Webinar 8:
Space Cooling

Act!onHeat SF1

- Serial 3:
  - Webinar 8
    - Strategical Heating & Cooling planning
    - Group support for municipalities and stakeholders

- Presented by:
  - e-think / Austria
  - TU-Wien / Austria

This webinar focuses on space cooling, covering increasing demand, reduction potential, and sustainable supply opportunities. The presentation is delivered by Aadit Malla from TU Wien, highlighting strategies to address cooling challenges in the context of rising demand and EU policy frameworks.

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- Part 1: Existing and projected demands and EU policy landscape
  - Space cooling demands in Europe, reasons for increasing space cooling demands
  - EU regulations related to space cooling, requirements within the Comprehensive Assessment in the EED Art. 25
- Part 2: Opportunities for reduction and sustainable supply
  - Reduction potential from passive measures
  - Identifying Sustainable Supply technologies - Central and Decentral
  - Impact of occupant behavior on cooling demand

Part 1: Existing and projected demands and EU policy landscape

- ❑Space cooling in Europe
- ❑Cooling demand: Data scarcity and Modelling
- ❑EU cooling policy and framework

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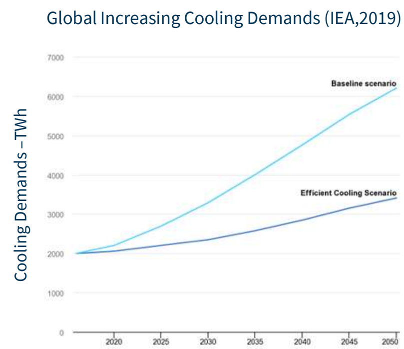
Space Cooling

“the process of cooling indoor air by removing heat from the air and providing buildings' occupants with thermal comfort”

Why cooling in Europe?

- Global temperature rises
- Higher affordability (increased GDP & reduced technology costs) for cooling technologies → resulting in higher diffusion rates
- Increasing living standards, improved comfort levels
- Focus on the heating season only when improving buildings' envelope and neglecting the chance to improve buildings' performance under winter and summer conditions
- Increasing window-wall-ratio



- The presentation focuses solely on space cooling, which refers to cooling aimed at maintaining indoor comfort for occupants. Process cooling is excluded from the scope.
- Global cooling demand is rising due to factors such as higher affordability, improved living standards, and increased comfort expectations.
- Innovative approaches offer opportunities to control demand growth and transition towards sustainable cooling supply solutions.
- A shift in building improvement strategies is needed to address performance during both summer and winter, emphasizing holistic climate-responsive designs.

Part 1: Existing and projected demands and EU policy landscape

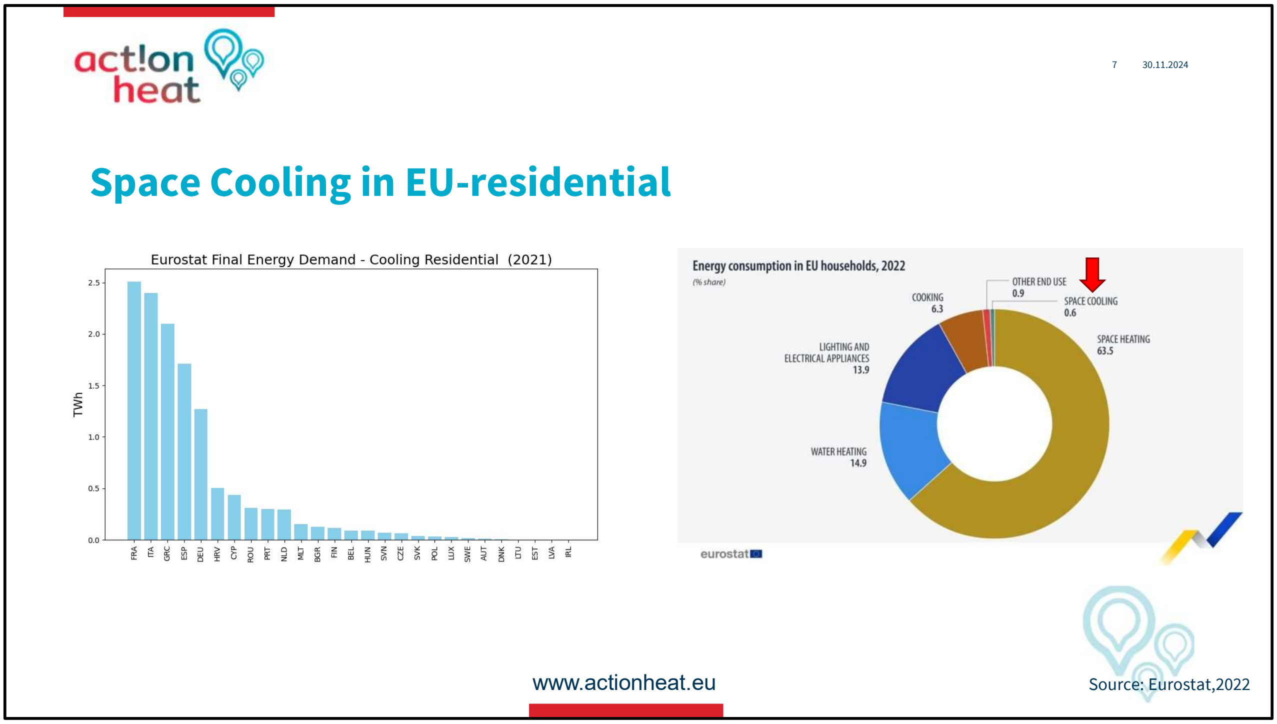
- ❑Space cooling in Europe
- ❑Cooling demand: Data scarcity and Modelling
- ❑EU Cooling policy and framework

Scarcity of Cooling data

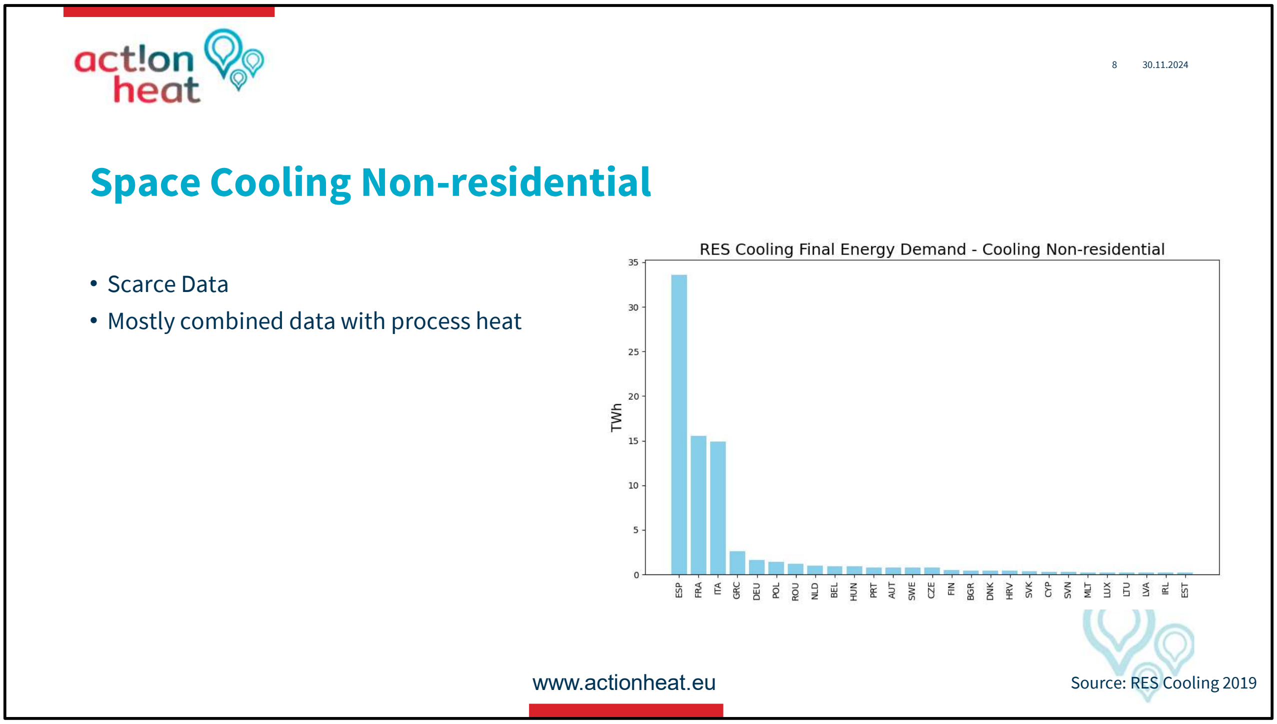
- Historical focus on heating
- Regional variability in data collection practice
- Cooling demand is coupled with electricity demand
- Until recent years there has been no/limited emphasis on cooling
- Finding a proxy to estimate the cooling demands

