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Pathways for the Decarbonisation

of the District Heating Systems in Drobeta-Turnu Severin and Craiova

Alexandru Ciocan
Mihai Constantin
Noah Murray
Alina Arsani

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Report Title

Pathways for the Decarbonisation of the District Heating Systems in Drobeta -Turnu Severin and Craiova

A study by

Energy Policy Group (EPG)
Constantin Noica 159, Bucharest, Romania
www.epg-thinktank.org, office@epg-thinktank.org

About EPG

EPG is an independent, non-profit think tank focused on energy and climate policy in Romania and the European Union. Founded in 2014, EPG operates as a policy research institute primarily financed through competitive grants, philanthropic organisations and, to a limited extent, private sector projects. EPG aims to promote an evidence-based dialogue on how to balance decarbonisation, economic competitiveness and social fairness, engaging decision-makers, industry, and the public.

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Disclaimer

The analysis presented in this report reflects the authors' perspective on the challenges faced by Romania's district heating systems and on the ways in which these systems can be modernised. The report does not necessarily propose an optimal solution. It shows that, in the case of the two municipalities assessed, there are viable alternatives to the use of fossil fuels. For this analysis, EPG benefited from a grant provided by the European Climate Foundation, and the manner in which the two municipalities were selected as study cases is described in the first part of the project.

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Key Findings

Decline of the district heating system. The cities of Drobeta-Turnu Severin and Craiova both run aging systems with major losses, which have resulted in a decline in connected consumers and production volumes. In Drobeta, over 4,000 households have disconnected from 2020 to 2024, while Craiova lost nearly 7,000 consumers in the same timeframe. Heat production fell by more than 20% in Drobeta and by almost half in Craiova in 2024 compared to 2020.

Cost escalation and subsidy burden. In Drobeta, production costs rose from around 400 RON/MWh in 2020 to over 650 RON/MWh in 2022, while in Craiova that rise was from 280 RON/MWh to more than 540 RON/MWh. In both cities, households pay far less due to heavy subsidies, creating a major fiscal burden for municipalities. In addition to support from local authorities, the current heat production plants require subsidies from central authorities. For Drobeta, this support is expected from the Ministry of Development and Public Works, for Craiova from the Ministry of Energy.

Unsustainability of individual solutions. Following the retirement of the Halânga plant, no concrete plans are in place for maintaining district heating services, thus raising the prospect of a full transition to individual gas boilers. Such a shift would require more than 61.5 million EUR in upfront investment, not including necessary network upgrades. Moreover, households would be exposed to rising costs under ETS 2 carbon pricing, while local air quality would deteriorate as NOx and particulate matter emissions increased, further entrenching dependence on fossil fuels.

Potential of renewable-based solutions. Large water-to-water heat pumps represent a viable alternative, with coefficients of performance between 3.5 and 4.5, producing 3.5–4.5 kWh of heat from every 1 kWh of electricity. Such solutions could, on their own, cover the need of Drobeta DH system, while for Craiova they could be integrated into a mix of technologies. International experience in Aalborg, Cologne, Esbjerg, and Vienna demonstrates the feasibility of systems ranging from 50 to 225 MW that supply tens of thousands of consumers. Although investment costs are significant (between €1.5 and €2.5 million per installed MW), these technologies offer both cost stability and substantial reductions in emissions.

Local opportunities. The Danube provides an abundant heat source for an 85 MW water-to-water heat pump, while wastewater heat recovery could deliver an additional 4.4 MW of thermal capacity. At the same time, a semi-centralised approach using air-to-water pumps at substations could eliminate heat transmission losses and reduce demand, improving overall system efficiency. For Craiova, on the other hand, a hybrid system consisting of a new CHP plant complemented by water-to-water heat pumps, either using the Jiu River as a source or installed in substations to increase the supply temperature, could help reduce the need for fossil fuels. A midterm thermal storage facility could also contribute in this regard.

Strategic conclusion. For Drobeta, maintaining the current system or replacing it with individual heating would be neither financially sustainable nor environmentally acceptable. A modernised district heating model, centred on large-scale heat pumps, renewable integration, building efficiency improvements, and energy storage, provides the most resilient and affordable pathway. Such an approach would align with EU climate objectives while ensuring long-term affordability and improved air quality for the city's residents.

Executive Summary

Romania's district heating systems, once central to urban energy supply, now face structural decline marked by aging infrastructure, high fuel costs, and growing consumer disconnections. To arrest this trajectory and restore affordability and reliability, several measures must be addressed. These include decarbonisation, with priority for electrification (including the integration of renewable energy sources), energy storage, and improved building efficiency, all calibrated to each city's specific context.

The case study of Drobeta-Turnu Severin illustrates these challenges clearly. Originally developed to support industrial production and later extended to residents, the system is now characterised by high technical and commercial losses, heavy reliance on subsidies, and recurring fuel insecurity. From 2020 to 2024, connected households fell from over 26,000 to just above 22,000, while annual disconnections reached 1,500 households in 2024. Production and consumption volumes dropped by more than 20% over the same period, with losses in 2024 exceeding 40% of generated heat. The cost burden has grown unsustainable. In 2020, thermal energy production cost was just above 400 RON/MWh; by 2024, it peaked above 650 RON/MWh. Fuel costs rose from 253 RON/MWh in 2020 to 460 RON/MWh in 2024. Municipal subsidies, which more than tripled between 2020 and 2024, now shield households from full exposure but strain local budgets. A scenario where consumers switch entirely to individual gas boilers would demand over €61.5 million in upfront investment, excluding gas network expansion, while exposing households to higher bills under ETS 2 carbon pricing and worsening local air pollution.

In Craiova, on the other hand, the number of connected households declined from nearly 60,000 to 53,000 in 2020–2024. Delivered-to-produced heat ratio slid from about 70% to 65%. Craiova's heat price rose fast, the subsidy bill increased dramatically, and households were shielded only by heavy local support. Plant-delivered costs climbed from 280 RON/MWh in 2020 to >540 RON/MWh in 2024, while neighbourhood plants[1] stayed near 800 RON/MWh, far above end-user tariffs. Households paid about 250 RON/MWh in 2020 and 340 RON/MWh in 2024, the municipality covering the gap. The household cost share of the heat bill jumped above 80% in 2021–2022, fell below 40% in 2023, then recovered slightly in 2024, mirroring price volatility and loss levels. In 2023, the city's subsidy outlay was over 5.5 times the 2020 level and nearly 3 times in 2024, amounting to over 138 million RON in five years. These trajectories confirm rising structural costs and a mounting fiscal burden without efficiency and fuel-switch measures.

Environmentally, reliance on fossil fuels, especially HFO and coal, generates high CO_2 emissions and pollutants directly impacting air quality. In contrast, large-scale heat pumps offer a competitive alternative. With coefficients of performance of 3–4.5, they deliver 3–4.5 kWh of heat per kWh of electricity consumed, making heat costs (considering the current values) comparable to individual boilers while enabling decarbonisation. International

[1] the term *neighbourhood plants* was used for *centrale de cvartal* in Romanian to distinguish them from *district heating plants*, which correspond to *centrale de zonă*.

examples (Aalborg, Cologne, Esbjerg, Vienna, and others) confirm that water-to-water and air-to-water heat pumps can cover tens of thousands of consumers cost-effectively, with specific investment costs of €1.5–2.5 million/MW installed for large capacities.

For Drobeta-Turnu Severin, a centralised solution could involve installing an 85 MW water-to-water heat pump using the Danube as a heat source, with potential downsizing to about 50 MW if building stock is renovated. Alternatively, a semi-centralised approach based on air-to-water pumps at substations would eliminate heat transmission losses, reduce demand, and accelerate implementation. Wastewater heat recovery could further provide around 4.4 MW of useful thermal capacity.

For Craiova, the situation may be similar. The city could harness the Jiu River's potential to complement the gas-fired plant for which Craiova II initially secured financing, such a heat pump can reach up to 50 MW. In addition, exploiting wastewater heat recovery could provide a source of clean heat. The advantage of having an operational CHP plant allows Craiova to explore on-site thermal energy storage, as well as the potential of ground-source heat pumps by leveraging the land and infrastructure already available, previously used for lignite storage. A key requirement for the gas-fired plant is the ability to supply process steam to industrial consumers such as Ford Otosan.

A modern, renewable-based district heating model integrating large-scale heat pumps, building renovations, and storage solutions is the most viable pathway. It ensures affordability, reduces emissions, improves air quality, and aligns with Romania's EU commitments, while maximising the use of EU financing opportunities under the PNRR and Modernisation Fund.

For the case of Drobeta, without firm action, as the city's gas network expands, consumers may turn to individual solutions. Even if from the local authorities' perspective this shift may seem the option requiring the least involvement, it is ultimately financially unsustainable, because households must cover the full cost of individual systems. It is environmentally unsustainable, as it locks consumers into continued gas use and maintains local pollution while moving away from climate objectives. It is also socially unsustainable, as vulnerable consumers are left without viable alternatives and face significant barriers to purchasing individual heating systems.

Therefore, to meet 21st-century needs, both the authorities and consumers must start with a different mindset. To strengthen decarbonisation options and modernise the district heating system in line with climate objectives, both central and local authorities have the following options:

Elaborate or update the Local Heating Strategy. Local heating strategies must be a directional document aligned with EU and national policies, with clear indicators and measurable targets. It should guide decisions, budgets, and projects. It must not be limited to a document prepared solely to meet ANRE's formal requirements or to support funding applications. Central authorities should also amend the legislation to include coercive measures for the absence of local heating strategies.

Prioritise Renewable-Based Solutions. Focus on large-scale heat pumps. Use the Danube and wastewater recovery as stable renewable sources. Position Drobeta as a model for other river cities. For Craiova, by contrast, modernise the system around a mix of technologies that support decarbonisation, rather than concentrate the entire load in gas-fired cogeneration.

Strengthen Energy Efficiency and Demand-Side Measures. Accelerate building rehabilitation to cut demand by 40–50%; demand reduction translates into direct budget savings for consumers, complemented by the installation of individual consumption management equipment. Link upgrades with new requirements to size capacity correctly and reduce costs.

Consider a semi-centralised heating model as an option. If a centralised solutions is no longer feasible, especially in cities where production has been effectively shut down or the legal status of the heat transmission network is complex, then consider installing air-to-water heat pumps in heat exchanger stations. Such an approach reduces reliance on the transmission network.

Leverage Available Funding Instruments. Central authorities should open the Modernisation Fund and other EU schemes to a wider set of projects, not only gas and networks. Thermal storage, geothermal, heat pumps, and solar thermal should be eligible to ensure financing for the right projects.

Ensure Social Equity and Affordability. Reducing heat production costs is essential to ease the financial pressure created by universal subsidies and to ensure the long-term sustainability of district heating systems. Municipal and national authorities should gradually move away from broad, undifferentiated subsidies that benefit all consumers regardless of income.

Complete the replacement of lignite capacity. At CET II Craiova, the investment must be reconsidered. Although the initial plan of 295 MWe and 256 MWth gas-fired CHP was considered and the new updated configuration appears more flexible, the CAF (heat only boilers) should be reassessed considering current demand, with potential resizing if required. In the long term, the district heating system should enable third-party access for additional producers, allowing gas input to be reduced. Even so, shifting a share of lignite generation to gas remains important.

Design a hybrid model. In the case of Craiova, developing a hybrid configuration that combines the new gas-fired CHP plant with large-scale water-to-water heat pumps or storage facilities represents a strategic pathway toward decarbonisation and cost stability.

Integrate thermal storage. Various energy storage configurations could contribute to balancing peak loads and optimizing CHP operation.

Modernise the transport and distribution network. Bring current losses down from 35% to EU benchmarks (≤15%), to reduce the fiscal burden of subsidies.

Phase out costly neighbourhood heating plants. Inefficient heating plants that currently produce heat at a high cost (around 800 RON/MWh) should be phased out and replaced with heat supplied from a centralised system contributing thus to lower bills.

Sumar executiv

Sistemele de încălzire centralizată din România, care odinioară erau esențiale pentru aprovizionarea cu energie a orașelor, se confruntă acum cu un declin structural marcat de infrastructura învechită, costurile ridicate ale combustibililor și creșterea numărului de consumatori care renunță la acest serviciu. Pentru a opri această tendință și a restabili accesibilitatea și fiabilitatea, trebuie abordate mai multe măsuri. Acestea includ decarbonizarea cu prioritate pentru electrificare (având în vedere integrarea surselor regenerabile), stocarea energiei și îmbunătățirea eficienței clădirilor, toate calibrate la contextul specific al fiecărui oraș.

Studiul de caz al orașului Drobeta-Turnu Severin ilustrează clar aceste provocări. Dezvoltat inițial pentru a sprijini producția industrială și extins ulterior la locuitori, sistemul se caracterizează în prezent prin pierderi tehnice și comerciale ridicate, dependență puternică de subvenții și insecuritate recurentă în ceea ce privește combustibilul. În perioada 2020-2024, numărul gospodăriilor conectate a scăzut de la peste 26 000 la puțin peste 22 000, în timp ce deconectările anuale au atins 1 500 de gospodării în 2024. Volumele de producție și consum au scăzut cu peste 20% în aceeași perioadă, pierderile din 2024 depășind 40% din căldura generată. Costurile au devenit insuportabile. În 2020, producția de energie termică costa puțin peste 400 RON/MWh, iar în 2024 a atins un nivel maxim de peste 650 RON/MWh. Costurile combustibilului au crescut de la 253 RON/MWh în 2020 la 460 RON/MWh în 2024. Subvențiile municipale, care s-au triplat între 2020 și 2024, protejează acum gospodăriile, dar pun presiune pe bugetele locale. Un scenariu în care consumatorii trec în totalitate la cazane individuale pe gaz ar necesita o investiție inițială de peste 61,5 milioane EUR, fără a lua în calcul extinderea rețelei de gaze, expunând în același timp gospodăriile la facturi mai mari în cadrul sistemului ETS 2 de stabilire a prețului carbonului și agravând poluarea locală a aerului.

În Craiova, pe de altă parte, numărul gospodăriilor conectate a scăzut de la aproape 60 000 la 53 000 în perioada 2020-2024. Raportul între căldura livrată și cea produsă a scăzut de la aproximativ 70% la aproximativ 65%. Prețul căldurii în Craiova a crescut rapid, factura subvențiilor a explodat, iar gospodăriile au fost protejate doar de un sprijin local puternic. Costurile livrate de centrala termoelectrică au crescut de la 280 RON/MWh în 2020 la >540 RON/MWh în 2024, în timp ce centralele de cartier au rămas la aproximativ 800 RON/MWh, cu mult peste tarifele pentru utilizatorii finali. Gospodăriile au plătit aproximativ 250 RON/MWh în 2020 și 340 RON/MWh în 2024, municipalitatea acoperind diferența. Ponderea costurilor cu căldura în cheltuielile gospodăriilor a sărit la peste 80% în 2021-2022, a scăzut sub 40% în 2023, apoi s-a redresat ușor în 2024, reflectând volatilitatea prețurilor și nivelurile pierderilor. În 2023, cheltuielile cu subvențiile orașului au fost de peste 5,5 ori mai mari comparativ cu nivelul din 2020 și de aproape 3 ori mai mari în 2024, cumulând peste 138 de milioane de RON în cinci ani. Aceste traiectorii confirmă creșterea costurilor structurale și a sarcinii fiscale fără măsuri de eficiență și de schimbare a combustibilului.

Din punct de vedere al mediului, dependența de combustibilii fosili, în special de păcură și cărbune, generează emisii ridicate de CO_2 și poluanți care afectează în mod direct calitatea aerului. În schimb, pompele de căldură la scară largă oferă o alternativă competitivă. Cu coeficienți de performanță de 3-4,5, acestea furnizează 3-4,5 kWh de căldură per kWh de energie electrică consumată, ceea ce face ca costurile de încălzire (având în vedere valorile actuale) să fie comparabile cu cele ale cazanelor individuale pe gaz, permițând în același timp decarbonizarea. Exemple internaționale (Aalborg, Köln, Esbjerg, Viena și altele) confirmă faptul că pompele de căldură apă-apă și aer-apă pot acoperi zeci de mii de consumatori în mod rentabil, cu costuri de investiție specifice de 1,5-2,5 milioane EUR/MW instalat pentru capacități mari.

Pentru Drobeta-Turnu Severin, o soluție centralizată ar putea implica instalarea unei pompe de căldură apă-apă de 85 MW care utilizează Dunărea ca sursă de căldură, cu posibilitatea reducerii puterii la aproximativ 50 MW în cazul renovării fondului imobiliar. Alternativ, o abordare semi-centralizată bazată pe pompe aer-apă la punctele termice ar elimina pierderile de transmisie, ar reduce cererea și ar accelera implementarea. Recuperarea căldurii din apele uzate ar putea furniza în plus aproximativ 4,4 MW de capacitate termică utilă.

Pentru Craiova, situația poate fi similară. Orașul ar putea valorifica potențialul râului Jiu pentru a completa centrala pe gaz pentru care Craiova II a obținut inițial finanțare, o astfel de pompă de căldură putând atinge până la 50 MW. În plus, exploatarea recuperării căldurii din apele uzate ar putea oferi o soluție de căldură curată. Avantajul de a avea o centrală CHP operațională permite Craiovei să exploreze stocarea energiei termice la fața locului, precum și potențialul pompelor de căldură sol-apă prin valorificarea terenului și a infrastructurii deja disponibile, anterior utilizate pentru stocarea lignitului. O cerință cheie pentru centrala pe gaz este capacitatea de a furniza abur industrial consumatorilor industriali, cum ar fi Ford Otosan.

