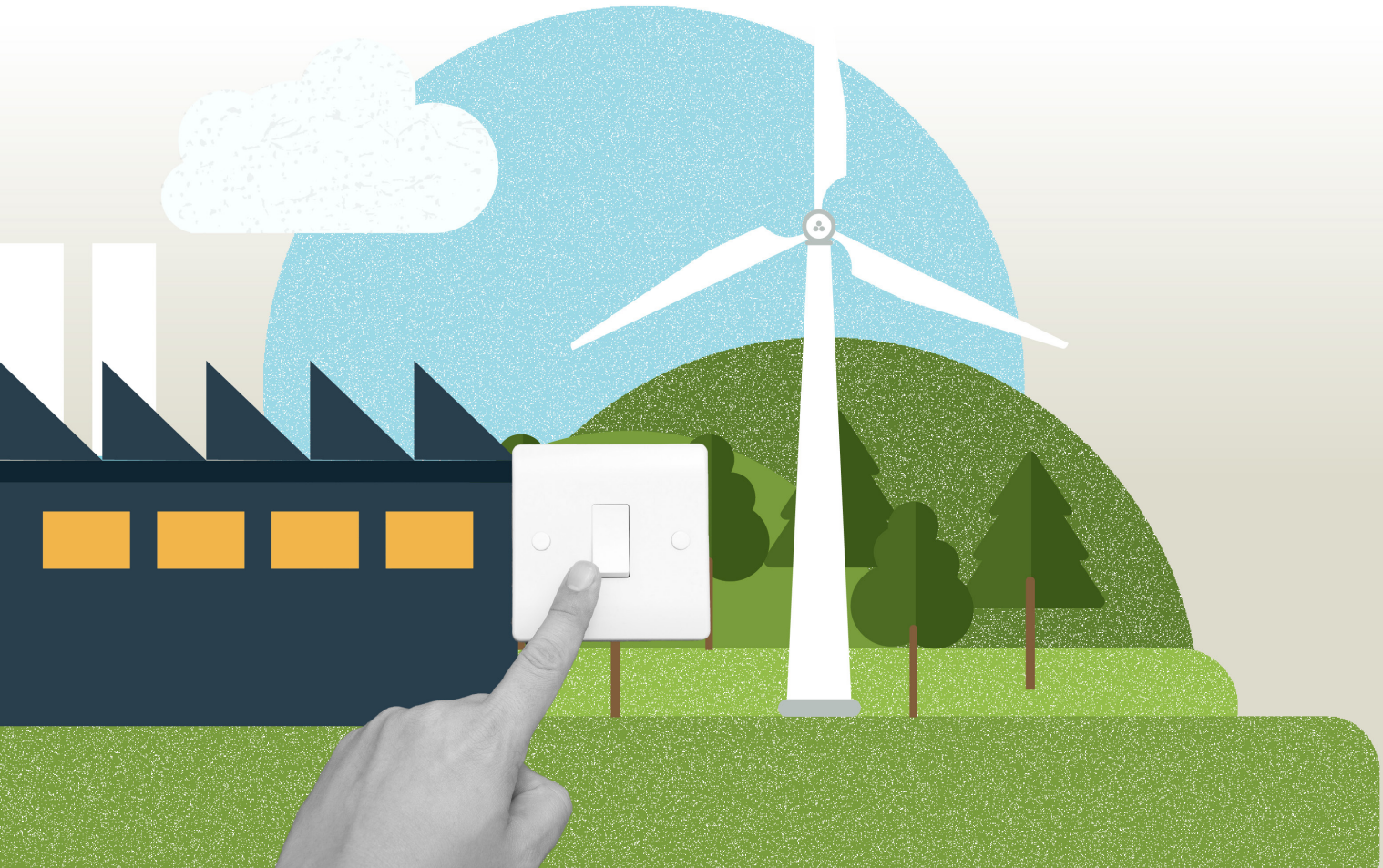
RESILIENT CITIES CATALYST

CLIMATE CHANGE HUB

Decarbonizing District Heating

Comparative Report to Inspire Kozani's Path to Clean and Affordable Heat

May 2025



Disclaimer

This report, Decarbonizing District Heating: Comparative Report to Inspire Kozani's Path to Clean and Affordable Heat, has been prepared for informational purposes only within the framework of the Energopolis 2.0 initiative, supported by the Global Covenant of Mayors for Climate and Energy and Bloomberg Philanthropies.

The findings, interpretations, and conclusions expressed herein are those of the authors and do not necessarily reflect the views of the funders, the Municipality of Kozani, or any of the cities featured in the case studies.

All visual materials, unless otherwise stated, are intended for illustrative purposes only. Graphics included in this report are proprietary to Resilient Cities Catalyst. Photographs have been sourced primarily from publicly available internet resources. Where possible, we have credited images to their respective owners. This use is intended solely for non-commercial, educational, and research purposes in line with fair use principles. If you believe any material has been used inappropriately, please contact us, and we will promptly address any concerns.

© 2025 Resilient Cities Catalyst and Climate Change Hub. All rights reserved.

Produced between: February - April 2025

Author: Haris Biskos

Strategic Contributions:

Konstantina Karydi, CEO, Resilient Cities Catalyst Europe
Paul Nelson, Founding Principal, Resilient Cities Catalyst
Maria Logotheti, President, Climate Change Hub
Marnie McGregor, Strategic Advisor, Global Covenant of Mayors for Climate & Energy

Designed by: Alex Quinto, Haris Biskos

Supported by:

Implemented by:

In partnership with:

Table of Contents

Introduction 06

Purpose and Scope of the Report 07

Why the City of Kozani? 08

Policy Background 20

Case Studies Detailed Presentation 26

Index of Case Studies 28

1. Saleska, Slovenia 30

2. Heidelberg, Germany 38

3. Pamplona, Spain 46

4. Växjö, Sweden 56

5. Salaspils, Latvia 64

6. Ghent, Belgium 72

Conclusion 82

Strategic Recommendations for Kozani's Decarbonization Pathway 85

Part II: Energopolis 2.0 Workshop 88

Introduction 90

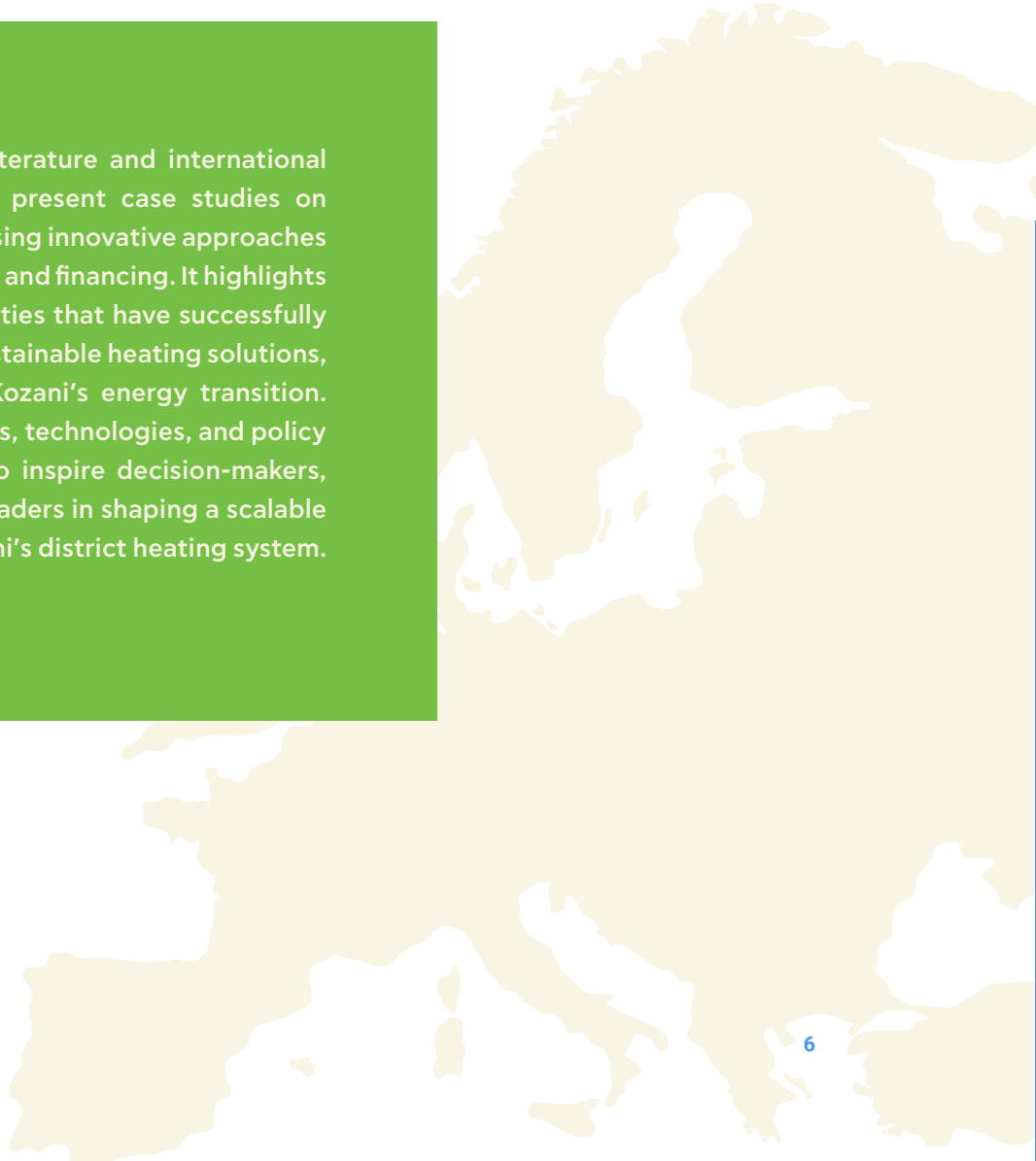
Setting the Stage 93

Co-designing Kozani's Transition Roadmap 106

Introduction

The transition to sustainable district heating is a critical challenge for cities across Europe, particularly for regions historically dependent on fossil fuels. Kozani, situated in Western Macedonia, has long relied on lignite-fired power plants to supply its district heating system, providing affordable warmth to thousands of residents. However, as Greece phases out coal, Kozani faces an urgent need to reinvent its energy infrastructure to ensure a clean, resilient, and economically viable heating future. This report, "Decarbonizing District Heating: Scalable Solutions and Financing Pathways for Kozani," presents a curated collection of international case studies that illustrate diverse approaches to the transformation of district heating systems. By showcasing pioneering strategies from cities that have successfully navigated this transition, the report aims to offer valuable insights and practical solutions tailored to Kozani's energy transition.

This report explores existing literature and international best practices to analyze and present case studies on district heating models, showcasing innovative approaches to decarbonization, governance, and financing. It highlights flagship cases from European cities that have successfully transitioned to cleaner, more sustainable heating solutions, offering valuable insights for Kozani's energy transition. By examining different strategies, technologies, and policy frameworks, this report aims to inspire decision-makers, stakeholders, and community leaders in shaping a scalable and just transformation of Kozani's district heating system.



Purpose and Scope of the Report

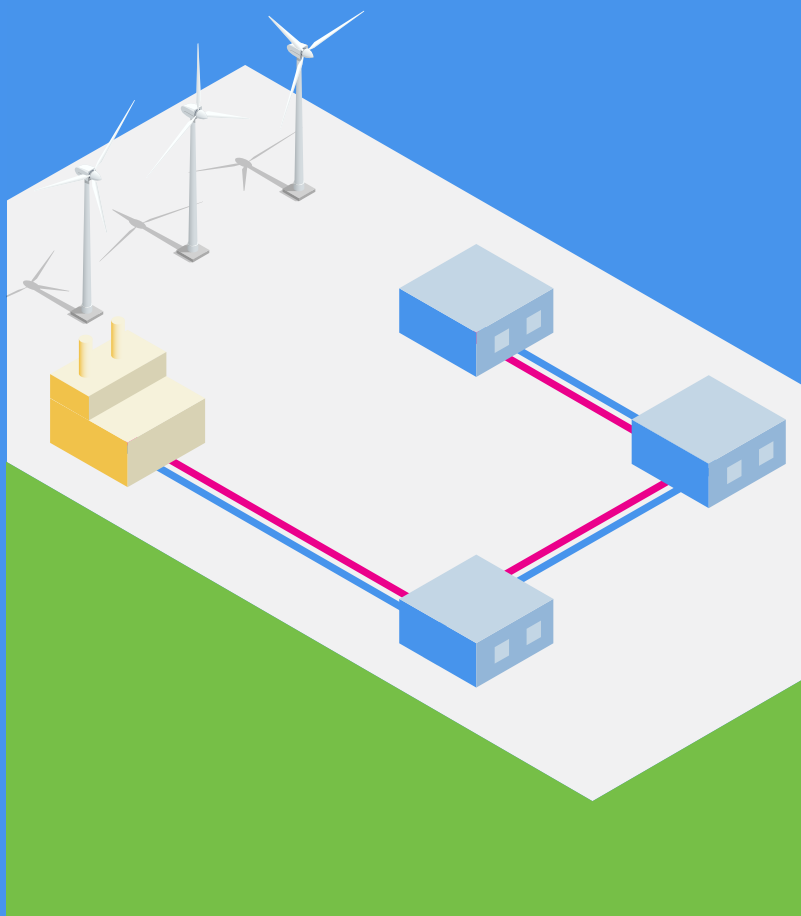
This report serves as a foundational resource for the **Energopolis 2.0** initiative, led by the Municipality of Kozani in collaboration with the international organizations **Resilient Cities Catalyst and Climate Change Hub, with funding support from the Global Covenant of Mayors and Bloomberg Philanthropies.**

It aims to inspire and guide local stakeholders—municipal authorities, energy providers, financial institutions, and community groups—by demonstrating how district heating systems can evolve toward sustainability. Through case studies covering governance models, financing mechanisms, technological innovations, and community engagement strategies, the report highlights scalable solutions that can be adapted to Kozani's unique context.

The transition to a decarbonized district heating system is not just an engineering challenge; it is an opportunity to rethink urban energy governance, integrate renewable sources, and ensure equitable access to affordable heating. This report seeks to address key questions: **How can Kozani leverage European and national policies to accelerate its transition? What financing mechanisms can support large-scale investments in clean district heating? What lessons can be drawn from cities that have successfully implemented similar transformations?**

By bridging policy insights with real-world case studies, this report provides a roadmap for Kozani's transition, offering practical models for implementation while fostering a shared vision for a cleaner, more resilient energy future.

The transition to a decarbonized district heating system is not just an engineering challenge; it is an opportunity to rethink urban energy governance, integrate renewable sources, and ensure equitable access to affordable heating



Why the City of Kozani?

Kozani is a mid-sized city in northern Greece and the capital of the Western Macedonia region. Home to roughly 70,000 people in its wider municipality (about 42,000 in the city proper), Kozani has long been known as Greece's leading energy-producing area due to its extensive lignite (brown coal) mining and power generation operations. For decades, this city's identity and economy have been intertwined with coal: massive open-pit mines and sprawling power plants dominated the landscape, providing jobs and generating a significant share of Greece's electricity. Today, Kozani stands at a crossroads. As the coal era fades, Kozani has become an iconic case of resilience amid energy transition – a community striving to reinvent itself economically and socially under ambitious climate targets and EU transition policies. This introductory chapter outlines Kozani's urban profile and historic role, the acute challenges it faces, and the policy-driven pathways now shaping its future.

Kozani's Urban Profile and Economic Landscape

Kozani is the administrative and commercial hub of Western Macedonia, a region bordering Albania and sitting in the mountainous north of Greece. The city developed historically as a trading center, but the discovery of lignite in the mid-20th century transformed its trajectory. By the late 20th century, Kozani and nearby towns like Ptolemaida had become the heart of Greece's state-owned power industry, with vast strip mines and lignite-fired power stations operated by the Public Power Corporation (PPC) dominating the local economy. This created a virtual single-industry economy – a "coal monoculture" – with power generation as the primary employer and source of income for thousands of families in Kozani and surrounding municipalities.

Over time, Kozani achieved a modest level of prosperity thanks to these energy assets, but it also became heavily dependent on a finite resource and an aging infrastructure. The city's infrastructure – from its district heating network to transport links and public facilities – was largely built around the needs of the lignite industry. For instance, Kozani's district heating system, one of the largest in Greece, was established in 1993 specifically to capture waste heat from nearby lignite power plants. This system expanded to heat 25,000 apartments (almost the entire city) via pipelines from the Agios Dimitrios power station. While innovative at the time and funded partly by EU regional programs, today that infrastructure is three decades old and in need of upgrades, especially as its original heat source is scheduled to shut down.

Demographically, Kozani and Western Macedonia face population stagnation and decline. The wider region's population fell by about 7% in the last decade, as younger residents moved to larger cities or abroad in search of opportunities beyond coal. This out-migration, combined with low birth rates, has left an aging population behind. The share of youth and working-age residents has shrunk

markedly, while the elderly population grows. Kozani's urban amenities – schools, healthcare, and cultural institutions – now serve a community grappling with demographic aging and a future far less certain than during the coal boom years. Economically, the city is seeking to diversify. Besides energy, Kozani is known for niche products like saffron crocus cultivation and has a university presence, but these sectors remain comparatively small. The overwhelming economic narrative has been the rise and now the fall of coal.

From Coal Energy Hub to "Region in Transition"

For over seven decades, Western Macedonia—with Kozani at its heart—was the engine of Greece's electricity production. Abundant lignite reserves discovered in the 1950s led to the construction of large coal-fired power plants that, at their peak, supplied more than half of the country's electricity. Kozani's identity became inseparable from coal, earning it the unofficial title of Greece's coal capital. The economic benefits were substantial: low-cost power, stable employment, and state investment. However, by the 2010s, the environmental and health costs of lignite combustion—air pollution, landscape degradation, and rising CO_2 emissions—became undeniable.

In 2019, Greece committed to phasing out all coal plants by 2028, with most closures front-loaded in Western Macedonia. By 2023, most of Kozani's older lignite units were shut down, leaving only Ptolemaida V, which is expected to convert to gas by 2028. This shift marked a historic transition: from a coal stronghold to a European Region in Transition, aligned with EU climate goals.



Lignite mining - Kozani, Greece

To support this shift, Western Macedonia developed the country's first comprehensive post-lignite plan and secured approximately €994 million from the EU's Just Transition Fund. These resources are earmarked for economic diversification, worker retraining, environmental restoration, and green infrastructure.

Adding to its strategic importance, Kozani was selected as one of the EU's "100 Climate-Neutral and Smart Cities" by 2030. This recognition reflects not only the city's ambitious goals but also its symbolic role as a testbed for Europe's climate transition. Kozani's experience illustrates the broader challenge facing coal-dependent communities across Europe: how to align the urgent demands of decarbonization with the need to protect local economies and maintain social cohesion.

Key Challenges in Kozani Today

The end of lignite production has left Kozani facing a set of deeply interconnected challenges that threaten its social and economic fabric:

- **Depopulation and Brain Drain** have intensified, with Western Macedonia's population shrinking by nearly 7% over the past decade. Younger residents continue to migrate in search of work, while birth rates decline. The result is a rapidly aging population and a diminishing workforce, weakening the city's long-term resilience.
- **Aging Infrastructure** further compounds the problem. Kozani's district heating system—once a model for capturing waste heat from lignite plants—is now over 30 years old and reliant on plants that are being decommissioned. Broader infrastructure, including transport, utilities, and public buildings, also requires modernization to meet new economic and environmental standards.



Large scale photovoltaic park in Kozani

- **Socio-Economic Vulnerabilities** are rising. Kozani's historical reliance on a single industry has left it exposed in the wake of coal's decline. Many local businesses are struggling, household incomes are falling, and poverty risks are increasing. The social fabric is strained, particularly among those who feel their sacrifices for Greece's energy security are being overlooked in this transition.
- **Unemployment** remains among the highest in Europe, with overall rates near 20% and youth unemployment even higher. Thousands of jobs have already been lost, and regional authorities face urgent pressure to generate new employment in emerging sectors.

Together, these challenges form a self-reinforcing cycle: economic stagnation fuels outmigration, which in turn reduces capacity for renewal. Breaking this cycle is central to Kozani's just and sustainable transition.

Energy Infrastructure and the Urgency of Lignite Phase-Out

At the heart of Kozani's transition challenge lies its energy infrastructure—particularly its **district heating network**, which supplies heat to nearly the entire city. For over three decades, this system has depended almost entirely on lignite-fired power plants. Steam and hot water from the nearby Agios Dimitrios plant—a five-unit facility—have been distributed to households via a pipeline network. With this plant now partially decommissioned and its remaining units set to close soon, Kozani faces an urgent risk: **the loss of its primary heat source without an immediate alternative in place**. The consequences for households and businesses would be severe, especially during winter months.

The shift away from lignite is driven not only by technical obsolescence but by policy imperatives. The EU's Emissions Trading System imposes high carbon costs on coal, while EU and national climate laws mandate deep emissions cuts and a full coal phase-out by 2028. Moreover, EU financial instruments now fund only heating systems based on renewable sources—excluding coal and even natural gas. This places pressure on local authorities to transition rapidly while maintaining service continuity.

To fill the electricity gap left by lignite, the region is turning to renewables. **A 204 MW bifacial solar farm—Greece's largest—was inaugurated near Kozani in 2022**. Built on reclaimed mining land, it represents a visible shift toward clean energy. More solar and wind projects are planned, repurposing former industrial areas.

Yet renewables bring limitations. Solar farms produce electricity, not thermal energy, and generate relatively few permanent local jobs. They cannot, on their own, replace the heating and employment functions once provided by lignite. This highlights Kozani's core resilience dilemma: how to decarbonize while safeguarding energy security and social cohesion. The city must not only embrace clean energy, but also ensure that its transition is inclusive, economically viable, and aligned with the everyday needs of its residents.

Exploring Sustainable Heating Solutions for Kozani

Replacing Kozani's lignite-based district heating system is a critical priority for both local authorities and national policymakers. With the retirement of the Agios Dimitrios power plant imminent, the city must urgently transition to **renewable alternatives** to maintain reliable, affordable heating for residents. Several clean energy options are currently discussed, also by this report, forming the basis of Kozani's "green heating portfolio."

BIOMASS-FIRED HEATING PLANTS



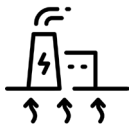
Nearby Amyntaio recently commissioned a 30 MW biomass boiler using locally sourced wood and agricultural residues. Kozani would require a significantly larger plant—around 90 MWth—to meet its heating needs. While biomass could create jobs in agriculture and forestry, ensuring a stable, sustainable fuel supply and minimizing air quality impacts will be key.

LARGE-SCALE SOLAR THERMAL SYSTEMS



Kozani's sunny climate offers excellent potential for heat generation via expansive solar collectors. Combined with seasonal storage systems—such as insulated reservoirs or underground pits—and heat pumps, such a setup could meet up to 30% of annual heating demand. Though capital-intensive, solar thermal systems run on free energy and could offer long-term savings.

GEOTHERMAL AND INDUSTRIAL HEAT PUMPS



This solution is being explored through geological studies. If low-to-medium enthalpy geothermal resources are confirmed, they could supply constant, zero-emission heat. Even shallow geothermal systems, paired with industrial-scale heat pumps, might cover around 10% of the city's demand. However, high upfront costs and drilling uncertainty require cautious evaluation.

ELECTRIC BOILERS AND THERMAL STORAGE



This solution could serve as flexible, quick-to-deploy backup or peak solutions. These systems would convert surplus renewable electricity—especially during low-demand periods—into heat stored for later use. This approach would help integrate the growing number of solar and wind projects in the region into the heat supply system.

WASTE HEAT RECOVERY AND BIOGAS



Though Kozani's industrial base is currently limited, future facilities such as data centers could offer recoverable heat. Biogas derived from organic waste or anaerobic digestion may play a supplementary role, though current estimates suggest it could only cover a small portion of overall demand.

All these solutions **align with EU funding eligibility,** as the EU now supports only renewable-based district heating projects. These alternatives also reduce exposure to fossil fuel price volatility and help decouple Kozani's energy future from geopolitical instability.

However, while technically feasible, implementing these systems citywide requires **major investment, careful planning, and staged roll-out**. The challenge is not a lack of options—but rather the political and financial coordination needed to act decisively. Kozani must now move from exploration to execution, a task that will test its capacity for innovation and long-term resilience.

The 2024 Kozani District Heating Agreement

In October 2024, after extensive negotiations, the Greek government, the municipalities of **Kozani, Ptolemaida, and Amyntaio, and the Public Power Corporation (PPC)** reached a pivotal agreement on the future of district heating in Western Macedonia. This comprehensive package aimed to resolve two pressing issues: the mounting debts of municipal district heating companies and the urgent need to secure a stable heat supply for the post-lignite era.

At the heart of the agreement is the construction of a new **natural gas-fueled combined heat and power (CHP) plant**. With a planned thermal capacity of approximately 65 MW, this plant will provide hot water to Kozani and potentially Amyntaio, while also generating electricity. It is expected to operate for about 15 years, effectively locking in natural gas as the main heating source until 2040–2041. The estimated capital cost for the CHP facility and associated infrastructure is €176 million.

A second critical component is the **interconnection of the Kozani and Amyntaio district heating networks** through a new pipeline. This approach aims to achieve economies of scale by using a single CHP plant to serve both towns. Amyntaio, which lost its lignite plant in 2019, will benefit from a restored heat supply. Ptolemaida, however, is not included in this long-term solution, raising concerns about its heating future.

During the interim period—before the gas plant becomes operational—the agreement proposes temporary solutions. Originally, large **electric boilers** were to be installed as a bridging measure. However, the agreement also leaves open the possibility of using **Ptolemaida V**, the newest lignite-fired plant, for heat production. Though designed to convert to gas by 2025, extending its lignite use raises environmental and financial concerns. Analyses suggest that, due to high carbon costs, heat from Ptolemaida V could be more expensive than alternatives—raising questions about Greece's coal exit credibility.

To address **financial challenges**, the agreement includes substantial debt relief and operational subsidies. The central government will cover at least €43 million of municipal heating debts, and PPC has committed to restructuring others. To ensure affordability, the state will also subsidize the CHP system through a two-pronged mechanism: a €2.9/MWh direct heating subsidy and a favorable CHP electricity tariff adjustment, funded through a national renewable energy account. Over 15 years, these subsidies could total around €85 million, spreading the cost of transition across taxpayers and electricity consumers nationwide.

