ENABLE DHC

INVESTMENT PLAN

For the District Heating system in Stryi

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SEN	Sensitive, limited under the conditions of the Grant Agreement	☐
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Nature of the deliverable		
R	Report, document	☒
DEM	Demonstrator, pilot, prototype, plan designs	☐
DEC	Websites, patents filing, press & media actions	☐
DATA	Datasets, microdata, etc.	☐
DMP	Data management plan	☐
ETHICS	Deliverables related to ethic issues	☐
SECURITY	Deliverables related to security issues	☐
OTHER	Software, technical diagram, algorithms, models, etc.	☐

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This template is prepared to support consortia participating in the LIFE Clean Energy Transition subprogramme in developing investment plans for existing or new district heating and/or cooling systems. The goal is to facilitate the preparation of plans that meet the "efficient district heating and cooling" criteria outlined in the Energy Efficiency Directive article 26, which is further explained in Commission Recommendation (EU) 2024/2395 [1].

[1] Commission Recommendation (EU) 2024/2395[1] of 2 September 2024 setting out guidelines for the interpretation of Article 26 of Directive (EU) 2023/1791 of the European Parliament and of the Council as regards the heating and cooling supply, available at https://eur-lex.europa.eu/eli/reco/2024/2395/oj/eng

1. Case Study Context and Transformation Objective

The district-heating system in Stryi is operated by the municipal utility Stryiteploenergo and is characterised by a decentralised structure comprising multiple local boiler houses serving separate heat-supply areas. The system supplies residential buildings, public institutions and other consumers across Stryi and surrounding settlements. At system level, the heat-generation portfolio comprises approximately 94 MWth of installed thermal capacity, with annual heat production of around 65 GWh. Heat generation remains predominantly based on natural gas, while woody biomass currently provides the main renewable contribution. The district-heating network extends for approximately 29 km, and progressive replacement of ageing sections with pre-insulated piping forms part of the ongoing modernisation process.

The principal transformation challenge is to reduce the system's dependence on fossil natural gas while maintaining reliable and affordable heat supply across a decentralised infrastructure. This requires a coordinated approach combining generation diversification, continued network rehabilitation, improved operational flexibility and, where technically feasible, gradual reduction of operating temperatures. The transformation must also account for changing heat demand resulting from building renovation, competition from individual heating systems and uncertainty regarding future customer development.

Existing woody biomass provides an established renewable-energy contribution and further technical potential has been identified within the wider system. However, sustainable fuel availability, fuel quality and long-term supply conditions constrain the extent to which biomass can provide a scalable decarbonisation pathway. In addition, the ENABLE DHC approach considers bioenergy as one component of a diversified future supply portfolio rather than as the sole long-term solution.

Other renewable and low-carbon options assessed for the Stryi case include heat pumps, photovoltaic electricity, thermal energy storage and high-efficiency cogeneration as a transitional technology. Ambient heat represents a potential renewable heat source for heat-pump integration, while solar photovoltaic generation can contribute to the electrification of heat production. No sufficiently quantified external waste-heat source has yet been confirmed for the assessed system. Future industrial development may nevertheless create additional opportunities, subject to source-specific assessment of available capacity, temperature level, location and operating profile.

Given the decentralised configuration of the Stryi system, the investment-planning approach uses a representative local boiler-house heat-supply area to investigate alternative transformation pathways in greater technical and economic detail. The results are intended to provide evidence for subsequent replication at comparable decentralised heat-supply areas rather than to prescribe a single solution for the entire network.

The overall transformation objective is therefore to establish a progressive, technically feasible and financially realistic pathway towards a more diversified, renewable and flexible district-heating system, while reducing exposure to fossil-fuel consumption and supporting future compliance with the efficient district heating and cooling criteria of Article 26 of Directive (EU) 2023/1791. The investment planning considers an approximately ten-year transformation horizon from 2026, while maintaining consistency with the increasingly stringent decarbonisation requirements applicable toward 2040, 2045 and 2050.

2. Solutions and Investment Scenarios Assessed

The technical assessment investigated alternative pathways for reducing fossil-fuel dependence in a representative decentralised heat-supply area of the Stryi district-heating system. The analysis considered the interaction between the existing biomass and natural-gas boilers and additional technologies including combined heat and power (CHP), thermal energy storage (TES), photovoltaic generation (PV) and a high-temperature heat pump (HP). All scenarios were assessed against the same heat-demand basis using hourly energy-system modelling, allowing their technical performance, operational flexibility, decarbonisation potential and relevance to the efficient-DHC criteria of the Energy Efficiency Directive (EED) to be compared.