Un model modern de încălzire urbană bazat pe energii regenerabile, care integrează pompe de căldură la scară largă, renovări de clădiri și soluții de stocare, este cea mai viabilă cale spre decarbonizare. Acesta asigură accesibilitatea, reduce emisiile, îmbunătățește calitatea aerului și se aliniază angajamentelor României față de UE, maximizând în același timp utilizarea oportunităților de finanțare ale UE în cadrul PNRR și Fondului de Modernizare.

În cazul Drobeta, fără măsuri ferme, consumatorii ar putea fi nevoiți să apeleze la soluții individuale. Această schimbare, chiar dacă din perspectiva autorităților locale poate părea opțiunea cu cea mai mică implicare, este în cele din urmă nesustenabilă din punct de vedere financiar, deoarece gospodăriile trebuie să suporte integral costul sistemelor individuale. Este nesustenabilă din punct de vedere al mediului, deoarece menține consumul de gaz, păstrând poluarea locală și îndepărtând orașul de obiectivele climatice. De asemenea, este nesustenabilă din punct de vedere social, deoarece consumatorii vulnerabili rămân fără alternative viabile și se confruntă cu bariere semnificative în achiziționarea sistemelor individuale de încălzire.

Prin urmare, pentru a răspunde nevoilor secolului XXI, atât autoritățile cât și consumatorii ar trebui să pornească de la o abordare diferită. Pentru a consolida opțiunile de decarbonizare și a moderniza sistemul de încălzire centralizată în conformitate cu obiectivele climatice, atât autoritățile centrale, cât și cele locale sunt încurajate să exploreze unele dintre următoarele opțiuni:

Elaborarea sau actualizarea strategiei locale de încălzire. Strategiile locale de încălzire trebuie să fie un document orientativ aliniat la politicile UE și naționale, cu indicatori clari și obiective măsurabile. Acesta ar trebui să ghideze deciziile, bugetele și proiectele. Nu trebuie să se limiteze la un document pregătit exclusiv pentru a îndeplini cerințele formale ale ANRE sau pentru a sprijini cererile de finanțare. Autoritățile centrale ar trebui, de asemenea, să modifice legislația pentru a include măsuri coercitive în cazul absenței strategiilor locale de încălzire.

Prioritizarea soluțiilor bazate pe energii regenerabile. Concentrarea pe pompe de căldură la scară largă. Utilizarea Dunării și a recuperării apelor uzate ca surse regenerabile stabile. Poziționarea orașului Drobeta ca model pentru alte orașe aflate pe cursul unui râu. În schimb, pentru Craiova, modernizarea sistemului în jurul unui mix de tehnologii care susțin decarbonizarea, în loc să se concentreze întreaga sarcină pe cogenerarea pe bază de gaz.

Consolidarea eficienței energetice și a măsurilor privind cererea. Accelerarea reabilitării clădirilor pentru a reduce cererea cu 40-50%, reducerea cererii traducându-se în economii bugetare directe pentru consumatori, completate de instalarea de echipamente individuale de gestionare a consumului. Corelarea modernizărilor cu noile cerințe pentru dimensionarea corectă a capacității și reducerea costurilor.

Luarea în considerare a unui model de încălzire semi-centralizat ca opțiune. Dacă soluțiile centralizate nu mai sunt fezabile, în special pentru orașele în care producția a fost efectiv oprită sau statutul juridic al rețelei de transport este complex, atunci se poate lua în considerare instalarea de pompe de căldură aer-apă în puncte termice. O astfel de abordare reduce dependența de rețeaua de transport.

Utilizarea instrumentelor de finanțare disponibile. Autoritățile centrale ar trebui să deschidă Fondul de Modernizare și alte scheme pentru un set mai larg de proiecte, nu numai pentru centrale în cogenerare pe gaze și modernizarea rețelelor de transport. Stocarea termică, energia geotermală, pompele de căldură și energia solară termică ar trebui să fie eligibile pentru a asigura finanțarea proiectelor potrivite.

Asigurarea echității sociale și accesibilitatea. Reducerea costurilor de producție a căldurii este esențială pentru a ușura presiunea financiară creată de subvențiile universale și pentru a asigura sustenabilitatea pe termen lung a sistemelor de încălzire centralizată. Autoritățile municipale și naționale ar trebui să renunțe treptat la subvențiile generale, nediferențiate, de care beneficiază toți consumatorii, indiferent de venituri.

Finalizarea înlocuirii capacității de producție pe bază de lignit. În cazul CET II Craiova, investiția trebuie reconsiderată. Deși planul inițial privind un CHP de 295 MWe și 256 MWth pe bază de gaz a fost actualizat și noul design este mai flexibil, capacitatea în CAF ar trebui reevaluată în funcție de cererea actuală. Și, dacă este nevoie, capacitatea trebuie reconsiderată. Pe termen lung, sistemul de încălzire urbană ar trebui să permită accesul pentru producători, permițând reducerea producției din gaz. Chiar și așa, transferul unei părți din producția de lignit către gaz rămâne important.

Proiectarea unui model hibrid. În cazul Craiovei, dezvoltarea unei configurații hibride care combină noua centrală de cogenerare pe bază de gaz cu pompe de căldură apă-apă la scară largă sau instalații de stocare reprezintă o cale strategică către decarbonizare și stabilitatea costurilor.

Integrarea stocării energiei termice. Diverse configurații de stocare a energiei termice ar putea contribui la echilibrarea sarcinilor de vârf și la optimizarea funcționării cogenerării.

Modernizarea rețelei de transport și distribuție. Reducerea pierderilor actuale de la 35% la valorile de referință ale UE (≤15%), pentru a reduce povara fiscală a subvențiilor.

Eliminarea treptată a centralelor costisitoare de cvartal. Centralele ineficiente care produc în prezent căldură la un preț ridicat (de 800 RON/MWh) ar trebui eliminate și înlocuite cu furnizarea de agent termic din unități centralizate eficiente, contribuind astfel la reducerea facturilor consumatorilor.

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Acronyms

ANRE	Romanian Energy Regulatory Authority
CCGT	Combined Cycle Gas Turbine
CHP	Combined Heat and Power
COP	Coefficient of Performance
DH	District Heating
EED	Energy Efficiency Directive
EPBD	Energy Performance of Buildings Directive
EPG	Energy Policy Group
ETS	Emissions Trading System.
EU COM	European Commission
MDLPA	The Ministry of Development, Public Works and Administration
NECP	National Energy and Climate Plan
RAAM	Romanian Autonomous Mining Administration
RENEL	Romanian Autonomous Electricity Authority
RES	Renewable Energy Sources
SACET	District Heating Supply System
SPAET	Public District Heating Service
STES	Seasonal Thermal Energy Storage

1. Introduction: The modernisation of district heating systems in Romania

District heating (DH) systems are municipal networks that contribute to cutting carbon emissions from buildings while ensuring that citizens have access to dependable and affordable heating. The recast Energy Efficiency (EED) and Energy Performance of Buildings Directives (EPBD) place renewed emphasis on high-efficiency district heating and cooling as enablers for achieving climate neutrality by 2050. Both directives highlight the need to integrate renewable and waste heat sources, improve energy efficiency at every stage of the supply chain, and promote digitalisation and consumer empowerment. Across Europe, efforts are underway to design an action plan on electrification, and a strategy addressing both heating and cooling needs (EU COM, 2025).

In the context of Europe's broader objectives, Romania has the chance and the challenge to transform its energy systems into modern, sustainable infrastructures. At present, national and local authorities are implementing measures to support investment in the modernisation of district heating networks. The National Recovery and Resilience Plan and the Modernisation Fund are two key drivers in this regard, with many municipalities preparing projects and seeking to access funds to finance the necessary upgrades. By the summer of 2025, funding allocated by the two programmes exceeds €1.2 billion (Ministerul Energiei, 2025), (Ministerul Energiei, 2025). Additional funding is provided by the Ministry of Development, Public Works and Administration.

Romania's district heating systems have a long history, having expanded rapidly in the 1960s and 1970s as part of the socialist model of urban development. Designed to provide affordable heat to large urban populations, they were heavily reliant on fossil fuels, particularly lignite and natural gas, and built with limited consideration for efficiency or environmental performance. Over time, poor maintenance, underinvestment, and declining consumer confidence led to high losses in distribution networks, escalating costs, and erosion of public trust following constant interruptions. Today, many existing DH systems operate with obsolete infrastructure, reduced customer bases, and mounting financial pressures, placing them at the heart of the debate on energy poverty and social equity. In a recent publication, EPG presented the challenges faced by DH systems, drawing on data from the country's eleven largest municipalities to illustrate these issues (EPG, 2025).

Romania's climate and energy policy frameworks now require a strategic rethinking of district heating. In the Long-Term Strategy and the National Energy and Climate Plan, the government has committed to phasing out inefficient, high-emission assets while expanding the role of renewable and low-carbon sources, including geothermal, biomass, biogas, solar thermal, and in the longer term, hydrogen. DH modernisation is thus positioned both as a decarbonisation instrument and a social policy tool ensuring cleaner air, stabilising household costs, and revitalising urban energy systems.

When modernising a DH system to meet today's requirements, it is important to adopt a clear plan that addresses both the supply and demand sides, as is illustrated in Table 1. Generation can consist of a mix of technologies, while for the end-user, energy must be managed efficiently, especially to reduce losses. Such an approach entails several challenges. Implementation takes time, and consumers' patience is limited. A phased approach is therefore essential, but it is equally important to maintain a forward-looking vision from the early stages of modernisation.

Past models relied on centralised generation using a single fuel. This approach is no longer efficient for capturing lower costs. To reduce costs, cities should adopt a diversified technology mix and implement robust energy management across generation, storage, and demand.

Table 1. Strategies for a modern DH system

Supply side strategies					Demand side strategies
Energy source	**Conversion technologies**	**Energy management**	**Distribution**	**Emissions reduction**	**Energy management**
Fossil fuel	Combined Heat and Power (CHP)			CCS	
RES Thermal Waste Heat (low temperature) Geothermal Hydrogen/ Biogas	Electric boilers Heat Pumps Combined Heat and Power (CHP)	Energy storage	Temperature reduction		Building renovation Energy storage

The present report focuses on two Romanian district heating systems, selected to develop tailored recommendations for their modernisation. The selection of the studied municipalities reflects the fragile state of their current operation and the imperative of decarbonisation and infrastructure renewal.

The factors taken into account are:

1. whether a district heating system (SACET) exists that aligns production with demand;
2. the main source of heat production;
3. the parameters at which heat supply is currently ensured;
4. the heat price and the efficiency of the system;
5. the plans and strategies outlined by the municipality for modernisation;
6. the alignment with decarbonisation targets and emissions reduction requirements;
7. the status of funding applications for production or grid modernisation.

1.1. General Approach to District Heating: Four Directions.

Stabilise and retain the customer base. Keep existing district-heating systems operational, prevent disconnections, and improve service quality.

Cut fossil fuel use and decarbonise the supply source. Replace coal/HFO and reduce natural gas by adding large heat pumps, (wastewater and river heat recovery), solar panels, sustainable biomass, geothermal, biogas/biomethane and waste-to-energy. Aim for a large percent of renewable or recovered heat in the mix by 2030.

Boost network efficiency and lower losses. Repipe with pre-insulated mains, install smart controls, and optimise temperatures to 4th- or 5th-generation levels. Target distribution flow losses under 15% and thermal agent temperatures below 70°C by 2030.

Improve building envelope efficiency. Coordinate DH investments with large-scale renovation of the building stock. Better insulation, double/triple glazing, and smart thermostats cut demand by 30-50 percent. This lowers peak loads and improves affordability, as shown in large renovation programmes.

2. Case study of Drobeta-Turnu Severin

2.1. Governance history

In 1982, Romania built a centralised heating system in Drobeta-Turnu Severin to supply industrial producers of heavy water, critical to the country's nuclear programme. Households were connected just as an afterthought.

The DH system changed hands repeatedly from the Ministry of Energy (until 1990) to the National Autonomous Administration of Electricity (RENEL), and finally in 1998 to the National Autonomous Administration for Nuclear Activities (RAAN), which managed a wide portfolio of assets in the nuclear energy sector, such as the heavy water plant, and the ROMAG-Termo power plant (also known as the Halânga thermal power plant). But after Romania's Cernavodă nuclear reactors came online in 1996 (Unit 1) and 2007 (Unit 2), demand for heavy water collapsed. As a result, RAAN's revenues evaporated and by 2013, drowning in debt, it entered insolvency and could no longer buy fuel for heat production.

Between 2013 and 2015, the Ministry of Energy ensured the continued of the heating system in Drobeta-Turnu Severin by providing means of emergency funding. In 2015, the local council created SPAET, a municipal company tasked with maintaining district heating services. Since then, SPAET has operated the system with a mix of municipal subsidies and its own revenues, while leasing the Halânga power plant, still owned by the insolvent RAAN, each winter season. Consequently, public authorities are still scrambling for a permanent solution to supply thermal energy.

2.2. System evolution

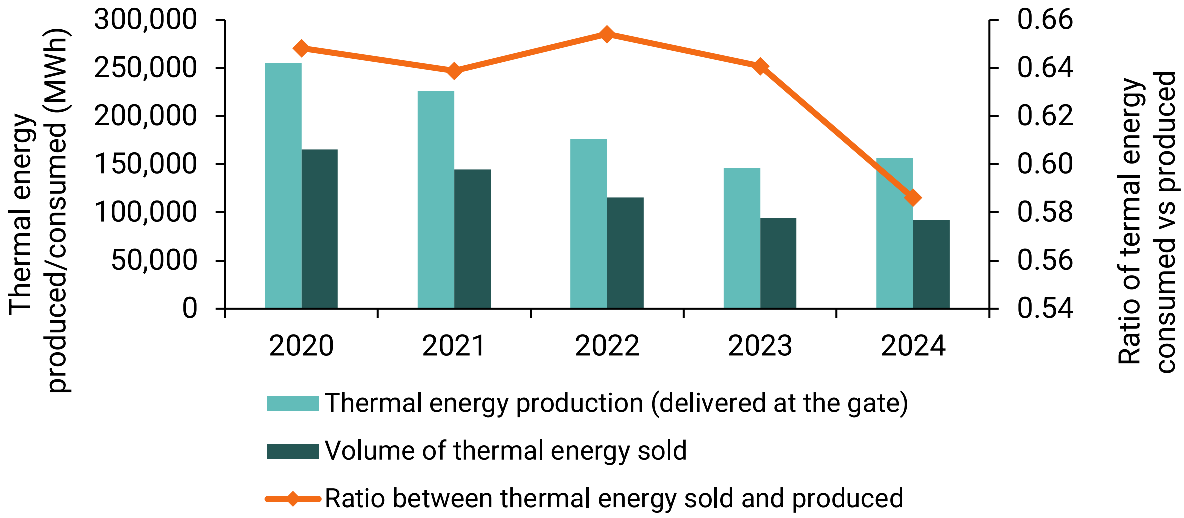
Since 1986, the district heating system in Drobeta-Turnu Severin has undergone one major renovation, between 2004-2009, with most of the network being now at least 15 years old, affected by maintenance issues that inflate costs and disrupt supply. But the real cause behind mass disconnections has been the inability to secure fuels, and therefore, provide services. Faced with unreliable heating in freezing winters, residents have fled to independent boilers and solar thermal collectors.

Every winter, SPAET leases two steam boilers from the Halânga thermal power plant, but this is a precarious solution. The plant remains owned by RAAN, which is selling off its assets to clear debts, which creates uncertainty about the future of the heating source. Halânga once used lignite, but it currently uses heavy fuel oil (HFO), a tar-like residual mixture left over from crude oil refining. HFO is less carbon intensive than coal, but still expensive for a cash-strapped operator. This means that the DH system in Drobeta-Turnu Severin faces two existential threats: RAAN finding a buyer, and operating costs spiralling out of control.

Between 2020 and 2024, thermal energy generation collapsed from over 250,000 MWh to 200,000 MWh in 2023, followed by a slight recovery in 2024 (Figure 1), with consumption lagging even further behind – a sign of increasing distribution losses. The ratio of energy sold to energy generated held steady at 64-65% between 2020 and 2022, before it plunged under

59% in 2024. This decline points to rising technical and commercial losses, and a diminishing number of connected consumers.

