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Governance Constraints in District Heating Transition: Evidence from the Danube Region

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ABSTRACT

District heating is a key component of Europe's pathway to climate neutrality,. particularly in Central and Eastern Europe where such systems remain structurally embedded. While existing research has extensively examined technological options and investment needs, it provides limited explanation for why transition outcomes vary across countries with broadly similar conditions. This paper addresses this gap by analysing district heating transition through the lens of governance and coordination capacity. Drawing on empirical evidence from the REHEATEAST project – including a multi-country stakeholder survey, utility-level data, and system-level analysis across eight Danube Region countries – the study identifies a structural mismatch between system complexity and institutional capacity. The results show that although decarbonisation technologies are widely available and financial resources increasingly accessible, their effective deployment is constrained by fragmented policy frameworks, weak planning capacity, and insufficient coordination across stakeholders and governance levels. By introducing the system-stakeholder mismatch perspective, the paper offers a novel explanation for uneven transition outcomes and repositions governance as a central determinant of implementation. The findings have direct implications for integrated heat planning and for improving the effectiveness of public funding in the 2028-2034 programming period.

Keywords

District heating;
Energy transition;
Governance;
Danube Region;
Stakeholder coordination

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1. Introduction

Despite unprecedented policy attention, technological progress, and growing financial support, the decarbonisation of district heating systems across Central and Eastern Europe remains uneven and, in many cases, slow. This is striking given that many systems operate under broadly similar structural conditions and have access to comparable technological solutions and funding opportunities. Within the eight countries analysed in this study, district heating systems (DH) serve approximately 9.5 million people, highlighting both the scale of the sector and the significance of divergent transition outcomes. In this study, transition outcomes refer to the observable results of district heating transition in relation to European Union energy

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Abbreviations

DH	District Heating	RED III	Renewable Energy Directive III
EIB	European Investment Bank	EU	European Union
DHC	District Heating and Cooling	RHE	ReHeatEast Project
EBRD	European Bank for Reconstruction and Development		

policy objectives. These include progress towards increasing the share of renewable and recovered heat, improving system efficiency, reducing greenhouse gas emissions, and implementing district heating modernisation projects, as reflected in the Renewable Energy Directive (Directive (EU) 2023/2413, RED III) [1] and the Energy Efficiency Directive (Directive (EU) 2023/1791) [2]. Rather than measuring these outcomes directly, this paper examines the governance and institutional conditions that influence their achievement across different national contexts. DH continues to play a major role in urban energy supply in the region, particularly in meeting residential heat demand. Its transformation is therefore central to achieving the European Union's 2050 climate neutrality objective, while also intersecting with broader concerns related to energy security, affordability, and regional development. Over the past decade, both academic research and policy frameworks have focused primarily on technological pathways – such as renewable integration, waste heat utilisation, and system modernisation – and on mobilising the financial resources required to implement them. However, these approaches provide only a partial explanation of transition outcomes.

A critical question remains unanswered: why do district heating systems with similar technological options and financial conditions follow markedly different transition paths? While existing studies offer valuable insights into what is technically feasible and economically viable, they provide more limited understanding of how these solutions are translated into practice and why implementation varies so significantly across contexts.

This paper addresses this gap by focusing on governance and coordination capacity as central determinants of transition. The paper introduces the concept of system-stakeholder mismatch, referring to the misalignment between the structural characteristics of district heating systems and the governance, institutional and stakeholder capacities required to manage their transition successfully. This perspective extends existing governance-oriented research by explicitly linking system complexity with stakeholder capacities as a joint explanation for uneven transition outcomes. Drawing on empirical evidence from the ReHeatEast project (RHE), covering eight countries in the Danube Region, it combines stakeholder survey data, utility-level information, and system-level analysis in a comparative, multi-layered framework.

This approach allows for a more integrated assessment of how structural system characteristics interact with institutional conditions. The analysis shows that the primary constraint of district heating transition is not the absence of technological solutions or financial resources, but a mismatch between system complexity and the capacity of institutions and stakeholders to coordinate, plan, and implement transformation processes. This mismatch manifests in fragmented policy frameworks, limited planning capacity, and weak coordination across governance levels. Even where technically viable and cost-effective solutions exist, their deployment is often constrained by insufficient institutional alignment.

