

L2H Low2HighDH

Unlocking Low-Grade Heat

Real solutions, investment pathways
and lessons from across **Europe**



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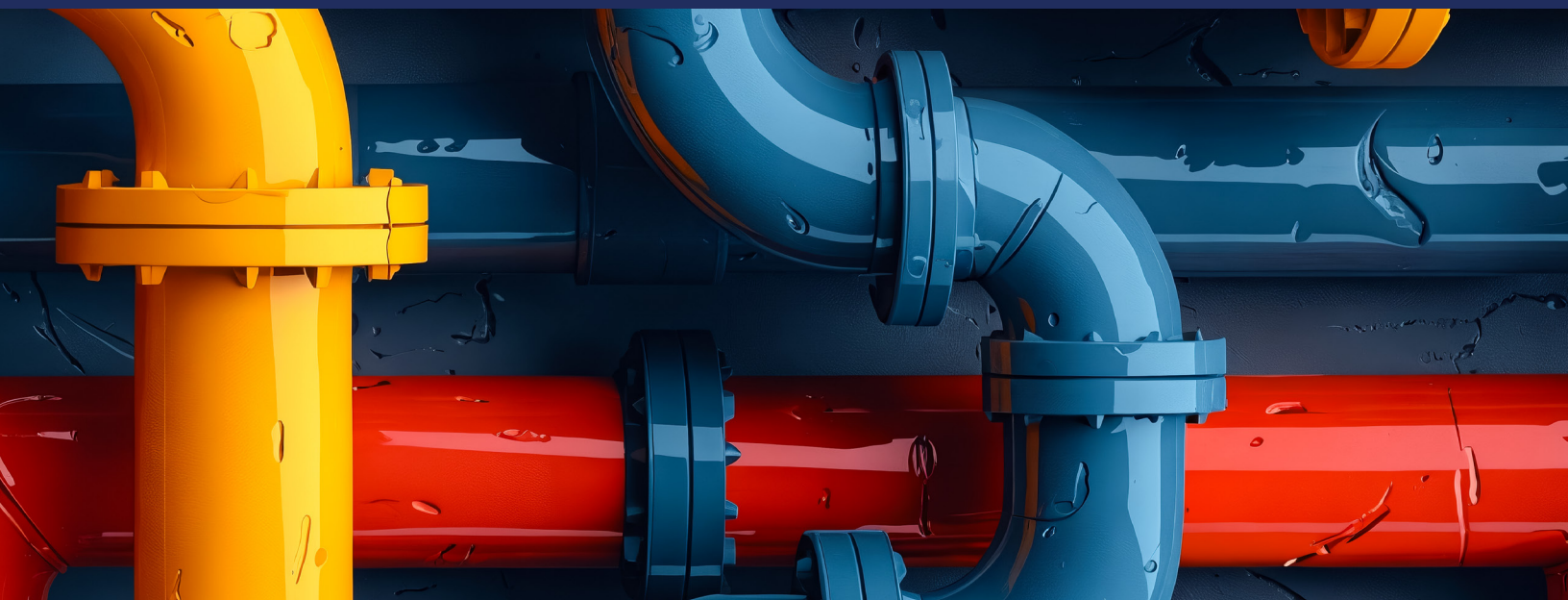


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Executive Summary

Three years of turning district-heating decarbonisation potential into investment pathways

Low2HighDH was initiated to help district heating owners and operators identify practical pathways for integrating low-grade renewable energy and waste heat into existing networks while maintaining reliable heat supply.

The three target countries started from different district heating contexts: Poland and Slovakia remain strongly dependent on fossil fuels, while Lithuania has already undergone a substantial transition towards renewable heat, predominantly biomass. Despite these differences, all three face the challenge of adapting existing high-temperature infrastructure so that lower-temperature renewable and recovered heat can play a greater role.

From October 2023 to September 2026, the project combined technical assessment, financial analysis, investment planning, stakeholder engagement and implementation-oriented support. The aim was not only to identify promising technologies, but to help real district heating systems move closer to investment and to convert their experience into knowledge that can be replicated elsewhere in Europe.

Low2HighDH at a glance



**Target
countries**



**DH systems
supported**



**Potential
investment**



**tCO₂/year
avoided**

Why Low2HighDH?

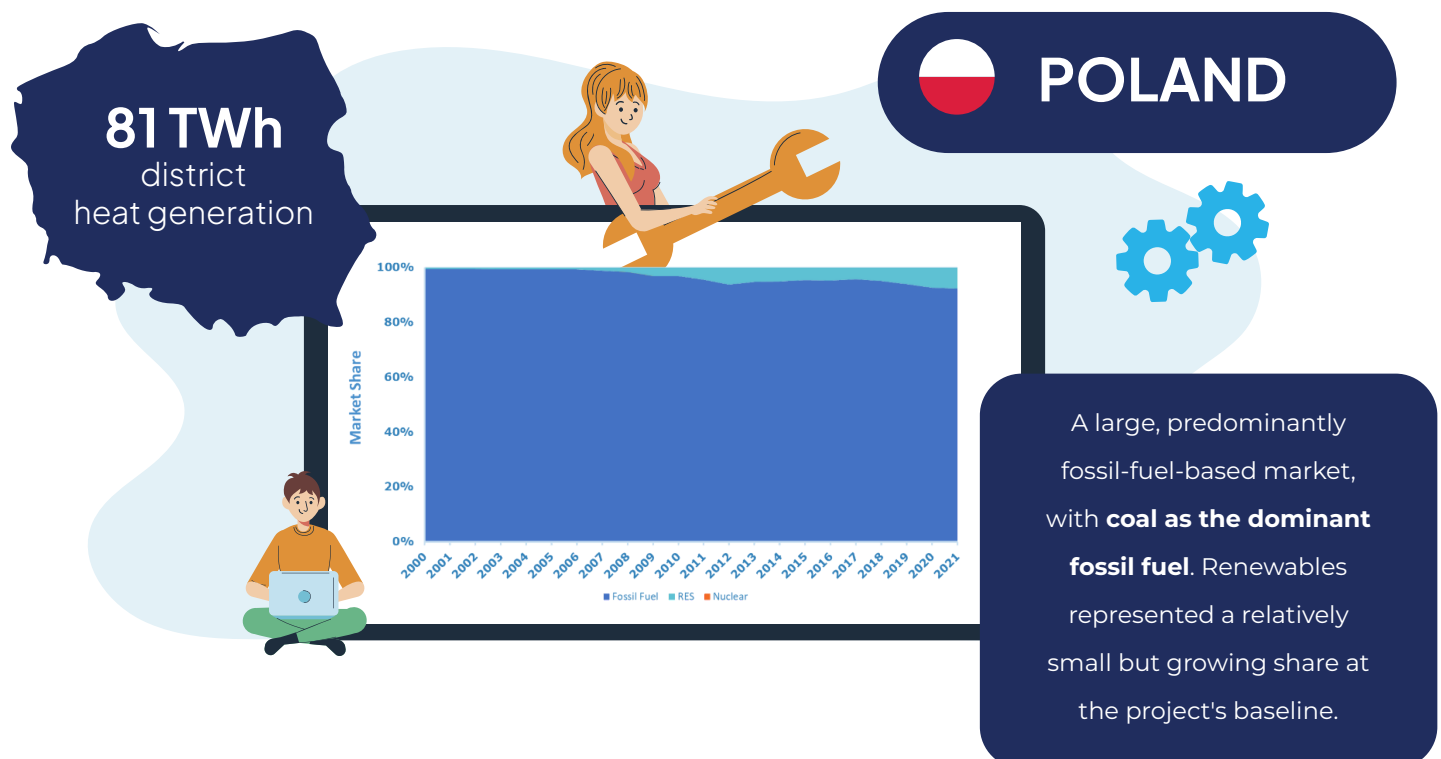
The challenge: decarbonising existing high-temperature district heating without starting from zero

District heating is already deeply embedded in the energy systems of **Poland, Slovakia and Lithuania**. Much of the infrastructure was developed decades ago and designed around **high operating temperatures, centralised generation and conventional fuels**. The systems analysed at the start of Low2HighDH typically operate at temperatures of around **70–120°C**, creating a particular challenge when integrating renewable and recovered heat available at much lower temperatures.

Replacing these networks is neither necessary nor realistic. The challenge is to **transform existing systems**, making better use of the infrastructure already in place while progressively integrating cleaner, locally available heat sources.

The three countries, however, entered this transition from **very different starting points**.

Three countries. Three starting points.

