-references for the moment, and their integration is not obvious yet. This can be partly because their timing has been affected by the revisions of legislation due to the fit-for-55 package. For example, the National Building Renovation Plans, replacing the former Long-Term Renovation Strategies, have delayed to the end of 2025 (due to the late adoption of the EPBD recast), whereas the other assessments were due by June 2024.
- Beyond the timing issue and the streamlining of the reporting processes, integration implies cross-cutting communication and coordination between various administrations or units. This is not straightforward and may take iterations before going from simple juxtaposition to real integration.

- Internal silos, bureaucratic inertia, and competing priorities may slow progress.

Lessons learned / knowledge available:

- Defining a clear mandate for a cross-cutting position in charge of heat resilience can give visibility to the topic and facilitate communication with multiple departments. This also helps mobilise support across departments and attract media attention (see e.g. Athen's Chief Heat Officer).
- A dedicated budget can help secure funding for implementing cross-cutting measures.
- Collaboration across levels of government is also essential to streamline policy implementation and financing.
- Integrating space cooling measures in overarching strategies such as energy and climate plans, adaptation plans or urban planning can support coordination among administrations and ensure that these measures remain on the agenda (see e.g. Hambourg Green Roof Strategy)
- For building-related measures, various regulations and requirements need to be considered (e.g. fire safety, acoustics, indoor air quality, protection of historical buildings or neighbourhoods) and may limit the options that can be implemented, notably for improving building envelope.

Suggested recommendations:

- ❖ **Strengthening the links between National Building Renovation Plans and Comprehensive Assessments on heating and cooling**
- ❖ **Ensuring visibility of space cooling or heat resilience in umbrella plans and strategies**
- ❖ **Defining a coordinator in charge of cross-cutting communication and cooperation**
- ❖ **Considering the needs of dedicated budget for cross-cutting measures**

4.3. Providing support for local authorities to develop solutions relevant to their territories

The issue(s):

- The role of local authorities is further highlighted by the EED recast adopted in 2023 that requires local heating and cooling plans in municipalities of more than 45000 inhabitants. These plans shall be aligned with other local climate, energy and environment planning requirements in order to avoid administrative burden for local and regional authorities and to encourage the effective implementation of the plans.
- An integrated approach could thus be derived from the one described in the previous section about the national level, as shown in the figure below. Further dimensions may be considered at the local level, notably urban planning.

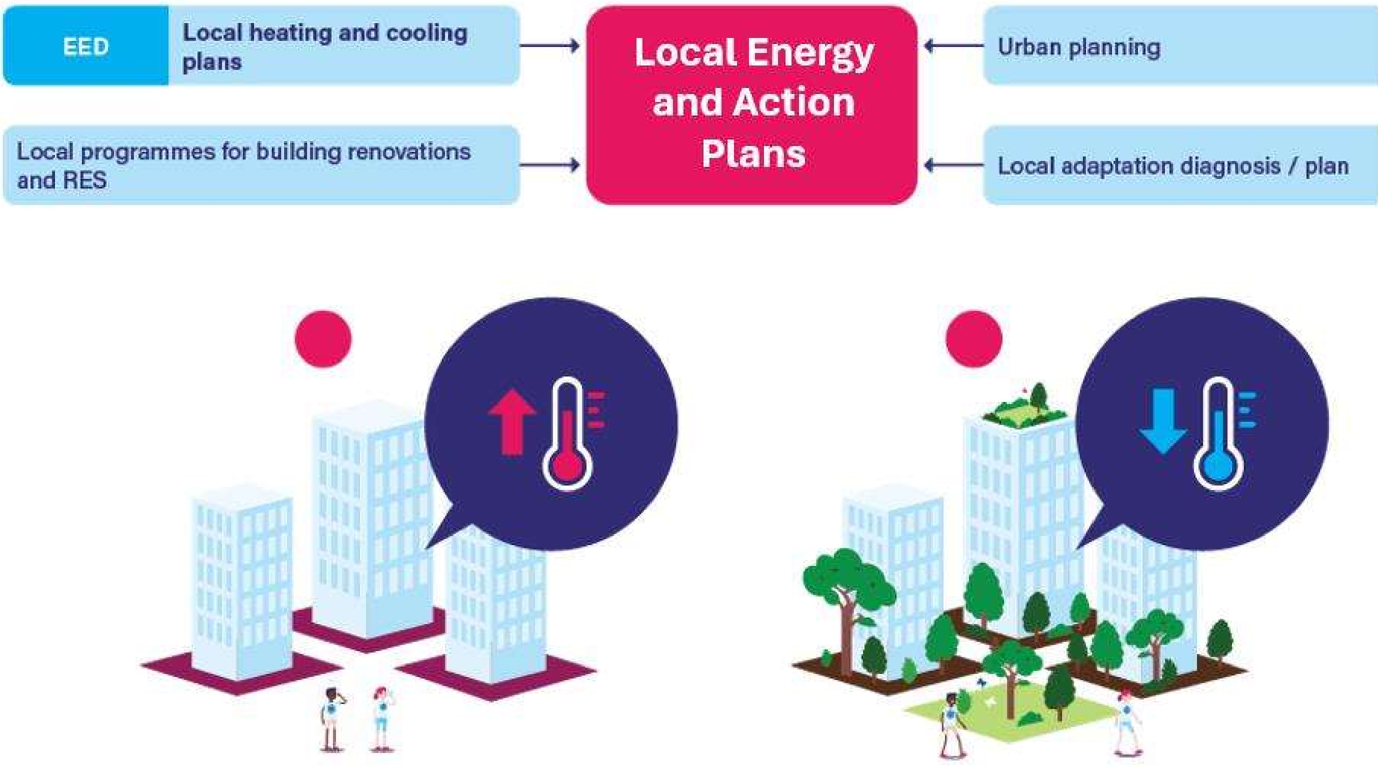

Figure 5. Integrated planning at local level.

- Similar challenges as at the national level apply at the local level (e.g. different timing in the planning processes, difficulties to coordinate various administrations or services). However, the local level may offer a more operational perspective and a field to experiment new approaches.
- Large discrepancies can be observed in the capacities and experience of local authorities. Some front-runners may experiment innovative approaches that pave the way for improvements in national regulations, guidelines or recommendations. Whereas other local authorities may struggle to comply with minimum requirements or disregard some aspects.
- About the provisions on local heating and cooling plans, the EED thus stipulates that "*Member States shall support regional and local authorities to the utmost extent possible by any means, including financial support and technical support schemes*". The local plans can for example start from the information available in the national comprehensive assessment on heating and cooling.
- Support to local authorities is even more important for a topic as complex as space cooling, for which information and experience might be less available (e.g. compared to space heating).
- The major role of local authorities in the field of space cooling is also because measures at building level cannot address all aspects (see also section 3.1): the urban environment can have a major impact on cooling needs and overheating risks, notably through urban heat island effects.

Lessons learned / knowledge available:

- Acknowledging the importance to consider measures beyond the building level, the former IEA EBC Annex 80 on resilient cooling (see section 3.1) is now continued with Annex 97 about "Sustainable Cooling of Cities"
- Several on-going European projects or initiatives develop support and experience sharing among local authorities, specifically for local heating and cooling plans (see e.g., ESCALATE, Plan4Cold, CHAMP) or for addressing heatwaves and improving heat resilience in cities (READY4HEAT, Cities Refresh campaign of the Covenant of Mayors).
- National resources and online platforms are also developed at national level, providing support in national language, which might be more effective to reach all municipalities. See for example the 'Cooler my City' platform in France.

Suggested recommendations:

- **Supporting cross-country experience sharing through European programmes**
- **Developing national platforms to provide support in national language and based on local examples**
- **Providing local authorities with funding proportional to their responsibilities**

5. Improving the way space cooling is addressed in the comprehensive assessments

Article 25(1) of the EED recast requires Member States to prepare comprehensive assessments on heating and cooling, that is now part of to their National Energy and Climate Plan (NECP). The first assessment was due by 2015, then with a first update in 2020 and the latest due by June 2024. The next update follows the same timeline as the NECP (draft due by January 2028, and final version by January 2029, in view of the 2031-2040 period).

The contents of these assessments are specified in Annex X of the EED recast. As regards cooling, this includes the assessment of the current cooling demand per sector and of the cooling supply by technology, cooling map to identify potentials for district cooling, a forecast of trends in the cooling demand for the next 10 years and perspective in the next 30 years, an overview of the existing policies and measures relevant to cooling, an analysis of economic potential for efficiency in cooling (using a cost-benefit analysis to compare cooling solutions), and an overview of the strategy and planned policies and measures to achieve the economic potential identified.

In theory, the comprehensive assessments should therefore provide a solid basis for a sound national heating and cooling plan, anticipating upcoming needs and coordinating actions to meet these needs in a cost-effective way.

As this chapter is focused on comprehensive assessments only, the structure is slightly different. We summarize first the issues and lessons learned related to comprehensive assessments (through the lens of space cooling), and then present the key suggested recommendations to improve the way space cooling is addressed in comprehensive assessments. These recommendations also build on the previous chapters.

The issue(s):

(based on the review of 2020 comprehensive assessments, see Broc et al. 2024)

- Comprehensive assessments progressively include more data about cooling. However, the focus is still on heating, especially when describing policies and measures, and even for the five countries with the largest cooling demand.
- This may be explained (1) by the prominent weight of space heating compared to space cooling in the final energy consumption, (2) because cooling is not a direct challenge for decarbonisation (as mostly supplied from electricity), whereas heating remains a major source of direct CO2 emissions, and (3) because data scarcity about cooling remains an issue.
- The approach and processes related to heating and cooling plans or assessments are often focused on the supply of heat and cooling (e.g. promoting district heating and cooling). This might be because the improvement of the building stock was addressed in the national LTRS – long-term renovation strategies (becoming national building renovation plans with the EPBD recast of 2024). However, the reviews of LTRS found that they were most often focused on reducing energy consumption due to space heating, similarly to the conclusions from the review of the comprehensive assessments.

- There is therefore a lack of data for scenarios to assess the impacts of changes in the building stock (e.g. due to renovation) on future cooling needs.
- Likewise, cooling is rarely addressed in the part about cost-benefit analysis, when comparing solutions. And when it is the case, this is mostly done by comparing active cooling systems with different efficiency levels, and possibly district heating.
- The EED recast clarifies in its Article 25(3) that the cost-benefit analysis part of the comprehensive assessments shall take into account the Energy Efficiency First (EE1st) principle. As regards space cooling, this should call for example to include passive measures in the comparison. Which has very rarely been done so far (see the example of Austria's 2024 comprehensive assessment in the annexes of this report).
- About policies and measures, most of the comprehensive assessments cover a broad scope, for example including measures for energy efficiency in buildings (building codes and schemes for building renovation), promotion of RES (mostly for heating) and development of district heating (sometimes also district cooling). However, the link with space cooling is rarely explicit, except for some references to energy labelling and regulations for air conditioners or cooling products, measures to promote district heating and cooling (when district cooling is clearly mentioned), and measures for RES for cooling (mostly about geothermal).
- When discussing measures for building renovation, the focus is usually on reducing the heating demand, the possible impact on the cooling demand being rarely mentioned (the same for shading for example). The description of the renovation schemes mentions that actions related to space cooling are eligible only for one Spanish programme (National Housing Plan 2018-2021), where efficient air conditioners and connection to district cooling can be eligible. Nevertheless, some schemes in other countries also include actions related to space cooling in their scope (e.g. France's white certificates, Italy's ecobonus), despite not being mentioned in the comprehensive assessment.
- Most of the 2020 comprehensive assessments did not include an explicit reference or link to adaptation strategy, plan or measures. Likewise, issues related to heat waves or urban heat islands are rarely mentioned. These points were not included in the Commission's Recommendation (EU) 2019/1659 on comprehensive assessments, which may explain this gap.

Lessons learned / knowledge available:

Lessons learned from the review of the 2020 comprehensive assessments[3]:

- The assessment of cooling needs per sector confirmed the negligible share of space cooling in energy consumption of residential buildings in most countries. Whereas this share was often around 15% or above (e.g. close to 30% in Spain) in the service sector. Likewise, despite the service sector representing a smaller share of the building stock, its cooling demand is higher than the one of the residential sector.
- The current lower equipment rate in the residential sector (compared to service sector) explains why a stronger growth in cooling demand is expected in the residential sector in the coming years.
- Overall, the assessments identified limited economic potential for district cooling. A few existing district cooling networks were reported, mostly used to supply large office buildings or neighbourhoods with high density of commercial buildings. District cooling seems to be more developed in Nordic countries (e.g. Finland) than in Southern countries (e.g. Spain and Greece), except for Italy (where district cooling was reported to grow). Which might be because district cooling has mostly developed there together with district heating (including in Italy) that supplies a large share of the buildings (in Nordic countries).

[3] 2024 comprehensive assessments were not available at the time of this review.

- When space cooling is covered in the cost-benefit analysis, the most cost-effective option is often found to be heat pumps (sometimes combined with photovoltaic systems, like in Cyprus' assessment).
- The number of new or planned measures with explicit link with space cooling was limited, including: an update of the national regulation for thermal energy systems for buildings (Spain), measures to develop district cooling (France, Greece and Italy), specific consideration about the possible introduction of new limits on the use of cooling systems to be evaluated by defining restrictions related to the climate zones (Italy).

Croatia's 2020 Comprehensive Assessment was one of the assessments including the most details and analysis about space cooling:

- Data specific to energy delivered and useful energy for space cooling, per main sector (residential, services and industry), and with further disaggregated data (e.g. individual houses / multifamily buildings ; sub-sector in services ; data and map per county).
- Comparison of a Baseline-As-Usual (BAU) scenario with a scenario with integrated measures showing that these measures would compensate most of the increase in cooling demand found in the BAU scenario.
- The main action type considered to reduce energy consumption from / improve efficiency in space cooling was the replacement of split systems with heat pumps. No financial incentive was planned for this action type, as it was estimated to be cost-effective already (positive Net Present Value).
- The development of district cooling was not foreseen. However, the use of heat from district heating system in the summer to power central absorption chillers for cooling spaces in larger non-residential buildings (e.g. hospitals, hotels, shops, etc.) which are already connected to the district heating system is considered as an option to replace compression chillers using refrigerants with high environmental impacts.

Lessons learned from the example of Austria's 2024 comprehensive assessment (see the annexes of this report for more details):

- Integrating space cooling into a comprehensive assessment requires additional data sources, new modelling routines, and close coordination between national statistics, technical modelling teams, and policymakers.
- One challenge was dealing with limited historical data on cooling systems, especially in the service sector. This can however be addressed using disaggregated technology stock estimates and assumptions from previous EU-level studies.
- From a policy perspective, the inclusion of space cooling improved the comprehensiveness and policy relevance of the assessment. It helps highlight the role of energy efficiency and demand-side measures in the cooling sector, and it provides a transparent framework for evaluating future investment needs and strategies.
- The Austrian case shows that it is feasible—and valuable—to integrate space cooling into national energy planning using structured methods and realistic scenarios. The approach developed through the CooLIFE project is applicable in other Member States and can support the broader effort to align national planning with EU climate and energy objectives.

5.1. Overcoming the data issue

Data limitations should not be an excuse to exclude or neglect cooling in the comprehensive assessments.

The size of the cooling issue varies very significantly from one country to another. However, the literature shows that, even in Nordic countries, space cooling needs to be addressed to avoid increasing overheating risks in existing buildings in the coming years.

The previous chapters have shown that **the literature about space cooling is quickly growing, and more and more resources are available** to support an assessment of cooling needs and a review of available solutions (see also the references section).

In any case, **the CoolLIFE tool can provide a first basis or benchmark** to assess the cooling demand in a Member State up to 2050. The results from the CoolLIFE tool should be taken with caution, as explained in the Wiki of the tool and in the example about Austria in the annexes of this report. For example, because it includes a number of assumptions (that can be changed by the user). Keeping this in mind, these results can help prioritize data collection and research to improve the reliability of the assessment.

About future weather files, **more datasets become available**, such as the one developed by the IEA EBC Annex 80 (Machard et al. 2024).

