



Cool LIFE

D8.2.

Final Publishable Report



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List of Acronyms

AC	Air Conditioning	RCP	Representative Concentration Pathway
CDD	Cooling Degree Days	RES	Renewable Energy Sources
GUI	Graphical User Interfaces	SME	Small and Medium Enterprise
HVAC	Energy Performance of Buildings Directive	KPI	Key Performance indicator
NECP	National Energy and Climate Plan		

Keywords List

- * Sustainable space cooling
- * Space cooling demand scenarios
- * Passive and nature-based solutions
- * Adaptive comfort and user behaviour
- * Local energy planning
- * Digital decision-support tools
- * Policy recommendations
- * Climate resilience in buildings

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Executive summary

The CoolLIFE project emerged in response to the rising challenge of increasing space cooling demand across Europe, a trend exacerbated by climate change, urbanisation, and shifting occupant expectations for indoor comfort. While significant policy and market efforts have focused on heating decarbonisation, the cooling sector has remained under-addressed, leading to a growing energy demand gap, especially in the residential sector.

CoolLIFE sought to close this gap by delivering two interconnected innovations: the CoolLIFE Tool and the Knowledge Hub. The former is an open-source modelling platform that enables mapping of current and future space cooling demand across EU27 territories, ranging from the hectare to the continental level. It integrates behavioural, legal, economic, technological, and climatic dimensions and offers users the ability to simulate and compare scenarios for 2030 and 2050. The Knowledge Hub complements this tool by serving as a structured, user-friendly repository of quality-assured data, best practices, and policy frameworks related to space cooling.

By integrating comfort, lifestyle and user behaviour factors with technical, legal and economic considerations, CoolLIFE's outputs support a holistic approach to space cooling demand management. The project focused especially on natural, passive, free cooling, and nature-based solution options, which are often overlooked despite their high potential. Tool development and validation were carried out in close collaboration with stakeholders, ensuring usability and practical relevance. Validation was conducted through case studies in Northern, Southern and Central Europe (Dublin, Bolzano/Bozen, and Naples), allowing for feedback across a spectrum of climatic and socioeconomic conditions.

Stakeholder engagement was central to the project's impact. Over the project period, CoolLIFE conducted more than 20 workshops and training events with municipalities, energy planners, policymakers, and industry stakeholders. These events fostered dialogue, gathered feedback for iterative tool improvement, and enabled local actors (e.g. municipal planning departments, regional authorities, utility companies, engineering companies, etc.) to embed the project's insights in planning and policy activities.

The policy framework considered in this project and relevant to space cooling goes from the regulations on space cooling equipment and buildings up to urban level (e.g. about urban heat island and district cooling), and local as well as national planning (e.g. assessment of future needs and potentials). Policy analysis found that space cooling is a field where the linkage between mitigation and adaptation strategies and policies is essential, considering impacts on health, economic activity, the electricity system, among others. Summer comfort should be a key parameter for climate-resilient buildings, considering whole-year comfort and anticipating future climate conditions. Planning and policies are needed to guide and promote sustainable solutions, as otherwise the major risk is actions and investments made in a hurry (e.g. during heat waves), resulting in higher costs, lower effectiveness and higher negative impacts (e.g. leakages of refrigerants from mobile air conditioning devices).

In conclusion, CoolLIFE helps laying the foundation for a data-informed, user-centric, and sustainability-oriented transition in the European space cooling sector. This report presents the project's context, methodological innovations, tools, results, lessons, and policy implications. Through its technical and institutional outputs, CoolLIFE contributes directly to European objectives on climate resilience, energy efficiency, and equitable access to thermal comfort.

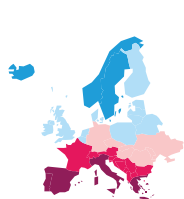
1. Introduction

Space cooling (SC) is a growing driver of energy consumption in Europe, particularly in the context of rising temperatures, increased urban density, and evolving user expectations. According to EU projections, space cooling demand will continue to grow steadily through 2050, with residential demand increasing disproportionately due to demographic and behavioural shifts, and more frequent and longer periods of warmer temperatures.

Despite these trends, cooling has traditionally received limited attention in energy policy and planning. National Energy and Climate Plans (NECPs) and long-term renovation strategies have prioritised heating, leaving cooling as a secondary concern, in line with the respective share of space heating and space cooling in the energy consumption of buildings. This asymmetry risks however undermining climate mitigation targets and exacerbating energy poverty and climate inequality, especially in Southern and Eastern Europe. Warmer temperatures in summer, and especially heat waves, represent already major issues for health, economic activity and the electricity system in an increasing number of countries.

The CoolLIFE project responds to this policy and research gap. It was launched in November 2022 under the LIFE Clean Energy Transition subprogramme (call 'LIFE21-CET-COOLING'), with the objective of advancing sustainable space cooling solutions through innovative, user-oriented tools and platforms. The project aligns closely with the goals of the European Green Deal (European Commission, The European Green Deal, 2019), the Renovation Wave initiative (European Commission, Renovation Wave Strategy, 2020), and the Fit for 55 package (European Council, 2019), all of which recognise the importance of enhancing energy performance and comfort in buildings.

The main objectives of the CoolLIFE project were to:



- * Develop a tool for mapping and simulating space cooling demand at multiple spatial scales and time horizons.



- * Promote passive, free, renewable energy sources (RES) powered, and nature-based space cooling solutions through scenario modelling and policy recommendations.



- * Create a publicly accessible knowledge repository on space cooling technologies, user practices, policies, and financing mechanisms.



- * Engage stakeholders across levels to co-design, test, and disseminate solutions.

By addressing space cooling demand through both technological and behavioural lenses, CoolLIFE contributes to building-level, municipal, and national strategies that are more robust, equitable, and future-proof.

2. CoolLIFE's Work Packages

The CoolLIFE project was organised into a series of interlinked Work Packages (WPs) that structured the workflow from research and data collection through tool development, validation, and dissemination. This structure allowed the consortium to manage complexity while ensuring that each thematic area contributed coherently to the project's overarching objectives. The WPs combined technical research and development, behavioural studies, policy analysis, and practical engagement with stakeholders, ensuring that outcomes were both scientifically robust and directly relevant for decision-makers and practitioners.

At the same time, the WP structure provided a clear framework for management, monitoring, and quality assurance. Milestones and deliverables were used to measure progress and ensure accountability, while regular meetings and review mechanisms supported knowledge exchange between partners. This collaborative organisation also encouraged interdisciplinary interaction, fostering links between engineering, social sciences, and policy analysis that were critical to addressing the multifaceted challenges of sustainable space cooling.

The following subchapters present each WP in turn, highlighting the most important activities carried out, the milestones reached, and the deliverables produced. Together, these summaries illustrate how the different strands of work complemented one another to ensure the project's overall success.

Work Package 1: Project management

WP1, led by EURAC Research, provided the essential management structure for CoolLIFE, running from the first to the last month. Its primary goal was to ensure effective coordination, documentation, financial administration, and supervision across all partners, while maintaining regular communication with CINEA. A key focus was fostering a constructive communication framework, ensuring transparency, and promptly addressing risks.

The WP was structured into five main tasks. Task 1.1 focused on organisation and communication, ensuring continuous exchanges via meetings, videoconferences, and email, supported by an intranet-based document repository. Task 1.2 organised one in-person meeting every six months, starting with the Kick-Off Meeting, complemented by regular cyber-meetings of the technical and communication boards. Task 1.3 covered financial administration, ensuring compliance with European and national regulations and supporting transparent accounting. Task 1.4 advanced gender balance and inclusivity to embed gender-neutral practices in training, communication, and dissemination. Finally, Task 1.5 oversaw progress monitoring and risk management, ensuring that deliverable deadlines, reporting, and consortium coordination remained on track.

The WP achieved several milestones, notably the establishment of strong communication protocols, the organisation of regular consortium meetings, and the implementation of structured risk management procedures. It also ensured that unexpected issues were managed swiftly, with corrective actions taken where necessary.

Deliverables under WP1 included:

- * D1.1 "Data Management Plan" (*Malla, D1.1 Data Management Plan, 2025*) – establishing protocols for the collection, storage, and dissemination of project data, in line with FAIR principles and GDPR.
- * D1.2 "Technical Progress Reports" (*Pezzutto & Moser, D1.2 Technical Progress Report, 2025*) – providing an interim overview of project status, challenges, and corrective measures.
- * D1.3 "Extract of project data from the LIFE KPI webtool" (*Pezzutto, D1.3 Extract of the project data from the LIFE KPI webtool, 2023*) – enabling performance tracking against LIFE programme indicators.
- * D1.4 "Updated extract of the project data from the LIFE KPI webtool" (*Pezzutto, D1.4 Updated extract of the project data from the LIFE KPI webtool, 2025*) – supplying final project data to evaluate impact.

Through WP1, CoolLIFE guaranteed sound governance and accountability, enabling all scientific, technical, and policy-oriented WPs to progress effectively. By embedding inclusive practices, transparent reporting, and robust risk management, WP1 laid the groundwork for the project's successful execution and long-term credibility.

Work Package 2: Technologies, measures, and energy demand assessment

WP2 established the technical evidence base of CoolLIFE by identifying, classifying, and quantifying space cooling technologies, measures, and demand across the EU-27. Its goal was to provide the analytical foundation for the modelling framework and the CoolLIFE Tool's calculation modules, ensuring that all subsequent work packages built on consistent, robust data.

D2.1 was entitled “Taxonomy of space cooling technologies and measures” (Duplessis, et al., D2.1. Taxonomy of space cooling technologies and measures, 2023). This classification went beyond conventional vapor compression (VC) systems to include 35 alternative technologies and a wide range of passive solutions. The taxonomy organized these into clear categories—passive, active, passive/active—while assessing their physical form of energy input, basic working principles, technology readiness, costs, relevance across different climatic contexts, and many other characteristics.

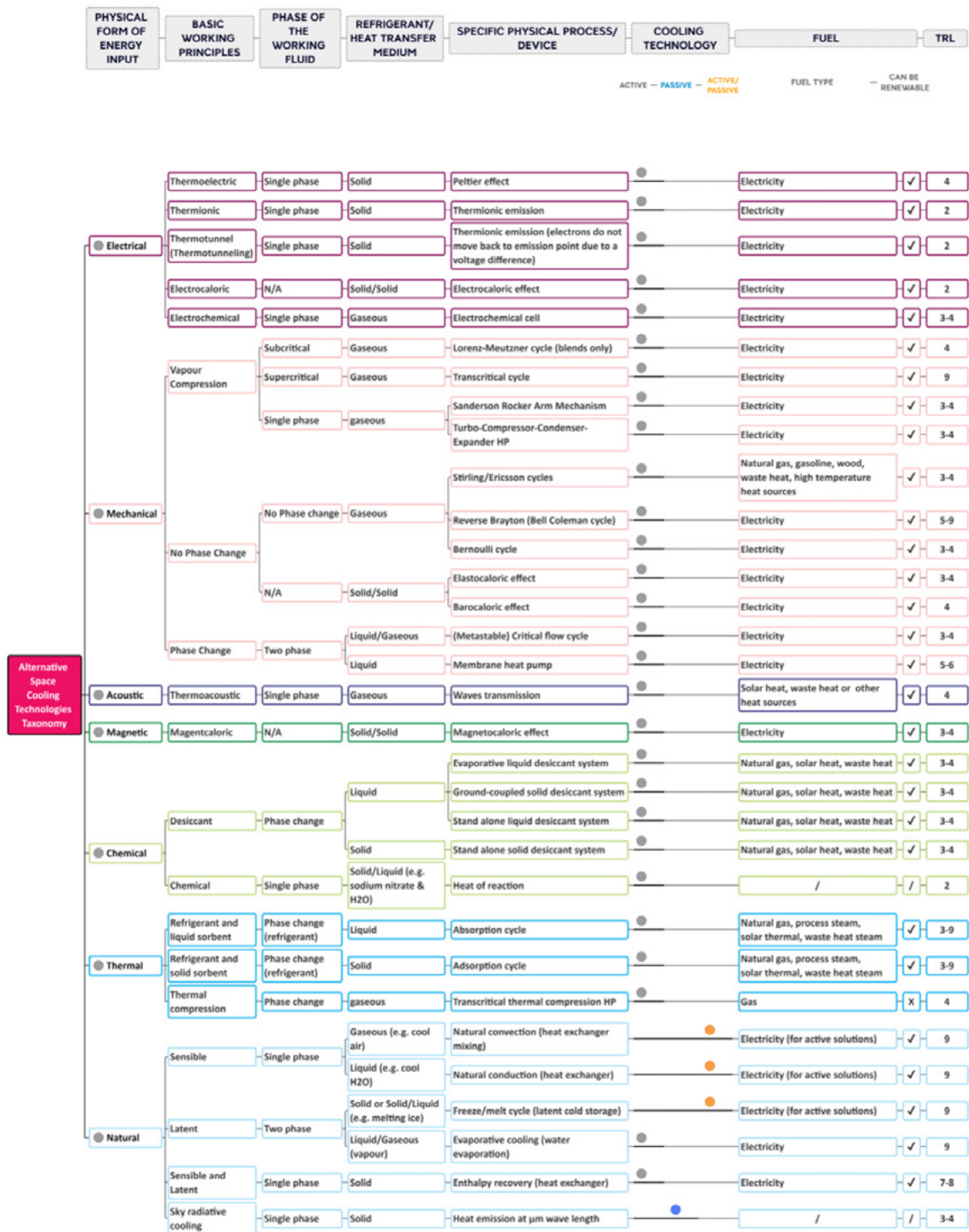


Figure 1. Taxonomy of space cooling technologies

In addition to the taxonomy of space cooling technologies, D2.1 also provided a detailed categorisation of cooling measures considering passive measures (as green roofs, opaque ventilation facades, and ventilated roofs), active measures (as rotating shading systems, automated screens, and ceiling fans), and comfort lifestyle and user behaviors (as opening/closing windows/doors or changing activity level).

D2.2 “Energy demand assessment” (Duplessis, et al., D2.2 Energy demand assessment, 2024) quantified the SC demand across residential and service sectors. For the base year 2021, total European SC demand was estimated at 545 TWh/year, with strong regional variation.

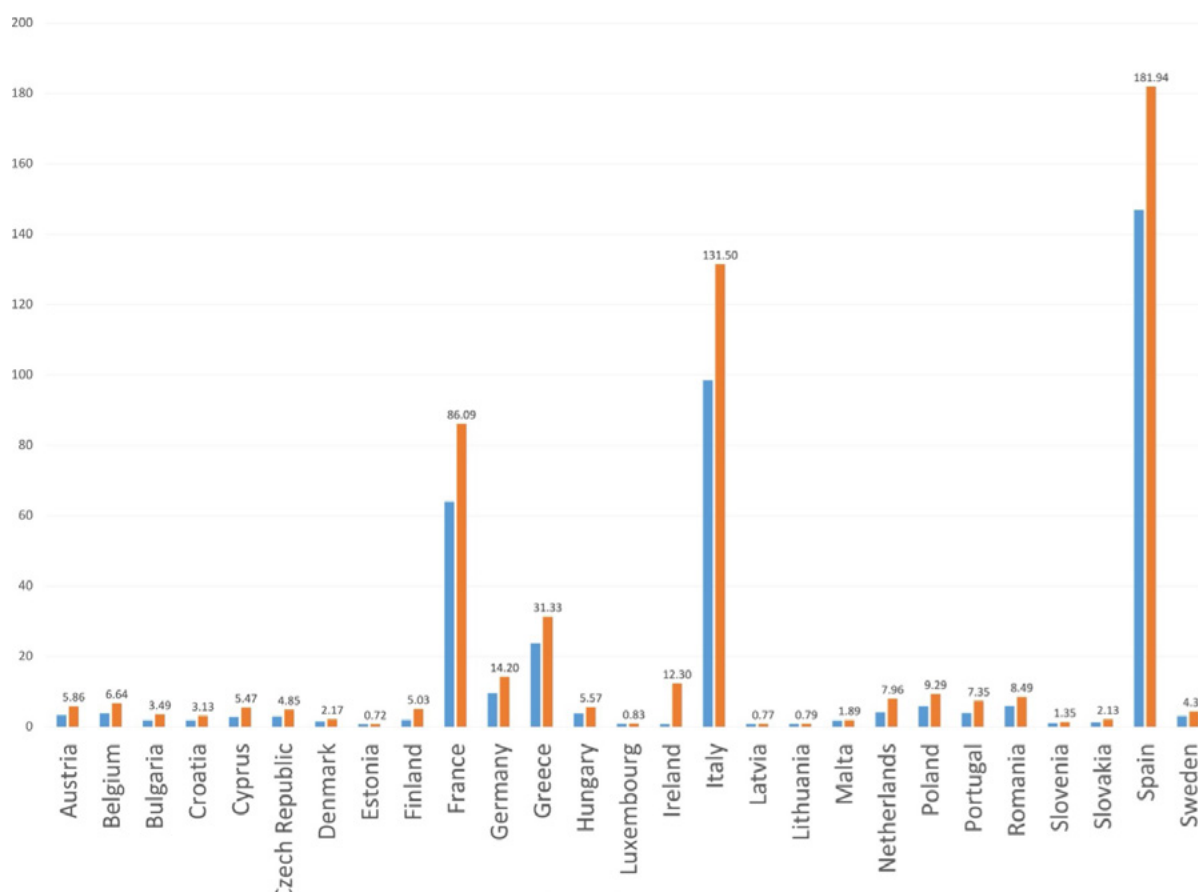


Figure 2. Energy demand for space cooling per country in the residential and service sector, EU27, the reference year 2021 (Orange) compared with year 2016 (Blue)

The graph above shows how space cooling demand was noticed to be rising sharply in the last few years. The contrast between 2016 and 2021 underscores the urgency of integrating space cooling into energy policy to avoid locking in unsustainable growth and peak load pressures.