PPC, formerly the dominant lignite producer and now repositioning as a renewables-focused utility, retains a central role in the new system. It will develop and operate the gas CHP, remaining the de facto heat supplier. Notably, the agreement guarantees PPC a fixed return, shielding it from fuel price volatility. However, this arrangement shifts long-term cost risks to the public if gas or carbon prices rise—raising concerns about affordability and accountability.

Reactions to the agreement have been mixed. On the one hand, it provided a timely and concrete solution to avoid heating disruptions during the winter, ensuring social continuity. It was endorsed by local mayors, the regional governor, and the national government as a pragmatic compromise.

On the other hand, **environmental groups and climate analysts criticized the plan** for extending fossil fuel use instead of accelerating clean alternatives. They argue it "locks in" dependency on gas well into the 2040s—contrary to European efforts to decarbonize building heat. In the absence of strong price protections, Kozani's residents could face rising bills if fuel or CO_2 prices spike.

Moreover, critics argue that the decision-making process lacked transparency and meaningful exploration of renewable-based heating options. Technologies such as solar thermal, biomass, or geothermal were reportedly sidelined in favor of a conventional, readily available solution. Civil society input was limited, fueling public skepticism about whether the deal truly reflects long-term community interests. The Greek environmental think tank Green Tank called the plan "harmful to the climate" and advocated for a full redesign focusing on renewables.

Nonetheless, the agreement now serves as the official roadmap. While not perfectly aligned with climate neutrality goals, it provides a **transitional solution that balances technical, financial, and political pressures.** It exemplifies the complex trade-offs faced by fossil-dependent cities during periods of rapid transformation.

Looking ahead, there is flexibility. If renewable projects can be deployed faster or more cost-effectively, parts of the gas CHP's output may be replaced by cleaner alternatives. Technologies and markets evolve, and Kozani may yet pivot sooner than planned. As such, the city's experience will be watched closely—offering important lessons to other coal regions striving to reconcile resilience, affordability, and sustainability.

Kozani in the EU Mission "100 Climate-Neutral and Smart Cities"

Amid significant local challenges, Kozani has emerged as a key player in Europe's climate innovation efforts. In 2022, it was selected by the European Commission as one of 100 cities (112 including non-EU participants) to participate in the **EU Mission for Climate-Neutral and Smart Cities by 2030**—a Horizon Europe flagship initiative promoting rapid urban decarbonization. Kozani's inclusion is particularly notable: it is one of only six Greek cities chosen, and the only one from a smaller coal-transition region, highlighting its symbolic and strategic importance.

Participation in the Mission brings both **opportunities and responsibilities**:

CLIMATE NEUTRALITY COMMITMENT Kozani has pledged to reach climate neutrality by 2030—20 years ahead of the EU target. Achieving this goal requires deep changes in energy, transport, building efficiency, and waste systems. Given its lignite-based legacy, Kozani's pledge is both challenging and potentially transformative.

ACCESS TO SUPPORT AND FUNDING While not offering blanket funding, the Mission unlocks access to EU instruments like Horizon Europe, EIB loans, and technical assistance via NetZeroCities. In 2023, Kozani received the EU "Mission Label," increasing its visibility and attractiveness for additional investment.

SOCIAL AND ECONOMIC CO-BENEFITS The Mission offers a platform for economic diversification and social renewal. Projects can create green jobs, retrain former coal workers, reduce energy costs, and improve urban quality of life. Citizen engagement is central, empowering residents to co-shape solutions.

STRATEGIC REFORMS AND PLANNING: The city is drafting a Climate City Contract to define its pathway to neutrality, building on earlier plans for clean energy and digital transformation. The strategy spans energy efficiency, rooftop solar, electrified transport, smart city technologies, and climate-resilient urban planning.

INNOVATION AND EXPERIMENTATION Kozani can test cutting-edge solutions—such as smart grids, battery storage, or green mobility systems—with the potential to scale nationally. Its manageable size makes full-city rollouts more feasible than in larger urban areas.

In sum, Kozani's participation complements its just transition by pairing climate ambition with inclusive innovation. Once defined by coal, the city now has a chance to lead by example—demonstrating how a mid-sized, fossil-dependent community can reinvent itself as a climate-forward, resilient city.

Outlook: Policies, Investments and Stakeholder Engagement Going Forward

Kozani's future will be defined by how effectively it navigates the complex transition away from lignite through a coordinated mix of policy support, financial investment, inclusive governance, and adaptive implementation. Several key areas will shape this path forward.

1. Evolving Policy Landscape
Kozani's transition is closely tied to broader EU and national climate and energy policies. At the European level, the tightening of climate targets—including the 55% emissions reduction goal by 2030 and full climate neutrality by 2050—means that policies and funding increasingly favor renewables, electrification, and efficiency. This benefits Kozani by opening new streams of EU financial support and regulatory incentives. However, it also means that interim reliance on fossil gas must remain temporary. With carbon pricing expected to rise significantly in the 2030s, gas infrastructure could become economically unviable.

At the national level, Greece is updating its National Energy and Climate Plan (NECP) to align with EU targets, with expectations of increased emphasis on clean energy. The Just Transition Development Plan for Western Macedonia is already in motion, with nearly €1 billion allocated for projects related to entrepreneurship, employment, and infrastructure. Kozani, as the regional capital, will play a leading role in implementing this roadmap. Sustained political commitment—from national government to local authorities—will be essential, especially through upcoming political cycles.

2. Investment Needs and Economic Opportunities
The scale of investment required is unprecedented for the region. While the €994 million from the EU Just Transition Fund provides a strong foundation, much more capital will be needed from private investors and additional EU mechanisms such as the Recovery and Resilience Facility and Cohesion Funds. Constructing Kozani's new gas CHP system and intermunicipal pipeline alone costs €176 million. Large-scale solar thermal, geothermal, or storage solutions could require tens of millions more.

Fortunately, Western Macedonia is becoming a magnet for clean energy development. PPC is investing heavily in photovoltaic capacity—aiming for over 2 GW in the region by mid-decade—while the European Investment Bank (EIB) has expressed readiness to co-finance transition-aligned projects. Public-private partnerships and citizen-led "energy communities" may further help spread financial risk and deepen local benefit. The key will be ensuring investments generate local value—through job creation, local procurement, and infrastructure that supports a diversified, post-lignite economy.

3. Inclusive Governance and Community Engagement
A just transition requires the full participation of affected communities. Early decisions, such as the 2024 heating agreement, left some residents feeling excluded or uninformed. To rebuild trust, Kozani must prioritize inclusive governance mechanisms going forward.

The EU Cities Mission explicitly requires participatory approaches. Kozani has already made progress: the Just Transition Observatory monitors implementation, and the University of Western Macedonia is contributing research and training to support the green economy. Retraining initiatives for former coal workers—into roles such as renewable energy technicians, energy auditors, and building retrofit specialists—are being expanded with EU funding.

Energy communities offer additional promise, enabling citizens to co-own and benefit directly from local renewable energy assets. Tools such as participatory budgeting, public consultations, and communication campaigns can help address local skepticism—especially among residents who feel they lost benefits like free heating and have yet to see returns from new energy investments. Mechanisms such as discounted tariffs or community reinvestment funds could help share benefits more equitably.

4. Knowledge Transfer and Strategic Support
Kozani does not stand alone in this transformation. EU platforms like the Coal Regions in Transition initiative and the Covenant of Mayors Europe Cities Heat Detox Campaign and facilitate peer learning and access to technical expertise. International actors like the World Bank and EBRD are also active in the region. Through these networks, Kozani can draw on best practices—such as mine reclamation, SME development, and green job training—and tailor them to local conditions.
Additionally, its participation in European city networks (e.g. Eurocities, ICLEI) through the EU Cities Mission elevates Kozani's visibility and can attract new partnerships and pilot opportunities.

5. Monitoring, Evaluation, and Flexibility
Finally, success will depend on regular monitoring and adaptive management. If specific actions—like workforce retraining or gas infrastructure—prove less effective or too costly under evolving conditions (e.g. rising CO_2 prices), Kozani must be ready to revise plans. The 2030 climate neutrality target is ambitious, and not all measures will proceed as expected. Annual reviews through the Mission framework and milestone-linked Just Transition funding will ensure accountability while enabling course correction.

Bibliogrpahy

Nikos Mantzaris, "Squaring the circle in Western Macedonia: The agreement on district heating is harmful to both the climate and Greek citizens," The Green Tank, Oct. 16, 2024
https://thegreentank.gr/en/2024/10/16/district-heating-western-macedonia-agreement-article/

The Green Tank, "Gas is not a realistic solution for district heating in Western Macedonia," interview summary, Oct. 2024.
https://thegreentank.gr/en/2024/10/15/district-heating-flashtv/

WWF Greece (LDK Consultants), "Sustainable District Heating Solutions for Western Macedonia – Final Report," 2023
https://wwfeu.awsassets.panda.org/downloads/district_heating_western_macedonia_en.pdf

Greek News Agenda, "Six Greek cities to become EU climate-neutral and smart cities by 2030," May 26, 2022.
https://www.greeknewsagenda.gr/six-greek-cities-to-become-eu-climate-neutral-and-smart-cities-by-2030/

Eurostat News, "Unemployment rate varied across EU regions in 2021," Apr. 29, 2022.
https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220429-1

Carbon Market Watch, "A breath of fresh air or an ill wind: The human benefits and costs of decarbonising coal regions," Jul. 6, 2023.
https://carbonmarketwatch.org/2023/07/06/a-breath-of-fresh-air-or-an-ill-wind-the-human-benefits-and-costs-of-decarbonising-coal-regions/

CINTRAN Policy Brief, "Post-lignite Era in Western Macedonia: Assessing the socio-economic effects of the Just Transition Fund," March 2024.
https://pta.pdm.gr/wp-content/uploads/2024/03/20240325_CINTRAN_Policy-Brief-Western-Macedonia.pdf

DEYAK Kozani, "District Heating of Kozani – History and Technical Data," via Just Transition Development Plan (consultation document). https://www.sdam.gr/sites/default/files/consultation/Current_situation_and_prospects_for_areas_in_energy_transition_in_Greece_EN.pdf

Euronews/Reuters, "Largest double-sided solar farm in Europe opens in Greece," Apr. 7, 2022, copernicus.eu.
https://www.euronews.com/green/2022/04/07/largest-double-sided-solar-farm-in-europe-opens-in-greece-supplying-power-to-75-000-househ

European Commission, "EU Mission: Climate-Neutral and Smart Cities – Kozani Profile," 2022. https://www.greeknewsagenda.gr/six-greek-cities-to-become-eu-climate-neutral-and-smart-cities-by-2030/

Policy Background: European and National Frameworks for Heating, Cooling, and Building Retrofit

The EU Policy Landscape for Heating, Cooling, and Building Renovation

The European Union has committed to ambitious climate and energy targets, including the complete decarbonisation of its building stock by 2050. The pathway to this objective requires coordinated action across multiple levels of governance—European, national, regional, and local—while integrating strategic planning for building retrofits, energy efficiency improvements, and decarbonisation of heating and cooling.

The **European Green Deal**, the **Renovation Wave Strategy**, and **Cohesion Policy** serve as the key EU-wide frameworks guiding investments and policy developments in this area. They offer a combination of legislative measures, financial instruments, and institutional support to accelerate climate neutrality. Additionally, the **National Energy and Climate Plans (NECPs)** and **National Building Renovation Plans (NBRPs)** of each Member State further shape how heating and cooling strategies are implemented at the local level.

A core element of this transition is the recognition of **district and neighbourhood-based approaches** as essential strategies to enhance cost-efficiency and effectiveness. These approaches, supported by the **Energy Performance of Buildings Directive (EPBD), Energy Efficiency Directive (EED)**, and **Renewable Energy Directive (RED)**, ensure that local and regional authorities take a proactive role in implementing integrated renovation programmes and local heating and cooling plans.

A core element of this transition is the recognition of district and neighbourhood-based approaches as essential strategies to enhance cost-efficiency and effectiveness.



Multilevel Governance and Policy Instruments for Heating and Cooling

The complexity of decarbonising heating and cooling systems necessitates a multilevel governance framework that aligns EU-wide directives with local actions. This is reflected in the **Urban Agenda for the EU**, which supports cities through thematic partnerships, such as the emerging **Building Decarbonisation Partnership**, to ensure effective policy implementation and funding access.

Key directives shaping the local heating and cooling sector include:

ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE (EPBD, 2024 revision): This directive mandates that Member States outline in their National Building Renovation Plans how they intend to renovate the worst-performing buildings by 2033 and reduce average residential energy demand by at least 20-22% by 2035. Local authorities play a role in implementing these renovations through spatially coordinated strategies.

ENERGY EFFICIENCY DIRECTIVE (EED, 2023 revision): The directive introduces a requirement for cities with over 45,000 inhabitants to develop local heating and cooling plans. This is a crucial regulatory step, as it compels local governments to assess and plan the decarbonisation of their district heating networks.

RENEWABLE ENERGY DIRECTIVE (RED, 2023 revision): The directive mandates an increase in renewable energy use in local heating and cooling systems. It encourages the integration of renewable energy communities and electricity market reforms to facilitate the transition away from fossil fuel-based heating.

FUTURE ELECTRICITY MARKET DESIGN (FED, ongoing reform): This initiative introduces incentives for integrating distributed energy resources, such as heat pumps, solar thermal systems, and battery storage, to enhance flexibility in energy use.

By coordinating these directives, Member States and cities can ensure a **holistic approach** to decarbonisation, linking building renovations with energy system transformations

The Role of Funding Mechanisms in Enabling the Transition

Financial resources are essential to enable cities to undertake deep building renovations and transition to clean heating and cooling. The **EU Multiannual Financial Framework (MFF) 2021-2027** and **Recovery and Resilience Facility (RRF)** together offer over **€100 billion in funding** for green transition projects, including district heating decarbonisation.

Key funding sources include:

- **European Regional Development Fund (ERDF) and Cohesion Fund**: These funds contribute approximately **€20 billion** toward energy renovation and efficiency projects. Cohesion Policy investments can be leveraged to scale **urban regeneration and energy renovation strategies** at the district level.
- **Just Transition Fund (JTF) and Modernisation Fund**: These funds support regions that are economically dependent on fossil fuels, such as **Western Macedonia in Greece**, in their transition toward renewable energy systems. JTF funding is critical for mitigating social and economic impacts of de-lignification while promoting sustainable alternatives like **renewable-powered district heating**.
- **Social Climate Fund (SCF)**: This new instrument, launched alongside **ETS2**, will allocate **at least €86.7 billion between 2026 and 2032** to support energy efficiency and clean heating solutions, particularly for vulnerable households.
- **European Investment Bank (EIB) and ELENA Facility**: The EIB provides financing through the **European Initiative for Building Renovation (EIB-R)** and **ELENA (European Local ENergy Assistance)** to support large-scale energy efficiency projects, including district heating modernization.
- **REPowerEU Initiative**: With **€72 billion in grants and €225 billion in loans**, this fund accelerates investment in **electrification of heating systems**, which is crucial for cities transitioning from fossil fuels to **heat pumps and renewable district heating**.
- **Horizon Europe & LIFE Programme**: These research and innovation programmes offer funding for pilot projects that develop new district heating models and integrated renovation strategies.

The Urban Agenda for the EU and City-Led Initiatives

Cities play a central role in Europe's transition to climate neutrality, particularly in decarbonizing heating and cooling systems. The **Urban Agenda for the European Union (UAEU)** provides a structured framework for cities, Member States, and the European Commission to collaborate on pressing urban challenges, including energy transition and climate adaptation. Several city-led initiatives and networks support municipalities in their efforts to decarbonize district heating and accelerate building renovation, fostering knowledge exchange and the implementation of best practices.

Key initiatives include:

- **Global Covenant of Mayors for Climate and Energy (GCoM)**: The **largest global alliance** for city climate leadership, engaging over **12,500 cities**, including **Kozani**, in setting ambitious energy efficiency and decarbonisation targets.
- **The European Covenant of Mayors** – The largest city-led climate and energy initiative in Europe, bringing together over 12,000 local governments committed to achieving EU climate and energy targets.
- **Energy Cities Network** – A key network supporting cities in their transition toward sustainable energy solutions by facilitating peer learning and advocacy for decentralized renewable energy systems.
- **The Cities Heat Detox by the EU Covenant of Mayors** – A dedicated initiative helping cities replace fossil fuel-based heating with clean energy solutions, providing guidance, case studies, and policy recommendations to accelerate the decarbonization of heating and cooling systems across Europe.
- **The Urban Agenda for the EU Partnership on Building Decarbonisation: Integrated Renovation Programmes and Local Heating and Cooling Plans** – A partnership dedicated to supporting cities in developing integrated renovation strategies and heating and cooling plans, ensuring alignment with EU directives and funding opportunities.
- **The Urban Agenda for the EU Partnership on Energy Transition** – This initiative has focused on unlocking the potential of urban energy systems, including district heating and cooling, energy communities, and the integration of renewable energy.
- **The Urban Transitions Mission** – A global alliance co-led by the European Commission, the Global Covenant of Mayors, and JPI Urban Europe, supporting cities in developing, piloting, and scaling innovative solutions for urban energy transitions.

- **ICLEI's 100% Renewable Energy Cities & Regions Network** – A global movement of local governments committed to transitioning toward 100% renewable energy, emphasizing integrated approaches to energy planning, including district heating and cooling solutions.

Several EU-funded projects under **Horizon Europe, Interreg, and UIA/EUI** have directly supported cities in developing **integrated renovation programmes**:

- **Vilawatt (Viladecans, Spain)**: Established a **public-private-citizen partnership** to improve energy governance and decarbonise district heating.
- **Decarb City Pipes 2050**: Supported **Vienna, Bilbao, and Munich** in developing **long-term heating and cooling decarbonisation roadmaps**.
- **Hotmaps (TU Vienna, Austria)**: Developed an open-source GIS tool to assist local authorities in designing **strategic heating and cooling plans**.
- **Rock the Block (Egaleo, Greece)**: A **participatory urban renewal project** integrating energy renovation and social housing transformation.

These initiatives demonstrate the power of **collaborative governance and EU financial support** in making urban energy transitions viable.



ELECTRIFICATION OF HEAT SUPPLY: Cities such as Copenhagen, Helsinki, and Amsterdam are rapidly integrating large-scale heat pumps and electric boilers powered by renewable electricity into their networks.



INTEGRATION OF SOLAR THERMAL AND GEOTHERMAL ENERGY: Cities like Växjö (Sweden) and Pamplona (Spain) are deploying solar thermal arrays and deep geothermal heat sources to reduce reliance on natural gas



WASTE HEAT RECOVERY: Cities like Paris are utilizing waste heat from data centers and wastewater treatment facilities to supply low-carbon district heating.



EXPANSION OF LOCAL ENERGY COMMUNITIES: EU directives promote the creation of community-owned district heating networks, integrating prosumers who generate, store, and sell renewable heat

The Role of District Heating in the Energy Transition

District heating networks play a critical role in **meeting decarbonisation targets** while ensuring **affordable and reliable heat supply** for urban populations. The transition away from **fossil fuel-powered district heating** toward **renewable and electrified heating** is one of the most significant challenges facing European cities.

Current trends in district heating transformation include:

- **Electrification of heat supply**: Cities such as **Copenhagen, Helsinki, and Amsterdam** are rapidly integrating **large-scale heat pumps** and **electric boilers** powered by **renewable electricity** into their networks.

- **Integration of solar thermal and geothermal energy:** Cities like **Växjö (Sweden)** and **Pamplona (Spain)** are deploying **solar thermal arrays** and **deep geothermal heat sources** to reduce reliance on natural gas.

- **Waste heat recovery:** Cities like Paris are utilizing **waste heat from data centers and wastewater treatment facilities** to supply low-carbon district heating.

- **Expansion of local energy communities:** EU directives promote the creation of **community-owned district heating networks**, integrating **prosumers** who generate, store, and sell renewable heat.

Conclusion: Towards a Decarbonised Heating Future

The regulatory, financial, and governance frameworks at the EU level provide a strong foundation for cities to implement **local heating and cooling plans** and **integrated renovation programmes**. For cities like **Kozani**, transitioning from **lignite-based district heating** to **renewable and electrified solutions** represents both a **challenge and an opportunity** to lead in sustainable urban energy systems.

By aligning **EU policy objectives, funding mechanisms, and city-led initiatives**, municipalities can ensure a **just and cost-effective energy transition** while delivering **climate-neutral, resilient, and livable urban environments**.

Case

Studies

Index of Case Studies

PHASED DISTRICT HEATING TRANSITION

Saleska Valley, Slovenia

Saleska Valley is transitioning away from lignite-fired district heating, aiming for 100% renewable energy by 2033. The plan includes network upgrades, efficiency improvements, and integration of clean energy sources to ensure affordability and sustainability. Funded by the Just Transition Fund, national resources, and an EIB/ELENA grant, this project provides insights into phased implementation and financial strategies for coal-dependent cities like Kozani.

INTEGRATED MUNICIPAL HEAT PLAN

Heidelberg, Germany

Heidelberg, district heating transformation integrates solar thermal, biomass, and large-scale heat pumps, targeting full decarbonization by 2030. A key aspect is alternative heating solutionsw for buildings not connected to the grid, including electric heat pumps. Funded through national subsidies and private investments, the initiative serves as a model for Kozani heating transition, demonstrating integrated planning and diverse funding mechanisms.

LARGE-SCALE ENERGY RENOVATION AND BIOMASS DISTRICT HEATING

Pamplona, Spain

The Txantrea district in Pamplona faced high energy consumption and outdated heating systems, leading to energy poverty. The city implemented large-scale energy renovations, including thermal insulation upgrades and a biomass-fueled district heating network, reducing energy consumption by 70% and cutting household heating costs by €560 per year. The €40M project was financed through an EIB loan, aligning with Pamplona's 2030 Energy Transition and Climate Change Strategy. This project demonstrates how biomass-based district heating can effectively reduce emissions and energy poverty.

BIOMASS-BASED DISTRICT HEATING

Växjö, Sweden

Växjö transitioned to a biomass-based district heating network using locally sourced wood chips and forest residues. The initiative reduced the city's reliance on fossil fuels and significantly lowered carbon emissions. Funded through municipal investments and EU grants, Växjö's approach showcases the effectiveness of biomass in district heating, an applicable model for regions with accessible biomass resources like Kozani.

SOLAR THERMAL DISTRICT HEATING

Salaspils, Latvia

Salaspils developed a solar thermal district heating plant to tackle high heating costs and energy poverty. The project, financed by EU funds and municipal investments, substantially lowered heating expenses and carbon emissions. As a signatory of the Covenant of Mayors, Salaspils committed to a 40% CO2 reduction by 2030. The initiative presents a scalable model for Kozani, integrating solar energy into district heating systems.

FOSSIL-FREE HEATING STRATEGY WITH HEAT PUMPS AND SMALL-SCALE DISTRICT HEATING

Ghent, Belgium

Ghent is phasing out fossil gas dependency through a strategy that emphasizes heat pumps, small-scale district heating, and social housing retrofits. The city's one-stop shop supports home renovations and heat pump adoption, ensuring buildings are prepared for future heating networks. With funding from city and regional budgets, as well as ELENA EIB, Ghent's model demonstrates the viability of decentralized heating solutions for coal-dependent municipalities like Kozani.

1 Saleska Valley SLOVENIA

Key Facts

<table>
<tr><td colspan="2">LOCATION
Šaleška (Saleska) Valley (incl. Velenje), Slovenia</td><td rowspan="2">RENEWABLE ENERGY CONTRIBUTION & MIX
Currently 0% (≈80% lignite, 20% gas); Target 100% renewable by 2033 (biomass and solar-thermal)</td></tr>
<tr><td>CITY POPULATION
61,442</td><td>POPULATION SERVED
~35,000 residents</td></tr>
<tr><td colspan="2">DISTRICT HEATING NETWORK LENGTH
~400 km</td><td rowspan="3">CO₂ EMISSIONS REDUCTION
~25,000 tCO₂/year cut in initial phase; ~80,000 tCO₂/year eliminated by full transition</td></tr>
<tr><td colspan="2">ANNUAL THERMAL ENERGY PRODUCTION
~320,000 MWh (320 GWh)</td></tr>
<tr><td colspan="2">TOTAL INVESTMENT COST
€150 million</td></tr>
<tr><td colspan="3">YEAR OF IMPLEMENTATION
2022</td></tr>
</table>

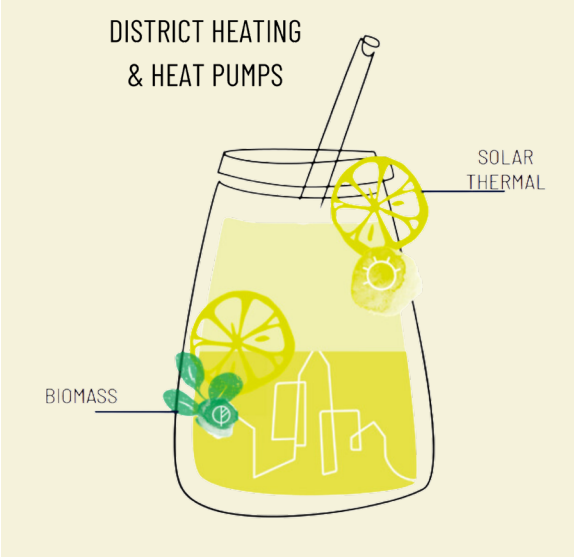
The challenge

The Šaleška Valley's district heating system has long relied on the Šoštanj lignite power plant (TEŠ) for steam and hot water. This coal-dependent setup faces an existential threat from Slovenia's plan to phase out coal by 2033. The aging network – established in 1959 – is inefficient, with thermal losses averaging 26.4% and a relatively low heat density. Heat consumption in the valley is about twice the national urban average, due to energy-inefficient buildings and outdated equipment. These factors made the system costly and carbon-intensive, and consumers faced occasional outages that eroded public trust.