Source: Eurostat, 2023

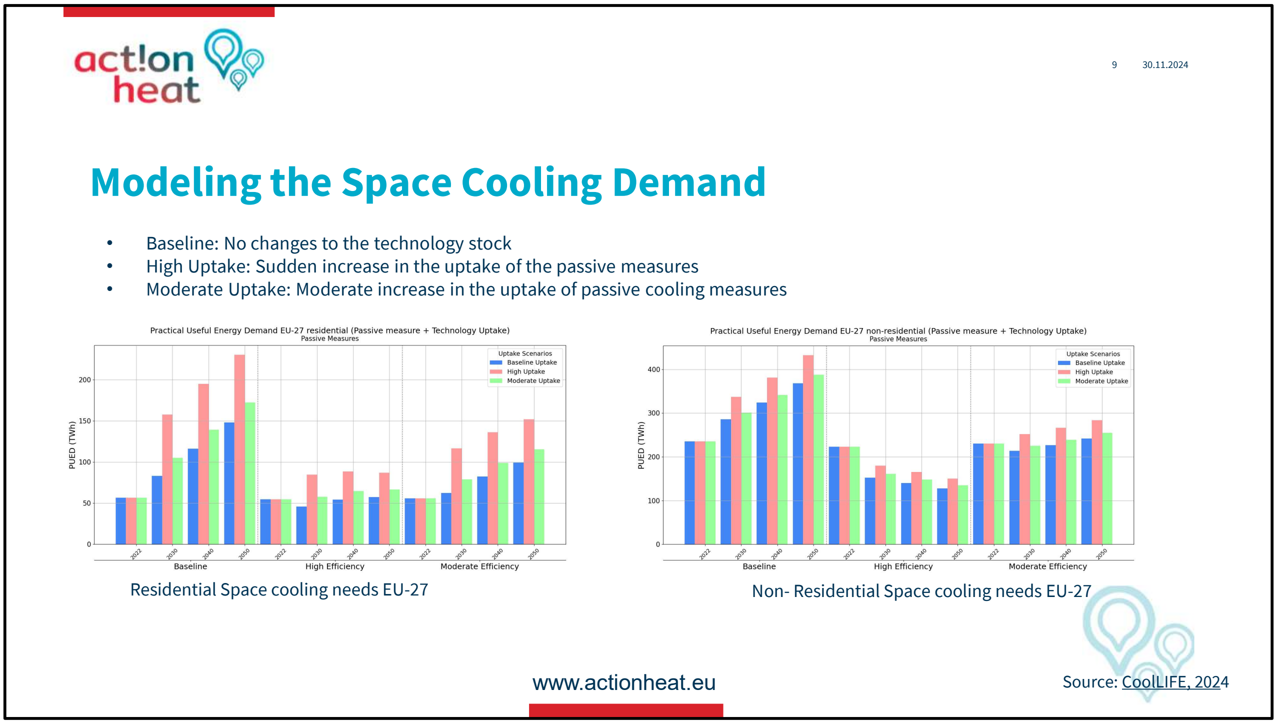
- The scarcity of reliable data complicates the prediction and modeling of cooling demand across Europe.
- Cooling demand has traditionally been overlooked, with more focus placed on heating data collection and analysis.
- Cooling Degree Days (CDD) provide a straightforward yet simplistic method for estimating cooling demand.
- Improved data collection practices and proxies are necessary for more accurate demand assessments, especially given regional variability.



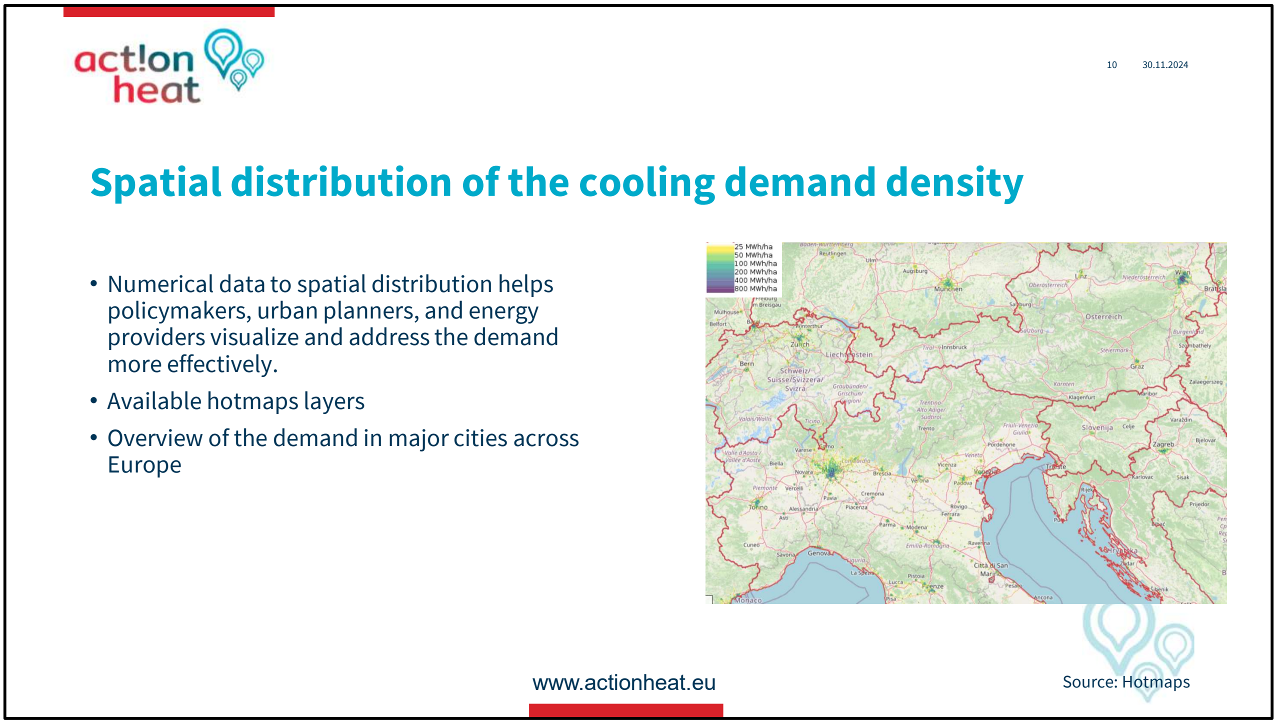
- Space cooling represents a minimal portion of the total energy demand in the EU residential sector.
- The demand is primarily influenced by external temperatures, building insulation quality, and occupant behavior.
- Increased affordability and diffusion of cooling technologies are gradually driving demand growth in residential buildings.
- Accurate demand modeling for this sector remains challenging due to limited data availability and historical focus on heating needs.