D2.3 carried out an “Impact assessment of active and passive solutions” (Malla, et al., 2024) using the Invert/EE-Lab model (e-think & Technische Universität Wien, 2025) to simulate future space cooling demand under different scenarios. The analysis demonstrated that a business-as-usual trajectory would result in a steep increase of cooling demand across the EU27, driven by higher penetration of air-conditioning units, rising comfort expectations, and climate change impacts. In contrast, ambitious combinations of passive measures (e.g., external shading, reflective roofs, advanced glazing) with efficient active systems lead to a substantial reduction of energy use for cooling. Under the most progressive scenario, space cooling demand in 2050 could be reduced by nearly 80% compared to the baseline projection. In addition, the scenarios illustrated co-benefits such as reduced emissions, improved resilience against peak loads, and positive macroeconomic impacts through energy savings and investment in efficiency.

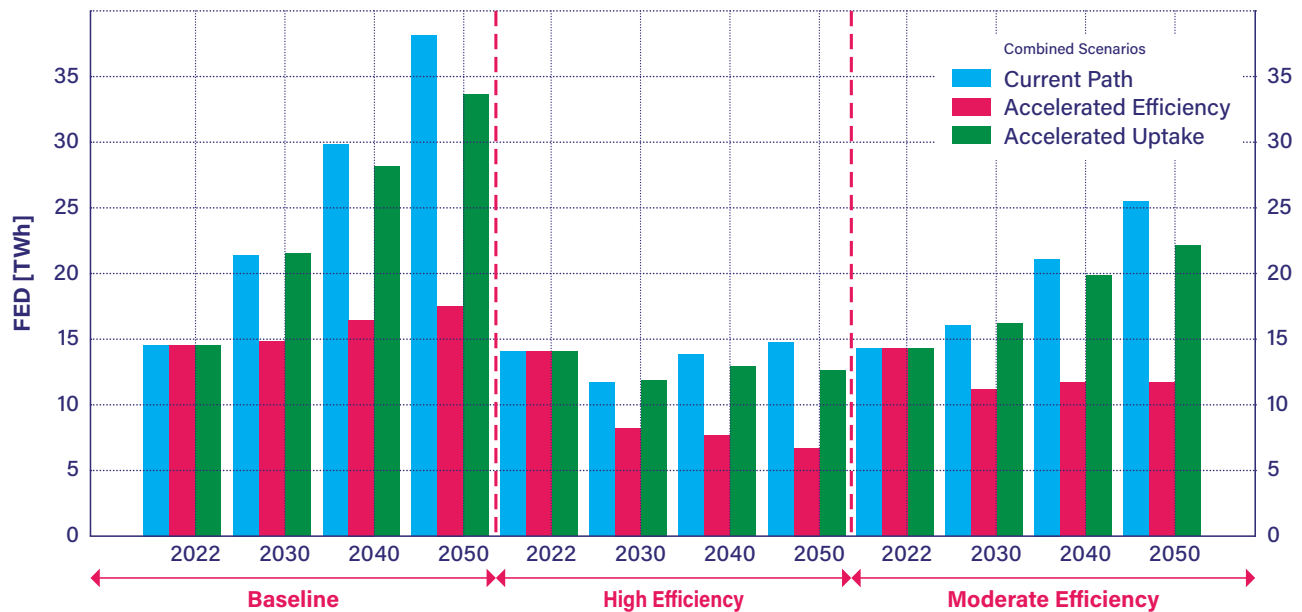


Figure 3. Final Energy demand in the EU-27 Residential sector (scenarios of active cooling diffusion of three technology improvement for three efficiency scenarios)

The graph above compares different scenarios for the residential sector and shows how integrated approaches can drastically curb future demand. The “best performing” scenario demonstrates the transformative impact of scaling up passive measures alongside efficient active systems, confirming the potential for sustainable space cooling transitions.

All the activities of WP2 built the foundation for the CoolLIFE Tool, clarifying technological pathways, quantifying future needs, and evidencing the benefits of systemic strategies.

Work Package 3: Comfort, lifestyle, and user behaviour

Work Package 3 investigated the role of comfort expectations, lifestyles, and user behavior in shaping space cooling demand, with the aim of reducing uncertainties in modelling and enhancing the effectiveness of sustainable SC strategies. By combining literature reviews, empirical data, simulation methods, and multiple impact assessments, WP3 demonstrated that behavioral aspects are decisive for both the scale and the variability of cooling needs in Europe.

D3.1 was entitled “Knowledgebase for occupant-centric space cooling” (Hurtado-Verazaín, et al., 2023). It highlighted the scarcity of robust empirical data on summer comfort, particularly in residential buildings, and emphasized the stochastic nature of user actions such as shading, thermostat adjustment, and natural ventilation.

D3.2 “Analysis of behavioral interventions across Europe” (Gelesz, et al., 2023) showed that simple, low-cost measures—such as feedback, dynamic pricing, nudging, or awareness campaigns—can reduce SC demand by 10–15%. Importantly, these measures are highly context-dependent, requiring cultural, climatic, and socio-economic considerations.

D3.3 “Multiple, socioeconomic impacts of sustainable space cooling” (Gelesz, et al., 2024) advanced the work of D3.2. Three main behavioral scenarios were modelled for residential and non-residential buildings: (i) *Unconscious* (mechanical cooling reliance without adaptation), (ii) *Mitigation* (reactive use of passive/adaptive measures once discomfort arises), and (iii) *Adaptation* (proactive behavioral changes to prevent discomfort). The simulations showed that mitigation strategies can reduce annual SC demand by 69–84%, while proactive adaptation can achieve reductions of up to 97–100%. For non-residential buildings such as offices, hospitals, hotels, and schools, significant reductions (40–76%) were also achievable by raising setpoints, using shading, and adopting night ventilation.

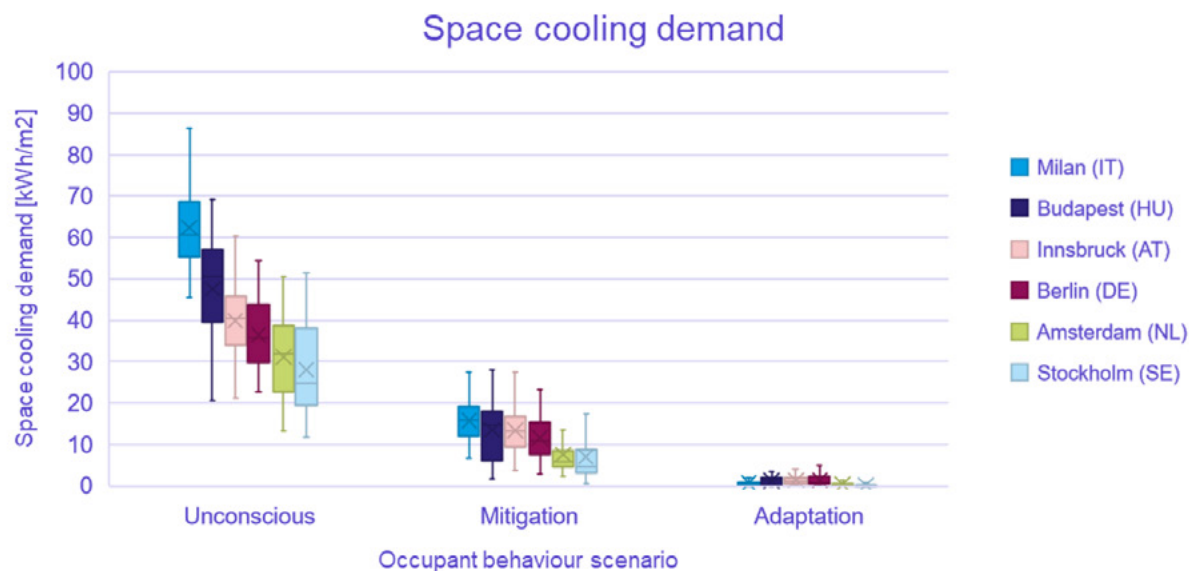


Figure 4. Effect of occupant behaviour scenarios on SC demand, considering all residential building types, for all simulated scenarios - annual space cooling demand of each scenario

The figure above compares annual space cooling demand across the Unconscious, Mitigation, and Adaptation scenarios for multiple residential building types in 6 different European cities. It clearly demonstrates the dramatic differences resulting from behavioral styles: while Unconscious use drives very high cooling needs, proactive Adaptation almost eliminates the need for space cooling in many cases. The results confirm that behavior is not a marginal factor but a structural determinant of cooling demand.

Beyond energy impacts, D3.3 assessed multiple socioeconomic co-benefits of behavioral interventions, including reduced summer energy poverty, avoided heat-related mortality and morbidity, improved productivity during heat waves, and lower emissions and import dependency. Monetization of these multiple impacts showed additional savings of 3–12% above direct energy cost reductions. (Gelesz, et al., 2024)

Overall, WP3 confirmed that occupant behavior is a central driver of space cooling demand, often determining the success or failure of technical interventions. Incorporating behavioral profiles and adaptive comfort assumptions into planning is therefore essential to avoid underestimating cooling needs or overlooking low-cost, equitable solutions.

Work Package 4: Policy, financing, and recommendations

WP4 analysed the institutional and financial context for sustainable space cooling across the EU27, combining a review of existing regulations, a mapping of financing schemes, and the development of targeted policy recommendations. The objective was to identify gaps in current frameworks and propose strategies to integrate space cooling more explicitly into European and national energy transition pathways.

D4.1 delivered a comprehensive “Review and mapping of legislations and regulations on sustainable space cooling at EU and national levels” (Broc, et al., 2024). It highlighted that while the EU policy framework increasingly refers to “heating and cooling” (e.g., through the Energy Efficiency Directive (European Commission, Energy Efficiency Directive, n.d.), the Energy Performance of Buildings Directive (European Commission, Energy Performance of Buildings Directive, 2025), and the Renewable Energy Directive (European Commission, Renewable Energy Directive, 2025), space cooling is rarely addressed with the same level of detail as heating. National regulations vary widely: some Member States have established building codes or efficiency standards for cooling, but others focus predominantly on heating, leaving SC insufficiently regulated. Importantly, space cooling is rarely prioritised in National Energy and Climate Plans, where it is often mentioned only in relation to peak electricity loads or energy security.

D4.2 was entitled “Review of financing schemes relevant for sustainable space cooling at EU and national levels” (Conforto, D4.2 Review of Financing Schemes Relevant for Sustainable Space Cooling at the EU and National Levels, 2024). The analysis revealed that although a wide range of instruments exists—including grants, green loans, green mortgages, tax rebates, guarantees, and revolving funds—few are explicitly designed for space cooling. Support mechanisms overwhelmingly prioritise heating or general renovation, with passive and hybrid cooling measures particularly underfunded despite their cost-effectiveness and resilience benefits. Furthermore, access to finance remains a major hurdle, especially for vulnerable households that are most at risk of heat stress. This fragmentation limits the uptake of innovative and sustainable space cooling solutions.

The figure below summarises the range of financing instruments in place across Europe. It shows the dominance of traditional measures such as grants and loans, while illustrating the relative scarcity of instruments directly supporting cooling. The figure reinforces the conclusion that SC remains a blind spot in financing design, with most schemes targeting heating or general building renovation.

	Traditional		Innovative	
Non-repayable	Grants, Prizes and Subsidies		Energy-Efficiency Feed-in)Tariff	
	Tax Incentives			
Debt	Loans		Green/Soft Loans	Energy Efficient Morgtages
			Green Bonds, Community Municipal Investment Bonds, Social Bonds	On-Bill Financing (OBF) Loans, Tariffs
	Credit Enhancement (guarantees, securities, insurances, additional collateral, etc.)		Energy Performance Contracting (EPC) and Agreements (EPA)	Energy Service Agreement (ESA)
				Green/Energy Revolving Funds
			Green Leasing, PACE	Crowdfunding
Equity	Third-Party Funding		Energy Communities/Cooperatives	
Other	Technical Assistance (TA), Project Development Assistance (PDA)	Advisory Services	Energy Efficient Quota Obligations	
		Capacity Building	One-Stop Shops (OSS)	

Figure 5. Financial instruments for energy efficiency in buildings, building renovation, heating and cooling, district heating and cooling

D4.3 “Recommendations for enhanced and integrated strategies, policies and schemes relevant for space cooling” (Broc, et al., 2025) translated these insights into policy recommendations, calling for stronger integration of space cooling into NECPs and long-term renovation strategies, the development of performance-based financing schemes, and the prioritisation of equity in subsidy design. The deliverable also emphasised the importance of linking space cooling to adaptation strategies, urban planning, and resilience policies, particularly through the promotion of passive and nature-based measures.

Together, these deliverables confirmed that sustainable cooling cannot be achieved without stronger regulatory integration and targeted financial instruments. WP4 therefore provided the institutional and economic framework that complements the technical and behavioural insights of WP2 and WP3, ensuring that CoolLIFE’s outputs are actionable in policy and practice.

Work Package 5: CoolLIFE tool and Knowledge Hub

WP5 represented the core development phase of the CoolLIFE project, translating the evidence and insights generated in earlier work packages into a practical, open-access tool for planners, policymakers, and practitioners. Its objective was to integrate technological, behavioural, and policy dimensions into a coherent decision-support system capable of assessing current and future space cooling demand and identifying effective measures at multiple scales.

This work package was also responsible for creating the CoolLIFE Knowledge Hub, an online repository bringing together deliverables, datasets, methodological documentation, and supporting resources. Together with the Tool, the Hub ensures transparency, replicability, and long-term accessibility of project outputs.

The activities in WP5 built directly on WP2 (technologies and demand assessment), WP3 (comfort and user behaviour), and WP4 (policies and financing), embedding their results in calculation modules (CMs), scenario modelling functions, and user guidance features. Validation and feedback from stakeholders further refined usability, ensuring that the Tool responds to the practical needs of end-users.

In the next subchapters, we will delve into the specifications of the CoolLIFE Tool and the Knowledge Hub, outlining their conceptual framework, detailed approach, calculation modules, supporting resources, and much more.

THE COOLLIFE TOOL

The **CoolLIFE tool** (CoolLIFE Tool, 2025) was designed as a decision-support platform to help assessing and planning sustainable space cooling strategies. It combines climatic and spatial data with socio-economic information to generate comparable scenarios and highlight potential impacts of different policy and planning options. Developed as an open-source and open-code tool, its structure ensures that the tool is both scientifically robust and practically useful for a variety of users. The following sections introduce the conceptual framework underpinning the tool and provide a detailed description of its approach.

Conceptual framework

To ensure the scientific rigour, transparency, and applicability of the project outputs in the development of the CoolLIFE Tool, a multi-method approach grounded in stakeholder co-creation, spatial modelling, behavioural analysis, and validation through real-world case studies was employed.

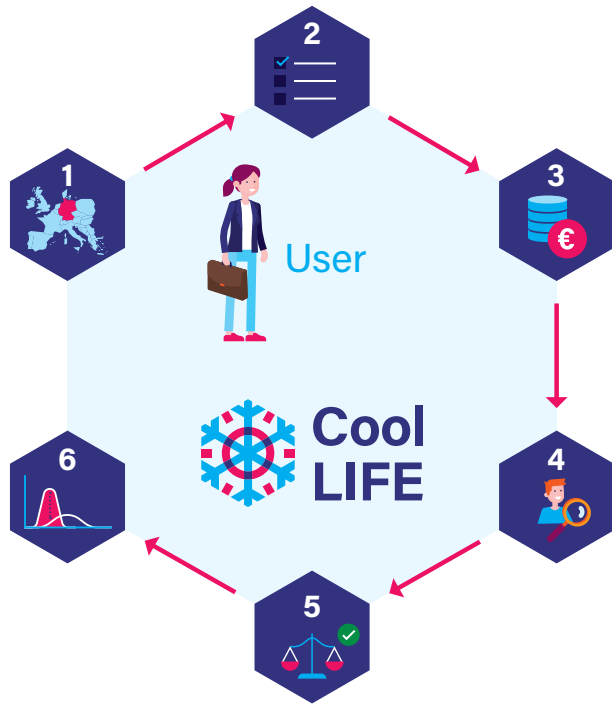


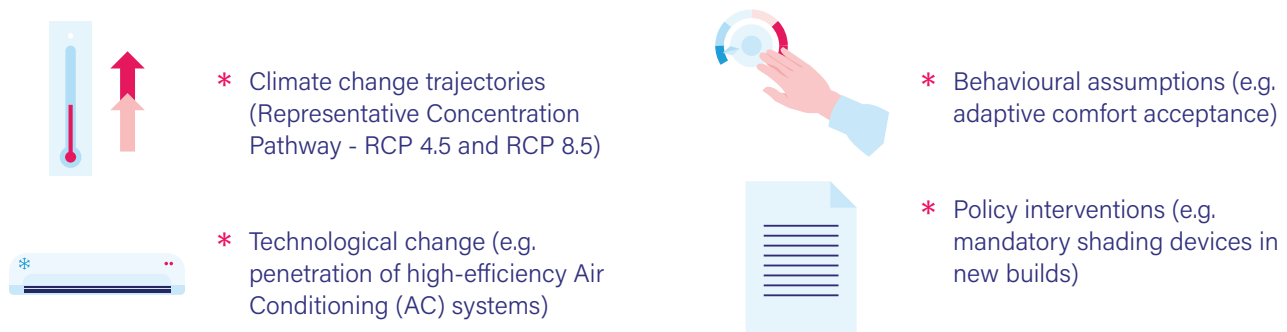
Figure 6. CoolLIFE toolchain

The CoolLIFE toolchain was created for this purpose: it is a modular framework that links the project's calculation modules into structured workflows reflecting real-world planning processes. Each toolchain can guide users from mapping space cooling demand to assessing reduction options, integrating behavioural and comfort data, exploring financing schemes, evaluating legal and regulatory implications, and testing demand-side management strategies. Developed with agile methods and user stories, the toolchain ensures flexibility and adaptability across spatial scales and contexts. By combining technical, economic, and policy dimensions, it provides an intuitive, open-access pathway to design and compare sustainable space cooling strategies.