Moreover, the transition posed significant financial and social hurdles. Modernizing one of Slovenia's largest district heating networks is estimated to cost on the order of €130 million, a sum impossible to raise locally without outside support. Initially, there was public skepticism – many residents (especially those employed in coal operations) were wary of the change, concerned about potential heating cost increases or reliability issues. However, the imperative to eliminate lignite and the opportunity to tap EU transition funds created strong motivation to pursue renewable solutions. Local leaders recognized that keeping a district heating system – but switching it to clean energy – was the only viable path to ensure future heat security and environmental protection.


RAZVOJNA AGENCIJA SAŠA
I FEEL SLOVENIA
Sofinancira Evropska unija
SKUPAJ DO PRIHRANKOV TOPLOTNE ENERGIJE
Preobrazba sistema daljinskega ogrevanja Šaleške doline
1 °C MANJ pomeni
6—8 %
manjšo porabo toplotne energije
3DIVERSE
Občina ŠOŠTANJ
MESTNA OBČINA VELENJE

Solution



The valley adopted a phased transformation plan (2022–2030) to reach 100% renewable district heating by 2033. The strategy is to gradually replace lignite with a diversified mix of renewable technologies while upgrading infrastructure. In Phase 1 (through 2026), the focus is on cutting heat demand and enabling lower-temperature operation. This involves retrofitting buildings to reduce consumption (targeting >30% demand reduction) and lowering the network's temperature regime to accommodate new heat sources. Concurrently, the distribution network is being renovated (better insulation, modern pumps and controls) to curb losses.

New renewable heat production units are introduced in stages. An electric boiler (high-voltage electrode) and large heat pumps will start supplying heat as coal use declines. The plan also includes a large solar thermal field paired with a thermal storage tank, to collect solar heat and store excess for use overnight or on cloudy days. A biomass boiler plant will provide renewable base and peak load, using local wood biomass. Other sources like geothermal or waste heat are be-

PROCESS

1

Demand Reduction and Network Modernization

The first phase focuses on reducing heat consumption and preparing the network for renewable integration. Key actions include large-scale building retrofits aiming to cut heat demand by over 30%, lowering network operating temperatures, and upgrading distribution infrastructure with better insulation, modern pumps, and smart controls. Simultaneously, the installation of pilot renewable units — a high-voltage electric boiler and large heat pumps — begins to gradually replace coal.

2

Expansion of Renewable Heat Production

This phase concentrates on scaling up renewable energy supply to progressively cover the valley's full heating demand. Major investments include constructing a large biomass boiler plant using local wood resources, installing an extensive solar thermal field combined with a thermal storage tank for overnight use, and evaluating additional sources like geothermal and industrial waste heat.
The goal is a fully renewable heat supply by 2030, ensuring flexibility and seasonal balancing.

ing evaluated to further diversify supply. By 2030, the district heating supply will be entirely from renewables – primarily solar thermal, biomass, and heat pumps – with thermal storage buffering seasonal and daily fluctuations. This diverse mix ensures a reliable heat supply even as the coal units are phased out.

Funding

A robust financing plan underpins the transformation, blending EU, national, and local resources. A cornerstone is the EU Just Transition Fund (JTF), which is providing major grants to Slovenia's coal regions for decarbonization. The Šaleška Valley project has secured support from the JTF (with required national co-funding) to cover a large share of Phase 1 investments. Slovenia's Climate Change Fund – fed by carbon allowance revenues – is also expected to co-finance the project, effectively redirecting pollution fees from the region back into clean energy. At the local level, KPV and the municipalities are contributing their own funds (particularly for network upgrades and planning studies), demonstrating local commitment.

To develop and implement the projects, Velenje obtained technical assistance from the European Investment Bank's ELENA program. The ELENA grant finances detailed project development (engineering designs, business plans, energy audits) for the renewable heat plants and building renovations, ensuring the plans are investment-ready. For later phases, additional financing like low-interest loans (for example, from the EIB or national sources) may be utilized to complement grants. By combining non-repayable funds with strategic loans and local investment, the €150 million transition program is financially viable without overburdening the community.

3

Full Transition, Optimization, and Fossil Fuel Exit

The final phase ensures the complete elimination of lignite and any fossil-fuel backup. The focus shifts to optimizing the entire system's performance: integrating digital monitoring, smart metering, and predictive maintenance technologies. Hydronic balancing, heat storage management, and load flexibility measures are refined.
By 2033, Šaleška Valley's district heating system will operate fully on renewable energy, delivering reliable, efficient, and affordable heating to over 35,000 residents without coal dependency.

The strategy is to gradually replace lignite with a diversified mix of renewable technologies while upgrading infrastructure. By 2030, the district heating supply will be entirely from renewables – primarily solar thermal, biomass, and heat pumps – with thermal storage buffering seasonal and daily fluctuations. This diverse mix ensures a reliable heat supply even as the coal units are phased out.

Impact

The ongoing transformation of the Šaleška Valley's district heating system has already produced significant measurable outcomes. In the initial phase, a combination of network upgrades and energy efficiency measures is delivering annual heat savings of about 76,559 MWh, roughly a 25% reduction in heat demand. This translates into cutting coal consumption by 21,150 tons per year and avoiding 25,269 tons of CO_2 emissions annually. These early gains underscore the project's cost-efficiency and climate benefits. Notably, the system supplies over 35,000 consumers (nearly 40,000 people plus 650+ industrial users) in Velenje and Šoštanj and local officials have managed to maintain affordable heating during the transition – as of late 2022, Velenje had the lowest heat price in Slovenia (~€79.5/MWh), about one-third of the cost in the most expensive cityThis indicates that decarbonization efforts have not come at the expense of energy affordability.

Looking ahead, modeled projections and targets point to even greater impact by 2030 and beyond. The Šaleška Valley's plan aims for a full transition to renewable heat by 2030–2033, in line with Slovenia's coal phase-out by 2033. By 2030, the city of Velenje (a EU Mission City for climate neutrality) is targeting a 55% reduction in greenhouse gas emissions (from 2005 levels), on the path toward climate neutrality by 2050. Replacing coal with a mix of heat pumps, solar thermal/PV, and other renewables will eliminate virtually all of the current ~80,000 tonnes of CO_2 emitted yearly by the heating system. In addition, the transition improves energy security by reducing reliance on a single lignite source and diversifying heat production. The project also brings social and economic co-benefits: it safeguards the continuity of heat supply after coal plant closure, creates jobs in new energy infrastructure, and improves local air quality. Overall, the Šaleška Valley's district heating transformation demonstrates a substantial impact in energy savings, emissions reduction, and resilience, with projections for 2030+ indicating a fully decarbonized, 100% renewable heating system that will serve the community reliably and cost-effectively for the long term.

Success Factors

Political Commitment and Coordinated Governance: Strong political will and unified vision among the municipalities of Velenje, Šoštanj, and Šmartno ob Paki, in partnership with KPV and the Šoštanj power plant (TEŠ), enabled coordinated planning. Aligning the transition with Slovenia's national coal phase-out plan (2033) provided regulatory certainty and urgency.

Phased, Systematic Transformation Strategy: A structured roadmap (2022–2033) allowed manageable progress, combining demand reduction (retrofits, network upgrades) with the gradual introduction of renewable heat sources (heat pumps, solar thermal, biomass). This adaptive strategy ensured early wins while preparing for a renewable future.

EU and National Funding Mobilization: External financing from the EU Just Transition Fund, Slovenia's Climate Fund, and the ELENA facility was essential. A mix of grants, loans, and local co-financing secured the €150 million investment plan without overburdening consumers.

Use of Existing Infrastructure and Local Resources: Reusing the TEŠ site and grid for renewable heat minimized costs and land-use conflicts. The planned biomass component leveraged local forestry residues, promoting regional economic benefits and supply security.

Public Engagement and Social Consensus-Building: Early outreach, transparent communication, and consumer empowerment (e.g., heat control units, technical support, affordability focus) fostered public trust and acceptance in a traditionally coal-dependent region.

Barriers

Technical Complexity of Coal-Based Infrastructure: Adapting a system optimized for lignite to flexible, renewable heat required extensive modernization, including pipeline renewal and system balancing.

High Heat Demand from Inefficient Buildings: Poor insulation and outdated equipment led to high energy consumption. Decarbonization required deep retrofits and behaviour change, with slow approval processes in multi-apartment buildings.

Financial Scale and Long Payback Horizon: The €150 million investment was challenging for the small region, necessitating layered funding. Future phases still depend on additional resources.

Regulatory and Social Consent Barriers: Unanimous approval from apartment owners was needed for building-level heat stations, overcome through proactive engagement and offering tangible benefits.

Risk of Supply Disruption During Transition: Maintaining uninterrupted heat supply required overlapping coal reduction with renewable deployment and installing temporary backup systems.

Relevance for Kozani

Planning ahead with a phased transition strategy is critical. The experience in Velenje demonstrates the importance of starting early and implementing successive stages that combine immediate energy efficiency improvements with the gradual deployment of new heat sources.

Kozani should similarly invest in early network upgrades and energy efficiency to reduce demand and ease the integration of renewables. Secondly, diversifying energy sources is key. Rather than replacing coal with one fuel (like natural gas), the Slovene plan uses a mix of solar thermal, biomass, heat pumps, and electric boilers – an approach Western Macedonia can emulateç.Kozani has comparable solar and biomass potential, and can explore geothermal or waste heat, to build a resilient multi-source heating system.

Another lesson is the value of stakeholder coordination and funding. In Šaleška, close cooperation between the utility, local authorities, and the power plant operator – combined with tapping EU just transition funds – was a game-changer. Kozani's authorities should forge similar partnerships and secure available EU/national grants for its transition. Finally, community engagement is essential to address public concerns and build trust. In Slovenia, transparent communication and involving citizens (via consultations and education) helped turn opinion in favor of the transition. Kozani can likewise involve residents in planning, address their fears, and highlight the long-term benefits of a clean heating transition to ensure public support.

Bibliography

1. **Balkan Green Energy News** (29 Aug 2023). Slovenian municipalities to decarbonize district heating system with TPP Šoštanj https://balkangreenenergynews.com/slovenian-municipalities-to-decarbonize-district-heating-system-with-tpp-sostanj

2. **Holding Slovenske Elektrarne (HSE)** – Press Release (21 Aug 2023). With the Šoštanj Thermal Power Plant towards a green transformation of the Šalek Valley district heating system. https://www.hse.si/en/with-the-sostanj-thermal-power-plant-towards-a-green-transformation-of-the-salek-valley-district-heating-system

3. **Municipality of Velenje** (2022). Green transformation of the district heating system in the Šalek Valley. https://www.velenje.si/en/projects-en/green-transformation

4. **Covenant of Mayors – Europe** (2023). Transforming Šaleška Valley's District Heating for a Sustainable Future. https://eu-mayors.ec.europa.eu/en/transforming-saleska-valleys-district-heating-for-a-sustainable-future

5. **Danfoss** (2022). Improved hydronic balancing of the district heating network in Slovenia. https://www.danfoss.com/en/service-and-support/case-stories/dhs/improved-hydronic-balancing-of-the-district-heating-network-in-slovenia

6. **EIT Climate-KIC** (6 Sep 2023). Coal Roots, Green Shoots: How Velenje is balancing an industrial past with a clean future. https://www.climate-kic.org/news/coal-roots-green-shoots-how-velenje-is-balancing-an-industrial-past-with-a-clean-future

7. **The Green Tank** (15 Oct 2024). Gas is not a realistic solution for district heating in Western Macedonia. https://thegreentank.gr/en/2024/10/15/district-heating-flashtv

8. **Balkan Green Energy News** (5 Feb 2024). Greece's coal region turns to PV, heat pumps for district heating. https://balkangreenenergynews.com/slovenian-municipalities-to-decarbonize-district-heating-system-with-tpp-sostanj

2 Heidelberg GERMANY

Key Facts

<table>
<tr><td colspan="2">LOCATION
Heidelberg, Germany</td><td rowspan="2">RENEWABLE ENERGY CONTRIBUTION & MIX
26.5% renewables (biomass, biogas, large-scale heat pumps); 50% climate-neutral heat</td></tr>
<tr><td>CITY POPULATION
~160,000</td><td>POPULATION SERVED
~81,000 residents</td></tr>
<tr><td colspan="2">DISTRICT HEATING NETWORK LENGTH
237 km</td><td rowspan="3">CO₂ EMISSIONS REDUCTION
~100,000 tCO₂/year avoided</td></tr>
<tr><td colspan="2">ANNUAL THERMAL ENERGY PRODUCTION
~685 GWh</td></tr>
<tr><td colspan="2">TOTAL INVESTMENT COST
~€825 million</td></tr>
<tr><td colspan="3">YEAR OF IMPLEMENTATION
2013</td></tr>
</table>

The challenge

Heidelberg faced a critical challenge in transforming its long-established district heating system from fossil fuels to renewable energy. Historically, the city's network relied heavily on coal and natural gas, including heat sourced from the large **coal-fired power plant** in nearby Mannheim and local gas cogeneration. This posed a major obstacle to Heidelberg's ambitious climate goals. Heating and hot water made up **more than one-third of Heidelberg's CO_2 emissions**, so decarbonizing heat was essential to meet the city's commitment to climate protection. In 2019, Heidelberg declared a climate emergency and set aggressive targets – aiming for climate neutrality by 2030 and a **95% reduction in greenhouse gases by 2050**. The status quo, with half the city's buildings connected to a mostly fossil-fueled district heating grid, was incompatible with these goals.

Several specific problems underscored the need for change. First, reliance on coal-based heat (via Mannheim's network) and on natural gas CHP meant high CO_2 emissions and exposure to **fossil fuel price volatility**. The city recognized that continuing to pipe in heat from a coal plant and running gas boilers would lock in carbon emissions incompatible with its "100% Climate Protection" masterplan.

Second, the impending phase-out of coal in Germany (and the expected shutdown or conversion of the Mannheim plant by 2030) threatened the **heat supply security.** Heidelberg needed alternative sustainable heat sources to replace this supply in a tight timeframe. Third, about 50% of buildings – especially older, poorly insulated ones – were still heated by **individual oil or gas systems**. Expanding the reach of district heating or other renewable solutions to these buildings was necessary to curb emissions and improve efficiency. This meant overcoming the logistical challenge of extending networks into built-up urban areas, which can be disruptive and costly.

In addition to technical and infrastructure issues, Heidelberg had to galvanize **stakeholder support and investment** for the transition. The city's leadership and utility were motivated by the imperative to reduce local air pollution and carbon footprint: for example, the district heating system historically had reduced reliance on thousands of coal stoves, improving air quality. Now the challenge was to build on that legacy and transform the system into one powered predominantly by renewable energy. The urgency of climate targets, combined with the need for a secure, affordable heat supply for citizens, set the context for Heidelberg's pursuit of a renewable-based district heating overhaul.

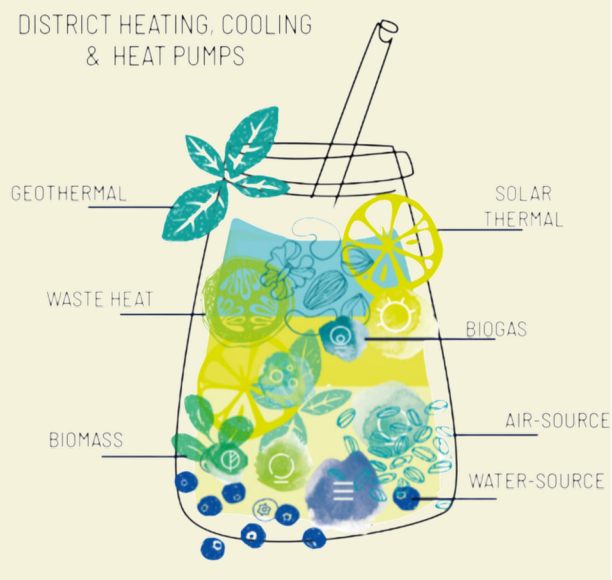
Solution

Heidelberg's approach to sustainable district heating involves integrating diverse renewable and low-carbon energy sources. The **"Green District Heating"** concept, led by Stadtwerke Heidelberg in partnership with the city's environmental agency, focuses on increasing the share of renewables in heat supply. A key initiative was the construction of a **wood-fired combined heat and power (CHP)** plant at Pfaffengrund, operational since 2013-2014. This biomass plant, using 90% locally sourced wood waste, supplies 14% of the city's heating needs and reduces CO_2 emissions by 32 kilotons annually. Additionally, four biogas/biomethane-fueled CHP units contribute 6% of the heat output, further decarbonizing the fuel mix.

To leverage external renewable sources, Heidelberg taps into **waste heat from Mannheim's waste-to-energy (WtE) plant** through a pipeline that connects both cities' networks. This partnership ensures that during summer, district heating is fully carbon-free. The biogenic portion of WtE heat qualifies as renewable, while the rest is considered climate-neutral. Stadtwerke Heidelberg and MVV Energie Mannheim have a long-term contract to progressively replace coal-based heat with sustainable sources by 2030.

Heidelberg also pioneers innovative technologies in district heating. In 2023, the city commissioned an **"innovative combined heat and power" (iKWK) system**, Germany's first of its kind. This system integrates three gas-fired CHP engines, industrial air-to-water heat pumps, and an electric boiler, all managed as a single flexible unit.

Heat pumps, capable of utilizing ambient air as low as 5°C, switch operation modes based on seasonal demand, maximizing the use of green electricity. A 20,000 m³ thermal storage tank, operational since 2019, stores excess heat from renewables and CHP plants, stabilizing both heat supply and the grid.



On the demand side, Heidelberg is expanding its district heating network, **targeting an increase from 50% to 70% coverage.** New urban developments, like Bahnstadt and Patrick-Henry-Village, rely entirely on district heating or renewable sources. For buildings outside the network, the city promotes alternative solutions like **electric heat pumps and solar thermal systems.** The governance structure involves Stadtwerke Heidelberg, the city council, and local environmental groups. Public participation is encouraged through energy cooperatives and investment opportunities in heating infrastructure.

By 2020, Heidelberg's district heating network reached 50% renewable energy, with plans to incorporate solar thermal and geothermal energy before 2030. This comprehensive strategy, combining technological innovation, regional partnerships, and policy support, positions Heidelberg on track for fully decarbonized heating by the end of the decade.

PROCESS

1

Initial Network and Regional Integration

Heidelberg's district heating began in 1934 and linked to Mannheim's network in the 1980s, importing heat.
By 2010, about 50% of the city relied on the system, which remained mostly fossil-fueled.
This long-standing infrastructure laid the foundation for future transformation into a greener, more integrated district heating system across the region.

2

Strategic Planning

In 2010, Stadtwerke Heidelberg launched "Energy Concept 2020" to expand and decarbonize heat.
A biomass CHP plant and biomethane CHP units came online by 2014.
Strong city leadership and public backing enabled progress toward greener heat, initiating a shift from fossil fuels to more sustainable district energy sources.

Funding

Heidelberg's transition to a renewable district heating system requires €825 million by 2030, covering new plants, network expansion, and infrastructure upgrades. The municipal utility, Stadtwerke Heidelberg, is the main investor, financing projects through **capital budgets and long-term loans**, often backed by public banks like KfW. Notable investments include a **€20 million wood-fired CHP plant** and a **€15 million heat storage tower**, both financed by the utility. The city's financial backing helps secure favorable loan terms, ensuring stable funding for the transformation.

National and state subsidies play a crucial role, with federal programs like the Combined Heat and Power Act and the Federal Funding for Efficient Heat Networks providing grants for integrating renewables and improving efficiency. A significant boost came from the 2023 iKWK plant, which received federal support after winning a competitive tender. The Baden-Württemberg government also supports municipal heat planning, with some funding allocated for feasibility studies and pilot projects. The European Union provides additional support through technical assistance and climate initiatives such as the Covenant of Mayors. While direct EU funding for Heidelberg's heating system is limited, participation in networks like C40 Cities has helped secure financial opportunities. EU programs have also contributed to research, such as the city's river heat pilot project.

Innovative financing includes **public-private partnerships and citizen investment**. In 2024, Stadtwerke Heidelberg raised €6 million through private equity, likely via green bonds or citizen shares. The utility also collaborates with cooperatives to fund small-scale renewable projects. Additionally, a long-term contract with MVV Mannheim helps distribute investment costs by sourcing external heat supply.
Overall, Heidelberg's funding strategy combines municipal investment, national and EU support, and community engagement, ensuring an economically viable transition to sustainable district heating.

3
Expansion and Optimization

By mid-2010s, renewable heat reached 20%. Heidelberg expanded the district network 3–4 km annually.
A 12,800 m³ hot water tower enhanced storage and flexibility. Collaboration with MVV boosted waste-heat use, reducing coal dependency. The city launched a Solar Campaign to promote solar thermal outside the network. Renewables hit 50% by 2020.

4
Heat Plan and Innovative Projects

In 2023, Heidelberg finalized its Municipal Heating Plan, targeting climate-neutral heat by 2030.
Germany's first air-source heat pump district project was commissioned, combining heat pumps and power-to-heat tech.
Despite COVID delays, it met deadlines. The city agreed with Mannheim to phase out coal by 2030 using river and geothermal heat.

5
Ongoing and Future Steps

Heidelberg is phasing out gas and coal, focusing on Neckar River heat pumps, sewage heat recovery, and solar thermal.
More buildings are being added yearly. By 2030, nearly all heat should come from renewables or waste.
Full climate neutrality is planned by 2035, cementing Heidelberg's leadership in sustainable district heating.

Impact

Heidelberg's renewable district heating initiative has significantly improved energy efficiency, reduced emissions, and brought economic and social benefits. By integrating **biomass, biogas, and waste heat**, the city achieved a 50% carbon-free heat supply by early 2020, cutting over 100,000 tonnes of CO_2 annually compared to a fossil-only scenario. The wood-fired Combined Heat and Power (CHP) plant alone reduces emissions by 32,000 tonnes per year. Between 1987 and 2015, stationary energy CO_2 emissions fell by 7%, despite increases in population and energy consumption. Heidelberg is on track to cut greenhouse gas emissions by 50% by 2030.

The system's efficiency has greatly improved through CHP technology and waste heat recovery, reducing dependence on fossil fuels. The wood CHP plant co-generates electricity, maximizing energy use, while industrial and waste-to-energy connections minimize heat loss. By 2020, **natural gas use for heating declined to 41% of total demand.** Expanding district heating networks and replacing oil boilers further enhanced fuel efficiency by 30–40% per building.

Economically, the district heating system provides stable prices, protecting consumers from fluctuations like the 2022 gas price surge, saving millions of euros. It also supports local employment in construction, operations, and biomass supply chains. Moreover, the innovative iKWK project has strengthened Heidelberg's reputation, attracting research initiatives and eco-tourism.

Energy security has improved with diverse renewable sources and large thermal storage, ensuring a stable supply even during peak periods or disruptions. Environmental and social benefits include improved air quality and reduced household emissions. Public engagement through site tours, events, and community involvement has fostered local pride and greater awareness of renewable energy, making Heidelberg a model for sustainable district heating in cities worldwide.



Combined Heat and Power (CHP) Plant Installation

Success Factors

Strong Political Commitment and Strategic Planning: Heidelberg's district heating transformation was driven by strong political leadership and clear climate neutrality targets within its "Energy Concept 2030." Close collaboration between the city administration and municipal utility, Stadtwerke Heidelberg, enabled strategic planning and effective resource mobilization.

Technological Innovation and Energy Diversification: Technological innovation was essential. The pioneering "iKWK" system, integrating CHP units, large-scale air-to-water heat pumps, and a 20,000 m³ thermal storage tank, boosted system flexibility. A diversified renewable energy mix — including biomass CHP, biomethane, waste heat from Mannheim, and future river-source heat pumps — enabled Heidelberg to surpass 50% renewable heat supply.

Stakeholder Engagement and Citizen Participation: Early and ongoing citizen engagement fostered acceptance. The iconic heat storage tower served both technical and educational roles, while citizen investment schemes and local energy cooperatives strengthened community involvement.

Robust Financial Framework and External Support: A mix of municipal investment, federal subsidies (e.g., Germany's CHP Act), and EU programs underpinned Heidelberg's financing. Long-term contracts with regional partners and EU-backed innovation funds ensured economic viability and accelerated renewable integration.

Barriers

Legacy Fossil Fuel Dependence and Supply Transition: Heidelberg's heavy reliance on coal and natural gas, particularly from Mannheim's CHP plant, created major decarbonization challenges. Replacing this supply while ensuring heat security required complex stakeholder negotiations.

Infrastructure Retrofitting and Technical Complexity: Expanding and modernizing the network involved integrating renewable technologies and laying new pipelines in dense urban areas, posing technical and logistical hurdles.

Stakeholder Coordination and Regulatory Hurdles: Aligning multiple stakeholders around climate goals demanded transparent governance. Regulatory requirements, like Baden-Württemberg's municipal heat planning, added complexity but ultimately strengthened strategic clarity.

External Disruptions and Project Delays: COVID-19 caused construction delays and supply chain issues. However, phased implementation, flexible project management, and sustained political support enabled Heidelberg to stay on track toward its 2030 climate-neutral heating target.

Relevance for Kozani

To secure a sustainable and affordable heat supply for its 28,000 connected apartments, Kozani must diversify its energy sources and modernize its district heating system. Drawing lessons from Heidelberg's transition, the city can combine biomass CHP using local forestry residues, large-scale solar thermal farms on reclaimed mine land, and geothermal or water-source heat pumps to create a resilient and flexible energy mix.

Integrating waste heat from industrial facilities and combining CHP units with heat pumps could further boost efficiency, grid stability, and renewable energy absorption. Equally important is proactive municipal planning — involving citizens, local industries, academia, and EU initiatives like Mission Cities — to build trust, secure acceptance, and shape an inclusive energy transition.

Upgrading infrastructure, expanding the network, and lowering operating temperatures will unlock greater renewable integration and system performance. EU funding can significantly reduce upfront investment costs, ensuring long-term price stability for consumers. By combining diversified renewable sources, flexible technologies, infrastructure improvements, and participatory planning, Kozani has a clear pathway to transform its heating system. With its strong solar potential, available land from former mines, and access to European transition funds, the city can build a sustainable, coal-free future and become a model for other lignite-dependent regions.