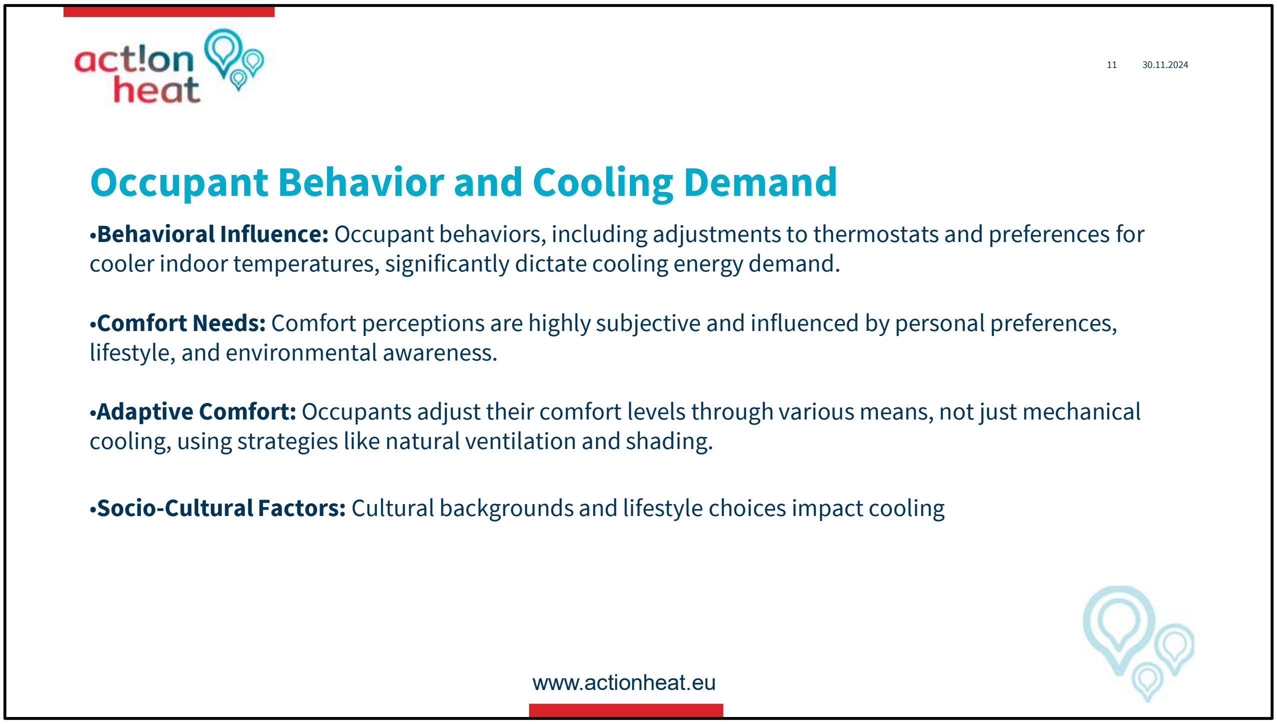
- In the non-residential sector, cooling demand data is often combined with process heat data, making it challenging to isolate specific cooling needs.
- The lack of granular data hampers accurate assessments and planning for space cooling in non-residential buildings.
- Non-residential cooling demand is influenced by operational schedules, internal heat loads, and building design
- Improved data segregation and collection methodologies are essential to understand and address the unique cooling requirements of this sector.



- The space cooling demand was modeled under three scenarios, each varying by the rate of uptake of passive cooling measures.
- The adoption rate and efficiency of passive measures significantly influence the potential for demand reduction.
- Large uncertainties exist regarding the future adoption rates of these measures and their real-world effectiveness.
- Passive measures include strategies like shading, advanced window glazing, night ventilation, and adjusting indoor temperature setpoints to reduce cooling needs.
- These scenarios aim to provide insights into how passive measures can contribute to sustainable cooling strategies.

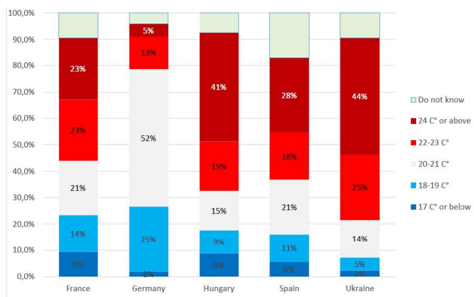


- Spatial data on cooling demand density adds an important dimension to planning and policy-making.
- It helps visualize demand patterns across regions, enabling targeted interventions for cooling infrastructure and energy supply.
- Policymakers, urban planners, and energy providers can use this data to address demand more effectively and equitably.
- Tools like Hotmaps layers can provide an overview of cooling demand in major cities, facilitating region-specific strategies for sustainable cooling.



- Occupant behavior significantly influences cooling demand, adding complexity to demand modeling efforts.
- Behavioral aspects, such as thermostat adjustments, preferences for cooler temperatures, and lifestyle habits, must be considered alongside building physics modeling.
- Comfort needs are subjective, influenced by socio-cultural factors, personal preferences, and environmental awareness.
- Incorporating these dynamic and human-centered factors is crucial for developing accurate and comprehensive space cooling demand models.

Comfort Ranges

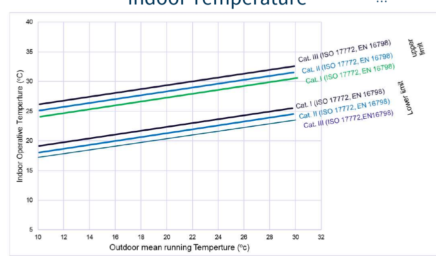


Preferred indoor temperatures in houses

- People with exposure to air-conditioning at work would also prefer one at home
- Demand is driven by the external temperatures, building insulation, energy prices and user preferences as well as the occupancy behavior(occupancy status)
- Typical thermostat setting found in air-conditioned setting 25-28°C

Cat I: Low flexibility for fluctuation
Cat II: slightly higher
…

Indoor Temperature



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Source: CoolLIFE, 2023

- The figure on the left illustrates preferred indoor temperatures across various countries, reflecting cultural and climatic differences.
- The bottom figure highlights the relationship between indoor temperatures and outdoor conditions, providing a framework for estimating comfort levels.
- These calculations are essential for architects, urban planners, and energy engineers to design energy-efficient HVAC systems tailored to local climatic variations.
- Properly designed systems can maintain thermal comfort while minimizing energy use, particularly in areas with significant fluctuations in outdoor temperatures.