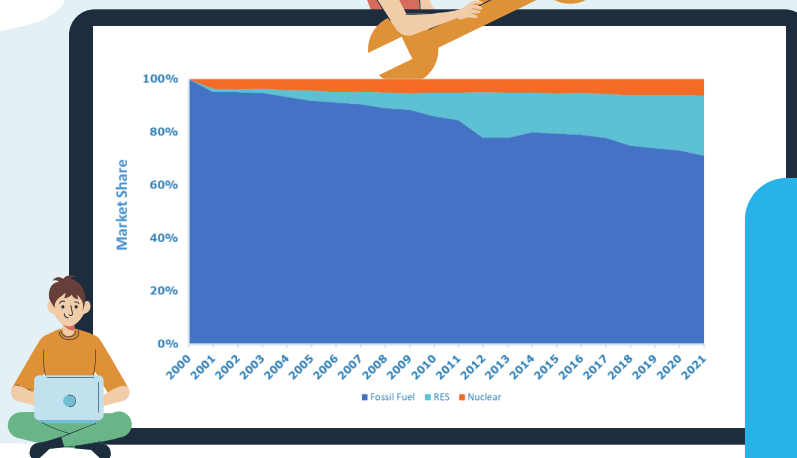


9 TWh

district heat
generation



SLOVAKIA



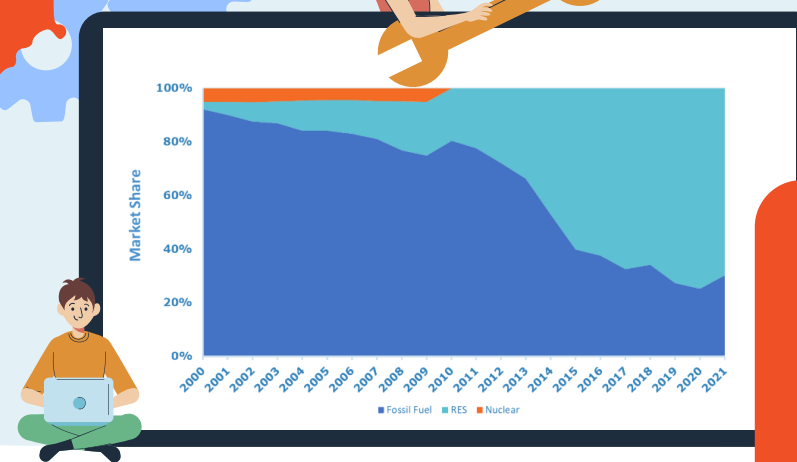
Fossil fuels remained dominant, particularly **natural gas**, while renewable heat—mainly biomass—was gradually expanding.

12 TWh

district heat
generation



LITHUANIA



A very different transition story: renewables had reached around **70% of district heat generation in 2021**, with biomass accounting for the overwhelming majority of renewable heat.

Different starting points. One shared challenge.

Despite these differences, the transition challenge is similar: **how can lower-temperature renewable and recovered heat be integrated into existing high-temperature networks?**

Low-grade sources such as **solar thermal, low-temperature geothermal and waste heat** may not directly provide the temperatures required by existing networks. The temperature gap can therefore require technologies such as heat pumps, alongside appropriate integration points, storage and system adaptations.

And technology is only part of the equation. Low2HighDH's initial analysis and expert consultation identified **technical, financial and regulatory barriers** that can prevent promising solutions from moving towards implementation.

47%

identified **technical barriers** as the most relevant challenge

45%

identified **financial barriers** among the most important obstacles

28%

identified **regulatory barriers** as the primary factor hampering integration

Low2HighDH therefore started not with the question of how to replace existing district heating, but how to transform it — combining existing infrastructure with new heat sources, technologies, financing and investment pathways.

The practical question

How can an existing district heating system move from fossil-fuel dependence towards renewable and recovered heat through a technically feasible, financeable and implementable pathway?

Low2HighDH responds by linking:

- system characterisation
- technical solution development
- economic and financial analysis
- investment planning
- stakeholder engagement
- RFQs and market engagement
- capacity building and replication



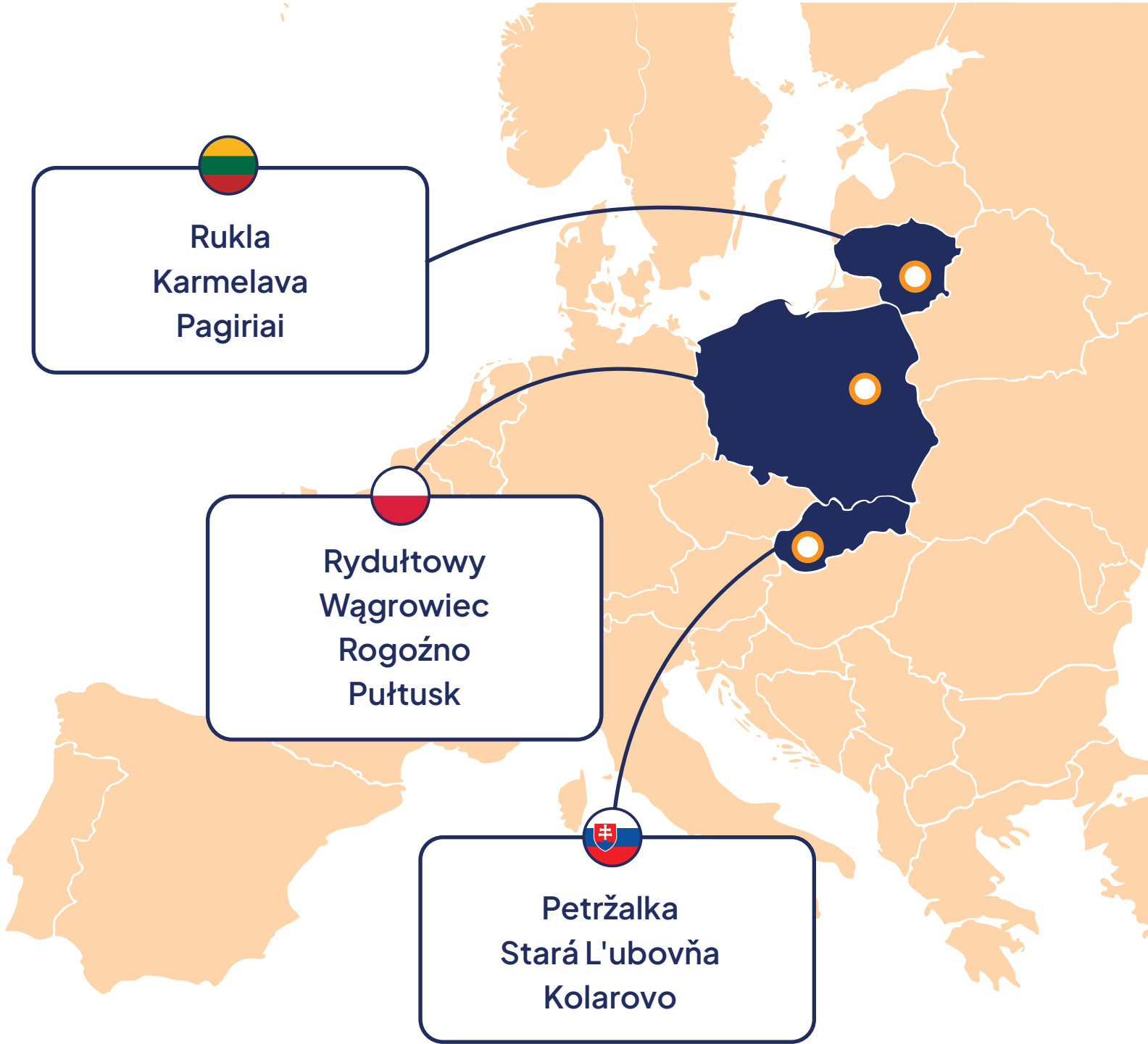
Project Scope and Objectives

33 district heating systems, three countries, one transferable support methodology

Low2HighDH is a three-year LIFE Clean Energy Transition project supporting high-temperature district heating systems in Lithuania, Poland and Slovakia. The project was designed to help participating owners and operators prepare investment pathways for integrating low-grade renewable energy and waste heat and progressing towards the Energy Efficiency Directive criteria for efficient district heating and cooling within a ten-year timeframe.

The project set out to

- Support at least 10 pilot and 20 replicant high-temperature district heating systems with tailored technical and investment-planning assistance. The project ultimately supported 33 systems: 10 pilots and 23 replicants.
- Explore solutions including heat pumps, waste heat, solar thermal and low-temperature geothermal energy.
- Identify financing approaches that can turn technically feasible concepts into credible investments.
- Support participating systems in moving towards the market, including Requests for Quotations for key suppliers.
- Build capacity and create a multi-level engagement structure — from Local Liaison Groups around individual systems, to National Stakeholder Communities and a project-wide Ambassador Community — supporting implementation, knowledge exchange and replication.
- Leave behind open-access technical, financial, policy and replication resources for use beyond the project.



Timeline

October 2023

September 2026



The Low2HighDH Approach

From understanding the system to preparing the investment

The project followed a practical progression rather than treating technology, finance and stakeholder engagement as separate exercises.