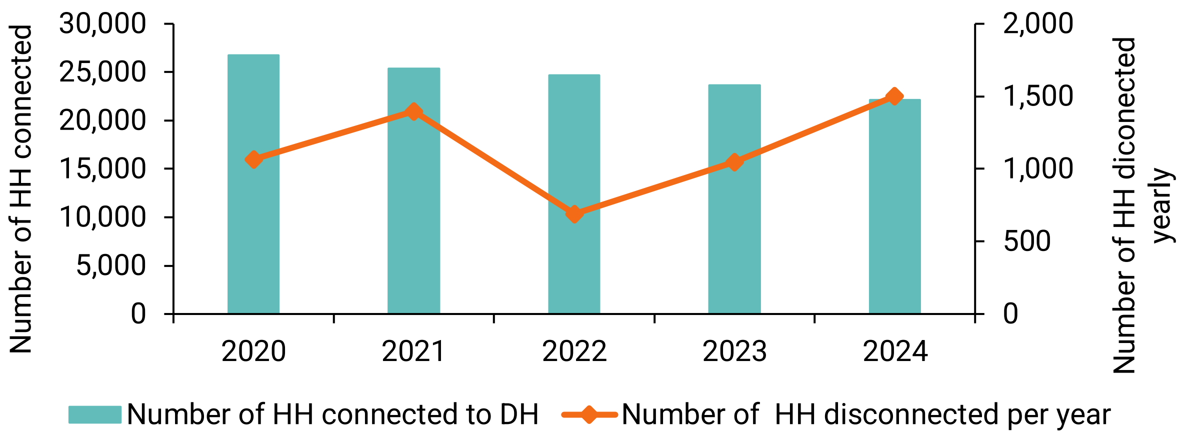
Figure 1. Evolution of thermal energy production and consumption



Source: EPG processing SPAET Drobeta and ANRE data

The number of connected households declined from over 26,000 in 2020 to just above 22,000, the annual disconnections reaching 1,500 in 2024 alone. The contracting consumer base represents an ongoing challenge for DH operators amid growing interest in alternative heating solutions.

Figure 2. Evolution of the number of connected household consumers

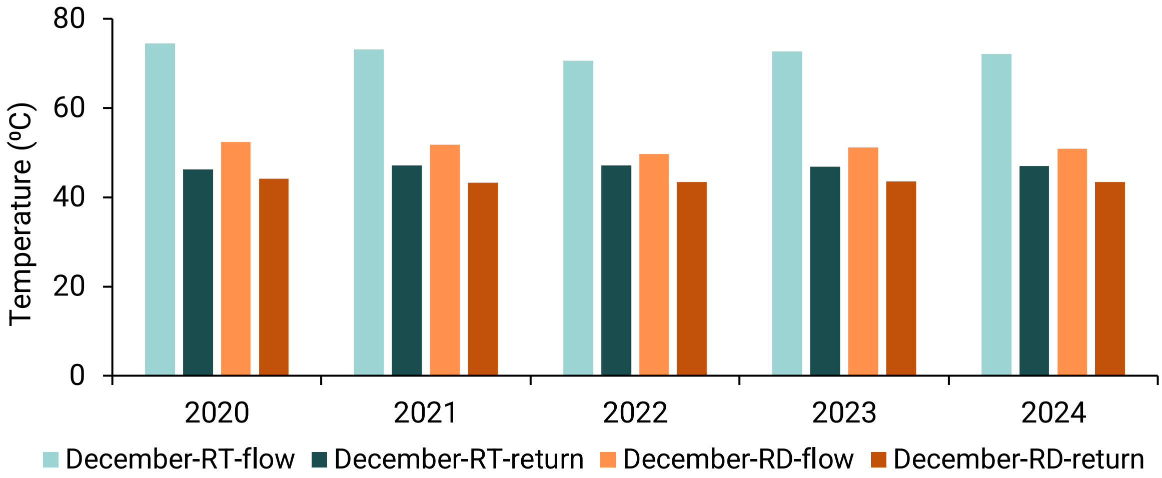


Source: EPG processing SPAET Drobeta and ANRE data

Flow and return temperature readings reveal the system's inefficiency. District heating works by circulating hot water through pipes. Therefore, the greater the temperature drop between outflow and return, the more energy has been delivered. But large losses in the transport and distribution networks signal aging infrastructure leaking heat into the ground.

Flow temperatures in the transport network (RT) average 70-75°C in December and January, well below the recommended 90-125°C threshold for a system with a set-up from the 1990s, with return temperatures of 47-50°C. In the distribution network (RD), flow temperatures drop further to 50-52°C, with return temperatures at 42-45°C. The smaller temperature differential indicates inefficient heat extraction and suboptimal operation of consumer installations, which often reflects ageing or poorly balanced network infrastructure.

Figure 3. Flow and return temperature transportation/distribution network

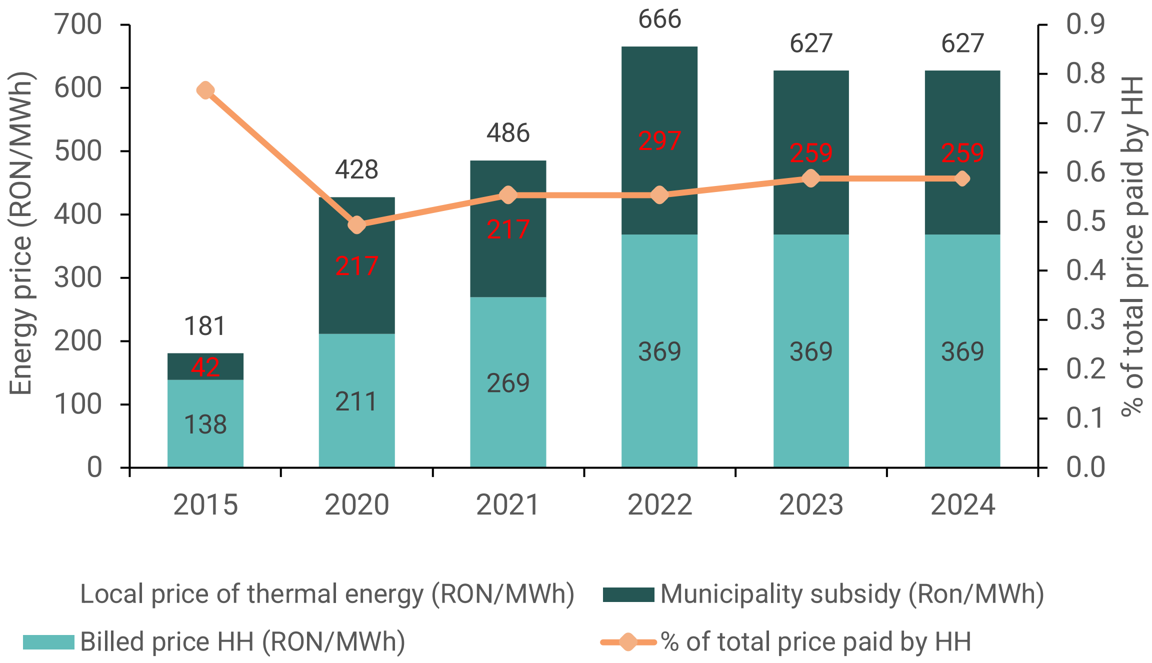


Source: EPG processing SPAET Drobeta and ANRE data

Between 2020 and 2024, the local price of thermal energy nearly doubled, from just over 400 RON/MWh to a 2022 peak of more than 650 RON/MWh, driven by soaring fuel prices, inflation, and the expense of propping up crumbling infrastructure. Prices stabilised in 2023 and 2024 but remained stubbornly high. Households were partially shielded, as their bills increased gradually from around 200 RON/MWh in 2020 to over 350 RON/MWh by 2024. The gap between the local cost of thermal energy, including production, distribution, and supply, on the one hand, and the billed price, on the other hand, was absorbed through municipal subsidies, which translates into massive fiscal pressure onto local budgets.

The contrast with 2015 is striking. Back then, the local price of thermal energy was below 200 RON/MWh, with billed household prices around 100 RON/MWh and only minimal subsidies required. The comparison underscores the deep structural changes in the energy market over the past decade, as well as the unsustainable reliance on subsidies to maintain affordability in the absence of systemic modernisation and efficiency improvements.

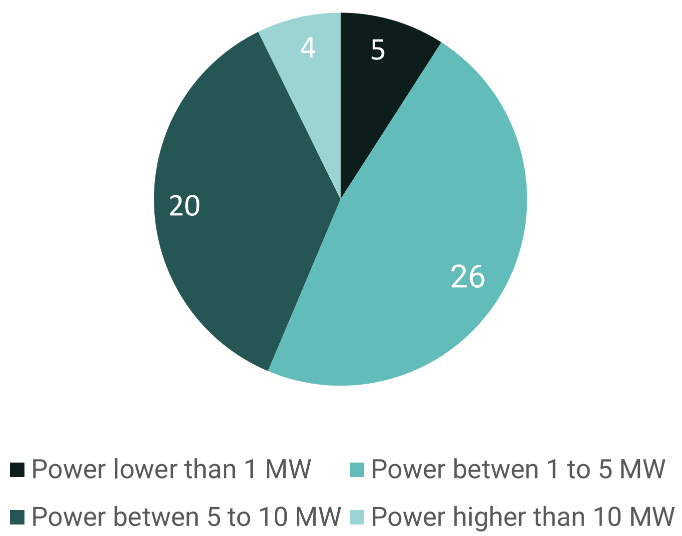
Figure 4. Thermal energy prices and municipal subsidy



Source: EPG processing SPAET Drobeta and ANRE data

Currently, Drobeta-Turnu Severin's DH system has 55 heat exchanger stations. 26 of them have capacities between 1-5 MW, another 20 operate between 5-10 MW, while only four exceed 10 MW. At least 13 heat exchanger stations are currently disconnected and no longer serve any consumers.

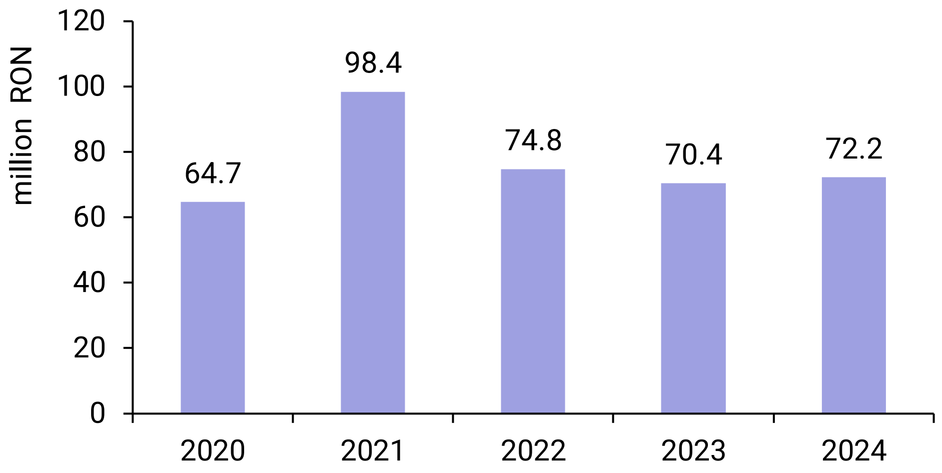
Figure 5. Number of thermal points in Drobeta-Turnu Severin's district heating system



Source: EPG processing SPAET Drobeta and ANRE data

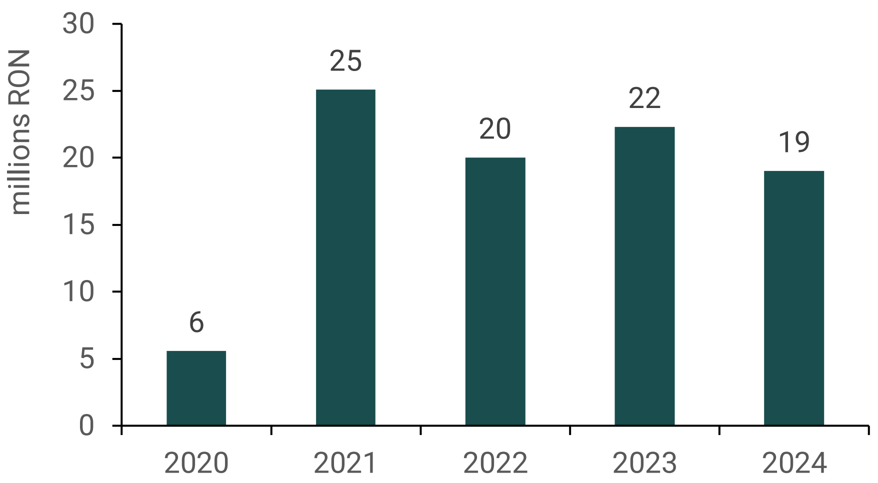
Although thermal energy production has declined, barring a 2024 uptick, fuel costs have climbed significantly from 253 RON/MWh for generation in 2020 to 460 RON/MWh in 2024. Even with subsidies, billed revenues fall short of fuel expenses, so SPAET Drobeta cannot operate without a public bailout. According to official statements for the 2025-2026 heating season, it requires 91 million RON in public support (Guvernul Romaniei, 2025). At least 93 million RON in support measures were allocated between 2020 and 2024.

Figure 6. Fuel cost for Drobeta DH system per year (million RON)



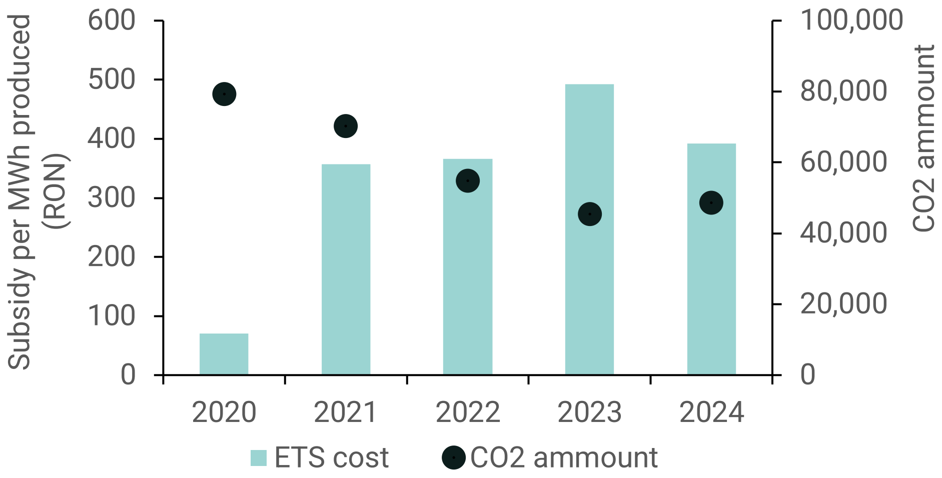
Source: EPG assessment based on SPAET Drobeta data

Figure 7. Annual subsidy paid by the municipality.



Source: EPG assessment based on SPAET Drobeta data

Figure 8. Estimated emissions and unit costs per MWh of thermal energy produced



Source: EPG assessment based on SPAET Drobeta data

As prices for petroleum products increased, the municipal subsidy had to rise from 6 million RON in 2020 to 25 million RON in 2021. Over the past three years the municipality's contribution has been close to 20 million RON per year. Figure 8 shows that even if the lower heat production contributed to reducing the total emissions, the subsidy per MWh paid by the municipality increased sixfold in 2023 compared with 2020.

2.3. Estimation of thermal energy consumption required to meet the demand in Drobeta

In the early 2020s, the DH system served roughly 27,000 households (80% of 33,500 (RecensamantRomania, 2021)), 137 economic operators, and 125 public institutions. By the end of 2024, this had shrunk to just 22,000 households (down by 19%), 105 economic operators (down by 23%), and 114 public institutions (down by 9%).

Energy demand calculations for households assume unrenovated buildings classified in energy performance class **D**, with class **B** considered as a renovated building according to the Methodology for calculating the energy performance of buildings, reference code Mc 001-2022 (MDLPA, 2023). For these dwellings, either the upper or lower value was deemed applicable, as detailed in Table 2. As thermal retrofits progress, energy consumption will decrease – meaning any centralised or semi-centralised solution must be sized for future, not present demand. Capacity right-sizing requires a higher upfront investment, but over-sizing wastes capital.

Table 2. Energy performance classes for collective buildings

The necessary amount for	Energy performance classes for collective buildings Primary energy consumption [kWh/m2/year]	
	D (unrenovated, low value)	B (renovated, high value)
Heating	150	84
Domestic hot water	65	57
Cooling	51	35

Source: EPG considered values based on Mc 001-2022

2.3.1. Individual heating system based on natural gas boilers

In a hypothetical scenario in which the DH system is abandoned and most consumers shift to individual gas boilers, the estimated investment would encompass not only the acquisition of the boiler units but also the installation works, together with the costs for technical design and permitting. All these costs are summarised in Table 3.

Table 3. Estimated cost for the installation of a residential gas heating system

Cost with	Value (RON)
Boiler (24 kW)	4,500
Installation costs	3,900
Technical design and permitting	2,000
Total	10,400

Source: EPG assessment based on commercial prices from various public websites in 2025

The figures below illustrate the annual natural gas expenditure that a consumer would incur solely to cover the demand for space heating and domestic hot water, with cooking excluded from the calculation, for a household with a floor area of 50 square meters. The values are presented both for a thermally renovated building and a non-renovated one. In addition, a separate scenario considers the entry into force of ETS 2, with the cost of allowances incorporated into the gas price (based on a carbon certificate price of €50 per tCO_2eq and a natural gas price of 330 RON/MWh).