Three investment scenarios were evaluated in addition to the existing reference configuration:

Scenario	Main configuration	Strategic role
Sc01 – CHP integration	Existing boilers supplemented by a natural-gas CHP unit	Transitional efficiency and cogeneration pathway
Sc02 – CHP + TES	CHP combined with short-term thermal energy storage	Transitional pathway with increased operational flexibility
Sc03 – PV + high-temperature HP + TES	Photovoltaic generation, high-temperature heat pump and thermal storage, with existing boilers retained for backup	Renewable-electrification and long-term decarbonisation pathway

Sc01 introduces high-efficiency cogeneration into the existing heat-supply configuration. Simultaneous production of heat and electricity can improve overall fuel utilisation and reduce operation of the separate gas boiler. The configuration is comparatively straightforward to integrate and can provide additional value through electricity generation. Its principal limitation is that the CHP remains dependent on natural gas. Sc01 is therefore considered primarily a transitional efficiency measure rather than a long-term decarbonisation solution.

Sc02 extends the cogeneration concept by adding thermal energy storage. The storage allows heat production to be partially decoupled from instantaneous heat demand, enabling the CHP unit to operate more flexibly and improving the ability to respond to electricity-market and heat-demand conditions. This configuration provides greater operational flexibility than Sc01, but it retains the same fundamental dependence on fossil natural gas. It therefore represents the strongest of the assessed transitional cogeneration options, rather than an end-state solution.

Sc03 follows a fundamentally different pathway based on renewable electrification. The concept combines photovoltaic electricity generation with a high-temperature heat pump and thermal energy storage, while retaining the existing boilers for residual demand, operational flexibility and security of supply. This configuration provides the greatest potential to reduce direct natural-gas consumption and progressively increase the contribution of renewable heat.

The main technical challenge of Sc03 is the integration of a high-temperature heat pump into a system currently operating at relatively high supply temperatures. Heat-pump performance under these conditions is more sensitive to ambient temperature, required supply temperature and part-load operation than in lower-temperature district-heating systems. Detailed design therefore needs to verify achievable seasonal performance, equipment suitability and the interaction between PV production, heat-pump operation, thermal storage and the electricity grid. Future reduction of district-heating

operating temperatures would further improve the technical and economic conditions for heat-pump integration.

From an EED perspective, Sc01 and Sc02 can contribute to the transition toward efficient district heating through the combined use of renewable heat and high-efficiency cogeneration during the earlier stages of the planning horizon. However, continued reliance on natural-gas CHP means that both pathways would require further transformation as the Article 26 criteria become progressively more stringent toward 2045 and 2050. Sc03 offers the clearest route toward these longer-term requirements because it shifts the heat-supply structure toward renewable electricity, ambient heat and thermal flexibility while reducing direct dependence on fossil-fuel heat generation.

On this basis, Sc03 is identified as the preferred long-term investment pathway. Its selection reflects its stronger structural decarbonisation potential, compatibility with increasing electrification of heat supply and greater alignment with the long-term direction of the EED efficient-DHC criteria. Sc02 remains a relevant transitional alternative where lower initial investment and cogeneration flexibility are prioritised. Final investment decisions should nevertheless be based on detailed feasibility work, including verification of heat-pump performance, electricity-system integration, local renewable-energy availability and updated techno-economic assessment.