In addition to this, the foundation of the CoolLIFE Tool is a geospatial-modelling framework capable of estimating space cooling energy needs at multiple levels of granularity. Building stock data was integrated with climate projections, socioeconomic data, and user behaviour models to forecast demand patterns under several future scenarios. The base year for modelling was 2020, while projections were developed for 2030 and 2050. The methodology and modelling logic are documented extensively in Deliverables D2.2 (Energy Demand Assessment) (Duplessis, et al., D2.2 Energy demand assessment, 2024), D2.3 (Impact assessment) (Malla, et al., 2024), D5.2 (Calculation modules on space cooling demand, technologies, user behaviour, economics and demand response) (Malla & Kranzl, D5.2 Calculation modules on, 2025), D5.3 (Testing summary and results for case studies) (Giussani & Pezzutto, 2025) and in the [CoolLIFE Wiki](#) (CoolLIFE Wiki, 2025). In addition to this, all calculation modules are open source and open-code as well as hosted in the [Tuleap repository](#) (CoolLIFE Tuleap Repository, 2025) under a Creative Commons CC BY 4.0 license, allowing technical users to access, modify, and extend the tools as needed. This approach ensures transparency, replicability, and adaptability to national and local contexts.

The team employed a modular architecture that allowed for flexible scaling and adaptation across territories. Input data were collected from public sources such as Eurostat (Eurostat, 2025), Copernicus Climate Data Store (Copernicus, 2025), and national statistics offices (e.g. [ISTAT](#) (Istat - Istituto Nazionale di Statistica, 2025), [Statistik Austria](#) (Statistics Austria, 2025), [Denmark Statistics](#) (Statistics of Denmark, 2025), etc.). These were complemented by targeted surveys and literature-based assumptions concerning occupant comfort behaviour, ventilation practices, and thermostat settings.

Scenario development was a critical component. Each scenario combined a set of drivers including:



Stakeholder input was gathered through a series of interactive workshops and webinars (D8.1 Communication and impact report (Vallespinos & Navarro, 2025)). These engagements informed scenario design, ensured local contextualisation, and tested tool assumptions. Specific feedback loops were created with partners in the three validation cities – Dublin (Ireland), Bolzano/Bozen (Italy), and Naples (Italy) - to tailor the tool's usability to end-user needs (D5.3 Testing summary and results for case studies (Giussani & Pezzutto, 2025)).

The behavioural module of the tool provides important information for decision-makers, presenting the geographical layout of traditional practices, different thermal expectations supporting more realistic forecasting of human-environment interactions. The presented case studies of behavioural intervention provide practical examples of how behavioural change can be initiated, motivated and maintained to reduce SC demand. (D3.2 Analysis of behavioural interventions across Europe (Gelesz, et al., 2023)).

Another key feature was the tool's spatial engine, capable of hectare-level resolution across all EU27 Member States. This was enabled through GIS integration and Python-based computation layers, described in Deliverable D5.2 (Calculation modules on space cooling demand, technologies, user behaviour, economics and demand response) (Malla & Kranzl, D5.2 Calculation modules on, 2025). Such granularity allows policymakers and planners to zoom into district-level demand profiles and overlay them with demographic or vulnerability data, offering unique insight into where interventions are most needed.

During the validation phase, the CoolLIFE Tool was tested against city-specific data from Dublin, Bolzano/Bozen and Naples. These validations used both quantitative comparisons with historical climate and energy datasets and qualitative feedback from municipal energy teams. The evaluation confirmed that the tool provided valuable foresight, particularly under higher emissions scenarios (RCP 8.5), where projected cooling demand tripled in multiple districts.

The project also prioritized tool accessibility. A lightweight online interface was developed, enabling non-technical users to explore key indicators. Tutorials, user manuals, and visual dashboards were provided as part of D5.3 Testing summary and results for case studies (Giussani & Pezzutto, 2025), increasing the likelihood of real-world application and replication beyond the project.

The validation phase applied the tool to the three cities to test its predictive reliability and user-friendliness. Results were compared with historical data where available, and qualitative assessments were made by local stakeholders. The validation results helped calibrate the model and guided improvements in the interface and scenario logic (D5.3 Testing summary and results for case studies (Giussani & Pezzutto, 2025)). In addition, a dedicated page labelled “Survey” was made permanently accessible through the Tool’s webpage to allow users to open an [online questionnaire](#) (CoolLIFE Toolbox - Online Questionnaire for Monitoring Interventions, 2025) designed to monitor interventions. This resource collects valuable feedback on the effectiveness of the Tool, its practical use, achieved outcomes, and further suggestions for improvement

Complementing the technical development, a set of policy pathways and economic implications were derived using comparative analysis of space cooling strategies and building typologies. These were then synthesised into guidelines and recommendations for integrating sustainable cooling into municipal energy and climate planning processes (D4.3 Recommendations for enhanced and integrated strategies, policies and schemes relevant for space cooling (Broc, et al., 2025)).

Detailed approach of the CoolLIFE Tool

The CoolLIFE Tool represents a major innovation in the mapping, simulation, and planning of space cooling demand across the EU. Designed as an open-source and open-code platform, it supports decision-making at multiple levels, from municipalities to national governments.

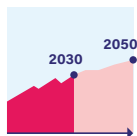
At its core, the tool provides:



- * Dynamic space cooling demand maps for the EU27 at resolutions ranging from 1-hectare grids to country-level aggregates.



- * Information on local factors influencing SC demand, like thermal comfort expectations and legally mandated summer setpoints



- * Scenario-based projections for 2030 and 2050, incorporating both climate models and socio-behavioural shifts.



- * Financing schemes and policy information per country (how space cooling is addressed in the main planning documents and policies relevant to space cooling).



- * Comparative evaluation of space cooling technologies and demand-side strategies.

Technologically, the tool is built on a web-based GIS platform using open-source libraries such as Leaflet, D3.js, and Python-based back-end engines. Data handling complies with FAIR (Findable, Accessible, Interoperable, Reusable) principles, ensuring that outputs correspond latter mentioned principle (D5.2 Calculation modules on space cooling demand, technologies, user behaviour, economics and demand response (Malla & Kranzl, D5.2 Calculation modules on, 2025), CoolLIFE Wiki (CoolLIFE Wiki, 2025)).

The user interface includes filters for:

- * Geographic area (country, region, urban/rural zones)
- * Time horizon (baseline, 2030, 2050)
- * Building type (residential, non-residential, with distinctions based on the age of construction)
- * Behavioural and policy scenarios

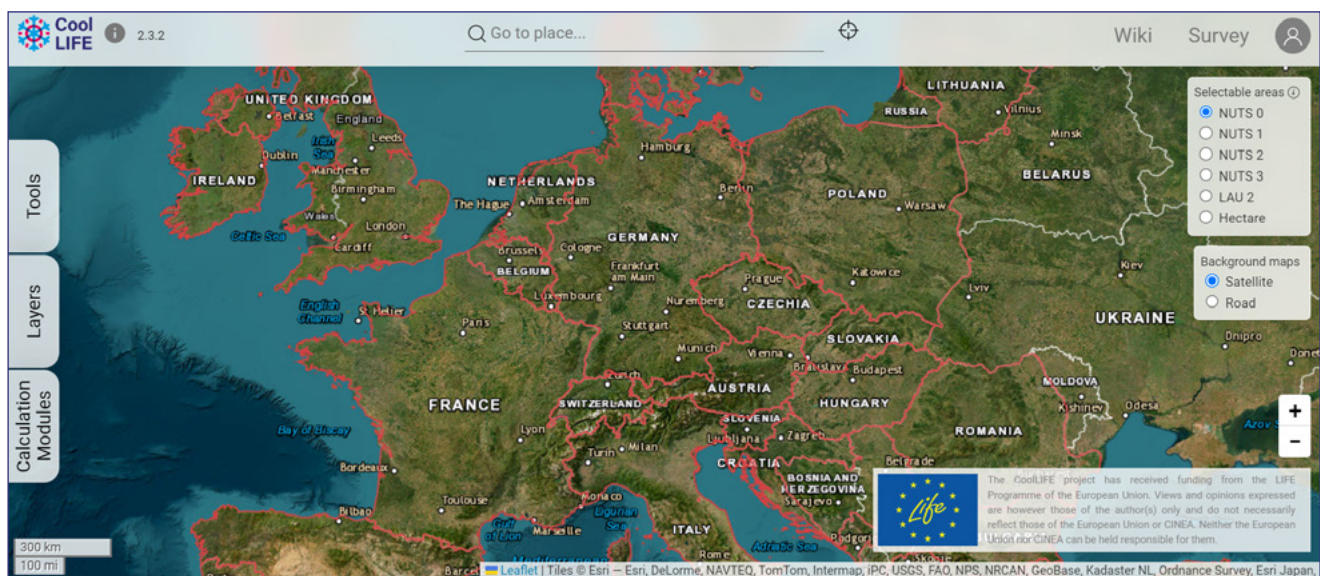
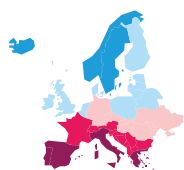


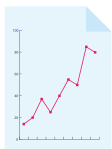
Figure 7. CoolLIFE Tool main page

This flexibility enables users to generate targeted insights. For example, a planner in Southern Italy can estimate how the uptake of passive measures might affect residential space cooling demand under RCP 8.5 in 2050. In addition to this, users are also able to upload their own data on the Tool in order to have more specific results.

The tool's outputs include:



- * Visual maps with energy intensity values ($\text{kWh}/\text{m}^2/\text{year}$)



- * Time series charts showing demand trends



- * Exportable datasets for integration with other planning tools

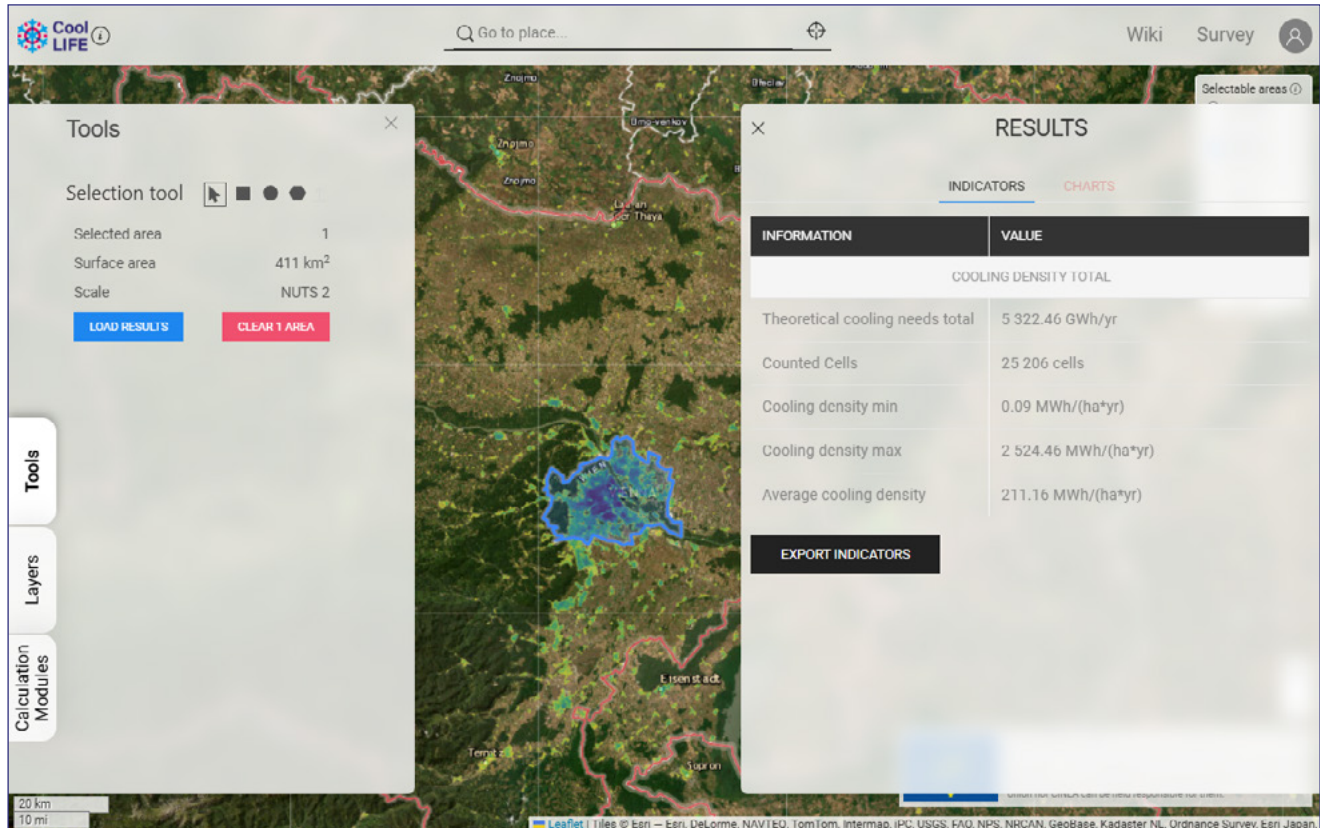


Figure 8. Results layout and how it can be observed on the platform

At the core of the CoolLIFE tool are a set of open-source Calculation Modules (CMs), which operationalize the platform and allow users to perform data-driven analyses of cooling demand, technologies, economics, behaviour, and policies. The modules are structured in four thematic categories—Cooling, District Heating and Cooling, Policy, and Finance—and can be used individually or combined into toolchains that replicate real-world planning processes. Each module is implemented as Python code, fully documented, and accessible in the public Tuleap repository (CoolLIFE Tuleap Repository, 2025) under a Creative Commons CC BY 4.0 license.

Space Cooling Demand: Estimates and visualizes cooling needs across the EU-27 at high spatial resolution (100×100 m). Supports scenario development for both present and future conditions, enabling planners to localize demand hotspots and identify priority areas.

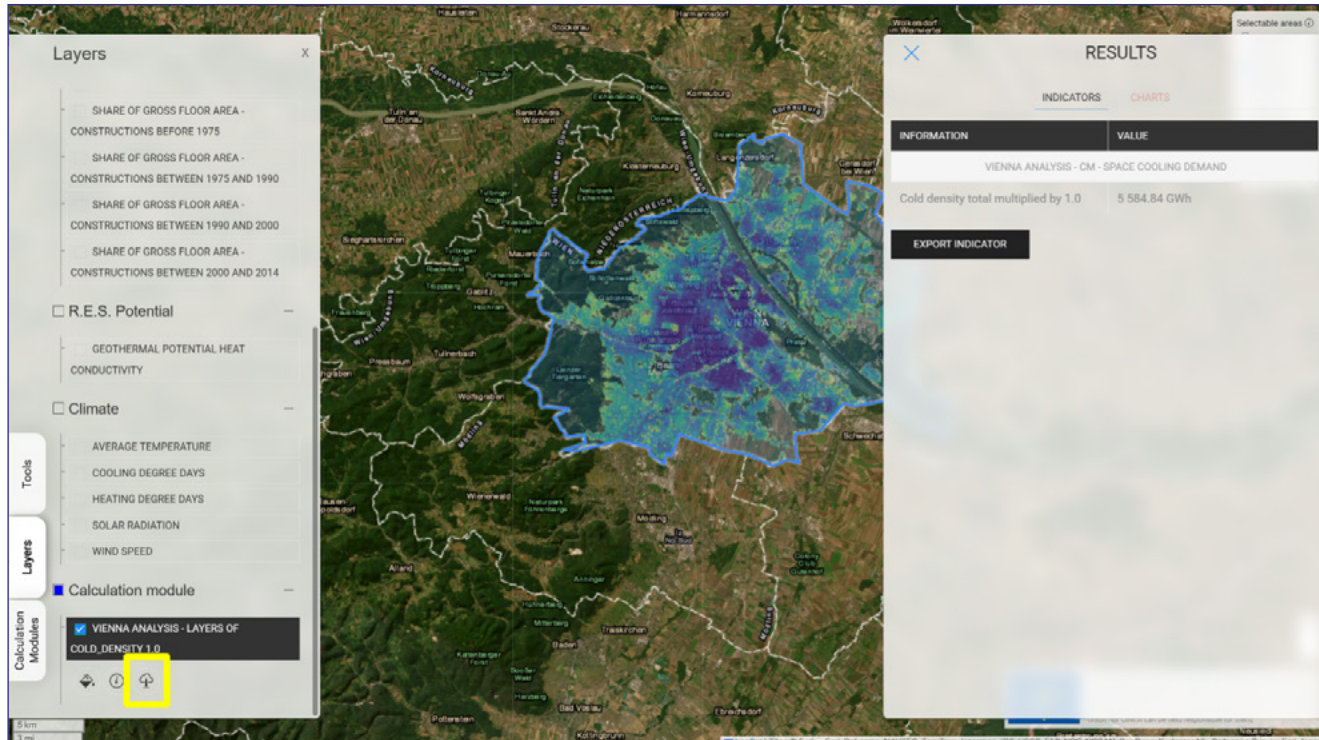


Figure 9. CM-Space Cooling demand

Technologies and Measures: Assesses electricity consumption and cooling capacity for residential and non-residential sectors. Allows scenario-based analysis of technology diffusion, efficiency improvements (SEER), and passive measures such as shading, fans, and ventilation. Outputs include cooled floor area, energy demand, and installed capacity.