Figure 9. Annual gas bill for heating

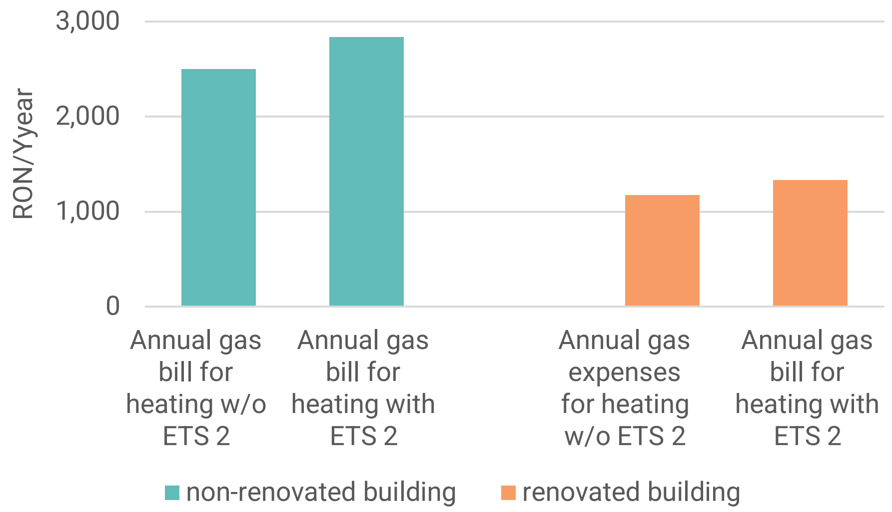
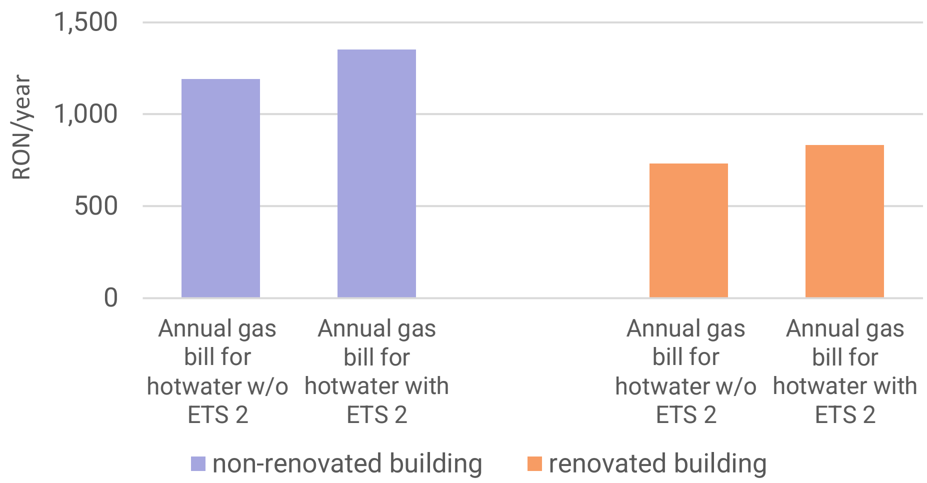


Figure 10. Annual gas bill for hot water



Source: EPG assessment

Thermal energy costs are presented on an annual basis, yet the financial burden on consumers is concentrated in January, accounting for about 25% of total heating demand, translating to natural gas bills for heating of roughly 650 RON for 50 square meters apartments. This concentrated expenditure creates significant affordability pressures, when coupled with the initial investment for the installation of the gas boiler and its annual maintenance fee.

As the municipal gas network expands, individual heating solutions are an appealing option for residents – so much so that the adoption of individual boilers appears inevitable. However, this seemingly pragmatic response faces three distinct challenges:

- Air quality deterioration, as current measurements already show PM2.5 concentrations exceeding 10 µg/m³ and NO2 levels above 20 µg/m³ according to European Environment Agency data from 2022 (EEA, 2024). A shift to individual combustion units would exacerbate these exceedances.
- Infrastructure disruption, considering the installation of individual connections requires extensive civil works, multiplying the disruption already associated with gas pipeline extensions throughout residential areas.
- Lost economies of scale, as decentralised heating forfeits the efficiency gains and emission controls achievable through centralised provision.

Municipalities such as Cluj-Napoca have decided since 2022 to prohibit individual boilers in newly developed apartment buildings, or at least limit heat supply to building-level plants (Primarie Cluj, 2022), recognising that heating infrastructure decisions shape urban air quality and liveability for decades.

For the modernisation and alignment of the DH system in Drobeta-Turnu Severin with new environmental requirements, local authorities may consider either a centralised solution based on a large-scale production source, or a semi-centralised option in which production units are distributed across the entire area served by the district heating network.

To supply more than 22,000 residential consumers, over 100 public institutions, and several economic operators in a system where network losses could be limited to 20% by infrastructure modernisation, the annual energy demand would exceed 230,000 MWh out of which ca. 55,000 MWh should be added for public institutions and economic operators, assuming non-renovated buildings. These values stand far above the thermal output delivered by SPAET Drobeta. The explanation is straightforward. The heating season begins late each year, and the system does not provide domestic hot water. An estimated 85 MW heat pump would be required to cover the full thermal demand, including the winter peak. This level is similar to the installed capacity of SPAET's two existing steam boilers, except that the network losses point to a far larger share of the supply heat.

Building renovation fundamentally alters this equation: with high thermal upgrades, the required heat pump capacity drops to approximately 50 MW. However, building renovation is a long-term and costly process. Only 10% of apartment blocks in Drobeta are included in the 2021-2027 financial framework for renovation, although the same buildings had initially been included in the previous programming period.

2.3.2. Large heat pump solution

Large heat pumps are among the technologies for thermal energy production that advance decarbonisation and gain increasing attention. A heat pump is a piece of equipment that extracts thermal energy from an external source and multiplies it through a compression cycle. It transfers the boosted heat into the building with very high efficiency. It works similarly to a refrigerator or air conditioner by extracting heat from external sources such as the air, ground, nearby water bodies, or industrial waste heat. The resulting heat is transferred to buildings or industrial systems, wherever it is needed. Because it transfers thermal energy and upgrades it rather than producing heat through combustion or electrical resistance, a heat pump can deliver significantly more energy than it consumes. Most household heat pump systems have a coefficient of performance around 4, meaning they provide four units of thermal energy for every unit of electricity consumed, making them three to five times more energy-efficient than conventional gas boilers.

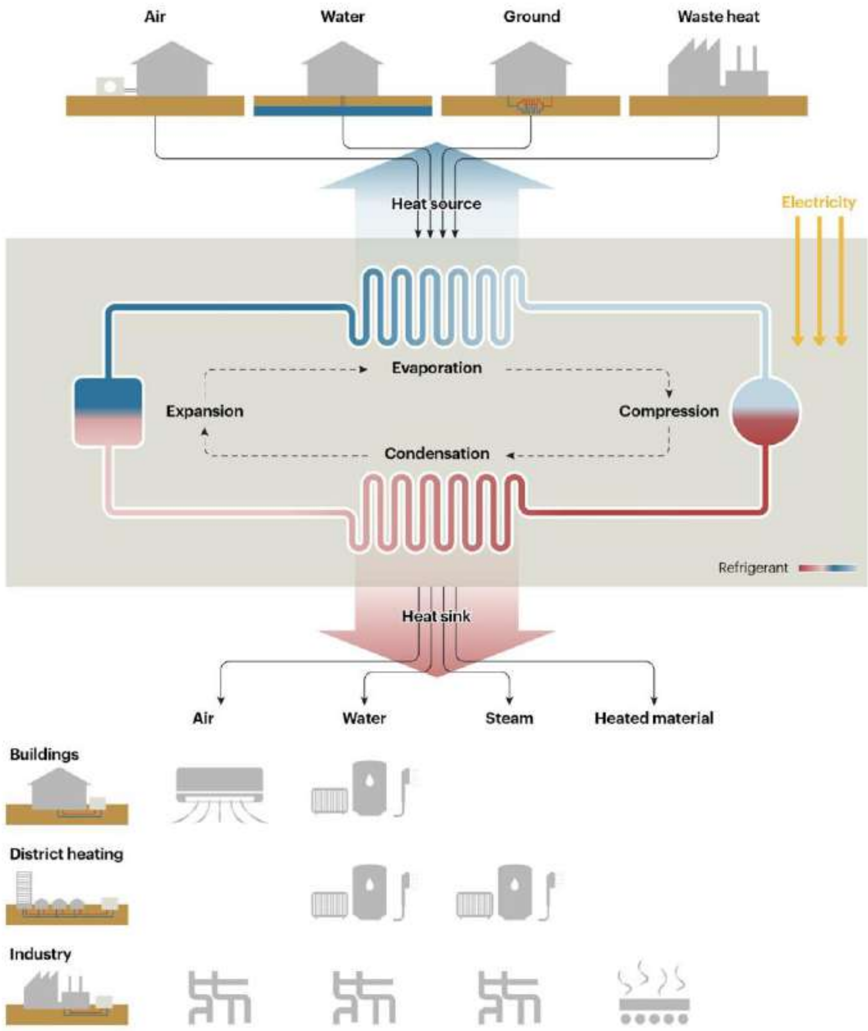
Technically, a heat pump contains a compressor and heat exchangers. The compressor circulates a refrigerant through a closed-loop cycle. First, heat is absorbed from the source through one exchanger; then, as the refrigerant is compressed, the temperature rises and heat is released into the building through a second exchanger. The heat can be distributed via radiators, underfloor systems, or air ducts. Some systems are also capable of providing cooling in summer. Larger-scale heat pumps, used in industry or district heating, require higher temperatures and often rely on waste heat from factories or wastewater, offering a clean and efficient option for urban heating infrastructures.

An important advantage of heat pumps is that they leave room for further modernisation of the system. While initially the energy will be drawn from the grid, and therefore the carbon footprint corresponds to that of the network, which will gradually decrease as new renewables are introduced, these systems can be complemented by the installation of dedicated renewable energy sources and, not least, by the integration of energy storage solutions, either in batteries for electricity or in other media for thermal energy storage.

Although ground-source heat pumps have higher efficiency, and waste heat could be an option, the proposals currently under consideration are limited to large-scale water-to-water or air-to-water heat pumps that can be installed in the existing heat exchanger stations. This approach would potentially allow for a faster implementation process, as it would make partial use of the existing infrastructure and avoid the need for a wide range of new permits.

In Drobeta-Turnu Severin, a potential option for thermal energy production is the deployment of large-scale heat pumps utilising the Danube River as a heat source. There are already numerous cities that have adopted heat pump solutions, some of which are mentioned in Table 4.

Figure 11. Schematic operating principle of a heat pump



Source: (IEA, 2022)

Table 4. Examples of cities where water-to-water heat pumps have been implemented in district heating systems

Large Water-to-Water HP	**Installed Capacity** (MW)	**Estimated number of consumers**	**Cost** (EUR mil.)	**Source**
Stockholm, Hammarbyverket,	225	800,000	N/A	(Stockholm Exergi AB, 2018)
Aalborg, Limfjord	177	48,000	230	(MAN-ES, 2024)
Helsinki, Katri Vala,	170	550,000	>20	(Aalto University, 2019)
Cologne, Rhine	150	50,000	200 – 280	(MAN-ES, 2024)
Vienna, Simmering	110	380,000	70	(Bloomberg, 2025)

Large Water-to-Water HP	Installed Capacity (MW)	Estimated number of consumers	Cost (EUR mil.)	Source
Berlin, Reuter Wes	75	1,400,000	200	(Federal Ministry for Economic Affairs and Energy, 2024)
Esbjerg, Port Esbjerg	70	25,000	N/A	(MAN-ES, 2024)
Hamburg, Dradenau	60	500,000	N/A	(EIB, 2024)
Espoo, Suomenoja	60	250,000	N/A	(Fortum, 2024)
Mainz	60	N/A	N/A	(SWR, 2025)

Source: EPG assessment

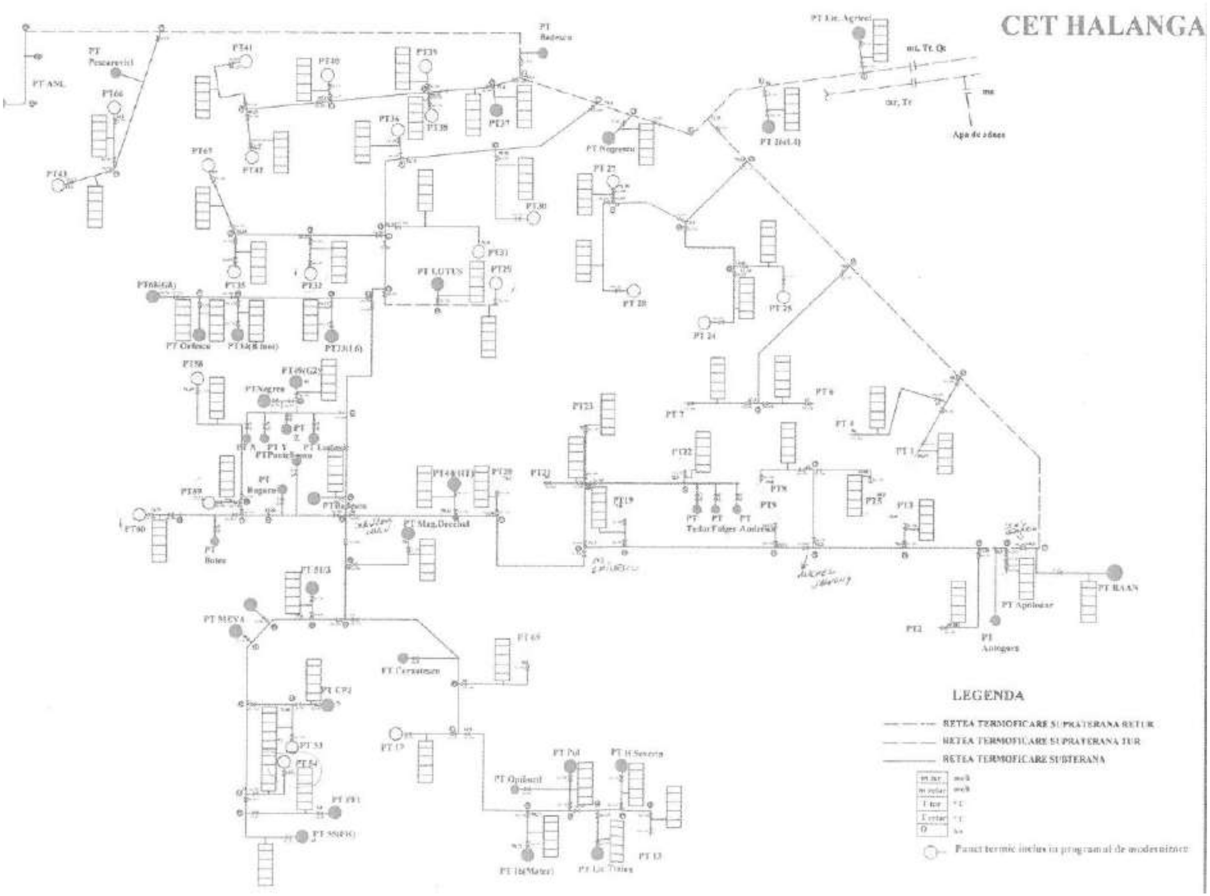
Based on these references, for large-scale water-to-water heat pumps, 50–150 MW, a typical specific cost would be €1.5-2.5 million/MW installed. Large heat pumps contribute to district heating supply, where systems are typically multi-source and the installed heat pump capacity does not directly correspond to the number of customers served.

A centralised solution based on a large-capacity heat pump would require identifying a suitable location in the southern part of the municipality for the construction of a new plant, as well as the development of a heat transmission network to connect it to the existing system. This, again, entails several challenges. Building the plant could take less time than building the pipeline to connect the city's southern area to the existing network. Even so, Drobeta-Turnu Severin could act as a first mover. This example could encourage other cities along the river to consider water-to-water heat pumps. However, to launch any project involving the transmission network, the local authorities must first clarify the legal status of the primary district heating network – owned, in Drobeta, by RAAN.

An alternative to a centralised DH system is a semi-centralised approach, which would dispense with the transmission network and rely solely on the distribution infrastructure. In this case, air-to-water heat pumps could be installed at local heat exchanger stations to meet the respective demand. Such a configuration would lower overall energy requirements by eliminating losses from the heat transmission network and heat exchanger stations. An additional benefit of heat pumps is their ability to also supply cooling during the warmer months.

Water-to-water heat pumps, such as those mentioned above, typically achieve a coefficient of performance (COP) between 3.5 and 4.5. This means that for every kWh of electricity consumed, they can produce between 3.5 and 4.5 kWh of thermal energy. As a result, the cost of the heat they generate is comparable to that of individual apartment gas boilers, as long as Romania's current price landscape shows an electricity-to-gas ratio of nearly 4:1. However, as renewables take a larger share of the energy mix, complemented by electricity storage, and as carbon allowance prices rise, there is a strong basis to expect the electricity-to-natural-gas price ratio to narrow.

Figure 12. Illustrating the distribution of heat exchanger stations and their corresponding capacity in the municipality of Drobeta-Turnu Severin



Source: SPAET Drobeta

An additional contribution to thermal energy generation could also come from the recovery of heat from wastewater. Based on a simple theoretical calculation, assuming that over 80,000 inhabitants (RecensamantRomania, 2021) generate approximately 12,000 m³/day of wastewater (150 litres per person), with typical wastewater temperatures ranging between 12-18°C in winter and 18-22°C in summer, a ΔT of 5 K can be considered. For a heat pump with a COP of 3, this would correspond to a recoverable thermal capacity of around 2.9 MW, which translates into approximately 4.4 MW of useful thermal output (counting heat recovered and the electricity consumed by the compressor). Such an option is feasible insofar as the transport network exists and can be easily accessed.