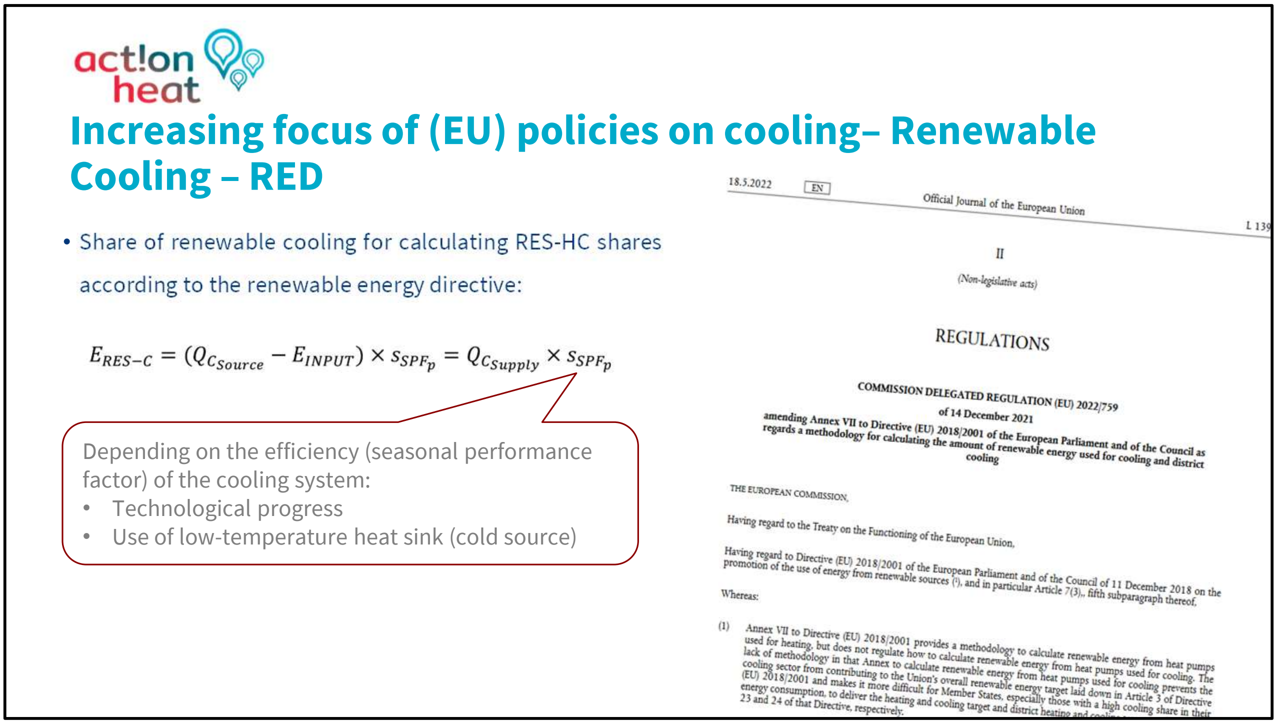
Part 1

- ❑Space cooling in Europe
- ❑Cooling demand: Data scarcity and Modelling
- ❑EU cooling policy and framework

EU Policy Framework

- Decarbonization targeted in heating and cooling as part of the European Green Deal and Fit for 55 initiatives.
- Renewable Energy Directive (2018/2001) enhances focus on renewable integration in heating and cooling sectors.
- Revised Renewable Energy Directive (2023/2413) strengthens and sets new targets for district heating and cooling.
- New provisions enable better use of waste heat and improve the role of heating and cooling in EU energy systems.

- The European Green Deal and the Fit for 55 package emphasize decarbonizing heating and cooling sectors to achieve climate neutrality by 2050.
- The Renewable Energy Directive (2018/2001) sets a binding overall Union target to reach a share of at least 32% of energy from renewable sources in the Union’s gross final consumption of energy by 2030.
- The revised Renewable Energy Directive (2023/2413) strengthens the heating and cooling target (Article 23) and the district heating and cooling target (Article 24). It also extends measures EU countries can take to achieve these targets and includes specific provisions on integrating waste heat and cold.
- These directives aim to enhance the role of heating and cooling in the EU's energy system integration, promoting the use of renewable energy sources and improving energy efficiency.



- EU policies are increasingly prioritizing the integration of renewable cooling within the broader energy transition agenda.
- The Renewable Energy Directive (RED) emphasizes renewable cooling as a key component for achieving energy efficiency and decarbonization targets.
- Renewable cooling is defined based on efficiency thresholds, promoting technologies like heat pumps, free cooling, and waste heat recovery.
- The RED encourages Member States to develop frameworks to support renewable cooling adoption and monitor its contribution to renewable energy targets.
- This focus aligns with the EU's Green Deal and Fit for 55 objectives to transition the heating and cooling sectors to sustainable and energy-efficient solutions.

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Requirements of the EED recast- MS Comprehensive Assessment

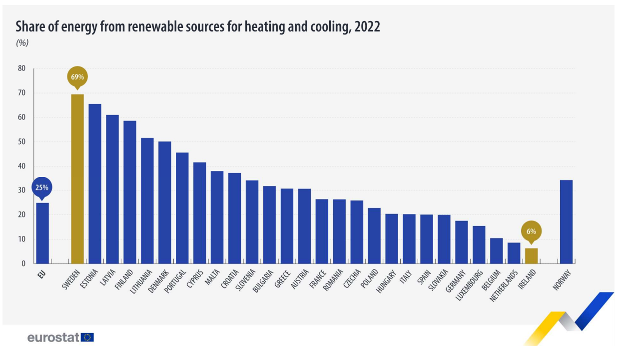
- **Demand Assessment:** Evaluate current and future cooling needs.
- **Technical Feasibility:** Identify viable cooling technologies.
- **Economic Analysis:** Perform cost-benefit and investment analysis.
- **Environmental Impact:** Estimate energy savings and emissions reductions.
- **Legal Framework:** Review regulatory barriers and incentives.
- **Infrastructure Requirements:** Outline necessary infrastructure for cooling.
- **Market Potential:** Analyze customer base and market size.
- **Best Practices:** Highlight successful case studies.
- **Risk Evaluation:** Identify and assess project risks.

- The EED recast requires member states to assess cooling demand, identify viable technologies, and evaluate economic and environmental impacts.
- It emphasizes addressing regulatory barriers, market potential, and infrastructure needs.
- Risk assessment and best practices are key to advancing sustainable cooling strategies.

Part 2: Opportunities for reduction and sustainable supply

- ❑Impact of Cooling on Achieving Renewable Energy Targets
- ❑Overview of Active and Passive Cooling Measures
- ❑Reduction potential from passive measures
- ❑ Evaluating Central and Decentralized Cooling Technologies

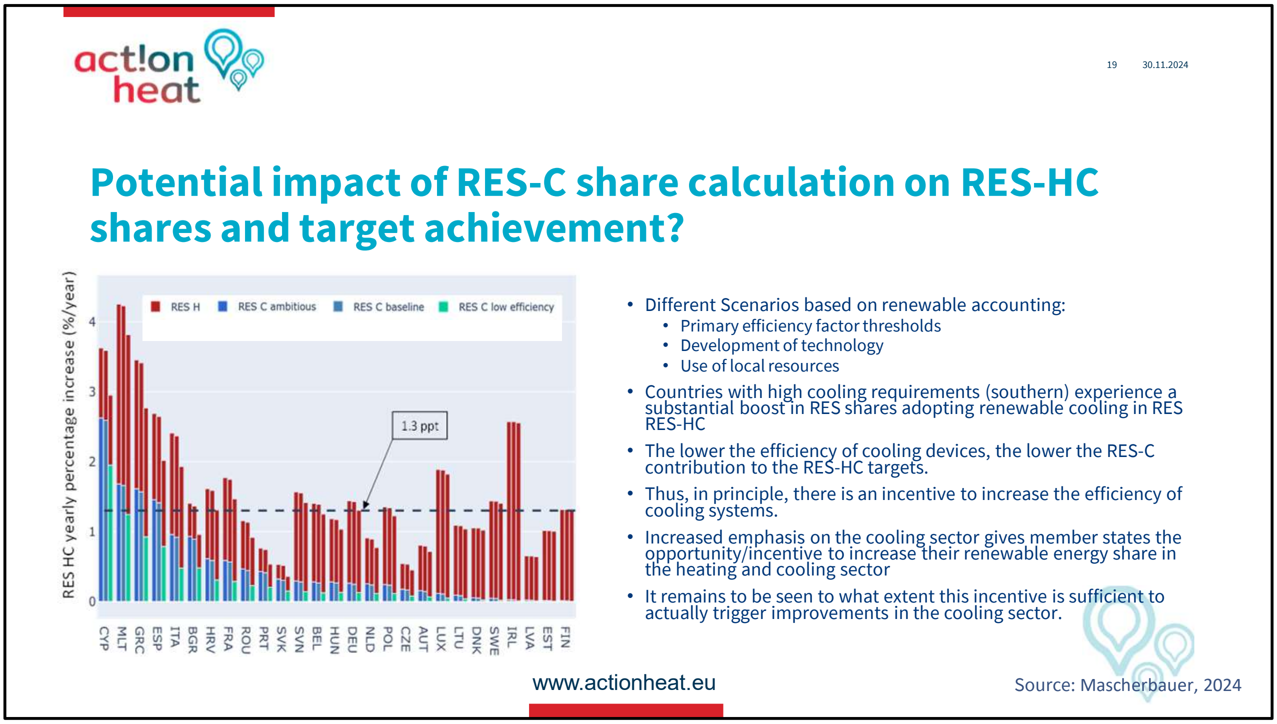
Current Share of renewables in Heating and cooling