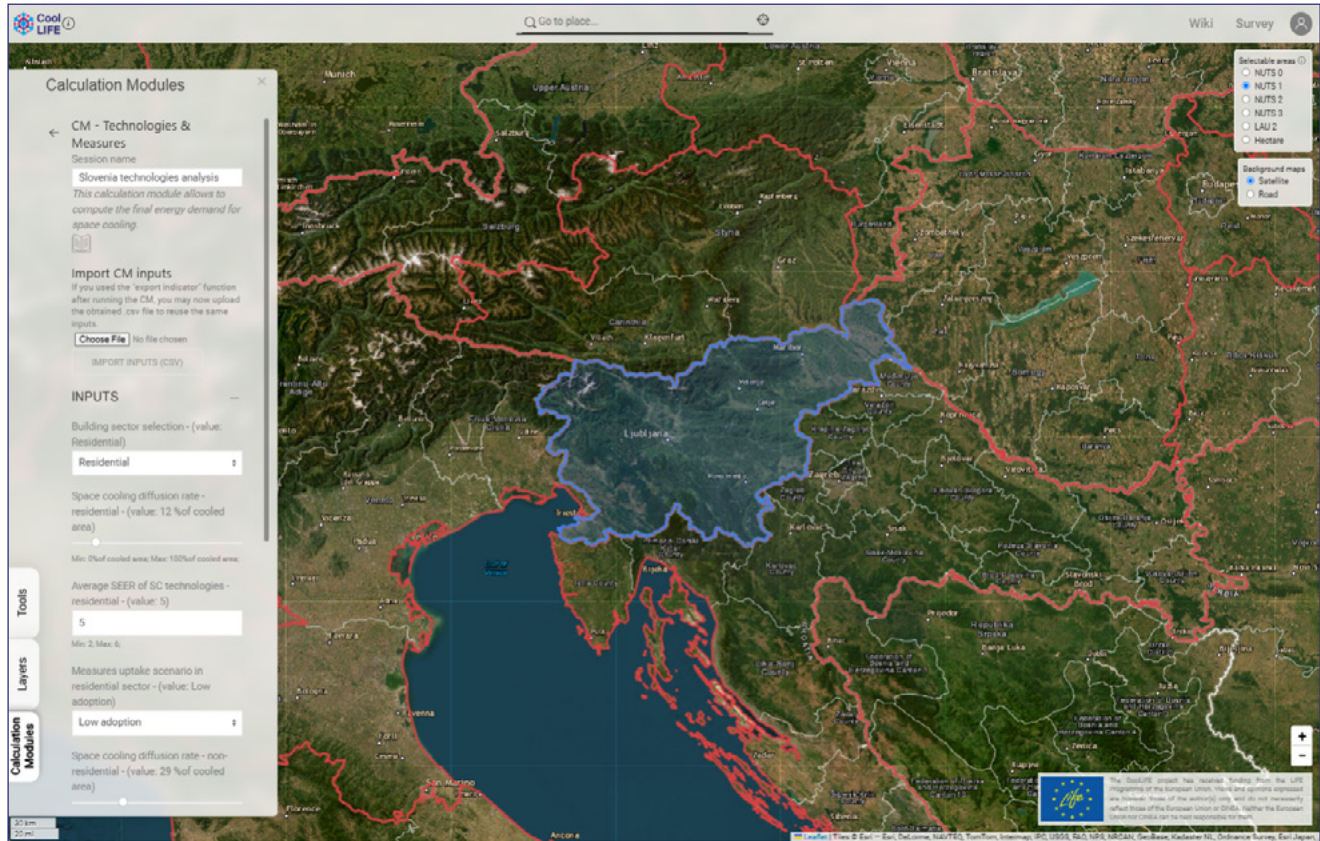


Figure 10. CM-Technologies and Measures

Comfort, Lifestyle, and User Behaviour: Provides insights into behavioural patterns and thermal comfort expectations that affect space cooling demand. Presents data on adaptive behaviours, thermostat settings, and cultural practices, supporting the design of socially adapted cooling strategies.

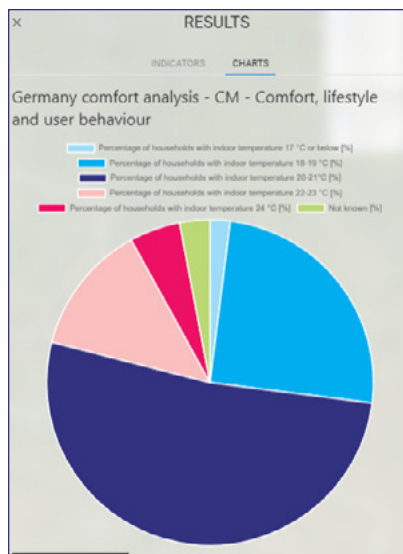
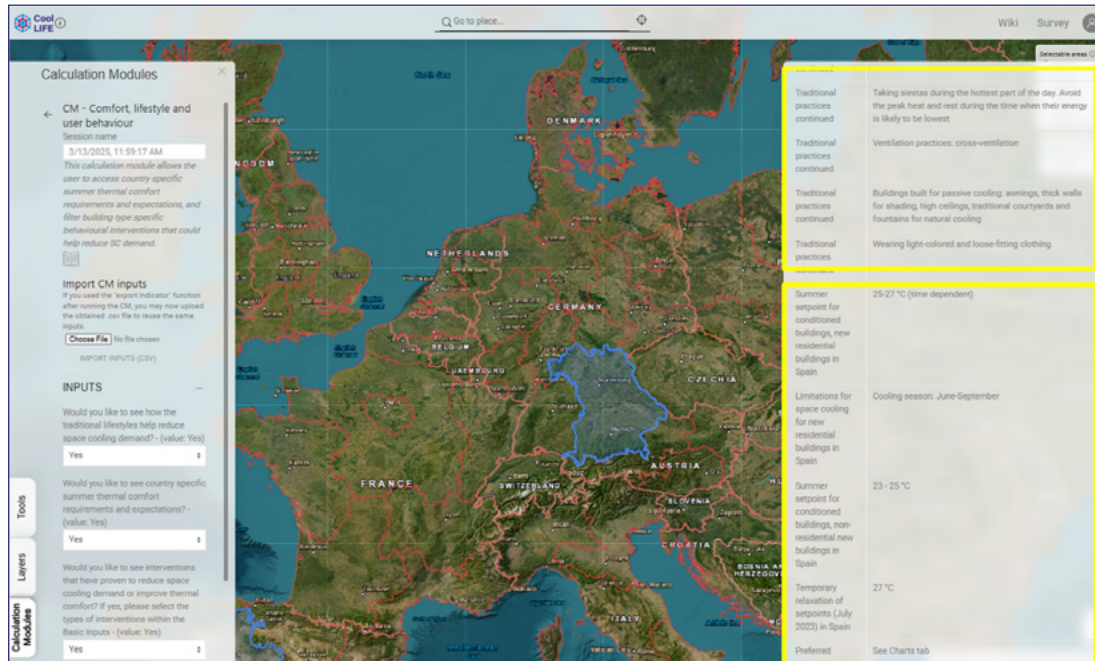


Figure 11. CM-Comfort, lifestyle, and user behaviour

Economic Feasibility: Evaluates the financial viability of active and passive cooling strategies. Produces indicators such as the Levelized Cost of Cooling (LCOC) and Levelized Cost of Energy Savings (LCES), supporting both national policy assessments and building-level investment decisions.

RESULTS	
INDICATORS	
INFORMATION	VALUE
CZECHIA NATIONAL ANALYSIS - CM - ECONOMIC FEASIBILITY	
country	CZE
Scenario Description:	In this scenario uptake of high efficiency packages of passive measure along with moderate diffusion levels of supply technology and high efficiency level of active technology improvement rates are expected for Czech Republic
Baseline Seasonal Energy Efficiency Ratio (SEER)	3.88
Improved Seasonal Energy Efficiency Ratio (SEER) in the Scenario	7.88
Base year Useful energy demand for Base Scenario	2 580.54 GWh
2050 Useful energy demand for Base Scenario	4 344.19 GWh
2050 Useful Energy Demand for Selected Scenario	884.51 GWh
Savings in the Useful Energy Demand by 2050	79.64 %
2050 Final Energy Demand for Base Scenario	1 120.47 GWh
2050 Final Energy Demand for Selected Scenario	89.55 GWh
Final Energy Demand savings estimated in this scenario by 2050	92.01 %
Levelized Cost of Energy Saving from selected passive measure per unit useful energy saved	150.29 EUR/MWh
Levelized Cost of Energy of the scenario measure per unit useful energy supplied	126.97 EUR/MWh
EXPORT INDICATORS	

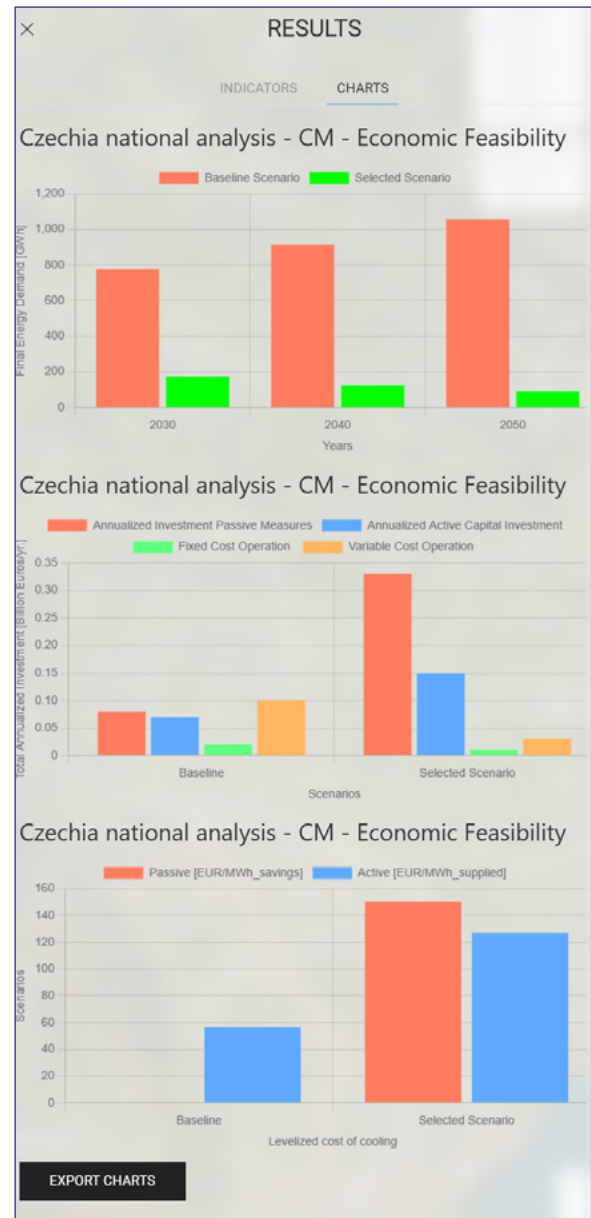


Figure 12. CM-Economic Feasibility

Demand-Side Management / Demand Response: Explores the potential for pre-cooling and load shifting to align cooling demand with photovoltaic (PV) supply. Provides indicators on daily load shifting potential at the national level, helping to increase renewable self-consumption.

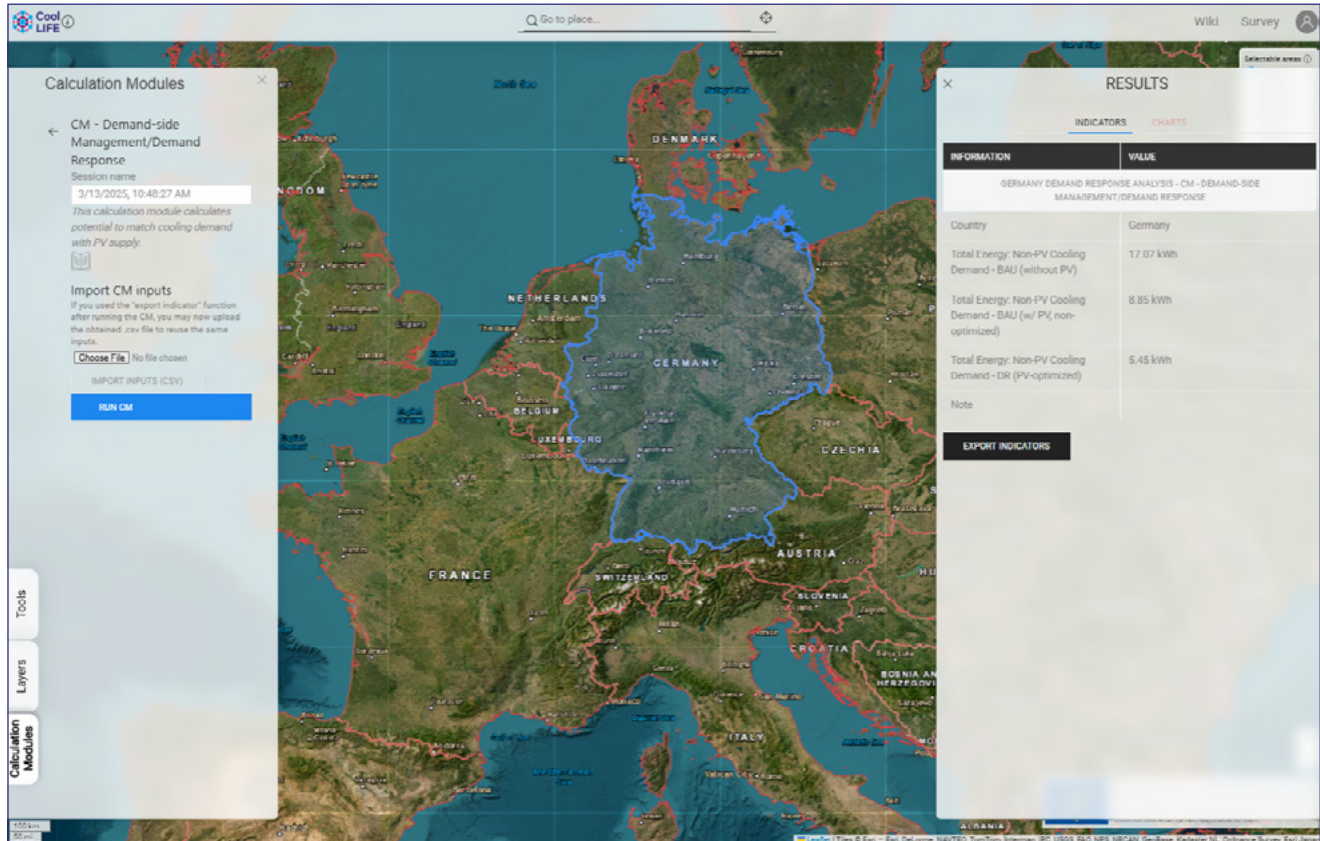


Figure 13. CM-Demand side Management

Mapping of Legal and Regulatory Information: Structures information on EU and national-level frameworks affecting cooling. Includes building codes, adaptation strategies, and financial support schemes, supporting policy coherence and planning alignment.

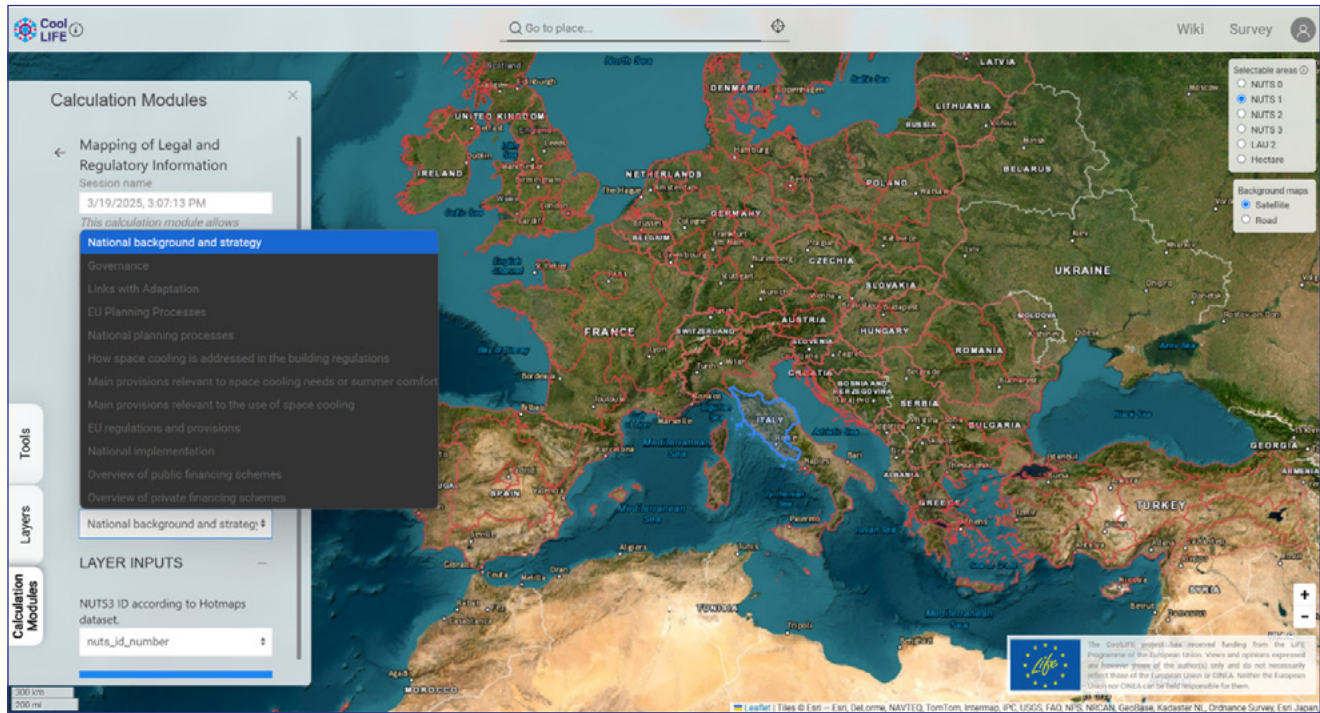


Figure 14. CM-Mapping of legal and Regulatory Information

Mapping of Financing Instruments: Offers access to a searchable database of public and private financing schemes across the EU-27. Users can filter schemes by country, funding type, and sector, with outputs designed to support project developers and public administrations.