5.2. Using sensitivity analysis to anticipate upcoming challenges

Tools like the CoolLIFE tool can be used to do sensitivity analysis. This is essential to address key sources of uncertainty (e.g. in climate projections) and to explore contrasted scenarios, and assess what types of solutions or policy interventions can be the most relevant.

5.3. What the Energy Efficiency First principle means for comprehensive assessments: considering a broader scope of options

Energy Efficiency First (EE1st) means to consider and compare a broad of options that could be used to meet given needs and policy objectives. In general, this is about providing a level-playing field to compare options related to energy supply and options related to energy demand. More specifically about space cooling, this means that the set of options considered should include options that can reduce space cooling needs (e.g. passive measures). In other words, the Cost-Benefit Analysis of space cooling options in the comprehensive assessments should not be limited to compare air-conditioning devices (including heat pumps) with different levels of efficiency.

Ideally the assessment would compare for example, building insulation, sun shading options, ventilation options, district cooling, and various individual cooling systems, with a cost-benefit analysis that would consider multiple impacts (final energy consumption, peak load, GHG emissions, comfort/productivity, health impacts…).

Being comprehensive in the assessment is however challenging. Stakeholder consultation can help select the options and assumptions for the scenarios to be assessed in priority.

5.4. Discussing the coordination between the national and local level

Article 25 of the EED recast stipulates that the newly required local heating and cooling shall align with the comprehensive assessments. Comprehensive assessments should therefore now be developed having in mind that one of their purposes is to provide reference data and a starting point for local heating and cooling plans.

This could be seen as an iterative process:

- the comprehensive assessment provides a basis / inputs (e.g. heating and cooling maps; cost-benefit analysis of typical solutions) for local heating and cooling plans
- then local heating and cooling plans may provide refined local data, revised assumptions, and raise solutions that might have been overlooked in the national assessment

Coordination should also occur in terms of policies and implementation, clarifying the roles and interactions between the different jurisdiction levels.

6. Conclusions

The literature about sustainable strategies for space cooling and climate-resilient buildings is quickly growing, showing how space cooling is related to a variety of topics (e.g. energy, health, adaptation). Selecting and designing solutions for sustainable space cooling goes beyond technical considerations about air-conditioning systems and buildings. Factors influencing thermal comfort and heat-related health risks can be as important, highlighting the importance to consider the differences among building occupants, building usage, as well as the interactions with and impacts of the surrounding environment.

The complexity to address all these issues and the expected growing cooling needs call for policy interventions to help plan and coordinate relevant strategies, building on the knowledge and experience gained from research and previous policies and measures.

The following table provides an overview of the recommendations suggested from the knowledge and experience gained along the CoolLIFE project, structured in main categories.

Table 1. Overview of the suggested recommendations.

Main category	Axis	Actions
Starting from the needs, anticipating changes	Starting from the building occupants – citizen	✓ Promoting studies to improve knowledge and data availability about space cooling-related behaviours ✓ Facilitating multidisciplinary exchanges and knowledge gathering ✓ Revising standards in line with current knowledge and allowing adaptation to specificities ✓ Specifying enabling conditions for efficient and adaptative behaviours ✓ Involving citizen and building occupants in the process to define strategies for sustainable space cooling
	What solutions for what conditions: considering operating limits and risks	✓ Linking implementation, monitoring and research to grow science-based evidence ✓ Maintaining future weather files including typical weather years ad heatwave events ✓ Providing methodologies to streamline sensitivity analysis ✓ Promoting heat-resilience assessments to anticipate overheating risks and prioritize asset managers' actions

		✓ Categorizing typical situations, operating limits and mix of solutions ✓ Involving building designers, owners and occupants in the definition of scenarios and analysis of results
	Linking mitigation and adaptation	✓ Mapping possible synergies and adverse effects of mitigation and adaptation measures ✓ Ensuring consistency among mitigation and adaptation policies ✓ Valuing co-benefits through co-funding
	Planning to avoid ineffective and expensive actions in a hurry	✓ Setting clear and measurable targets with regular monitoring ✓ Structuring action plans from short-term to long-term ✓ Providing stability and visibility about funding
	Sustainable space cooling for all: addressing summer energy poverty	✓ Prioritizing decent living conditions over energy savings ✓ Identifying priority target groups ✓ Using targeted and dedicated measures
	Towards efficient and climate-resilient buildings	✓ Ensuring renovation programmes are ‘fit for cooling’ ✓ Favouring deep renovations and synergetic actions ✓ Ensuring that building regulations address summer comfort and overheating risks ✓ Revising Energy Performance Certificates to include information about summer comfort
A multilevel approach to provide whole-year comfort in a sustainable way	Promoting broader markets of sustainable space cooling solutions linked to adaptation and resilience strategies	✓ Raising awareness about alternatives to air conditioning systems ✓ Providing professionals with set of technical recommendations ✓ Including space cooling solutions in the plans about skills and supply chain for the buildings sector ✓ Supporting innovation, demonstration and performance-based approaches
	Ensuring an effective enforcement of regulations applicable to	✓ Strengthening cooperation in market surveillance ✓ Accompanying the transition to natural réfrigérants

	cooling systems, from design to disposal	✓ Strengthening the measures dealing with AC systems' end of life
Considering space cooling in the overall energy and climate framework	Assessing the main issues raised by space cooling in the country	✓ Mapping and quantifying the expected impacts of warmer summers and extreme heat events ✓ Ensuring up-to-date information of stakeholders
	Coordinating the way space cooling is addressed in national planning	✓ Strengthening the links between National Building Renovation Plans and Comprehensive Assessments on heating and cooling ✓ Ensuring visibility of space cooling or heat resilience in umbrella plans and strategies ✓ Defining a coordinator in charge of cross-cutting communication and cooperation ✓ Considering the needs of dedicated budget for cross-cutting measures
	Providing support for local authorities to develop solutions relevant to their territories	✓ aa
Improving the way space cooling is addressed in the comprehensive assessments		✓ Overcoming the data issue ✓ Using sensitivity analysis to anticipate upcoming challenges ✓ What the Energy Efficiency First principle means for comprehensive assessments: considering a broader scope of options ✓ Discussing the coordination between the national and local level

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D4.3. Recommendations for enhanced and integrated strategies, policies and schemes relevant for space cooling

ANNEXES

Cool LIFE

Co-funded by the European Union

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- Building regulations
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- Policy recommendations

Disclaimer

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France's workshop

This workshop was held online on 2nd of July, 2025.

Background and objectives of the workshop

Rising temperatures increase the need for cooling in buildings. More frequent and intense heatwaves mean greater risks, particularly in terms of health and safety of the electrical system. France is one of the 4 European countries with the highest energy consumption for air conditioning in buildings. According to the 2024 update of the comprehensive heat and cooling assessment, cooling requirements in France (including the French overseas departments) in 2022 were 26 TWh for residential buildings, and 34 TWh for tertiary buildings. According to CEREN data, air-conditioning remains a use with a very small share of final energy consumption in the residential sector, but already accounted for 8% of consumption in the tertiary sector in 2015.

Recent revisions to policies and regulations have given greater prominence to these issues. For example, summer comfort is now better taken into account in the RE 2020 (cf. degree-hour of discomfort indicator), which is one of the provisions identified in measure 9 (Adapting housing to the risk of extreme heat) of the 3rd PNACC (National Plan for Adaptation to Climate Change).

The aim of this workshop is to discuss needs assessment, solutions for minimizing the use of air conditioning and policies for promoting these solutions, based on the work of the European CoolLIFE project.

Agenda

Part I – Assessing SC needs	
15 minutes	**CoolLIFE** project outcomes and tool introduction | Bruno Duplessis (Mines Paris-PSL)
15 minutes	**Discussion**
Part II – Promoting solutions	
10 minutes	**Overview of European and French policies, best practices and developments |** Jean-Sébastien Broc (IEECP)
20 minutes	Discussion

Participants

External participants:

- *Jean-Marie Alessandrini – Centre Scientifique et Technique du Bâtiment (CSTB)*
- *Clément Dimanche – Direction de l'Habitat, de l'Urbanisme et des Paysages (DHUP) – Ministère de la Transition Ecologique et Solidaire*

- *Hakim Hamadou – Agence de la Transition Ecologique (ADEME)*
- *Vincent Lapayre – Direction de l'Habitat, de l'Urbanisme et des Paysages (DHUP) – Ministère de la Transition Ecologique et Solidaire*
- *Charlie Le Galludec – CEREMA*

CoolLIFE participants:

- *Jean-Sébastien Broc – IEECP*
- *Bruno Duplessis – Mines Paris-PSL*

Minutes

Part 1 – CoolLIFE project outcomes and tool introduction

After a brief introduction to the objectives, organization and scope of the CoolLIFE project, B. Duplessis presents the main results of the project and introduces the knowledge hub and the online CooLIFE tool. He gives a quick demonstration of the tool's visualization, calculation and data access functions, before taking questions from participants.

The first questions concern the methods used in the tool to calculate air-conditioning requirements and develop prospective scenarios. Participants expressed their interest in these functionalities in relation to their own prospective studies. To this end, it would be useful to pool the results of the different studies carried out by each participant, to reinforce the analyses carried out independently. In this respect, the French situation is relatively privileged, insofar as the building data available are relatively rich and enable a fairly fine granularity to be achieved. Nevertheless, comparisons on a regional or national scale would be interesting.

While participants are interested in using the tool's outputs for prospective analysis, they recognize that the tool requires some effort to get to grips with. The Wiki pages offer users the opportunity to self-train, get to grips with the tool and more easily grasp the various (and very numerous) functionalities offered by the tool. It is also specified that the tool is more relevant at a strategic, territorial planning level than at the building scale: it is aimed less at building owners than at local authorities, town planners and energy distributors.

Part 2 – Overview of European and French policies

J.-S. Broc briefly reviews the European regulatory framework and highlights the historical segmentation of regulatory approaches to heating and cooling issues in buildings. More recently, however, there has been a desire to promote more integrated approaches, both at EU level and in certain Member States.

In France, the relative weight of heating-related energy consumption overshadows cooling-related issues in heating-cooling policies. In practice, summer comfort is more explicitly addressed in plans and measures for climate change adaptation (see for example the third National Adaptation Plan published in March 2025). In this respect, local authorities are more likely to take up the issue, particularly during heatwaves. From the user's point of view, in the absence of a policy framework, we may have to deal with the issue as a matter of urgency, and make the use of air conditioning the norm, with no alternative and no particular constraints.

Crossing the review of policies and measures in France and in other European countries, the presentation then suggests key issues and good practices that could help enhance or structure policies for sustainable space cooling. The discussions then highlighted the need for local authorities to build up their technical skills in the field of cooling, notably now in the context of the local heating and cooling plans required by the new Energy Efficiency Directive. Tools such as those proposed by CooLIFE and CEREMA in the near future, for example, are precisely designed to support this upskilling, although they cannot replace engineering work on the design of climatic systems on a building scale.

The discussion then focuses on the need to question, first and foremost, the level of service expected by building owners during heat waves. At what point (and how?) do we assess that the indoor environment of a building no longer meets the expected level? It is suggested that decisions to renovate and/or install air-conditioning systems should be based on a systematic analysis of the risk of exceeding this operating limit, now and in the decades to come. The phrasing of recommendations is also discussed, to avoid misinterpretation or too simplistic debates. Policy discussions about space cooling should not be restricted to positions in favour or against the use of air conditioning systems.

The concepts of expected level of service and operating limit can be a good basis to explain that some solutions (e.g. passive measures, fans) can be considered relevant up to certain limit conditions, beyond which other solutions (e.g. air conditioning systems) might become necessary. A key question is then about the probability for the operating limits to be exceeded, considering frequency, intensity and duration/length. This is therefore critical to anticipate the impacts of climate change when assessing the needs and solutions.

Another key question in this discussion is to what extent the service should be maintained. The recent heat wave in France gave the example of municipalities that had to decide whether to let the schools open, or to close them temporarily. Until recently, the need for air conditioning in educational buildings was rarely considered, as higher temperatures and heat waves mostly occurred during summer school holidays. In recent years, such conditions happened before the end of the school year. This also disturbed the conditions for final exams. This can be addressed in several ways:

- adapting the service (e.g. changing the schedule, anticipating that schools may be closed a few days per year, depending on weather conditions)
- adapting the buildings and their surroundings (e.g. playground), thereby improving the operating limit, and making that they would be exceeded less frequently
- installing air conditioning systems

The discussion makes it clear that there is no silver bullet. The relevant mix of solutions depends on the expected climate conditions, the possibility to adapt the service and the possibility to adapt the buildings (e.g. difference between the cases of new buildings and existing buildings). This calls for a better knowledge about operating limits, how to characterise/assess them, positive impacts of passive or active measures, negative impacts of climate change.

Finally, the discussion highlights the need to harmonize energy and health requirements stemming from regulations with initially distinct objectives. The discussion mentions the ISO Technical Committee 159 dealing with ergonomics of the physical environment, where the concept of risk is a key issue, notably for standards dealing with adaptation.

Italy’s workshop

The workshop was held online on 8th of April, 2025.

Background and objectives of the workshop

Rising temperatures increase the need for cooling in buildings. More frequent and intense heatwaves mean greater risks, particularly in terms of health and safety of the electrical system. Italy is one of the 4 European countries with the highest energy consumption for air conditioning in buildings, with air conditioning already regularly creating summer peak loads (up to black outs).

The aim of this workshop is to discuss needs assessment, solutions for minimizing the use of air conditioning and policies for promoting these solutions, based on the work of the European CoolLIFE project.

Agenda

11:00	Round of introduction
11:10	Presentation of the CoolLIFE project and main outputs (by Simon Pezzutto, EURAC)
11:25	Presentation of the CoolLIFE tool (by Simon Pezzutto, EURAC)
11:30	Open discussion about the CoolLIFE tool and space cooling policies
12:00	End of the workshop

Participants

External participants:

- *Federico Benvenuti, Carmen Gangale – Italy’s National Contact Points of the LIFE programme,*
- *Federica Cortesini, Enrico Bonacci – MASE (Ministry of Environment and Energy Security)*

CoolLIFE participants:

- *Simon Pezzutto, Riccardo Fraboni, Flavia Trovalusci – EURAC*

Summary of the discussions

There is a need for planning incentive and regulatory measures. Tools like the CoolLIFE tool provide a knowledge base that helps legislators plan and direct resources correctly. Integrating national databases on building stock to offer tools to legislators and the market (energy service providers/designers, etc.).

First questions about the CoolLIFE tool were about the data sources and how the data were validated. It was explained that the data is generated by Eurac Research and is available as open-source on GitLab. For validation, the project includes pilot studies: municipalities provide feedback based on their use of the tool, and comparisons are made between their own data and the tool's outputs. With the follow-up project ReLIFE, EURAC aims to improve the GIS-based dataset, working more precisely.

It was mentioned that olito is developing a tool very similar to ReLIFE (solar and thermal observations studying individual buildings to provide an output of energy classification/installation of renewable sources, etc.).

The questions continued about the purposes of the tool and its intended uses. Referring to Article 25 of the Energy Efficiency Directive (EED), the tool is especially relevant for national comprehensive assessments, and municipal heating and cooling plans. The most important aspect would be the economic and financial evaluation of Heating & Cooling (H&C) measures, particularly for municipalities, and helping them choose the most suitable options.

Practical questions followed about the timeline of the project. The tool will be shared with ministries. By the end of April, there will be a meeting with the Greek Ministry in Athens. An online tutorial has already been recorded and made available.

Participants mentioned that it would be helpful to gather structured feedback from other MASE colleagues. Such feedback is welcome, particularly on how useful the tool is for creating comprehensive assessments and National Energy and Climate Plans (NECPs). The goal is to use that feedback to further improve the tool.

Participants found the CoolLIFE tool interesting. For the comprehensive assessment modeling, MASE usually works with public agencies like GSE (Gestore Servizi Energetici). For the PNIEC (Italian NECP), RSE (Ricerca sul Sistema Energetico) leads the process, followed by GSE and ENEA.

Participants suggested to contact ANCI (National Association of Italian Municipalities), the Agenda 21 Coordination or the Covenant of Mayors to promote networking on the project within municipal associations.