From a sustainable energy planning perspective, district heating transition can therefore be understood as a multilevel coordination challenge, where outcomes depend on the alignment between system design, investment strategies, and governance capacity. The findings suggest that technological and financial inputs alone are insufficient; effective transition requires institutional systems capable of managing complex infrastructure change. By introducing a system-stakeholder mismatch perspective, this paper contributes to the literature by offering a governance-centred explanation of uneven transition outcomes. It shows that divergence is driven less by differences in available solutions and more by the ability of institutional systems to translate these into coordinated and sustained action.

2. Literature review

DH systems are widely recognised as key infrastructures in the transition towards climate-neutral energy systems, particularly in urban contexts with concentrated heat demand. European energy planning studies have consistently highlighted district heating as a strategic component of the decarbonisation of the European energy system through the combined integration of renewable heat, energy efficiency and coordinated heat planning [3]. Much of the literature approaches this transition as a technical and system-design challenge. Energy planning research[4],[5] highlights the role of DH in integrating renewable energy, waste heat, and sector coupling, while long-term analyses demonstrate efficiency gains from low-temperature and integrated system. Studies on advanced generations of district heating [6],[7] further emphasise decentralised substations, bidirectional networks, and flexible operation. While these contributions establish technological feasibility [8], they offer limited insight into implementation. Recent reviews further emphasise that district heating should be understood as a core component of clean energy systems, enabling the integration of renewable energy, waste heat, thermal storage and sector coupling rather than functioning as an isolated infrastructure [9]. Recent studies have also shown that technological transition alone does not guarantee successful implementation, as local conditions, planning choices and system characteristics substantially influence transition outcomes [10].

Numerous studies focus on policy frameworks and governance. Research on European heating strategies and regulatory environments underlines the importance of stable policy design [11], incentives, and coordination [12]. Recent studies further demonstrate that successful district heating transition depends not only on technological innovation but also on coherent policy frameworks, stable regulation and effective governance arrangements [11]. International comparisons further demonstrate that the development and performance of district heating systems depend not only on technological solutions but also on national institutional settings, regulatory frameworks and governance arrangements [13]. Municipal planning capacity has also been identified as a critical factor for successful district heating implementation, demonstrating that effective local governance can substantially improve both planning quality and long-term implementation outcomes [14].

More broadly, socio-technical transition literature conceptualises energy transitions as multilevel, actor-driven processes shaped by interactions between technologies, institutions, and markets [15], while temporal perspectives highlight uneven dynamics influenced by institutional inertia [14] [16]. These approaches recognise governance as critical but often remain insufficiently grounded in sector-specific conditions. Similarly, long-term planning has been identified as a key prerequisite for the successful transition of district heating systems from fossil-based to renewable energy sources [17].

Empirical work increasingly examines stakeholder perspectives. Survey-based studies show that utilities, policymakers, and consumers identify different barriers [18], including financing, infrastructure constraints, regulatory uncertainty, and social acceptance[19]. Recent research emerging from the RHE project [20]confirms that governance quality, planning coherence, and coordination capacity shape these perceptions more strongly than technological availability. However, stakeholder insights are rarely connected systematically to system-level characteristics. Previous reviews have also noted that research on district heating has traditionally focused on technical and regulatory aspects, while stakeholder involvement and perception remain comparatively underexplored [21].

Traditional planning approaches often struggle to integrate technical, economic and social priorities simultaneously, while stakeholder acceptance has become a critical determinant of successful implementation [22].

Recent studies increasingly argue that district heating planning should move beyond purely techno-economic assessments by explicitly incorporating governance and stakeholder perspectives into planning processes [22]. At the same time, spatial and structural perspectives emphasise that DH systems are territorially embedded. Studies of renewable and excess heat potentials show[23]] that technical opportunities are widely available, but their utilisation depends on regional planning capacity and institutional coordination [24]. Social science research further highlights uneven impacts, including links to energy poverty, particularly in post-socialist contexts[19].