- Data only on cooling is not available
- Considering the delegated act was in place in 2021 this data should include cooling, but needs to be confirmed with MS
- Hard to estimate what percentage of cooling demand is met by renewable

Source: EUROSTAT, 2022

- Data on the share of renewables specifically for cooling is limited, as current statistics often combine cooling with heating data.
- The Renewable Energy Directive (RED) aims to integrate cooling into renewable energy targets, emphasizing the need for accurate and updated data.
- Member states are encouraged to evaluate and report renewable cooling contributions to better align with EU energy goals.



- The efficiency of cooling systems significantly influences renewable cooling (RES-C) contributions to renewable heating and cooling (RES-HC) targets.
- High cooling demands in southern regions can substantially boost renewable shares with effective RES-C integration.
- Policies encourage improving system efficiency and adopting renewable technologies to meet EU decarbonization goals.

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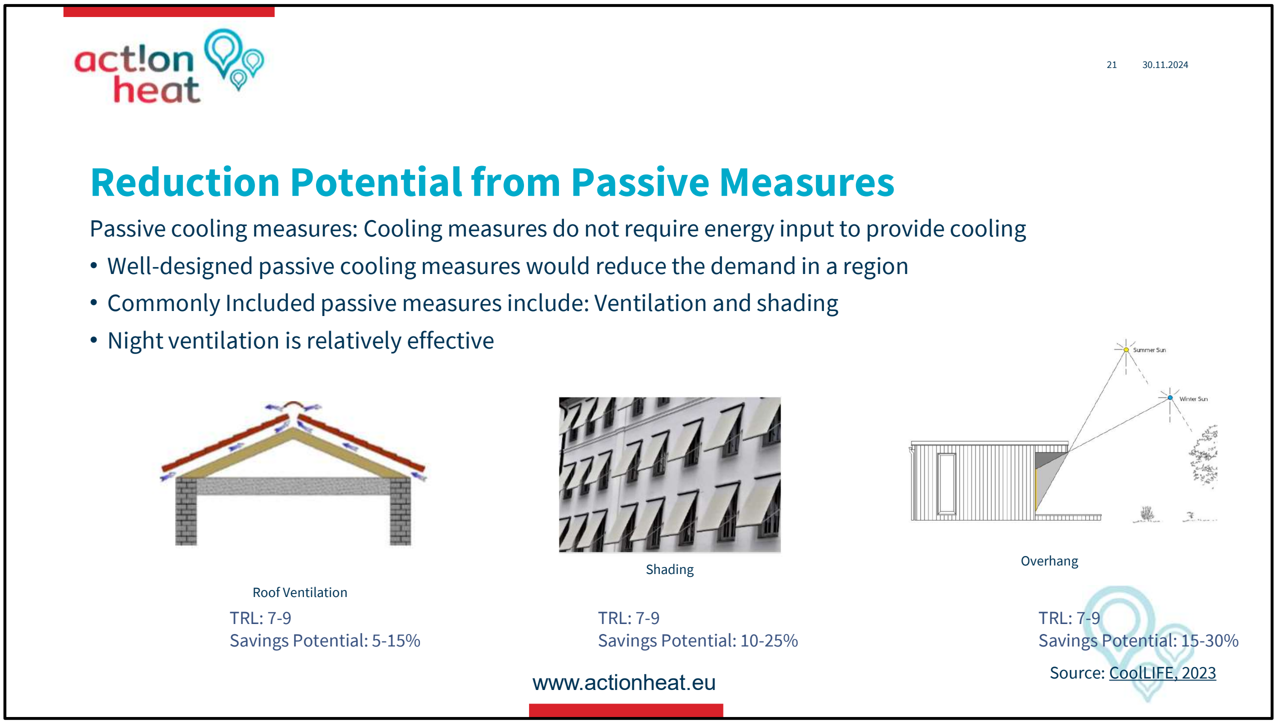
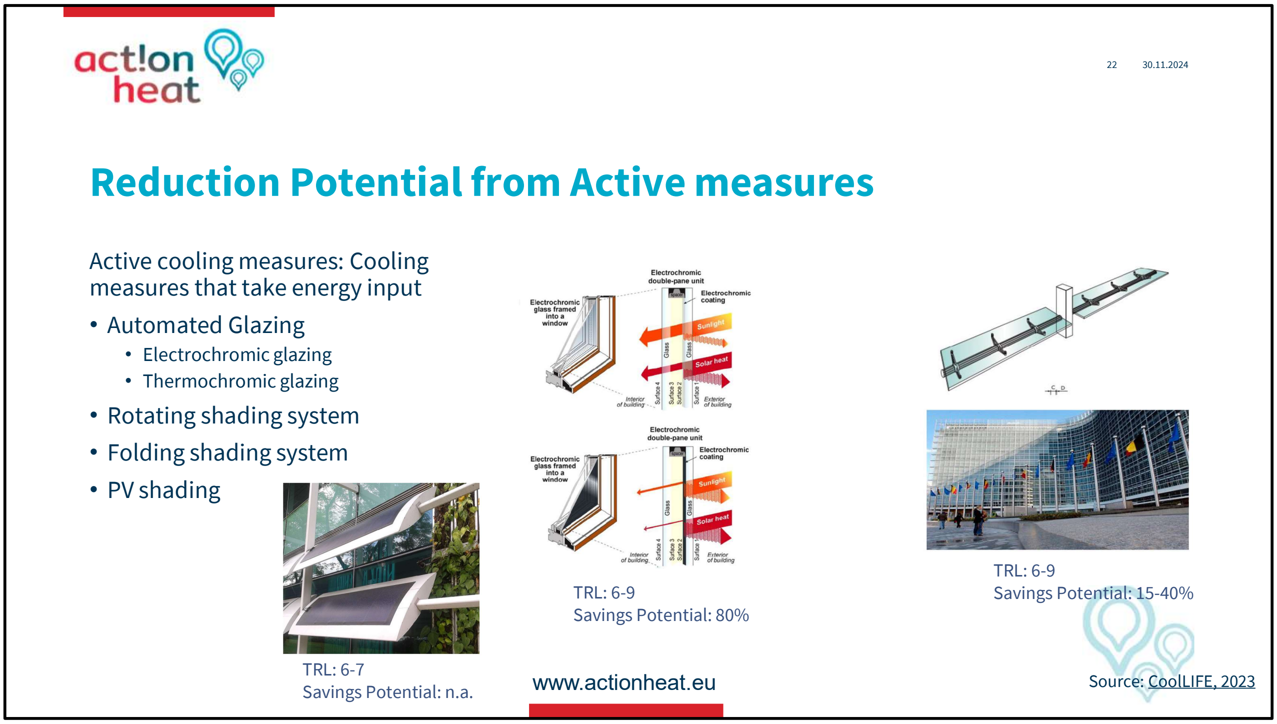


- Passive cooling measures, such as shading, ventilation, and roof insulation, significantly reduce cooling energy demands, with savings potential ranging from 5% to 30%.
- The **Technology Readiness Level (TRL)** largely defines the cost and savings potential of these measures, impacting their adoption feasibility.
- Some measures are easy to integrate, while others require substantial building design alterations, which can increase costs.
- Prioritizing scalable and cost-effective measures is key to achieving sustainable cooling strategies.