Bibliography

1. **CITÉGO (2019) – Heidelberg: Sustainable Living for All** https://www.citego.org/bdf_fiche-document-1822_en.html

2. **Covenant of Mayors Europe (2023) – Heidelberg's District Heating Story** https://eu-mayors.ec.europa.eu/en/heidelbergs-district-heating-story

3. **REN21 (2021) – Renewables in Cities: Heidelberg Entry** https://www.ren21.net/cities-2021/cities/heidelberg/heidelberg

4. **Stadtwerke Heidelberg (April 2024) – "90 Jahre Fernwärme in Heidelberg" Press Release** https://www.mrn-news.de/2024/04/12/90-jahre-fernwaerme-in-heidelberg-jubilaeumsfeier-mit-vielen-infos-rund-um-zukunftsfaehiges-heizen-spass-und-unterhaltung-529066

5. **Energy & Management (via Bayern Innovativ) (July 2023) – "Nationwide we are the first"** https://www.bayern-innovativ.de/en/emagazine/detail/en/page/nationwide-we-are-the-first

6. **Rhein-Neckar-Wiki (Updated 2014) – Holz-Heizkraftwerk Heidelberg** https://rhein-neckar-wiki.de/Holz-Heizkraftwerk_Heidelberg

7. **Solarserver.de (July 2023) – MVV and Stadtwerke Heidelberg Deepen District Heating Cooperation** https://www.solarserver.de/2023/07/25/fernwaerme-mvv-und-stadtwerke-heidelberg-vertiefen-kooperation

8. **Climate Chance (2019) – Synthesis Report: Heidelberg, Germany** https://www.climate-chance.org/wp-content/uploads/2020/04/synthesis-report-2019-local-action-book-case-heidelberg_germany-p72.pdf

9. **NetZeroCities (2023) – Kozani Pilot City Profile** https://netzerocities.eu/kozanis-pilot-city-activity-neutron

3 Pamplona SPAIN

Key Facts

<table>
<tr><td colspan="2">LOCATION
Pamplona, Navarre, Spain</td><td rowspan="2">RENEWABLE ENERGY CONTRIBUTION & MIX
~90% biomass,
~10% natural gas</td></tr>
<tr><td>CITY POPULATION
~209,000</td><td>POPULATION SERVED
~4,500 households (~10,000 residents) in the Txantrea district + several public buildings</td></tr>
<tr><td colspan="2">DISTRICT HEATING NETWORK LENGTH
~4.5 km of pre-insulated double piping</td><td rowspan="3">CO₂ EMISSIONS REDUCTION
~7,000 tCO₂/year cut (~80% reduction) by replacing fossil fuel boilers with biomass</td></tr>
<tr><td colspan="2">ANNUAL THERMAL ENERGY PRODUCTION
~35–40 GWh, covering heating and hot water needs for 4,500 homes</td></tr>
<tr><td colspan="2">TOTAL INVESTMENT COST
~€13.7 million for the district heating system (two phases); additional ~€44 million invested in building renovations under the Efidistrict program</td></tr>
<tr><td colspan="3">YEAR OF IMPLEMENTATION
Initiated in 2014 (Efidistrict program); biomass district heating network construction began in mid-2010s; first phase operational in 2022; full completion expected in the second half of 2023</td></tr>
</table>

The Challenge

Pamplona's Txantrea (Chantrea) quarter, a mid-20th-century social housing district, faced severe energy and urban challenges prior to the project. The neighborhood's building stock – largely constructed in the 1950s–70s – was ageing and inefficient, resulting in some of Spain's least energy-efficient residential buildings. Poor insulation and antiquated heating systems meant high energy consumption, discomfort, and elevated heating costs for residents. This contributed to energy poverty, with low-income households struggling to afford adequate heating. Before intervention, heating was supplied by multiple small communal boilers (eight separate fossil-fuel heat networks) that were inefficient, outdated, and costly, leading to unreliable service and a negative public image of district heating. The scattered gas or oil boilers not only yielded high greenhouse gas emissions, but also locked residents into volatile fossil fuel prices.

By the early 2010s, the need for urban regeneration and climate action in Pamplona had become pressing. At the city and regional level, ambitious climate targets were set (Pamplona's Climate Change Strategy 2030 and Navarre's 2030 roadmap) emphasizing carbon reduction and clean energy. The Txantrea district was identified as a priority due to its high energy demand and socio-economic vulnerability. The challenge was to drastically reduce CO_2 emissions and energy consumption while improving living conditions in this dense urban neighborhood. This meant addressing both supply-side issues (inefficient, fossil-fueled heat supply) and demand-side issues (poor building insulation and design).

Furthermore, any solution would require overcoming resident skepticism and coordinating action across thousands of privately-owned flats – a complex social and logistical task. In summary, Pamplona faced the dual challenge of modernizing an outdated district heating infrastructure and retrofitting an entire neighborhood's buildings to alleviate energy poverty, cut emissions, and align with the city's climate goals. These challenges set the stage for Pamplona's decision to implement a renewable-based district heating system as a cornerstone of the Txantrea urban regeneration (Efidistrict) project.

The Solution

Pamplona implemented Efidistrict Txantrea, a large-scale district retrofit and clean heating project, combining deep building renovations with a renewable-energy-powered district heating (DH) system. Over 2,300 apartments in Txantrea underwent thermal retrofits, including facade and roof insulation, window upgrades, and energy efficiency improvements, reducing household energy consumption by 70% and enhancing comfort.



Pamplona's Txantrea quarter residential blocks

On the supply side, the project replaced outdated gas and oil boilers with a centralized biomass-fueled DH plant at the neighborhood's edge. The plant houses two wood-chip-fired biomass boilers with a 39 MW capacity, relying on locally sourced forest biomass. This renewable fuel covers 90% of heating needs, with a 10% natural gas backup for peak loads or emergencies. A 1,800 m^3 hot water accumulator tank was incorporated to stabilize operations, ensuring efficient biomass usage and minimizing gas consumption.

A 4.5 km insulated distribution network was installed to deliver centrally heated water to buildings and return cooled water to the plant in a closed loop. The DH system replaced eight separate boiler rooms, creating a single, optimized heating network. Advanced combustion control and electro-filters drastically cut particulate and CO_2 emissions by 80%. The plant integrates automated fuel feeding from a 1,500 m^3 underground biomass silo, ash removal, and real-time monitoring, ensuring high efficiency and reliability. Heat exchangers in buildings transfer thermal energy from the network, providing a steady heating and hot water supply.

Governance was structured as a public-private partnership (PPP). The regional public housing agency NASUVINSA, acting on behalf of Navarre's government, led the initiative and owns the infrastructure. ENGIE España, selected through a tender process, built and operates the system via its subsidiary, Districalor Renovable de Pamplona, under a 36-year concession. This model combines public oversight and funding with private-sector expertise in energy management. Key stakeholders include Pamplona City Council and Burlada Municipality, with some public buildings in Burlada also connected.

Community engagement was central. A neighborhood office was established to inform residents, coordinate retrofits, and promote participation. With over 800 community meetings, the project secured resident buy-in, ensuring smooth implementation.

PROCESS

1

Assessment and Community Mobilization

Between 2013–2015, the Government of Navarre and NASUVINSA launched the Efidistrict project in Txantrea with EU MLEI grant support.
They conducted energy assessments, feasibility studies, and carbon footprint analysis comparing gas with biomass.
A local project office was established, focusing on technical design for district heating and extensive community outreach to present refurbishment plans and gauge residents' interest in centralized heating.

2

Construction and System Rollout

With EU and regional funding, the first phase of Efidistrict began with building retrofits and heating network planning.
By 2015, renovations started in Txantrea's underserved areas, alongside designing the biomass plant and pipelines.
Key steps included securing the energy center site and permits. By 2017, 600 apartments were renovated, building public trust. The EU-supported phase concluded in 2018, , having laid the technical and financial foundations for the heating network.

Overall, Pamplona's strategy integrated building efficiency upgrades with a renewable district heating system, significantly reducing carbon emissions while providing affordable, low-carbon heat. By leveraging local biomass and a cooperative governance model, Efidistrict Txantrea showcases a scalable, sustainable pathway for urban heating decarbonization.

Funding

The total investment for Pamplona's Txantrea district heating system was approximately €13.7 million, sourced from both public and private funds. The financing structure was strategically designed to balance costs and leverage European support, ensuring that the project remained financially viable. A significant portion of the funding came from regional and EU sources. The Government of Navarre, through its public company NASUVINSA, contributed €6.8 million, which accounted for roughly half of the total cost. Of this, 50% (around €3.4 million) was co-financed by the European Regional Development Fund (ERDF). The project was selected as part of Navarre's ERDF Operational Program 2014–2020, aiming to enhance energy efficiency and renewable energy in public infrastructure. The EU grant, made available through ERDF, aligned with the EU's climate objectives as part of the Mobilising Local Energy Investments initiative. Additionally, early-stage technical assistance for the project, such as feasibility studies and business model development, was supported by over €1 million in EU Project Development Assistance under the Efidistrict project.

3

Expansion and Inauguration

Following competitive procurement, ENGIE secured the contract in 2019–2020, starting construction. Engineering was finalized, equipment purchased, and by 2021, the energy plant and 24.5 MW biomass boiler were underway.
By 2022, 3 km of piping connected initial buildings. The system went live in early 2023, heating 2,200 homes. Expansion continued, and by March 2024, the biomass district heating system was inaugurated.

Community engagement was central. A neighborhood office was established to inform residents, coordinate retrofits, and promote participation. With over 800 community meetings, the project secured resident buy-in, ensuring smooth implementation.

The remaining €6.9 million of the total cost came from ENGIE, the private concessionaire. ENGIE España, via its subsidiary Districalor Pamplona, provided the necessary capital to build the plant and network, in return for the long-term right to operate the system and sell heat. Under the public-private partnership (PPP) contract, ENGIE will operate and maintain the system for 36 years, recovering its investment through heat sales to residents. This concession model reduced the upfront financial burden on the public sector while ensuring professional management of the infrastructure.

Pamplona's city council and the local government also supported the project by providing land and facilitating permits, including the use of publicly owned land or the plant's construction. This in-kind contribution lowered project costs, while the City of Pamplona and nearby Burlada municipality contributed to the project's bankability by agreeing to purchase heat for public buildings like schools and sports centers. Furthermore, alongside the heating network, public funds totaling €44 million were invested in building renovations, including insulation and urban regeneration projects in Txantrea. These efforts, funded through a mix of regional subsidies, European Investment Bank loans, and homeowner contributions, complemented the district heating system by reducing overall demand.

Pamplona's district heating project thus exemplifies a blended financing approach, with public funds de-risking the initiative and attracting private investment. The combination of ERDF and Horizon 2020 funding provided not only financial support but also technical expertise, boosting the project's credibility and securing political and community backing.



Boiler installed at the heating plant being built in Txantrea

Impact

The Pamplona Txantrea renewable district heating project has had significant impacts in energy, environmental, economic, and social aspects. One of the most notable outcomes is the substantial energy savings. Thanks to deep renovations and a new heating system, household energy consumption in the serviced buildings has decreased by around 70% compared to 2014 levels. This has led to an average reduction of €560 per year in heating bills per household, easing energy poverty and allowing residents to use their savings for other necessities.

In terms of energy production, the biomass plant now generates 35–40 GWh of heat annually, replacing fossil fuel use. The switch from individual natural gas boilers to a centralized renewable source results in a CO_2 emissions reduction of about 7,000 tonnes per year, an 80% cut in emissions related to heating. This is equivalent to removing thousands of cars from the road. Additionally, the plant's modern emission controls improve local air quality by reducing particulate and NOx emissions, providing cleaner air for the neighborhood.

The project also positively impacts the local economy. By utilizing regional biomass, it supports the local forestry sector and may create jobs in biomass fuel supply. The long-term operation of the district heating network also generates skilled jobs in plant maintenance and energy services. Socially, the project improves residents' thermal comfort, contributing to better health by reducing dampness and respiratory issues. High satisfaction levels and pride in the neighborhood's transformation are evident, as improved insulation and modern heating systems have increased property values and revitalized the area.

Moreover, the project fosters social cohesion through community involvement and has become a model for sustainable urban energy systems in Spain. It demonstrates how local governments and citizens can collaborate to combat climate change while improving daily life, inspiring similar initiatives in other cities and contributing to Pamplona's 2030 climate goals.

Thanks to deep renovations and a new heating system, household energy consumption in the serviced buildings has decreased by around 70% compared to 2014 levels. This has led to an average reduction of €560 per year in heating bills per household, easing energy poverty and allowing residents to use their savings for other necessities.



Success Factors

Political Leadership and Vision: A strong commitment from the Government of Navarre and Pamplona's authorities was essential to the project's success. Their focus on carbon reduction and citizen well-being, guided by the 2030 Energy Transition plan, ensured continuous support and resource allocation, empowering NASUVINSA to lead the project.

Holistic and Integrated Approach: The project's success was driven by a comprehensive approach that addressed both building efficiency and heating supply. By integrating the biomass plant with broader neighborhood regeneration efforts, the project maximized its impact. For instance, building insulation reduced the need for a larger and less efficient heating system.

Community Engagement: Early and ongoing engagement with residents fostered trust, turning potential opposition into broad support. The creation of a neighborhood office and an intensive communication campaign were pivotal in securing community buy-in and social facilitation.

Experienced Partnerships and Financial Ingenuity: The choice of proven technologies, alongside experienced partners like ENGIE, reduced risk. The PPP model effectively allocated risks between the public and private sectors and ensured long-term professional management. Creative financial solutions, combining EU grants, regional funds, and private investments, made the project viable and attractive.

Leverage of European Programs: The involvement of European initiatives like STARDUST for technical advice and MLEI for funding bolstered the project's credibility and provided necessary expertise to ensure smooth implementation.



Pamplona's Txantrea quarter residential blocks before retrofits

Barriers

Public Skepticism and Coordination Challenges: Overcoming public skepticism and convincing homeowners to allow construction in their buildings was a significant challenge. Extensive engagement and communication efforts helped alleviate concerns and build trust.

Logistical and Technical Obstacles: Installing a new heating network in a densely built area presented logistical hurdles, such as digging up streets and constructing a large plant close to residences. These challenges required careful planning to minimize disruptions.

Regulatory and Organizational Challenges: As one of Spain's first neighborhood-scale biomass networks, navigating legal and regulatory frameworks for the PPP and heat supply contracts was time-consuming and complex.

Financial Risks and Delays: Rising equipment costs and potential cost overruns posed financial risks. Strong project management and phasing helped keep the budget under control. Delays were also caused by unforeseen construction issues, such as hidden underground infrastructure, and challenges in coordinating retrofit schedules with network construction. The COVID-19 pandemic, overlapping with construction, may have led to slowdowns or supply delays.



Officials from Nasuvinsa, Pamplona City Council, and partners visit Colonia San Miguel to launch the Efidistrict Txantrea renovation

Relevance for Kozani

Successful transition to sustainable district heating requires a combination of renewable energy supply and energy efficiency on the demand side. For Kozani, improving insulation in older buildings can significantly reduce energy needs, leading to a smaller, more cost-effective heating plant and improved comfort for residents.

Leveraging local resources will be crucial. Western Macedonia's availability of biomass, and possibly geothermal or solar potential, presents an opportunity for a diverse renewable energy mix. Pamplona's model of using certified local biomass with a gas backup for peak demand offers a practical example of reliability and fuel diversification. Kozani can aim for a similarly high renewable share — Pamplona achieved around 90% — which would deliver substantial CO_2 reductions.

Governance will also play a critical role. A public-private partnership (PPP), where the municipality oversees the project while private operators invest and manage it, could attract expertise, financing, and ensure affordability for citizens. A transparent framework and strong concession agreements will be essential.

Building trust and acceptance within the local community is another key factor. Kozani could adopt Pamplona's approach of public meetings and dedicated information offices to inform and engage residents, address concerns, and highlight benefits such as lower bills.

Finally, a phased implementation, starting with a pilot area and gradually expanding, could help Kozani manage costs effectively while repurposing its existing district heating infrastructure.

Bibliography

1. **Energy Cities (2019) – Pamplona: Neighbourhood Reduces Citizens' Energy Bills by €560/Year** https://energy-cities.eu/a-district-of-pamplona-reduces-citizens-energy-bills-by-e560-year/

2. **EPAH Atlas (2022) – Efidistrict Pamplona** https://energy-poverty.ec.europa.eu/discover-community/epah-atlas/

3. **Science X (Phys.org) (2022) – Innovative District Heating System Set to Cut CO_2 Emissions by 80%** https://sciencex.com/wire-news/432559181/innovative-district-heating-system-set-to-cut-co2-emissions-by-8.html

4. **Government of Navarre (2022) – La Central de Calor de la Txantrea: 4.500 Viviendas** https://www.nasuvinsa.es/es/actualidad/la-central-de-calor-de-la-txantrea-podra-abastecer-en-2023-de-calefaccion-y-agua

5. **ENGIE España (2024) – El Gobierno de Navarra Pone en Marcha la Primera Central y Red de Calor en Txantrea** https://www.engie.es/el-gobierno-de-navarra-pone-en-marcha-en-la-txantrea-la-primera-central-y-red-de-calor-a-escala-de-barrio-alimentada-de-biomasa-de-astilla-forestal

6. **Pamplona City Council (2030) – Energy Transition and Climate Change Strategy** https://stardustproject.eu/wp-content/uploads/2023/06/03-Pamplona-DIGITAL.pdf

7. **H2020 STARDUST (2023) – Pamplona: Innovative District Heating System Info Sheet** https://stardustproject.eu/wp-content/uploads/2023/06/03-Pamplona-DIGITAL.pdf

8. **Interreg Europe (2021) – New District Heating with Biomass in the Framework of the Efidistrict Project** https://www.interregeurope.eu/good-practices/new-district-heating-with-biomass-in-the-framework-of-the-efidistrict-project

9. **Rockwool Group (2020) – Urban Regeneration Through Renovation – Pamplona, Spain** https://www.rockwool.com/group/advice-and-inspiration/case-studies/urban-regeneration-through-renovation

10. **Municipal Power Magazine (2020) – "The local energy agency and support for self-consumption drive energy transition in Pamplona."** https://municipalpower.org/articles/the-local-energy-agency-and-support-for-self-consumption-drive-energy-transition-in-pamplona

4 Växjö SWEDEN

Key Facts

<table>
<tr><td colspan="2">LOCATION
Växjö, Sweden</td><td rowspan="2">RENEWABLE ENERGY CONTRIBUTION & MIX
>98% renewables (woody biomass, forestry residues); 100% biofuel since 2019</td></tr>
<tr><td>CITY POPULATION
~95,000</td><td>POPULATION SERVED
~80–85% of city residents (~7,000 homes, 700 businesses)</td></tr>
<tr><td colspan="2">DISTRICT HEATING NETWORK LENGTH
~350 km</td><td rowspan="3">CO₂ EMISSIONS REDUCTION
~249,000 tCO₂/year avoided; per capita emissions reduced by 58% (from 1993 – to 2017)</td></tr>
<tr><td colspan="2">ANNUAL THERMAL ENERGY PRODUCTION
~539 GWh (2017)</td></tr>
<tr><td colspan="2">TOTAL INVESTMENT COST
~€100–120 million for latest expansion; decades of national & EU-supported investments</td></tr>
<tr><td colspan="3">YEAR OF IMPLEMENTATION
DH network established in 1970, biomass conversion started in 1980</td></tr>
</table>

The Challenge

Växjö's journey toward a renewable-based district heating system was driven by urgent economic and environmental challenges. In the 1970s, the city – like much of Sweden – was highly dependent on fossil fuels, with oil supplying about 80% of its energy. The first district heating plant built in 1974 burned heavy oildiva-portal.org. This dependence left Växjö vulnerable to the 1970s oil crises, which caused fuel price spikes and threatened energy security. City leaders grew concerned about relying on imported oil for heating homes and businesses, recognizing the need for a more secure and affordable local energy sourcediva-portal.org. At the same time, burning oil in numerous local boilers was contributing to air pollution and environmental degradation, including poor air quality and acidification of lakes in the surrounding "Land of Lakes" regiondiva-portal.org. By the late 1960s, Växjö had already begun tackling environmental issues (notably cleaning its polluted lakes) – this cultivated a political culture that prioritized sustainability.

By the 1980s, climate change was emerging on the global agenda, adding impetus to act. Växjö's leaders saw an opportunity to cut carbon emissions by shifting away from fossil-fueled heating. In 1996, following the Rio Earth Summit and Agenda 21, Växjö became the first city in the world to declare a goal of becoming fossil-fuel free by 2030. This unanimous political decision formalized the city's commitment to combat climate change at the local level.

The challenge was clear: transition the city's district heating from oil to renewable energy to reduce CO_2 emissions, while ensuring reliable heat supply and keeping costs reasonable for residents. Local policymakers were also motivated by Sweden's progressive energy policies – for example, Sweden introduced a national carbon tax in 1991, making fossil fuels more expensive and renewable energy more competitive. In summary, Växjö's initial drivers were to end its fossil fuel dependency, address environmental concerns (from local air quality to global CO_2 emissions), and fulfill a visionary policy commitment to sustainability. This required overcoming inertia in the heating sector and finding a viable alternative fuel source that leveraged local strengths.

The Solution

Växjö addressed its energy needs by utilizing local forestry residues to power a centralized district heating and electricity system, replacing oil-fired boilers with renewable biomass. At the heart of this transformation is the Sandviksverket combined heat and power (CHP) plant, operated by Växjö Energi AB (VEAB). The plant primarily runs on wood chips, bark, sawdust, and tree branches—by-products of the region's forestry industry—turning what was once waste into a sustainable fuel source. Biomass now accounts for nearly 100% of the plant's fuel, and wood ash is returned to forests to support a circular economy.

The Sandviksverket CHP plant has multiple boiler units and a large thermal storage tank for hot water. The facility features a high-efficiency circulating fluidized bed boiler (Sandvik III, commissioned in 2015), producing 40 MW of electricity and 65 MW of heat. Older units, such as Sandvik II (1996), contribute additional capacity. Oil-fueled boilers remain as emergency backups, but since 2019, even these have been converted to bio-oil. The CHP plant operates in "heat-following" mode, adjusting its output based on heating demand, with electricity as a by-product. This setup results in an overall fuel efficiency of about 90%, significantly higher than separate heat and power generation systems. A 60-meter heat accumulator tank stores hot water, allowing the plant to balance supply and demand while minimizing emissions and backup fuel use.

By the late 2010s, Växjö's district heating system had become nearly 100% renewable. Peat, once a minor fuel source, was phased out to meet stricter carbon targets. Biomass is sourced within an 80 km radius, reducing transport emissions and supporting the local economy. Approximately 60 truckloads of wood chips arrive daily in winter. The plant's advanced flue gas cleaning system ensures low emissions. Additionally, since 2007, surplus heat has powered an absorption chiller, providing district cooling to a hospital and shopping mall. The CHP plant generates about 200 GWh of electricity annually, supplying nearly half of Växjö's total consumption.

VEAB, the municipally owned utility, played a key role in aligning energy investments with climate goals. Partnerships with local forest industries secured long-term biomass supply contracts, while Swedish policies, such as carbon taxes and green certificates, supported bioenergy's financial viability.

EU-funded projects introduced further innovations, including district cooling and solar-assisted buildings. Växjö's transformation showcases a holistic approach to sustainable energy, integrating local bioenergy, advanced CHP technology, district heating expansion, and forward-thinking governance to achieve a climate-friendly energy system.

Funding

The transition of Växjö's district heating system from fossil fuels to biomass required significant investment, funded through municipal resources, national grants, and EU programs. The most substantial investment was the construction of the Sandvik III biomass CHP unit (2012–2015), costing approximately 1 billion SEK (€100+ million). Växjö Energi, the municipal utility, financed this through loans and city capital, with political support due to its strategic importance. Effective project management ensured the investment stayed within budget.

Earlier, the Swedish government's Local Investment Programme (LIP) provided SEK 5.4 billion (~€600 million) for local environmental initiatives. Växjö secured LIP funding to expand biomass CHP capacity, notably Sandvik II (1996), reducing upfront costs. The Swedish National Energy Agency also supported related projects, such as a biogas plant. EU funding played a key role in innovation, with Växjö participating in the EU SESAC project (2005–2011), receiving part of its €10.4 million grant to implement advanced biomass solutions, district cooling, and environmental management systems. Additional grants from Sweden's Climate Investment Program (KLIMP) in the mid-2000s supported sustainable transport and efficiency efforts.

PROCESS

1
District Heating Foundation

In 1970, Växjö initiated the construction of a centralized district heating network.
By 1974, the Sandvik I plant, an oil-fired boiler with a small steam turbine, became operational, supplying heat to a limited downtown grid. Though entirely fossil-fueled, this system demonstrated the viability of centralized heating. The oil price shocks of the late 1970s spurred the city to seek alternative energy sources.

2
Biomass Conversion

In 1980, Växjö aimed to reduce oil dependency driven by cost and environmental concerns.
The city leveraged local forestry resources, co-firing wood chips and sawdust at Sandvik I.
By 1983, biomass supplied 80% of the plant's fuel, positioning Växjö as a pioneer in wood chip heating. The municipality expanded district heating, converting homes from oil heaters and growing its customer base.

Växjö's financial model relied on reinvesting VEAB's profits into system upgrades instead of distributing dividends, ensuring long-term sustainability despite long payback periods. Revenue came from heat and electricity sales, Nordic power market participation, and waste wood tipping fees.

Sweden's carbon tax (1991) further incentivized biomass by making fossil fuels more expensive. By leveraging municipal leadership, national and EU funding, and reinvested utility revenues, Växjö successfully financed its district heating transformation. Today, the system operates with competitive heating tariffs, proving the long-term economic viability of renewable district heating.

Impact

Växjö's transition to a renewable district heating system has delivered significant environmental, economic, and social benefits. The city has dramatically reduced carbon emissions, with fossil CO_2 levels per capita dropping by 58% from 1993 to 2017. The heating sector alone cut emissions by three-quarters, avoiding 249,000 tonnes of CO_2 annually. As a result, Växjö now boasts some of the lowest per capita emissions in Europe and is on track to becoming fossil fuel-free by 2030.

Currently, 90–95% of the city's heating demand is met by district heating, replacing thousands of oil and electric heaters with a highly efficient CHP system. With an efficiency rate of around 90%, it reduces energy consumption while ensuring reliable supply, even in winter. Additionally, nearly half of Växjö's electricity is now renewably generated, enhancing local energy security.