Overall, the literature addresses technology, policy, stakeholders, and spatial conditions largely in isolation. Successful energy transition depends not only on the preparation of strategic plans but also on their implementation, continuous monitoring and organisational learning throughout the transition process [25]. Recent IJSEPM contributions have substantially advanced district heating planning through spatial modelling, optimisation methods, heat mapping and integrated energy system approaches. At the same time, recent editorials emphasise that future research should increasingly address the governance, institutional and implementation dimensions of sustainable energy transitions alongside technological innovation [26]. This perspective is consistent with recent findings showing that organisational challenges may outweigh purely financial constraints in sustainability transitions [27]. Despite these important advances, limited attention has been given to how increasing system complexity interacts with governance capacity, institutional arrangements and stakeholder coordination in shaping implementation outcomes. This gap is particularly relevant in Central and Eastern Europe, where district heating systems operate under diverse institutional conditions and strong legacy constraints.

This paper contributes by linking system-level characteristics with stakeholder-based evidence to explain uneven transition outcomes. By focusing on the relationship between system complexity and governance capacity, it offers a more integrated explanation of divergence in district heating transition pathways.

3. Data and methodology

3.1. Data sources

The analysis draws on empirical material collected within the RHE project, comprising three complementary datasets that capture district heating systems from both technical and governance perspectives across eight Danube Region countries (Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Romania, Serbia, Slovakia, and Slovenia).

First, a structured stakeholder survey was conducted among key actor groups involved in district heating systems, including heat producers and utilities, authorities and regulators, technology suppliers and contractors, financiers and investors, and consumers and media representatives. A total of 249 stakeholders were invited to participate, resulting in 127 valid responses across the analysed countries. Response rates ranged between 33% and 64% depending on the country.

The distribution of responses across stakeholder groups was as follows: approximately 44-51 responses from heat producers and utilities, 25-32 from authorities and regulators, 19-25 from technology suppliers and contractors, 13-19 from financiers and investors, and a smaller number of responses from consumers and media representatives. Differences in group sizes partly reflect variations in national stakeholder structures and survey implementation. The survey followed a harmonised design based on standardised questionnaires developed for each stakeholder group. Within each category, identical question sets were applied across all participating countries, with only minor language adaptations where necessary. Appendix A provides a brief overview of the survey methodology, stakeholder groups, questionnaire structure, and examples of the original questionnaire templates. This design ensured comparability across countries and stakeholder groups.

Second, a comparative utility-level database was compiled, covering more than 170 district heating providers across the participating countries. The database includes key system indicators (e.g. installed capacity, number of consumers, and system size and density) as well as organisational and operational characteristics (e.g. ownership structure, management conditions, and operational practices). The dataset was constructed by aggregating project-level data contributions from national partners, supplemented by publicly available sectoral data where necessary, and harmonised to ensure cross-country comparability of core indicators.

Third, country-level qualitative assessments were used to contextualise both survey responses and system-level data. These assessments cover regulatory frameworks, policy design, and institutional arrangements and sector-specific constraints influencing district heating systems in each country. Together, the three data sources provide a multilayered empirical basis linking system characteristics, stakeholder perspectives and governance conditions.

3.1.1 Survey design and content

The stakeholder survey combined closed-ended and open-ended questions to capture both structured assessments and qualitative insights. Closed-ended questions mainly used Likert-scale evaluations and priority rankings, while open-ended questions allowed respondents to describe key challenges and development needs in their own words. The questionnaire focused on a consistent set of topics across all stakeholder groups, including technical system issues (e.g. heat losses and infrastructure condition), financial constraints, regulatory frameworks, and organisational and coordination-related challenges. Question wording was adapted to the specific role of each stakeholder group, but the underlying topics remained the same across countries. Examples of survey questions included: “Are there any barriers to adopting new technologies in the DH sector?”, “Are there any regulatory barriers or challenges hindering the development of DH infrastructure?”, and “What fundamental changes are needed, technical, organisational, or financial, to improve existing DH systems?”. Respondents were also asked to rank the biggest expected challenges for district heating, including future lower demand, transition from fossil fuels, legal frameworks, consumer loyalty and technology change.

Open-ended responses were reviewed and grouped thematically in line with these topics and used to support the interpretation of the survey results.