- Active cooling measures, such as electrochromic glazing, thermochromic glazing, and PV shading, require energy input but offer significant savings potential, ranging from 15% to 80%.
- Advanced technologies provide better energy-saving potential but come at higher costs, requiring a balance between upfront investment and long-term efficiency gains.
- The **Technology Readiness Level (TRL)** for these measures varies, impacting their integration feasibility and market adoption.
- These systems are ideal for projects where high savings justify the cost, but careful evaluation of costs and integration challenges is necessary.

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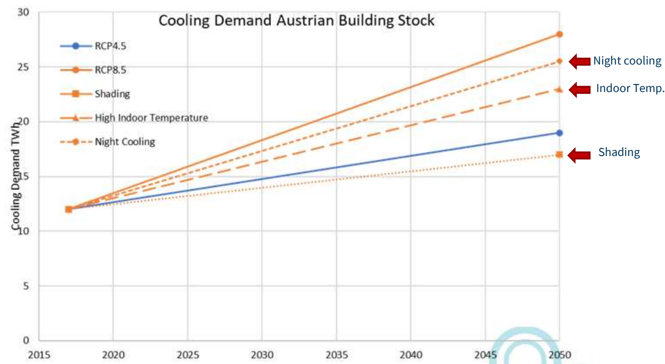
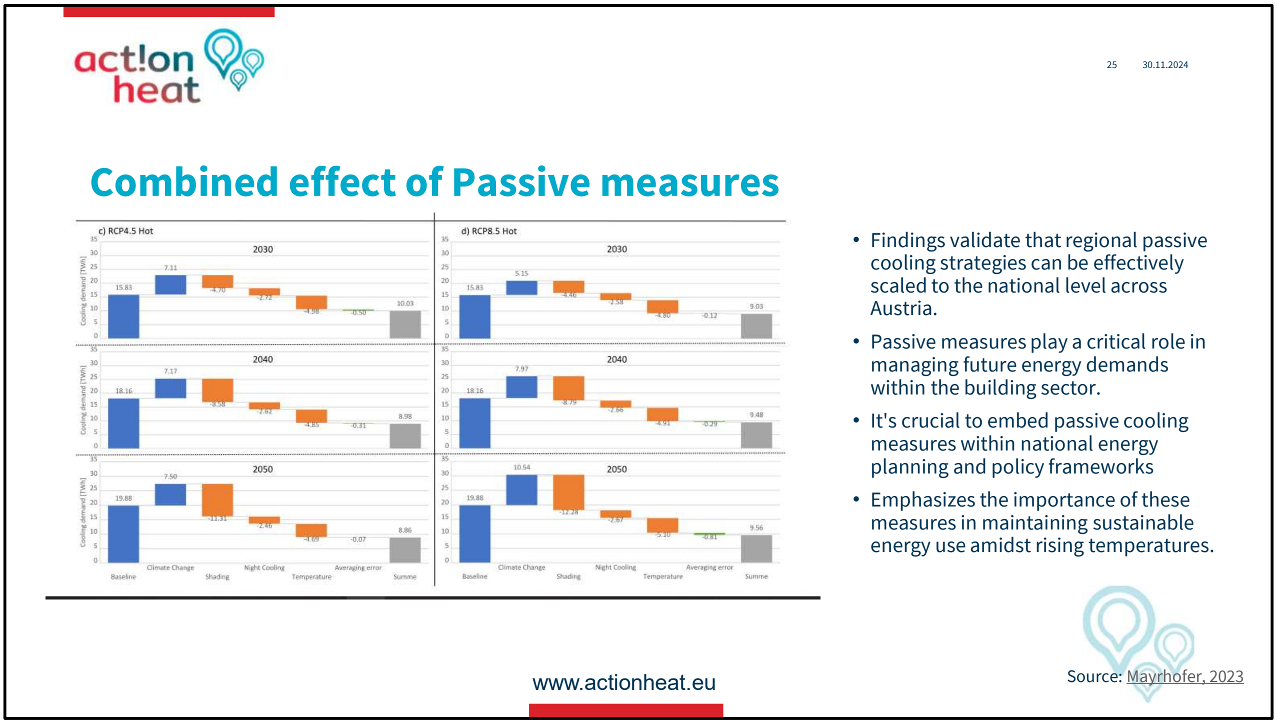
Modelling the effect of passive cooling measures on future energy needs for the Austrian building stock

- Analyzing the effects of the measures on a country-level
- Impact of passive cooling measures (shading, night ventilation) and sufficiency measures (high indoor temperature)
- 100% technology saturation



Source: Mayrhofer, 2023

- The modeling assesses the impact of passive cooling measures, such as shading and night ventilation, on future energy demands for the Austrian building stock under **Representative Concentration Pathways (RCPs)**.
- Under RCP 4.5 (stabilization by 2040) and RCP 8.5 (high GHG emission scenario), cooling demand is projected to increase significantly by 2050.
- Despite these increases, passive measures and sufficiency strategies (e.g., higher indoor temperatures) offer a substantial reduction potential of 68–73% in energy demand.
- The results underscore the importance of incorporating regionally optimized passive cooling strategies into Austria's energy policies to mitigate climate-induced demand increases.



- Passive cooling measures, such as shading, night ventilation, and maintaining higher indoor temperatures, have a combined potential to significantly reduce energy demand.
- Modeling for Austria shows these measures can mitigate the impacts of rising temperatures under RCP 4.5 and RCP 8.5 scenarios.
- Scaling passive strategies to the national level is essential for sustainable energy planning and achieving climate resilience.
- These findings highlight the critical role of passive measures in reducing future energy needs while addressing increasing cooling demands driven by climate change.

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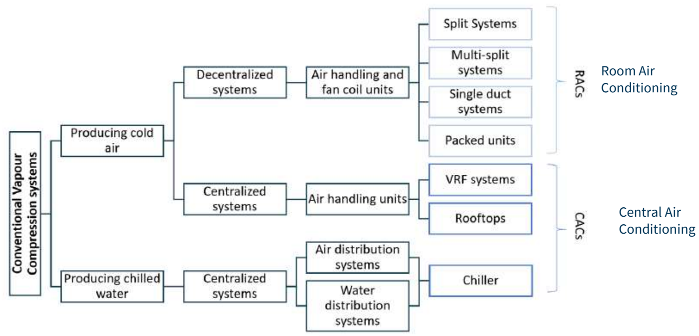
Cooling Supply Technologies

Active cooling technologies: Appliances that require energy input for cooling

- Free cooling sources: the source is free (ambient air, ground, water body) but still requires energy input to transport heat against the direction of its flow



Vapor Compression Units

$$COP_{max} = \left(1 - \frac{T_{cold}}{T_{hot}}\right)^{-1}$$

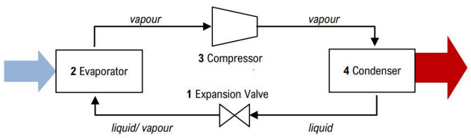
* Theoretical maximum that can be achieved without any losses in the compressor.

Source: CoolLIFE, 2023

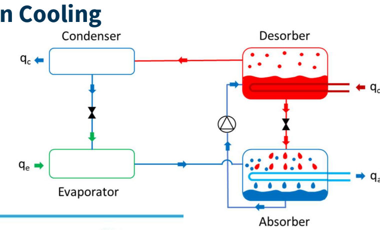
- Cooling supply technologies include active systems like vapor compression units, central air conditioning, and room air conditioning.
- **Free cooling sources**, such as ambient air, ground, or water bodies, offer sustainable options but require energy input to transport heat.
- Advanced cooling technologies are essential for achieving higher efficiency and reducing emissions in line with EU climate goals.
- Selection of supply technologies should balance efficiency, cost, and sustainability to address both current and future cooling demands.