X

RESULTS

INDICATORS CHARTS

INFORMATION	VALUE
SLOVAKIA FINANCING INSTRUMENTS - MAPPING OF FINANCING INSTRUMENTS	
Number of schemes found in SK	11
Download filtered schemes from Layers. The complete Mapping of Financing instruments can be found on the CoolLIFE website, in the section resources:	https://coolife.revolve.media/resources/
Scheme 1	Munseff
Scheme 2	GEFF Commercial and Residential
Scheme 3	Green Loans
Scheme 4	ECO Mortgage
Scheme 5	Green mortgage
Scheme 6	Green mortgage
Scheme 7	Blue Planet Mortgage TB
Scheme 8	A sustainable home mortgage
Scheme 9	Green loan for eco-technologies
Scheme 10	Credit for a healthier Earth
Scheme 11	Sustainable Housing Loan

EXPORT INDICATORSEXPORT EXTRA FILES

Figure 15. CM-Mapping of Financing Instruments

District Cooling: Assesses the techno-economic feasibility of district cooling networks at 100×100 m resolution. Identifies potential areas for cost-effective deployment and compares levelized costs against individual space cooling solutions.

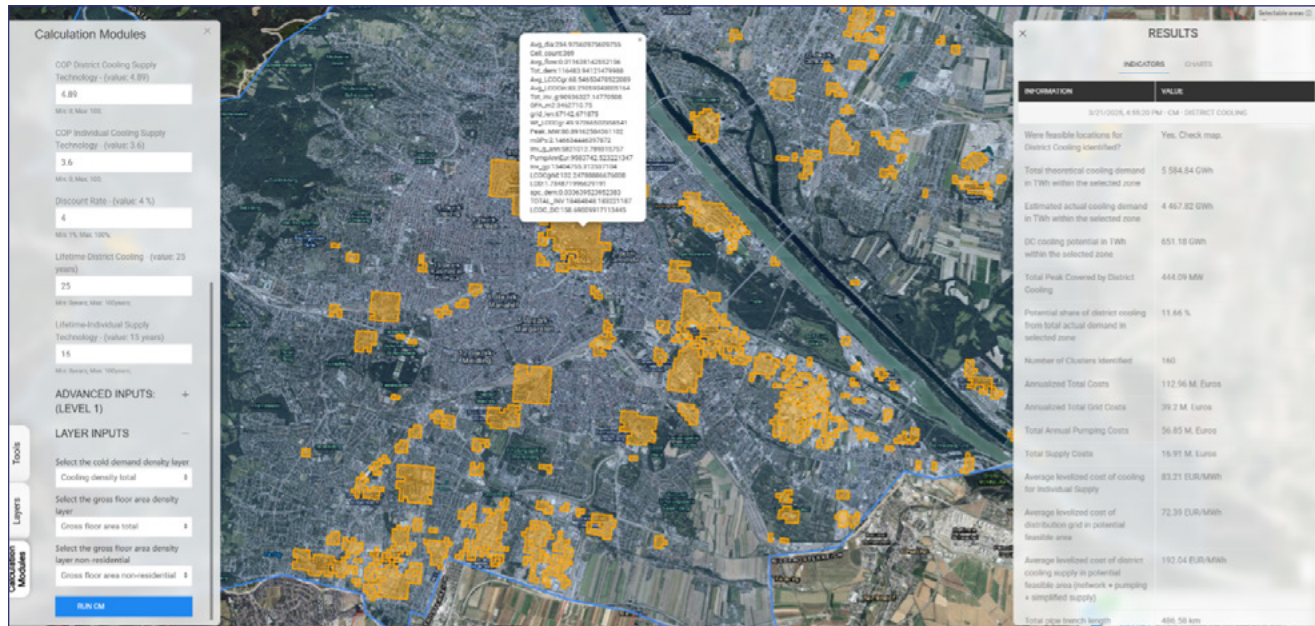


Figure 16. CM-District Cooling

Together, these modules provide the analytical backbone of the CoolLIFE platform, ensuring transparent, replicable, and actionable support for sustainable cooling strategies across Europe.

The usability testing process allowed to show that even non-technical users could navigate the interface effectively after minimal training. Feedback from municipalities highlighted the value of having both granular and high-level overviews within a single platform (D6.2 Training Report (Conforto & Akhatova, D6.2 Training report, 2025)).

Security and scalability were also priorities. The tool is hosted on a secure EU-based server and is regularly updated to reflect new climate and energy datasets. A user manual and open Application Programming Interface documentation were also developed to facilitate third-party use and integration (D5.2 Calculation modules on space cooling demand, technologies, user behaviour, economics and demand response (Malla & Kranzl, D5.2 Calculation modules on, 2025), and CoolLIFE Wiki (CoolLIFE Wiki, 2025)).

The CoolLIFE Tool stands as a first-of-its-kind system to bridge the gap between advanced modelling and practical, accessible policymaking support in the domain of sustainable space cooling: it is now accessible at <https://tool.coollifeproject.eu/> (CoolLIFE Tool, 2025), and is complemented by a dedicated CoolLIFE Wiki (CoolLIFE Wiki, 2025) that offers detailed guidance, background material, and tutorials. In addition to this, the project team has also prepared a series of 12 video tutorials available on a playlist on YouTube (CoolLIFE's Youtube Tutorials, 2025). These tutorials guide users through each of the calculation modules of the tool, show the application of the tool to 7 typical case studies, and provide full training tools and strategies for sustainable space cooling. CoolLIFE project website, its resources, the CoolLIFE Tool, and the CoolLIFE Wiki, illustrating their application across different use cases. They provide step-by-step support to help practitioners, local administrations, and stakeholders make effective use of the materials developed within the project.

To support the uptake of project outcomes, we provide below a curated set of links to the main CoolLIFE resources. This list is designed to make it easier for stakeholders to directly access and apply the tools, knowledge bases, and communities developed within the project.

- * CoolLIFE Project Website: <https://coollife.revolve.media/>
Central hub for information on the project's objectives, methodology, case studies, and results. It also provides access to project news, publications, and upcoming events.
- * CoolLIFE Tool: <https://coollife-project.github.io/wiki/>
Open-source and open-code platform supporting the assessment of space cooling demand, integration of passive measures, and evaluation of policy scenarios at different spatial scales.
- * CoolLIFE Tool's CM's code: <https://vlhtuleap.hevs.ch/plugins/git/coollife>
Open source code of CoolLIFE's Calculation Modules
- * CoolLIFE Survey: <https://ec.europa.eu/eusurvey/runner/CoolLIFEToolbox>
- * An online questionnaire available through the Tool's webpage, designed to monitor interventions. It collects feedback on the Tool's effectiveness, practical use, outcomes, and user suggestions for improvement.
- * CoolLIFE Knowledge Hub: <https://knowledgehub.coollifeproject.eu/>
Online repository providing access to project deliverables, datasets, guidelines, and other key outputs to support replication and decision-making.
- * CoolLIFE Knowledge Hub's code: https://github.com/ewilczynski/coolife_kh/blob/main/coolife_knowledgehub.txt
- * Open access code of CoolLIFE's Knowledge Hub
- * CoolLIFE Wiki: <https://coollife-project.github.io/wiki/>
A collaborative knowledge base that documents technical guidance, calculation modules, methodological notes, and user experiences to support replication and learning.
- * Video Tutorials (YouTube): <https://www.youtube.com/playlist?list=PLK1DMovauS8PP4RDFx6tmKwjfoCk9xAez>
A series of tutorials guiding users through the CoolLIFE website, Tool, and Wiki, including practical examples of their application to different use cases.
- * CoolLIFE Community (LinkedIn): <https://www.linkedin.com/groups/10058401/>
An online professional network created to exchange insights, share experiences, and foster collaboration among researchers, practitioners, and policymakers engaged in sustainable cooling.

THE KNOWLEDGE HUB

The CoolLIFE Knowledge Hub (CoolLIFE Knowledge Hub, 2025) was developed as an integral component of the CoolLIFE project to support evidence-based decision-making and foster knowledge dissemination on sustainable space cooling across Europe. It complements the CoolLIFE Tool by offering a structured, openly accessible digital platform that hosts curated, high-quality resources relevant to energy efficiency, climate resilience, and urban cooling strategies in the EU context. Its primary goal is to facilitate access to scientific, technical, and regulatory knowledge for stakeholders ranging from public authorities and municipal planners to researchers, policy analysts, and consultants.

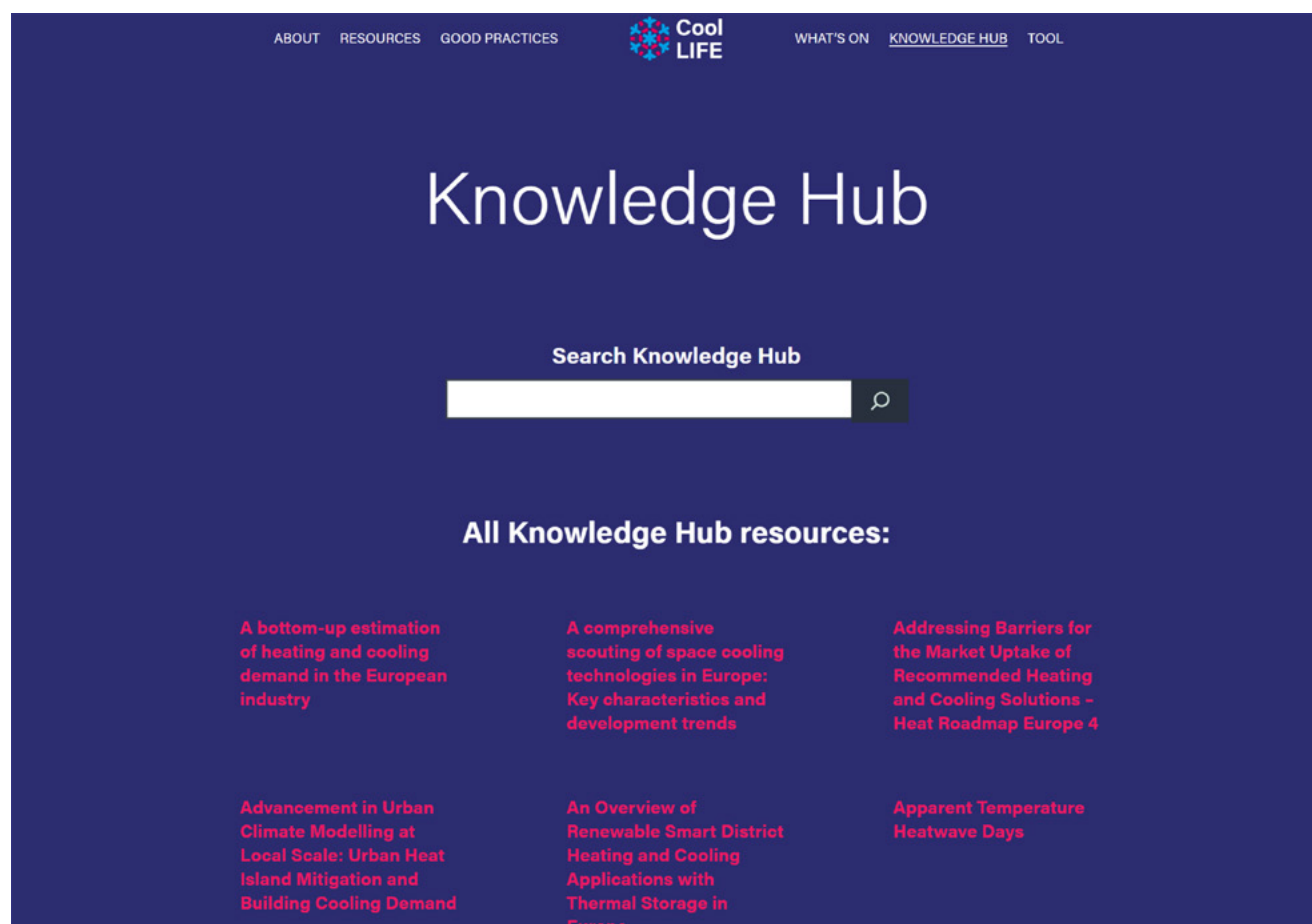


Figure 17. User Interface of the Knowledge Hub

The platform includes more than 50 rigorously selected resources drawn from EU regulations, national frameworks, scientific literature, grey reports, open-access datasets, and project-specific outputs. All materials have been reviewed based on clear quality criteria, including their credibility, relevance to European space cooling needs, thematic scope, and usability for technical and policy audiences. These resources cover a wide thematic range: cooling technologies and systems, behavioural modelling, urban heat mitigation, building energy performance, equity and vulnerability to heat, and climate adaptation strategies. Each entry is enriched with structured metadata—such as title, publication year, author(s), keywords, and geographic relevance—and assigned persistent links to ensure traceability and citation. The resources are fully aligned with FAIR principles, making them findable, accessible, interoperable, and reusable, as outlined in Deliverable D5.1 CoolLIFE tool and knowledge hub.

Navigation and access to the Knowledge Hub are designed to be intuitive and efficient. Users can search via keyword, filter content by thematic tags, and explore documents according to document type or policy relevance. The platform interface allows for both quick look up and deep exploration. Thematic tags are used to connect related materials across categories, making it easier for users to retrieve interconnected information and compare sources addressing similar issues. The Hub is accessible through the project website and directly at: <https://knowledgehub.coollifeproject.eu>.

The Knowledge Hub is not intended as a general-purpose document archive but as a highly targeted, practical resource for professionals engaged in sustainable urban planning and policy design. It was developed in close alignment with the structure and functionality of the CoolLIFE Tool. This integration allows users working within the CoolLIFE Tool environment to seamlessly access relevant documentation, guidelines, and background references through links embedded in the interface and the project Wiki. These embedded connections reduce the cognitive load for users, improve the interpretability of model outputs, and allow a smoother user experience that connects simulation to strategy. For instance, users assessing space cooling demand projections or scenario outcomes can consult linked EU policy documents, technical guides on passive cooling, or behavioural studies to better understand assumptions and implications. This deepens the Tool's utility as a decision-support system and improves its alignment with institutional practices.

Several user groups and use cases were explicitly considered in the design of the Knowledge Hub. Municipal planning departments can use the platform to inform the integration of space cooling needs into local energy and adaptation plans. Technical consultants may rely on it to identify applicable benchmarks and space cooling performance metrics, while academic users can retrieve foundational and up-to-date studies for analysis. The platform also supports institutions looking to monitor compliance with evolving EU policies or to identify best practices from across Europe. The Knowledge Hub is particularly helpful in overcoming institutional knowledge fragmentation and in supporting the mainstreaming of space cooling within wider sustainability frameworks.

The Knowledge Hub was developed using open-source technologies and modular architecture to ensure longevity, transparency, and future scalability. The back-end system supports updates to the repository and offers the potential for future enhancements, including user-generated contributions and automated content indexing. User feedback loops—particularly from workshops and pilot testing activities documented in D5.3 Testing summary and results for case studies (Giussani & Pezzutto, 2025) and D6.2 Training report (Conforto & Akhatova, D6.2 Training report, 2025)—were instrumental in shaping the platform's final structure, navigation logic, and thematic prioritization. Suggestions from stakeholders led to improvements in filtering options, better cross-referencing among entries, and the expansion of resources related to policy frameworks and behavioural interventions.

Rather than simply collecting documents, the Knowledge Hub serves a strategic knowledge management role within the CoolLIFE ecosystem. It connects scientific insight with operational planning, supports the localization of EU policy objectives, and encourages interdisciplinary approaches by making behavioural, technological, and regulatory content easily accessible

in one platform. In doing so, it contributes to institutional capacity-building and supports the scaling and replication of sustainable space cooling strategies across the EU-27.

As climate change increases the urgency of addressing urban space cooling needs, the Knowledge Hub provides a dynamic foundation for shared learning, policy alignment, and technical development. It ensures that the outputs of CoolLIFE remain accessible, usable, and impactful beyond the duration of the project, serving as a durable resource for the broader transition toward climate-resilient and energy-efficient cities.

Work Package 6: Training and capacity building

WP6 was dedicated to ensuring that the CoolLIFE Tool and Knowledge Hub could be effectively understood, applied, and replicated by a wide range of end-users, from public authorities and policymakers to researchers and practitioners. Building on the technical, behavioural, and policy foundations developed in earlier work packages, WP6 translated these insights into accessible resources and structured capacity-building activities. Its overarching goal was to maximise usability, encourage adoption, and create feedback loops for continuous improvement.

The work package produced two key deliverables. D6.1 “User Manual and Guidelines” (Conforto & Akhatova, D6.1 CoolLIFE Tool & Knowledge Hub: User Manual and Guidelines, 2025) provided a comprehensive documentation suite, including the CoolLIFE Wiki (CoolLIFE Wiki, 2025). Together, these resources present the Tool’s structure, methodologies, input data requirements, and functionalities in a clear and user-friendly way. They also incorporate worked examples and case studies to demonstrate practical applications. Importantly, the guidelines were designed to be relevant to different user profiles—technical experts, policymakers, and practitioners—thus ensuring transparency, replicability, and adaptability across diverse contexts.

D6.2 Training Report (Conforto & Akhatova, D6.2 Training report, 2025) documented an extensive programme of training activities that aimed to familiarise stakeholders with the Tool and gather feedback on its usability. In total, 18 events were organised, reaching 653 participants from 46 countries. The training formats ranged from webinars and targeted workshops to summer schools and academic lectures. Sessions placed a strong emphasis on interactivity, encouraging participants to experiment with the Tool and share insights for its refinement. Feedback highlighted the value of real-world case studies (Dublin, Bolzano, Naples, Austria) in demonstrating applicability, as well as the importance of tailoring content to different user groups. Lessons learned also stressed the benefits of combining online and in-person formats and the need to embed considerations of equity when designing capacity-building activities.

Throughout WP6, sustained efforts were made to build institutional capacity and ensure lasting impact. Training materials, manuals, and tutorials were made permanently accessible via the Knowledge Hub, providing a long-term resource for continued learning and replication. More than 650 participants engaged with CoolLIFE resources, confirming both the broad interest and the international relevance of the project.

The main milestones were the completion of the User Manual and Guidelines and the delivery of the training programme. Achieved on time, these milestones marked the successful completion of WP6, ensuring that users were not only introduced to the Tool but also supported in applying it effectively.