Participants asked whether an Italian version of the tutorial is planned. Which could indeed be prepared.

CoolLIFE could also be included in one of the regular communications about Italian LIFE projects.

Integrating Space Cooling into National Energy Planning: the Austrian Experience with Comprehensive Assessment on heating and cooling

Factsheet prepared by Aadit Malla (TU Wien) | July 2025

Background and objectives

Under Article 25(1) of the recast Energy Efficiency Directive (EED, (EU) 2023/1791), all EU Member States are required to carry out a **comprehensive assessment of the potential for efficient heating and cooling**. These assessments must be updated every five years and are intended to support long-term planning efforts that align national infrastructure and investment decisions with the EU's broader energy efficiency and climate targets. The comprehensive assessment on heating and cooling shall now be attached to Member States' National Energy and Climate Plan (NECP), linking in practice the assessment on heating and cooling with the umbrella planning on energy and climate.

Annex X of the EED outlines what these assessments should include—such as an overview of heating and cooling demand across sectors, an evaluation of cost-effective efficiency measures, and an analysis of the potential for integrating renewable energy, high-efficiency cogeneration, and district energy systems. Importantly, the assessments should also take a forward-looking view, exploring future scenarios while incorporating spatial data and regional development plans.

Although **cooling** is explicitly part of the scope, it has **often been underrepresented** in past assessments (in 2015 and 2020). This is partly due to the low share of cooling in most Member States' final energy consumption (compared to heating), but also due to a lack of robust data, and because cooling demand tends to be more fragmented and harder to forecast than heating. However, rising summer temperatures, growing urban populations, and increasing demand for indoor comfort are making space cooling a more pressing policy issue—both in terms of energy demand and grid impacts.

Austria's 2024 Comprehensive Assessment makes a conscious effort to address this gap. With support from the CooLIFE project, the assessment includes a detailed and structured analysis of current and future cooling needs, providing a **practical example of how space cooling can be better integrated into national energy planning**. This document presents Austria's experience as a good practice case, with the aim of supporting other Member States in developing their own approaches to cooling within the framework of Article 25 EED.

Methodology

Austria's assessment of space cooling demand was based on a structured, **bottom-up modeling** approach developed in the CooLIFE project. The main tool used was the Invert/EE-Lab model, an established simulation framework designed to assess energy demand and efficiency potentials in the building stock. The model combines national building data, climate assumptions, technology characteristics, and behavioral parameters to estimate current and future demand under different scenarios.

The CoolLIFE project has received funding from the LIFE Programme of the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

The methodology follows a multi-step process. First, it defines the physical characteristics of Austria's **building stock** using archetypes differentiated by construction period, renovation status, and building type (residential and non-residential). These archetypes are then linked to passive parameters (e.g. thermal mass, insulation, window performance, shading devices) and active cooling systems (e.g. air conditioners, heat pumps), allowing for the simulation of both useful and final energy demand for space cooling.

Second, **several scenarios** were developed to explore how demand could evolve **toward 2050**, depending on the uptake of passive measures, the market penetration of active technologies, and the level of technological improvement. The "WEM" (With Existing Measures) scenario reflects a conservative pathway based on current trends, while the "Transition" scenario assumes more ambitious renovation and adaptation efforts in line with climate neutrality goals. Climate change effects are also accounted for using a projected temperature increase of 0.8°C by 2050.

In terms of indicators, the model calculates **useful energy demand** (the energy required to meet comfort needs), **final energy demand** (after accounting for technology performance), and **related costs**. The cost analysis includes capital costs for passive and active systems, operational costs (especially electricity use), and considers the effect of different efficiency levels. This enables a **comparison of the cost-effectiveness** of passive cooling solutions against the provision of cooling through active systems.

Data sources include EUROSTAT (for sectoral energy use), national statistics from Statistik Austria, prior studies (e.g. Krutzler et al., 2023; Kranzl et al., 2022), and outputs from the Austrian NECP. For the service sector, where data on installed cooling systems is limited, estimates were derived from previous EU-funded research using stock inventory methods and assumed energy performance levels.

The methodology is **transparent, modular, and designed to be transferable**. It can be applied by other Member States using their national data and adapted to regional planning contexts. While the CooLIFE platform also supports spatial visualization of energy indicators, the analysis done for Austria's comprehensive assessment on heating and cooling focused primarily on aggregated national-level results.

Implementation

In Austria, the comprehensive assessment is coordinated by the **Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK)**, which holds responsibility for submitting the report to the European Commission. For the 2024 update, the ministry commissioned TU Wien and e-think energy research to provide technical support, particularly for modeling energy demand and evaluating the role of space cooling.

TU Wien and **e-think research** applied the Invert/EE-Lab model to simulate current and future cooling demand, using national statistics, building archetypes, and technology data. **Two main scenarios** were developed over multiple rounds of discussions with BMK: the "With Existing Measures" (WEM) scenario, reflecting current trends, and the "Transition" scenario, which assumes more ambitious renovation activity, higher uptake of passive measures, and improved technology performance.

The analysis included **sensitivity tests** on behavioral changes, market uptake, and efficiency levels. Compared to previous assessments, this version represents a clear evolution by **integrating cooling more systematically into national planning**, using methods developed through the CooLIFE project.

Results and impacts

The results show a potentially sharp increase in cooling energy demand, especially in the residential sector, in the absence of policy or technical interventions. However, even moderate implementation of passive measures significantly reduces energy use and delays the need for active system expansion.

Key findings include:

- In most scenarios, **the cost of saving energy through passive measures is lower** than the cost of supplying space cooling via active cooling systems.
- **Passive measures help mitigate peak demand**, supporting grid stability and reducing long-term infrastructure needs.
- **Efficiency improvements** in active cooling technologies (e.g., higher seasonal performance factors) have a **strong influence** on total energy and cost outcomes.
- The **Transition scenario**, which includes more ambitious uptake of both passive and efficient active technologies, results in **substantially lower final energy demand by 2050**.

For more details, see the report of Austria's 2024 comprehensive assessment (in German).

Lessons learnt

From the implementation side, integrating cooling into the CA required additional data sources, new modeling routines, and close coordination between national statistics, technical modeling teams, and policymakers. One challenge was dealing with limited historical data on cooling systems, especially in the service sector. This was addressed using disaggregated technology stock estimates and assumptions from previous EU-level studies (e.g. Kranzl et al. 2022).

From a policy perspective, the inclusion of space cooling improved the comprehensiveness and policy relevance of the assessment. It helps highlight the role of energy efficiency and demand-side measures in the cooling sector, and it provides a transparent framework for evaluating future investment needs and strategies.

The Austrian case shows that it is feasible—and valuable—to integrate cooling into national energy planning using structured methods and realistic scenarios. The approach developed through the CooLIFE project is applicable in other Member States and can support the broader effort to align national planning with EU climate and energy objectives.

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Εξοικονομώ-Αυτονομώ (Exsoikonomo-Autonomo) – Residential Energy Renovation Programme (Greece)

Factsheet prepared by Evangelos Kyrou (ABUD) | July 2025

Background and objectives

The “Exsoikonomo” programme is Greece’s flagship residential deep energy renovation scheme, which was introduced to raise Greece’s sluggish renovation rate and reduce household energy consumption.

It was initially launched in 2013, as the continuation of the successful Programme “Energy Saving at Home”. The latest iteration, “Exsoikonomo-Autonomo”, was launched in December 2020 with higher subsidy rates and more streamlined processes, designed to:

- Improve residential building energy performance and reduce energy bills.
- Enhance comfort, including a growing emphasis on summer overheating control and space cooling concerns.
- Promote active and passive technologies in Greek homes.
- Decrease carbon emissions from the residential sector.

The programme is aligned with the EU Renovation Wave objectives and funded under the National Recovery and Resilience Plan “Greece 2.0”. The target is to upgrade the Greek housing stock and tackle energy poverty, via tailored grants and loans administered by the Ministry of Environment and Energy. Specific operational objectives include:

- **Energy savings**: Achieve at least 30% reduction in primary energy use per dwelling.
- **Scale**: Renovate tens of thousands of residences per year, with quotas per region to ensure balanced uptake.
- **Equity**: Prioritise vulnerable households via an explicit low-income budget (€100 M) and extra top-up rates.
- **Quality**: Promote high-performance interventions, i.e., insulation, efficient HVAC, solar thermal, executed by certified professionals.

Key features

Eligibility: Private homeowners, i.e., houses, apartments, and multi-apartment buildings (when ownership structure permits collective works).

Subsidy rates: 40-85%, depending on income category, type of intervention, and building location:

- 65-85% for lower-income households (≤ €20k annually), including energy poverty and COVID-19 bonuses [income brackets determine base subsidy from 55% to 65% of eligible costs, plus a 10% “energy-poverty” premium and a 10% “COVID-19” bonus (up to 85 % total)].
- 40-65% for higher-income applicants.

Interest-free loan supplement via Hellenic Development Bank covers the remaining expenses.

Eligible measures include:

- Thermal envelope upgrades: Thermal insulation (walls, roof, floor) and replacement of window frames.
- Installation of heat pumps, A/C units and high-efficiency HVAC systems.
- Solar thermal systems and PV panels.
- Shading systems, e.g., blinds, awnings, external solar protection.

The CoolLIFE project has received funding from the LIFE Programme of the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

- Passive cooling strategies, e.g., night ventilation, white-roof treatments.
- Smart-home energy monitoring and automation systems.

There are **expenditure caps**, e.g., a maximum of €6k for solar water heaters, €25k for solar thermal installations. Moreover, there is loan complement – partner banks, e.g., NBG and Eurobank, offer "eco-loans" covering up to 70% of project cost, with a fixed rate and no pre-notation mortgage.

Energy performance requirements: Achieve at least a 3-class improvement in EPC rating or reach class B (steady-state). Third-party inspections (energy audits) pre- and post-implementation are mandatory for each household.

Implementation

Governance:

- **Ministry of Environment & Energy** (MoEE) (ΥΠΕΝ): Programme design, legal framework and overall supervision.
- **Technical Chamber of Greece** (TEE): Administrative coordination and help-desk support.
- **Centre for Renewable Energy Sources** (CRES, Greek energy agency): Monitoring, measurement, control and verification of savings under "Autonomo" phase.

Additional support: Hellenic Development Bank (HDB) and other banks, e.g., NBG and Eurobank.

Application process: Performed via online platforms with support from certified energy auditors and contractors. Documents required include Energy Performance Certificate (EPC) calculation and income declaration.

Energy audits: Conducted before and after work to verify compliance. Linked to KENAK standards (Greek Building Energy Code), including summer-comfort metrics.

Timeline: Projects must be completed within approximately 12 months after contract approval.

Customer journey:

1. Homeowner registers and submits basic data via gov.gr portal or regional TEE offices.
2. Energy audit and cost-quotation by accredited technician.
3. Online submission of application; grant decision within statutory timeframe (~90 days).
4. Contracting works, completion, inspection, verification, and final grant disbursement.

Evolutions & IT improvements:

Post-2021 digital platform enhancements streamlined document upload and eased audit scheduling, thus reducing dropout rates by an estimated 20%.

Budget (or other cost data)

Programme budget (for 2021 cycle): €632 million (75% subsidy rate, plus regional/top-up premiums):

- Dedicated allocations, e.g., €100 million for low-income households.
- An additional €110 million tranche has opened since 2023, exclusively for energy-vulnerable households.

Total allocated funding for 2021-2026: €1.3 billion (across multiple cycles, i.e., 2021, 2023, and 2025).

Source of funding: EU Recovery and Resilience Facility, Cohesion Funds, and national contributions.

Caps: €50,000 per home, €80,000 for type B buildings, €290,000 for multi-apartment buildings.

- Interest-free loan (100% interest subsidy), with caps based on household and building type.

Results and impacts

Outputs (by 2019):

- Approximately 130,000 buildings had been renovated under "*Exoikonomo I & II*" (2010-2019). Similar uptake was expected with the "*Autonomo*" round.
- Annual energy savings **853 GWh/year** (30% per building) and approximately **612 kt CO_2/year** reduced.

Outputs (by 2024):

- Over 120,000 applications had been submitted (2021-2024) (with a growing interest in shading and cooling upgrades), from which over 30,000 applications had been approved nationwide. Total approved applications amounted to contracts worth over €220 million.
- Dedicated roll-out in energy-vulnerable segment: 2,500 households were supported in the second phase alone.
- Estimated annual energy savings **>1,000 GWh/year** (average ≥32 % primary energy reduction per dwelling) and carbon emissions savings **~300 ktCO_2/year**.

Shift in priorities: While early rounds focused on heating and insulation, recent calls showed growing uptake of space cooling and shading solutions, i.e., "*Exsoikonomo-Autonomo*" prioritised space cooling through both shading and insulation.

Social benefits: Average energy bill savings **~€450/year** per household, improved thermal comfort, health, and living standards overall, increased property value, heated interest and increased market for energy service companies (ESCOs), energy auditors, smart-home systems and other automation technologies.

Lessons learnt

- **Integrating summer comfort** criteria in building programmes is key in a Mediterranean country; while initial programmes underemphasised passive cooling, shading strategies are now becoming essential. Demand for solar-shading devices and A/C units rose significantly after 2022 heat waves.
- **Energy inspection** compliance added rigor and clarity, distinct pre- and post- inspection improved outcomes.
- **Digital resilience**: Digital simplification (e-platform, online submissions) reduced complexity and improved accessibility. Process simplification, e.g., digital platform and pre-approved contractors, improved uptake. Early platform overloads led to multiple "*application windows*" and staggered regional launches; robust server scaling was critical.
- **Equity** remains a key concern, as low-income homeowners still face financial barriers and often struggle to pre-finance renovation works, despite high subsidy rates. The dedicated €110 million budget tranche proved essential to effectively reach vulnerable groups, although uptake remained limited until targeted outreach campaigns were launched.
- **Grant-loan synergy** effectively addressed key market barriers: 70% of participants stated that they would not have proceeded with renovations without subsidies.
- **Stakeholder coordination**: Close collaboration between the Ministry of Environment and Energy (MoEE/ ΥΠΕΝ), the Technical Chamber of Greece (TEE), and the Centre For Renewable Energy Sources (CRES) improved audit consistency, although continued training for inspectors remains necessary.

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Interview with Stefanos Pallantzas (Hellenic Passive House Institute, HPHI)

Interviewee: *Stefanos Pallantzas, Civil Engineer (NTUA), Passive House Certifier, Hellenic Passive House Institute (HPHI), experienced professional with the "Εξοικονομώ-Αυτονομώ" scheme,* **Date**: July 6, 2025, **Place**: Athens

1. What was the original inspiration behind the "Εξοικονομώ-Αυτονομώ" scheme?

The initial inspiration behind the "Εξοικονομώ-Αυτονομώ" scheme was multifaceted, emerging from the need to address major challenges in Greece's building sector. Key motivations included the necessity for substantial energy efficiency improvements and reduced energy consumption, given that the majority of Greek buildings are old and highly energy-intensive. Improving energy performance aimed to lower the country's energy footprint and reduce household energy costs. Simultaneously, improving the quality of living and residential conditions through energy renovations was another important goal, aiming to provide enhanced thermal comfort, reduced operational expenses, and increased property values. The programme was also strategically envisioned as an economic stimulus to support local employment, particularly in the construction sector and related fields such as engineering services and building-materials supply.

Notably, the "Autonomo" aspect of the scheme placed emphasis on energy autonomy and the optimal integration of renewable energy solutions and passive-house principles. This component reflected a growing understanding of the necessity for a holistic and ambitious approach to building design, aimed at achieving higher levels of energy independence and sustainability, aligning with the standards of passive and nearly zero-energy buildings (nZEB).

Moreover, environmental protection and addressing climate change were significant drivers. The scheme was directly aligned with Greece's commitments under EU climate policies, specifically regarding emissions reduction from buildings and achieving European climate targets for 2030 and beyond. The scheme also served the critical purpose of complying with European directives and legislation, particularly the Energy Performance of Buildings Directive (EPBD), thus ensuring that national policies matched European regulatory expectations.