Decentral Supply Technologies

Vapour Compression



Absorption Cooling



Source: Venegas, 2020

- Decentralized cooling technologies, such as vapor compression and absorption systems, offer flexible and localized solutions for cooling needs.
- These technologies are particularly suitable for areas without centralized infrastructure or where retrofitting existing buildings is required.
- While decentralized systems provide adaptability, centralized systems often achieve **higher efficiencies through economies of scale**, making them more energy and cost-effective in dense urban areas.
- Decentralized technologies remain a critical component of a diversified and sustainable cooling strategy.

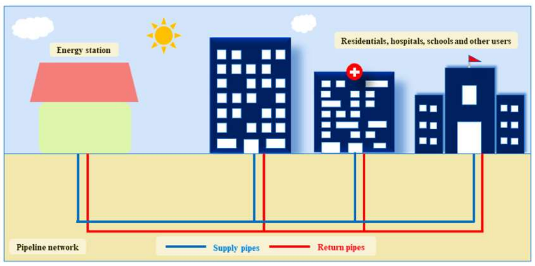
Commonly Used Cooling Technologies

System Types	Costs (€/Units)	(Typical) SEER
Movables	409	2.49
Small Split (<5 kW)	1,051	4.4
Big Split (>5 kW, inclusive ducted)	1,692	4.17
Variable refrigerant flow systems	19,720	3.96
Rooftop + Packaged	18,135	3.88
Chillers (air-to-water) < 400 kW	20,768	3.51
Chillers (air-to-water) > 400 kW	111,370	3.52
Chillers (water-to-water) < 400 kW	1,676	4.8
Chillers (water-to-water) > 400 kW	88,033	5.8

Source: EURAC, 2021

- Centralized cooling technologies, such as district cooling, achieve **higher efficiencies through economies of scale** and are ideal for dense urban areas.
- Key components include distribution networks, service pipes, and energy transfer systems, ensuring reliable and efficient cooling delivery.
- Seasonal Energy Efficiency Ratios (**SEER**) represent average efficiency values but depend heavily on usage patterns and operational conditions.
- Centralized systems offer environmental and economic advantages, supporting sustainable urban cooling strategies.

Central Supply Technologies



District Cooling

Components of District Cooling Systems:

- Distribution System
  - Transmission Grid
  - Distribution Grid
  - Service Pipes
- Cooling Source
- Energy Transfer System

Important Operating Parameters

- Delta T
- Pipe and pump sizing
- Heat exchangers with longer thermal lengths are used

Source: Xu,2021

- District cooling has evolved since its inception in the late 19th century, with the first systems developed in the USA and Europe.
- Modern systems are highly efficient, leveraging centralized cooling sources and advanced distribution networks.
- The technology has expanded globally, with over 150 systems in Europe as of 2017, delivering approximately 10 PJ of energy annually.
- Continued development is driven by urbanization, rising cooling demands, and the need for sustainable, large-scale cooling solutions.

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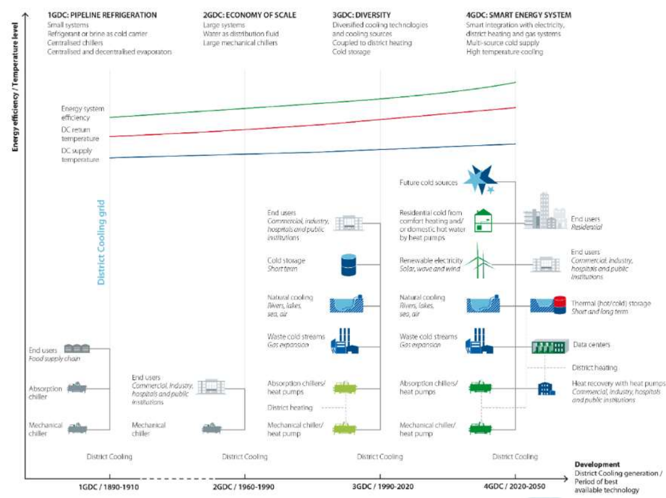
Development of District Cooling

History …

- 1890s.. USA systems with central condenser and distributed evaporator
- 1962.. First DC in the USA
- 1967.. Hamburg
- 1967.. Paris
- …

150 European Systems delivering 10 PJ energy (2017)



Source: Werner, 2017, Ostergaard, 2022

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- Low-temperature district cooling networks utilize ambient or waste cooling sources to improve energy efficiency and sustainability.
- These systems reduce energy losses during distribution and enable the integration of renewable and free cooling sources, such as groundwater or ambient air.
- Low-temperature networks are a key innovation for modernizing district cooling systems and aligning with decarbonization goals.
- Their implementation supports reduced operational costs and emissions, making them ideal for future-proof urban cooling strategies.

Low-Temperature Networks

B 02	Groundwater + decentral LTHP - LT Network						
	T Source [°C]	T Grid [°C]	aquifer / ground	storage	heating / cooling		type
	10	10-25	Aquifer	no	Heating	Cooling	Basic
Technology	• Groundwater wells • Grid to transport water • LTHP to lift temperature at end users (decentralized) • 5G DHC						

Examples	***Friedberg, Germany*** [8]; *Shallow aquifer well doublets, 5GDH; only Heating*

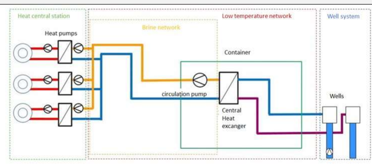
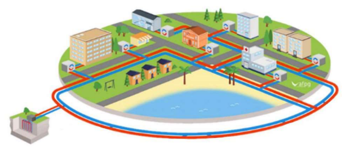


Figure 5: Scheme of the low temperature network operating with groundwater in Friedberg.

B 07	BHE + decentralized LTHP - LT Network						
	T Source [°C]	T Grid [°C]	aquifer / ground	storage	heating / cooling		type
	-4 – 25	10	Ground	yes	Heating	Cooling	Basic
Technology	• Borehole heat exchangers (type: 1-U, 2-U, coaxial; depth: 50-200 m; spacing; 6-8 m) • One or several heat pumps for each user • 5GDHC distribution grid						



Source: SAPHEA, 2023

- Low-temperature networks enhance energy efficiency by reducing distribution losses and utilizing renewable or free cooling sources like groundwater or ambient air.
- These systems support the integration of decentralized and centralized cooling technologies, enabling greater flexibility and sustainability.
- They align with decarbonization objectives, offering reduced emissions and operational costs compared to traditional high-temperature networks.
- Low-temperature networks are pivotal for modernizing district cooling systems and future-proofing urban cooling solutions.