Economically, the transition has proven cost-effective. Heating tariffs remain stable, shielding residents from volatile fossil fuel markets. The shift to biomass has strengthened the local economy by keeping energy expenditures within the region—fuel payments support local forest owners, contractors, and bioenergy businesses.

3

Formalizing the Vision and Expansion

In 1996, the City Council adopted the "Fossil Fuel Free Växjö" goal. That year, the Sandvik II biomass combined heat and power (CHP) unit was constructed, running on over 95% biofuel.
The district heating network was extended to surrounding villages, utilizing small wood-chip boilers. In 1998, fiber-optic cables were installed alongside heat pipes, showcasing innovative infrastructure planning.

4

Optimization and Innovation

Efforts in the 2000s focused on efficiency and peak load management. In 2004, a large hot water accumulator was added to optimize energy storage.
By 2006, a district cooling network utilizing biomass-powered absorption chillers was introduced.
The EU-supported SESAC project in 2007 further advanced Växjö's clean energy reputation through solar PV integration and biomass gasification research.

5

Final Push to Fossil-Free

Between 2012–2015, Sandvik III, a new 105 MW_th biomass CHP unit, was constructed, replacing the last oil-fired capacity.
This was the city's largest investment, ensuring an uninterrupted transition.
By 2018–2019, fossil oil use was completely phased out, and the district heating system was declared fossil-free in December 2019.

This transition has driven regional growth, creating jobs in wood chip harvesting, transport, and equipment maintenance. While initial investments were high, long-term savings from using waste biomass and electricity sales have balanced costs.

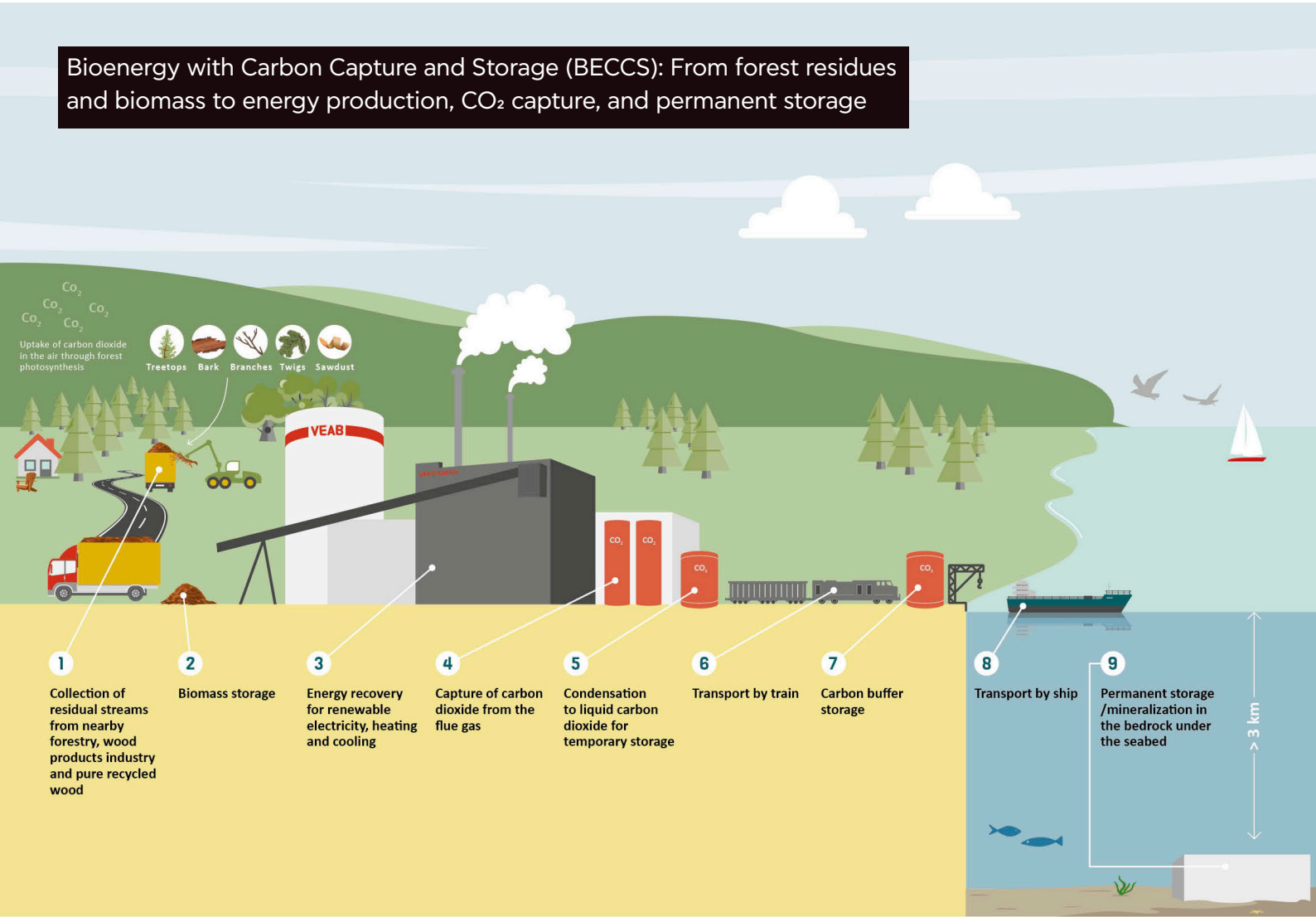
Beyond emissions reduction, the shift to biomass has improved air quality by eliminating sulfur and heavy metals from oil combustion. Växjö's success has gained global recognition, fostering civic pride and encouraging further sustainability initiatives. Overall, the project has created a cleaner environment, a stronger economy, and a more engaged community.

Success Factors

Political Leadership and Consensus: A unanimous commitment across political parties provided stability, ensuring long-term investments survived electoral cycles. The City Council's 1996 decision to pursue fossil-fuel independence unified efforts and demonstrated sustained leadership. Researchers highlighted that cross-party consensus was a crucial foundation for success.

Municipal Ownership and Integrated Planning: With the city owning its energy utility (VEAB), Växjö could prioritize environmental and social benefits over short-term profits. Public ownership enabled coordination between planners and the utility, such as integrating fiber-optic internet installation with heating infrastructure. This approach reduced costs and fostered public trust, as residents saw tangible benefits and transparency.

Bioenergy with Carbon Capture and Storage (BECCS): From forest residues and biomass to energy production, CO_2 capture, and permanent storage



Local Resource Availability: Situated in a heavily forested region, Växjö leveraged biomass from sawmills and forestry operations, making district heating cost-effective and fostering self-reliance. Sweden's early carbon tax (1991) further enhanced biomass competitiveness, reinforcing the city's sustainable strategy.

Public Engagement and Awareness: Växjö invested in environmental education and awareness campaigns, securing broad public acceptance. By displaying real-time emissions and performance data, the city built trust. Over time, sustainability became a point of local pride, encouraging voluntary participation.

Phased, Learning-by-Doing Approach: Instead of radical transformation, Växjö adopted an incremental strategy. Starting with co-firing wood in the 1980s allowed adjustments and minimized risks. Each phase incorporated lessons from previous ones, ensuring steady progress.

Barriers

Public Skepticism: Early on, citizens hesitated to connect to district heating, fearing costs and reliability issues. Växjö addressed this through education, financial incentives, and showcasing savings.

High Upfront Costs: Major infrastructure investments had long payback periods. Växjö secured grants (LIP, EU SESAC) and leveraged Sweden's green finance policies, framing costs as future investments.

Technical & Logistical Challenges: Reliable biomass fuel supply and system integration posed difficulties. Strict fuel quality controls, supplier contracts, and strategic scheduling helped ensure stability.

Institutional & Market Hurdles: Aligning the city-owned utility with sustainability goals required mandates prioritizing climate targets. Market fluctuations in electricity prices were managed by optimizing heat-led operations.

Cultural Change & Continuity: Long-term commitment was maintained by integrating sustainability into budgeting, monitoring, and international partnerships. This institutionalization ensured momentum beyond political terms.

Ultimately, Växjö's experience highlights that strong governance, public engagement, and adaptability are crucial for large-scale energy transitions.

Relevance for Kozani

Kozani can build a sustainable biomass supply chain by collaborating with farmers, forestry agencies, and the wood industry to utilize agricultural and forestry residues. Returning biomass ash to forests can enhance soil health and close resource loops, while also generating rural income.

The city's existing lignite-based district heating infrastructure offers a solid foundation for transformation. Växjö's example shows that retrofitting with biomass boilers or combined heat and power (CHP) units is feasible, allowing Kozani to primarily focus on fuel switching and technological upgrades. Centralized biomass heating can improve efficiency and enable electricity generation, maximizing environmental and economic benefits.

Strong political commitment and clear climate targets will be essential. Establishing a dedicated project entity within the municipal structure, similar to Växjö's utility VEAB, could effectively manage the transition and align public goals. EU funding instruments, particularly the Just Transition Fund, provide important financial support for this shift.

Technical solutions should respond to Kozani's milder winters, with options like heat storage and smart grid systems improving flexibility and performance. Public engagement from an early stage is critical to build trust and overcome possible resistance, as shown in Växjö's experience. With strategic planning and stakeholder collaboration, Kozani has the tools to successfully transform its district heating system into a sustainable, biomass-powered model.

Bibliography

1. City of Växjö (2010) – Environmental Programme 2010 https://www.crcresearch.org/book/export/html/3870

2. Chartier, C. (2015) – Energy Democracy: A Case Study of Energy Generation in Växjö https://www.diva-portal.org/smash/record.jsf?dswid=5606

3. Community Research Connections (n.d.) – Växjö, Sweden: The Greenest City in Europe https://www.crcresearch.org/book/export/html/3870

4. Interreg Europe (2021, January 22) – Lessons from Sweden: Welcome to Växjö Energy! https://energy-cities.eu/a-district-of-pamplona-reduces-citizens-energy-bills-by-e560-year/

5. Interreg Europe (n.d.-a) – Sandvik Biomass Tri-generation Plant Cluster- https://projects2014-2020.interregeurope.eu/potent/news/news-article/11025/lessons-from-sweden-welcome-to-vaxjo-energy

6. Interreg Europe (n.d.-b) – Växjö Energi: 100% Fossil Free Production of Heat and Power https://energy-cities.eu/a-district-of-pamplona-reduces-citizens-energy-bills-by-e560-year/

7. Nordregio (2016) – Växjö, Europe's Greenest City https://energy-cities.eu/a-district-of-pamplona-reduces-citizens-energy-bills-by-e560-year

8. Smart City Sweden (n.d.) – Sandviksverket Combined Power and Heating Plant – Växjö https://energy-cities.eu/a-district-of-pamplona-reduces-citizens-energy-bills-by-e560-year/

9. Växjö Energi AB (2013) – Växjö Energi investerar i Sandvik 3 https://energy-cities.eu/a-district-of-pamplona-reduces-citizens-energy-bills-by-e560-year/

10. Wilson, A. (2007) – Notes from Sweden #4: CHP and District Heating https://energy-cities.eu/a-district-of-pamplona-reduces-citizens-energy-bills-by-e560-year/

11. WWF (2012, March 1) – Växjö Local Energy: Local Ambitions Deliver World-Class Mitigation https://energy-cities.eu/a-district-of-pamplona-reduces-citizens-energy-bills-by-e560-year/

5 Salaspis LATVIA

Key Facts

<table>
<tr><td colspan="2">LOCATION
Salaspils, Latvia</td><td rowspan="2">RENEWABLE ENERGY CONTRIBUTION & MIX
94% of the district heat comes from renewable sources. Biomass thermal ~16%, with only ~6% from natural gas as fossil backup. In summer, solar can at times mee t 100% of the load, while in winter gas is used just for peak demand</td></tr>
<tr><td>CITY POPULATION
~22,000</td><td>POPULATION SERVED
~17,000 residents</td></tr>
<tr><td colspan="2">DISTRICT HEATING NETWORK LENGTH
~20.6 km</td><td rowspan="3">CO₂ EMISSIONS REDUCTION
~90% compared to 2012 levels</td></tr>
<tr><td colspan="2">ANNUAL THERMAL ENERGY PRODUCTION
~60,000 MWh</td></tr>
<tr><td colspan="2">TOTAL INVESTMENT COST
€7.1–7.3 million</td></tr>
<tr><td colspan="3">YEAR OF IMPLEMENTATION
2018–2019</td></tr>
</table>

The challenge

Salaspils, a small city near Riga, faced a common challenge for cold-climate European cities: a heating system historically reliant on fossil fuels. The local district heating (DH) network, dating back to the Soviet era, was in poor condition by 2011 with 100% of heat production dependent on fossil fuel (natural gas) and outdated infrastructure. This legacy system led to high greenhouse gas emissions and left the city vulnerable to volatile gas prices and fuel supply risks. Heating is the largest energy-consuming sector in Latvia, and many centralized systems suffered from aging equipment and insufficient use of renewables. Salaspils was no exception: the old gas-fired boilers were inefficient and expensive to run, causing concern over rising heat tariffs and energy security.

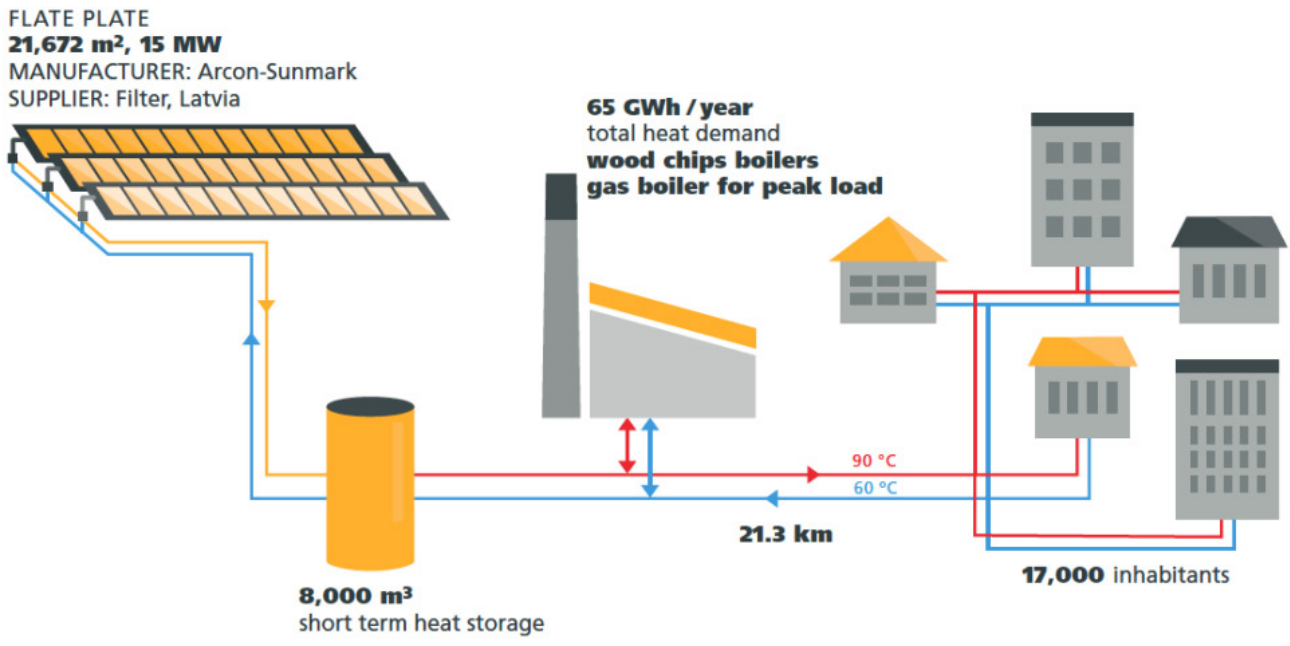
By the mid-2010s, multiple factors pushed Salaspils to seek a cleaner, more resilient solution. EU climate policies provided a strong impetus – Latvia, like all EU members, faces targets to cut emissions and increase renewables by 2030, on the path to EU's climate neutrality goal by 2050. Salaspils had been a signatory of the Covenant of Mayors since 2011, voluntarily committing to CO_2 reductions. The national climate and energy plan (2021–2030) also called for decarbonizing heating. Thus, local leaders felt pressure to modernize the DH system in line with these goals.

In addition to environmental drivers, economic and security motivations were at play. Latvia imports natural gas, so reducing reliance on imported fossil fuel was seen as a way to improve local energy independence. The volatility of gas prices (and the prospect of future carbon taxes on fossil fuels) threatened the affordability of heat for residents. Salaspils wanted to stabilize and lower heating costs for the community. However, transitioning to renewables with the existing setup was impossible due to obsolete equipment and lack of alternative fuel capacity. The challenge, therefore, was to comprehensively modernize the district heating system – replacing or retrofitting infrastructure and changing the energy mix – to achieve sustainability, reliability, and cost-effectiveness.

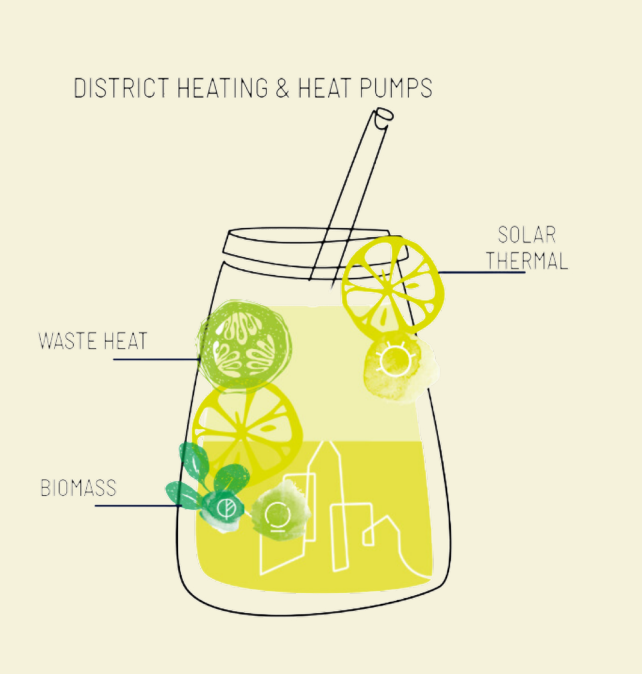
Solution

The decarbonization solution implemented in Salaspils is a hybrid renewable district heating system combining solar thermal collectors, biomass heating, and thermal storage, with a small fraction of natural gas for backup. The municipal heating company Salaspils Siltums oversaw the installation of a 21,672 m² solar collector field (flat-plate collectors, ~15 MW peak capacity) coupled with a massive 8,000 m³ insulated water storage tank. This solar thermal park – one of the largest in Europe – harnesses the sun's energy to provide a substantial portion of the town's heat demand.

In parallel, the DH system's main base-load supply was shifted to biomass. A new wood-chip boiler house was built, equipped with a 3 MW biomass boiler (in addition to an existing 7 MW wood-chip boiler that had been installed a few years prior). These biomass boilers now handle the bulk of heating needs, especially in winter. The existing gas boilers were retained solely as a backup and peak load source (for example, on the coldest days or if other units are down). By 2023, this configuration allowed Salaspils to produce 94% of its heat from renewables, essentially using gas only for peak shaving.



Crucially, the system includes integration and control technologies to ensure reliability despite the variability of renewable sources. The 8,000 m³ thermal storage tank acts as a buffer: it is charged with excess heat when production (especially solar) exceeds immediate demand, and discharged when needed, thus balancing supply and demand. This design solved the common issue of solar output fluctuations by storing daytime solar heat for use at night or during cloudy periods. In essence, during sunny summer days the solar field can heat the storage to high temperatures, and that stored heat can provide hot water to the network



after sunset. A glycol-based heat transfer system connects the solar collectors to the storage to prevent freezing and corrosion, given Latvia's cold winters. All heat sources are managed by an automated control system, which was introduced early in the process . Real-time data acquisition allows the utility to monitor production, demand, and network losses continuously. The control logic prioritizes the solar and biomass sources: in summer, the solar collectors often supply nearly 100% of the heat demand (with biomass boilers turned off to avoid inefficient low-load operation).

In intermediate seasons, solar energy still contributes significantly on clear days, reducing the biomass fuel consumption. In winter, the biomass boilers provide the

PROCESS

1
Initial Planning and Vision

Salaspils Siltums first envisioned solar thermal integration in 2014 after leadership attended an international solar district heating conference in Denmark.
Following extensive research and a detailed feasibility study in January 2017, the technical and economic viability of a large-scale solar plant was confirmed. By February 2017, the utility secured essential EU co-funding, aligning with European energy efficiency priorities.

2
Early Network Modernization

Before integrating solar, major upgrades prepared the system. In 2012, outdated gas boilers were replaced with efficient models, and pipelines were refitted with pre-insulated pipes to minimize heat loss.
A 7 MW biomass boiler was added in 2015, followed by a flue-gas condenser in 2016 to boost heat recovery. By 2017, these improvements enabled a 56% renewable heat supply, ready for solar integration.

3
Project Financing and Stakeholder Alignment

The €7.3 million project was financed through a blend of EU Cohesion Fund grants (€2.7 million), a commercial loan from SEB Bank (€2.8 million), and local municipal investment (€1.8 million).
Effective stakeholder engagement, led by project head Ina Berzina-Veita and strongly supported by local authorities, facilitated regulatory approvals and industry support.

bulk of heat, but even then the solar field contributes whenever sunlight is available (for example, on a sunny winter noon, solar output can supplement the boilers). The gas boilers only fire up to cover peak loads in very cold weather or during maintenance, ensuring the system's reliability even in extreme conditions. This smart integration means the different technologies work in tandem: solar energy has effectively replaced a large portion of what would otherwise be fossil fuel output, biomass provides a renewable and dispatchable base load, and gas is an emergency/top-up source.

Funding

The Salaspils project's financing is a prime example of how blended funding can drive a municipal clean energy project. The total investment for the solar thermal integration (including the solar field, storage tank, and biomass boiler house) was approximately €7.1–7.3 million. To fund this, Salaspils Siltums and the city assembled a package combining European Union grants, a commercial bank loan, and own funds:

About €2.7 million (roughly 37% of the cost) came as a grant from the EU Cohesion Fund, part of the EU structural funds aimed at supporting infrastructure in member states. This grant was secured through Latvia's operational program for energy efficiency and renewable energy (2014–2020 period). Essentially, the EU covered a significant portion of the capital cost because the project aligned with EU objectives (reducing emissions, increasing renewable energy use). The grant drastically improved the business case, lowering the amount of money that needed to be borrowed or injected by the company.

An additional €2.8 million was financed via a loan from SEB Bank, a major Baltic bank. The loan was arranged on favorable terms (likely low interest and long tenure), as the project was considered low-risk and "green." According to Salaspils'

4

Implementation and Technical Integration

Physical implementation began swiftly in mid-2018. Danish company Arcon-Sunmark provided 1,720 solar collectors, and Latvian firm Filter managed their on-site installation alongside the 8,000 m³ thermal storage tank and new biomass boiler.
Through efficient management, prefabrication, and phased integration, the system was operational by September 2019, ahead of schedule and without disruptions to heat supply.

5

Governance and Community Engagement

The municipal board and city council actively oversaw the project, supported by Salaspils Mayor Raimonds Cudars.
Regular public outreach through local media and social platforms secured community buy-in by highlighting cost savings and environmental benefits.
National political backing, including high-profile endorsement, also facilitated smooth approvals and expedited administrative processes.

6

Addressing Challenges

Initial skepticism about solar viability in Latvia was overcome by showcasing international examples and a successful local pilot in 2017. Expert partnerships ensured smooth technical integration through testing and phased commissioning.
Close collaboration with municipal and national authorities streamlined permitting and reduced financial risks, enabling timely, cost-effective project completion ahead of the 2020 heating season.

director, banks were “happy to finance green projects” with good conditions, indicating that the project’s sustainability focus made it attractive to lenders.
The loan is being repaid over time from the savings and revenue of the heating company – effectively leveraging future operational savings to pay for the upfront investment.

The remaining portion (~€1.6–1.8 million) was covered by Salaspils Siltums’ own funds or equity, which could include retained earnings or a capital contribution from the municipality. Over the years, the utility had a policy of reinvesting profits (reportedly 50% of profit goes back into system development), which likely helped accumulate some funds for this project. Local co-investment also demonstrated commitment, which probably strengthened the grant application (showing that the city had “skin in the game”).

Success Factors

Strong Political Will and Climate Alignment: Salaspils’ transformation was driven by alignment with EU climate goals and Latvia’s national energy strategy. As a signatory of the Covenant of Mayors since 2011, Salaspils committed early to ambitious CO_2 reduction targets. This political commitment created policy continuity and prioritized heating decarbonization within municipal strategy, ensuring projects were not derailed by short-term pressures.



Aerial view of the Salaspils District Heating plant in Latvia - showing the solar thermal field, heat storage tank, boiler facility, and supporting infrastructure of the renewable energy-based district heating network

Municipal Utility Leadership and Long-Term Vision: The municipally owned Salaspils Siltums was a decisive asset. Its strategic policy of reinvesting 50% of profits into system upgrades created a financial buffer and technical readiness for large-scale renewable integration. Its local ownership structure fostered accountability and allowed rapid decision-making aligned with public interest.

Smart Technical Integration of Renewable Sources: A hybrid system combining solar thermal (15 MW peak), biomass boilers (10 MW total), and an 8,000 m³ thermal storage tank enabled year-round flexibility and energy security. Automated controls optimized the dispatch of solar and biomass, with natural gas used only for peak loads. The thermal tank was critical to balancing solar variability and maintaining supply reliability even in winter conditions.

Effective Use of EU and Blended Financing: The project's financing model was a best-practice example of combining EU Cohesion Fund grants (€2.7 million), commercial bank loans (€2.8 million), and municipal own funds (~€1.6 million). This blended model reduced upfront cost burdens while improving project bankability and enabling long-term affordability.

Public Communication, Trust, and Affordability Gains: Salaspils Siltums engaged the community proactively, emphasizing benefits like reduced heat tariffs (by ~5%) and greater price stability amidst volatile fossil fuel markets. Delivering immediate cost savings alongside environmental benefits generated widespread acceptance and trust in the transition process.