2. What challenges arose during its development or implementation?

Major challenges during implementation included bureaucratic complexity, such as extensive paperwork, slow approvals and fund disbursements, and frequent changes to guidelines, which caused confusion among participants. Financial obstacles were also significant, as rising construction material and labour costs (exacerbated by the energy crisis and geopolitical developments) often exceeded the initially allocated budgets, forcing homeowners to contribute more than expected. In addition, access to interest-free loans was restricted by creditworthiness criteria, excluding many lower-income households.

Technical challenges included widespread urban planning irregularities, inconsistent material and construction quality, and coordination issues within apartment buildings. Furthermore, limited public awareness, particularly during the COVID-19 period, and a shortage of qualified professionals hindered effective implementation, contributing to suboptimal renovations and the persistence of energy poverty.

3. Which factors contributed most to its success, and how are these related to cooling measures?

Although Mr. Pallantzas believes that no version of the "Εξοικονομώ" programme has fully achieved its potential, he highlights several positive factors that distinguished the "Exoikonomo-Autonomo" scheme from previous editions. The substantial subsidy rates, reaching up to 90% in some cases with a budget ceiling of €50,000, acted as a powerful economic incentive, enabling even deep retrofits aligned with passive house standards. Rising energy costs, especially in the wake of the energy crisis, increased public awareness of heating and cooling expenses, further enhancing the scheme's attractiveness.

Additionally, the prospect of increased property value provided a strong secondary incentive for homeowners to invest in upgrades.

Notably, the scheme supported the installation of mechanical ventilation systems with heat recovery, addressing indoor air quality issues, such as mould and moisture, while reducing overall energy demand. Mr. Pallantzas expressed particular satisfaction in having contributed to the inclusion of this measure. Furthermore, the scheme incentivised the adoption of renewable energy technologies, including PV systems and solar thermal installations, which promoted energy autonomy and contributed to meeting Nearly Zero-Energy Building (nZEB) goals.

In terms of sustainable cooling solutions, the programme indirectly encouraged measures that support summer thermal comfort and reduced reliance on active cooling systems. These measures included better insulation, airtightness, shading, and mechanical, natural, or mixed ventilation principles.

Finally, although the programme did not explicitly mandate passive house standards, it successfully raised awareness and market interest in high-performance building practices, paving the way for future advancements in sustainable and climate-resilient architecture.

4. **How has the scheme evolved (main changes, etc.) in recent years?**

The “Εξοικονομώ” scheme evolved through successive iterations (notably in 2021, 2023, and 2025), aiming to simplify application procedures and improve accessibility, though these changes had limited success. The budget reduction from €50,000 to €30,000 per dwelling led to lower-quality and less ambitious interventions. While the scheme continued to prioritise vulnerable households, the available support remained insufficient to fully cover costs, leaving many low-income applicants unable to participate meaningfully.

The persistent challenge of including apartment buildings remained unresolved, and the programme’s "*spreading funds thinly*" approach further weakened its effectiveness. Efforts to digitise processes and reduce bureaucracy have also had limited impact so far. According to Mr. Pallantzas, these cumulative changes have eventually reduced the programme's potential rather than enhancing its efficacy.

5. **What future developments or adaptations are planned? What are the main challenges for the coming years?**

Future plans indicate a shift towards a more advanced model, emphasising the energy renovation of vulnerable households, integrating geographical and social criteria, and increased involvement of energy providers. However, Mr. Pallantzas expresses concern that the programme continues to focus on individual applicants (citizens) rather than on buildings as the core renovation target.

Looking ahead, several major challenges remain. These include addressing Greece’s aging and poorly insulated building stock, effectively incorporating apartment buildings (with full subsidies where necessary), and better tailoring financial mechanisms. While grants should remain available for low-income households, middle-income households could instead benefit from interest-free loans or tax incentives. Stronger promotion of deep renovations to achieve Nearly Zero-Energy Building (nZEB) standards is also essential.

In addition, widespread training programmes are needed to address professional knowledge gaps and enhance the quality of energy upgrades. Finally, Mr. Pallantzas stresses the urgent need to revise the current KENAK energy code, which sets only minimum and often insufficient requirements, to enable more ambitious and impactful energy efficiency improvements across the sector.

6. **If you could go back in time, what do you think could have been done differently?**

Mr. Pallantzas stresses that the program should have prioritised deep renovations and nZEB/passive building standards from the outset, establishing more ambitious energy performance targets rather than merely incremental improvements. Simplifying administrative procedures, including fewer required documents and user-friendly digital platforms, could have reduced delays and increased engagement. Pre-approvals for standardised interventions, faster subsidy disbursement (including larger upfront payments), and incorporating simplified processes for resolving minor urban planning irregularities would have further streamlined participation.

Moreover, ensuring higher quality materials and installations, alongside comprehensive certification and training programs for engineers and construction teams, could have significantly improved outcomes. Additionally, a clear, targeted public information campaign, emphasising both economic and quality-of-life benefits, would have reduced scepticism and increased uptake, fostering a strategic, holistic approach focused on sustainable long-term building efficiency rather than short-term financial distribution. He concludes that political and scientific reasoning were often overridden by short-term populist thinking and reactive decision-making.

Greek National Heatwave Plan (Εθνικό Σχέδιο Διαχείρισης Καύσωνα) & Athens Chief Heat Officer / Urban Cooling Initiative

Factsheet prepared by Evangelos Kyrou (ABUD) | July 2025

Background and objectives

Greece has experienced an intensification of extreme heat events, with temperatures regularly exceeding 43 °C, especially in dense urban zones like Athens. In fact, Athens is one of Europe's hottest capitals.

In response, the **Greek National Heatwave Plan** was launched in 2022 by the Ministry of Health, in coordination with EODY, the Civil Protection Authority, and EMY (National Meteorological Service), in order to reduce heat-related morbidity and mortality.

Meanwhile, Athens has become a leader in heat resilience and pioneered in municipal heat resilience by appointing Europe's first **Chief Heat Officer (CHO)** in 2021, in partnership with the Adrienne Arsht-Rockefeller Foundation Resilience Canter and C40 Cities, becoming the first city globally to hire a CHO. The goal was to orchestrate citywide measures to protect residents from extreme heat, by leading efforts to mitigate the urban heat island effect, enhancing public cooling infrastructure, while institutionalising long-term urban adaptation planning.

Athens now embeds "*cooler city*" strategies into planning. Measures include urban greening (planting pocket parks and shade trees to lower street temperatures), reusing water from an ancient aqueduct for irrigation, and promoting simple fixes, like whitewashing building exteriors and installing exterior shutters to block sun. The city has published design guidelines for cool public spaces (using materials and landscaping to dissipate heat). Implementation is driven by the municipality and resilience partners, with community engagement. While quantitative energy savings are still being assessed, Athens's example highlights leadership and planning as "*policy lab*" for urban cooling.

Key features

The programme key features can be categorised into three aspects, as follows:

1. **Early Warning & Communication:**
    - Multi-level heat alerts (categories 1-6) issued by EMY and the National Observatory, based on historical mortality and weather data.
    - A heat-health risk algorithm and a public "*heatwave survival guide*" provides guidelines and practical advice, i.e., hydration, timing outdoor activities, staying indoors or in other cool places, and seeking public cooling facilities, via municipal communication channels, media and SMS.

2. **Cooling Infrastructure & Behavioural Measures:**
    - **Passive urban cooling initiatives**: tree planting and awareness campaigns, façades whitewashing, shading canopies, expansion of green infrastructure, e.g., cool corridors, establishment of cooling routes and cool neighbourhoods with increased shade and vegetation, and pocket parks in dense urban zones. An example of urban cooling initiative in Athens municipality is the reuse of the ancient Hadrian's aqueduct for sustainable irrigation and revitalisation of urban parks and green space.

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- Activation of **"*Cooling Centers*"** across many municipalities during heatwaves**,** established city-wide in libraries, community halls, and public buildings; used by approximately 35,000 people during the summer of 2023. Moreover, Athens launched the *Extrema* mobile app, integrating GIS mapping for identifying nearby cooling centres and safe walking routes.
- **Operational & behavioural changes**: relaxed dress codes for public employees, shifted working hours for municipal facilities, night-time ventilation in public spaces, and monitored outdoor working schedules.

3. **Coordination Across Actors & Leadership**
   - Local "*heat action teams*" established across municipalities, linked to pandemic-like capacity**,** to prepare and operate during heat events, by focusing on vulnerable groups.
   - Interagency partnerships emphasised in Athens: municipal and NGO collaboration, e.g., Red Cross trainings, Mayor's office and urban planning departments coordination with NGOs Resilience Center, Chief Heat Officer (CHO)'s office setting city targets, and health services to protect vulnerable groups, including elderly, homeless, and chronically ill.

Specifically for Athens under **CHO** leadership, it has implemented passive and nature-based solutions, including:

- **Building retrofits**: encouraging white exterior paints and external shutters to reduce heat absorption.
- **Urban greening**: creating *pocket parks*, planting trees on streets and squares to shade surfaces and cool the air.
- **Design guidelines**: use of heat-reflective materials and water features in public spaces.
- **Using ancient aqueduct water**: irrigating new green belts and fountains to increase evaporative cooling.

Implementation

The launch of the National Heatwave Plan in 2022 was coordinated by the **Ministry of Health**, in collaboration with the **Civil Protection Authority** and **EODY**, with the target to mitigate health risks and reduce heat-induced illness and deaths through coordination across different levels of government and the healthcare system. The main aspects regarding programme implementation and involved actors are summarised below:

- **Lead agency**: Ministry of Health, Civil Protection Authority & EODY oversee public-health communication, issue annual updates and lead nation-wide guidance for municipalities.
- **Other actors:** EMY and National Observatory of Athens provide climate forecasting and heat warnings/ alerts.
- **Municipal level and activation timeline:** Each municipality is responsible for preparing "*Cooling Center*" lists, forming local heat action teams, and submitting heat readiness reports by 31 May each year. Activities and operations run between **June-August**; however, pre-summer assessments occur between **March-May**.
- **Public awareness**: TV, radio, website alerts, SMS, and municipal communication channels complement local campaigns.
- **Chief Heat Officer (CHO)**: In Athens, the CHO operates from the "*Municipal Climate Resilience Office*", collaborating with urban planners and international partners, e.g., UN-Habitat, C40 Cities. Athens CHO office, established by Mayor Kostas Bakoyannis, partners with *Arsht-Rockefeller Foundation* and *C40 Cities* for programme design.
- **Digital tools**: A GIS-based heat action dashboard & the *Extrema Global* mobile app identify safe public routes and air-conditioned centers.

Budget (or other cost data)

Funding: No major new budget is dedicated, **no fixed or centralised national budget**; resourcing is supported through **municipal operational budgets**, **EU Recovery & Resilience Facility (RRF)** for adaptation infrastructure and communications, and **international partnerships** (Arsht-Rock, Red Cross Climate Centre, UNDP). For instance, existing city maintenance funds were reallocated, e.g., more tree planting in planned budgets.

Athens municipal budget: **~€120,000/year** (2022-2024) dedicated to *Cooling Center* operations (including staffing such as doctors, nurses, or social workers), public campaigns and city awareness efforts**,** shade canopies, app and heat-mapping tool maintenance**,** media outreach**,** Chief Heat Officer (**CHO**) coordination, and equipment deployment.

Results and impacts

As a result, Athens now has an organisational structure for heat, i.e., CHO, dozens of micro-parks ("*cool islands*"), and water misting points have been installed. Preliminary monitoring indicates shaded areas are **~2°C** cooler. Though difficult to quantify yet, these interventions are expected to reduce heat-related illness and air-conditioning usage. Athenians report immediate benefits, e.g. shaded streets are comfortable. The list below summarises key impacts:

- **Cooling-center engagement**: 7 cooling centres in Athens, **35,000+ visits** during summer 2023 heatwaves.
- **Public awareness**: **~70%** of residents in Greater Athens report awareness of heat-health recommendations and heat mitigation actions; many now use *Extrema App* to locate cooling centres and safe walking routes.
- **Resilience building & Increase of green spaces and infrastructure projects**: **~10,000** trees planted since 2021, expansion of urban shade via pocket parks, cool façades, and upgraded ventilation in schools and libraries. Irrigation via Hadrian's aqueduct cools urban hotspots.
- **Global recognition**: through the introduction of the CHO role, as well as a *heatwave categorisation system* (developed in collaboration with *Meteo.gr* to classify heat events based on anticipated health risk, which triggers warning protocols and preparedness actions based on heatwave severity). Athens' **CHO model** is now being replicated in Dhaka, Santiago, Freetown, Miami, and Los Angeles. It is recognised at **COP28** and is featured by **C40 Cities**, the **World Bank**, and **UN-Habitat**.

Lessons learnt

- **Municipal leadership is key and transformative:** Leadership and cross-department teamwork are critical. CHOs can accelerate climate-health strategy adoption and align climate-resilient urban planning agendas.
- **Public engagement strengthens trust, while increasing effectiveness and targeting of interventions:** A key insight is that public awareness through the CHO communications increases support for such changes. Athens, for instance, shows how even a dense Mediterranean city can leverage cultural heritage (aqueducts) and low-tech fixes (façade whitewash) for cooling.
- **Low-cost passive cooling strategies can deliver high-impact, measurable health benefits:** Behavioural and operational interventions, e.g., relaxed dress codes, adjusted working hours, are effective and fast to deploy, low-capital and high-impact.
- **Digital mapping tools offer significant diagnostic value:** Cooling-centre usage and app data enable municipalities to improve targeting and coverage of interventions.
- **Monitoring deficiencies in the digital diagnostics still exist and should be improved**: There is need for systematic tracking of indoor temperatures, visits, and health outcomes, related to the cooling centres.
- **Support for municipalities should expand to ensure nation-wide capacity for heat resilience:** Greater support is needed for smaller municipalities, lacking **technical or financial capacity**, to cover coordination gaps and meet operational standards.

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Interview with Dr. Eleni (Lenio) Myrivili – Global Chief Heat Officer, UN Habitat & Arsht-Rock

Interviewee: **Dr. Eleni (Lenio) Myrivili** – Chief Heat Officer, City of Athens (2021-2023)

1. What was the original inspiration behind the "Athens Chief Heat Officer" initiative?

The Athens CHO initiative was rooted in the city's earlier participation in the *100 Resilient Cities* programme, which launched in 2014. During her time as Chief Resilience Officer, Dr. Myrivili led a broad participatory process that involved close to 1,000 interviews with citizens, stakeholders, and experts. Through this process, extreme heat emerged as a top public concern, signalling the need for a new governance approach to urban climate risks. The initiative was designed not only to deliver technical solutions, but also to shift urban culture, while engaging the public in meaningful co-design of urban resilience strategies and encouraging collaboration across departments and with private and civil society actors.

The appointment of a Chief Heat Officer (CHO) for Athens in 2021, supported by the Atlantic Council's Climate Resilience Center (formerly the Arsht-Rock Resilience Center), built on this foundation. Athens became the first city in Europe to establish such a role. The CHO had direct mandate and access to the Mayor, which gave the position visibility and influence across multiple departments. The initiative aimed to promote a holistic heat resilience strategy with a clear urban narrative that would resonate both locally and internationally.

2. What challenges arose during its development or implementation?

Despite its innovative character and visibility, the CHO initiative faced several structural challenges. As the position was advisory and not elected or administrative, it relied heavily on political support and soft power rather than formal authority. There was no dedicated municipal budget allocated to the CHO's agenda, which limited its capacity to act and implement. Most resources were secured through MoUs (i.e., *Memoranda of Understanding*) with academia and other public or private partners, or through small project-based grants from Arsht-Rock, complemented occasionally by municipal funding for aligned actions.

Another challenge was that climate adaptation was not a top priority within the city's broader political agenda, which sometimes made it difficult to drive change across departments. Internal silos, bureaucratic inertia, and competing priorities often slowed progress. Moreover, reaching vulnerable populations, e.g., the elderly, low-income residents, or those living in refugee camps or housing, was complicated by incomplete data and limited outreach infrastructure. While the role generated significant awareness, translating this into systemic policy shifts required further institutional backing.