Surveys were administered using a combination of online questionnaires, structured interviews, and expert consultations, depending on the national context and stakeholder accessibility.

3.1.2 Data quality and limitations

The survey data should be interpreted with some limitations. Before the analysis, all returned questionnaires were reviewed for completeness and consistency. Only completed and valid responses were included in the analysis, while missing answers to individual questions were treated as missing values and no imputation was applied. Response rates varied across countries (33-64%), and the number of respondents differed between stakeholder groups, resulting in uneven representation across both dimensions. Consumer and media responses were limited, for example in Bosnia and Herzegovina, where this stakeholder group was not systematically covered. Similarly, some stakeholder categories were represented by only a small number of respondents, such as financiers and investors, where in certain cases only a single response was collected (e.g. Bosnia and Herzegovina).

To account for these limitations, the analysis focuses on identifying recurring patterns across countries and stakeholder groups rather than relying on direct quantitative comparisons between individual countries. The survey results are therefore interpreted as indicative of stakeholder perceptions and common implementation challenges rather than statistically representative national estimates. To strengthen the interpretation of the findings, the survey results were considered together with the utility-level database and the country-level assessment, allowing conclusions to be drawn from multiple complementary sources of evidence.

3.1.3 Coding of qualitative responses

Open-ended responses were analysed using thematic coding in order to identify recurring themes and common issues across countries and stakeholder groups. Responses were grouped based on content similarity and their relation to the main analytical dimensions applied in the study. The coding process followed an iterative approach, where initial themes (such as technological barriers, financial constraints, regulatory issues, and coordination challenges) were identified and then refined through repeated reading and comparison of responses. The analysis focused on frequently mentioned challenges and institutional constraints across countries and stakeholder groups. The qualitative material was used primarily to support and contextualise the interpretation of survey results, rather than to produce standalone quantitative indicators.

3.1.4 Utility-level database

The utility-level database was compiled from data collected across the eight participating countries by the RHE project consortium. In addition to the stakeholder survey, the project involved national energy agencies, energy efficiency organisations, specialised technical partners and an external expert company responsible for supporting the technical assessment and data collection. The dataset covers more than 170 district heating systems and providers, including both large urban systems and smaller municipal networks. It is based on available company-level information, national sector statistics and project data collection, depending on data availability in each country. The database includes a limited set of comparable indicators, such as installed capacity, number of systems and number of consumers, which were available for most participating countries.

At aggregate level, the dataset reflects substantial cross-country differences in system structure, for example: Hungary (213 systems; approx. 8,180 MW installed capacity), Bulgaria (10 systems; approx. 1,820 MW), and Slovakia (around 200 systems). These differences are used in the analysis to characterise system size, fragmentation and structural conditions.

Data availability is not uniform across all utilities, and not all variables are consistently reported. For this reason, the database is used at aggregated level to support cross-country comparison and to identify general structural patterns rather than for detailed utility-level benchmarking. In the analysis, these aggregated system characteristics are interpreted together with the stakeholder survey results, allowing stakeholder perceptions to be assessed against observable differences in system scale, fragmentation and structural conditions.

3.2 Analytical approach

The study applies a qualitative, comparative approach to examine how system characteristics and stakeholder perceptions jointly shape district heating transition conditions across the eight countries. Rather than isolating individual variables or developing a formal quantitative model, the analysis focuses on identifying consistent patterns across countries through combined interpretation of system-, utility-, and stakeholder-level data. The analysis proceeds in three steps. First, system-level and utility-level data are examined descriptively to identify differences in system size, number of systems, and general structural characteristics across countries. Second, stakeholder survey results are analysed to capture how different actor groups perceive transition barriers, with responses grouped into technological, financial, regulatory, and coordination-related categories. Third, these data are interpreted jointly, using country-level policy and institutional context to assess how system characteristics relate to perceived barriers and coordination challenges.

This approach allows the identification of recurring cross-country patterns linking system structure and stakeholder perceptions, without assuming uniform conditions across national contexts. This triangulated approach links the survey evidence, utility-level database and country-level qualitative assessments, making it possible to interpret perceived transition barriers in relation to actual system structures and governance contexts.