Barriers

Lack of Local Experience with Solar District Heating: Being Latvia's first large-scale solar DH project, there was no local technical precedent. Salaspils mitigated this through knowledge transfer partnerships with Danish experts, pilot projects, and capacity building within Salaspils Siltums.

Legacy Infrastructure Constraints: The aging Soviet-era network suffered from high heat losses. However, prior investment in pipeline insulation and efficiency improvements reduced losses and enabled integration of low-temperature renewable heat sources without extensive retrofitting.

High Upfront Capital Costs: The scale of investment required could have been prohibitive. Strategic use of EU grants and bank loans, supported by a clear and credible business case, ensured financial viability.

Operational Learning Curve and System Complexity: Integrating multiple renewable sources and advanced control systems required staff training and operational adaptation. Salaspils addressed this through technical education, real-time monitoring systems, and phased implementation to manage risk during the learning process.

Relevance for Kozani

Diversifying heat sources is essential for Kozani's transition from lignite-based district heating to renewables. Salaspils moved from gas-only to a hybrid system with solar thermal, biomass, and gas backup, improving reliability and reducing risks. With far higher solar irradiance than Latvia, Kozani could prioritize solar thermal — installing large collector fields on repurposed lignite sites and using seasonal storage to shift summer heat to winter demand. Biomass from agricultural residues or sustainable forestry could provide additional winter baseload.

Accessing EU funding is critical. Kozani, as part of a Just Transition region, is well-positioned to leverage resources from the Just Transition Fund or Green Deal tools — provided it builds a strong, EU-aligned proposal.

Upgrading infrastructure will be equally important. Salaspils improved insulation and installed digital controls for smarter energy management — measures Kozani should replicate to enable efficient integration of renewables.

Building community trust and rolling out changes gradually is another key lesson. Salaspils engaged citizens early, communicated benefits clearly, and implemented renewables step by step, ensuring uninterrupted service. Kozani can follow the same approach — starting small, proving success, and scaling up in phases to deliver a stable, secure, and sustainable heating future.

Bibliography

1. **Lebedeva, K. et al (2023) – "Solar district heating system in Latvia: A case study." Journal of King Saud University - Science.** Academic study analyzing Salaspils' solar DH performance with simulations **https://jksus.org/solar-district-heating-system-in-latvia-a-case-study**

2. **Salaspils Siltums – Development & Technologies – Official company information on the history and technologies of Salaspils' DH system** **https://salaspilssiltums.lv/en/par-uznemumu/attistiba-un-ieviestas-tehnologijas**

3. **Covenant of Mayors (2023) – "Salaspils' solar heat detox."** Profile of Salaspils on the EU Covenant of Mayors website highlighting its 88% heat CO_2 reduction and journey since 2017 **https://eu-mayors.ec.europa.eu/en/salaspils-speedy-heat-detox**

4. **Bärbel Epp (2019) – "15 MW SDH plant inaugurated in Latvia."** Solarthermalworld.org article reporting Salaspils' solar field launch, technical specs, and financing **https://solarthermalworld.org/news/15-mw-sdh-plant-inaugurated-latvia**

5. **CEE Bankwatch (2019)** – "First large-scale solar district heating plant in the Baltics opens in Latvia." Press release/blog detailing project cost (€7.08 M), funding (EU Cohesion €2.73 M), and expected impacts (20% solar share, 5% tariff cut) **https://bankwatch.org/blog/first-large-scale-solar-district-heating-plant-in-the-baltics-opens-in-latvia**

6. **District Energy Climate Awards (2017)** – Salaspils case summary (Modernization Award) emphasizing 90% renewables in DH, largest solar field in Eastern Europe, and replication potential via EU co-financing **https://www.districtenergyaward.org/wp-content/uploads/2021/06/64a576aaa511448999e06bdcbc217e52tmp1.pdf**

7. **The Green Tank (2024)** – "Squaring the circle in Western Macedonia: ...district heating..." Opinion piece critiquing Kozani's gas CHP plan as climate- and cost- risky **https://thegreentank.gr/en/2024/10/16/district-heating-western-macedonia-agreement-article**

8. **WWF Greece Report (2021)** – "Sustainable District Heating Solutions for Western Macedonia." Study exploring 100% RES heating scenarios (solar thermal, heat pumps, etc.) for Kozani/Ptolemaida **https://wwfeu.awsassets.panda.org/downloads/district_heating_western_macedonia_en.pdf**

9. **Latvia National Energy & Climate Plan 2021–2030 –** Government document outlining targets for renewable heating and reducing fossil fuel use in district heating (context for projects like Salaspils) **https://jksus.org/solar-district-heating-system-in-latvia-a-case-study**

6 Ghent BELGIUM

Key Facts

<table>
<tr><td colspan="2">LOCATION
City of Ghent, East Flanders, Belgium</td><td rowspan="2">RENEWABLE ENERGY CONTRIBUTION & MIX

New networks use ~100% waste heat and biogas
Legacy city network is gas-CHP (0% renewable, but ~35% more efficient than individual gas boilers)</td></tr>
<tr><td>CITY POPULATION
~264,000</td><td>POPULATION SERVED
~1,500 - 5,000 people</td></tr>
<tr><td colspan="2">DISTRICT HEATING NETWORK LENGTH
~27 km total (23 km main city network + ~4 km industrial waste-heat loop in port area)</td><td rowspan="3">CO_2 EMISSIONS REDUCTION
~5,800 tCO_2 cut per year through energy renovations (2014–2019).
District heating supply yields ~34% lower CO_2 emissions compared to individual heating systems</td></tr>
<tr><td colspan="2">ANNUAL THERMAL ENERGY PRODUCTION
~70 GWh</td></tr>
<tr><td colspan="2">TOTAL INVESTMENT COST
~€130 million</td></tr>
<tr><td colspan="3">YEAR OF IMPLEMENTATION
1958 - first DH system launched, 2014 - major expansion of clean heating & retrofit initiatives began</td></tr>
</table>

The challenge

Ghent's motivation to move away from fossil gas is driven by climate goals, energy security, and social concerns. In 2021, residential energy use (mainly for heating) made up about a quarter of Ghent's CO_2 emissions. The vast majority of homes are heated with imported natural gas, exposing residents to volatile prices and high carbon intensity. Indeed, the city counts ~112,000 gas connections and residents spend over €134 million on gas annually. Continuing this status quo conflicts with Ghent's pledge to be carbon-neutral by 2050.

The housing stock in Ghent is old and energy-inefficient – many 19th-century terraced houses and post-war buildings with poor insulation. This results in high heat demand and wasted energy. Cold, inefficient homes also exacerbate energy poverty: lower-income households struggle to afford adequate heating.

Ghent recognizes that a climate-neutral transition must also address this social challenge, ensuring vulnerable residents are not left behind. In recent years, rising fossil gas prices (and a cost disparity where electricity can cost ~5× more per kWh

than gas) have made the switch to clean heating even more daunting without support.

Heating-related emissions also impact local air quality. By phasing out gas boilers and improving buildings, Ghent can cut urban NO_x/CO_2 pollution and improve public health. Additionally, hotter summers are increasing cooling needs, which gas boilers cannot provide – but electric solutions (like heat pumps) can double for cooling. Overall, the challenge is multifaceted: retrofit an aging building stock, shield residents from fuel poverty, and replace a city-wide dependence on gas with sustainable heating – all while keeping the transition affordable and equitable.

Solution

Ghent is addressing the challenge of reducing its carbon footprint and phasing out fossil fuels with a multifaceted approach aimed at making its buildings more energy-efficient and heating systems fossil-free. One of the key initiatives is "De Energiecentrale," a city-run one-stop-shop designed to help residents and co-ops future-proof their buildings. The service offers free energy audits, personalized renovation coaching, and financial support to help homeowners transition to green heating systems, such as heat pumps and solar thermal. In addition to technical advice, the Energiecentrale assists with accessing grants and low-interest loans, removing financial barriers to renovation. Special attention is given to vulnerable households, offering free energy scans and interest-free loans for low-income families to afford efficiency upgrades and heating replacements. The program has already helped thousands of homeowners make their homes more energy-efficient and gas-free by 2024.

Ghent has also led the way in implementing renewable district heating in new developments, notably at the De Nieuwe Dokken eco-district. This innovative neighborhood is powered by a 4th-generation district heating system that draws heat from renewable or recovered sources. Approximately two-thirds of the heat comes from industrial waste heat sourced from a nearby soap manufacturing plant, while the remaining third is derived from locally harvested sewage heat and biogas. The heat is distributed through a closed-loop network that serves the entire district, eliminating the need for individual boilers in homes. In addition to heating, the district integrates solar power and a district battery, which also powers heat pumps and shared electric vehicles. The governance model of the system is notably social: when residents purchase a home in De Nieuwe Dokken, they automatically become shareholders of DuCoop, the cooperative utility that owns and operates the system. This model ensures that residents benefit from stable and low heating costs, contributing to a sense of ownership and community involvement.

Another exemplary project in Ghent is the Cohousing Kerselaar in Oostakker, which was completed in 2017. This cooperative housing development features a fully electric, gas-free design with a mini geothermal heat network at its core. The

heating system is powered by a central ground-coupled heat pump located in the common building, which feeds low-temperature heat to each home's underfloor heating system. The buildings are constructed to passive-house standards, ensuring optimal energy efficiency. Each home also includes a small booster heat pump to provide domestic hot water. The Kerselaar project is a pioneering example of a private micro-district heat network in Flanders and highlights the potential of community-led, decentralized heating solutions.

In addition to these projects, Ghent's Klimaatstad program supports the creation of energy communities to manage local energy generation and consumption. Initially focused on solar power projects like "Buurzame Stroom," this program is now expanding to include shared heating and cooling systems. The city encourages residents to form cooperatives or associations to invest in these solutions, with the goal of creating a network of "fossil-free islands" throughout the city. Each neighborhood's solution can differ based on its unique needs, whether it be a network of individual heat pumps or a shared geothermal loop.

The city supports these efforts with its "Check je Huis" tool, which helps residents identify green heating options for their homes, and renovation coaches who guide them on which heating system—air-source, ground-source, or others—best fits their situation. By combining deep renovations with the deployment of heat pumps and small-scale district heating systems, Ghent is creating a diverse, integrated approach to phasing out gas and fostering sustainable energy solutions across the city.

Ultimately, Ghent's strategy represents a comprehensive mix of demand reduction through building retrofits and supply transformation via district heating and heat pumps. This approach relies on both top-down infrastructure and bottom-up engagement, ensuring that every neighborhood has a tailored, sustainable solution to reduce its carbon footprint and transition to a fossil-free future.

PROCESS

1

Establishing the One-Stop-Shop

In 2013, Ghent launched De Energiecentrale - building on earlier local energy initiatives - evolving from basic renovation advice to a full support center.
Key steps included training renovation coaches, creating a helpdesk, establishing a Climate Fund, and partnering with the Flemish Energy Agency to offer zero-interest loans, particularly for low-income households.

2

Scaling Through Neighborhood Campaigns

Ghent's participation in the EU LIFE BE REEL! project from 2018 helped scale up energy renovation efforts. The city launched neighborhood campaigns with door-to-door outreach, enabling group purchases of insulation, heat pumps, and solar PV. Its Energiecentrale streamlined coordination between homeowners, social housing providers, and vetted contractors through a "Marketplace," improving workflow efficiency and facilitating large-scale retrofits.

Funding

Municipal Investment and Revolving Funds: Ghent's transition strategy is underpinned by substantial municipal funding. The city allocates recurring budgets for the operation of De Energiecentrale, treating it as a long-term public service. A key financial tool is the revolving Climate Fund, which capitalizes low-interest renovation loans, making retrofits accessible to a wide public. The city also co-finances social housing projects—such as the €212,000 contribution to the gas-free apartments on Kraankinderstraat—providing essential match funding for larger grant schemes.

Regional and EU Support: Additional funding comes from the Flemish Government's Energy and Climate Pact, which supported projects like the Muide geothermal pilot with a €465,000 grant. The region also subsidizes zero-interest "Energiehuis" loans for low-income households, with Ghent pioneering this program by covering interest through regional support.

At the European level, **EU LIFE and Horizon 2020 programs** played a key role. The BE REEL! project supported Ghent's neighborhood-based renovation campaigns, while RENERGETIC and Interreg helped fund the smart energy infrastructure at De Nieuwe Dokken—including heat pumps, storage, and monitoring systems.

Citizen Co-Financing and Private Sector Involvement: Ghent actively promotes citizen investment. In De Nieuwe Dokken, the DuCoop cooperative raised capital through shares sold to residents and ethical investors, with heat bills and connection fees servicing the investment. At Cohousing Kerselaar, residents financed the shared ground-source heat pump system collectively—turning energy users into energy owners. The city facilitates such initiatives through legal templates

3

Integrating Heating Infrastructure into Urban Planning

Ghent integrated renewable heat planning into urban development, starting with the De Nieuwe Dokken project in 2012. Feasibility studies led to the creation of DuCoop in 2016 to design, finance, and operate the system.
Construction (2019–2024) aligned with housing rollouts, while residents participated through info sessions and governance meetings, fostering trust and cooperation.

4

Piloting Small-Scale and Retrofit District Heating

Building on its 2023 warmtevisie map, Ghent piloted geothermal heating in retrofit areas like Muide-Meulestede, drilling boreholes under a sports field to serve nearby homes.
Workshops engaged residents, while coordination involved city departments, WoninGent, private owners, and funders. Ghent also partnered with DSO Fluvius to align grid upgrades with rising heat pump demand.

and cooperative models. Private utilities have also contributed. Luminus invested €5 million to expand Ghent's main DH network with a CHP and large heat pump, receiving operational rights in return.

Blended Finance Strategy: Ghent combines local, regional, EU, and citizen funding, while tapping federal renovation subsidies and EU Cohesion Funds (e.g. for the Rooseveltplaats battery project). This stacked approach spreads risk and ensures both public-interest and investor-driven projects can advance. Notably, DuCoop's energy infrastructure cost ~€15 million, while the city aims to revolve €30 million in renovation loans by 2030—illustrating Ghent's commitment to long-term, inclusive financing.

Impact

Ghent's integrated approach is delivering tangible results across environmental, social, and economic dimensions. Energy savings and emissions reductions are steadily increasing as thousands of buildings are upgraded for efficiency or transitioned to renewable heating. Through De Energiecentrale, more than 17,000 households have undertaken energy-saving renovations, with average energy reductions of up to 50% per home. These improvements have contributed to a cumulative reduction of approximately 5,800 tonnes of CO_2 annually in the residential sector.

The one-stop-shop has enabled deep retrofits, including insulation, glazing, and heat pump installations, which not only reduce carbon but significantly lower utility bills. In social housing, newly constructed gas-free complexes—such as the 26-unit development with an E-score of 20—consume 50–70% less energy than older buildings, offering both climate benefits and affordability for low-income tenants. Citywide, Ghent's residential CO_2 emissions are beginning to decline as fossil gas boilers are systematically phased out.

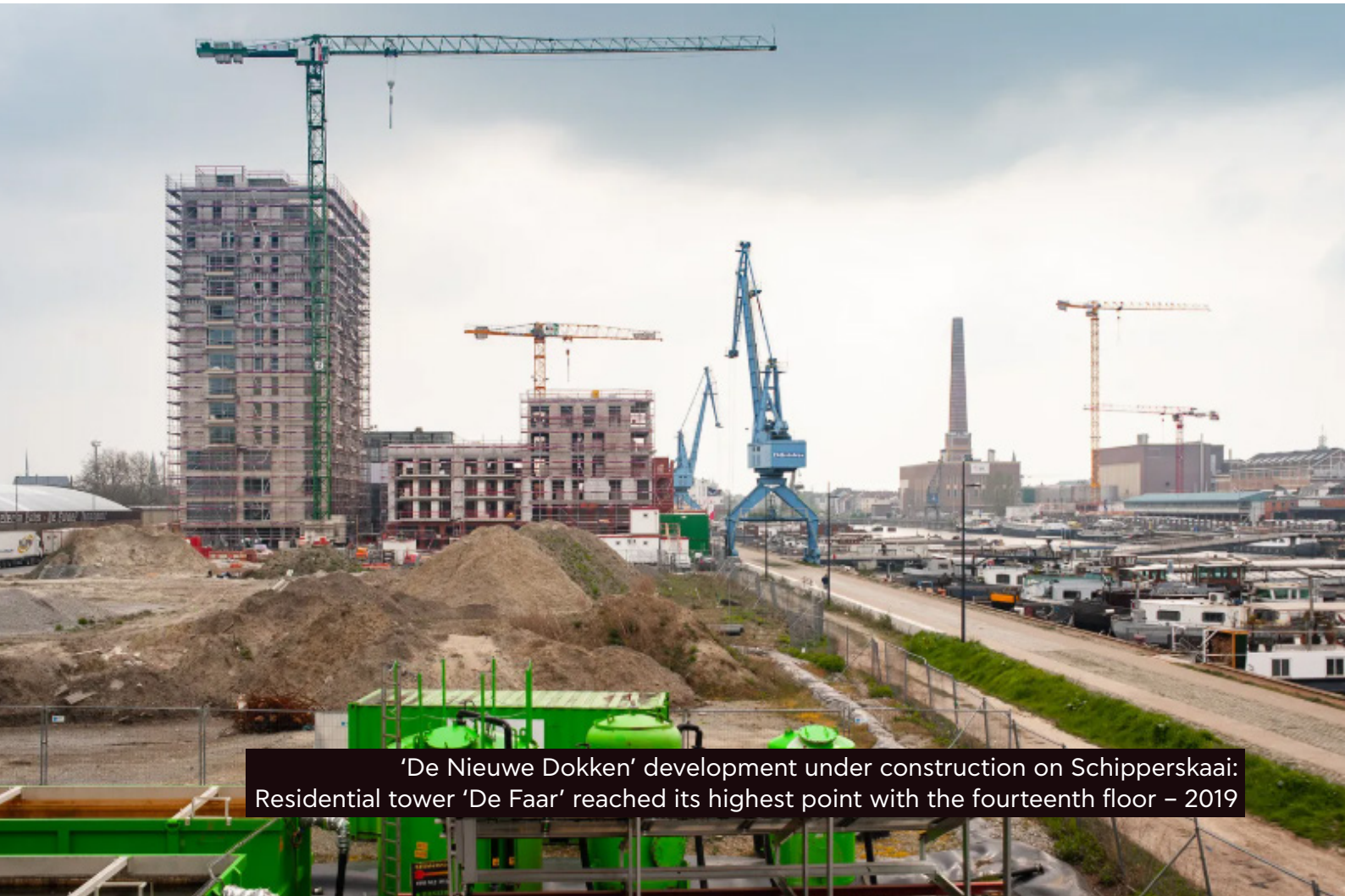
The rollout of renewable heat networks has further demonstrated viable, scalable alternatives. At De Nieuwe Dokken, 400 households now receive heating and hot water via a low-temperature district system that recovers industrial and biogenic waste heat. With an annual capacity of about 4,500 MWh, the system avoids an estimated 900 tonnes of CO_2 each year. Residents also benefit from heating costs around 20% lower than the city average, thanks to high system efficiency and the cooperative model of ownership. Smaller-scale initiatives like Cohousing Kerselaar—which operates a shared ground-source heat pump—have shown that collective systems are feasible even at the scale of a dozen homes. These examples have inspired replication in projects like Bijgaardehof and informed Ghent's broader strategy on collective installations.

Social outcomes are equally strong. Over 10,000 free energy scans and nearly 550 zero-interest loans have helped hundreds of vulnerable households reduce their bills by 20–30%, improving comfort and financial resilience. Projects like DuCoop have engaged citizens directly as co-investors and co-managers of local energy infrastructure. The transition has also generated green jobs, particularly in construction and energy services. Overall, Ghent's model shows that decarbonization and social justice can be pursued together—by linking local engagement, affordability, and low-carbon technology in a just, inclusive transition.

Success Factors

Political Commitment and Strategic Vision
Ghent's clear climate goals—paired with its long-term warmtevisie—offered a roadmap for transitioning off fossil fuels. High-level political support enabled city departments to coordinate effectively, commit resources, and lead cross-sectoral collaboration.

Institutional Anchor: De Energiecentrale
The creation of the one-stop-shop Energiecentrale was pivotal. By centralizing renovation guidance, technical advice, and financial tools, the city made it significantly easier for residents to act. The personalized approach—free renovation coaches—built trust and momentum that policy alone could not achieve.



'De Nieuwe Dokken' development under construction on Schipperskaai: Residential tower 'De Faar' reached its highest point with the fourteenth floor – 2019

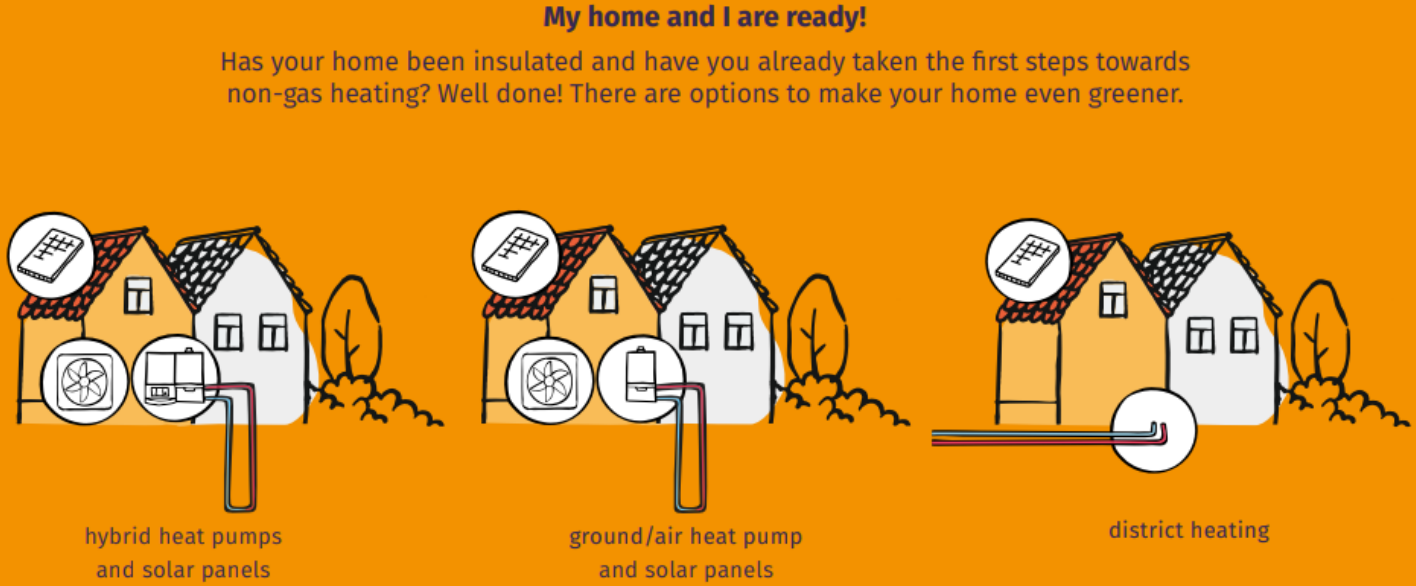
Integrated Urban Planning
Tying social housing construction and neighborhood redevelopment directly to energy and heating infrastructure allowed Ghent to synchronize new developments with renewable heat networks. This alignment made long-term planning more efficient and climate-responsive.

Community Engagement and Ownership Models
Public participation was a strength. Projects like Nieuwe Dokken and local heat pilots were co-designed with residents, housing companies, and local businesses. The cooperative model (e.g. DuCoop) turned potential resistance into active ownership and buy-in.

Technical and Financial Innovation
Partnerships with universities, EU programs, and startups enabled the piloting of hybrid heat sources and 4th-generation district heating. A multi-tier financing model—combining municipal, regional, EU, and citizen capital—lowered risk and made both retrofits and new heat networks feasible.

Barriers

Economic Challenges: Energy Pricing
Electricity's higher cost (partly due to taxes) made heat pumps less attractive compared to gas. Ghent addressed this by promoting excellent insulation, hybrid systems, and collective heat solutions to improve cost-effectiveness while lobbying for national pricing reform.



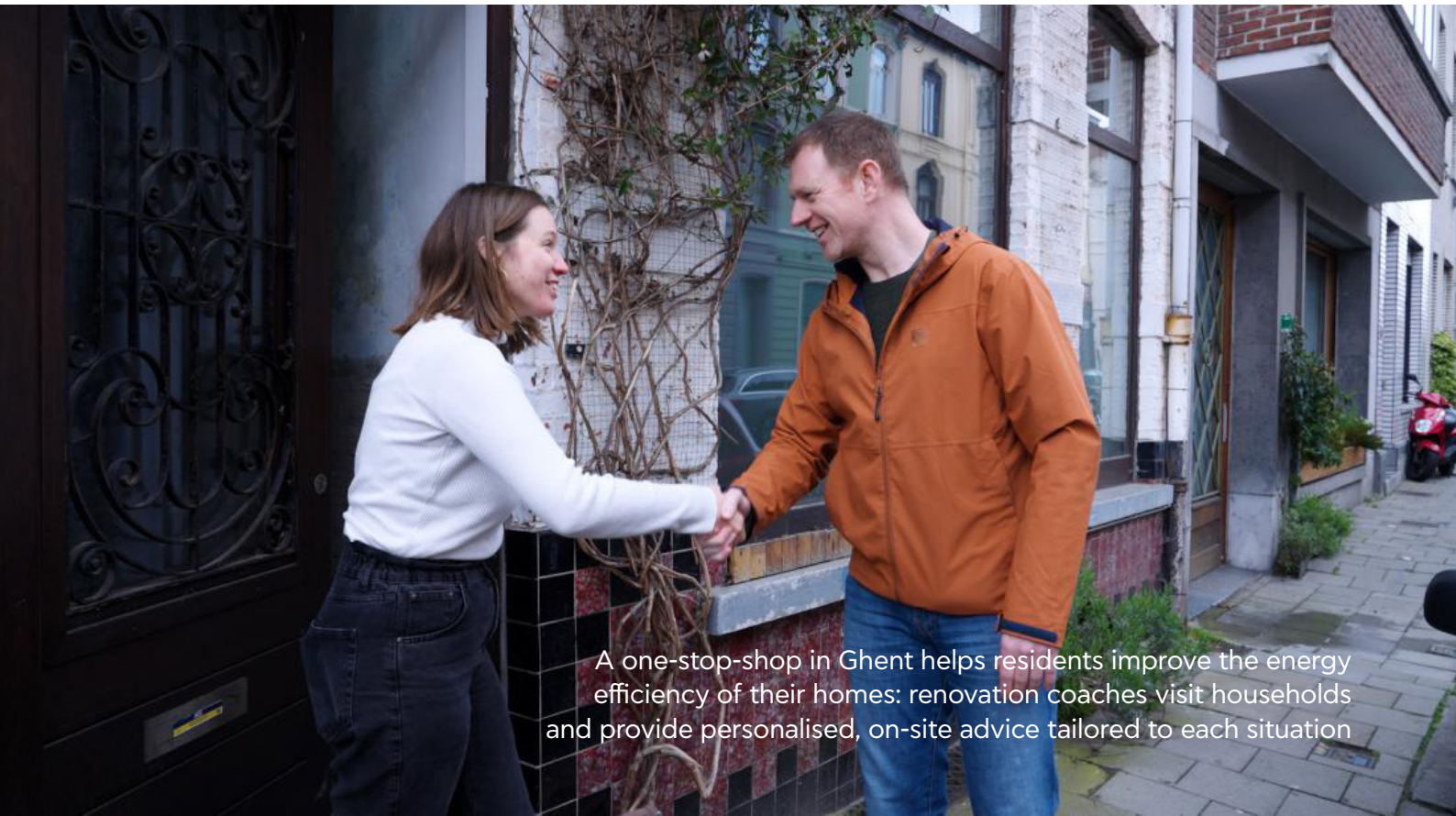
Pathways for Ghent Households to Transition to Non-Gas Heating by 2050

Behavioral Inertia and Complexity
Many residents hesitated to renovate due to uncertainty or perceived difficulty. Energiecentrale tackled this using behavioral insights, clear guidance, and logistical support, helping people move from indecision to action.