- 1 Understand the system** – Establish the baseline: heat production and demand, existing generation assets, network temperatures and pressures, infrastructure condition, fuels, ownership, market conditions and expected future demand.
- 2 Map the opportunity** – Identify locally available renewable, environmental and waste-heat resources and assess opportunities to reduce network temperatures, modernise connected buildings and integrate new heat sources.
- 3 Develop technical options** – Assess not only which heat source could be used, but also where and how it could be integrated: through direct integration, pre-heating, return-line integration, partial substitution or full substitution supported by temperature-upgrading technologies.
- 4 Test the economics** – Assess investment and operating costs, energy prices, future heat demand and revenues, market trends, regulation and financing conditions.
- 5 Build the investment pathway** – Translate the preferred technical solution into an investment plan, defining the required investment, implementation route, financing options and next steps towards delivery.

6 Engage the ecosystem – Bring together the actors needed to develop, finance and implement the transition. Low2HighDH organised engagement at three interconnected levels:

LOCAL



Local Liaison Groups –

Connecting each supported system with municipalities and other actors relevant to project development and implementation.

NATIONAL



National Stakeholder Communities –

Bringing together district heating, policy, technology, finance and other stakeholders in Lithuania, Poland and Slovakia to exchange knowledge and address common transition challenges and implementation.

**EUROPEAN /
PROJECT-WIDE**



Ambassador Community –

Extending the network beyond the directly supported systems to share project knowledge, encourage peer exchange and support wider replication.

Together, these communities connected site-level project development with national knowledge exchange and wider European replication.

7 Move towards implementation – Progress beyond feasibility through investment planning, engagement with potential suppliers and financiers and the preparation and launch of RFQs where applicable.

8 Replicate – Convert the experience from the supported systems into transferable guidance, technical and financial resources, generic use cases, capacity-building materials and recommendations for other high-temperature district heating systems.

From open call to tailored support

Participation in the Low2HighDH support facility followed a structured process:



Applicants provided information on their systems and implementation conditions. Selected cases were then developed further with the responsible project partners, with the scope, objectives, required inputs, expected outputs and timelines defined for the support activity.

Three Years of Low2HighDH

From knowledge to real district heating investment pathways

1. Building the evidence base

The project first established the technical, market and financial basis for supporting real district heating systems. It characterised the district heating context in Lithuania, Poland and Slovakia, analysed barriers and opportunities for low-grade heat integration and developed portfolios of technical and financial solutions.

This included 24 technical integration strategies, with 10 representative configurations analysed in greater detail, providing the technical foundation for the subsequent site-specific work.



2. Finding the systems

Two Calls for Applications were built into the project approach during 2024 and 2025 to identify district heating systems where Low2HighDH support had a realistic prospect of progressing towards implementation. Applicants first needed to fill in surveys in EUsurvey form and eligible cases were then assessed according to implementation readiness and technical, financial and regulatory conditions before the support scope was defined with the selected participant.

3. Developing site-specific solutions

Participating systems were analysed individually to identify technically suitable transition pathways. The process was stakeholder-driven, with the project team maintaining regular contact with each site to ensure that the proposed solutions reflected local priorities, operational conditions and development plans. Rather than applying a predetermined technology, the analysis considered a broad portfolio of options, ranging from direct renewable or waste-heat integration and pre-heating to the use of heat pumps and other temperature-upgrading technologies.

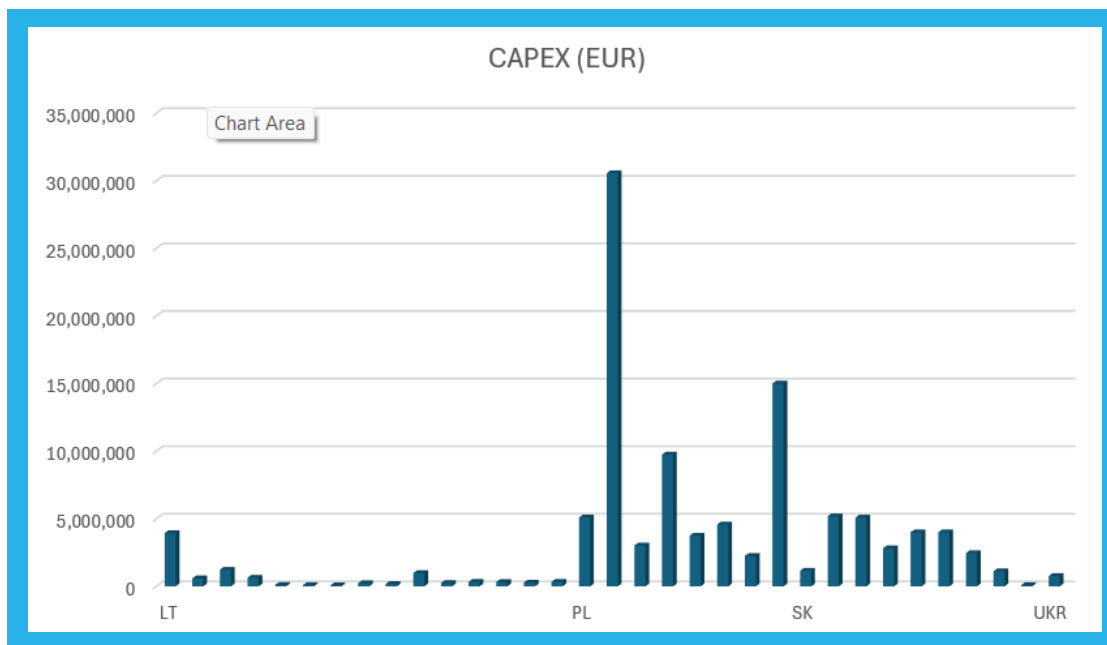
Local Liaison Groups (LLGs) anchored this process locally, bringing together actors with a direct interest in implementation, including municipalities, owners, developers and consumer representatives. Their involvement helped ensure that proposed solutions reflected local priorities and implementation conditions, while strengthening local ownership of the emerging investment pathways.

The assessments resulted in a portfolio of site-specific transition pathways across 33 district heating systems. Heat pumps emerged as the most frequently identified enabling technology, particularly air-source solutions, while other cases drew on locally available resources including geothermal energy, mine water and wastewater heat. The resulting configurations demonstrate that low-grade heat can be integrated into existing high-temperature networks through different approaches, depending on source availability, network temperatures, demand profiles and existing generation assets.



4. Making solutions bankable

Technical options were translated into investment pathways by combining technical assessment with economic and financial analysis. Across the portfolio, the project identified €110.5 million in potential sustainable-energy investment, while examining financing and implementation approaches appropriate to different ownership, regulatory and market conditions.



5. Moving towards the market

The support was designed to continue beyond feasibility analysis through Rough Order of Magnitude (ROM) approach and supplier engagement. The first steps towards implementing the proposed solutions were taken across the project sites. Ten simplified Requests for Information, based on a ROM approach, were prepared to support initial engagement with potential suppliers. In parallel, ten tailored financial and regulatory workplans were developed to guide the sites towards investment readiness. This support has already contributed to tangible progress, with implementation works underway at least two sites.

6. Building a community for replication

Alongside its work with individual district heating systems, Low2HighDH created a wider community around the transition. **Local Liaison Groups supported project development at site level, National Stakeholder Communities connected actors within the three target countries, and the Ambassador Community extended exchange beyond the directly supported systems.**

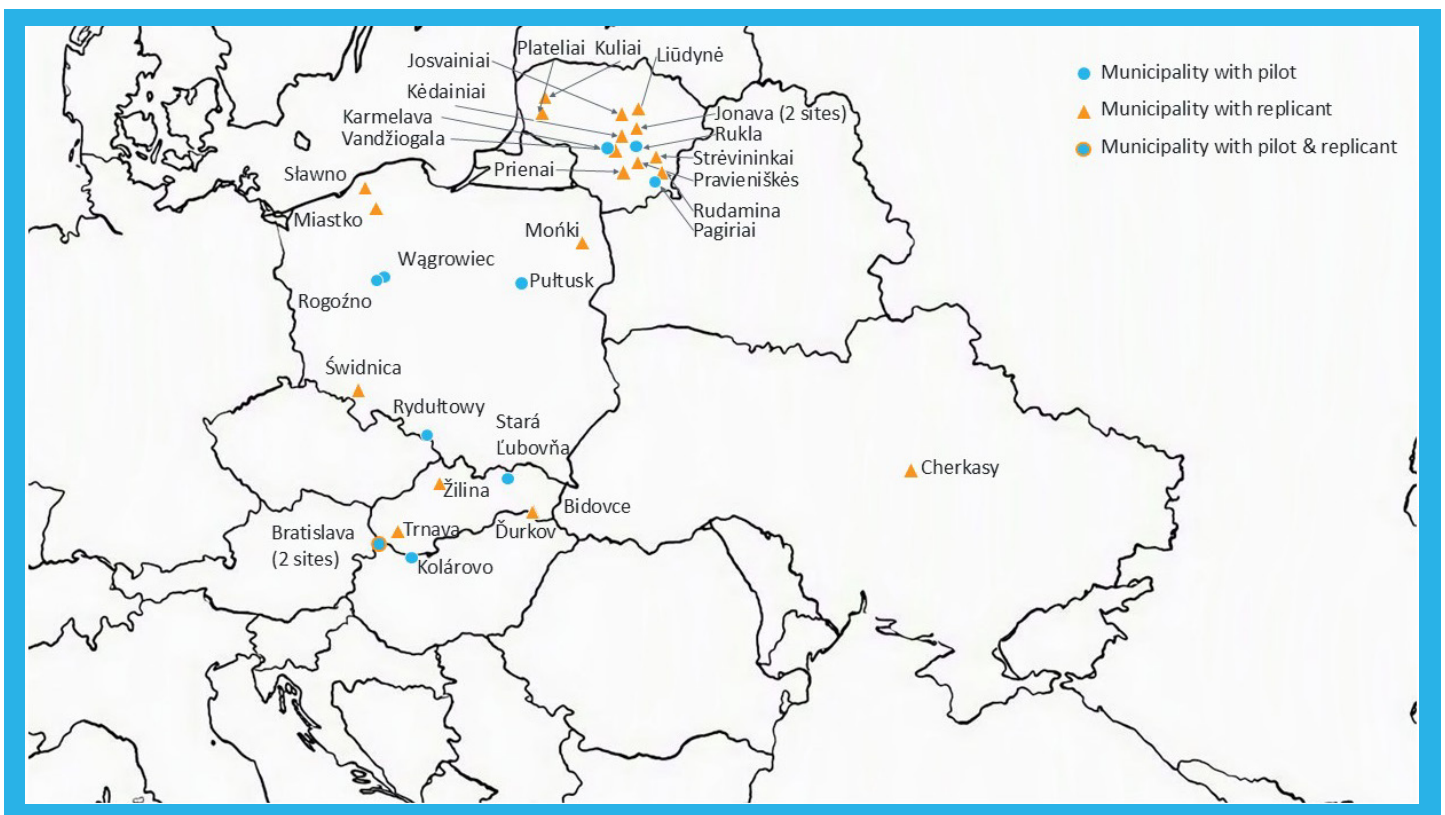
These networks were complemented by training, webinars, roadshows and participation in external events, creating multiple routes for transferring the knowledge generated through the project to other district heating operators and stakeholders.