A system of this kind, harnessing wastewater heat, is installed in Vienna. The wastewater heat recovery operates by circulating treated water from the Ebswien treatment plant through pipelines, from which heat of approximately 6°C is extracted and the cooled wastewater is then discharged back into the Danube. This low-grade heat is captured by three large-scale French-built heat pumps installed on-site, which upgrade it into hot water for the city's district heating network. The system relies on renewable energy, one third of the electricity required is supplied by the Freudenau hydropower plant. In its first phase, the three heat pumps provide a combined thermal capacity of around 55 MW, sufficient to heat approximately 56,000 households in Vienna. The total investment for this phase amounted to about €70 million. However, by 2027, the capacity is expected to double to 110 MW, extending coverage to around 112,000 households. Importantly, the installation operates within a multi-layered district heating system and serves primarily as a base-load source, rather than covering peak demand on its own (Klinger, 2023) (Wien Energie, 2024).

Table 5. Examples of cities where air-to-water HP have been implemented in DH systems

Large air-to-water heat pumps	Installed Capacity (MW)	Estimated number of consumers where heat pumps contribute	Source
Faaborg	10.5	2,200	(multikoel energi, n.d.)
Heidelberg	4 x 1.5	3,000 – 3,500	(EU COM, n.d.) (energie-experten, n.d.)
Frederiksberg (Copenhagen)	6.5	4,000	(DBDH, 2025)
Lidzbark Warminski	2.6	1,000	(globenergia.pl, 2024) (The National Centre for Research and Development, n.d.)
Large-capacity heat pumps can serve multiple heat exchanger stations			
Helsinki	20 – 33	30,000	(MAN-ES, 2024)
Svendborg	25 – 37	7,000	(Ingenior huse, n.d.)
Silkeborg	22	58,000	(Ingenior huse, n.d.), (Silkeborg Forsyning, 2023)

Source: EPG assessment

Installing medium or large heat pumps or other major electricity consumers should be straightforward in Mehedinți County. The region benefits from a strong transmission backbone anchored by three major electricity producers: the Porțile de Fier I hydropower plant (1,167 MW), the Porțile de Fier II hydropower plant (321 MW), and the Gogoșu hydropower plant (54 MW), alongside the Halânga thermal power plant (246 MW), which operated until recently. Together, these facilities indicate the presence of a well-developed electricity transmission network in the region and facilitate the integration of new consumers such as mid/large-scale heat pumps. Moreover, according to data from Transelectrica, by September 2025 Mehedinți had over 38 MW of installed prosumer capacity. In addition, under the National Recovery and Resilience Plan, Drobeta-Turnu Severin secured financing at the end of 2024 for the construction of a 4.7 MW photovoltaic plant expected to generate about 7 GWh of electricity annually (Romania Actualitati, 2024).

3. Case study: Craiova

3.1. Governance history

In the late 1960s and early 1970s, Romanian authorities decided to invest in the construction of a large combined heat and power plant (CHP) in Craiova to serve both industrial and residential consumers. The main objective was to supply power to the city's growing industrial base, including major facilities on the Electroputere industrial platform and other heavy industry, while at the same time providing district heating for households. The system was designed as a centralised network of heat production and transport, making Craiova one of Romania's power centres equipped with district heating infrastructure.

The first generating units were commissioned at CET Craiova I, followed in the early 1980s by the much larger CET Craiova II, with lignite-fired units of 150 MW each. The plant was connected to an extensive DH transport and distribution network, delivering hot water and steam to industry and to residential apartment buildings throughout the city. Like Drobeta during the communist period, the system was managed under the Ministry of Energy, then transferred in 1990 to the National Autonomous Administration of Electricity. Following further restructuring, the system came under the National Power Company and later Termoelectrica, while production was gradually integrated into the portfolio of Complexul Energetic Oltenia.

For decades, the district heating system in Craiova relied on CET Craiova II as its backbone, which supplied both electricity and thermal energy in cogeneration. By the mid-2000s, the city also invested in several small gas-fired neighbourhood and apartment building heating plants to complement the central supply. These decentralised units, known as centrale de cvartal, had a total installed capacity of about 44 MW and were equipped with high-efficiency gas boilers. Those were meant to increase flexibility, reduce distribution losses, and cover local peaks in demand.

Despite these investments, the system faced several challenges. CET II's reliance on lignite generated significant CO_2 emissions and local air pollution, while network inefficiencies resulted in heat losses above 30%. Fuel and maintenance costs increased steadily, and by the 2010s the affordability of DH became a pressing issue. To keep the service accessible, the municipality provided substantial subsidies, which placed an increasing burden on local finances. This situation has become common at the national level.

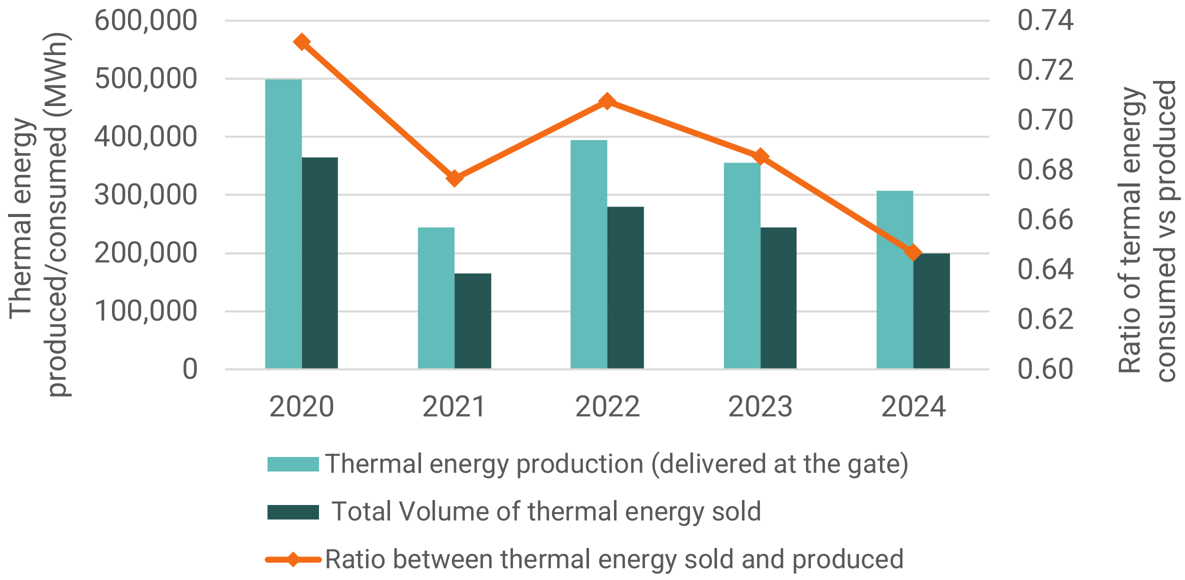
In recent years, the energy transition agenda has had a direct impact on Craiova. Plans were announced to phase out the lignite units at CET II and replace them with a new gas-fired CHP unit of 295 MW, supported through the Recovery and Resilience Plan (RRP). After several failed attempts to select a contractor, the project can no longer be completed within the RRP timeframe and will therefore be relocated to the Modernisation Fund. The objective is to ensure continuity of supply while lowering emissions and securing compliance with EU climate targets. Meanwhile, TermoUrban Craiova SRL, the municipal operator, has sought to modernise the distribution network, improve efficiency, and integrate renewables.

The path forward, combining new gas-based capacity, smaller centralised or even decentralised plants, and renewables will determine whether Craiova can sustain a DH service that is affordable, reliable, and sustainable. The authorities in Craiova could also consider a regional development approach, as in the long-term industrial growth may contribute valuable waste heat to the district heating system. At the same time, these choices must reduce dependence on fossil fuels and align the city with national and EU decarbonisation goals.

3.2. System evolution

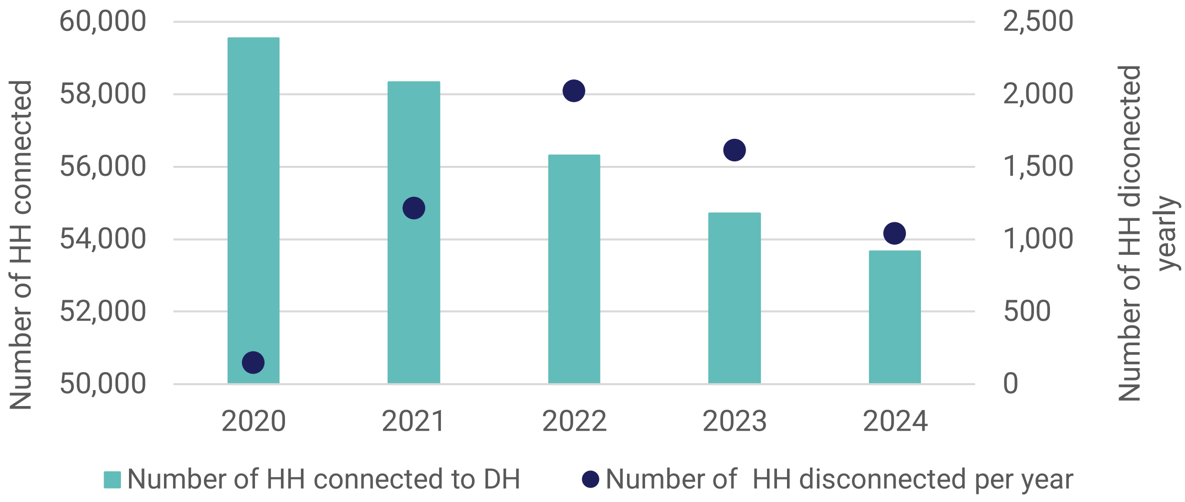
Between 2020 and 2024, Craiova's district heating system was in continuous decline, both in terms of production and the number of connected consumers. Thermal energy production dropped sharply after 2020. From about 500,000 MWh delivered at the plant gate in 2020, production fell to nearly half in 2021. A partial recovery followed in 2022, but volumes decreased again in 2023 and 2024, staying below the 2020 level. Consumption of thermal energy gauged by the sold volume followed the same trend but remained lower than production every year. The ratio between sold energy and produced energy indicates the scale of losses in the system. In 2020, nearly 70% of the produced energy reached consumers; by 2024 this share had declined to almost 65%. This persistent gap highlights the technical network inefficiencies, which continue to weigh heavily on the operator.

Figure 13. Thermal energy production and consumption



The number of connected households also decreased. In 2020, almost 60,000 consumers were linked to the system, but by 2024 only about 53,000 remained. Each year, several thousand households are disconnected, reflecting the preference for individual solutions, mainly gas boilers. The demand reduction has further undermined the network efficiency and the operator's financial sustainability.

Figure 14. Number of connected household consumers



Source: EPG assessment based on SACET Craiova data

The DH system in Craiova includes 105 heat exchanger stations (with five currently in reserve) and 15 neighbourhood heating plants (with four in reserve). Concerning heat exchangers stations, 34 have an installed capacity of up to 5 MW, 58 between 5 and 10 MW, and only 13 more than 10 MW. As to the neighbourhood heating plants, three have a capacity of up to 1 MW, eight are between 1 and 5 MW, and only four exceed 5 MW. In addition, there are 36 apartment-building heating plants, of which ten are currently in reserve.

Figure 15. Number of neighbourhood heating plants

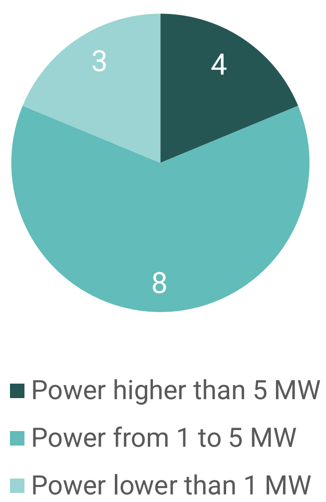
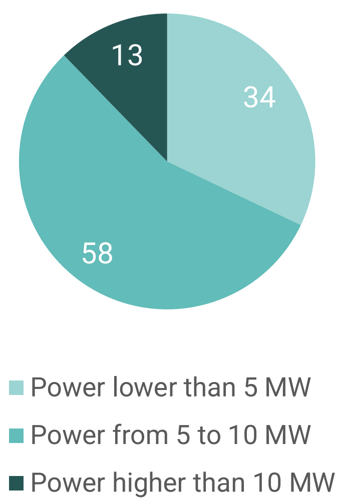
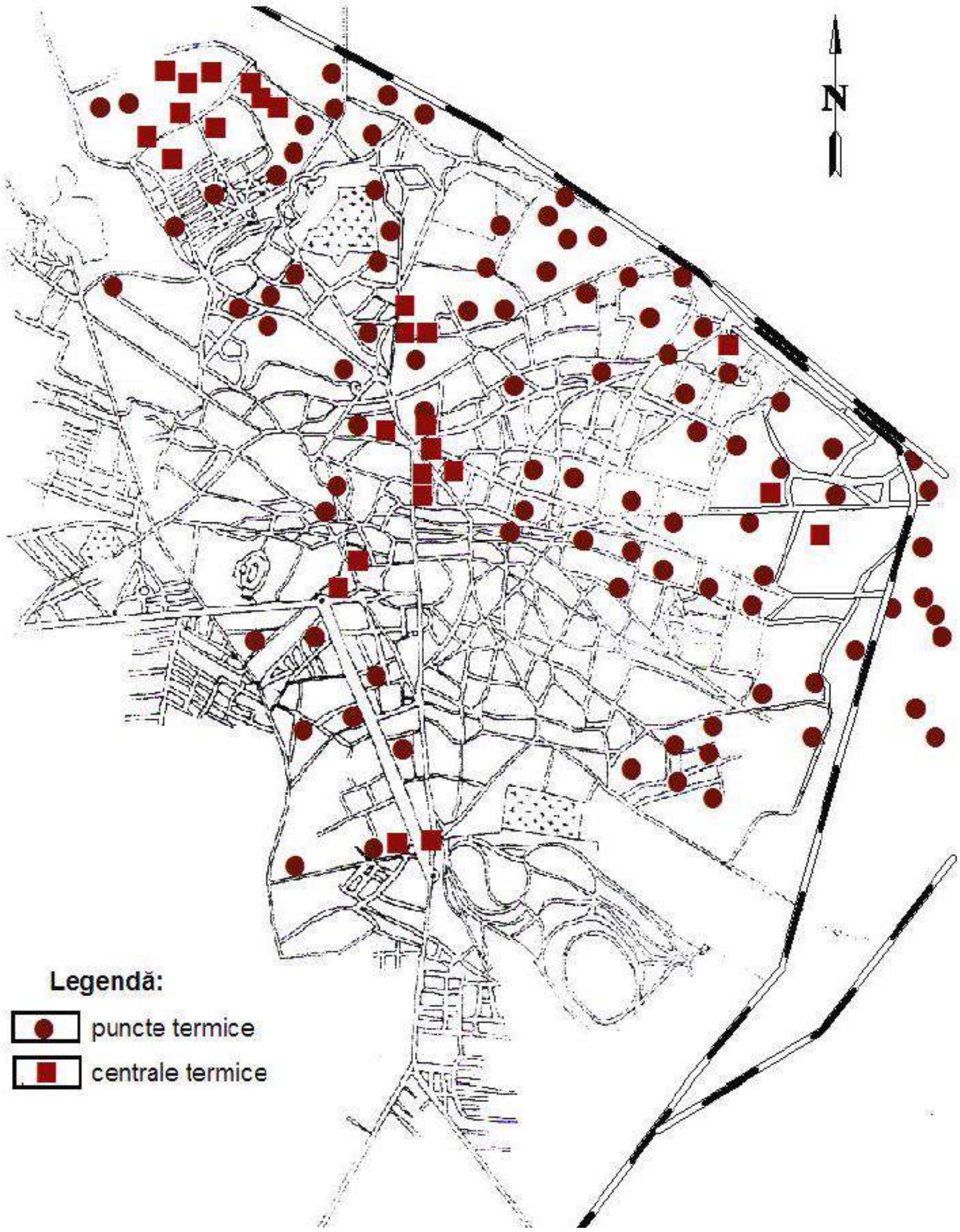