3. Which factors contributed most to its success?

Several elements were pivotal to the initiative's early success. First and foremost was the direct link to the mayor's office, which ensured that the CHO had access to decision-making spaces and visibility at the highest level. This political positioning was essential for mobilising support across departments and for attracting media attention. The initiative received significant local and international coverage, which helped elevate heat as a mainstream climate concern and boosted public engagement.

Substantively, the CHO office developed key tools to enhance heat preparedness in the city. These included Athens' first heatwave categorisation system in collaboration with Meteo.gr, along with the development of early warning protocols, municipal hotlines, and clinical guidelines for the health sector to respond to extreme heat events [*i.e. to guide medical professionals how to prevent or treat heat-related illness during extreme events*]. Moreover, the initiative promoted the link between urban greening and cooling, contributing to major public investment in park renovations and urban nature. The public narrative shifted as citizens increasingly understood the importance of shade, greenery, and public space in managing rising urban temperatures.

4. How has the scheme evolved (main changes, etc.) in recent years?

Following Dr. Myrivili's tenure, the CHO initiative has been further institutionalised within the Municipality of Athens. Her successor, *Elissavet Bargianni*, continues the role from within the city administration, ensuring continuity. The scope of work has been refined into a more structured Heat Action Plan, with clearer metrics and implementation pathways. Mapping of vulnerable groups has improved, and coordination with national frameworks, such as the National Heatwave Plan and Civil Protection alerts, has become more integrated.

The initiative has moved from being a high-level pilot to an operational policy stream within the city. It now supports the development of more systemic resilience-building efforts, spanning from neighbourhood-level interventions to broader strategic planning. While resource challenges remain, the institutional memory and public awareness generated by the initiative have laid a strong foundation for future action.

5. What future developments or adaptations are planned? What are the main challenges ahead?

Although Dr. Myrivili is no longer directly involved with the municipality and cannot speak to its current plans, she outlined several priority actions that she personally considers essential to advancing urban heat resilience in Athens. Firstly, she stressed the importance of securing a stable, multi-year budget specifically dedicated to heat adaptation projects, alongside scaling data-driven outreach and support services targeted at elderly and low-income households. Moreover, she emphasised the need to formally embed heat metrics and related regulations into local building codes, urban planning processes, and renovation schemes.

In relation to public space management, she recommends adopting the comprehensive Heat Risk Reduction Guidelines developed specifically for the Athens Metropolitan Area. Further, she highlights the necessity of closer collaboration across multiple levels of government to streamline policy implementation, financing, and coordination. Dr. Myrivili also envisages practical infrastructure and mobility transformations, including establishing a fleet of small municipal buses, prioritising slow and sustainable mobility, and reducing car usage in the center of Athens.

Additional key measures include setting regulations for sustainable air-conditioning use, introducing clear cooling targets, pedestrianising major urban streets, and creating vertical, densely forested green corridors across the city. She also proposes using compact, mobile sewage-treatment units for efficient park irrigation, allocating dedicated funding for urban tree care and biodiversity protection, and developing a robust network of public drinking-water fountains.

Together, these comprehensive actions would significantly strengthen Athens' resilience against heat risks, enhancing both the urban environment and public health.

6. If you could go back in time, what do you think could have been done differently?

Reflecting on her tenure, Dr. Myrivili notes that, given the opportunity, she would have placed greater emphasis on securing a stable and dedicated budget, along with a formal mandate to ensure effective, institutionalised cross-departmental coordination. She also highlights the importance of establishing clear and measurable targets, particularly for urban cooling strategies and outreach to vulnerable communities, enabling better tracking of impact and effectiveness.

In addition, Dr. Myrivili emphasises that she would have advocated more strongly for the comprehensive actions outlined in her vision for the future (as described in her response to question 5), to accelerate Athens' resilience against heat risks.

Hamburg Green Roof Strategy

Factsheet prepared by Adrienn Gelesz (ABUD) | July 2025

Background and objectives

In cities, where concrete and asphalt absorb and radiate heat, the **Urban Heat Island (UHI)** effect increases the need for space cooling. High outdoor temperatures hinder nighttime ventilation and cause a rise in the energy use of space cooling devices. Tackling UHI is important for reducing space cooling demand. UHI can be addressed in policies on local / municipal levels, through smart urban planning and strategies that promote **green infrastructure** like pervious paving, Nature-based Solutions, including green roofs. Hamburg is an example where the installation of green roofs is successfully promoted through policy measures. Green roofs help reduce indoor temperatures and combat UHI by increased insulation level and using evapotranspiration to release moisture into the air, which not only lowers energy demands for air conditioning but creates a more comfortable and sustainable living environment.

The **Green Roof Strategy of Hamburg** was launched in 2014 as part of water-sensitive and heat-adapted urban and open space development to activate previously untapped open space potential, develop opportunities for the multiple use of open spaces, and contribute to climate protection and adaptation. Hamburg was the first major German city to launch such a comprehensive green roof strategy, where the success of the program is due to its comprehensive nature: it encompasses four levels of action: **promotion, dialogue, demand, and support.** The initiative is in constant evolution, now including green walls and raising the bar through requiring mandatory installation of green roofs in the building codes. The scheme was developed by the Free and Hanseatic City of Hamburg, which is both a municipality and a city-state within the Federal Republic of Germany. The Ministry for Environment, Climate, Energy and Agriculture (Behörde für Umwelt, Klima, Energie und Agrarwirtschaft – BUKEA) is responsible for this initiative, involving several other actors and partners.

Key features

The has a long history in incorporating binding green roof regulations in land-use plans for more than 20 years. The majority of green roofs have been achieved through regulations in development plans or urban development contracts. To assist with the planning of green roofs, the municipality's Ministry of Environment and Energy (Behörde für Umwelt und Energie) published the brochure "Green Roofs. Guidelines for Planning" with the three main focuses of "Knowledge, Planning, Action." The brochure is intensively used by stakeholders in the city's administration, as well as by architects and developers, such as housing cooperatives and investors, and, as feedback and mailing requests show, in other cities. The guidelines provide support for arguments in urban land-use planning and building permit procedures, among other areas, and standardize regulations and justifications for green roofs in development plans.

The strategy has been extended to vertical greenery as well. The Green Wall Strategy consists of the three building blocks "Knowledge, Communication, and Construction." The "Green Walls Handbook" has been developed for this purpose so far, providing colorful, richly illustrated information.

Regulatory side – overarching and consensus-based

The CoolLIFE project has received funding from the LIFE Programme of the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

The strategy was pushed forward by Hamburg's Environmental Ministry, while the Green Roof strategy was developed in close cooperation with different special authorities. Integration of the common goals of the green roof strategy into overarching strategies like the Hamburg Climate Plan, Rainwater InfraStructure Adaptation (RISA) Strategy, and the Qualitäts Offensive Freiraum (quality offensive for open space), and vice versa, increased the strategy's legitimacy, giving it a wide and stable foundation. The implementation is also supported by the district authorities – to apply the developed instructions for green roofs and facades. The city of Hamburg regularly reviews its green roof legislation, in particular the ecological quality standards for the roofs. As a result, the latest regulations already set out requirements for the mandatory installation of green roofs. According to the Hamburg Climate Protection Act (HmbKliSchG), owners of buildings whose construction begins after January 1, 2027, must permanently green any new roofs with a pitch of up to 10 degrees on at least 70% of the gross roof area, using diverse and structurally rich vegetation, with a minimum of extensive green roofing. This requirement also applies to significant roof renovations that begin after January 1, 2027, with the condition that the net roof area must be greened. At the same time 30% of the roof area must be equipped with PV from January 1, 2024.

Financial support – multiple incentives

Financial support consists of direct and indirect elements. On one hand, a split wastewater fee was introduced for buildings with green roofs, on the other hand, a voluntary program was launched to support the installation costs for green roofs and facades, as outlined below.

Technical Support

A comprehensive set of digital, accessible information is available in for planners, builders, and associations in the format of booklets and planning guidance, maintenance and care, and well documented case studies, including technical, legal aspects and cost ranges that also help practical implementation. Fundamental questions regarding fire protection and green facades are compiled in FAQs (frequently asked questions) on planning and publication (www.hamburg.de/broschueren/).The platform #moinzukunft also supports active discussion on climate protection and adaptation measures, including the green roof strategy.

The city also offers advice about green roofs free of charge through the EnergieBauZentrum and the "ZEWUmobil" energy experts from the Centre for Energy, Water and Environmental Technology (ZEWU). Information booklets on the case studies present not only the system specification but also include indications on the level of total costs and benefits.

Public Relation and Dissemination

The initiative has a strong PR and dissemination background, which requires a dedicated full-time communication officer and structured co-creation processes. An own brand is created with a website, brochures and flyers, posters in the urban area, film contributions, and publications in daily newspapers and trade magazines as well as on social media. Publicity campaigns are organized, with international outreach; regular meetings with multipliers from professional associations and contributions to trade fairs, lectures and events for different stakeholders are provided. The promotion of roof greening is also important recognition options for parties involved, it can be seen as a flagship for sustainable companies in the city, as well as competitions are provided for individuals where green roof and facade projects are awarded and also used to generate best practice examples and promote the funding program.

Public recognition campaigns

The "Hamburg Award for Green Buildings" recognizes green roofs and green facades that exemplify quality, design, and use in Hamburg and neighbouring districts. It had been opened three times, in 2017, 2022 and 2025.

In 2025, the winners will receive a total of €6,000 in prize: €2,500 for first place, €2,000 for second place, and €1,500 for third place. Companies who receive funding can receive recognition as "Hamburg Environmental Partners" providing visibility to their sustainable and responsible practices.

Science-based evidence

The strength of the program also lies in the scientific research supporting the development of the promoted solution. A federal grant was used to pay a part-time HafenCity researcher for 2-3 years. The green roof strategy also takes advantage of joint programs for example EU funded research to support the improvement of the implementation of green roofs and facades. These include experimenting with design options to increase biodiversity, providing smart flow control for the water management of the roofs, and monitoring of the retention capacity.

Implementation

One of the key aspects to the success of the program is the **constant evolution** of its components, with **multifaceted elements**. The strategy was launched in 2014, followed by the funding scheme in 2015. In 2017, the prize was introduced. In 2018 the study "Hamburg's Green Roofs - An Economic Assessment" was published examining the economics of extensive green roofs in Hamburg. The same year, a flagship project of the municipality was completed.

In 2021, the program expanded to include green facades, with support from the Green Urban Labs pilot project, within the federal research program Experimental Housing and Urban Development (ExWoSt). The initiative was taken to a next level from January 1, 2024 when the Hamburg Climate Protection Act was amended with the Climate Protection Strengthening Act that requires the combination of photovoltaic systems with vegetation, as **solar green roofs** for new buildings as far as it is technically and economically feasible after 2027. The biosolar roofs further enhance efficiency, as these solar panels will work more efficiently over green roofs, while at the same time, shades the vegetation on the roofs, enhancing biodiversity.

Budget (or other cost data)

Hamburg itself showed leadership and an **exemplary role** in the implementation of the program. In 2018, €7.5 million was allocated for green roofs for public school construction. Municipal bodies are also committed to increasing roof and façade greening. A flagship project is the greening of the DESY research hall in Bahrenfeld — one of the largest building greening projects in the Hanseatic city: around 4,600 m² of façade and flat roof area of the existing Hall 36 were planted with approximately 25,000 grasses, perennials, and climbing plants, with total funding of €410,000 provided by Hamburg's Environmental and Energy Authority.

Green roofs are also indirectly supported through the **reduction in wastewater fee splits**. As green roofs retain a large amount of rainwater, rainwater fees can be reduced by an average of 50% for a house owner or can even be eliminated if rainwater is fully retained on site. This is a practical example about how multiple benefits can contribute to co-funding.

An essential point for financing the measures is **blending funding sources.** The necessary resources for staff to address the action levels were financed, among other things, through federal grants and provided by the municipalities own budget and climate adaptation funds. Material resources, such as those for public relations, were acquired through separate printed materials and future budget appropriations. This requires long lead times and decision-making processes, patience, and attention to seeking and finding synergies. The Hamburg's Ministry for Environment, Climate, Energy and Agriculture invested about € 500,000 of its own resources until 2022 for the implementation of the overall Green Roof. In addition, the Ministry and the Harbour City University received € 300,000 in federal grants on expenditure basis from the German Ministry of the Environment under a funding programme supporting local activities for the adaptation to climate change.

Financial incentives boost the uptake of the implementation of the strategy: while the benefits of Nature-based Solutions including green roofs are received by the community, most of the roofs are privately owned. Financial incentives are particularly relevant to bring on board the general public, experts and get media attention. The support by national funding programs from the Federal Ministry of Environment is helpful as those programs foster the exchange also beyond the city scope.

In **2015**, the Hamburg Ministry for Urban Development and Environment allocated **€3,5 million** to encourage green roof construction on both new and renovated buildings in Hamburg. In the first six years, 280 applications had been submitted, and 86,000 m² of green roofs had been approved, receiving over €2 million in total. Private individuals and companies applied equally for the grants. The buildings where the green roofs were installed were mainly new buildings (75%). The initial funding rate was 60 % for the installation costs of the green roof, with a limit of 50.000 € per building. In 2020, the funding program was extended for five years, and subsidies were increased by 20% due to rising construction costs, as well as expanded to include facade greening.

In **2023**, the green roof strategy funding program has been endowed with a further **€3.5 million** and is currently available until the end of 2026. Property owners will receive grants of 60 % of the construction costs for **private owner-occupiers and homeowners' associations** and between 40% and 60% for **commercial applicants**, for new or existing buildings. Funds can be applied for voluntarily by planning to install at least 20 m² of green roofing with a soil layer of at least 8 cm in depth. Green roofing measures for residential and non-residential buildings are subsidized with up to **€100,000 per applicant** via the Hamburg IFB bank.

An estimation from 2021 calculated at least **€22 million investment** in the creation of green roofs in Hamburg **over seven years**, based on the growth of **50 hectares of green roofs** in Hamburg.

Results and impacts

The study "Hamburg's Green Roofs - An Economic Assessment" from 2018 concluded that the cost of building a green roof amounts to about 0.4-1.3% of a buildings' overall construction costs. Repair costs are on the hand smaller, as thanks to the protection from climate impacts, the life expectancy of a green roof increases to 30-50 years compared to the 15-25 years of black roofs (i.e. without greening). In contrast, a black roof is subject to regular renovation cycles every 15-25 years. When considering life-cycle costs over a 40-year period, the black roofs and green roofs have similar costs. On the benefit side, green roofs reduce cooling needs through a higher thermal inertia and summer the evaporative cooling and have advantages on a wider scale. While this had not been quantified for Hamburg, A study conducted by Niachou in Greece revealed that green roofs can reduce the energy utilized for cooling from 2 % up to 48 % with an indoor temperature reduction up to 4 K. Apart from the reduction of UHI already mentioned, social benefits if are seen when used as an open space, they provide an area for biodiversity, increase air quality, and offer an increase in performance if installed together with solar panels. Direct cost benefits can come from the "green added value" of usable intensive green roofs, which increases rental income by 6-8%, according to an estimate by TÜV Süddeutschland.

GIS-based research evaluated the potential impact of the program, assessing that over 40% of the city's roofs are flat and suitable for greening. In the first seven years of the program, until 2021, the area of green roofs in Hamburg had increased by approximately 50 hectares. The total urban green roof area was reported to be approximately 175 hectares, of which 39% was created in residential buildings, 35% in industrial and commercial buildings, and 26% in other buildings. Half of Hamburg's roofs are flat or low sloping, where the share of green roofs was approximately 5%.

Lessons learnt

The success of the strategy lies in the **comprehensive approach** through multiple actions including regulatory, financial, participatory and informational branches. By recognizing the **synergies** of different positive aspects (i.e. reducing energy demand directly and through UHI, improved rainwater management and increasing biodiversity) involving all bodies of the city in the process with regular updates about the progress helped raise the awareness of the topic and show the successful implementation.

The main **challenges** were mentioned as low technical knowledge and trust. Real estate industry and planners were identified as key stakeholders in the field of green building projects, who need to be convinced with sufficient evidence-based arguments to support the implementation – e.g. in aspects of fire safety, water retention potential, and also maintenance issues were raised. For example, the increased presence of animals, e.g. the case of seagulls breeding on a large green roof during spring were not celebrated by all parties – which calls for dialogues and awareness raising as well as management needs.