WP6 therefore transformed CoolLIFE from a research initiative into a usable, replicable, and policy-relevant platform. By producing detailed documentation, delivering training to hundreds of practitioners, and embedding user feedback, it ensured that the Tool and Knowledge Hub will continue to support sustainable space cooling planning well beyond the project’s lifetime.

Work Package 7: Sustainability, replication, and exploitation of project results

WP7 focused on maximising the long-term impact of CoolLIFE by ensuring that its results could be replicated, exploited, and sustained beyond the project's lifetime. It combined strategies for replication, engagement with civil society, benchmarking against existing planning tools, and an assessment of the project's own environmental footprint, providing a holistic perspective on how sustainable space cooling can be embedded in practice across Europe. Ensuring the long-term impact of CoolLIFE was in fact a strategic goal embedded in the project's design. To this end, sustainability and replication measures were pursued through partnership arrangements, open-access commitments, and capacity-building activities.

The work began with the stakeholder analysis and user stories (MS3), which were instrumental in tailoring the Tool and Knowledge Hub to real-world needs. By identifying the roles, priorities, and barriers of different actors—from policymakers to urban planners and civil society organisations—these milestones ensured that the project's exploitation and replication strategies were grounded in practical realities. The user stories further illustrated how different actors could interact with CoolLIFE outputs, guiding the design of functionalities and the framing of capacity-building efforts.

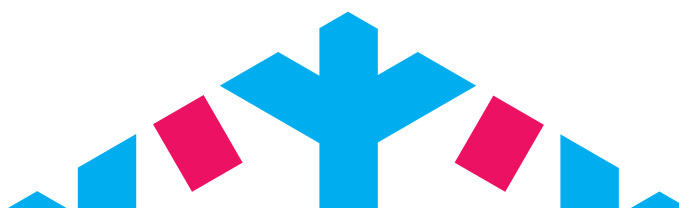
Building on this foundation, D7.1 Exploitation and Replication Strategy (Fraboni, 2025) mapped pathways for extending CoolLIFE results to other regions and contexts. It stressed that successful replication depends on enabling conditions such as data availability, institutional readiness, and the integration of cooling into NECPs and local climate action plans. With this objective, the CoolLIFE Tool will remain publicly accessible, hosted by EURAC Research with periodic updates ensured through institutional support and ongoing collaborations. Its modular architecture allows adaptation to new data, regional contexts, and policy frameworks, and the availability of documentation/training resources will be able to support the autonomous onboarding of new users. The Knowledge Hub will continue to exist as a living repository, inviting contributions from external partners and new projects, curated by the CoolLIFE network; a public Zotero library (CoolLIFE's Zotero Library, 2025) which aggregates relevant references on sustainable space cooling, has also been created to foster the diffusion of the knowledge

D7.2 "Impacts on civil society and opportunities of social innovation" (Bottino-Leone, Navarro, & Pezzutto, D7.2 Impacts on civil society and opportunities of social innovation, 2025) explored how CoolLIFE outputs could engage citizens, especially vulnerable groups disproportionately exposed to heat stress. The deliverable argued that sustainable cooling is not only a technical and policy challenge but also a social justice issue, and recommended approaches such as participatory planning, community-based cooling solutions, and equity-focused subsidies.

D7.3 "Review of Mapping and Planning Tools" (Bottino-Leone, et al., 2023) and their application benchmarked CoolLIFE against existing digital instruments, highlighting its unique strengths in integrating behavioural data, spatial granularity, and scenario modelling. This comparison also identified opportunities for interoperability with broader climate adaptation and energy planning platforms, reinforcing the replicability of the Tool across diverse contexts.

Finally, WP7 addressed its own operational sustainability through MS7 "Project Environmental Footprint and Mitigation Strategies". The assessment showed that the project's footprint was modest, largely linked to travel and IT infrastructure, and mitigation measures such as reducing flights, favouring online meetings, and promoting sustainable event practices were implemented consistently.

WP7 managed to deliver a comprehensive framework for exploitation, replication, and sustainability. By combining early stakeholder analysis and user stories with a strategic roadmap, social innovation insights, benchmarking, and environmental accountability, it ensured that CoolLIFE is not only technically sound but also socially relevant, transferable, and credible as a model for sustainable cooling transitions across Europe. Furthermore, the project's outcomes are feeding into European initiatives such as the Covenant of Mayors (European Commission, EU Covenant of Mayors, 2025) and LIFE Clean Energy



Transition (European Commission, Clean Energy Transition, 2025) sister projects. These linkages ensure continued visibility and policy relevance of the CoolLIFE outputs. In summary, CoolLIFE is designed not as a standalone project but as a catalyst for broader, sustained change in the way cooling is planned, managed, and understood in Europe.

Work Package 8: Dissemination, communication, and networking

WP8 ensured that the results and impacts of the CoolLIFE project were effectively communicated, disseminated, and embedded within relevant European and international debates. WP8 developed and implemented a comprehensive communication and dissemination strategy. This work package was central to raising awareness of space cooling challenges, promoting sustainable solutions, and ensuring wide uptake of the project's outputs.

A major milestone of WP8 was the preparation of MS4 "Dissemination and Communication Plan", which built upon earlier iterations and outlined the overall strategy, target audiences, channels, and expected outcomes. This plan identified key stakeholder groups, from policymakers and municipalities to energy service companies, architects, and civil society, and tailored messaging to their needs. The strategy emphasized three complementary dimensions of CoolLIFE's added value: environmental (greenhouse gas reduction, nature-based solutions, efficient planning), economic (market uptake of innovative cooling, new jobs, financing schemes), and societal (thermal comfort, equity, summer energy poverty).

In parallel, Deliverable D8.1 "Communication and Impact Report" (Vallespinos & Navarro, 2025) monitored progress against KPIs, documenting outreach activities, scientific publications, event participation, media coverage, and digital performance. It demonstrated measurable results, including growth in website traffic (over 1,800 unique users), expansion of the newsletter subscriber base, and strong engagement on social media, notably LinkedIn. It also captured the outcomes of key events such as participation at EUSEW (European Commission, European Sustainable Energy Week - EUSEW, 2025) 2023 and 2024, the ECEEE (Efficient Buildings Europe, 2025) Summer Study, and the mid-project virtual event. These activities strengthened visibility, credibility, and cross-project collaborations with initiatives like COOLING DOWN (European Commission, COOLING DOWN project, n.d.) and Plan4Cold (European Commission, Supporting South Europe municipalities in the definition of Sustainable Local Heating and Cooling Plans - LIFE23-CET-Plan4Cold, 2025).

Communication activities combined technical dissemination with broader public outreach. WP8 established the project website as the main hub for results, launched newsletters and videos, and deployed a Good Practices campaign (CoolLiving) (CoolLiving, 2025) that used accessible visuals and storytelling to raise awareness about sustainable behaviours. Social media played a pivotal role, with consistent growth in followers and engagement rates across platforms. Media relations were reinforced through press releases and non-technical articles, ensuring resonance beyond the scientific community. Importantly, WP8 designed legacy and networking actions to ensure continuity beyond the project's lifetime, aligning with the Green Deal (European Commission, The European Green Deal, 2019), Energy Performance of Buildings Directive (European Commission, Energy Performance of Buildings Directive, 2025), and Renovation Wave (European Commission, Renovation Wave Strategy, 2020) objectives.

In sum, WP8 achieved its mission of translating CoolLIFE's technical achievements into impactful messages tailored to different audiences. By integrating dissemination and communication into every stage of the project, and by grounding activities in clear KPIs and user-focused strategies, WP8 maximised awareness, uptake, and long-term impact of CoolLIFE's tools and findings.

3. Case studies

To test and refine the CoolLIFE Tool and to ground its outputs in real-world contexts, three case studies were carried out in municipalities with distinct climatic and socio-economic profiles: Dublin (Ireland), Bolzano (Italy), and Naples (Italy). These pilot locations were selected to reflect Northern, Central, and Southern European conditions respectively, ensuring that the tool's applicability could be validated across a wide spectrum of space cooling-related needs and planning contexts (D5.3 Testing summary and results for case studies (Giussani & Pezzutto, 2025)). An additional national case study was also done for the entire territory of Austria.

In Dublin, representing Northern Europe, the prevailing climate is relatively cool, with long winters and mild summers. As such, the municipality reported that space cooling is not a major concern, and there is limited experience or demand for active space cooling. Nonetheless, the CoolLIFE Tool was tested to explore its potential in specialized contexts such as managing urban heat island effects, commercial space cooling loads, and short-term heatwaves. The municipality expressed that the tool's current configuration, while useful, was constrained by its strong focus on space cooling rather than integrated energy management. Their feedback emphasized the need for predictive climate scenario modelling and proposed broader energy balancing tools that could help optimize both space heating and cooling across seasonal cycles. They also requested advanced features such as microclimate mapping and actionable guidance for green infrastructure implementation, suggesting the potential evolution of the tool into a comprehensive urban climate adaptation platform (D5.3 Testing summary and results for case studies (Giussani & Pezzutto, 2025)).

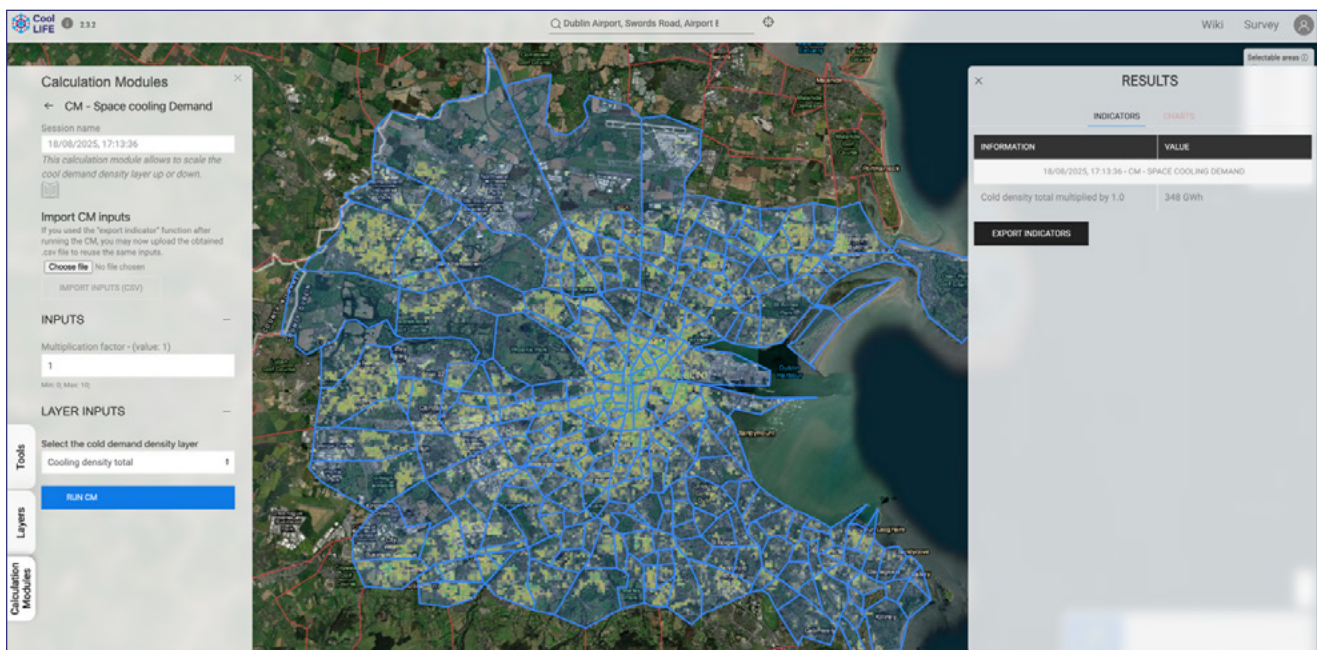


Figure 18. Dublin space cooling demand assessment

In Bolzano, located in South Tyrol and representing Central Europe, the municipality faces increasingly complex space cooling challenges due to the intensification of urban heat islands, more frequent tropical nights, and prolonged heatwaves. While the region traditionally focused on space heating, rising temperatures have brought attention to the vulnerability of its urban areas. Feedback from Bolzano revealed that the CoolLIFE Tool lacked sufficient capacity to model peak space cooling loads and their implications for local energy systems. The municipality emphasized the need for load forecasting modules, especially those capable of managing diurnal heat patterns and supporting distributed energy resources. Furthermore, the local administration highlighted a strong interest in using the tool to assess health-related outcomes of space cooling interventions, particularly for vulnerable populations during extreme heat events. The pilot also stressed the need for the tool to better address passive cooling strategies and green urban infrastructure planning, reinforcing the importance of context-specific solutions informed by high-resolution spatial data (D5.3 Testing summary and results for case studies (Giussani & Pezzutto, 2025)).

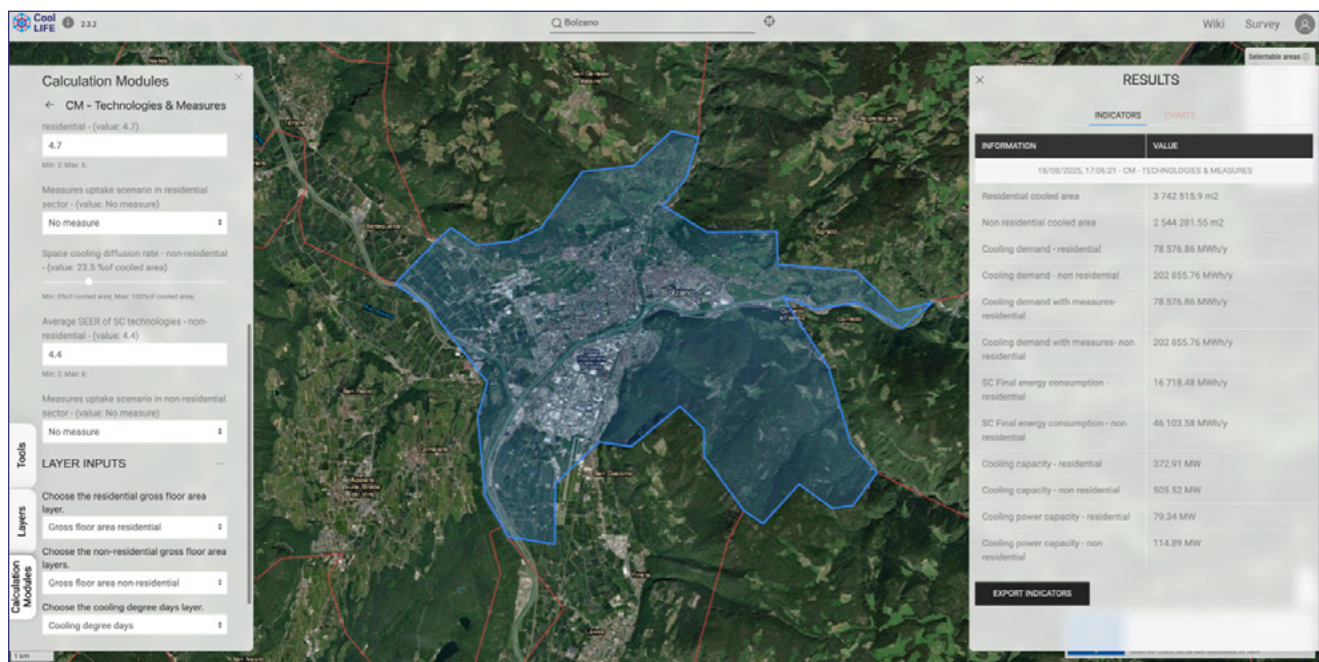


Figure 19. Bolzano space cooling technologies and measures assessment

In Naples, as a Southern European pilot site, the municipality highlighted significant and growing space cooling needs, driven by Mediterranean climate conditions with long, hot summers and increased frequency of extreme heat events. The pilot emphasized key concerns such as energy poverty during heatwaves, especially among vulnerable groups, and the rising pressure placed on energy systems during peak demand periods. While the municipality welcomed the CoolLIFE Tool's core functionalities, they pointed out its limited support for renewable and passive cooling solutions. A particular request was made for better integration of economic assessments and feasibility studies for solar and renewable-powered space cooling technologies. Given the city's heavy reliance on tourism, there was also a recommendation to develop targeted modules for hospitality sector space cooling performance, including benchmarking and sustainability guidance. The pilot ultimately advocated for the inclusion of a socio-economic vulnerability assessment component, enabling planners to target interventions more equitably and efficiently (D5.3 Testing summary and results for case studies (Giussani & Pezzutto, 2025)).