Low2HighDH approach

No two district heating systems are identical. Network size, temperatures, fuel mix, heat demand, locally available resources, ownership and financing conditions differ. This diversity is central to the value of Low2HighDH.

Unlike projects built around pre-defined consortium pilot sites, Low2HighDH selected participating systems through open Calls for Applications. This created a demand-driven portfolio of real district heating systems whose operators had an active interest in exploring their transition options. The project could therefore apply and validate its support methodology across diverse real-world conditions, responding to actual market needs rather than pre-selected demonstration cases.



Technical Solutions: From Low-Grade Heat to Existing Networks

Low2HighDH developed a portfolio of **24 technical strategies** for integrating low-grade renewable and waste heat into existing high-temperature district heating systems. The solutions explore different combinations of heat sources, existing generation assets, integration points and enabling technologies. **Ten representative configurations were analysed in greater detail.**

24 strategies built around four questions:

- 1 Where does the heat come from?** – Solar thermal · geothermal · industrial and municipal waste heat.
- 2 Does it need a temperature boost?** – Heat pumps · mechanical vapour recompression · heat transformers.
- 3 How can it enter the existing system?** – Pre-heating · return/supply-line integration · partial substitution · larger-scale replacement.
- 4 How can the system remain flexible and reliable?** – Thermal storage · existing boilers/CHP for peaks and backup.

The portfolio shows that decarbonisation does not necessarily require replacing existing district heating infrastructure. Low-grade heat can be progressively integrated into existing systems, with temperature-upgrading technologies helping bridge the gap between the available heat source and the temperatures required by the network.

From a portfolio of options to the right solution

There is **no single technical pathway** suitable for every district heating system. The most appropriate solution depends on the characteristics of the existing network and the locally available energy resources: **the type, temperature and availability of the heat source, network operating temperatures, heat-demand profile, existing generation assets and the required temperature lift** all influence what can realistically be integrated.

The Low2HighDH Technical Solutions Portfolio therefore works as a **menu of possible integration strategies rather than a catalogue of ready-made solutions**. Low-grade heat can be introduced at different points in the system and at different levels of intervention — from pre-heating and return-line integration to partial substitution or more extensive replacement of existing fossil-fuel generation. Where source temperatures are too low for direct integration, technologies such as **heat pumps, mechanical vapour recompression or heat transformers** can bridge the temperature gap, while thermal storage can provide additional flexibility.

The key is therefore to **start with the system, not with the technology**: identify the available local resources, understand the network and demand conditions, screen the technically compatible options and only then select the configuration that merits further technical, economic and investment analysis.

Local resources + System conditions → Technical screening → Suitable configuration → Investment case



Turning Solutions into Investments

Aggregating individual site work into a portfolio-level picture

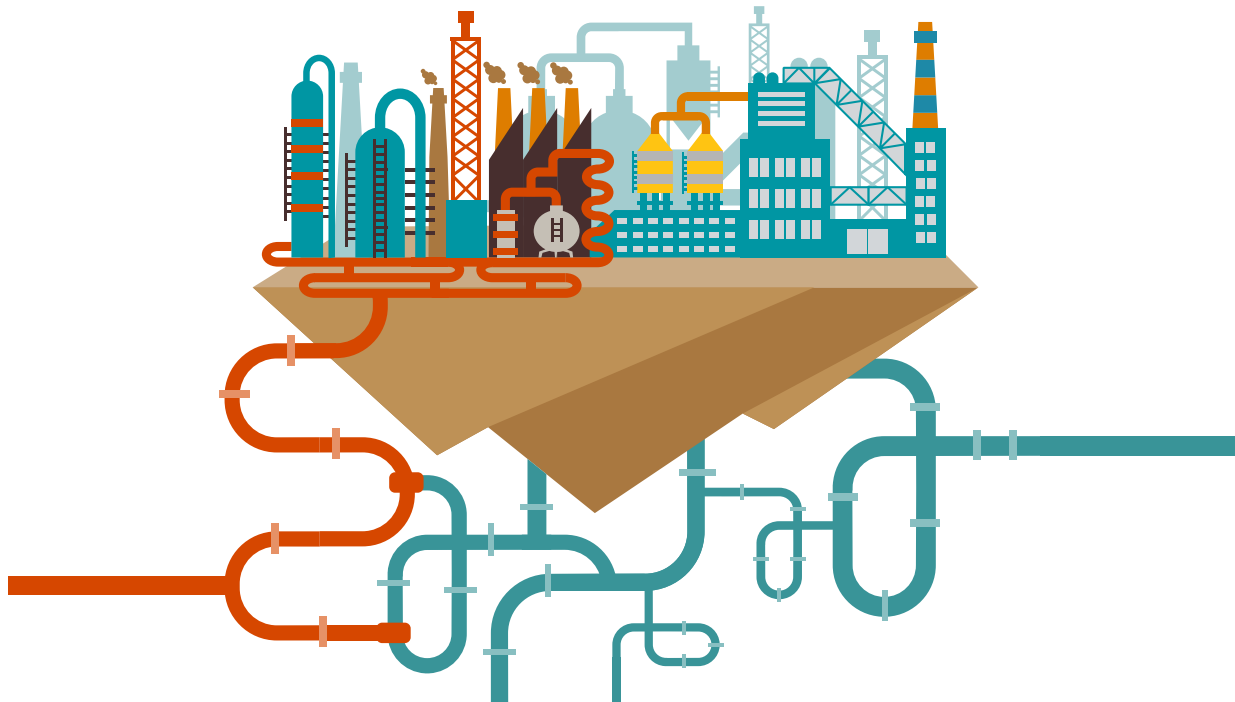
From technology portfolio to site-specific investment

The next step was to translate the preferred technical pathways into investment cases. Across the 33 supported systems, the project assessed the potential heat contribution and indicative investment associated with the proposed solutions, creating a portfolio-level picture of the scale and diversity of the investment opportunity.

Solution family	Sites	Capacity / heat contribution	Estimated investment
Air-source heat pumps	22	145.5 GWh/year	€41.6m
Water / mine-water heat pumps	3	22.2 GWh/year	€11.4m
Wastewater heat + heat pump	1	5.2 GWh/year	€3.0m
Low-temperature geothermal	5	31.4 GWh/year	€44.4m
Geothermal + heat pump	1	8.8 GWh/year	€9.7m
Biomass	1	0.4 GWh/year	€0.1m
TOTAL	33	213.5 GWh/year	€110.5m

What the portfolio tells us

- **Heat pumps dominate the identified pathways.** Air-source heat pumps alone account for 22 of the 33 proposed solutions and around 145.5 GWh/year of potential heat contribution.
- **Local resources shape the solution.** Where suitable resources exist, mine water, wastewater, geothermal and other locally available heat sources create alternative pathways to conventional heat generation.
- **Investment needs vary substantially.** Low-temperature geothermal represents fewer projects but a comparatively large share of estimated investment, reflecting its infrastructure and development requirements.
- **There is no standard investment package.** The appropriate solution depends on source temperature and availability, network conditions, demand, existing assets and local investment conditions.