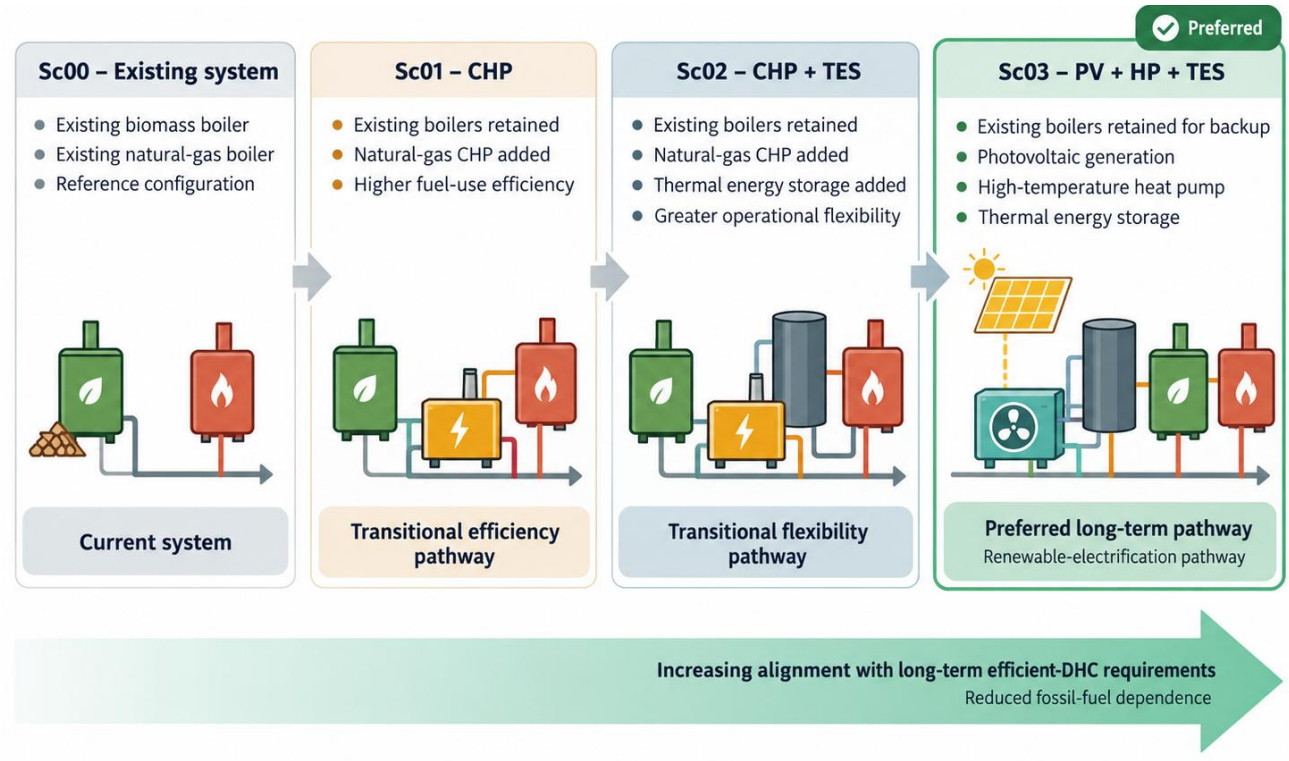


Figure 1. Indicative renewable and fossil/cogeneration heat shares of the assessed scenarios compared with selected Article 26 milestones. Results represent screening-level modelling of the representative case.

3. Investment and Implementation Outlook

3.1. Expected Impact

The selected Sc03 – PV + high-temperature heat pump + thermal energy storage pathway is intended to shift the representative Stryi heat-supply area from predominantly combustion-based heat production toward a more electrified, renewable and flexible configuration. The concept combines approximately 0.50 MWp of photovoltaic generation, a 0.50 MWth high-temperature heat pump and 50 m^3 of thermal energy storage, while retaining the existing boilers for operational flexibility and security of supply.

From a technical perspective, the investment would introduce three complementary capabilities: renewable electricity generation, electrified heat production and short-term thermal flexibility. Thermal storage can decouple heat generation from instantaneous demand, while the existing boilers provide resilience during periods of low renewable availability, equipment outages or commissioning.

Screening-level modelling indicates that the selected configuration has the potential to eliminate direct natural-gas use for normal heat production in the representative case, while substantially increasing the contribution of renewable heat. The principal environmental benefit is therefore a reduction in direct fossil-fuel consumption and associated on-site CO_2 emissions. The pathway would also reduce long-term exposure to natural-gas dependence and support progressive alignment with the increasingly stringent efficient-DHC requirements under Article 26 of the Energy Efficiency Directive.

The wider socio-economic value lies in demonstrating a replicable approach for modernising decentralised municipal heat-supply systems. If technically and economically validated, the concept could inform similar investments at other suitable boiler-house areas in Stryi, while supporting local renewable-energy use, modernisation of municipal energy infrastructure and development of technical expertise in heat-pump and storage operation.

3.2. Implementation Roadmap

Implementation is proposed as a phased process so that the principal technical and financial uncertainties can be resolved before full investment commitment.

Phase	Indicative timeframe	Main actions
Feasibility validation	2026–2027	Confirm heat-demand characteristics and renewable-resource availability; refine the energy model; verify PV potential, electrical connection requirements and achievable heat-pump performance
Detailed design and financing	2027	Complete site surveys, hydraulic and electrical design, equipment specifications, permitting assessment, financing applications and procurement preparation
Procurement and construction	2027–2028	Tender and procure PV, heat-pump and thermal-storage equipment; undertake required civil, hydraulic and electrical works
Commissioning	2028	Integrate control systems, undertake functional and safety testing, commission equipment and train operating staff
Monitoring and optimisation	2028–2030	Monitor heat-pump performance, PV generation, storage utilisation, energy balances and operating costs; optimise system dispatch
Replication assessment	From 2030	Assess technical and economic transferability to comparable decentralised heat-supply areas within Stryi

A stage-gate approach is recommended: progression to procurement should follow successful validation of heat-pump performance, electrical-grid integration, site suitability and updated investment economics.

3.3. Key Risks and Enabling Conditions

The investment pathway combines established technologies, but their integration under the operating conditions of the Stryi heat-supply system introduces several important risks.