Technical Constraints in Dense Areas
Installing systems in older, compact neighborhoods posed physical challenges (e.g. space for heat pumps, street works). Pilots like the Muide geothermal project helped build acceptance and demonstrate feasibility while mitigating disruption.

Regulatory and Infrastructure Limitations
Grid capacity for electrification remains a concern. Ghent coordinates closely with grid operator Fluvius and is exploring thermal storage and peak-shaving. Regulatory adaptation was also needed—such as legal frameworks for cooperatives and low-temperature heating—which the city addressed through continuous engagement with regional authorities.

In sum, Ghent's success relied on visionary leadership, integrated delivery structures, active citizen roles, and creative funding. Despite clear barriers, the city's hands-on, adaptive approach has shown how urban heating transitions can be both ambitious and achievable.



A one-stop-shop in Ghent helps residents improve the energy efficiency of their homes: renovation coaches visit households and provide personalised, on-site advice tailored to each situation

Relevance for Kozani

Combining multiple solutions rather than relying on a single technology is essential for Kozani's heating transition. Energy efficiency, decentralized systems, and strategic infrastructure upgrades must go hand in hand. Establishing a one-stop-shop, similar to Ghent's Energiecentrale, could guide households on insulation, heating upgrades, and financing options — critical to protecting vulnerable residents from high energy costs during the shift away from lignite.

Reducing heating demand through deep retrofits would make renewable or low-temperature energy sources more viable. Restructuring Kozani's existing district heating network into smaller zones supplied by geothermal, biomass, or heat pumps mirrors Ghent's experience with communal systems like Muide or Nieuwe Dokken. Kozani could tap into local resources, such as shallow geothermal under public areas or waste heat from industry, while new or retrofitted buildings could adopt decentralized, fossil-free systems.

Creating a local energy cooperative, inspired by Ghent's DuCoop, could drive projects through citizen investment and collective ownership, strengthening participation and trust. Crucially, Kozani can leverage Greece's Just Transition mechanism to secure funding and policy support, adopting an integrated approach that combines building renovation, renewable heating, and community engagement to deliver a resilient and socially inclusive energy future.

Bibliography

1. **Stad Gent (2024). Gent gaat voor een gasloze toekomst –** City of Ghent news release outlining the 2050 fossil-free heating vision and heat zoning approach **https://stad.gent/nl/groen-milieu/nieuws-evenementen/gent-gaat-voor-een-gasloze-toekomst**

2. **European Commission (2024).** One-stop-shop for energy renovation advice in Ghent **https://sustainable-energy-week.ec.europa.eu/news/one-stop-shop-energy-renovation-advice-ghent-announced-finalist-2024-european-sustainable-energy-2024-05-07_en**

3. **Stad Gent (2023).** Persbericht: 26 nieuwe sociale woningen – Kraankinderstraat **https://www.thuispuntgent.be/sites/default/files/202304_Oplevering%20Kraankinderstraat_0.pdf**

4. **DuCoop (n.d.).** DuCoop Initiatives – Nieuwe Dokken **https://ducoop.be/en/initiatives**

5. **De Grote Verbouwing (2022). De Nieuwe Dokken** **https://degroteverbouwing.eu/en/building+blocks/de+nieuwe+dokken**

6. **Ecobouwers (2017). Woning en paviljoen te cohousing Kerselaar** **https://www.ecobouwers.be/woningen/woning-en-paviljoen-te-cohousing-kerselaar**

7. **Bouwkroniek (2022). Voetbalveld Standaard Muide wordt warmtebron voor buurt** **https://bouwkroniek.be/duurzaamheid/voetbalveld-standaard-muide-wordt-warmtebron-voor-buurt-49791**

8. **VRT NWS (2024). Gent wil 4.500 gebouwen/jaar van gas op duurzame alternatieven** **https://www.vrt.be/vrtnws/nl/2024/04/19/gent-energietransitie-klimaatneutraal-fossiele-brandstof-aardgas/**

9. **Renergetic EU Project (2021).** New Docks (Ghent) Pilot Description **https://www.renergetic.eu/new-docks**

10. **BE REEL! Project (2019).** Collective renovation projects in Ghent **https://www.be-reel.be/c11-demonstration-project-collective-renovation-projects-in-ghent-en-clone**

Conclusion

Towards a Resilient, Affordable, and Decarbonized Heating Future for Kozani

Context: Kozani's Crossroads and the Imperative for Change

Kozani stands at a historic crossroads as it navigates the complex transition away from lignite-based district heating towards a sustainable, climate-neutral future. This report has analyzed multiple international examples, providing insights into how diverse European cities have successfully transformed their district heating systems through renewable sources, innovative governance, community engagement, and robust financing strategies. Drawing from the experiences of Šaleška Valley (Slovenia), Heidelberg (Germany), Pamplona (Spain), Växjö (Sweden), Salaspils (Latvia), and Ghent (Belgium), this conclusion synthesizes critical lessons, identifies opportunities and challenges specific to Kozani, and proposes a strategic pathway forward.

As Greece accelerates its coal phase-out, Kozani's lignite-powered district heating network, established in 1993, is quickly becoming obsolete. The recent agreement in October 2024, which proposed a natural gas CHP plant as an interim solution, reflects the complexity of balancing immediate heat supply security and long-term sustainability objectives. Nevertheless, the need to align with European climate commitments—especially Kozani's ambitious goal of climate neutrality by 2030 as part of the EU Mission "100 Climate-Neutral and Smart Cities"—adds urgency to exploring and implementing robust renewable energy alternatives.

Lessons from International Experiences: Critical Elements for a Successful Transition

Across the studied cities, several overarching lessons emerged consistently, providing Kozani with essential insights for its upcoming transformation:

Early and Phased Strategic Planning
Successful district heating transformations start with detailed planning and careful phasing of implementation. Šaleška Valley's approach, for example, illustrates the importance of a comprehensive phased strategy (2022–2033), allowing early

efficiency gains and infrastructure upgrades to gradually integrate renewable heat sources. Similarly, Heidelberg's systematic long-term approach—initiated in 2010 with "Energy Concept 2020"—demonstrates how incremental progress, supported by targeted investments and clear milestones, ensures steady advancements towards climate neutrality.

Kozani should prioritize comprehensive planning, investing in efficiency upgrades, modernizing aging infrastructure, and progressively integrating renewable solutions, enabling manageable risk and cost-effective deployment.

Energy Source Diversification for Resilience
Cities like Växjö, Salaspils, and Ghent highlight the critical importance of diversifying heat supply to enhance resilience. Rather than depending solely on biomass or gas, these cities have strategically combined multiple renewable sources, including solar thermal, biomass, geothermal, waste heat, and heat pumps, alongside energy storage solutions. Salaspils successfully combines solar thermal collectors with biomass and natural gas for backup, creating a flexible system capable of reliably meeting seasonal variations.

Given Kozani's high solar potential, potential biomass resources, and emerging opportunities for waste heat recovery, a similarly diversified renewable mix could significantly reduce the city's vulnerability to fuel price volatility, increase energy security, and ensure continuity of service even during challenging periods.

Importance of Demand-Side Efficiency Measures
Energy efficiency is paramount in the transition process. Pamplona's Efidistrict project in the Txantrea neighborhood demonstrates the significant impact of combining large-scale energy efficiency retrofits with renewable-based district heating, achieving up to 70% reductions in household energy consumption. Similarly, Ghent's Energiecentrale initiative emphasizes deep renovations, reducing overall heating demands substantially.

Kozani's aging building stock presents an opportunity to achieve significant energy demand reductions through comprehensive retrofits—upgrading insulation, installing efficient windows, and deploying smart building controls. These demand-side interventions will not only lower emissions and operational costs but also improve residents' thermal comfort and reduce energy poverty.

Innovative Governance and Stakeholder Engagement:
Transparent governance, effective stakeholder coordination, and inclusive community participation significantly contributed to the success of all studied cities. Pamplona's public-private partnership model, Växjö's municipally-owned utility

structure, and Ghent's citizen-led cooperative (DuCoop) exemplify innovative governance mechanisms that have built trust, facilitated cooperation, and secured community buy-in.

Kozani can benefit from establishing similar innovative governance structures—perhaps a dedicated municipal energy agency or cooperative—to oversee project implementation, manage stakeholder relationships, and ensure community ownership and acceptance. Citizen involvement in the planning and decision-making process will be essential for fostering trust and ensuring social equity in the transition.

Blended Financing and Mobilizing EU Resources

Financing emerged as a cornerstone for all successful case studies, combining local, national, EU, and private-sector resources. Notably, Šaleška Valley utilized EU Just Transition Fund grants alongside national funding; Heidelberg leveraged national subsidies, municipal budgets, and citizen investments; and Salaspils combined EU Cohesion Fund grants, municipal resources, and bank loans.

Kozani's status as part of Greece's Just Transition regions positions it advantageously to access substantial EU funding, such as the Just Transition Fund, Horizon Europe programs, and various EU Cohesion instruments. Strategic leveraging of these resources, complemented by private-sector partnerships and community-based financing mechanisms, can significantly reduce the economic burden and accelerate Kozani's sustainable district heating transition.

The need to align with European climate commitments—especially Kozani's ambitious goal of climate neutrality by 2030 as part of the EU Mission "100 Climate-Neutral and Smart Cities"—adds urgency to exploring and implementing robust renewable energy alternatives.



Identified Challenges and Barriers to Anticipate

However, the transition process also entails significant challenges, which Kozani must proactively address:

- **Technical and Infrastructure Complexity:** Integrating diverse renewable heat sources, retrofitting existing pipeline networks, and deploying advanced storage and control systems are complex undertakings, requiring considerable technical capacity-building.
- **Financial and Investment Risks:** High upfront investment costs and potential uncertainty around long-term economic viability necessitate meticulous financial planning, blended funding strategies, and risk-sharing partnerships.
- **Social Acceptance and Public Engagement:** Transitioning away from traditional lignite-based systems can trigger public skepticism or resistance due to perceived reliability risks or cost concerns. Transparent communication and meaningful citizen participation will be vital.
- **Institutional Capacity and Regulatory Frameworks:** Ensuring alignment between local, national, and EU regulatory frameworks and strengthening municipal capacity for project management and implementation will be essential to avoiding procedural delays or administrative bottlenecks.

Strategic Recommendations for Kozani's Decarbonization Pathway

1. Launch an Integrated Municipal Energy Initiative

Kozani should establish a dedicated municipal energy agency or cooperative—similar to Ghent's Energiecentrale or Pamplona's NASUVINSA—to centralize planning, streamline governance, and support residents and businesses through financing, technical assistance, and project coordination.

2. Invest in Demand Reduction

Implement large-scale building efficiency upgrades through municipal programs, incentivized renovations, and targeted support for vulnerable households. Achieving significant early gains in energy efficiency will simplify the shift to renewable sources, reduce peak demand, and protect consumers from price volatility.

3. Deploy a Diversified Renewable Heating Portfolio

Develop a hybrid renewable heating system, combining large-scale solar thermal plants (utilizing Kozani's high solar irradiance and available post-mining sites),

biomass CHP systems (leveraging regional agricultural and forestry residues), geothermal potential, and possibly waste heat recovery and industrial heat pumps. Incorporating substantial thermal storage infrastructure will ensure system resilience and flexibility.

4. Secure Long-term, Blended Financing

Leverage Greece's Just Transition Fund allocations, supplemented by EU Cohesion Funds, Horizon Europe projects, and national green finance programs. Public-private partnerships and citizen co-financing models (such as cooperative shares or community-owned district heat networks) should also be explored to share investment risks and ensure financial sustainability.

5. Prioritize Robust Stakeholder and Community Engagement

Facilitate comprehensive public consultations, transparent project communications, and active citizen involvement, particularly targeting vulnerable households and former lignite-sector workers. Creating community advisory panels or cooperatives, modeled after Ghent's DuCoop, could significantly enhance local ownership, acceptance, and social resilience during the transition process.

6. Ensure Adaptability and Continuous Monitoring

Adopt adaptive management practices, allowing for regular assessment, monitoring, and adjustment of strategies. Given evolving technological landscapes, market conditions, and regulatory environments, maintaining flexibility will be crucial for Kozani's long-term success.

Kozani's district heating transformation is far more than a local infrastructure project—it is an opportunity to redefine the city's socio-economic identity, showcasing how coal-dependent regions can successfully transition towards sustainability and resilience.





Part II

Energopolis 2.0 Workshop

Kozani

April 3-4, 2025

Introduction

Executive Summary

The Energopolis 2.0 Workshop held in Kozani, Greece, on April 3–4, 2025, marked a pivotal step in defining a coherent and actionable roadmap for the city's transition to decarbonized district heating. The workshop was organized by the Municipality of Kozani, Resilient Cities Catalyst, and the Climate Change Hub, in partnership with the Covenant of Mayors Europe, financed and supported by the Global Covenant of Mayors. It brought together a diverse group of stakeholders and political leaders including the Regional Governor of Western Macedonia, the Mayor of Kozani, regional Mayors from the Western Macedonia Region, representatives from the European Commission, EU Institutions and initiatives, academia, technical experts, and local actors.

Key themes that emerged from the two-day intensive workshop included the urgent need for **integrated approaches to energy transition**, the critical importance of **citizen participation**, the role of **diversified renewable energy sources**, and the necessity of clearly **structured financing and investment mechanisms**. International experiences presented by experts from Resilient Cities Catalyst, the Covenant of Mayors Europe, the Wuppertal Institute, and the EBRD highlighted successful cases from Velenje (Slovenia), Heidelberg (Germany), Pamplona (Spain), and other European cities, providing valuable insights and adaptable solutions relevant to Kozani's specific context.

The participants unanimously recognized significant challenges: technical and economic uncertainties surrounding the transition from lignite dependency, inadequate citizen engagement, limited access to financing, and the lack of mature, locally adapted technical solutions. However, these challenges were viewed not only as barriers but as strategic opportunities to redefine Kozani's approach, strengthening local participation and ownership of the energy transition process.

To this end, a set of targeted recommendations were co-developed by stakeholders, emphasizing the establishment of a comprehensive and participatory energy transition strategy, anchored in clear political leadership and robust technical support. Recommendations included setting up local energy hubs and consultation offices, leveraging diversified renewable sources such as biomass, solar thermal, and waste heat from future data centers, and securing financing from European sources (EIB, EBRD, EU Just Transition Fund).

In conclusion, the workshop established strong alignment and consensus around a phased, participatory approach for Kozani, advocating a transition that is socially fair, economically viable, and environmentally sustainable. The key outcome was a collective commitment to continue collaboration and immediate action, positioning Kozani not only as a model for Greece but as an inspiring benchmark for coal-dependent regions throughout Europe.

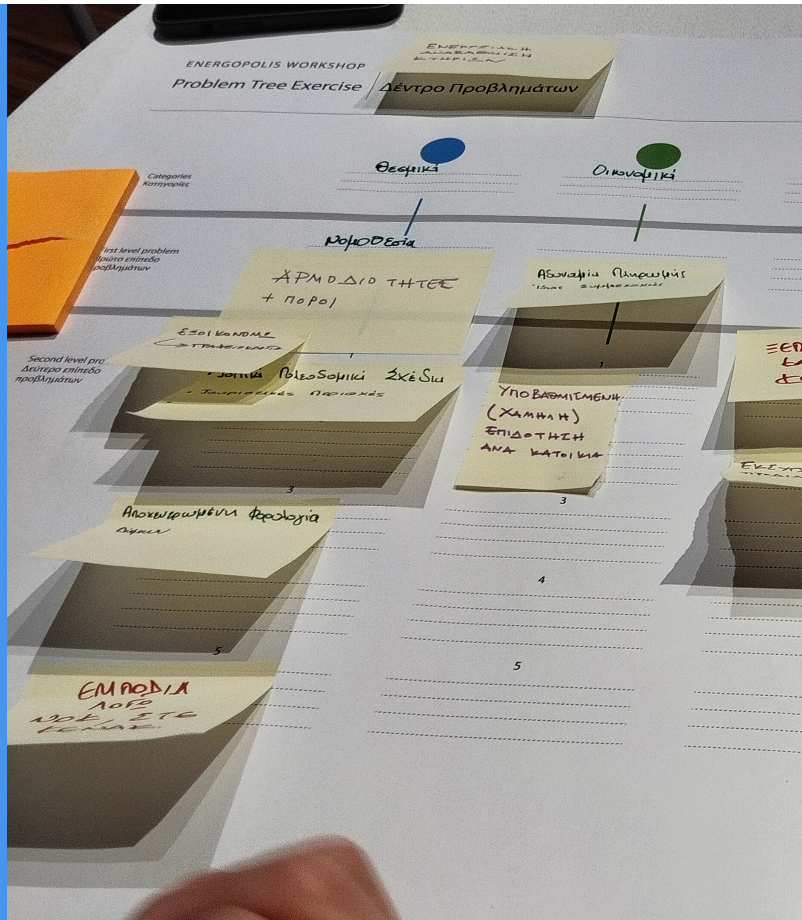
Workshop Context and Methodology

The Energopolis 2.0 Workshop, held in Kozani, Greece, on April 3–4, 2025, aimed to address one of the most urgent challenges facing the city: **the sustainable transformation of its district heating system away from lignite dependency.** Organized by the Municipality of Kozani, the Resilient Cities Catalyst and the Climate Change Hub, in partnership with the Covenant of Mayors Europe, and supported by the Global Covenant of Mayors, the workshop brought together critical stakeholders to chart a collective pathway toward a clean, affordable, and just energy future for the region.

Kozani's historical reliance on lignite for heating and energy generation has defined its economic and social landscape for decades. However, recent European and global climate commitments—including the European Green Deal, the Just Transition Mechanism, the EU's Mission "100 Climate-Neutral and Smart Cities and the Covenant of Mayors' climate neutrality objectives—necessitate rapid shifts away from fossil fuels. The European Union has clearly articulated ambitious targets aiming for significant emissions reductions by 2030, and complete climate neutrality by 2050, driving cities across the continent to implement comprehensive local energy plans. Against this backdrop, the workshop was designed to provide Kozani with concrete tools, inspiration, and strategic partnerships essential for a successful energy transition.

Participants of Energopolis 2.0 represented a diverse and influential group of stakeholders, each bringing unique perspectives critical for a holistic approach. At the political level, participants included the the **Regional Governor of Western Macedonia Region, Mr. George Amanatidis, the Mayor of Kozani, Mr. Ioannis Kokkaliaris and the Mayor of Amynteo, Mr. Ioannis Liasis.** From the European dimension, representatives from the European Commission, the European Investment Bank (EIB), and the European Bank for Reconstruction and Development (EBRD) contributed

The workshop established strong alignment and consensus around a phased, participatory approach for Kozani, advocating a transition that is socially fair, economically viable, and environmentally sustainable.



key insights into EU policy frameworks, financing instruments, and successful project case studies. Experts from EU institutions and initiatives, academia and research organizations, technical specialists in district heating solutions, and local community representatives further enriched discussions with practical, technical, and socially-informed perspectives.

The workshop employed a **structured methodology** combining plenary presentations, moderated panels, interactive thematic discussions, and breakout group sessions. During the first day, international best practices were presented to highlight successful European cases such as Velenje, Heidelberg, and Pamplona, emphasizing tangible approaches, governance models, technology choices, and financial mechanisms. These presentations set the stage by illustrating proven solutions adaptable to Kozani's specific challenges. The second day was designed around active co-design, that followed a series of political panels, where stakeholders collaboratively worked in breakout groups to define a phased roadmap for Kozani's transition. Facilitated by expert moderators, these groups focused on three critical areas: **transition the district heating infrastructure towards renewables; implementing large scale private and public building retrofits; addressing the issue of energy poverty,** particularly in remote communities.

The overarching aim was not merely theoretical but inherently **action-oriented**, ensuring outcomes would directly inform policy decisions, infrastructure planning, and funding strategies. By grounding discussions in both technical feasibility and socio-economic viability, the workshop sought to produce actionable pathways underpinned by local ownership, technical innovation, and robust financial planning.

This report provides a comprehensive account of the discussions, findings, and agreed-upon strategic pathways developed throughout the Energopolis 2.0 Workshop, serving as a foundational document to guide Kozani's journey toward sustainable, decarbonized heating.



Setting the Stage

Keynote Addresses & Opening Remarks: Setting the Stage

The Energopolis 2.0 workshop commenced with insightful keynote political addresses that outlined the urgency, challenges, and opportunities for transitioning Kozani's district heating system to sustainable solutions. These opening statements established a clear context and a collective vision, shaping the productive discussions that followed.

Ioannis Kokkaliaris, Mayor of Kozani

Mayor Ioannis Kokkaliaris warmly welcomed participants, highlighting the workshop as a crucial step for Kozani's future. He emphasized that the **energy transition must be sustainable, inclusive, and economically viable.** Recognizing Kozani's long energy heritage, he underlined the importance of **moving from lignite to innovative, local, renewable heating solutions.**

Mayor Kokkaliaris stressed that the transition must **support remote and vulnerable communities,** ensuring that no citizen is left behind. He called for drawing inspiration from **successful European cities**, using best practices to craft a **realistic roadmap** for Kozani's transformation. Finally, he urged all stakeholders to **work together to make Kozani a model city of clean energy and resilience,** leveraging available financing mechanisms to secure a **just and affordable** energy transition.

Ioannis Sakiotis, European Commission Representative

Speaking on behalf of the European Commission, Ioannis Sakiotis reaffirmed Europe's unwavering goal: a **climate-neutral continent by 2050**. Despite new geopolitical challenges, including energy security concerns amplified by the war in Ukraine, **the green transition remains the EU's strategic priority.**

He pointed out that substantial resources are available: **€1.6 billion allocated to Greece** through the Just Transition Fund and Recovery and Resilience Facility, offering a critical opportunity for Western Macedonia. However, he emphasized that **strong social alliances** — between **local authorities, citizens, businesses, and academia** — are vital for success.

Sakiotis praised Kozani's investments in public and sustainable infrastructure and stressed that **continuity, local ownership, and civic engagement** are fundamental to a successful transition. He closed with a message of **optimism and support**, confirming that the European Commission is ready to assist Kozani in this endeavor.

Konstantina Karydi, Resilient Cities Catalyst Europe, VP Climate Change Hub

Workshop moderator Konstantina Karydi framed the gathering's ambitions: to **bridge policy theory with practical municipal action**. She emphasized two main objectives:

- First, **supporting a real, pragmatic transition** in a mid-sized European city facing typical challenges: limited resources, time pressure, and staffing shortages.
- Second, **identifying actionable solutions** for district heating decarbonization, tackling energy poverty, and enabling the energy renovation of private housing.

Karydi underlined the need for **realism over idealism**: recognizing today's constraints while **forging pathways to progress step-by-step**. She advocated for an integrated approach that **combines immediate funding opportunities** with **long-term strategic investment**, warning against fragmented, short-sighted planning.

"We are here to open roads, not just diagnose problems," she stated — a phrase that captured the spirit of the workshop perfectly.

Mayor Ioannis Kokkaliaris warmly welcomed participants, highlighting the workshop as a crucial step for Kozani's futur and emphasized that the **energy transition must be sustainable, inclusive, and economically viable.**



Mayor of Kozani, Ioannis Kokkaliaris

Kozani's Decarbonization Challenge: Local Perspectives

At the Energopolis 2.0 Workshop, local officials offered critical reflections on the **multidimensional challenge** of transitioning Kozani's district heating system away from lignite dependency — addressing not only technical but also social, economic, institutional, and environmental dimensions.

From Legacy to Transition: Kozani's Urgent Call for a New Energy Mindset

Deputy Mayor Georgios Alexandridis opened with a reminder of Kozani's **historical reliance on lignite**, dating back to the 1950s with the establishment of PPC/DEH (the Public Power Corporation of Greece). For decades, lignite fueled both the **local economy and the energy infrastructure** of Western Macedonia, creating thousands of jobs and shaping the region's identity.

However, **international and European commitments** — notably the **Paris Agreement (2015), the European Green Deal (2020), and Greece's National Energy and Climate Plan** — have accelerated the timeline for moving beyond coal. Instead of a gradual transition by 2050, Western Macedonia now faces a compressed horizon toward 2028, presenting an immense socio-economic challenge.