However, through well composed, detailed **educational materials**, cutting-edge **scientific research**, the barriers are being overcome, which result in the project being a beacon for cities worldwide. To take the strategy to the next level, further challenges need to be addressed. For example, in lack of correlations for noise mitigation and air quality improvement of green walls, these concepts are difficult to make mandatory in the planning sector. There is still room for research to provide suitable scientific evidence.

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Ecobonus (Italy) – 50 % Income-Tax Deduction for Fixed External Solar-Shading Devices

Factsheet prepared by Dario Bottino-Leone (EURAC) | June 2025

Background and objectives

Italy's Ecobonus has been the backbone of national incentives for energy-efficiency in residential buildings since 2007. Solar-shading devices (awnings, external venetian blinds, brise-soleil, pergolas, roller shutters, etc.) became explicitly eligible on 1 January 2015 via the 2015 Stability Law (Law 190/2014), initially at a 65 % rate. From 1 January 2018 the rate was permanently set at 50 %, with the maximum deductible expenditure fixed at €60 000 per housing unit (considering all works) and the benefit spread over 10 equal annual instalments.

Un-shaded glazing is a principal driver of summertime overheating in Italy's existing housing stock, particularly after successive record heatwaves in 2017–2023. By linking the deduction to technical performance and façade orientation (East / South / West only), the measure intends to:

- cut residential cooling demand and related electricity peaks;
- complement envelope insulation measures that mainly address winter losses;
- contribute to the 2030 National Energy and Climate Plan (PNIEC) target of –9.3 Mtoe final energy.

No quantitative target is set for shading alone, but annual monitoring against the trajectories set in Italy's National Energy and Climate Plan (PNIEC) is performed by ENEA.

Key features

Element	Specification	Legal / technical basis
Incentive	50 % personal (IRPEF) or corporate (IRES) tax deduction, spread over 10 years	Art. 14, DL 63/2013 as amended; Agenzia Entrate guidelines (agenziaentrate.gov.it)
Spending cap	€60 000 per property unit (considering all works)	Law 190/2014 (reteambiente.it)
Eligible devices	Altough this measure is not specific for shading, it includes benefits for fixed or mobile external solar-shading systems mechanically fastened to the building envelope (awnings, external blinds, brise-soleil, pergolas, technical shutters)	ENEA Vademecum (efficienzaenergetica.enea.it)
Performance requirements	CE marking; solar-energy transmittance *g*tot ≤ 0.35 (UNI EN 14501)	(mansarda.it)

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Element	Specification	Legal / technical basis
Façade orientation	Only façades from East through South to West are admissible; North-facing surfaces excluded	(mansarda.it)
Payment method	“Bonifico parlante” (traceable bank transfer with fiscal codes and law reference)	Agenzia Entrate circulars
Alternative monetisation	Optional invoice discount / credit transfer (cessione del credito) allowed for works finished ≤ 2024; strongly restricted from 2025	DL 11/2023
Documentation	Upload of intervention file to ENEA portal within 90 days after works completion	(efficienzaenergetica.enea.it)

Implementation

Lead bodies:

- Technical & monitoring: ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development).
- Fiscal management: Agenzia delle Entrate (Revenue Agency).

Stakeholders: Certified installers, product manufacturers, tax advisers, homeowners’ associations, and local authorities (for façade permits in historic centres).

Process (customer journey):

- Homeowner commissions a qualified installer; device compliance (CE, g_{tot}, orientation) is verified.
- Works are paid via “bonifico parlante”.
- Installer or homeowner uploads the project to the ENEA “bonusfiscali” portal within 90 days.
- Deduction is claimed in the next income-tax return (Mod. 730 or Redditi Persone Fisiche), with instalments over ten years or monetised upfront through credit transfer where still permitted.

Scheme evolution:

2015: inclusion of solar shading at 65 %.

2018: rate reduced to 50 %.

2020–2021: temporary invoice-discount / credit-transfer mechanism (DL Rilancio 2020).

2024: credit transfer curtailed; focus returns to ten-year deduction.

Budget (or other cost data)

Ecobonus is not a direct-expenditure programme; its cost appears in the State budget as lost tax revenue:

Year	Investments in solar-shading (M€)	Implied fiscal cost over 10 y (50 %) (M€)	Source
2021	513	≈ 257	(media.enea.it)
2022	482	≈ 241	(media.enea.it)

Administrative costs (ENEA portal, help-desk, annual reports) are borne by the Ministry of Environment & Energy Security and are estimated at < €3 million per year (internal ENEA data, not published).

Results and impacts

- **Activity level.** 2021: ~120 000 shading files submitted (11 % of all Ecobonus files). 2022: ~105 000 files (11 %). media.enea.itmedia.enea.it
- **Investments mobilised.** €995 million in 2021-2022 (see budget table).
- **Average investment per application file** (for shading): about 4400 euros
- **Energy & climate effects.** ENEA attributes 46 GWh/year of annual primary-energy savings to the 2022 cohort of shading projects (≈2 % of total Ecobonus savings) and ~10 kt CO_2/year of avoided emissions (ENEA confidential break-down, derived from Rapporto Detrazioni 2023 tables 4-16).
- **Comfort & adaptation.** Field monitoring in climate zones C-D shows indoor operative-temperature reductions of 2–4 °C during summer heatwaves when dynamic shading is deployed (case-studies in Rapporto Efficienza Energetica 2023, chap. 7).
- **Geographical distribution.** In 2023 climate zone E alone (Northern Italy) accounted for 71 % of shading files, confirming the relevance of overheating even in traditionally "heating-dominated" areas (cosmoserr.it). Moreover, this confirms how tax credits are primarily used by wealthier households.

Lessons learnt

- **Targeted technical criteria matter.** The orientation and g_{tot} thresholds maximise cooling-load reduction per € invested.
- **Administrative complexity is still a barrier**. SMEs and homeowners report that ENEA portal procedures and the "bonifico parlante" format add transaction costs; digital simplification is recommended.
- **Stable, medium-level incentives work**. Lowering the rate from 65 % to 50 % (2018) did not cause a drop in uptake, suggesting that market confidence and ease of claim are more critical than nominal percentage.
- **Integration with major envelope works is limited**. Shading is often installed as a stand-alone measure; bundling with window replacement or façade insulation could yield greater system benefits.

- **Policy alignment with heat-health strategies**. The measure indirectly supports the National Heat-Health Plan by mitigating indoor heat stress in vulnerable households; explicit coordination would enhance co-benefits.

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Interview with national expert

Where does the original idea of the scheme come from?

The scheme originates at the intersection of EU decarbonisation directives and a national need to modernise a dispersed, ageing building stock while overcoming split-incentive barriers. From the outset, ENEA's mandate was to provide the technical backbone: define minimum performance requirements, standardise documentation for applicants and installers, and build a data infrastructure to track measures and estimate energy savings. In practical terms, the idea was to catalyse private investment into cost-effective retrofits by lowering perceived risk and upfront cost, while ensuring verifiable, durable performance. Over time, the scope has evolved from single-measure upgrades (e.g., envelopes, heating systems) toward more integrated packages that deliver deeper and more persistent savings.

What have been the main difficulties encountered in developing or implementing the scheme?

Three stand out. First, regulatory volatility: frequent adjustments to rates and eligibility can undermine planning by households, SMEs, and supply chains. We mitigate this with advance notice, technical clarifications, and robust transition rules. Second, measurement and verification (M&V): translating design-stage savings into realised, meter-level outcomes is non-trivial; we have progressively aligned guidance with IPMVP-style principles and strengthened ex-post checks. Third, administrative complexity and equity of access: documentation can be a barrier for small actors. We respond with plain-language guidance, training for professionals, audit-ready templates, and a digital portal that improves data completeness and reduces errors. Capacity constraints in local permitting and the variability of workmanship quality remain persistent challenges.

What success factors would you have identified?

Stability and predictability are foundational—multi-year policy horizons reduce strategic uncertainty. Standardisation—from product classes and U-values to contract templates and M&V protocols—lowers transaction costs and supports quality assurance. Data transparency is another lever: feedback loops to market actors (aggregated dashboards, benchmarks) improve decision quality and trust. Ecosystem capacity matters: trained designers, installers, and energy auditors, combined with accredited ESCOs, accelerate throughput without compromising quality. Finally, integration with finance—from on-bill repayment to credit guarantees—helps crowd-in private capital, particularly for deeper renovations with longer paybacks. Where these elements co-exist, we observe higher take-up and more durable savings.

What have been the main changes in the scheme in recent years? Are there further developments planned? Or what would be the main challenges for the coming years?

The next frontier is to link incentives more tightly to verified performance, shifting from deemed savings toward meter-based metrics where feasible, while still keeping the scheme user-friendly. We also aim to encourage deeper, staged renovations rather than isolated measures, leveraging building-level roadmaps and digital tools (e.g., energy passports, interoperable data standards). Key challenges include ensuring supply-chain resilience (skills, components), addressing energy poverty with targeted support, and improving grid-interactive efficiency (demand response, heat pumps with smart controls). Finally, maintaining policy coherence across national and regional instruments will be critical to avoid duplication, rebound effects, or unintended market distortions.

If you could go back in time, what would you do differently?

I would front-load three design choices. First, end-to-end digitalisation from day one—unique building IDs, standard taxonomies for measures, and API-ready data—so evaluation and fraud-prevention are built-in, not bolted-on. Second, a progressive ramp-up: pilot cohorts with randomised audits and control groups to calibrate incentive levels and administrative burden before national rollout. Third, a stronger early emphasis on quality infrastructure—accredited training, commissioning protocols, and post-installation inspections—because durable performance depends as much on execution and O&M as on equipment specs. I would also simplify the communication architecture to citizens and SMEs: fewer rates, clearer eligibility, and standard contract clauses to cut negotiation time and increase trust.

Italian Energy Efficiency Fund II (IEEF II) – Private-Equity Platform for the Energy Transition

Factsheet prepared by Dario Bottino-Leone (EURAC) | June 2025

Background, objectives and key features

IEEF II is the second closed-end alternative investment fund promoted and managed by **Fondo Italiano per l'Efficienza Energetica SGR (FIEE SGR)**. Launched in July 2020 and closed in January 2022 at **€201 million** (target €175 million), it was conceived to mobilise large-scale private capital for energy-efficiency and distributed-energy businesses that are otherwise underserved by conventional bank lending (source: fieesgr.com).

The fund's mission is to:

- support Italy's 2030 National Energy & Climate Plan (NECP) by scaling **ESCO** (Energy Services Companies) and "energy-as-a-service" business models;
- catalyse investment in **energy communities, innovative HVACR** (Heating, Ventilation, Air Conditioning and Refrigeration) **technologies, building-scale storage and renewables**;
- deliver a target net IRR (Internal Rate of Return) of **10–12 % over 12 years** while avoiding > 1 Mt CO_2.

Implementation

- **Management company:** FIEE SGR (licensed AIFM, Rome).
- **Governance:** an **Advisory Board** representing investors vets deals above thresholds and conflict-of-interest cases (source: fieesgr.com)
- **Pipeline origination:** proprietary sourcing from ESCO networks, utilities and technology vendors; co-investment with founders retained for operational continuity.
- **Investment process (≤ 20 weeks):** screening ↠ technical/market due-diligence (with ENEA benchmarks) ↠ ESG (Environmental, Social, and Governance) assessment ↠ Investment Committee ↠ closing.
- **Technical assistance:** the fund covers up-front audit/design costs (recoverable at financial close) and offers post-investment engineering support to accelerate project roll-out—crucial for small municipal or condominium markets.
- **Public-policy interface:** MASE recognises IEEF II as a complementary instrument to the National Energy-Efficiency Fund, facilitating blending where grants/subsidies are available (e.g. Conto Termico for public lighting).

The CoolLIFE project has received funding from the LIFE Programme of the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

Budget (or other cost data)

Item	**Amount / share**	**Notes**
Committed capital	**€201.4 m** (100 %)	1/2022 final close(fieesgr.com)
· EIB anchor stake	€40 m (19.9 %)	InvestEU/EFSI window(eib.org)
· Italian institutional investors	€157 m (78 %)	Pension & insurance
Capital deployed (Dec 2024)	**€143 m** (71 %) across 6 platforms	(fieesgr.com)
Average equity ticket	€23.8 m	range €12–35 m
Management & impact fees	1.8 % p.a. + 20 % carry above 8 % hurdle	Fund rules

Results and impacts

Indicator	**Cumulative**	**Comment**	**Source**
Investments closed	6 portfolio companies (energy services, storage, energy communities, HVACR)	first exit in 2022 (PLT Energia → Plenitude)	(fieesgr.com)
Energy saved	**7,593 MWh/year** verified operational savings	early stage; ramps up with project roll-out	(fieesgr.com)
Renewable electricity generated	7,663 MWh/year	from PV/wind assets inside portfolio	(fieesgr.com)
CO_2 avoided	**154,528 t CO_2eq** (lifetime to date)	scope 1+2 avoidance	(fieesgr.com)
Employment	> 870 FTEs (Full Time Equivalent) across subsidiaries	incl. 210 new green jobs	(fieesgr.com)

Indicator	Cumulative	Comment	Source
Financial performance	First exit multiple > 3× MOIC (Multiple of Invested Capital); net IRR tracking at 11.4 %	internal estimate, EY-limited assurance	Manager data

* Full impact verification is published annually in the **FIEE SGR Impact Report**.

Lessons learnt

- **Patient equity unlocks fragmented markets.** Traditional debt shies away from small-ticket, multi-site efficiency projects; a specialised PE (Private Equity) vehicle can aggregate and professionalise them.
- **Anchor public capital de-risks private commitments.** The EIB's €40 m anchor share was pivotal for attracting domestic pension funds.
- **Platform logic beats single-asset finance.** By buying controlling stakes in ESCOs or community-energy developers, the fund gains pipeline optionality and operational synergies.
- **Early ESG integration pays off.** Transparent SFDR (Sustainable Finance Disclosure Regulation) reporting and third-party assurance shortened LP (Limited Partners) due-diligence cycles and broadened the investor base.
- **Exit pathway proven.** The 2022 divestment of PLT Energia to ENI-Plenitude demonstrated liquidity and high returns in the Italian energy-transition space, boosting confidence for Fund III (launch expected Q4-2025).

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PNACC Passive-Cooling Guidelines for Residential Buildings (Italy)

Factsheet prepared by Dario Bottino-Leone (EURAC) | June 2025

Background and objectives

The latest Italian **National Adaptation Plan** (Piano Nazionale di Adattamento ai Cambiamenti Climatici – PNACC) was approved on 21 December 2023 by Ministerial Decree 434/2023 and entered into force on 21 February 2024. It lists 361 adaptation actions, with **one chapter devoted to passive cooling in buildings** as a response to the sharp rise in heat-wave frequency and electricity peaks for air-conditioning.

More specifically about the residential sector, about 75 % of Italian dwellings are poorly insulated and increasingly overheat in summer. The PNACC therefore calls for widespread deployment of low-energy cooling measures in homes built before 2006, with the dual aim to:

- cut household cooling demand by up to 40-50 % where feasible;
- reduce heat-related morbidity and mortality, especially among elderly occupants.

No stand-alone quantitative target is fixed for passive cooling, but the plan requires regions and municipalities to include such measures in local adaptation plans and to monitor progress annually against national heat-health indicators.

Key features

The chapter of the PNACC about passive cooling includes information and promotes the following main types of solutions:

Component	**Guideline / requirement**	**Source**
Night ventilation	Encourage cross-ventilation or stack ventilation when outdoor air is ≥ 3 °C cooler than indoor; recommended purge period 22:00-06:00.	PNACC text (Ch. Settore “Insediamenti urbani”) (infobuildenergia.it)
Solar shading	External shutters, awnings, brise-soleil; aim for total solar-energy transmittance *g*tot ≤ 0.35 (UNI EN 14501).	PNACC + ENEA guidance (efficienzaenergetica.enea.it)
High-albedo / “cool” materials	Light-coloured or reflective roof and façade finishes to keep surface temps ≤ 45 °C under peak sun.	PNACC annex II (methodological guide)

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Component	Guideline / requirement	Source
Green façades / roofs	Promote climbers, pergolas, vegetated trellises on south- and west-facing walls; extensive green roofs on flat terraces.	PNACC annex II
Behavioural protocols	Close shutters and windows on sun-exposed façades during daytime; schedule internal heat-gain activities (cooking, laundry) outside peak hours.	ENEA citizen guide (efficienzaenergetica.enea.it)
Integration with renovation incentives	Guidelines cross-reference Ecobonus (50 % deduction) and Superbonus (70-110 %) so that shading and insulation can be claimed together.	PNACC–Ecobonus cross-table

Implementation

Lead ministry: MASE (Ministry of Environment & Energy Security).