From Investment Plans to Implementation

Financing and market engagement

Low2HighDH was designed to move participating systems beyond technical feasibility. Investment planning, financing and interaction with potential suppliers are therefore central to the final project story.

Making the projects bankable

The project considered financing mechanisms such as public subsidies, bank loans, private finance, equity, leasing/renting and ESCO-type approaches.

There is no single financing structure suitable for every district heating transition project. The appropriate approach depends on project size, ownership, maturity, available public support, borrowing capacity and the allocation of technical and commercial risks.

Three practical considerations are particularly important:

1 Public funding can reduce the initial investment barrier.

Grants and subsidies can improve project economics and innovative solutions common in DH modernisation.



2 Financing and implementation models can unlock investment. In line with the EU recommendation on unlocking private financing for energy efficiency, **blended finance is key to mobilising private capital.** Public funding can be combined with debt, equity and private investment to reduce risk and improve bankability, while models such as ESCOs, Energy Performance Contracting, BOT structures, operational renting and subscriptions can redistribute investment, operating and performance responsibilities.



3 Bankability depends on more than technical feasibility. A technically sound solution still needs predictable revenues, manageable operating costs, a credible implementation pathway and sufficient certainty over how investment costs will be recovered. These factors directly influence the ability of operators to attract external financing.



Low2HighDH in Practice

Different countries, different systems, different pathways

Low2HighDH applied the same transition methodology across district heating systems with very different starting points. **Lithuania, Poland and Slovakia differ in the scale of their district heating sectors, existing fuel mixes, network characteristics and locally available heat resources.** This diversity is reflected in the solutions identified through the project: there is no single route to cleaner district heating, but rather a portfolio of pathways adapted to local conditions.

Across the full portfolio of 33 supported systems, the investment pathways identify €110.5 million in potential investment, with the potential to replace 213.5 GWh of fossil energy and avoid 68,333 tonnes of CO₂ emissions annually. The scale and composition of this opportunity vary considerably between countries, reflecting differences in existing systems, locally available resources and the technical pathways identified.

The investment opportunity across the project portfolio

Country	Systems	Heat potentially decarbonised	CO ₂ potentially avoided	Potential investment
Lithuania	15	30.0 GWh/year	7,268 t/year	€9.6m
Poland	8	147.2 GWh/year	52,882 t/year	€74.0m
Slovakia	9	35.0 GWh/year	7,908 t/year	€25.9m
Ukraine	1	1.4 GWh/year	275 t/year	€0.8m
TOTAL	33	213.5 GWh/year	68,333 t/year	€110.5m

Figures represent the estimated potential identified through the investment-planning process and should not be interpreted as investments or impacts already realised.



Lithuania – Lithuania enters the transition from a comparatively advanced position, having already substantially reduced fossil-fuel use in district heating, predominantly through biomass. Low2HighDH therefore explored the next stage of diversification, with the assessed sites strongly oriented towards air-source heat pumps and the further electrification of heat supply. The Lithuanian cases demonstrate how low-grade solutions can complement an already changing heat mix rather than simply replace a single dominant fossil fuel.



Poland – Poland represents the largest concentration of potential impact among the assessed systems. The cases cover a particularly diverse range of resources, including mine-water heat, geothermal energy, wastewater heat and air-source heat pumps. Against the background of a large district heating sector that remains strongly dependent on fossil fuels, particularly coal, these cases illustrate the scale of the opportunity to use locally available renewable and recovered heat to progressively displace conventional generation.



Slovakia – The Slovak portfolio combines water- and air-source heat pumps, geothermal solutions and biomass, illustrating how different resources can play different roles within existing networks. The cases reinforce one of the project's central findings: the transition does not necessarily require replacing the entire existing system. Low-grade heat can become part of a hybrid generation mix, while existing assets continue to provide peak-load capacity, backup and security of supply. This staged approach is also reflected in the project's Local Replication Roadmap.



Ukraine – The project portfolio also includes Cherkasy, Ukraine, where a geothermal solution was assessed. While Ukraine is outside the project's three core target countries, its inclusion extends the practical application of the Low2HighDH approach to another district heating context and contributes to the project's wider replication potential.



**DH systems
supported**



**Potential
investment**



GWh/year



**tCO₂/year
avoided**

**ONE METHODOLOGY. MANY TRANSITION
PATHWAYS.**

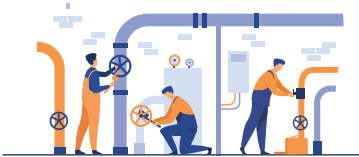
Building Capacity and Community

The transition depends on people as much as technology

Transforming district heating requires more than identifying the right technical solution. It also requires **knowledge, coordination and commitment from the actors who will plan, finance, approve and ultimately implement the transition.**

Low2HighDH therefore combined direct support to district heating systems with capacity building and stakeholder engagement. Through **training, practical resources, peer exchange and dedicated stakeholder communities**, the project strengthened local knowledge and ownership while creating channels for sharing experience across countries and beyond the directly supported systems.

Three levels of engagement



Local Liaison Groups

Created around the supported systems to bring district heating operators together with municipalities and other relevant local actors. They provided a space to discuss technical options, local priorities and implementation conditions and helped maintain stakeholder involvement as the cases developed.



National Stakeholder Communities

Connected district heating operators, public authorities, technology providers, financial actors and other stakeholders in Lithuania, Poland and Slovakia, creating opportunities to exchange experience, discuss common barriers and share approaches emerging from the project.



Ambassador Community

Extended the Low2HighDH network beyond the participating sites, bringing together interested organisations and professionals to share project knowledge, exchange experience and support wider uptake and replication of the project results.

From engagement to replication

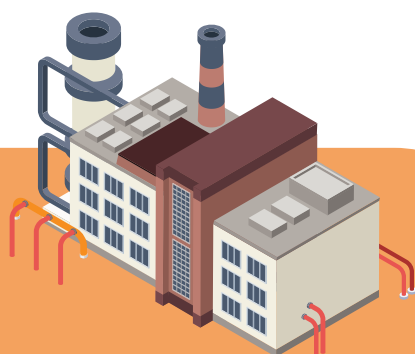
Together with **webinars, training activities, roadshows, practical tools and open-access resources**, these communities help ensure that the knowledge developed through Low2HighDH does not remain within the project. Instead, it can be used by other district heating operators, authorities and stakeholders looking to develop their own pathways towards cleaner heat.



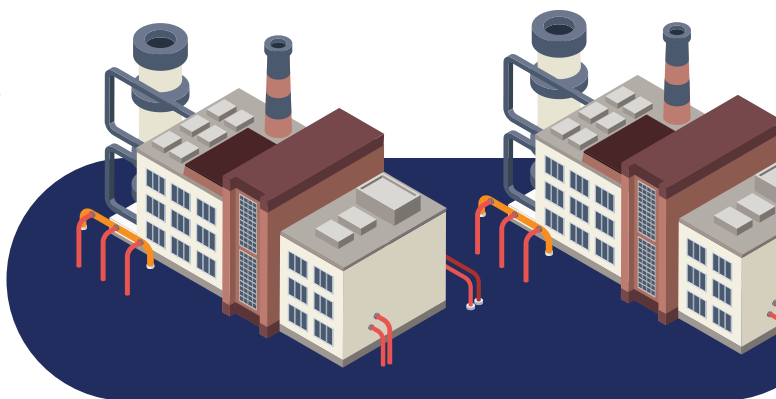
LOCAL EXPERIENCE



SHARED KNOWLEDGE



STRONGER CAPACITY



REPLICATION

Challenges Encountered

What made the transition difficult – and what the project learned from it

Availability and quality of site data

The Low2HighDH methodology was designed to support pre-feasibility assessments using readily available site data. Unlike more detailed approaches, the use of nPro requires a more limited set of inputs and enables operators to map potential solutions, discard alternatives that are clearly unsuitable and focus further efforts on the most promising options.

The resulting analysis should therefore be understood as an initial screening rather than a detailed feasibility assessment. A positive result indicates that a solution merits further investigation, but its technical and financial performance must still be confirmed through more detailed analysis before investment. This approach makes the methodology easier to apply and replicate, particularly where comprehensive or highly detailed system data are not yet available.

Integration into existing high-temperature systems

Integrating low-grade heat into an existing high-temperature network requires a system-level approach. Low-grade sources may not directly provide the temperatures required by the network, making the temperature gap between the source and the network a critical design parameter. Depending on the system, solutions may involve direct integration, pre-heating, return-line integration or partial/full source substitution supported by heat pumps or other temperature-upgrading technologies.

Low2HighDH therefore considered not only which renewable or recovered heat source was available, but also where it could enter the existing system and how much temperature upgrading would be required. In many cases, staged or hybrid configurations provide a practical transition route while retaining existing generation for peak demand or backup.

Investment costs and financing conditions

Technically promising solutions must also have a viable investment pathway.

