The CoolST Project - Adapting to Climate Change Impact: Crafting South Tyrol's Cooling Future for Energy Resilience

The increasing demand for cooling is emerging as one of the most pressing energy and infrastructure challenges in Europe. As temperatures rise due to climate change, households, businesses, industries, and the transportation sector require more energy for space and process cooling, putting pressure on electricity systems, infrastructure, and climate goals. In South Tyrol (ST), a mountainous region of northern Italy, average annual temperatures have already increased by approximately 1.5°C since the 1960s, with the frequency of tropical nights—where temperatures do not fall below 20°C—rising significantly. Urban areas such as Bozen/Bolzano now experience around 14 heatwaves per year, with projections suggesting that summer temperatures could increase by up to 5°C by the end of the century. These trends, combined with population growth, urbanization, and changing comfort expectations, are driving an increase in cooling demand across all sectors.

Despite the growing importance of cooling, detailed knowledge about the market, energy use, and social and environmental impacts in ST remains limited. The CoolST project addresses this gap by providing the first comprehensive, interdisciplinary assessment of the region’s cooling market, spanning residential, tertiary, industrial, and transportation sectors. Its novelty lies in the integration of engineering, economics, user behavior, biology, health, and policy—fields that have not previously been studied together in the context of cooling in ST. By combining these domains, CoolST explores cooling use patterns, energy consumption, economic costs (both capital and operational), health impacts related to climate change, and effects on biodiversity, while producing actionable insights for policymakers, energy providers, and civil society.

The primary aim of CoolST is to generate missing data and transform it into usable knowledge. While previous studies at the EU and international level provide general information about cooling markets, technology, and policies, they offer only limited guidance for regional contexts. CoolST fills this gap through a mixed-method, bottom-up approach. Primary data is collected across ST to capture the distribution of cooling units, types of equipment, operating hours, efficiency levels, refrigerant use, and sector-specific usage patterns. This information is then validated and enriched through consultation with local experts, ensuring reliability and relevance for policy and planning purposes.

CoolST also employs parametric simulations and scenario modeling to project future cooling demand and energy consumption until 2040. Simulations integrate local climate datasets, population data, building stock archetypes, and social clusters, enabling a detailed understanding of how cooling demand may evolve under different climate and socioeconomic scenarios. This approach allows the project to not only assess the current status of cooling in ST but also anticipate future pressures on energy systems, infrastructure, and public health. By covering all major sectors—residential, tertiary, industrial, and transportation—CoolST provides a holistic picture of regional cooling needs, highlighting potential hotspots of energy consumption and infrastructure stress.

A key innovation of CoolST is its emphasis on knowledge accessibility and policy relevance. The project establishes the CoolST Knowledge Hub, an online, open-source repository of quality-controlled data on the cooling market, and the CoolST Tool, which converts complex datasets into easily understandable visualizations and interactive outputs. These tools are designed to support a wide range of stakeholders, from energy providers and transmission/distribution system operators (TSO/DSOs) to policymakers and citizens. Additionally, CoolST produces policy briefs, scenario workshops, and visual storytelling outputs to engage decision-makers and raise awareness among the general public. By translating scientific data into actionable knowledge, the project facilitates informed strategies to manage rising cooling demand, reduce energy costs, and mitigate greenhouse gas emissions.

The project's interdisciplinary design is central to its novelty. Engineering and building science methods enable detailed mapping of cooling technologies and energy flows, while economic analysis assesses the costs associated with cooling adoption and operation. Insights from user behavior studies inform how residents and organizations use cooling systems, highlighting opportunities for energy savings through behavioral interventions and demand-side management strategies. Biological and ecological analyses explore the impact of cooling practices on local biodiversity and natural systems, while health studies examine the consequences of rising indoor temperatures and extreme heat events on human well-being. Policy analysis ties these dimensions together, producing evidence-based recommendations for sustainable and equitable cooling strategies in ST.

CoolST also addresses the replicability and scalability of its methodology. While focused on ST, the project provides a transferable framework for other regions experiencing rising cooling demand, urbanization, and climate pressures. By combining data collection, simulations, scenario analysis, and stakeholder engagement, the methodology can be adapted to different climates, urban forms, and socioeconomic contexts, providing a model for holistic cooling market assessments across Europe and beyond.

The practical implications of CoolST are substantial. Current estimates suggest that cooling accounts for approximately 500 GWh/year in ST, representing around 17% of the region's electricity consumption—higher than the EU average of 13.5%. Understanding which sectors and areas contribute most to this demand allows energy providers and policymakers to design targeted interventions, such as demand-side management, adoption of energyefficient technologies, integration of renewable energy sources, and the promotion of nature-based cooling solutions. For the residential sector, which is expected to experience the largest growth in cooling demand by 2030/2050, communication and awareness-raising activities are central to encouraging sustainable use patterns and behavioral changes.

The project's focus on policy relevance and societal engagement is reflected in its outputs. Scenario workshops and visual storytelling provide platforms for stakeholders to explore potential futures, understand the implications of different policy choices, and co-develop strategies to meet rising cooling needs sustainably. Policy briefs summarize scientific insights in a format tailored for decision-makers, highlighting practical recommendations to reduce energy consumption, improve system efficiency, and minimize environmental and social impacts. Through these outputs, CoolST not only advances scientific understanding but also supports actionable change in regional energy planning and climate adaptation.

In conclusion, CoolST represents a novel, interdisciplinary, and regionally focused initiative that integrates engineering, social sciences, environmental studies, and policy analysis to address the challenges of rising cooling demand in South Tyrol. By generating missing data, modeling current and future energy consumption, and translating findings into actionable knowledge, the project provides valuable guidance for energy providers, infrastructure operators, policymakers, and citizens. Its methodology is designed to be replicable for other regions, offering a framework for understanding and managing cooling demand in the context of climate change, urbanization, and energy transition. Ultimately, CoolST demonstrates how interdisciplinary approaches can deliver both scientific insights and practical solutions, supporting the development of sustainable, resilient, and equitable cooling strategies in the transition era.