Identifying District Cooling Feasibility

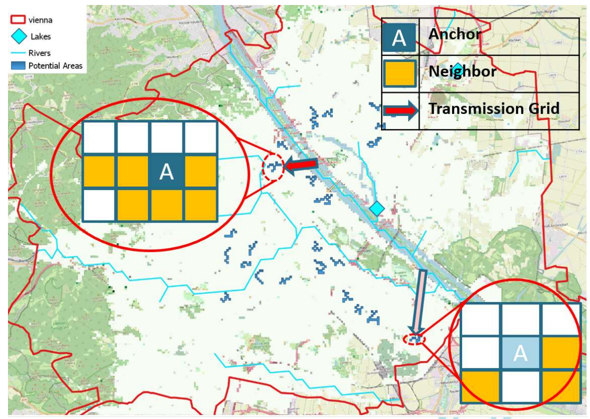
In a city/region,

- Which locations show feasibility for investment in DC networks?
- How much demand for cooling can be covered?
- What are the tentative investments?

$$\frac{1}{n}\sum_{n=1}^{n} L_{G_{an}} \leq LCOC_{ind_{an}}$$

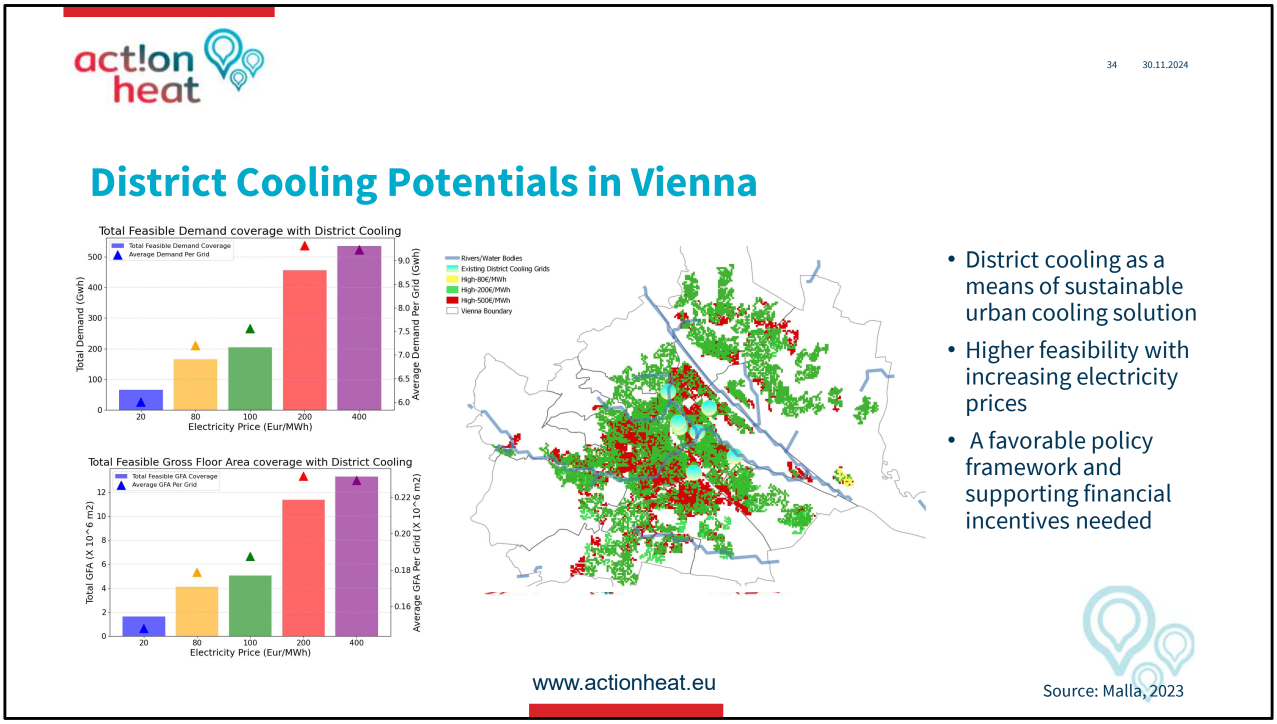
$$LCOC_{DC_c} = L_{G_c} + \frac{crf \cdot (I_{pump} + I_{trans} + I_{supply}) + O_f + ElecP \cdot (O_{v_{pump}} + O_{v_{supply}})}{\sum UED_{act_i}}$$

$$LCOC_{DC_c} \leq LCOC_{ind}$$

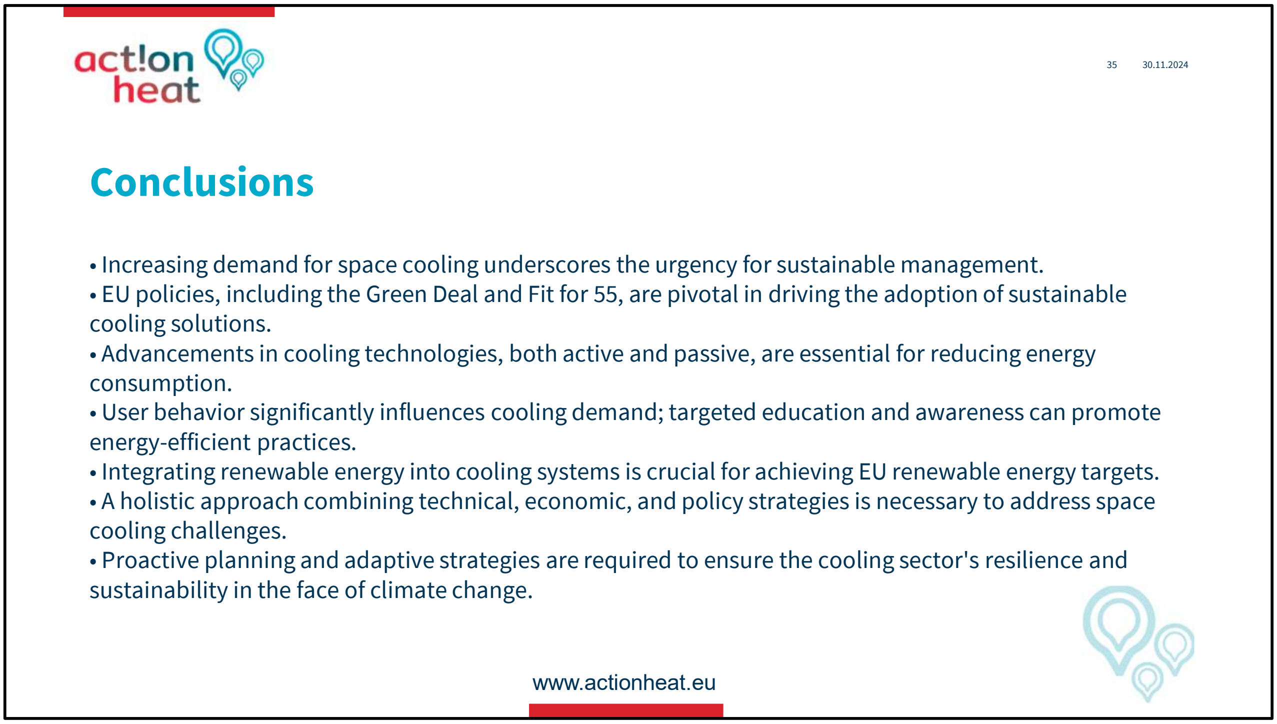


Source: Malla, 2023

- Feasibility assessments for district cooling focus on identifying locations with sufficient demand density to justify investment in infrastructure.
- Key considerations include the percentage of cooling demand that can be met, initial investment requirements, and operational efficiencies.
- These evaluations guide policymakers, urban planners, and investors in determining where district cooling networks are most viable and impactful.
- Accurate feasibility studies are critical for optimizing resource allocation and maximizing the sustainability benefits of district cooling systems.



- District cooling offers a sustainable solution for Vienna, improving energy efficiency and reducing emissions.
- High upfront costs necessitate **supporting incentives** and policy frameworks to ensure financial viability and encourage adoption.
- Rising electricity prices enhance the economic appeal of district cooling systems, making them a competitive option.
- Scaling district cooling aligns with Vienna’s climate and sustainability goals, contributing to long-term urban development plans.



- Rising cooling demand necessitates urgent action for sustainable management through energy-efficient and renewable solutions.EU policies like the Green Deal and Fit for 55 are key drivers in adopting sustainable cooling technologies and achieving decarbonization targets.
- Advancements in both active and passive cooling measures are critical to reducing energy consumption and emissions.
- User behavior significantly influences cooling demand, highlighting the need for education and awareness to promote energy-efficient practices.
- A holistic, integrated approach combining technical, economic, and policy strategies is essential to address the challenges of space cooling.

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Thank you.

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