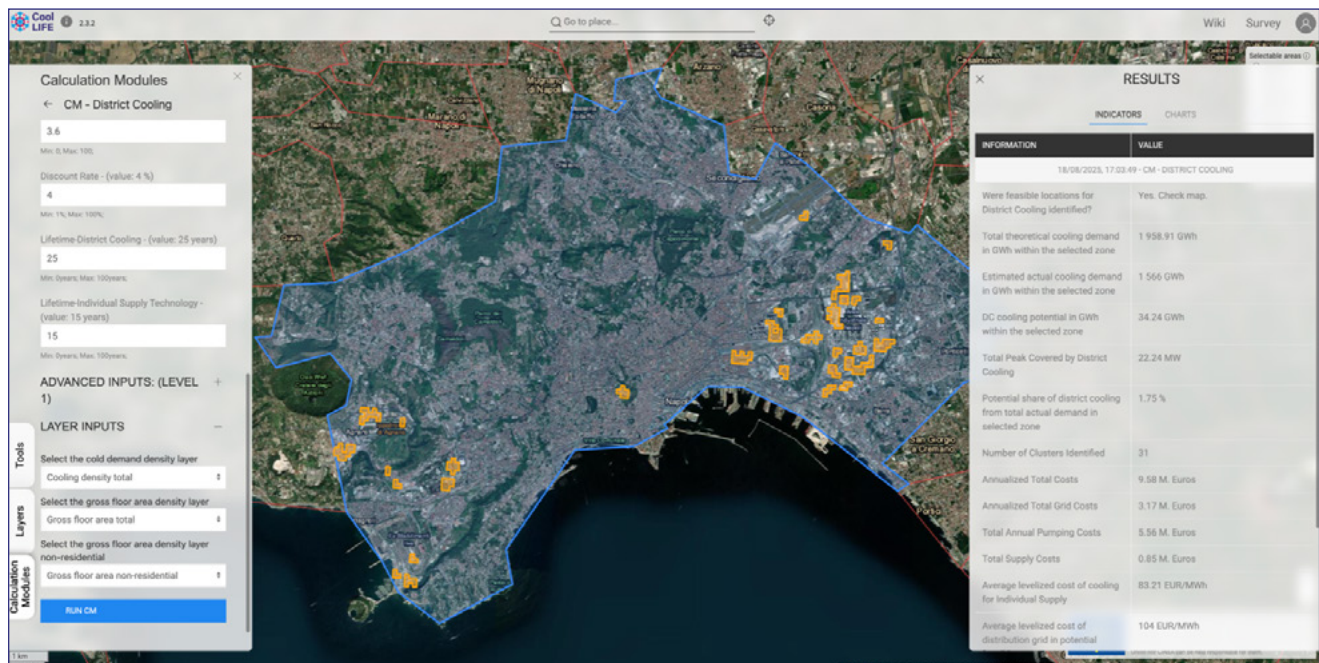


Figure 20. Naples' district cooling feasibility assessment

The Austrian case study was conducted at the national scale within the framework of the Comprehensive Assessment of the Potential for Efficient Heating and Cooling. The analysis employed the CoolLIFE tool to provide an overview of Austria's current and future space cooling demand, the related objectives, strategies, and policy measures, as well as the economic potential for efficient space cooling. In addition, the study identified potential and planned strategic measures for further tapping this potential. Results show that Austria's space cooling need is expected to rise considerably in the coming decades. Without interventions, annual demand could exceed 7,000 GWh by 2050. However, when prioritizing the uptake of passive measures such as shading, improved building design, and natural ventilation, the demand can be limited to below 2,500 GWh per year, demonstrating the crucial role of non-technical solutions.

Austria is characterized by a comprehensive legal and regulatory framework addressing space cooling at national, regional, and local levels. These provisions cover energy efficiency standards, demand reduction measures, and mandatory inspections of equipment, providing an enabling environment for efficient space cooling. At the same time, the economic perspective is highly relevant: energy costs for cooling are projected to increase beyond 200 EUR per MWh by 2050, further highlighting the urgency of integrating efficiency and passive strategies into Austria's long-term planning.

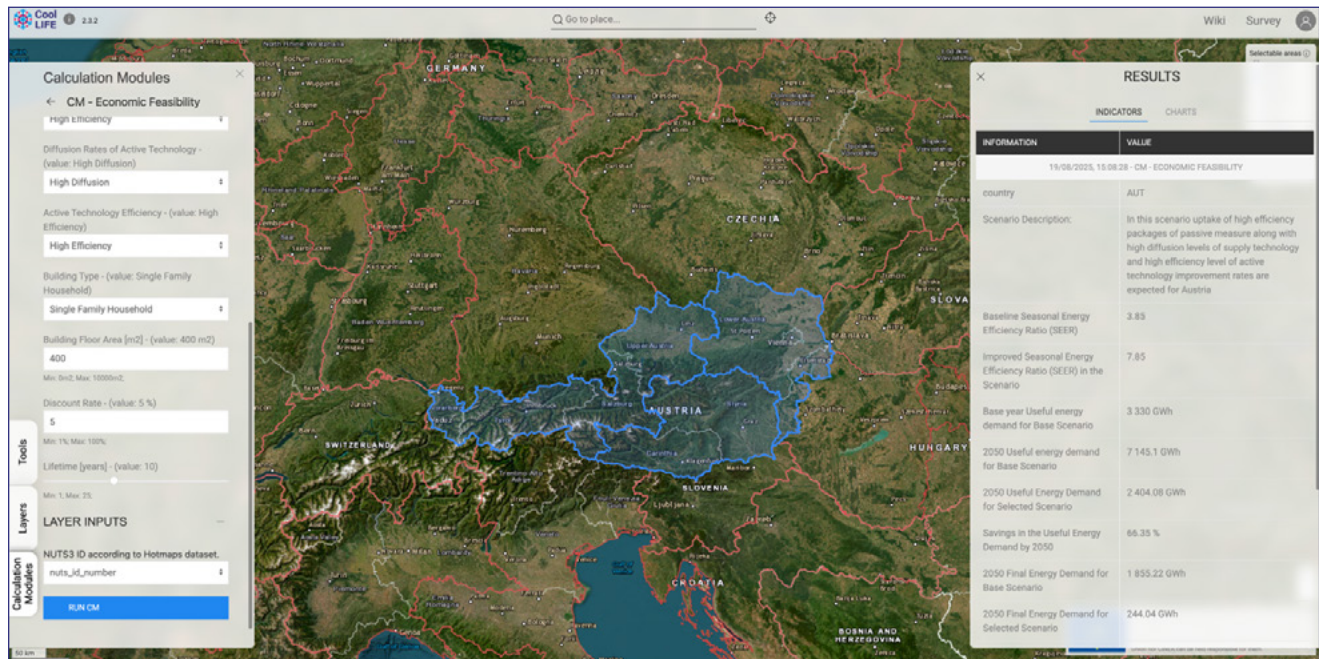


Figure 21. Austrian national level case study

Across all three case studies, the tool was evaluated through iterative testing protocols and interviews with municipal representatives. This process provided rich insights into both the strengths and limitations of the CoolLIFE Tool. It became clear that while the tool performs well in estimating spatially resolved space cooling demand, its uptake and perceived utility are highly dependent on local climatic priorities and institutional capacities. Feedback loops established with local users led to meaningful improvements in user interface design, data integration, and the scope of analysis. Municipalities valued the transparent modelling approach and expressed interest in continuing to use the tool beyond the project lifetime, especially if future iterations could include broader energy planning functionalities and stronger health, equity, and resilience indicators (D5.3 Testing summary and results for case studies (Giussani & Pezzutto, 2025)).

These case studies demonstrate that the CoolLIFE Tool has the capacity to support diverse planning needs under varying climate conditions. However, they also underscore the importance of contextualisation, participatory feedback, and adaptability in digital tools aimed at sustainable energy transitions. The experiences of Dublin, Bolzano, and Naples provide an empirical foundation for refining the tool further and scaling its use across Europe.

4. Stakeholder engagement and dissemination

Involving key stakeholders was central to the CoolLIFE project, ensuring that its outputs addressed real-world needs, were co-designed with users, and were effectively disseminated across Europe. The project's communication and dissemination strategy - outlined in Deliverable 8.1 Communication and impact report (Vallespinos & Navarro, 2025) and based on the stakeholder mapping presented in Deliverable 7.3 Review of mapping and planning tools and their application (Bottino-Leone, et al., 2023) - focused on public authorities, urban and regional planners, energy agencies, building professionals, and civil society organisations. These groups were selected both for their relevance to the residential space cooling sector and for their potential to replicate and scale up project results in local planning and policy frameworks.

Over the course of the project, CoolLIFE participated in over 30 stakeholder engagement events, including thematic workshops, webinars, bilateral meetings, and national roundtables. These events were held both in person – e.g., for the three national policy workshops (Italy, Greece and France), and for conferences (e.g. ECEEE 2024 Summer Study, C4E Forum 2025) and online to reach broader audience across Europe, with special attention to diversity and inclusion. In total, more than 500 participants from 18 countries engaged with the project's activities, contributing to local knowledge and supporting the validation of project findings and outcomes. A country specific representative survey reaching 1,000 respondents was set up to gather empirical information on summer thermal comfort expectations and their actions to maintain thermal comfort (D3.1 Knowledgebase for occupant-centric space cooling (Hurtado-Verazaín, et al., 2023)).

Workshops were structured around thematic modules, allowing participants to connect project findings with their specific local contexts and planning challenges. Topics addressed included:

- * Mapping and understanding local space cooling needs
- * Integrating space cooling into NECPs and renovation strategies
- * Passive and nature-based space cooling solutions in urban planning
- * Using and interpreting CoolLIFE Tool outputs

Each workshop included live demonstrations of the CoolLIFE tool, along with tailored guidance on its use in local planning contexts. After each session, participants were invited to provide feedback via a structured form, while the tool itself includes an embedded survey to collect data on user roles, intervention types, applied technologies, and perceived usability and effectiveness. Stakeholders generally appreciated the user-friendliness of the CoolLIFE website and default datasets, while finding the calculation modules more complex. They valued the integrated mapping, clarity, and usefulness of the tools for planning and policy support. Suggestions included clearer interlinkages of inputs/outputs, more interactive training, and stronger focus on economic feasibility. This feedback has been key to the iterative development and refinement of the tool. Beyond live events, dissemination was supported through a range of communication channels, including newsletters, social media, expert articles, and strategic partnerships with networks such as FEDARENE (FEDARENE - European Federation of Agencies and Regions for Energy and Environment, 2025), Energy Cities (Energy Cities - The European learning community for future-proof cities, 2025), BUILD UP (European Commission, BUILD UP, 2025), and the European Heat Pump Association (ehpa - european heat pump association, 2025). All major deliverables were made available via the project website and the CoolLIFE Knowledge Hub. Summary briefs were prepared in multiple languages to ensure accessibility.

Social media engagement significantly exceeded expectations. The number of LinkedIn followers surpassed original targets well before the end of the project, this reflects the growing visibility and relevance of the CoolLIFE project across professional communities, and the demand for information and experience sharing in the field of sustainable solutions for space cooling. To further strengthen outreach and exchange, the project also established the [CoolLIFE LinkedIn Community](#) (CoolLIFE's LinkedIn Community, 2025). This platform was designed to connect researchers, practitioners, and policymakers, enabling them to share experiences, discuss challenges, and access project updates in real time. By creating a space for dialogue beyond formal project activities, the community supports the long-term visibility and uptake of sustainable cooling solutions

A specific communication effort targeted policy audience, culminating in the integration of policy recommendations into Deliverable D4.3 and their dissemination at the final public event, which involved representatives from the EU, national and local levels, as well as public bodies, trade organisations, and NGOs. These efforts were aimed at aligning the project's findings with recent emerging EU policy directions, including the REPowerEU plan (European Commission, REPowerEU, 2022), the revised EED (European Commission, Energy Efficiency Directive, n.d.) and EPBD provisions (European Commission, Energy Performance of Buildings Directive, 2025), and the upcoming new EU heating and cooling strategy (Euroheat & Power, 2025).

To reach a broader and more general audience, the project also launched the CoolLiving campaign (CoolLiving, 2025), a storytelling initiative that communicated good practices in space cooling through relatable characters. This initiative aimed to raise awareness among households and non-expert audiences and complemented the more technical dissemination activities targeting professionals and policymakers.

To ensure continuity beyond the project's lifetime, CoolLIFE launched a Community of Practice focused on sustainable space cooling, bringing together technical experts, researchers and energy professionals. This initiative aims to ensure continuity in the exchange of knowledge and foster the long-term adoption of the CoolLIFE tools and approaches.

Through its integrated stakeholder engagement and dissemination efforts, CoolLIFE not only promoted its tools and findings but also built a shared understanding among diverse actors of the challenges and opportunities for sustainable space cooling.

5. Main lessons learnt

The implementation of the CoolLIFE project yielded several insights for the future of sustainable space cooling policy, planning, and technology development across Europe.

First, it became evident that addressing behavioural aspects is as critical as promoting technical solutions. Occupant behaviour—starting from using heat generating equipment, ranging through thermostat settings to the use of shading and ventilation—plays a major role in determining space cooling energy use (D3.3. Multiple, socioeconomic impacts of sustainable space cooling (Gelesz, et al., 2024)). These behaviours are highly context-dependent and influenced by cultural, economic, and climatic factors, which are not addressed in the standard assumptions used for planning and predicting space cooling demand. Empirical data collection on local habits, uptake of passive measures can not only help in selecting appropriate behavioural interventions, but could improve the uncertainties of predictions, which is also crucial for the stability of electricity grids. Simulations confirmed that through conscious behavioural adjustments which target the avoidance of discomfort conditions before they happen, the need for active space cooling can be avoided to a high extent. The internal heat loads like lighting and equipment generating heat – e.g. cooking-, as well as the shading and nighttime ventilation are critical in tackling the growing demand.

Passive space cooling measures appeared to remain underexploited despite their potential. CoolLIFE identified consistent barriers across the case study regions, including lack of technical guidelines, limited financial incentives, and insufficient regulatory mandates. Uptake is further hindered by the dominance of active space cooling mindsets and limited awareness among designers and developers: Deliverable D3.2 Analysis of Behavioural Interventions Across Europe (Gelesz, et al., 2023), showed that user decisions on ventilation, shading, and air conditioning use are highly variable and culturally rooted.

Other crucial lessons relate to the role of financing schemes. Current incentives across Europe rarely target cooling explicitly, with most support mechanisms focusing on heating or general renovation. As a result, SC—particularly in residential contexts—remains under-recognised, leaving households without dedicated options for sustainable cooling upgrades. Where incentives exist, they tend to favour active technologies such as heat pumps and air conditioners, while passive and hybrid solutions like shading, insulation, or ventilation are chronically underfunded, despite their cost-effectiveness and resilience to climate change. CoolLIFE highlighted that financial support must also be equity-oriented, as vulnerable households—those most exposed to heat stress—are typically least able to access existing schemes. Designing targeted subsidies and social support programs would therefore ensure that sustainable cooling contributes to reducing, not deepening, inequalities. Another strategic approach is to integrate cooling measures into broader renovation or climate resilience programmes, thereby bundling SC support with ongoing building upgrades or greening projects, and avoiding the need to create parallel administrative systems. The CoolLIFE project showed that performance-based incentives, rewarding measurable comfort improvements or reduced peak demand, could drive more holistic and efficient market responses. Awareness and accessibility remain equally crucial: even well-designed schemes risk low uptake if they are poorly communicated or administratively complex, especially for non-experts (D4.2 Review of financing schemes relevant for space cooling at the EU national levels (Conforto, D4.2 Review of Financing Schemes Relevant for Sustainable Space Cooling at the EU and National Levels, 2024)).

The project proved also that reducing space cooling demand is not only beneficial through energy savings. In addition to direct costs and benefits, the project addressed multiple impacts, social, economic and environmental co-benefits of reduction of space cooling behavioural changes. (D2.3: Impact Assessment (Malla, et al., 2024) and D3.3. Multiple, socioeconomic

impacts of sustainable space cooling (Gelesz, et al., 2024)). The findings show that data collection on topics like summer energy poverty and health impacts of heat wave are critical in the upcoming years.

The project confirmed that data and tools are key enablers of effective planning. Prior to CoolLIFE, many authorities lacked disaggregated, spatially relevant data on behavioural aspects and space cooling needs and energy use. This absence impedes planning, prioritisation, and monitoring of space cooling interventions. The availability of scenario-based, locally adaptable outputs empowered stakeholders to design more targeted and efficient interventions therefore the CoolLIFE Tool's ability to produce hectare-level spatial projections was welcomed by planners.

Cross-regional learning proved to be a strong asset. By comparing and contrasting experiences from Dublin, Bolzano/Bozen, and Naples the project was able to surface common challenges as well as context-specific strategies. This comparative approach also enhanced the tool's flexibility and transferability

Stakeholder co-creation was vital not only for usability but also for legitimacy. By involving end-users in design and testing, the project ensured that its products were not only technically sound but also attuned to institutional realities and planning processes. This participatory model is recommended as a best practice for future digital tool development initiatives in the energy and climate domains (D8.1 Communication and impact report (Vallespinos & Navarro, 2025)).

Another critical insight relates to the overlooked issue of urban cooling equity. Vulnerable groups—such as elderly residents, low-income households, and those with health conditions—often face the greatest exposure to urban heat but have the least access to space cooling technologies. Deliverable D4.1 Review and mapping of legislations and regulations on sustainable space cooling at EU and national levels (Broc, et al., 2024) identified the need for disaggregated vulnerability mapping to prioritise these populations in policy planning. Embedding equity indicators in the CoolLIFE Tool and Knowledge Hub supports targeted interventions and aligns with the 2023 EED (European Commission, Energy Efficiency Directive, n.d.) recast which formalised access to adequate space cooling as part of EU energy poverty criteria.

Institutional capacity emerged as another decisive factor. While the technical capabilities of cities varied, their willingness to engage and adapt planning practices improved markedly when provided with training and support. For example, the Vienna University of Technology (Technische Universität Wien -TUW) embedded the tool into its energy planning unit workflows. This experience highlights the value of long-term institutional partnerships and capacity-building initiatives alongside technical roll-outs.

Interdisciplinary approaches showed to be key to modelling success. Deliverables D2.2 Energy demand assessment (Duplessis, et al., D2.2 Energy demand assessment, 2024) and D5.3 Testing summary and results for case studies (Giussani & Pezzutto, 2025) show that successful space cooling demand modelling requires close integration of engineering, behavioural science, urban planning, and data science. Siloed approaches result in overly technical models with limited policy relevance or accessibility, and because of this should not be preferred.

To ensure replication, both institutional alignment and technical adaptation proved necessary. While the CoolLIFE Tool is designed for EU-wide use, Deliverable D7.1 Exploitation and replication strategy (Fraboni, 2025) shows that scaling its use to new cities requires both technical adjustments (e.g. local input data) and institutional readiness (e.g. mandates to include cooling in NECPs). City-level replication is feasible but dependent on these enabling conditions. Effective communication and strategic framing emerged as significant factors. Deliverable D8.1 Communication and impact report (Vallespinos & Navarro, 2025) points to the success of tailored communications, such as the CoolLiving campaign (CoolLiving, 2025), in raising awareness of sustainable space cooling. Language, visuals, and story-based formats help bridge the gap between technical content and public understanding.