Figure 16. Number of heating points



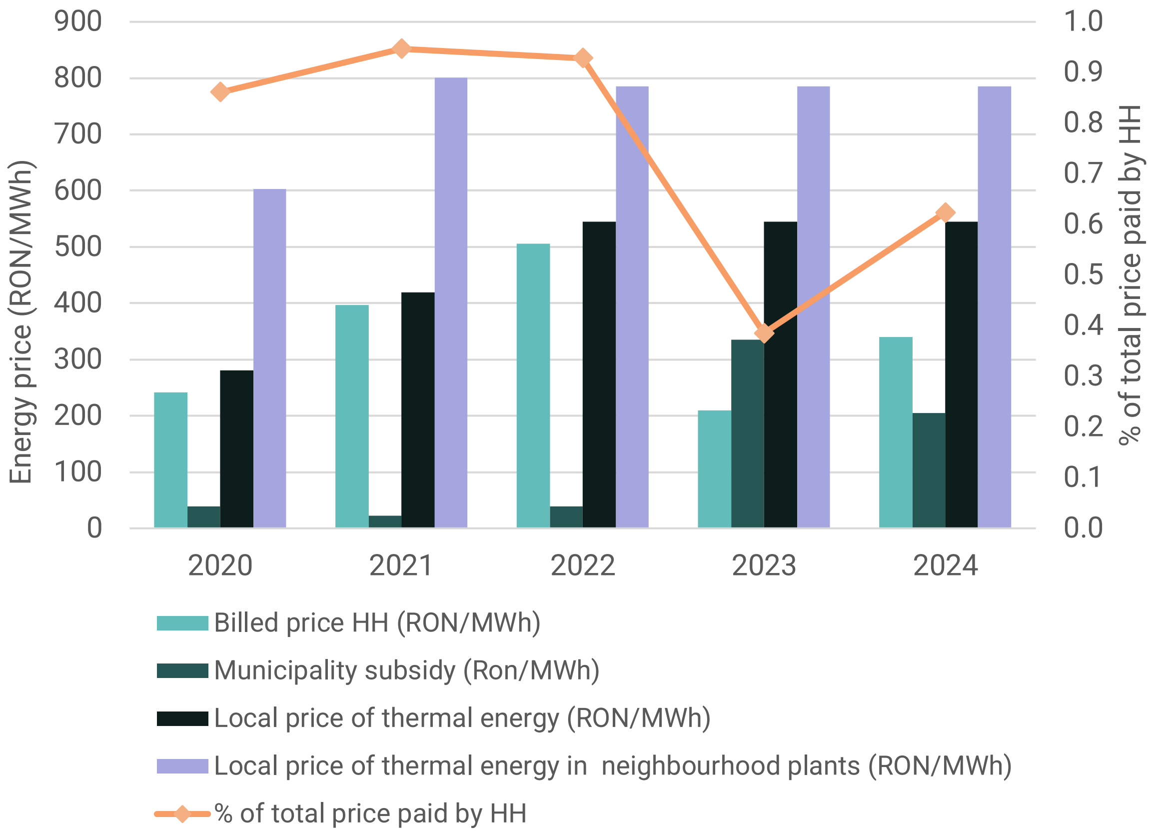
Source: EPG assessment based on SACET data

Figure 17. Illustrating the distribution of heat exchange stations and their corresponding capacity in the municipality of Craiova



Source: Primaria Craiova, 2023

Figure 18. Thermal energy prices and the municipal subsidy



Source: EPG assessment based on SACET Craiova and ANRE data

Cost developments illustrate both the pressure faced by the operator and the city. Local production and distribution costs for heat supplied by the Craiova II plant increased from around 280 RON/MWh in 2020 to more than 540 RON/MWh in 2024, while the cost of heat produced in neighbourhood plants remained close to 800 RON/MWh throughout the period. For households, the billed tariff was only about 250 RON/MWh in 2020, reaching about 340 RON/MWh in 2024. The difference was covered through municipal subsidies. The share paid directly by households varied from above 80% in 2021-2022 to less than 40% in 2023, before recovering in 2024. This volatility and the persistent gap between actual costs and billed prices increase the fiscal burden on the city.

In summary, between 2020 and 2024 Craiova's DH system was marked by declining production, falling consumer numbers, rising technical losses, and higher costs. Despite subsidies that kept household bills relatively stable, the financial pressure on the city has grown, while the overall sustainability of the system is at risk unless major investments in efficiency and renewable integration are implemented.

3.3. Estimation of thermal energy required to meet demand in Craiova

In 2025 Craiova still has a large number of DH clients, both households and economic operators, as well as public institutions. The sizing of production capacity should start from the premise of covering current consumers, while also considering the possibility of new ones. Currently, the two cogeneration units plus two hot water boilers can generate 602 MW of thermal output. At the same time, in addition to the Craiova II plant, both the neighbourhood plants and the apartment buildings-scale plants contribute to the thermal energy supply. The total installed capacity in the thermal points amounts to 695 MW. To supply 53,000 consumers living in buildings of class **D** energy efficiency for Oltenia's climate region, it would take installed capacities of around 200 MW to cover heat and water demand in the winter season, including 20% network losses. However, by improving the buildings' energy class, the production/installed capacity could be reduced to 117 MW.

Figure 19. Distribution of thermal energy over a year (%)

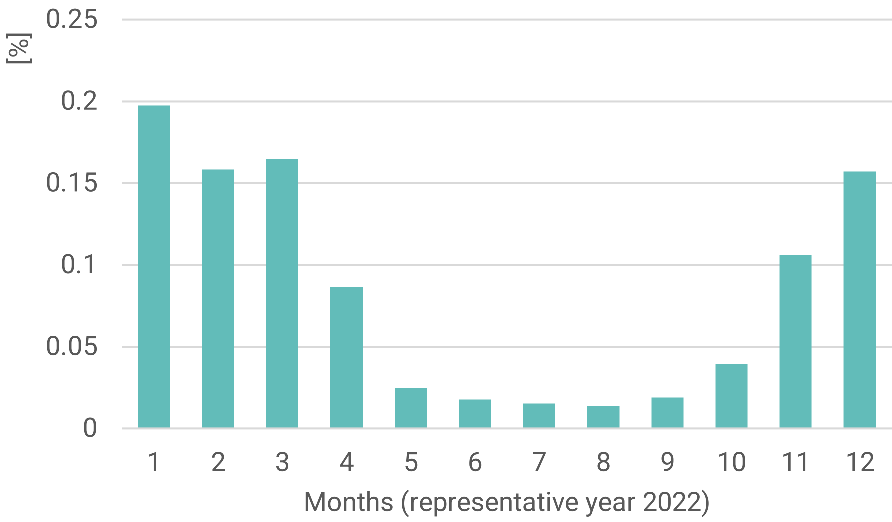


Figure 19 illustrates the monthly distribution of thermal energy consumption for the representative year 2022. The highest amount of energy is required in January, which accounts for ca. 20% of the annual consumption. The heat supply starts gradually in October and ends in April. During the summer season, when only domestic hot water is needed, the monthly consumption represents about 2-3% of the annual total.

Unlike Drobeta, where the arrangement of the main production sources is more complicated, Craiova has multiple choices. Although by now the construction of a gas-fired plant should have been at an advanced stage, the slow pace has raised doubts that the plant can still be financed as initially planned through the PNRR, since even at the time of this writing the tender had not been completed. As a gas-fired unit will most likely still be built, the local authorities should also consider a series of additional solutions and technologies to their current plans and, in the future, reduce the use of fossil fuels. Installing storage systems, perhaps even in the plant itself, or adding large capacity heat pumps that could harness the thermal potential of the nearby Jiu River may prove to be viable options. Neighbourhood and apartment buildings-scale heating plants can be modernised with air-to-water heat pumps based on photovoltaic or solar thermal panels. PV panels can normally be installed on most heat exchanger stations where the roof structure allows it. Although their placement is limited by the available surface, when combined with heat pumps, their contribution can be significant.

In terms of heat produced and supplied, theoretical calculations show that, in Craiova in 2024, household heat (about 307 GWh) is below the value estimated under the MDLPA methodology, assuming all buildings are in energy class D, all dwellings are occupied, and consumption is uniform (545 GWh). The calculations are, of course, theoretical; a more detailed profiling of the buildings in terms of energy efficiency and living space would result in more accurate and possibly improved values. Even so, the lower value may indicate that some consumers with control devices curtailed use, some reduced consumption because of costs, or the system was unable to supply the full demand. The vision for a decarbonised and modern system must be defined from the outset, as any subsequent intervention may require adjustments to the infrastructure, particularly if the hydraulic circuit would be affected.

3.3.1. CHP solution

If a high-efficiency CHP remains the preferred modernisation option, thermal energy production costs are estimated using ANRE's methodology, which allocates fuel and emission costs between electricity and heat using reference efficiencies for separate production. The calculation considers how much fuel would be required to produce the same amount of electricity and heat separately, and then allocates the actual fuel proportionally (ANRE, 2024).

In a simple theoretical example, for a plant with reference efficiencies of 52% for electricity and 90% for heat, and actual gross efficiencies of 35% electric and 45% thermal, this translates into an electricity-to-heat ratio of 0.78 and an overall efficiency of 80%. Based on this approach, around 42% of the fuel is allocated to heat and 58% to electricity. Consequently, the cost of producing one MWh of thermal energy in such a cogeneration plant is about 312.6 RON. This goes up to around 382 RON/MWh when including the cost of CO_2 emissions, assuming an allowance price of €70 per tonne of CO_2eq. This value does not take into account the costs of operation, transport, and supply, considering only the production cost. In the case of using boilers to cover the thermal energy demand, a solution mainly applied for peak load coverage, the production cost is even higher than 445 RON/MWh

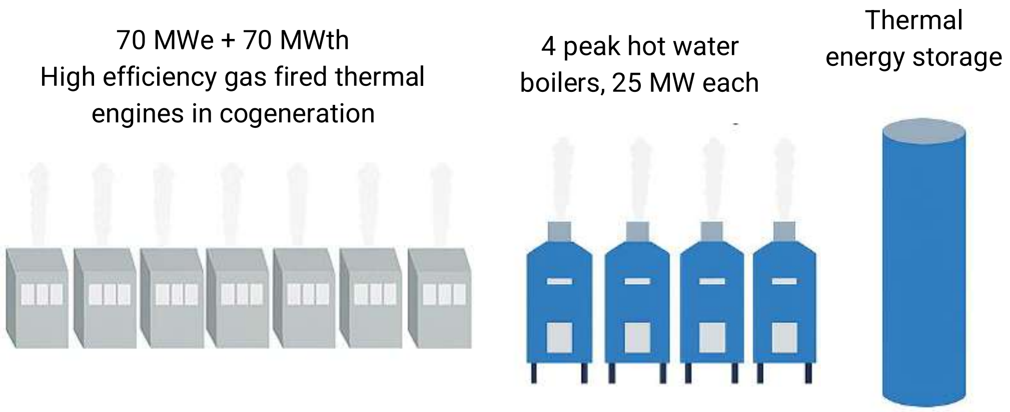
Table 6. Production cost estimation per technology

Production cost per technology	**Cost** RON/ MWh (including CO_2)
High-efficiency cogeneration power plant	382
Hot water boilers (CAF)	445

Source: EPG assessment

Adding operating and maintenance costs, along with transport, distribution, and supply tariffs, and factoring in 20% network losses, the realistic costs per MWh of thermal energy would be 770 RON/MWh for CHPs and 760 RON/MWh for CAFs with VAT included. This price can be further reduced through various cost-sharing mechanisms, one example being the support scheme for high-efficiency cogeneration that is included in any electricity consumer bill.

Figure 20. Illustrating a schematic CHP plant potential design for Craiova



Source: EPG assessment

Figure 21 illustrates the operating principle of a cogeneration plant equipped with seven internal combustion engines, four peak boilers and a thermal energy storage reservoir. Unlike the initial solution proposed for financing under the PNRR (two gas turbines and one steam turbine with capacities of 295 MWe and 256 MWt, respectively), the current configuration offers greater flexibility. It includes seven thermal engines producing 70 MW of both electricity and heat, while peak demand hours are covered by four hot water boilers. In addition, a thermal storage tank is planned to balance the system during periods of low heat demand.

The thermal energy demand in Craiova is significant, and the construction of a new gas-fired plant does not by itself solve the challenge of decarbonisation of the DH system. A possible use of biomethane blended with natural gas would help reduce emissions. Although most cogeneration plants currently under development at the national level, including the one in Craiova, are expected to be able to incorporate up to 20% hydrogen, it is unlikely that hydrogen will be widely used, on account of cost considerations.

On the one hand, hydrogen use would require dedicated infrastructure or the conversion of parts of the existing gas network. A gradual transition is difficult to implement, given the aging infrastructure and the risks to which household consumers would be exposed, as the same distribution network supplies both large industrial users and residential customers. Hydrogen is expected to remain an expensive product, but the use of other clean gases, such as biomethane, is much more realistic.

3.3.2. Large heat pump solution

For a large-capacity heat pump of 50 or even 100 MWth, the share of water subtracted from the Jiu River flow would be up to 6.3% in the average annual flow in the case of a 100 MW unit operating with a low temperature difference (in an open loop system). If the temperature difference increases, the percentage of required water decreases proportionally. In the case of a closed-loop system, heat is extracted from the river through submerged coils or dedicated heat exchangers.

Table 7. Heat pump volumetric flow required

Temperature variation (K)	Volumetric flow required (m3/s)	Volumetric percentage of water taken from the Jiu River (%)
COP = 4, Q = 100 MWth, W = 25 MWe		
ΔT = 3	5.97	6.3
ΔT = 5	3.58	3.77
COP = 3, Q = 100 MWth, W = 33 MWe		
ΔT = 3	5.34	5.6
ΔT = 5	3.2	3.37
COP = 4, Q = 50MWth, W = 12.5 MWe		
ΔT = 3	3	3.14
ΔT = 5	1.8	1.9
COP = 3, Q = 50 MWth, W = 16.7 MWe		
ΔT = 3	2.68	2.9
ΔT = 5	1.6	1.7

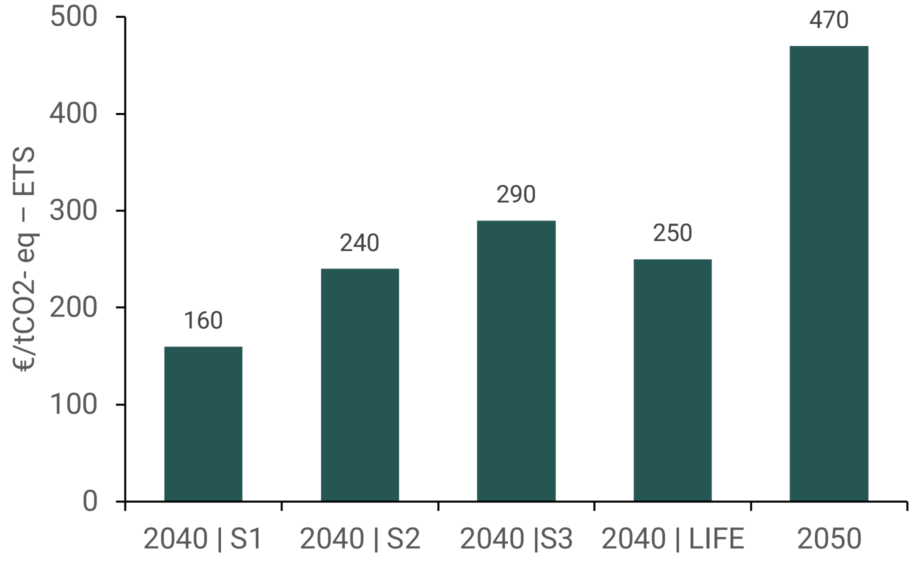
Source: EPG assessment

While natural gas still serves as a transition fuel, the authorities in Craiova should seriously explore alternative technologies. On the one hand, investments in large-scale natural gas plants are costly, and their payback is difficult to anticipate. With strict decarbonisation policies and rising gas costs (through ETS), it is expected that more and more consumers will switch to electric appliances and gradually abandon those running on gas. This trend will initially put pressure on the electricity distribution networks, which must be bolstered to absorb the increase in demand, as well as on the gas sector, where declining consumption will most likely lead to higher costs for the remaining connected consumers.

Installing a large-scale heat pump that uses the Jiu River as an energy source is not easy. It would require a new transport pipeline from the river to the existing district heating network. This would involve both the lead time of the actual construction and for a series of administrative procedures, including land acquisition and permitting.

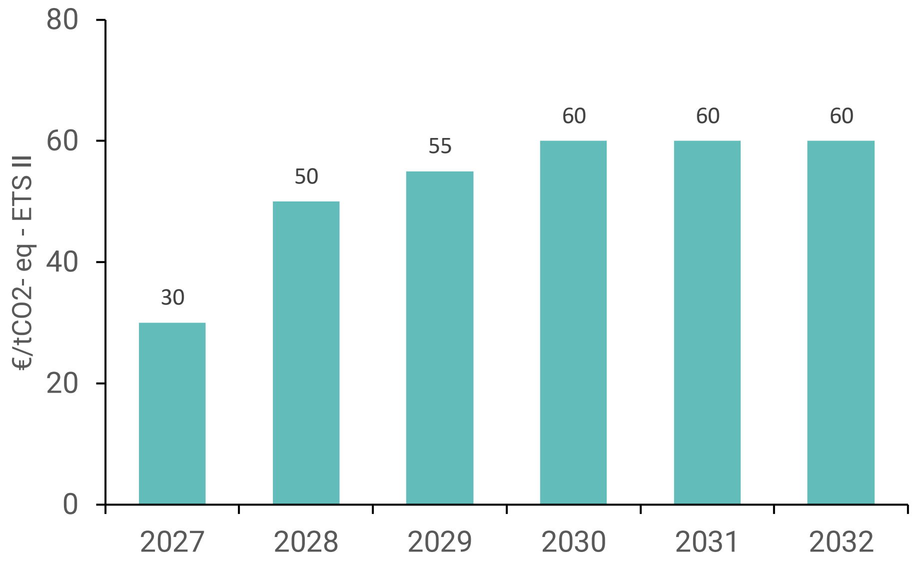
In the long term, an approach based on multiple production capacities (e.g., water-to-water heat pumps, etc) is probably the right option. As more renewables are installed, they provide, up to a certain point, the basis for lower prices. In contrast, natural gas prices remain difficult to predict, with the cost of carbon allowances expected to make gas increasingly more expensive. As the price ratio between electricity and gas narrows, heat pumps become a serious contender. However, it is important to follow a local strategy with clear objectives and steps.