Low-grade renewable and waste-heat projects can require substantial upfront investment[PK1.1][PK1.2][LD1.3], while their economics are affected by electricity prices, tariff conditions, financing costs and access to public support. Low2HighDH therefore considered financing alongside technical solutions and identified relevant grants, concessional financing instruments and financing institutions. The project experience reinforces the need to address technical design, investment planning and financing together from an early stage. Low2HighDH therefore considered project structure and financing from the early development stages, including public support, debt and equity options, blended finance and alternative ownership or delivery models.

Regulatory and market conditions

Technical feasibility does not automatically lead to implementation when regulatory and market conditions remain unfavourable. The project identified tariff methodologies, electricity charges, access to public support and the interaction between electricity and heat markets as factors that can materially influence investment decisions. Conditions differ considerably between Lithuania, Poland and Slovakia, but the common lesson is the need for greater long-term predictability and better coordination between heating, electricity, buildings and local energy planning.

Stakeholder coordination and decision-making timelines

District heating investment decisions involve a wider ecosystem than the operator alone. Ownership structures, municipalities, heat users, regulators, technology providers, heat-source owners and financiers can all influence whether an investment progresses. The Low2HighDH methodology therefore considered ownership, stakeholder relationships and implementation capacity already during case selection and case-study definition.

What We Learnt

Main lessons from supporting real high-temperature district heating systems

- 1 There is no universal technical solution.** Existing generation, network temperatures, demand profiles, infrastructure and locally available heat sources determine which transition pathway is feasible.
- 2 Low-grade heat must be assessed at system level.** Source temperature and availability, network temperatures, demand profiles, integration points, storage, backup and existing generation assets need to be considered together.
- 3 Heat pumps are an important enabling technology.** They can make low-temperature renewable and waste-heat sources useful for existing networks, including through hybrid configurations and temperature upgrading.
- 4 Technical feasibility and financial viability must be developed together.** Financing is not the final step after technology selection: project structure, public support, financing conditions, ownership and risk allocation can influence which technical pathway is realistically implementable.
- 5 Low-grade heat sources can be integrated into existing high-temperature district heating systems.** Rather than requiring a system-wide reduction in network temperatures or extensive modifications to buildings and substations, Low2HighDH focuses on solutions that upgrade and integrate low-grade renewable and recovered heat into existing networks. This approach enables operators to decarbonise heat generation while limiting disruption and avoiding major interventions on the demand side.

- 6 A staged transition is the most practical pathway for existing district heating systems** Full replacement of existing networks would require extensive and disruptive interventions, particularly in urban areas with underground piping infrastructure. Instead, hybrid configurations can progressively integrate renewable and recovered heat while making use of existing assets for peak demand, backup and security of supply. Operators should therefore prioritise solutions that maximise the use of existing infrastructure and allow renewable heat capacity to be added gradually as technical and financial conditions permit.
- 7 The required temperature lift matters.** The larger the difference between the source temperature and the network temperature, the more demanding the upgrading process becomes in terms of efficiency and economics. Low-grade renewable and recovered heat can cover a substantial share of demand, while existing fossil-fuel boilers can continue to provide backup and meet peak winter loads, as remains common in many district heating systems. Operators should therefore assess the temperature lift and expected operating profile carefully, prioritising low-grade heat for base-load supply and limiting fossil-fuel generation to periods of peak demand.
- 8 Stakeholder engagement is essential for implementation.** Municipalities, building owners, users, suppliers and financial institutions can determine whether projects progress from planning to investment. Their early involvement helps identify regulatory, technical, commercial and financing requirements, while building support for the proposed solution. Operators should therefore map relevant stakeholders and engage them throughout project development, assigning clear roles and maintaining regular communication as the project advances.
- 9 An investment plan is a starting point, not the end of the transition.** Technical and financial feasibility must be followed by decisions on financing, permitting, procurement and implementation. Turning a viable concept into an implemented project requires continued commitment from operators, authorities, financiers and other relevant actors.

Recommendations for the Future

Turning project experience into action

For policymakers and energy authorities

- Provide predictable, multi-year regulatory and support frameworks that allow district heating operators to prepare and finance long-term decarbonisation investments.
- Better integrate heat and electricity-system planning, recognising the flexibility that large-scale heat pumps, electric boilers and thermal storage can provide.
- Coordinate building renovation, district heating and local energy planning, taking account of existing infrastructure and locally available renewable and excess-heat resources.

For municipalities and local/regional authorities

- Integrate district heating into local energy and building-renovation planning, considering heat demand, existing infrastructure and locally available renewable and waste-heat resources together.
- Facilitate early cooperation between district heating operators, building owners, industries and other local heat-source owners.
- Support long-term local transition planning so that infrastructure and investment decisions are consistent with the future decarbonisation pathway of the district heating system.



For district heating owners and operators

- Start with the system, not the technology. Characterise existing generation, network temperatures and pressures, demand and operational constraints before selecting a solution.
- Map local renewable and recovered-heat resources early, including their temperature, capacity, availability, distance from the network and integration requirements.
- Develop the technical and financing pathways in parallel. Consider CAPEX, OPEX, energy prices, financing conditions, public support, ownership and project structure while technical alternatives are still being compared.
- Plan network and demand-side transformation together with generation changes. Assess whether lower network temperatures, modernised substations, building renovation and improved controls can make low-grade heat easier to integrate.

For financial institutions and investors

- Engage with projects during the development stage, not only when a financing request is submitted. Early dialogue can help project promoters understand the information, risk allocation and financial performance required for investment.
- Consider blended structures where appropriate. Combining public support with debt, equity or private capital can reduce risk and help mobilise investment.
- Consider alternative ownership and delivery structures alongside conventional lending. ESCOs, Energy Performance Contracts and project-finance structures can redistribute investment and performance risks.

For technology providers and engineering/EPC actors

- Design solutions around actual network temperatures, demand profiles and source conditions rather than standard technology configurations.
- Minimise unnecessary temperature lift where possible, as heat-pump efficiency and economics depend strongly on the gap between source and delivery temperatures.
- Consider integration requirements—including heat exchangers, thermal storage, backup generation, electrical connections and network adaptations—as part of the solution rather than as separate downstream issues.

Replication, Impact and Legacy

How the Low2HighDH experience can continue beyond the project

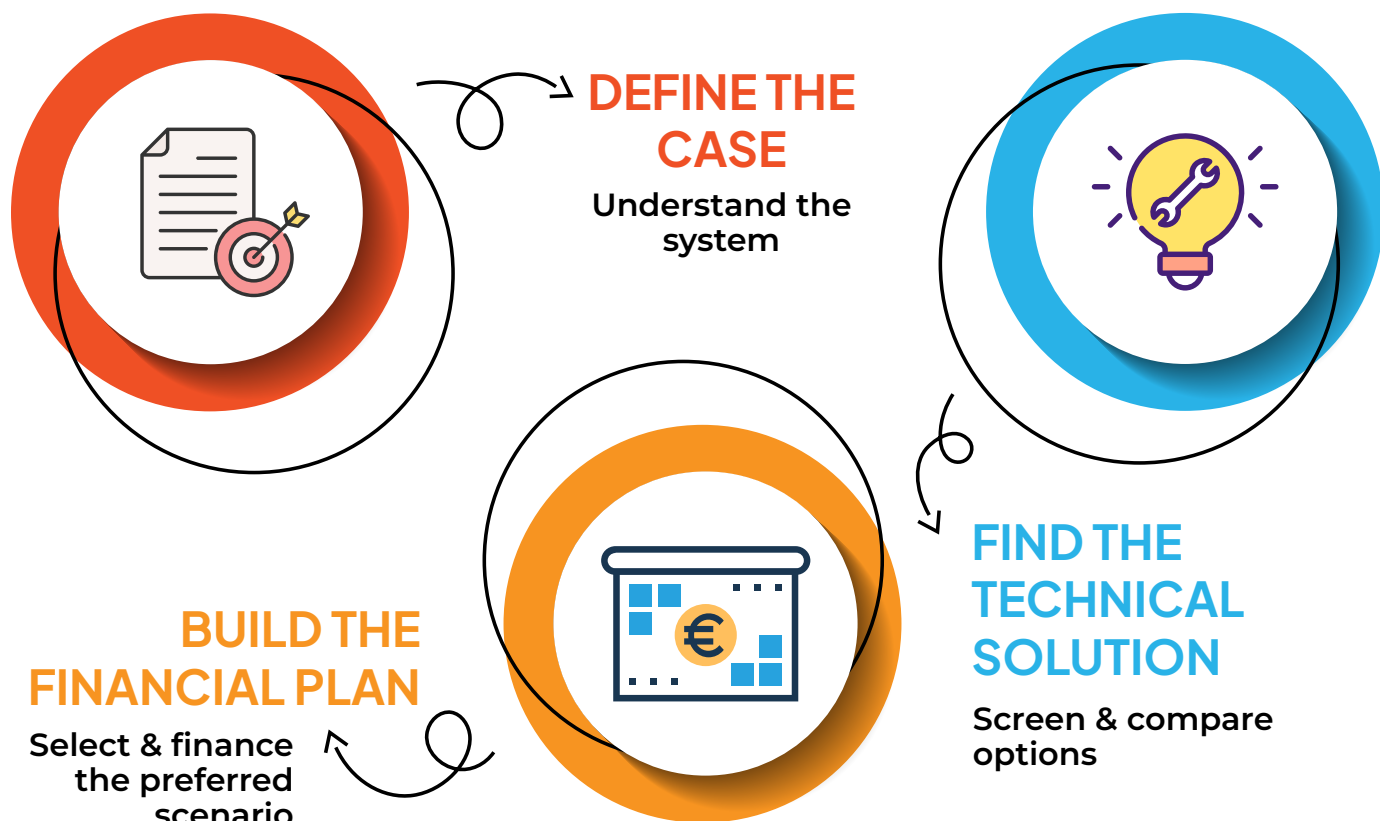
The value of Low2HighDH extends beyond the participating systems. The project's technical and financial portfolios, investment-plan experience, generic use cases, capacity-building materials, policy work and replication roadmap are intended to support other high-temperature district heating systems facing similar transition questions.