The policy analysis confirmed that 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 climate-friendly alternatives. The review of space cooling technologies (D2.1 Taxonomy of space cooling technologies and measures (Duplessis, et al., D2.1. Taxonomy of space cooling technologies and measures, 2023)) however, showed that these alternatives are rarely ready to be massively deployed.

At building level, while space cooling is assumed to be included in the energy performance calculations and requirements due to the EPBD (European Commission, Energy Performance of Buildings Directive, 2025), the way it is addressed in national building regulations may vary among countries. The EPBD recast 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, as well as developing context-based assumptions for the behavioural modelling, including the use of passive measures.

At urban level, the EED (European Commission, Energy Efficiency Directive, n.d.) 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. This is usually addressed in adaptation plans. This shows how space cooling is at the intersection of mitigation and adaptation strategies and policies.

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 (European Council, 2019) may improve this, for example with the EPBD (European Commission, Energy Performance of Buildings Directive, 2025) recast emphasising more the importance of summer comfort, and the EED recast introducing an official EU definition of energy poverty, clarifying that adequate space cooling is part of the basic levels and decent standards of living and health.

Proactive planning for space cooling resilience under climate uncertainty also emerged as a key lesson. Deliverable D5.3 Testing summary and results for case studies (Giussani & Pezzutto, 2025), demonstrated that failing to consider future climate trajectories leads to severe underestimation of peak cooling needs. Stakeholders stressed that decision-makers often base planning on historical norms, which are no longer valid under current warming trends. The CoolLIFE Tool's ability to simulate space cooling demand under multiple Representative Concentration Pathways gave stakeholders a realistic sense of what unmanaged demand growth could mean for energy infrastructure and health systems. This scenario-based planning capacity should be standard in future urban and national cooling strategies. It also enables links with resilience planning, particularly in cities already developing climate adaptation or heat action plans. By integrating adaptive comfort thresholds and future socio-economic changes, such approaches can build a much-needed buffer against extreme heat shocks.

Overall, these lessons underscore that achieving a sustainable space cooling transition requires not just technology, but aligned behaviours, policy frameworks, and institutional capacities across Europe.

6. Policy recommendations

The CoolLIFE project has shown that transitioning to sustainable space cooling requires action across sectors, levels of governance, and roles—from policymakers to end users. This section expands on the original policy-focused recommendations by incorporating targeted advice for other critical actors: technology developers, installers, users, researchers, and data providers. These insights are derived from CoolLIFE's modelling work, stakeholder consultations, validation workshops, and literature synthesis.

Policy and planning recommendations

- * Integrate space cooling strategies explicitly into National Energy and Climate Plans, long-term renovation strategies, and local climate action plans.
- * Include passive and nature-based solutions in building codes and urban planning regulations.
- * Establish financial incentives for sustainable space cooling upgrades, particularly targeting vulnerable groups.
- * Mainstream space cooling considerations into EU and national building renovation programmes.
- * Align public procurement rules and city planning standards with performance-based space cooling criteria.
- * Strengthen regulatory action on fluorinated gases (F-gases), accelerating their phase-out and promoting the adoption of low-GWP refrigerants in cooling technologies.
- * Develop performance-based financing schemes that reward verified comfort improvements, reduced peak loads, or efficiency gains, rather than technology-specific rebates.
- * Embed space cooling strategies in resilience and adaptation frameworks, linking them to urban heat island mitigation and nature-based solutions such as urban greening or reflective surfaces.

Technical and market recommendations

- * Promote innovation and market entry for high-efficiency, low-global-warming-potential (GWP) space cooling technologies.
- * Encourage modular system designs and scalable passive technologies adaptable to various building types.
- * Develop certification and labelling schemes that cover both active and passive space cooling solutions.
- * Standardise product declarations on energy use and comfort impact in varying climate conditions.
- * Incentivise hybrid approaches that combine passive and active elements, ensuring that passive measures are prioritised as the first line of defence against rising heat loads.

Installer and maintenance professional recommendations

- * Expand training programmes for heating, ventilation and air conditioning professionals on passive strategies, efficient sizing, and adaptive comfort principles.
- * Disseminate simplified technical guides and decision trees to aid in appropriate system selection and installation.
- * Encourage preventive maintenance standards that ensure long-term performance and refrigerant containment.
- * Promote installer networks or certification bodies that specialise in low-impact and hybrid cooling systems.

User behaviour recommendations

- * Promote behavioural campaigns around efficient space cooling use, including thermostat setpoints, shading use, and night ventilation.
- * Use monetary incentives to reduce peak loads, adapt feedback and social comparison and nudges to adapt passive and behavioural practices
- * Foster awareness of adaptive comfort and acceptable indoor conditions in different climate zones.
- * Encourage co-design of space cooling interventions in residential renovations, engaging occupants from the outset.
- * Create easy-to-use mobile apps incorporating gamification or household tools that visualise personal space cooling consumption.
- * Relax dress codes, allow flexible work schedules during summer and heat waves

Research and innovation recommendations

- * Support interdisciplinary research on climate-resilient space cooling, combining engineering, social science, and urban planning.
- * Fund pilot projects that demonstrate the benefits of passive and hybrid (active and passive) space cooling systems in real-life conditions.
- * Advance studies on systemic impacts of space cooling, including interactions with heating, renewables, and energy storage.
- * Promote open-access modelling libraries and shared testbeds for comfort-based cooling system design.
- * Support multidisciplinary research on multiple socio-economic impacts of summer discomfort, including summer energy poverty.
- * Expand empirical data collection on occupant behaviour, thermal expectations, and cultural practices in summer, to allow country-specific usage profiles and more accurate demand projections.

Data and monitoring recommendations

- * Mandate collection of spatially resolved space cooling demand data in national statistics.
- * Develop EU-wide guidelines for cooling-related KPIs, including peak load indicators and comfort performance.
- * Foster open data sharing and interoperability to support digital tools like the CoolLIFE Tool (CoolLIFE Tool, 2025).
- * Encourage local authorities to publish anonymised building-level energy datasets to support community planning.
- * Collect behavioural data on summer occupancy, patterns of using passive and behavioural measures in avoiding thermal discomfort, to provide schedules as inputs for improved energy use predictions and planning
- * Extend building stock data with parameters highly influencing space cooling demand. Current classifications like Tabula concentrate on fabric performance; while glazing ratio, existence of shading devices and typical urban environment are decisive factors in heat loads that influence space cooling demand.
- * Establish systematic monitoring of financing schemes related to space cooling, ensuring that access, uptake, and effectiveness—particularly for vulnerable groups—are evaluated and improved over time.

Other recommendations

- * Extend the CoolLIFE Tool and the Knowledge Hub as an example for domestic hot water (DHW), where similar challenges of demand forecasting, efficiency, and integration with renewable sources persist. By adapting the taxonomy, behavioural insights, and scenario-based modelling developed for cooling, the approach could support policy, planning, and user awareness in the DHW sector, which also represents a significant share of household energy demand.
- * Leverage the CoolLIFE approach as a replicable model for other end-use sectors where demand is growing but underrepresented in policy, such as refrigeration or industrial cooling. The principles of transparency, open access, and participatory co-creation can guide the design of future digital tools beyond space cooling.

7. Scientific and technical impact

The CoolLIFE project has made a meaningful contribution to both scientific research and applied technical innovation in the field of sustainable space cooling. Its methodological advancements, data products, and modelling tool provide new avenues for understanding and addressing space cooling demand in a systemic, future-oriented manner.

On the scientific front, the project bridged a notable gap in existing literature and modelling capabilities by incorporating user behaviour, comfort preferences, and socio-economic heterogeneity into demand forecasting (D3.1 Knowledgebase for occupant-centric space cooling (Hurtado-Verazaín, et al., 2023), D3.2 Analysis of behavioural interventions across Europe (Gelesz, et al., 2023), D3.3 Multiple, socioeconomic impacts of sustainable space cooling (Gelesz, et al., 2024)). The inclusion of adaptive comfort models and cross-climatic behavioural insights represents a substantial evolution in energy demand modelling for the built environment. The contrasting of space cooling demand using theoretical and empirical behavioural data highlights the high uncertainties when using standard data for predictions.

Technically, the CoolLIFE Tool stands out for its open-source nature, spatial granularity, and usability. Unlike many existing energy tools, it is specifically tailored to space cooling, integrates geospatial visualisation with scenario analysis, and is accessible to non-expert audiences. The tool's code base, the documentation (D5.2 Calculation modules on space cooling demand, technologies, user behaviour, economics and demand response (Malla & Kranzl, D5.2 Calculation modules on, 2025)), and CoolLIFE Wiki (CoolLIFE Wiki, 2025) are being used as references for new initiatives in urban climate resilience and energy planning.

The Knowledge Hub complements this by creating a durable, expandable resource environment that brings together space cooling-related information from across disciplines and governance levels. By adopting FAIR principles, the project has set a precedent for transparency and interoperability in energy and climate data platforms.

These outputs have already stimulated academic interest, with preliminary results presented at conferences such as BEHAVE (European Commission, BEHAVE, 2025), Sustainable Places (Sustainable Places, 2025), ECEEE (Efficient Buildings Europe, 2025) 2024 Summer Study, and EUSEW (European Commission, European Sustainable Energy Week - EUSEW, 2025). Follow-up research collaborations have been initiated with both academic and municipal partners, ensuring the scientific and technical legacy of CoolLIFE continues to grow. And papers have already been published in scientific journals.

References of the papers presented at international conferences or published in scientific journals:

- * Pezzutto, S., Broc, J.-S., Duplessis, B., Trovalusci, F., Lionggo, I., Athanasiou, D., Clero, J., & Conforto, G. [Making EU policies fit for sustainable space cooling : First reducing the needs by adopting a systemic view](#). Proceedings of the ECEEE 2024 Summer Study.
- * Bottino-Leone, D.; Balest, J.; Cittati, V.M.; Pezzutto, S.; Fraboni, R.; Beltrami, F. Review of Existing Tools for the Assessment of European Building Stock Energy Demand for Space Heating and Cooling. Sustainability 2024, 16, 2462. <https://doi.org/10.3390/su16062462>
- * Elnagar, E., Pezzutto, S., Duplessis, B., Fontenaille, T., Lemort, V., A comprehensive scouting of space cooling technologies in Europe: Key characteristics and development trends, Renewable and Sustainable Energy Reviews, 2024,186, 113636, <https://doi.org/10.1016/j.rser.2023.113636>

8. Challenges encountered

While the CoolLIFE project achieved its core objectives, several challenges were encountered along the way, reflecting the complexity of developing innovative, user-friendly tools for sustainable space cooling in a diverse European context. These challenges are grouped below by project objective and linked to relevant deliverables for transparency.

1

Challenge 1: Integrating diverse data sources for modelling space cooling demand

The project required the harmonisation of heterogeneous datasets (climate, socio-economic, behavioural, technical) across the EU27. Variability in data resolution, availability, and definitions made this task resource-intensive and sometimes imprecise. For example, fine-grained building-level data were difficult to obtain for certain regions, requiring the use of proxy indicators or assumptions (D4.1 Review and mapping of regulations on sustainable space cooling (Broc, et al., 2024)).

2

Challenge 2: Capturing user behaviour realistically in demand modelling

Although behavioural aspects were a distinguishing feature of the CoolLIFE Tool, quantifying and incorporating comfort preferences proved difficult. Regional behavioural data on thermostat use, ventilation habits, and adaptive strategies were limited or non-comparable. (D3.2 Analysis of behavioural interventions across Europe (Gelesz, et al., 2023)) Stakeholder workshops revealed divergent perceptions of comfort, particularly between Northern and Southern Europe, making generalisation a challenge (D4.1 Review and mapping of regulations on sustainable space cooling (Broc, et al., 2024), D6.2 Training report (Conforto & Akhatova, D6.2 Training report, 2025)).

3

Challenge 3: Balancing complexity and usability in tool design

Designing the CoolLIFE Tool to be both technically robust and accessible to non-expert users created trade-offs. Some advanced modelling features were scaled back to preserve clarity and user experience. Initial usability testing revealed that less experienced users struggled with interpreting multi-scenario outputs, prompting interface redesigns (D5.2 Calculation modules on space cooling demand, technologies, user behaviour, economics and demand response (Malla & Kranzl, D5.2 Calculation modules on, 2025)).

4

Challenge 4: Engaging stakeholders consistently throughout the project

Despite strong engagement overall, maintaining consistent involvement from diverse stakeholders across all phases (co-design, testing, dissemination) was logistically difficult. Constraints included language barriers, shifting institutional

priorities, and varying levels of technical expertise. This showed to affect the pace of feedback loops (D8.1 Communication and impact report (Vallespinos & Navarro, 2025)).

5

Challenge 5: Limited attention to cooling in existing planning frameworks

Municipalities and national authorities often lacked mandates or procedures to incorporate space cooling into energy and climate planning. As a result, local partners struggled to contextualise the tool's outputs within their official strategies. This reflects a broader structural issue rather than a project-specific failure, but it constrained the potential for immediate uptake (D6.2 Training Report (Conforto & Akhatova, D6.2 Training report, 2025))

6

Challenge 6: Complexity in representing passive space cooling options

Passive cooling strategies are highly context-dependent and often non-standardised, making their representation in scenarios and tool functionalities difficult. Unlike active systems, passive measures lack uniform performance metrics, requiring innovative assumptions and simplifications in the modelling process (D4.1 Review and mapping of regulations on sustainable space cooling (Broc, et al., 2024) , D5.2 Calculation modules on space cooling demand, technologies, user behaviour, economics and demand response (Malla & Kranzl, D5.2 Calculation modules on, 2025)).

7

Challenge 7: Post-project maintenance and scaling

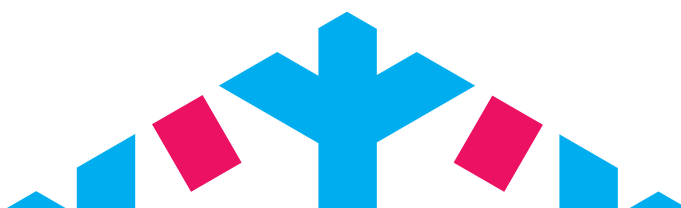
Ensuring the long-term use and update of project tools remains a challenge, particularly in the absence of a centralised EU space cooling strategy. While partners have committed to maintaining the platform, sustainable governance models for open tools require further development, including funding pathways and institutional hosting arrangements (D8.1 Communication and impact report (Vallespinos & Navarro, 2025)).

Despite these challenges, the project team actively sought adaptive solutions, and the learnings gained fed directly into improvements and future planning. Addressing these barriers systemically will be key to unlocking the full potential of tools like CoolLIFE in supporting a sustainable space cooling transition.

8

Challenge 8: Building stock data

CoolLIFE has adapted a modelling approach based on building archetypes developed from a wide range of sources like Tabula (TABULA WebTool, 2017), areal and satellite photos, etc. Parameters not available on a wide scale were determined through statistical data and expert judgement. Improving data availability on building stock characteristics like glazing ratio, shading and internal loads would boost the prediction reliability of space cooling demand when hectare level is considered.



9. Conclusions and outlook

The CoolLIFE project has successfully addressed a critical gap in Europe's energy transition by focusing on space cooling, a sector that has too often remained in the background of research and policy. Rising temperatures, urban heat islands, and growing comfort expectations are driving up space cooling needs, with major implications for energy demand, public health, and electricity system resilience. Yet, while heating continues to dominate the policy agenda, the role of space cooling has been underestimated. CoolLIFE has made a decisive contribution by developing open-access tools, integrating behavioural, climatic, and spatial data, and working closely with stakeholders to ensure that outputs are practical, policy-relevant, and grounded in real-world conditions.

The project has shown that space cooling needs are systematically underrepresented in national and European frameworks. At EU level, heating and cooling are treated jointly under the Energy Efficiency Directive and the Energy Performance of Buildings Directive. However, in practice, national strategies still privilege heating, with space cooling mentioned only marginally in National Energy and Climate Plans. Regulatory and financial mechanisms typically target equipment or general efficiency upgrades, while holistic space cooling strategies remain rare. Financing options exist—grants, loans, tax rebates—but they are fragmented and rarely tailored to space cooling, leaving adoption uneven across countries. Stronger alignment between EU-level ambitions and national implementation will be crucial to ensure that best available technologies and passive measures are deployed in an integrated way.

Methodologically, CoolLIFE also uncovered gaps in the evidence base. Data on capital and operating expenditures for Space cooling technologies and passive measures were scarce or outdated. To overcome this, the project engaged experts directly, building a robust dataset that supports calculation modules and scenario analysis. This experience highlights the need for continuous empirical work, particularly on behavioural factors such as thermal comfort, presence, and adaptive practices, which significantly affect demand and vary across countries.

Looking forward, CoolLIFE offers a strong foundation for continued research and policy development. Its emphasis on transparency, replicability, and relevance ensures that the tools are not only usable today but adaptable for future needs. By making all components open-source and openly documented, the project has lowered the barrier for researchers, planners, and local authorities to replicate, extend, and institutionalize its outputs. This creates the conditions for broader deployment across Europe and fosters a culture of knowledge sharing around sustainable cooling.

As climate impacts intensify, the importance of data-driven and people-centred space cooling planning will only grow. Rising urban heat stresses require responses that combine technical measures with behavioural insights, financial innovation, and coherent policy frameworks. CoolLIFE demonstrates how such an integrated approach can be built, tested, and translated into practice. More than just a tool, the project provides a replicable model for delivering systemic change: linking scientific rigour with participatory processes, addressing gaps in data and financing, and embedding space cooling firmly within the wider sustainability agenda.

In sum, CoolLIFE has established a new benchmark for how space cooling can be integrated into Europe's energy transition. To safeguard resilience, equity, and climate neutrality, it will be essential to mainstream space cooling into policy, strengthen targeted financing, and expand empirical knowledge. CoolLIFE has laid the groundwork for this shift, offering not only innovative tools but also a scalable approach that can drive long-term transformation in this emerging domain.

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