Technical bodies: ISPRA (national adaptation platform) and ENEA (efficiency agency) develop manuals, webinars and check-lists for homeowners and local planners.

Municipal role: Each municipality must insert passive-cooling prescriptions in its local adaptation plan (Piano di adattamento locale – PAL) within two years; typical steps are:

1. Climate-risk screening of the housing stock (overheating map).
2. Measure selection (shading, ventilation, greenery) using PNACC decision tree.
3. Citizen outreach via neighbourhood workshops and condominium meetings.
4. Monitoring: log indoor temperature campaigns and report to the National Adaptation Observatory.

Pilot cities (e.g. Bologna, Padova) already follow this workflow under EU-Covenant PAESC plans.

Budget (or other cost data)

PNACC is financed through the National Climate Adaptation Fund (€1.2 billion, 2024-2030). No ring-fenced line exists for residential passive cooling; however:

- ENEA estimates that €6 million per year is used for training, guidelines, and the on-line help-desk.
- Municipalities may tap EU Cohesion Policy 2021-2027 and PNRR funds for green-roof and shading pilots (typical grant €150–250 per m² for green roofs, €200–300 per window for external shutters).

Results and impacts

Indicator	Pilot results	Reference
Indoor temperature reduction	2–4 °C drop during 2023 heat-wave events in retrofitted flats (Bologna + Padova case studies).	ENEA monitoring reports 2024
Energy-use cut	Passive cooling measures can lower annual cooling electricity by up to **50 %** when insulation and shading are combined.	(efficienzaenergetica.enea.it)
User satisfaction	84 % of surveyed households reported “notable improvement” in summer comfort after installing shutters and practising night purge.	ENEA 2024 survey
Scaling potential	If adopted in all pre-2006 dwellings, PNACC projects a national saving of ~4 TWh/year and avoidance of ~1 Mt CO_2 eq /year by 2035.	PNACC impact model (Annex III)

Lessons learnt

- **Behaviour + hardware**: Night-time ventilation protocols are as important as physical upgrades; occupant training must accompany technical measures.
- **Low-regret sequencing**: External shading is cheap (< €200 per window) and can be installed ahead of deep renovations, giving immediate relief.
- **Need for data**: Few municipalities measure indoor heat; PNACC now recommends low-cost dataloggers in a sample of dwellings to build an evidence base.
- **Synergy with fiscal schemes**: Aligning passive-cooling guidelines with existing Ecobonus incentives accelerates uptake.
- **Equity angle**: Passive solutions help low-income households avoid “summer energy poverty”, but dedicated grants are still scarce.

Sources

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Interview with national expert

Where does the original idea of the scheme come from?

The impetus is twofold. First, Italy's rapid increase in heat-wave frequency and intensity—with associated health risks—demands low-regret measures that work even during grid stress. Second, electricity peaks from air-conditioning are growing, especially in summer evenings. Within the National Climate Change Adaptation Plan (PNACC)—approved on 21 December 2023 (Ministerial Decree 434/2023) and in force since 21 February 2024—we identified passive cooling as a priority thread across the Plan's 361 adaptation actions, with a dedicated chapter for residential buildings. The idea is to mainstream a toolbox of no- or low-energy strategies (solar control, cool materials, ventilative cooling, thermal mass management, greenery) that reduce overheating risk, protect vulnerable occupants, and curb peak demand—while remaining feasible across Italy's diverse climates and housing typologies.

What have been the main difficulties encountered in developing or implementing the scheme?

Three categories. (i) Technical and climatic heterogeneity: From Alpine valleys to coastal cities, design responses differ; guidance must be both archetype-based and location-specific. Downscaling future climate projections to building-level metrics (e.g., hours above comfort thresholds) is non-trivial. (ii) Regulatory and governance fragmentation: National guidelines must align with regional building codes, heritage constraints, and condominium rules; moreover, acoustic and security requirements may limit night-time ventilation in urban areas. (iii) Practice and behaviour: Quality of installation (e.g., external shading brackets, air-tightness around frames) and occupant practices (shading use, night purging) determine outcomes. To mitigate, we paired prescriptive recommendations (e.g., external solar-shading priority, reflective roof finishes, cross-ventilation paths) with performance-oriented checks using dynamic simulation and adaptive comfort criteria, plus plain-language guidance for households and training modules for professionals.

What success factors would you have identified?

Evidence-based standardisation is pivotal: pattern books with replicable details (over-window awnings, shutters, brise-soleil anchors, insect-screen-compatible openings) and minimum performance descriptors (solar-factor ranges, surface reflectance, ventilation rates) reduce design and permitting frictions. Prioritising external over internal solar control delivers consistently higher impact. Ventilative cooling with night flushing works best when coupled with exposed thermal mass and secure openings; simple devices like ceiling fans markedly extend comfort envelopes at negligible energy cost. Cool roofs/facades provide building- and neighbourhood-scale benefits, especially where urban heat island effects are strong. Finally, integration with health and social policy (e.g., protection of heat-vulnerable groups, social housing pilots) ensures equitable uptake and higher societal value.

What have been the main changes in the scheme in recent years? Are there further developments planned? Or what would be the main challenges for the coming years?

Two development tracks and two challenges. On development: (1) Implementation notes for Regions and municipalities, including checklists for building permits and model clauses for condominium decisions; (2) A performance-linked approach—progressively shifting from deemed measures to meter- and sensor-informed indicators (overheating degree-hours, hours within adaptive comfort bands), while keeping user pathways simple. On challenges: (a) Capacity and supply chains—we need trained installers for external shading, airtightness, and reflective coatings, as well as reliable product labelling; (b) Policy coherence and funding—aligning passive-cooling actions with renovation programmes, heat-health plans, and EPBD-driven requirements to avoid duplication or rebound effects. Monitoring real homes through low-cost temperature loggers and short post-occupancy surveys will be key to iterative improvement.

If you could go back in time, what would you do differently?

I would sequence three elements earlier. First, a national data backbone for overheating: harmonised taxonomies, unique building IDs, and open archetype libraries to accelerate modelling and evaluation. Second, staged pilots in social housing across three climate archetypes (North/Centre/South) with randomised inspections—to calibrate thresholds, costs, and user guidance before national roll-out. Third, a stronger communication “rule-of-thumbs” layer for households (e.g., “external shade before noon, night purge after 22:00, fans to extend comfort by ~2–3 °C operative temperature”), co-designed with behavioural experts. This would have reduced time-to-impact and improved the fidelity between paper guidance and outcomes in lived-in homes.

PREPAC – Energy Requalification Programme of the Central Public Administration (Italy)

Factsheet prepared by Dario Bottino-Leone (EURAC) | June 2025

Background and objectives

Article 5 of the EU Energy-Efficiency Directive (EED) 2012/27/EU, has required Member States to renovate ≥ 3 % per year of the usable, covered, air-conditioned floor area of central-government buildings. Italy transposed it with Legislative Decree 102/2014. Then, Decree 16 September 2016 (so-called "DM PREPAC") established the PREPAC grant scheme to meet that obligation. For Italy, the stock to be addressed represent about 16 million m² in ministries, constitutional bodies and armed-forces buildings (source: odyssee-mure.eu)

Strategic goals for PREPAC (2021-2030) align with the provisions of Articles 5 and 6 of the EED recast (EU)2023/1791:

- renovate on average 480 000 m² per year (≥ 3 % of stock);
- cut central-government final-energy use by ≥ 1.9 % per year;
- act as an *"exemplary role"* for regional and municipal estates.

Key features

Element	Specification	Legal / technical basis
Financial support	Non-repayable grant up to **100 %** of eligible costs; resources: €75 million/year (2021-2030) after €355 million in 2014-2020	DM PREPAC 2016; Cabina di Regia funding decisions (pubblicazioni.enea.it)
Beneficiaries	Central public administrations (ministries, constitutional bodies, defence, justice, inland-revenue, etc.)	D.Lgs 102/2014, Art. 5
Project ranking criteria	(i) **Cost of saved energy** (€/kWh, 45 % weight); (ii) co-financing share; (iii) completion time; (iv) *exemplary* projects (≥ 50 % primary-energy cut & envelope + systems) reserve 20 % of funds	DM PREPAC 2016, Annex A (pubblicazioni.enea.it)

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Element	Specification	Legal / technical basis
Eligible interventions	Envelope insulation, window replacement, HVAC upgrade (condensing boilers, heat-pumps), LED lighting, BACS, PV/solar-thermal	Linee guida ENEA–GSE 2017 (certifico.com)
Exclusions	Buildings < 250 m², strictly protected heritage where energy performance requirements conflict, purely military premises, places of worship	DM PREPAC 2016, Art. 2
Funding flow	State budget item financed by part of ETS auction revenues and a levy on natural-gas bills; disbursed via MASE–GSE convention	ENEA report 2024 (pubblicazioni.enea.it)

Implementation

- **Governance:**
  - **Cabina di Regia per l'Efficienza Energetica** (chaired by MASE) issues the annual call and final approval.
  - **ENEA** and **GSE** carry out technical-economic appraisal and monitoring.
- **Annual cycle (simplified):**
  1. **Call published** (March–April).
  2. **Project submission** by 15 July through GSE portal (diagnosis or EPC mandatory).
  3. **Joint ENEA–GSE assessment** → merit ranking.
  4. **Decree of approval** (December) allocates grants; conventions signed.
  5. **Works** must finish within 36 months; progress and savings reported in the ENEA 4E database.
- **Support tools:** Pre-diagnosis templates, cost-optimal calculators and help-desk webinars (≥ 600 PA staff trained in 2024). mase.gov.it

Budget (or other cost data)

Period	Grants committed	Mean grant / project	Surface upgraded	Source
2014-2020	**€355 million**	€1.3 million	1.96 million m²	(pubblicazioni.enea.it)
2021-2022	**€75 million yr^{-1}** (statutory allocation)	€1.6 million	0.61 million m²	(pubblicazioni.enea.it)
2014-2023 **total**	**≈ €430 million** invested	—	2.56 million m²	(media.enea.it)

*Median cost of saved primary energy 2016-2022 = €130 /MWh (average = €145 /MWh).

Results and impacts

- **Uptake:** 677 proposals submitted (2014-2023); **310** funded (46 % pass-rate). pubblicazioni.enea.it
- **Energy savings:** preliminary monitoring indicates **1.1 ktoe (2021)** and **0.94 ktoe (2022)** annual primary-energy reduction from completed projects – c. **38 GWh yr^{-1}** electricity equivalent. odyssee-mure.eu
- **Emission cuts:** ≈ 260 kt CO_2 cumulated 2014-2023 (ENEA model). pubblicazioni.enea.it
- **Progress vs. 3 % target:** renovated area averages **~2 % yr^{-1}**; thus PREPAC covers ≈ 67 % of the legal obligation – supplementary measures are planned under the new EED-III transposition. odyssee-mure.eu
- **Typical interventions (share of funded actions 2014-2022):** window replacement 33 %, envelope insulation 26 %, HVAC replacement 19 %, LED lighting 15 %, rooftop PV 11 %. gse.it

Lessons learnt

- **Cost-effectiveness discipline works.** Weighting the €/kWh indicator steers proposals toward high-yield actions and holds the median cost at €130/MWh.
- **Administrative capacity is the bottleneck.** Ministries with dedicated energy teams (e.g. Defence, Economy) capture > 80 % of funds, while smaller bodies rarely apply. Targeted TA and simplified templates are expanding participation.
- **Ringfencing for comprehensive ("exemplary") projects**. They deliver > 50 % energy cuts but need longer preparation; reserving 20 % of funds for them is essential to avoid a bias toward light retrofits.
- **COVID-19 & alternative incentives reduced submissions** in 2019-2021; alignment with "Conto Termico" and PNRR funds is now explicit to prevent cannibalisation.
- **Monitoring quality and impacts.** Since 2022, all projects must install metering for post-intervention verification, strengthening the evidence base for NECP reporting.

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Interview with national expert

Where does the original idea of the scheme come from?

PREPAC was conceived to operationalise Article 5 of the EU Energy Efficiency Directive 2012/27/EU, which requires Member States to renovate ≥3% per year of the useful floor area of central-government buildings. Italy transposed this obligation through Legislative Decree 102/2014, and the Decree of 16 September 2016 ("DM PREPAC") established a dedicated grant line to deliver those annual renovations in a structured, transparent way. The policy logic is straightforward: target a portfolio of cost-effective, replicable measures—envelope upgrades, high-efficiency HVAC and controls, lighting, building automation—prioritised by primary-energy savings and cost-effectiveness, while ensuring minimum comfort and quality standards for public services.

What have been the main difficulties encountered in developing or implementing the scheme?

Three families of challenges emerged. (i) Asset and data heterogeneity: central administrations manage diverse building types and conditions; establishing robust baselines (audits, metered data, hours of use) and comparable key performance indicators takes effort. (ii) Procurement and scheduling constraints: projects must comply with public-procurement rules and often operate in occupied buildings; this affects phasing, cost control, and time-to-completion. (iii) Regulatory interfaces: heritage restrictions, fire safety, acoustics, and indoor-air-quality requirements can limit design options, especially for deep envelope works. To mitigate these, we issued standardised technical dossiers, provided ex-ante design reviews, and promoted bundling of similar buildings to achieve economies of scale and reduce transaction costs.

What success factors would you have identified?

Clear governance and roles—policy steering by the Ministry, technical guidance and appraisal by ENEA, implementation by the beneficiary administrations—keeps decision paths short. Standardisation is essential: templates for energy audits and M&V plans, model technical specifications aligned with Green Public Procurement criteria, and checklists for commissioning reduce variability and rework. Portfolio thinking—aggregating buildings by archetype and climate—improves predictability of outcomes and procurement leverage. Performance orientation—ranking proposals by expected primary-energy savings (kWh/y), €/kWh saved, and qualitative risk factors—helps allocate scarce funds efficiently. Finally, capacity building (training designers, RUPs, and facility managers) sustains quality from design through operation.

What have been the main changes in the scheme in recent years? Are there further developments planned? Or what would be the main challenges for the coming years?

Two development tracks are in focus. First, deeper integration of performance evidence: progressively strengthening meter-informed baselines, post-retrofit M&V, and feedback loops to refine design guidelines over time—without overburdening administrations. Second, digitalisation: a more API-ready data backbone linking building registries, audits, works progress, and energy billing will streamline reporting and ex-post evaluation. The main challenges are stable multi-year funding to sustain a predictable pipeline; supply-chain and skills availability for quality envelope works and commissioning; and policy coherence with other instruments (e.g., Conto Termico, renovation waves, and green-procurement rules) to avoid overlaps and unintended incentives. For complex assets and protected buildings, early coordination with heritage authorities remains critical.

If you could go back in time, what would you do differently?

I would front-load four design choices. (1) A unified asset registry for the central-government stock, with unique building IDs and standard taxonomies for systems and uses—this would have accelerated baselining and portfolio aggregation. (2) Pre-approved, archetype-specific tender kits (technical specs, drawings, M&V protocols) to shorten procurement timelines and reduce design variance. (3) A staged rollout with pilot cohorts and randomised technical inspections to calibrate thresholds, cost benchmarks, and risk allowances before scaling nationally. (4) Stronger emphasis on operations and maintenance from day one—commissioning, controls tuning, and simple operator dashboards—because a significant share of savings depends on how buildings are run after handover.