Figure 21. EU Commission estimated trajectory for ETS carbon price



Source: EPG assessment based on Commission staff working document

Figure 22. Harmonised trajectory for the common value for the ETS 2 carbon price estimate

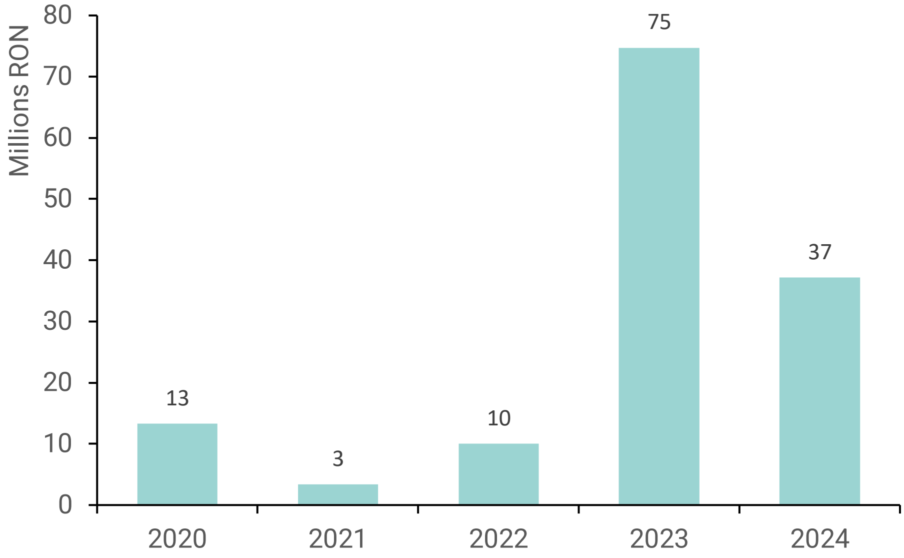


Source: EPG assessment based on Commission notice – Guidance for the SCP

In the energy transition, fossil fuels face rising carbon costs. Figures 21 and 22 present the Commission's working scenarios for CO_2 allowance prices. For fossil use in industrial plants covered by ETS 1, modelled carbon values reach €160-290 pet tCO_2eq in 2040 and €470 per tCO_2eq in 2050 – considerably higher than today's carbon prices.

ETS 2 will introduce a carbon price for fossil fuels used in buildings. The Romanian Government recently adopted a decision proposing a derogation until 2031 from the 2027 term foreseen in the ETS directive. It remains to be seen how the European Commission will position itself on this matter (Guvernul Romaniei, 2025). In effect, recent discussions between the Commission and several Member States seem to have converged toward a one-year postponement of the regulation's entry into force till 2028. The Commission's planning assumptions (in 2020) used price references of €30 per tCO_2 in 2027, €50 in 2028, €55 in 2029, and €60 in 2030-2032. Individual gas boilers and fossil fuel cooking appliances will carry an explicit CO_2 cost. These figures must be examined carefully. In any cost estimate, values may change. However, these are not just passive calculations, but results that can be achieved through the adoption of policies. As a country with significant household and large-scale CHP production and natural-gas consumption, Romania must see that costs remain affordable.

Figure 23. Annual subsidy paid by the municipality



Source: EPG assessment

In Craiova, the district-heating subsidy has posed a major challenge over the past five years. In 2023, the amount allocated by the municipality was more than 5.5 times the 2020 level, while in the last year it was nearly triple. In total, over the last five years, the municipality has contributed more than 138 million RON to subsidising DH supply during the winter season.

3.3.3. What is the emissions intensity of each technology?

Fossil-fuel heat carries a heavy carbon load. Lignite emits about 378 $kgCO_2eq$ per MWh of heat, heavy fuel oil about 310, and natural gas about 224. A modern heat pump connected to the existing national grid delivers the same MWh with roughly 88 $kgCO_2eq$, so emissions are cut by about 77% vs lignite, 72% vs oil, and 61% vs gas. Renewable heat options register under 15 $kgCO_2eq$ per MWh, which means a 93-96% drop vs fossil alternatives. Electric resistance heating is near 310 $kgCO_2eq$ per MWh at today's grid mix, so electrifying with heat pumps is more environmentally friendly and economical in terms of production cost than a simple resistor. It should also be noted that as the share of renewable energy increases, emissions continue to decline.

Table 8. Emissions intensity per source of production

Source of heat production	$kgCO_2eq/MWh$	Source
Coal lignite	378	(IPCC, 2006), (EIA, 2024)
Heavy fuel oil	310	(EIA, 2024)
Natural gas	224	(EIA, 2024)
Electricity grid (Electric resistance heating vs heat pump)	310/88	(EU COM, 2023)
RES	<15 wind, <43 PVs, <25 Hydro	(UNECE, 2021), (JRC, 2025)

Source: EPG assessment

Table 9. Estimation CO_2 emissions in Craiova based on the source of heat

Source of heat production	Estimation CO_2 emissions [kt]
Lignite	206
Natural gas	122
Electricity grid (Electric resistance heating vs heat pump)	168/47
RES	16

Source: EPG assessment to cover the requirement of 545 GWh/year

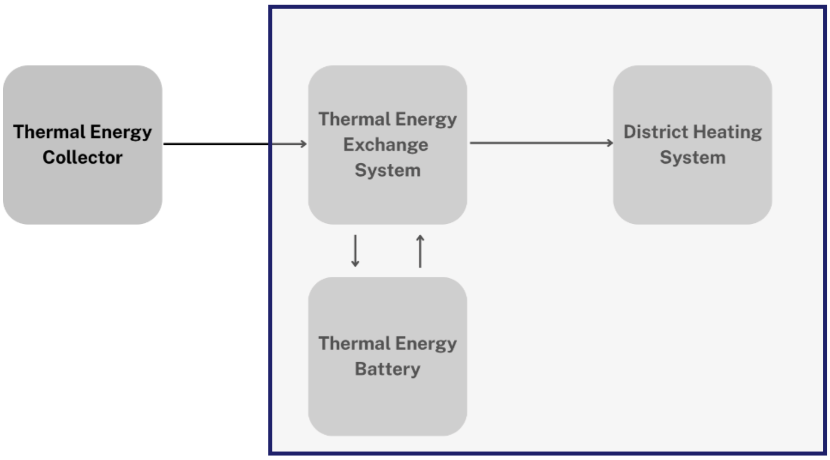
*For fossil-fuel operation, we account for the emissions allocated exclusively to heat. In cogeneration, there will be emissions which will come from the electricity side too.

4. Thermal energy storage

Energy storage for heating systems is also gaining more ground. As with electricity, the energy produced during off-peak hours is used later, when demand increases. In general, storage solutions are integrated into hybrid systems, where thermal energy is produced from multiple sources, with emphasis on renewable sources.

Whether we refer to short-term storage over hours or days, or to seasonal storage, in principle all thermal energy storage systems exhibit three main features: a collector, a battery, and an exchange mechanism. Collectors capture thermal energy and transfer it into the battery via the exchange mechanism, gradually raising the temperature of the battery to the desired level. Later, when heating services are needed, the exchange mechanisms work in reverse, this time transferring thermal energy to water or air, which can be used for DH.

Figure 24. Schematic representation of the principle of thermal energy storage



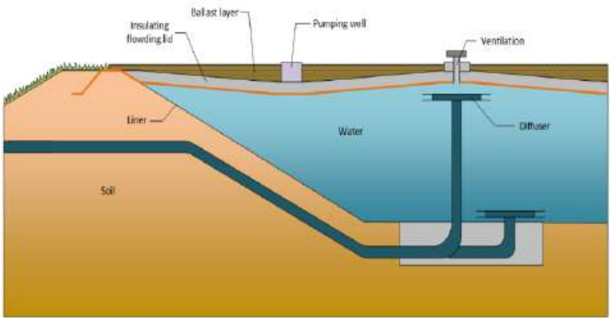
Thermal energy storage technologies have existed for decades in different parts of the world and in different technological iterations, but they usually serviced a single building or residence. Presently, there is a renewed interest in utilising thermal storage at scale for applications to DH, through consumption of excess energy generated during summer months. The possibility of using fossil-fuel-based thermal energy storage exists, but it depends on the arbitrage between summer and winter fuel prices exceeding the construction cost of the storage facilities over the long term. RES are predicated on storage technologies working around their seasonal production bottlenecks, and therefore many modern examples of energy storage in District Heating use some form of RES storage.

4.1. Types of seasonal thermal energy storage systems

Depending on the configuration of a city's DH system, it is possible to choose either short-term storage or long-term/seasonal storage. In the case of seasonal storage, dependence on fossil fuels can be significantly reduced.

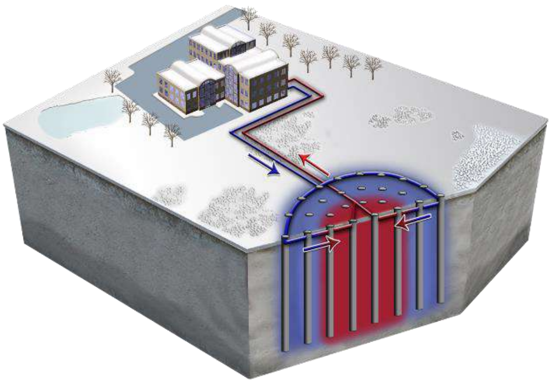
Tank Thermal Energy Storage (TTES): Comprises a large, insulated container which stores water. It heats up water during the summer months, which can be drawn from during the winter months for DH.

Pit Thermal Energy Storage (PTES): Comprises an inverted pyramid-shaped dugout, filled with water and other materials in suspension, and covered with a watertight seal on the surface. The heating medium itself is not drawn from for DH if it consists of a mix of water and gravel; instead, water pipes run through the medium, whose contents are heated through conduction.



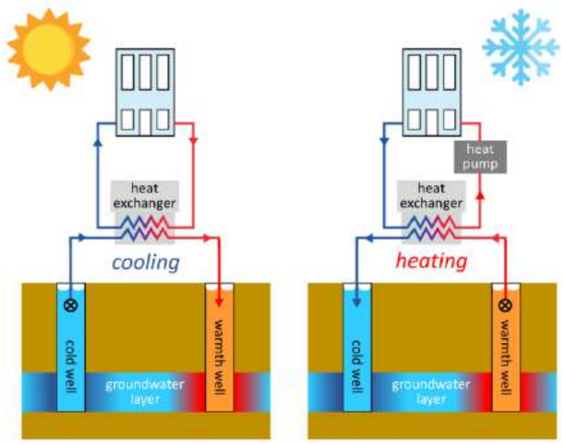
Source: Large and Growing Markets, 2020

Borehole Thermal Energy Storage (BTES): Consists of a series of excavated boreholes that lead into an underground rock or soil deposit, which contains doublets for heat transfer. Hot water is injected into these doublets during summer to warm the deposit, while cold water is injected during the winter to be heated and used for DH.



Source: Underground Energy

Aquifer Thermal Energy Storage (ATES): Consists of two wells dug into the earth. During summer, cold groundwater is extracted from one well, run through a building where it absorbs heat and cools the structure, before being deposited into the second well. In winter the flow is reversed, heating buildings instead.



Recent examples of seasonal thermal energy storage

20th-century examples of STES systems relied on fossil-fuel-powered boilers or CHP generators to heat their deposits of water (except for ATES systems), but almost all recent STES projects for DH rely on renewables for the production of thermal energy. This effort intends to work around the mismatch between RES seasonality and periods of heating demand. Intuitively, the opportunities for savings via arbitrage are higher through usage of RES-based electricity, as opposed to the arbitrage between seasonal fossil fuel prices which have a lower spread, albeit still a large one. In summary, new STES developments are meant to leverage location-specific conditions such as geology, daylight hours, wind seasons, and other environmental factors, allowing for decarbonised systems which reliably pay themselves off while at the same time reducing DH prices for their consumers.

Examples of STES systems applied for DH uses:

DH Storage Tank in Berlin (TTES):

One of the newest additions to the STES capabilities of the Berlin DH system, the TTES system has a discharge capacity of 2,600 MWh of thermal energy. The system has a heat retention rate of about 97% of the thermal energy stored. The fill time for the facility is two months, and it is reliant on the capture of excess wind power. Although it can be used for intra-seasonal storage, the excess availability of wind power during wintertime in Germany makes it usable as short-term storage of thermal energy.

Figure 25. Tank Thermal Energy Storage (source)

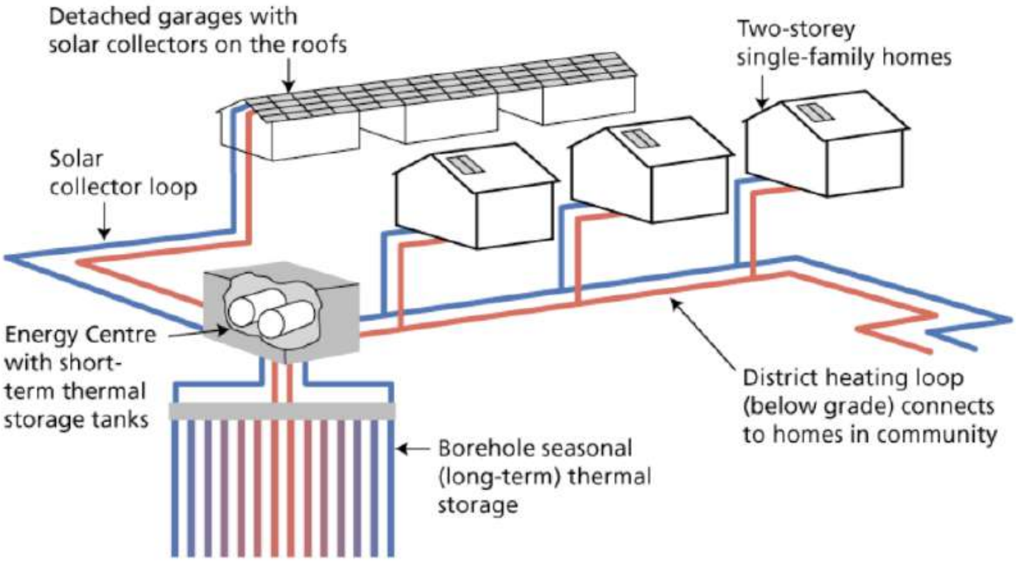
Solar DH project in Dronninglund, Denmark (PTES):

One of the first large-scale solar fields in Europe, commissioned for the purpose of providing DH to 1,350 consumers with an attached PTES. The solar plant has an energy efficiency of about 40%, but the energy retention rate of the PTES system is 95%. The total project cost was about €15 million, with a payback time of 25 years, throughout which the DH cost to consumers is reduced to €60/month. The project costs were conspicuously higher due to its solar field being an emerging technology at the time.

Drake Landing Solar Community (BTES):

A housing complex in Canada consisting of 52 homes, outfitted with 800 solar thermal collectors, achieved 97% heat energy sufficiency from the usage of its BTES. Heating costs were maintained at a flat €41/month. Notably, the BTES system took four summers to bring to the required heat level, after which it was drawn from for 17 years before being decommissioned.

Figure 26. Borehole Thermal Energy Storage – A housing complex in Canada



Source: ISES Solar World Congress, 2017

Eindhoven Technical University integrated ATES system:

TU/e developed an aquifer thermal energy storage system that managed to provide baseload heating of approximately 14 degrees during the wintertime. This system manages to drastically reduce the demand for heating during winter months, as buildings are kept at a constant 15°C. Notably, this system does not require any generated heat and transfers thermal energy to the wells via heat exchange with the building.

There are different options for thermal energy storage systems that can be implemented and many good practice examples from other countries. While short-term solutions can be integrated into existing systems, long-term storage involves considerable dimensions and requires a more tailored approach that also considers the way energy is produced.

Table 10. Comparison of different Seasonal Thermal Energy Storage technologies

Type of system	Max. storage temp.	Geological requirement	Scalability	Efficiency range	CAPEX range	OPEX range
	°C	-	No. of HH eq	%	€/kWhth	€/kWhth
TTES	95	Low	1 – 8,000	70 – 96	0.7 – 5.6	130 – 260
PTES	90	Low	10 – 8,000	55 – 82	0.5 – 2.9	47 – 88
BTES	70	High	1 – 1,000	20 – 76	0.4 – 0.8	81 – 435
ATES	65	high	5 – 10,000	45 – 77	~0.05	51 – 265

Source: ScienceDirect, 2021

Table 10 contains a comparison of the four thermal energy storage technologies described above. Only the mature heat storage technologies are considered in this analysis, which have been successfully implemented in various geographical regions around Europe.

The first relevant parameter is the maximum storage temperature. Should the storage system be placed at a relatively high distance from the final user, the temperature of the storage medium needs to be as high as possible to compensate for the losses in the transport and distribution network. In most cases, such storage systems are accompanied by auxiliary heating sources (heat pumps, gas boilers, electrical heaters) that can either contribute additional thermal energy to the heating fluid leaving the storage system or an additional stream to the supply of thermal energy. From this point of view, for the two studied cases (Drobeta and Craiova), the TTES and PTES systems seem to be the most convenient ones, as they store energy at high temperature, more than 90°C.