The main technical risk concerns the performance of the high-temperature heat pump. Existing district-heating temperatures are relatively high, which can reduce heat-pump efficiency, particularly during cold-weather operation. Supplier performance verification, seasonal-COP assessment and, where feasible, progressive reduction of network operating temperatures are therefore important enabling conditions.

A second technical and economic risk concerns the interaction between PV generation, electricity demand and the electricity grid. Renewable electricity production and heat demand do not occur simultaneously throughout the year, making appropriate control, thermal storage and grid interaction essential. Detailed electrical assessment and optimisation of local renewable-electricity utilisation are therefore required before implementation.

Other important risks include changes in investment costs, energy prices, financing conditions, technology eligibility and permitting requirements. These should be addressed through supplier quotations, sensitivity analysis, diversified or concessional financing, early regulatory coordination and phased project development.

Resource availability and security of supply remain relevant considerations. Retaining the existing heat-generation assets during the initial implementation phase provides an important resilience measure by maintaining heat supply during periods of insufficient renewable generation, maintenance or equipment outages.

Overall, successful implementation depends on four principal enabling conditions: validated heat-pump performance, technically feasible grid integration, access to suitable financing, and continued coordination between the operator, municipality, technical partners and relevant infrastructure stakeholders.

3.4. Stakeholder Engagement & Endorsement

Stakeholder involvement in the Stryi case has been organised through the ENABLE DHC DHC Working Group, bringing together Stryiteploenergo, Stryi City Council, City Institute and relevant technical partners. The Working Group has supported the identification of transformation priorities, technical-data collection and discussion of potential measures for modernising the local heat-supply system.

Initial discussions addressed biomass-based heat generation, heat pumps and broader decarbonisation opportunities. Subsequent exchanges considered more specific pre-feasibility topics, including cogeneration for public buildings, integration of heat pumps with thermal storage, GIS and hydraulic modelling, building-level energy efficiency and improved heat regulation.

These discussions provided the stakeholder basis for assessing the investment pathways presented in this plan. In particular, the technical options investigated in the representative case reflect measures identified jointly during the ENABLE DHC planning process.

At the current stage, however, the preferred Sc03 configuration should be regarded as the outcome of the investment-planning assessment rather than as a formally approved investment commitment by Stryiteploenergo. Formal confirmation by the DHC operator and Stryi City Council is therefore an important next step before detailed design, financing and procurement.

Stakeholder engagement should continue throughout project development, with particular attention to operator participation in equipment selection and operating strategy, municipal approval and financing, coordination with the electricity-distribution system operator, and communication with the public institutions served by the selected heat-supply area.

4. Conclusions and Key Lessons

The Stryi investment-planning process demonstrates that the transformation of a decentralised district-heating system should be approached through a combination of generation diversification, electrification, thermal flexibility and continued infrastructure modernisation, rather than through a single technology solution. The case also shows the value of assessing representative local boiler-house systems in greater detail where a full system-wide transformation model is not yet available.

Among the pathways assessed, the combination of photovoltaic generation, a high-temperature heat pump and thermal energy storage emerged as the preferred long-term option. Its main advantage is the potential to reduce direct natural-gas dependence while increasing the contribution of renewable and electrified heat. By contrast, CHP-based options can improve fuel utilisation and operational flexibility in the transition period, but their continued reliance on natural gas limits their compatibility with progressively stricter long-term decarbonisation requirements.

A key lesson from the case is that high-temperature district-heating operation is a critical constraint for heat-pump integration. The technical and economic performance of the preferred pathway therefore depends strongly on achievable seasonal heat-pump efficiency, electricity-system integration and the future evolution of network operating temperatures. Thermal storage provides an important enabling function by increasing operational flexibility and helping to match renewable-energy availability with heat demand.

The case further highlights that renewable-energy potential alone is not sufficient to define an investment pathway. Sustainable biomass availability, electricity-market conditions, grid capacity, investment cost, financing conditions, permitting requirements and security of supply must all be considered together. Retaining existing heat-generation assets during the initial transition can provide valuable operational resilience while new technologies are commissioned and optimised.

Progress toward implementation should therefore follow a phased and evidence-based approach, beginning with validation of heat demand, renewable-resource availability, heat-pump performance and grid conditions, followed by detailed design, financing, procurement, commissioning and monitored operation. Formal confirmation by the DHC operator and municipality remains an important prerequisite before investment commitment.

For other district-heating systems facing similar challenges, the principal transferable lesson is that decentralised systems can be transformed progressively through modular local investments, provided

that each intervention is assessed within a broader long-term decarbonisation strategy. Representative-case analysis, combined with staged validation and replication, can provide a practical route for reducing technical and financial risk while moving toward more renewable, flexible and efficient district-heating systems.

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