Alexandridis stressed that the effects are already visible: **Western Macedonia lost around 30,000 residents between 2011 and 2021,** mainly young people migrating in search of better opportunities. District heating, once built on the "infinite" availability of lignite, is now at a crossroads, increasingly unsustainable due to **rising CO_2 prices** and **tightening EU restrictions** on fossil fuel subsidies.

The Deputy Mayor emphasized that the municipality, despite limited time and resources, secured a stabilization agreement with DEYAK (the Kozani District Heating Company) in October 2024. Yet **stabilization is not enough**. The goal must be to ensure that district heating remains a **reliable, affordable, and sustainable public service for all citizens**.

In closing, Alexandridis invoked Einstein's famous insight: **"You cannot solve a problem with the same thinking that created it."** Kozani must embrace a **new mindset**, crafting innovative pathways for clean and resilient heating solutions.

Rebuilding Social Cohesion and Public Trust for a Just Transition in Kozani

Secretary General Periklis Aliferis reinforced the urgency of **rethinking Kozani's transition strategy,** framing it through a **social lens** as much as a technical one. He highlighted a fundamental lesson from successful urban transitions across Europe: **no city achieves energy transformation without the full participation of its citizens.** Referencing examples from the workshop and a telling historical anec-

dote from Turkey's economic crisis, Aliferis emphasized that **building public trust is crucial.** As he put it: "Without trust, no change can proceed."

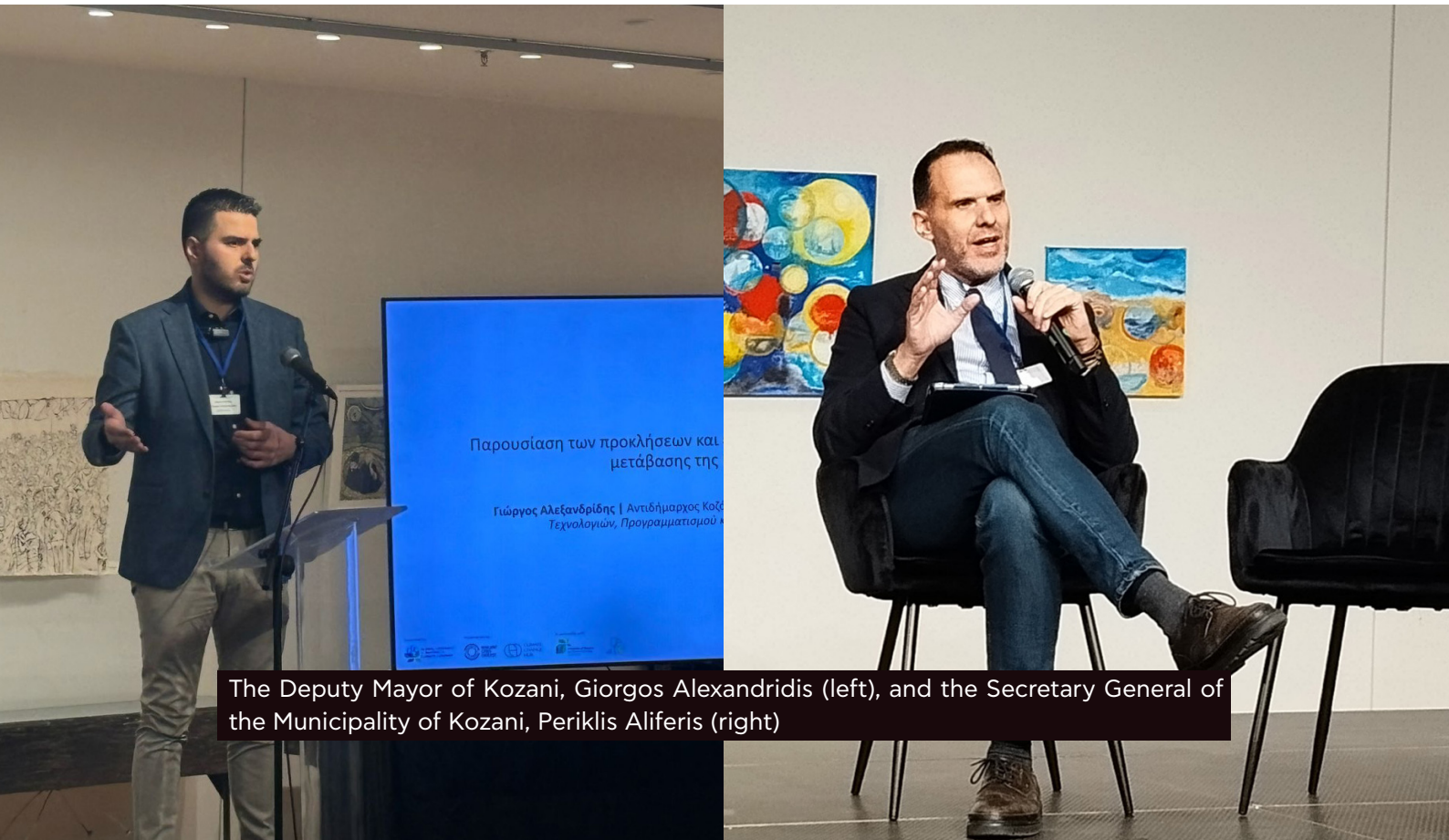
Aliferis painted a vivid picture of the regional decline: the 2010 Greek financial crisis initiated a downward spiral, weakening the economic base of Western Macedonia. This trend was compounded during the COVID-19 pandemic, which saw an **uncontrolled proliferation of photovoltaic parks** in the absence of spatial planning. Local industries and farmers now struggle to find available energy space — exacerbating **social tensions and a sense of injustice**.

He noted that while renewable energy sources (RES) are not inherently problematic, **their benefits must be distributed fairly**, with local communities playing an active role in planning and benefiting from investments.

The Secretary General was particularly critical of the **contradictions** in the current approach: although massive investments in RES are subsidized, **local energy communities** — formed by citizens — face **barriers and disconnections** during peak periods, undermining their viability.

Finally, Aliferis stressed that **decarbonization without a clear roadmap and prioritization of social equity is not a true transition. Participation, preparation, and fairness** must be at the heart of Kozani's efforts. He warned that **abandoning rural areas** and neglecting the primary sector would not only worsen social inequality but **jeopardize the very foundation of sustainable regional development**.

In his words: **"Patriotism is not just about defense; it's about building the conditions so that people can live, thrive, and love their land."** For Kozani, a just, inclusive, and citizen-centered transition is the only viable path forward.



The Deputy Mayor of Kozani, Giorgos Alexandridis (left), and the Secretary General of the Municipality of Kozani, Periklis Aliferis (right)

International Experiences: Insights from European Cities and Institutions

The Energopolis 2.0 Workshop provided Kozani with a wealth of insights from leading European initiatives, demonstrating that **decarbonizing district heating** is not only possible but can also drive **economic resilience, energy independence**, and **social innovation**. Experts shared comparative experiences, practical solutions, and key lessons to inspire Kozani's transition journey.

Building Momentum through the Covenant of Mayors Europe

Allison Le Corre introduced the Covenant of Mayors Europe as the **largest movement of local governments** working on climate and energy, with **over 11,000 signatories** across the continent. Kozani, an early member since 2011, was recognized for its commitment to climate neutrality.

Le Corre presented the **"Cities' Heat Detox" campaign**, launched to support local authorities in **cleansing heating systems of fossil fuels**. She emphasized the importance of local action following the recent revision of the **Energy Efficiency Directive**, which mandates that **cities over 45,000 inhabitants** must develop **local heating and cooling plans.** This provides a **legal and strategic opportunity** for Kozani to structure its future heating transition.

The Detox campaign showcases cities that have successfully phased out fossil fuels, using **geothermal energy, solar thermal, biomass, and waste heat**. Le Corre also announced upcoming opportunities for technical assistance and peer learning, notably the **decarbonization crash course in Prague** and one-to-one project support through the Covenant.

Key message: Kozani's district heating transition can be accelerated by embedding local heating planning in its governance structures and tapping into Europe's growing support ecosystem.

Lessons from Coal Regions Transitioning District Heating

Jannis Beutel from the Wuppertal Institute presented findings from a **Working Group on District Heating** under the Coal Regions in Transition Initiative. Through exchanges among coal-dependent cities in Slovenia, Slovakia, Hungary, Bulgaria, and Greece, a **Toolkit for District Heating Decarbonization** was co-developed, offering practical advice tailored to regions like Kozani.

The case of **Velenje, Slovenia** highlighted a phased strategy:

- **Short-term measures:** Reducing network temperatures and improving system efficiency.

- **Long-term vision:** Transitioning to **geothermal, solar thermal, and heat pumps,** supported by the **Just Transition Fund and EIB's technical assistance**.

Importantly, Beutel stressed the need to **prioritize feasible actions immediately** while preparing for larger transformations. Timing, planning, and early wins (**like waste heat recovery**) are essential to build momentum and public trust.

Key message: Decarbonization is a marathon requiring early victories, flexible strategies, and continuous learning.

The Financial and Technological Imperatives for Modern District Heating

Greg Gebrail of the EBRD discussed the financial and technical foundations required for a successful transition. He outlined the EBRD's role in financing district heating modernization across Europe and stressed that, **by 2035, at least 35% of district heating systems' energy must come from renewables or waste heat** to maintain EU support eligibility.

Gebrail introduced case studies like **Pristina and Novi Sad**, where cities combine **solar thermal fields, heat pumps, electric boilers**, **and seasonal thermal storage to create flexible, resilient, low-carbon** district heating systems. These systems can store surplus energy and respond dynamically to fluctuating electricity prices, ensuring economic viability.

Gebrail highlighted that EBRD has already prepared a project proposal, **PPP model for Kozani and neighboring municipalities**, integrating **solar thermal, heat pumps, and large-scale storage**, aiming for a **42% renewable share by 2040**.



However, he also warned of **major challenges**: political turnover, tariff instability, procurement cost volatility, and regulatory hurdles. **Combining grants and flexible loans** is critical to address these challenges effectively.

Key message: Blending innovative technologies with diversified financing is the recipe for resilient, affordable heating systems.

Kozani as a Global Urban Transition Leader

Representing the **Global Covenant of Mayors, Marnie McGregor** positioned Kozani as a **potential global model** for sustainable district heating transitions. As one of **Europe's 100 Climate-Neutral Cities by 2030**, Kozani has a unique opportunity to access **technical expertise, peer-learning programs, and investment support** at the highest levels.

McGregor emphasized that **local leadership, community engagement, and strategic partnerships** with institutions like the EIB, EBRD, and EU missions are crucial to succeed. She highlighted how cities like Kozani can shape **global urban transition narratives**, providing inspiration far beyond Greece.

Key message: Kozani's success is not just local — it will resonate across Europe and internationally as a model of climate leadership.

Comparative Learnings from Velenje, Heidelberg, and Pamplona

In a closing synthesis, **urbanist expert Haris Biskos** provided a comparative analysis of cities that faced challenges similar to Kozani's and successfully transformed their district heating systems.

- **Velenje:** Transitioning from coal to 100% renewables by 2033 through staged energy efficiency and infrastructure upgrades.
- **Heidelberg:** Building a **multi-source system** including biomass, waste heat, solar thermal, and thermal storage, supported by **green bonds** and municipal funding.
- **Pamplona:** Renovating social housing and introducing **biomass-powered district heating**, with **deep citizen engagement** and innovative **public-private partnerships** (PPPs).

Biskos concluded that a **phased, diversified, and community-driven approach** is essential for Kozani. Pilot projects, tailored technical mixes, and inclusive financing strategies must be at the heart of the city's transformation.

Key message: Kozani should combine bold ambition with grounded realism: acting now while planning for deeper future transformation.

Financing and Investment Opportunities for Kozani's Transition

The Energopolis 2.0 Workshop highlighted that no successful energy transition — and especially one as complex as decarbonizing Kozani's district heating system — can be achieved without **robust, blended, and strategic financing**. International, national, and local actors converged to outline the **available tools, mechanisms, and challenges** for unlocking investments towards a clean and affordable energy future for Kozani.

European Investment Bank (EIB): Strategic Lending and Technical Assistance

Eleni Gioti, Advisor and Coordinator from the European Investment Bank (EIB), emphasized the EIB's critical role in supporting **climate adaptation and energy transition projects** through:

- **Direct loans to public entities** with favorable conditions (low interest rates, long grace periods).
- **Private sector engagement** via intermediary banks.
- **Project finance models** where future revenues serve as collateral.
- **Higher-risk instruments** via the European Investment Fund (EIF).

Beyond financing, **technical assistance** remains a core pillar. Through the **ELENA program (European Local Energy Assistance) and JASPERS facility**, the EIB helps local authorities mature energy projects by funding feasibility studies, business cases, and tender preparation. **Projects must be ready for tender within three years** to maintain eligibility.

Additionally, Kozani — being among Europe's 100 climate-neutral cities — can tap into the **special €2 billion loan window** the EIB created for cities with a **Mission Label under the NetZero Cities framework**.

Key opportunity: Kozani can apply for ELENA support to finance the preparation of detailed engineering studies for the integration of renewables and thermal storage into its district heating network.

Climate City Capital Hub: Building Investment Readiness

Georgios Ioulianos from the newly established Climate City Capital Hub (CCCH) underlined the need for **investment-ready projects** rather than just visions. He stressed that:

- **112 Mission Cities** collectively need an estimated €650 billion to achieve their climate neutrality goals.

• Available EU and national public funds will only cover **10–15%** of these needs.

Therefore, **mobilizing private capital** through innovative, bankable projects is essential. The Hub provides **technical guidance** (needs analysis, project prioritization, economic modeling) and **links cities to investors via its Neutral Capital Center.**

For Kozani, the immediate steps include:

• Conducting a **needs assessment** of energy demand,
• Defining **clear project pipelines** with prioritized investments,
• Preparing **investment-grade business cases** for each project phase.

Key opportunity: Kozani can work with the CCCH to develop a structured investment strategy combining grants, loans, and private funding for its district heating transition.

EBRD: Experience in District Energy PPPs and Green Transition

Maria Tzanidaki, Principal Manager at the Greek PPP Preparation Facility (GPPF), described how the **European Bank for Reconstruction and Development (EBRD)** assists cities in structuring **Public-Private Partnerships (PPPs)** to implement energy transition projects.

In Greece, the EBRD has developed an efficient framework:

• **Strategic studies and pre-feasibility assessments** for district heating and other green infrastructures.

Mayor Ioannis Kokkaliaris warmly welcomed participants, highlighting the workshop as a crucial step for Kozani's futur and emphasized that the **energy transition must be sustainable, inclusive, and economically viable.**



- Drafting and managing **tender procedures** for PPPs.
- Monitoring **project implementation post-contract** signature.

The **PPP model** combines **30–40% public funding** (e.g., grants from the Recovery and Resilience Facility) with **private equity and loans**, ensuring financial viability while transferring operational risks to the private sector.

In Kozani's case, the GPPF is already supporting the preparation of a **PPP scheme for the next phase of district heating modernization**, potentially involving:

- Solar thermal fields.
- Large-scale heat pumps.
- Seasonal thermal energy storage.
- Integration of waste heat sources (e.g., data centers).

Key opportunity: Kozani can use PPP models not only for energy projects but also for energy renovation of public and private buildings, creating synergies across sectors.

FCNC: Strategic Use of PPPs for District Heating and Beyond

Apostolos Papadopoulos, Managing Director of FCNC, reinforced that **PPPs are not a panacea** but a powerful tool when carefully prepared.

Drawing from past successful PPP projects in Western Macedonia (e.g., DIADYMA Waste Management), Papadopoulos emphasized that:

- **Strong public sector leadership and preparation** are critical.
- **Technical and legal advisory support** must be robust.
- **Public consensus and citizen engagement** are vital to prevent delays or rejection.

He stressed that Kozani's projected investment needs of **€850 million** for heating, building renovation, and low-carbon infrastructure over the next five years require:

- **Mixing multiple sources:** EU grants, national funds, municipal budgets, PPP investments, and private equity.
- **Phasing projects** strategically to avoid overwhelming debt capacity.

Key opportunity: Kozani can diversify funding sources through blended finance strategies, not relying solely on public subsidies.

European Commission Perspective: Unlocking Innovation Funds

Finally, **Maria Yeroyanni from the European Commission's DG Research & Innovation** highlighted Kozani's unique advantage: being part of the **Cities Mission opens** direct access to:

- **Pilot Cities Program** funding for testing innovative technologies.
- **Twinning projects** for peer-learning with other cities.
- **Driving Urban Transitions (DUT) Partnership calls** with €450 million funding available by 2030.

Moreover, by participating actively in platforms like the **Urban Transition Mission** at the global level, Kozani can position itself for **additional innovation funding** beyond traditional EU structural funds.

Key opportunity: Kozani should actively pursue Horizon Europe, LIFE, DUT, and NetZero Cities funding opportunities to pilot advanced district energy solutions and citizen-driven projects.

Strategic Reflections from Mayors & Regional Leadership

The final panel sessions of the Energopolis 2.0 Workshop provided **deep strategic insights** from the region's highest elected officials — a crucial reality check on the technical discussions that had preceded. The debate clearly illuminated that **political leadership, regional coordination, and active community engagement** will be decisive for Kozani's and Western Macedonia's clean energy future.

The Regional Perspective: Governor Giorgos Amanatidis

Giorgos Amanatidis, Governor of Western Macedonia Region, set the tone by emphasizing that **regional energy transition requires structured, holistic planning** — a point too often overlooked. Despite being historically dubbed the **"energy heart of Greece,"** Western Macedonia has **never had a comprehensive regional energy plan.**

The Governor stressed several urgent needs:

- Conducting an **inventory of energy inputs and outputs**.
- Developing **resource management strategies** to maximize local benefits.
- Balancing **environmental responsibility, citizen affordability, and economic viability**.

He posed critical questions that remain open:

- What is the **optimal energy mix** moving forward?
- How can **heat prices** be stabilized for residents amid volatile gas markets?
- Should district heating systems move towards **interconnected solutions**, to optimize supply and demand across municipalities?

In his concluding remarks, Amanatidis insisted that **political decisions must be rooted in technical soundness and realistic economic assessments** — not in short-term or emotional reactions.

The Mayoral View: Kozani and Amyntaio

Both **Ioannis Kokkaliaris, Mayor of Kozani, and Ioannis Liasis, Mayor of Amyntaio**, provided powerful testimonies on the front-line realities facing municipalities.

Mayor Kokkaliaris outlined the **immense pressures** faced by the municipalities after the closure of lignite plants. He noted that **accepting natural gas as a transitional solution was not a first choice, but a survival decision** to avoid the collapse of the district heating system.

However, he expressed strong belief that **new alternatives must now be actively pursued**, including:

- **Large-scale integration of waste heat** from upcoming data centers.
- **Energy renovation of the building stock** to reduce demand.
- **More assertive political negotiation** for local energy access rights.

Importantly, Mayor Kokkaliaris stressed that **district heating must remain a public good**, aligned with social equity and environmental goals, not merely an economic utility. He concluded with a resounding call for **full citizen involvement**:
"No transition will succeed if it is designed **without** the people who will live it."

Mayor Liasis warned **against an energy transition without social justice**. He reflected on Amyntaio's harsh experience: although biomass-based district heating was installed to replace lignite, **without accompanying building renovations, citizens did not feel the intended benefits**.

He shared concerns about:

- **Skyrocketing heating costs.**
- **Lack of timely support programs** (such as delayed rollout of subsidies for heat pumps).
- **Absence of adequate use of local renewable resources**, like geothermal energy.

Most crucially, Liasis noted that **energy poverty is driving depopulation**, with villages losing residents at alarming rates.

He emphasized:

- The need for **massive, targeted building upgrades** across rural areas.
- **Citizen ownership** of the new energy model.
- **Immediate mobilization of resources** to avoid the worsening spiral of rural abandonment.

Common Messages and Regional Consensus

A few **clear convergences** emerged among the leaders:



COORDINATED PLANNING: Coordinated planning between Kozani, Amyntaio, and neighboring municipalities is essential.



POLITICAL COURAGE: Political courage will be needed to avoid repeating the mistakes of fragmented and uncoordinated lignite-era development.



ACTIVE CITIZEN ENGAGEMENT Active citizen engagement — not afterthought consultation — is critical.



LONG TERM VISION: Long-term vision over short-term fixes must guide investment and policy choices



ENERGY DEMOCRACY: Access to energy produced locally should be prioritized for the local population, ensuring energy democracy and fair distribution of benefits.



INNOVATION-SOLIDARITY-SUSTAINABILITY As a final note, it was recognized that while Western Macedonia's past energy leadership rested on lignite, its future leadership must rest on innovation, solidarity, and sustainability.

Co-Designing Kozani's Transition Roadmap:

Outcomes from Interactive Sessions

The **co-creation sessions** of the Energopolis 2.0 Workshop represented a crucial moment for **Kozani's decarbonization journey**. Experts, local officials, and stakeholders engaged in three structured working groups, each addressing a different cornerstone of the energy transition: **District Heating Transition Strategy, Private Building Retrofits, and Energy Poverty in Remote Communities.** Below we summarize the key findings, strategic challenges, and proposed solutions from each group.

Working Group 1: District Heating Transition Strategy

Facilitators: Nikos Davos (CLUBE) and Vasileios Panousis (DEYAK)



A. Challenges Identified:

- **Low citizen engagement:** Information dissemination about district heating plans is inadequate, fostering distrust and alienation.
- **Unstable investment environment:** Rapid technological changes and energy price volatility complicate project planning.

» **Technological complexity:** The range of alternative solutions (natural gas, heat pumps, waste heat, hydrogen, storage systems) creates uncertainty and risk of wrong choices.
» **Regulatory and market barriers:** Current rules impose significant carbon costs on district heating, despite its decarbonization contribution. Moreover, relationships with major players like DEI remain unequal.
» **Competition pressure:** Individual heating solutions (pellet boilers, heat pumps) become attractive to users, threatening the viability of district heating networks
» **Critical timing gap:** The closure of lignite plants by end-2026 creates a looming supply gap that temporary contracts only partially cover.

B. Proposed Solutions:

» **Structured participation mechanisms:** Establish permanent multi-stakeholder groups, ensuring constant dialogue based on facts and options.
» **A flexible and phased Transition Roadmap:** Defining technology mixes, stages of investment, financial needs, and governance models.
» **Diversified technology strategy:** Combine multiple sources such as heat pumps, waste heat from data centers, renewables with storage, and eventually hydrogen
» **Exploration of new financing models:** Pursue Power Purchase Agreements (PPAs), Public-Private Partnerships (PPPs), and collaborations with ESCOs.
» **Political and regulatory advocacy:** Push for the removal of carbon cost penalties and more direct municipal access to energy investments.

Working Group 2: Private Buildings' Retrofits

Facilitator: Stefanos Palantzas (Hellenic Passive House Institute)



A. Challenges Identified:

» **Ineffective regulatory framework:** Current building codes (e.g., KENAK) are outdated and poorly enforced, offering limited real energy savings.
» **Access to finance:** Many households cannot afford the co-financing required under current subsidy programs, and ESCO models are rarely applied to residential retrofits.

» **Technical deficiencies:** Projects often rely on assumed values rather than measured performance (e.g., airtightness is not tested).
» **Social inertia:** Lack of awareness and collective action, especially in multi-apartment buildings, hampers deep renovation efforts.
» **Training gaps:** There is a shortage of properly trained engineers and contractors able to deliver high-quality energy renovations.

B. Proposed Solutions:

» **Reform KENAK and introduce mandatory verification:** New standards should rely on real performance calculations (e.g., ISO 13790) and require post-renovation validation.
» **Municipal acceleration role:** Kozani Municipality can act as an "aggregator" of renovation projects to attract ESCOs, and facilitate group retrofits.
» **Improved support programs:** Increase subsidy levels for low-income households and adapt schemes to favor ESCO-driven interventions.
» **Localized technical support hubs:** Establish "Neighborhood Energy Offices" staffed by engineers to guide citizens through renovation processes.
» **Strengthen ESCO market:** Introduce payment guarantees and flexible financial agreements to de-risk private sector participation.

Working Group 3: Addressing Energy Poverty and Rural Isolation

Facilitator: Konstantina Karydi (Resilient Cities Catalyst Europe)



A. Challenges Identified:

» **High unemployment and energy poverty:** Inability to afford adequate heating or cooling is widespread, particularly in rural areas.
» **Poor building stock:** Old, inefficient houses dramatically increase energy bills.
» **Rural exodus:** Many residents leave villages during winter, exacerbating demographic decline.
» **Lack of benefit sharing:** Despite renewable energy investments in the region, local communities largely miss out on direct benefits.

B. Proposed Solutions:

- **Dual-track interventions:** Energy renovations must be linked with economic revitalization efforts, particularly in agriculture and small entrepreneurship.
- **Data-driven needs assessment:** Conduct door-to-door surveys in at least 2,000 households to map energy poverty, renovation needs, and opportunities for economic resilience.
- **Local knowledge partnerships:** Collaborate with the University of Western Macedonia for data analysis and program design.
- **Creation of energy information networks:** Deploy "Energy Information Desks" across rural communities to support citizens in accessing funding and renovation programs.
- **Mobilizing finance:** Design blended finance packages combining grants, affordable loans, and resilience-building activities (e.g., drought-resilient farming).
- **Strengthening rural entrepreneurship:** Support the development of micro-cooperatives and other local business models tied to sustainable energy practices.

Cross-Cutting Lessons

Three major cross-cutting conclusions emerged across all groups:

1. **Citizen-centric design is essential:** Without active community participation, neither technical solutions nor financial mechanisms will be sustainable.
2. **Integration of sectors is vital:** District heating decarbonization, building renovation, and rural revitalization must be planned as an interconnected system, not isolated tracks.
3. **Kozani must lead with flexibility and innovation:** A rigid, "one-size-fits-all" approach is doomed to fail. Success requires strategic flexibility, diversified funding strategies, and bold political leadership.

The workshop closed with a shared understanding: the decarbonization journey for Kozani must be locally driven, socially just, and technologically diverse, combining tradition and innovation for a truly resilient energy future.

Supported by:
GLOBAL COVENANT of MAYORS for CLIMATE & ENERGY

Implemented by:
RESILIENT CITIES CATALYST
CLIMATE CHANGE HUB

In partnership with:
Covenant of Mayors for Climate & Energy EUROPE
Cities Heat