A simple replication pathway

The key principle is to screen before selecting. Replication does not mean copying a technology from one district heating system to another. It means applying a common process to understand the existing system, identify locally available resources, assess their technical compatibility and determine the role each option could play in the future heat mix.

The **Low2HighDH Local Replication Roadmap** translates this principle into three stages: **define the case → assess technical feasibility → develop the financial plan.** The process starts by characterising the existing district heating system, future heat demand, stakeholders and regulatory conditions. Potential renewable and waste-heat sources are then screened and combined into alternative technical scenarios, which are sized and compared before the most promising options progress to financial assessment.

Replication should therefore cover the **whole project-development chain**, not only technology selection. A technically suitable solution still needs a credible economic case, an appropriate financing structure, stakeholder commitment and a clear route towards implementation. The transferable value of Low2HighDH lies in this **common decision-making process**, while the technical solution and financing structure remain tailored to local resources, network conditions, demand patterns and regulatory and financing opportunities.



Final impact dashboard

Indicator	Final result
DH systems supported	33
Potential sustainable energy investment	€110.5 million
Fossil energy replaced	213.5 GWh/year
CO ₂ emissions avoided	68 333 t/year

Where investment, energy and CO₂ figures are derived from the investment plans rather than projects already commissioned, they represent potential/estimated impacts and not impacts already realised.

Continue the transition with Low2HighDH

- **Technical Solutions Portfolio** - 24 strategies for integrating low-grade renewable and waste heat into high-temperature district heating, including 10 detailed technical and economic models.
- **Financial Tools Portfolio** - Practical guidance for screening low-grade renewable and waste-heat solutions for different district heating configurations.
- **Investment Plans / case material** - Financing instruments, project structures and implementation models relevant to low-grade renewable and waste-heat investments.
- **Generic Use Cases** - Guidance for moving from system characterisation and technical alternatives towards pre-feasibility, financial assessment and investment planning.
- **Local Replication Roadmap** - A transferable pathway for applying the Low2HighDH methodology to other district heating systems.
- **Policy Recommendations** - Recommendations for improving the enabling conditions for district heating decarbonisation.
- **Training materials and videos** - Capacity-building resources for district heating operators, authorities and other stakeholders.



Conclusion and Outlook

The project ends, the transition continues...

Low2HighDH leaves a clear message: **Europe's existing district heating networks can begin integrating low-grade renewable energy and recovered heat now**, without waiting for a single breakthrough technology or rebuilding entire systems from scratch. The transition will necessarily look different in every place, shaped by network temperatures, demand, existing assets, local heat resources, ownership, regulation and access to finance.

Across Lithuania, Poland and Slovakia, the project turned this complexity into a practical route from ambition to investment. Its headline results are:

- **33 district heating systems supported**
- **24 integration strategies developed**
- **€110.5 million in estimated investment potential**
- **213.5 GWh/year of fossil energy potentially replaced**
- **68,333 tonnes of CO₂/year emissions potentially avoided**

These figures represent the potential of the investment plans rather than impacts already realised, but they demonstrate the scale of opportunity that can be unlocked when system characterisation, technical screening, economic assessment and market engagement are brought together.

The strongest lesson is clear: technology alone does not deliver decarbonisation. Promising heat pumps, solar thermal, geothermal and waste-heat solutions become implementable only when they are matched with credible financing, predictable regulation, suitable tariffs, coordinated heat and electricity planning and sustained cooperation among operators, municipalities, heat-source owners, technology providers, investors and users. Three conditions can reduce risk while preserving reliability and affordability:

- **Early stakeholder involvement**
- **Staged and hybrid configurations**
- **Parallel development of the technical and financial cases**

The project ends, but the transition continues. Replication does not mean copying the same solution from one network to another; it means **applying a disciplined process**: characterise the system, map local resources, screen and compare options, build the investment case, define financing, engage the actors who can unlock delivery and move towards procurement and implementation. Low2HighDH's portfolios, investment-planning experience, generic use cases, capacity-building materials and replication roadmap provide a practical starting point for other European networks. **The next step is implementation**: turning the plans prepared through the project into operating assets, monitoring their performance and carrying the lessons forward into the next generation of district heating investments.

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Annex I. From Investment Plans to Implementation

Turning technical opportunities into investment pathways

Low2HighDH prepared investment pathways for 33 district heating systems, comprising 10 pilots and 23 replicants. The work explored how renewable energy and recovered heat available locally could be integrated into existing high-temperature district heating networks and translated into realistic investment opportunities.

The complete investment plans contain sensitive technical, commercial and financial information and are reported separately to the European Commission through the project's sensitive deliverables. This public annex therefore presents their main findings in a consolidated and anonymised form. It does not disclose the names of the supported systems or operators, or any site-level operational and financial information.

Pilot and replicant plans are presented separately because they received different levels of support. The pilot plans combined market, technical and financial analysis with implementation-oriented activities. The replicant plans identified potential technical pathways and provided operators with tools and guidance for their further development.

The investment plans represent project-development and pre-feasibility outputs. They do not constitute final investment decisions, confirmed financing arrangements or completed investments.

The investment opportunity at a glance

Across the 33 investment plans, Low2HighDH identified:

- €110.5 million in estimated sustainable energy investment potential,
- 213.5 GWh/year of fossil energy that could potentially be replaced,
- 68,333 tonnes of CO₂ emissions that could potentially be avoided each year.

These figures describe the estimated potential of the investment plans. They do not represent investments already completed or impacts already achieved.



investment
pathways



million
investment
potential



of fossil energy
potentially
replaced



tCO₂/year
avoided

The technical pathways identified

The investment plans examined a range of solutions adapted to the resources and operating conditions of the supported district heating systems. The resulting portfolio is strongly centred on heat pumps, which can raise the temperature of environmental, renewable or recovered heat so that it can be used in existing high-temperature networks.

Proposed solution	Systems	Potential heat contribution	Estimated investment
Air-source heat pumps	22	145.5 GWh/year	€41.6 million
Water-source or mine-water heat pumps	3	22.2 GWh/year	€11.4 million
Wastewater heat and heat pump	1	5.2 GWh/year	€3.0 million
Low-temperature geothermal	5	31.4 GWh/year	€44.4 million
Geothermal and heat pump	1	8.8 GWh/year	€9.7 million
Biomass	1	0.4 GWh/year	€0.1 million
Total	33	213.5 GWh/year	€110.5 million

The table presents each investment pathway under its principal solution family. The figures represent estimates developed through the investment-planning process and remain subject to further technical definition, validation and investment decisions.

Air-source heat pumps represent the most widely identified pathway, accounting for 22 of the 33 proposed solutions and approximately 145.5 GWh/year of potential heat contribution. Low-temperature geothermal solutions require a larger estimated investment relative to the number of systems, reflecting the infrastructure and development requirements associated with this resource. Water, mine-water and wastewater sources offer further opportunities where suitable resources are locally available.

The portfolio confirms that there is no single solution for district heating decarbonisation. The appropriate technical pathway depends on the temperature and availability of the heat source, network temperatures, seasonal demand, existing generation assets, infrastructure constraints and local investment conditions.

Pilot Investment Plans

Comprehensive support for ten district heating systems

The ten pilots received the project's most comprehensive level of assistance. For each pilot, the investment-planning process connected four elements:

Market and demand analysis → Technical solution → Financial assessment → Implementation pathway

The process started with the district heating system rather than with a predetermined technology. The project considered existing generation assets, network conditions, expected heat demand, locally available heat sources, costs and implementation constraints together.

This resulted in a tailored investment pathway for each pilot, showing how an initial decarbonisation opportunity could progress towards a more clearly defined investment concept.

Planning for future heat demand

District heating investments have long operating lives. New equipment must therefore be sized not only for current heat sales, but also for expected future demand.

The pilot analyses considered factors such as:

- **changes in the number of connected consumers,**
- **renovation of connected buildings,**
- **reductions in heat consumption per building,**
- **potential new connections or network extensions,**
- **possible customer disconnections,**
- **local development and demographic trends,**
- **heat-pricing and revenue conditions.**

This helped reduce the risk of oversizing new capacity and ensured that the technical solutions reflected likely future conditions. The resulting forecasts provided planning assumptions for the technical and financial analyses, rather than guaranteed predictions of future demand.