Ανακυκλώνω - Αλλάζω συσκευή (Recycle – Change my appliance)

Factsheet prepared by Konstantina Karalaiou (IEECP) | July 2025

Background and objectives

The "Recycle - Change my appliance" scheme was a subsidy programme designed to address excessive energy consumption used for cooling purposes, and promote the recycling of old and inefficient cooling appliances (i.e. air conditioners, refrigerators, and freezers), to be replaced with new and more efficient ones.

This has been the largest programme for recycling and replacement of electrical appliances in Greece, where citizens of all income categories could apply, while emphasis was given to prioritizing poor households. This subsidy programme was a nationally funded programme that was initiated in 2022 and was terminated within the same year. It was part of Greece's National Energy and Climate Plan for 2021-2030.

Key features

The subsidy concerned the replacement and recycling of:

- old air conditioners: manufactured according to outdated technologies and with old refrigerant (up to two appliances): to be replaced with new ones, of energy class from A ++ or higher (i.e. A+++),
- old refrigerators with old energy classification (up to one appliances): to be replaced with new ones, with energy class E or higher (i.e. D, C, B, A) (considering the new EU energy labelling scale)
- old freezers (up to one appliances): to be replaced with new ones, of new energy class from F or higher (i.e. E, D, C, B, A)

Beneficiaries' selection: Applications are ranked and selected according to economic and social criteria (income per household member; family member with a disability; single parent families; number of dependent members). Vulnerable households get a higher score.

Each application included a total of one to three devices to be replaced, with the possibility to submit one application per adult.

The eligibility criteria concerned 4 income categories (higher grant rate for lower income):

- below €5,000: 50% grant rate
- over €5,000 and up to €10,000: 45% grant rate
- over €10,000 and up to €20,000: 35% grant rate
- over €20,000: 30% grant rate

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Practical aspects:

- Eligible costs included both the net value of the device and the VAT, depending on the buyer's place of residency.
- The subsidy was provided through vouchers issued by the programme, which could be used when purchasing a new appliance at electrical appliances retail stores, and cover part of the total cost.
- For each purchase of a new subsidized appliance, there was a parallel obligation to dispose for recycling an old appliance belonging to the same category (scrappage scheme).

Implementation

Design and preparation of the scheme: A step-by-step guidance was published by the **Greek Ministry of Environment and Energy** to support the residents with the application procedure for the replacement of their appliances (relevant material published in Greek here). At the same time, the successful implementation of the programme required informing and guiding the local retail and manufacturing ecosystems. Therefore, official guidance by the national authority was tailored for retailers, such as electrical appliance stores (relevant material published in Greek here), manufacturers, representatives, and distributors, (relevant material published in Greek here), as well as technicians (relevant material published in Greek here). The full implementation guidebook is provided in the Greek language here.

Implementation, monitoring and controls: The "Implementation and Control Body" and the "Certification and Payment Agency" were the main authorities that aimed at securing the successful and fair programme implementation. In short, the "**Implementation and Control Body**" was responsible for issuing the provisional and final results of the evaluation and announcing the lists of funding applications that may be subsidized by the Programme. The tasks of the "**Certification and Payment Agency**" included (1) certifying the procedures of the Program, including the sale of new subsidized appliances and the withdrawal of an equal number of old ones, and (2) providing the corresponding subsidy (payment to suppliers).

Customer's journey/application: The main steps for the application to programme included:

- Submission of an application via the website gov.gr. During this process, certain information, such as the electricity metering and income data, were verified.
- If the application was approved, the applicant received a voucher within 3 to 4 weeks after the application platform closed
- The applicant could use the voucher at an official retailer/energy services provider; with the use of the voucher, the buyer paid only the remaining cost of the new appliance of their choice. The old/replaced appliance was collected by the retailer for recycling, to validate the subsidy

Budget

Programme Budget: The programme was supported by a national public budget, amounting to EU 286.000.000. The subsidy started from 30% and reached up to 50% of the cost of the devices, while the final grant amount per device was capped from €135 to €710, depending on the type of device that was recycled. The budget allocation across the Greek regions is presented in the following table.

Results and impacts

Programme impact: The programme aimed to reduce the electricity consumption by up to 40%, while the reduction of the energy bill of a house can exceed €300 on an annual basis, depending on the category and the use of the device that was replaced. The total energy savings through this programme were estimated to reach 209,000 MWh per year (source: MURE database), which is equivalent to the annual electricity consumption of all the houses in a city with a population of 100,000 inhabitants. The results of the programme, in terms of application numbers and appliance replaces are presented in the table below (data last updated in June 2025).

Overall the scheme supported the **replacement of more than 630 000 air-conditioners**.

	Air-conditioners	Refrigerators	Freezers
Number of Vouchers Published	489,386	356,083	95,703
Sales of Appliances			
The appliance is available for use	167,314	98,424	44,256
The appliance has been reserved/redeemed by a merchant.	322,072	257,659	51,447
Recycled Appliances			
The appliance has been handed over for recycling by the private individual to the retailer.	77	19	13
The old appliance has been handed over by the retailer to a recycling organization.	1,214	248	58
Disposal has been confirmed by the Certification and Payment Agency.	632,283	254,907	50,419

Source: based on data available at https://allazosyskevi.gov.gr/proodos-statistika-stoicheia/

Lessons learnt

A variety of sources[1] underlined that the "Recycle – Change my appliance" programme was unsuccessful, due to the fact that a great number of applications were rejected.

At the same time, the subsidy incentive distorted the market behavior, as many retailers raised the prices of the appliances[2]. Therefore, the programme's amount provided to the applicants was not enough, in certain cases, to cover a significant amount of the new appliance's price.

Sources

- *Detailed description of the scheme in the MURE database: https://www.measures.odyssee-mure.eu/energy-efficiency-policies-database.html#/measures/4551*

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- *Results' data source: https://allazosyskevi.gov.gr/proodos-statistika-stoicheia/*

Environmental regulation (RE2020) for Buildings (France)

Factsheet prepared by Bruno Duplessis (MinesParis - ARMINES) | July 2025

Background and objectives

The environmental regulations for new building construction (RE 2020) came into force on January 1, 2022, gradually replacing the 2012 thermal regulations (RT 2012) [1]. In response to the Grenelle de l'Environnement (2009), the RT 2012 aimed to make low-energy buildings the norm, with a requirement to control energy needs and consumption, and a performance target for summer comfort. RT 2012 also introduced a requirement for the use of renewable energies in detached and semi-detached houses. The new regulation, RE 2020, responds to the French Energy Transition for Green Growth Act (*"Loi pour la Transition Energétique et la Croissance Verte"* (LTECV) 2015) and the French Housing, Planning and Digital Development Act (*Loi "Évolution du logement, de l'aménagement et du numérique"* (ELAN) 2018) by pursuing the objectives of improving the energy performance of new buildings, reducing their impact on the climate (taking into account greenhouse gas emissions over the entire life cycle of buildings) and adapting them to future climatic conditions (reinforcing summer comfort and mitigating overheating risks).

Key features

RE 2020 applies to the construction of buildings or parts of buildings for residential use, but also to buildings or parts of buildings for office use, or for primary or secondary education. It consists of a regulatory energy and environmental assessment of buildings.

The **energy assessment** considers the building's heating, cooling, domestic hot water, ventilation and lighting consumption (and their auxiliaries), as well as consumption linked to the internal mobility of occupants (use of elevators or escalators), including consumption linked to any parking lots (lighting and ventilation).

The **environmental assessment** takes into account the impact on climate change of the building and the development of the plot (external developments outside the building, networks, energy production systems and parking lots). In contrast, **regulatory requirements** focus on the impact of building components and energy consumption during operation.

The **conventional duration** of the building's operating phase taken into account in the calculation is 50 years.

The **energy performance calculation method** uses identical or similar calculation algorithms to those used in the previous regulations, with a few adaptations and additions, particularly with regard to summer comfort. RE 2020 introduces a new requirement for discomfort degree-hours (DH), with a new calculation method that takes into account the **effects of climate change** on buildings: future temperature trends, and heat waves that will become more frequent, more intense and longer [2]. For summer comfort calculations only, the updated meteorological scenarios include the **insertion of a heatwave sequence in the conventional weather files**.

The indicator used to assess discomfort is the **discomfort degree-hour (DH)**, expressed in °C.h and represents the level of discomfort caused by a heatwave. It represents the level of discomfort perceived by occupants. More concretely, this indicator resembles a counter that accumulates, over the summer period, each uncomfortable

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degree for each hour of the day and night. Uncomfortable degrees are conventionally those that exceed a comfort indoor temperature, which generally varies between 26 and 28°C depending on outside temperatures

RE 2020 introduces **two discomfort thresholds**, based on the DH indicator in °C.h:

- a high threshold (DH_max, which depends on building's usage and external constraints), above which the building is not compliant with regulations (excessive discomfort),
- a low threshold (350 °C.h) below which the building is considered comfortable during heatwave periods.

Between these two thresholds, the building complies with the regulatory requirement, but to encourage the achievement of the low threshold with passive levers, a cooling lump sum is added to the energy consumption assessing the energy performance of the building.

RE 2020 defines also two thresholds that the building's indoor temperature must not exceed (when the building is occupied) to avoid discomfort:

- at night, a temperature threshold of 26°C;
- during the day, an adaptive temperature threshold between 26° and 28°C.

Beyond these thresholds, every degree in the building is considered uncomfortable for the occupant. During the day, this threshold is constant, but not necessarily identical to that of the previous day. It varies from one day to the next to take into account the human body's ability to adapt to high temperatures after a succession of hot days, up to a maximum of +2°C compared with the consensus threshold of 26°C.

Implementation

Applying the assessment method to a building project or an existing building requires the use of one or more assessment software programs. It is essential to start with carrying out an energy assessment. As a second step, and based on the data from the first assessment, an environmental assessment should be carried out.

Software approved for regulatory calculations using the Th-BCE 2020 method can be used to carry out the energy assessment and produce the outputs required to assess the environmental impact of energy consumption. It also creates a standardized thermal study summary file in an output format that must be compatible with the assessment of the building's environmental performance.

As for energy and summer comfort, the software used to carry out the environmental assessment required to calculate the "greenhouse gas emissions" indicators must be approved by the Ministry and enable the new calculation method based on life cycle analysis to be taken into account, in compliance with the RE 2020 decree. These software approved for regulatory calculations in accordance with the general rules for calculating energy and environmental performance, can be used to carry out the environmental assessment and to create a standardized energy and environmental study summary file.

Budget (or other cost data)

Not available

Results and impacts

The previous regulations had led to significant discrepancies, observed in the field, between compliance with energy performance standards and the summer comfort actually perceived by occupants. The new regulation is designed to reduce these discrepancies. However, it is too early to draw up an assessment of its implementation less than 3 years after it came into force.

Sources

[1] « Textes réglementaires [archive] », Ministère de la Transition écologique, sur RT-RE-bâtiment, seen on 2025 July, 15th

[2] Guide RE2020, Réglementation environnementale des bâtiments neufs, Ministère de la Transition Ecologique, CEREMA, janvier 2024

National heat wave management plan

Factsheet prepared by Bruno Duplessis (MinesParis - ARMINES) | July 2025

Background and objectives

Manifestations of ongoing climate change, heat waves are becoming increasingly intense, frequent, early and long. In France, before 1989, they occurred on average once every 5 years. Since 2000, they have recurred every year. And the increase in heatwaves is set to continue: in 30 years' time, there will be twice as many. Heatwaves have a significant impact on health, particularly among vulnerable populations such as the elderly and children. But they also affect the environment (drought, forest fires, etc.), agriculture, the economy and social and cultural life.

The latest version of the national heatwave management plan was presented in June 2023 by the Minister of Ecological Transition and Territorial Cohesion. The aim of this new plan is to extend the mechanism managed by the Ministry of Health [1], by broadening it to include impacts that are not directly health-related: transport, energy, agriculture, education, sports, etc.

Key features

The national heatwave management plan is based on the specific vigilance system set up by Météo France[3] and is structured around four key areas:

- limit the impact on the daily lives of French people
- ensure the continuity of essential public services
- ensure the continuity of economic life
- protect natural environments and resources.

The national heatwave management plan includes 27 detailed actions – 15 of which were effective from summer 2023 – aimed at four different audiences: the general public, young people and vulnerable people, workers and businesses, athletes and spectators at cultural events [2]. To this must be added the annual preparation of actors in the electrical sector.

Implementation

Some of the 25 actions are implemented every year, in advance of periods of high heat wave risk. Other actions will be implemented when a heat wave is forecast or underway. Heatwaves are generally forecast a week or so in advance, thanks to weather forecasting models from Météo France. This time must be used to alert the various players involved in risk prevention and management. These actions may be adapted and/or implemented specifically to take into account the particular situation of overseas territories.

[3] Météo-France is the official meteorological and climatological public service in France

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Targeted audience	Yearly implementation	Periods of high heat wave risk
For the general public	Awareness and communication campaign on small-scale renovation work Inventory of cool islands and public fountains in municipalities Promoting the state start-up “Plus fraiche ma ville”[4]	Awareness and communication campaign on the behaviors to adopt at home Information and empowerment campaign for animal owners and keepers Awareness and communication on the risk of drowning Dissemination of prevention messages in transport SMS broadcasting by telephone operators in exceptional situations
For the young people and vulnerable people	Mobilization of young people on universal national service to register vulnerable people on local registers and support climate change awareness campaigns Raising awareness among tutors/curators of the need to register vulnerable persons in communal registers Introduction of an annual inspection of cooled rooms and summer comfort equipment in schools, nurseries and examination rooms. Setting up a control system for rooms and refreshed premises that can be used for examinations	
For the workers and businesses	Creation of a guide for companies on work that can be carried out in offices	Awareness and communication campaign on the behaviors to adopt at work Reinforcement of labor inspection controls Restriction of live animal transport and management of peak activity by rendering companies

[4] This action is the subject of a separate factsheet

Targeted audience	Yearly implementation	Periods of high heat wave risk
For the athletes and spectators at cultural events	Campaign to raise awareness among sports and cultural event organizers of best practices in the event of heat waves Information for sports instructors	Information for sports instructors and cultural event organizers
For the actors in the electrical sectors	Every year, before the summer, the Ministries of Energy Transition and Ecological Transition and Territorial Cohesion organize a meeting with the main actors in the electricity sector and the public establishments concerned (Météo France, Office Français de la Biodiversité, etc.) to review seasonal forecasts and share procedures in the event of a heat wave and the methods for distributing the various information bulletins.	The national grid operator (RTE) and the main distribution system operator (Enedis) strengthen their monitoring and response resources for heatwave and drought periods

These actions are implemented by the ministries concerned, in liaison with the Ministry of the Interior and Overseas Territories where appropriate, depending on the situation and with the contributions of various associated public operators (Ademe, Anah, France Renov, Santé Publique France, Institut National de la consommation,), public and private companies in the transport sector (railways, public transport, air transport, road infrastructure operators)and local authorities (Mayors, prefects) They complement the national health crisis management and support system managed by the Ministry of Health, as described in the interministerial instruction of May 27, 2024 on the health management of heat waves in mainland France [3].

Budget (or other cost data)

Not available

Results and impacts

Not available

Lessons learnt

Two elements stand out in the context of this action plan:

- Firstly, the need to coordinate this plan with the health crisis management plan, and to mobilize public services from different ministries and geographical levels, as well as numerous public companies,
- On the other hand, the need to develop long-term actions to anticipate both the availability of means of action and improve the resilience of buildings and their occupants to heatwaves.

Sources

[1] https://www.santepubliquefrance.fr/determinants-de-sante/climat/fortes-chaleurs-canicule/notre-action/#tabs

[2] Plan de gestion des vagues de chaleur, Ministère de la Transition Ecologique, 7 juin 2023. Available at https://www.ecologie.gouv.fr/sites/default/files/documents/08.06.2023_Plan_vagues_de_chaleur.pdf

[3] Instruction interminitérielle n°DGS/CCS/UDP/DGOS/DGCS/DGT/DGSCGC/DGEC/DJEPVA/DS/DGESCO/DIHAL/2024/70 du 27 mai 2024 relative à la gestion sanitaire des vagues de chaleur en France métropolitaine. Available at https://sante.gouv.fr/IMG/pdf/instruction_vague_de_chaleur_2024_70.pdf

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