The same systems are also less demanding in terms of geological conditions to be met for nominal operation. While BTES and ATES require adequate soil structure and, in the case of ATES, a natural aquifer, TTES and PTES do not depend on such geological parameters.

The scalability of the system is given by the number of equivalent households that can be heated with the energy stored in the system. Although this parameter is highly variable in terms of households' thermal insulation, climatic region and other factors, the comparison provides an order of magnitude of the thermal energy that could be stored by the system.

The efficiency of the storage system is given as the ratio between the input thermal energy and the energy discharged for heating. Most of the existing systems use solar energy input. By means of solar collectors, thermal energy is accumulated during the warm season, leading to a slow and gradual increase of the thermal storage medium. Some systems also use geothermal energy, where available.

An analysis of the CAPEX and OPEX of the four technologies, as estimated based on the projects already implemented and reported in the literature, reveals that these costs are highly dependent on the actual configuration and usage profile of the storage system. One can observe that the levelized cost of heat (LCOH) dispensed by the PTES is the most accessible today, comparable to (or just slightly higher than) the cost of heat produced by more traditional systems, like gas-fired boilers or even heat pumps. The LCOH values in Table 10 have three components: a component related to the renewable energy input (in this case, represented by solar collectors), a component for the thermal storage itself (the storage medium, the container or reactor and the charging/discharging device), and a component related to the auxiliary heating device (heat pump).

Therefore, considering the combination of the above-mentioned factors, the PTES systems seem to be the most appropriate ones to consider for the DH upgrade of both Drobeta and Craiova. For an optimal performance of the energy storage system, it would need to be coupled with one or multiple heat pump modules that complement the energy discharged from storage at peak demand. The thermal energy of the PTES and heat pumps can be considered either as complementary to a direct source of heat (CHP or a gas-fired boiler) or as a standalone, modular system, that can supply 100% of the heating demand, by selecting the number and geographical positions of the modules. This hybrid system can be directly connected to the existing transport and distribution network, thus minimising the additional investment and duration of development.

5. Comparing district heating tariffs with other European cities

In many European cities, large-scale heat pumps account for a significant portion of DH production, which is clearly reflected in the low consumer prices.

In Copenhagen, where seawater heat pumps, wastewater heat recovery and large thermal storage tanks are already integrated in the urban DH system, typical residential heat tariffs are in the order of €0.10-0.12 kWh, which corresponds to roughly 500-600 RON/MWh (Hofor, 2025). Danish utilities benefit from preferential electricity tariffs for heat pumps and from access to low-temperature renewable sources, which keeps the heat price stable and predictable for end users, despite high gas-price volatility after 2022. Copenhagen is currently expanding large seawater heat pumps at Nordhavn and other harbour sites to further reduce natural gas input. These systems are operated as part of a fully planned phase-out of individual gas boilers in buildings. This makes Copenhagen one of the reference cases in Europe for competitive low-carbon district heating.

In Aalborg, where industrial waste heat from the Aalborg Portland cement plant and large-scale seawater heat pumps are integrated into the urban DH system, residential heat tariffs are around €0.13 kWh including VAT, corresponding to roughly 650-700 RON/MWh (Aalborg Forsyning, 2025). District heating already covers about 80% of the municipality's heat demand and 99% in the city itself, with surplus heat from cement production supplying around 30,000 dwellings and about 1.3 million GJ of heat per year. Aalborg is building one of the world's largest seawater-based heat pump plants – a 177 MW installation expected to deliver up to 700,000 MWh of heat annually and cover one-third of the city's total district heating demand, using CO_2 as refrigerant and renewable electricity (Aalborg Forsyning, 2025).

Berlin is moving in the same direction, but from a different starting point. The DH network in Berlin (owned since 2024 by the city through Berliner Energie und Wärme, formerly Vattenfall Wärme Berlin) is the largest district heating network in Western Europe. The operator is now replacing coal and gas-based combined heat and power with large river-water and wastewater heat pumps, plus seasonal thermal storage. Current residential district heating prices in Berlin are typically in the range of €0.12-0.20 kWh, which corresponds to 600-1,000 RON/MWh, with a reported average about 850 RON/MWh. For new "green heat" products such as the "Natur Mix" tariff that prioritises renewable and recovered heat, the published working price is around €0.10-0.11 kWh including VAT, which corresponds to roughly 500-550 RON/MWh (BEW, 2025). This indicates that large heat pumps and low-temperature sources can keep prices in a competitive band. Berlin's long-term decarbonisation strategy is explicit as long as the city plans to shift district heating toward wastewater, river water, industrial waste heat, and deep geothermal by 2045.

Other German cities such as Hamburg and Cottbus are now developing very large heat pumps using river water and lake water (the Ostsee lake at Cottbus) to replace lignite and gas in district heating. Published targets for residential tariffs in these decarbonised systems are typically €0.10-0.16 kWh, which corresponds to 500-800 RON/MWh. Hamburg reports new-customer tariffs around €0.14 kWh (about 710 RON/MWh) for heat increasingly based on large-scale river-water heat pumps and recovered industrial heat. Cottbus publicly positions its future lake-water heat pump system as competitive with gas and clearly below the 1,000 RON/MWh level that appears in smaller, fossil-based German networks (Wien Energie, 2025).

Vienna is in transition from gas and waste incineration toward large wastewater heat pumps, deep geothermal, and industrial waste heat. Vienna Energie has announced a dedicated tariff structure ("Klima fit") for new building connections, with an energy price of ca. €74 MWh (around 370 RON/MWh) before fixed capacity charges, and maintains city-wide residential district heating bills that correspond roughly to €0.11-0.16 kWh (ca. 550-800 RON/MWh). Even after the latest adjustment for the 2025/2026 heating season, Vienna is among the cheapest major DH systems in Austria, even as discounts applied during the energy crisis are being reduced. Vienna authorities consider that, going forward, large-scale heat pumps using wastewater and geothermal heat will replace natural gas and determine the tariff. This is part of the plan to fully switch Vienna's DH to RES and waste heat by 2040 (Wien Energie, 2025).

Linz follows a similar model to Vienna, combining waste-to-energy, biomass, and increasingly large heat pumps taking heat from wastewater and industrial sources. The target communicated by Austrian utilities for these electrified, low-temperature supply chains is to keep household district heating tariffs broadly comparable to Vienna's lower range, typically in the order of €0.11-0.16 kWh (about 550-800 RON/MWh), while phasing out fossil-fired CHP. This is the same cost band in which operators expect to operate once large heat pumps and thermal storage are fully integrated in the network (Wien Energie, 2025).

Finland, especially Helsinki and Espoo, already runs very large wastewater and seawater heat pumps that cover a major share of urban heating demand. Because these pumps are supplied by comparatively cheap, low-carbon electricity from nuclear and hydro, and deliver high seasonal performance factors, the effective delivered heat cost is typically around €0.10-0.13 kWh (roughly 500-650 RON/MWh). These systems have been in use for years and are considered a benchmark for stable, low-cost, low-carbon district heat at metropolitan scale (Finnish Energy Association, 2023).

All mentioned cities point to the same conclusion. Large-scale heat pumps integrated in DH, supplied by stable low-temperature sources such as seawater, lakes, rivers, sewage, or industrial waste heat, and supported by thermal storage, can hold residential tariffs in the band of roughly 500-800 RON/MWh without relying on permanent budget subsidies. For Romania, such prices, when adjusted for purchasing power, could be difficult for consumers to bear. Importantly, district heating prices in most European systems are already considerably higher than those currently paid by Romanian household consumers excluding municipality subsidy. Only sustained investments in system modernisation, loss reduction, and building insulation to lower heat demand can lead to lower DH costs in the future.

6. Conclusions

The current DH systems in Drobeta-Turnu Severin and Craiova are at a breaking point. The infrastructure is obsolete, with heat losses exceeding acceptable thresholds and high maintenance costs that erode both municipal and household budgets. The reliance on an ageing lignite and heavy fuel oil-based system has resulted in recurring pollution episodes and incompatibility with national and EU decarbonisation targets. The financial burden of subsidies, necessary to maintain affordability, has placed a growing strain on the local budget, without addressing systemic inefficiencies.

The comparison between collective DH and individual solutions is central to future planning, especially for Drobeta. Individual gas boilers or electric heating systems may appear cheaper in the short term, yet they create significant external costs. Gas boilers lock households into fossil dependency, generate local air pollution (NOx and particulate matter), and expose consumers to fuel price volatility. Electric heaters are extremely inefficient and drive-up electricity bills. In contrast, a modernised district heating system based on RES-fuelled heat pumps, or other renewable based technologies and complemented by energy efficiency measures offers both cost stability and reduced environmental impact over the medium and long term.

Cost estimates from comparable projects in Constanța, Vâlcea, and Iași counties show investment ranges of €100-150 million for large-scale cogeneration or heat pump plants of 150-160 MW thermal capacity. While such capital requirements may appear high, they must be contrasted with the cumulative costs of fragmentation: higher household bills, health-related costs from air pollution, and the long-term lock-in of fossil infrastructure. Moreover, EU financing instruments like the Modernisation Fund, and cohesion policy can significantly reduce the financial burden on local authorities if projects are prepared strategically.

Integration of RES is not only feasible but necessary. Large water-to-water heat pumps using the Danube/Jiu or wastewater can deliver COP values of 3.5-4.5, translating into competitive heat prices comparable to individual gas boilers but without the associated carbon footprint. In addition, such systems allow for future integration with renewable electricity generation and thermal storage, enhancing energy security and price stability.

Continuing with a centralised heating system or shifting entirely to individual solutions is a decision to be taken soon and communicated to consumers. Of course, a modern system does not only involve production and transmission, but also individual metering. The sustainable path lies in a modern, renewable-based DH model that ensures affordability, drastically reduces emissions, and aligns with Romania's long-term climate commitments. While investment costs are substantial, they are justified by the combination of EU support mechanisms, reduced operational expenses, and significant social and environmental co-benefits.

The case of Craiova demonstrates the cost estimates for a new high-efficiency gas CHP unit, when including operation and maintenance, network tariffs, and heat losses, point to a delivered cost of around 760-770 RON/MWh for households. This level is higher than the tariffs paid today, which remain heavily subsidised by the municipality, highlighting the fiscal risk of continuing to rely on fossil-based generation. At the same time, Craiova has a wider range of decarbonisation choices than other cities. Beyond the planned gas-fired CHP, the system could integrate large-scale water-to-water heat pumps using the Jiu River, or even heat pumps to boost fluid temperature, thermal storage to optimise operation and reduce peak costs, and the progressive phase-out of costly neighbourhood plants. In addition, distributed upgrades such as air-to-water heat pumps at block-scale substations and rooftop photovoltaics can further reduce fossil fuel dependence.

Together, these measures provide multiple pathways for Craiova to secure a reliable and affordable DH service, while gradually decarbonising the system. Relying solely on a new CHP would address short-term security of supply, but only a hybrid strategy that combines CHP with renewable-based technologies can ensure long-term cost stability, fiscal sustainability, and alignment with Romania’s climate objectives.

The two municipalities must clarify the status of their district heating systems. Both Drobeta-Turnu Severin and Craiova own their DH distribution networks, while the transport infrastructure and production assets are operated by separate entities. EU legislation sets distinct requirements for CHP producers and for district heating systems. Thus, a CHP producer is not necessarily required to integrate renewable energy or waste heat into the DH system. In Drobeta-Turnu Severin the situation is even more complex, considering a new generation capacity, the municipality must identify the company responsible for developing and operating that asset.

6.1. Drobeta-Turnu Severin — District Heating

Strengths	Weaknesses
• Presence of a compact district heating system • Proximity to the Danube • Existing operating know-how • Adequate regional grid capacity	• Fossil dependence • No real SACET operator • High heat losses • Ageing substations • High return temperatures • Limited customer metering
Opportunities	**Threats**
• Large river-water heat pumps • Wastewater heat recovery • Accessing EU and national grants • Smart metering and two-part tariffs (fixed and variable charge) • Thermal storage for peak shaving	• Customer migration to individual systems • Gas and CO_2 price volatility • Underfunded CAPEX and delays • Negative public perception

Priority steps:

1. Elaborate a clear DH local strategy that incorporates both heat production and supply, along with the definition of a governance model
2. Design a least-cost supply mix and investment plan
3. Develop an integrated SACET plan with heat-led dispatch rules
4. Build a production facility – launch a large heat pump project
5. Lower supply and return temperatures
6. Roll out smart meters to all consumers

6.2. Craiova — District Heating

Strengths	Weaknesses
• The existence of a CET and a DH system • Significant number of consumers • Extensive thermal-point network • Multiple connection nodes for new sources • Strong public sector demand • Land availability for new assets	• Fossil fuel dependent • High network losses • High subsidy burden • Aged thermal points equipment • Hydraulic imbalances • High operating temperatures • Limited meeting devices
Opportunities	**Threats**
• Large heat pump supplementing CHP production • Land availability for new assets • Short-term thermal storage • Rooftop solar thermal with short-term storage • Demand response through two-part tariffs	• Continuing using fossil fuel • Gas and ETS price volatility • Subsidy burned • Financing and permitting delays • Maintenance workforce constraints • Negative public perception • Customer churn to individual systems

Priority steps:

1. Clarify Craiova II pathway and operating model
2. Elaborate a clear DH local strategy that incorporates both heat production and supply, along with the definition of a governance model
3. Develop an integrated SACET plan with heat-led dispatch rules
4. Modernise the transport and distribution grid, alongside the thermal points
5. Deploy a thermal storage energy facility
6. Launch of a building efficiency programme.

7. Policy recommendations

- **Prioritise Renewable-Based Solutions**

Local authorities, with the support of central authorities, may consider large-scale heat pumps (water-to-water and air-to-water) as a central element of Drobeta-Turnu Severin's modernisation strategy. Using the Danube as a thermal source, together with wastewater heat recovery, would secure a stable, renewable, and low-emission supply of heat. In this regard Drobeta could become a case of good practice in Romania, so other cities lying alongside rivers could look for a similar approach.

Craiova should also consider alternative technologies and not rely solely on cogeneration plants. As carbon allowance prices increase and the power system integrates more renewable energy and storage, heat pumps could play an important role. Other solutions could also contribute, such as solar thermal panels, waste heat recovery, even biomass. In the long-run, gas-fired plants will find it difficult to operate economically.

- **Preserve and Modernize District Heating Systems**

Safeguard existing networks by resizing them to real demand, upgrade infrastructure to reduce losses, and integrate renewable and low-carbon heat sources, supported by EU and national funding. The network modernisation must take into account the connection of new heat production sources and thus be designed in terms of hydraulic flows, including future operation at lower temperature levels.

- **Strengthen Energy Efficiency and Demand-Side Measures**

Thermal rehabilitation of buildings must be accelerated to reduce demand by up to 40-50%. Linking DH upgrades with building renovation programmes ensures that investments in new generation capacity are correctly dimensioned and cost-efficient. A clear and coherent strategy for buildings energy efficiency has a direct effect on the proper sizing of the production capacity.

- **If a centralised option is too complex, develop a semi-centralised heating model**

As long as the local authorities in Drobeta do not own the Halânga assets, and building a new heat pump-based plant in the southern area of the city is deemed too difficult, an alternative is to implement a semi-centralised solution, that is install air-water heat pumps in the existing heat exchanger stations.

- **Leverage Available Funding Instruments**

Access to the Modernisation Fund, and other EU financial mechanisms should be improved. A clear pipeline of projects, prioritising renewable integration, grid flexibility, and storage, should be submitted to ensure timely absorption of funds. Most of the time, local authorities develop projects to tap available funds, aiming to fix an immediate problem rather than follow a clear strategy. At present, the strategic directions set out in the LTS (Long-Term

Decarbonisation Strategy) and NECP should be the primary drivers for channelling funds toward clean technologies in this sector.

- **Promote Sector Coupling and Digitalisation**

The DH operator should integrate electricity, heat, and cooling services within a digital management platform. Smart metering and predictive maintenance would reduce losses and improve consumer confidence. Moreover, energy production in hybrid systems enables efficient energy management, which can lower costs.

- **Ensure Social Equity and Affordability**

As subsidies currently burden local budgets, reforms should focus on reducing production costs and improving efficiency. Added social measures (e.g., targeted subsidies for vulnerable households) should replace blanket support schemes.

Taken together, these trends confirm the fragile state of the sector and reinforce the need for comprehensive modernisation measures. Addressing losses across the production and distribution chain, improving network efficiency, and integrating cleaner technologies are essential steps towards restoring reliability and aligning the system with national and European decarbonisation objectives.

The path forward involves aligning national objectives with EU requirements: investing in heat network refurbishment, deploying smart metering and digital monitoring, and building flexible systems capable of integrating diverse energy sources. Such a transition will not only help Romania meet its commitments under the EED and EPBD, but also enhance resilience, improve the quality of life in cities, and unlock new financing opportunities through European funds.

The modernisation of district heating is more a necessity rather than an option, taking Romania from its fossil fuels-based past into a hi-tech, low-carbon future. To achieve these objectives, it is essential for central and local authorities to work together in identifying solutions that can be translated into the modernisation of DH networks. Local authorities, in particular, ought to elaborate plans and strategies and ensure their implementation. At the same time, central authorities should direct a greater share of funding towards clean solutions at local level, while reducing support for technologies with an uncertain future.

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