Selecting the technical pathway

Each pilot was assessed individually. The project reviewed the existing assets, network temperatures, operating profile and availability of local heat sources before identifying the most promising configuration for further development.

Technical modelling was used to compare potential configurations and examine their expected contribution over the year. The results were considered alongside practical factors such as available space, source temperature, distance from the network, connection requirements and the temperatures required by the district heating system.

Heat pumps emerged as an important enabling technology. They can upgrade lower-temperature renewable, environmental or recovered heat so that it can be used in existing networks. Their performance and operating cost, however, depend strongly on the temperature difference between the source and the heat supplied to the network.

Selecting an appropriate integration point and avoiding unnecessary temperature lift are therefore critical to both technical performance and project economics.

Building on existing infrastructure

The proposed pathways do not require the complete replacement of existing district heating networks. Instead, they show how renewable and recovered heat can be integrated progressively while existing assets continue to support the system.

Existing boilers, combined heat and power units or other generation assets can continue to provide:

- **peak winter demand,**
- **backup capacity,**
- **operational flexibility,**
- **security of heat supply.**

This makes staged and hybrid configurations particularly relevant. Renewable or recovered heat can cover a growing share of annual demand, while existing assets remain available when additional capacity or higher temperatures are required.

Renewable or recovered heat for base load + existing assets for peaks and backup
= staged transition

A staged approach can reduce immediate implementation risks, limit disruption and allow operators to gain practical experience before developing subsequent investment phases.

From technical feasibility to financial viability

The financial assessment translated the selected technical configuration into an investment case.

Investment requirements extend beyond the cost of purchasing the principal technology. Depending on the project, additional expenditure may be needed for:

- **heat exchangers and pumping equipment,**
- **piping and network connections,**
- **electrical connections,**
- **control systems,**
- **thermal storage,**
- **civil and construction works,**
- **engineering, installation and commissioning.**

Operating costs are equally important. For heat-pump projects, the principal drivers include electricity prices, efficiency, annual operating hours, maintenance requirements and the cost of the fuels being replaced.

Consequently, the option with the strongest technical performance is not necessarily the most attractive investment. The selected pathway must balance energy performance, capital costs, operating expenditure, emissions reductions and the operator's ability to recover the investment.

Financing the transition

The pilot plans considered potential combinations of:

- **operators' own resources,**
- **commercial or concessional debt,**
- **public grants and subsidies,**
- **equity or private investment,**
- **blended-finance structures,**
- **alternative ownership and implementation models.**

Public funding can help reduce the initial investment barrier, particularly where projects involve innovative technologies, substantial integration works or environmental benefits that are not fully reflected in heat tariffs.

Combining public support with debt, equity or private investment can help mobilise additional capital. However, financing depends not only on the availability of funding. Investors and lenders also require adequate information on revenues, operating costs, project risks and the capacity to repay the financing.

The plans therefore show that the technical solution, financing structure and implementation model must be developed together.

Moving towards implementation

The support provided to the pilots continued beyond technical and financial analysis. It helped operators identify the decisions and further work required before procurement, financing and construction.

Non-binding technical documentation supported initial engagement with potential suppliers and contractors. Financial and regulatory roadmaps identified potential funding routes and issues requiring further examination. The proposed pathways were also discussed with relevant local stakeholders.

The next steps differ between projects, but commonly include:

- **validating technical data and assumptions,**
- **completing detailed engineering,**
- **confirming permits and connection requirements,**
- **obtaining updated costs,**
- **identifying the final financing structure,**
- **completing formal procurement,**
- **securing the necessary approvals.**

The pilot plans provide a practical basis for this next phase. They do not replace the detailed technical, procurement and financing work required before implementation.

Replicant Investment Plans

Extending the Low2HighDH approach

The 23 replicants enabled the project's approach to be applied across a broader and more diverse group of district heating systems.

The replication support was adapted based on the experience gained with the pilots. Preparing a complete market, technical and financial assessment requires extensive operational, commercial and financial information, as well as continued interaction with operators to validate data and assumptions.

The replicant plans therefore focused on:

- **identifying a potential site-specific technical solution,**
- **helping operators understand the information needed for further development,**
- **providing a preliminary market and financing framework,**
- **strengthening the operators' capacity to continue the investment process.**

The replicant plans are not shorter versions of the pilot plans. They represent a different level of support, designed to provide a larger number of operators with a credible starting point for developing their projects.

Identifying a technical direction

The core result for each replicant was a proposed technical pathway based on the available information about the existing system, its operating conditions and potential local heat sources.

These proposals demonstrate an important principle:

Replication means applying a common decision-making process, not copying the same technology from one system to another.

Operators need to characterise their own systems, map locally available heat sources, compare technically compatible options and identify the configuration best suited to their circumstances.

The replicant proposals therefore identify directions for further investigation. Before making an investment decision, operators will need to confirm:

- **heat-source availability and reliability,**
- **network temperatures and demand profiles,**
- **equipment capacity,**
- **integration and connection requirements,**
- **investment and operating costs,**
- **regulatory and permitting conditions.**

Developing the business case

The replicant plans provide a structured framework for developing the market and financial components of the investments.

The framework covers the main factors that should be considered:

- **present and expected heat demand,**
- **customer and building-stock developments,**
- **capital and operating expenditure,**
- **electricity and fuel prices,**
- **applicable heat tariffs,**
- **public support programmes,**
- **potential debt or private financing,**
- **ownership and implementation options.**

A proposed technical solution does not by itself establish that an investment is financially viable. Operators must complement the technical proposal with validated demand forecasts, updated cost estimates, revenue analysis and financing assumptions appropriate to their circumstances.

Building local capacity

Replicants received access to the project's technical and financial materials. They were also offered an nPro licence and opportunities to discuss potential solutions with technical experts from the consortium.

This support was complemented by six training webinars:

- **one general technical webinar,**
- **three country-specific technical webinars,**
- **two general financial webinars.**

The objective was to help operators understand the available technologies, use the project's analytical resources and identify the next steps needed to advance their projects.

For many replicants, these next steps will include additional data collection, more detailed technical modelling, preparation of demand and revenue forecasts, development of a financial model and engagement with authorities, financiers and potential suppliers.



Two Levels of Support, One Common Objective

	Pilots	Replicants
Systems supported	10	23
Main objective	Develop an integrated investment pathway	Identify a technical pathway and support further development
Market analysis	Site-specific demand and commercial assessment	Framework for subsequent assessment
Technical analysis	Comparison of alternatives and development of a selected configuration	Proposed solution requiring further validation
Financial analysis	Financial modelling and financing scenarios	Assumptions, methodology and potential financing sources
Implementation support	Supplier engagement, roadmaps and stakeholder discussions	Capacity building and guidance on subsequent steps
Result	Pre-feasibility investment pathway	Preliminary replication and project-development pathway

The distinction reflects the different depth of support provided. Both groups contribute to the same objective: helping district heating operators move from a general interest in decarbonisation towards a structured investment process.

A separate breakdown of investment, energy and emissions results between pilots and replicants is not included in this public annex. Results are presented at portfolio level to protect sensitive information and avoid disclosing or enabling the identification of individual projects.

What the Investment Plans Show

Five common findings emerge from the investment-planning work.

- 1 Start with the system, not the technology** – The appropriate solution depends on the existing network, operating temperatures, demand profile, generation assets and locally available heat sources.
- 2 Low-grade heat can be integrated progressively** – Complete replacement of existing systems is neither necessary nor generally realistic. Staged and hybrid configurations can increase renewable and recovered heat while retaining existing assets for peaks, backup and security of supply.

- 3 Temperature matters** – The larger the temperature difference between the heat source and the network, the more energy is needed to upgrade the heat. Source temperature, network temperature and operating profile directly affect efficiency and cost.
- 4 Technical and financial planning must proceed together** – A technically feasible solution still needs manageable operating costs, predictable revenues, appropriate financing and a credible route to implementation.
- 5 An investment plan is a starting point** – Further engineering, permitting, procurement, financing and stakeholder decisions are needed before construction. The investment plan organises this process and helps the operator identify the most relevant next steps.
- 5 The Path Towards Implementation** – Low2HighDH helped the participating systems move from technical potential towards structured investment pathways. The common process emerging from the plans is:

Understand the system → Map local heat sources → Compare technical options → Select a pathway → Build the financial case → Engage stakeholders and suppliers → Procure, finance and implement

The technical solution and financing structure remain specific to each district heating system. What can be replicated is the process used to prepare and make the investment decision.

The 33 investment plans identified a substantial potential project pipeline. Realising that potential will depend on continued engagement by district heating operators, municipalities, public authorities, technology providers and financial institutions.

The plans provide a bridge between identifying an opportunity and preparing an implementable project. Their long-term value will be demonstrated as operators validate the proposed solutions, secure the necessary approvals and financing, and translate the identified pathways into operating investments.



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