3.3 Integrating system complexity and stakeholder capacity

The core analytical contribution of the paper lies in integrating system-level characteristics with stakeholder-based evidence to identify a recurring pattern across countries: a structural mismatch between system complexity and governance and stakeholder coordination capacity. System complexity is understood through observable system characteristics, including network scale, infrastructure legacy, system fragmentation, fossil fuel dependence, technological diversification and the need for coordinated investment. Governance and stakeholder capacity is understood through planning competence, institutional coordination, regulatory stability, data availability, financial coordination and stakeholder engagement.

The concept of system-stakeholder mismatch is used as an interpretive framework rather than as a quantitative index. It captures situations where the technical and organisational requirements of district heating transition exceed the capacity of institutions and stakeholders to plan, coordinate and implement change. The framework is operationalised through the joint interpretation of three empirical layers: utility-level data describing system structures, stakeholder survey evidence identifying perceived barriers, and country-level assessments describing regulatory and institutional contexts.

This approach makes it possible to move beyond a descriptive list of barriers. It allows the analysis to assess whether barriers identified by stakeholders correspond to structural system conditions and governance weaknesses observed at country level. The aim is not to rank countries or produce a formal typology, but to identify recurring alignment and misalignment patterns that help explain why technically feasible and financially supported transition options remain under-implemented in many cases.

4. Results

4.1 Structural asymmetries across district heating systems

The comparative analysis shows that district heating transition in the RHE countries starts from highly uneven conditions.

Table 1: Structural characteristics of district heating systems in the RHE countries

Country	Flats heated by DH (%)	Installed DH capacity per user (kW)	Residential DH clients per km pipeline	Number of DH systems	Total installed capacity (MW)
Bulgaria	30	1.32	196	10	1,820
Bosnia and Herzegovina	11	16.66	n/a	29	5,300
Croatia	11	4.50	~350	60	1,840
Hungary	15	5.80	~345	213	8,180
Romania	11	2.60	~235	49	7,500
Slovakia	40	1.12	~270	200	2,300
Serbia	18	3.82	~240	64	6,400
Slovenia	17	4.73	169	101	1,970

Penetration rates range from 11% in Bosnia and Herzegovina, Croatia, and Romania to 40% in Slovakia, while installed capacity per user varies from 1.12 kW to 16.66 kW. These differences point to markedly different infrastructure legacies, system scales and operational conditions. The particularly high values observed in

Bosnia and Herzegovina suggest oversized infrastructure and legacy lock-in effects, whereas countries such as Slovakia and Bulgaria operate more compact, or mature configurations. These findings indicate that district heating transition does not begin from a common structural baseline, highlighting the need to interpret technological and governance challenges within highly differentiated system contexts.

Table 1 confirms that the analysed systems differ not only in size, but also in density, penetration and fragmentation. Slovakia and Bulgaria show relatively high district-heating penetration, while other countries operate smaller or more fragmented systems. The very high installed capacity per user in Bosnia and Herzegovina – points to oversized legacy systems and structural inefficiencies. These differences indicate that transition conditions are not uniform. At the same time, structural variation alone does not fully explain implementation differences, which makes it necessary to examine how these system conditions interact with governance, planning and stakeholder capacities.

4.2 Country-specific empirical patterns

Country-level evidence provides further insight into how structural conditions, technological readiness and governance constraints combine in different contexts shaping transition outcomes. Table 2 does not rank national systems but shows how similar transition technologies are embedded in different institutional and operational settings. Across countries, technological options are generally recognised, but implementation is constrained by institutional and governance-related factors rather than technical limitations.

4.3 Technological availability and underutilisation

Stakeholder responses and country-level assessments consistently indicate that a broad range of decarbonisation technologies is already recognised across the RHE countries. Biomass-based heat production, geothermal energy, solar thermal applications, industrial waste heat recovery, large-scale heat pumps, cogeneration upgrades, and digital monitoring solutions were repeatedly identified as technically feasible transition options. This suggests that technological awareness is generally present across the region, although the maturity of implementation differs substantially between the countries.

At the same time, the degree of implementation varies considerably. In countries such as Slovakia and Hungary, several of these technologies are already embedded in existing systems. In contrast, Bosnia and Herzegovina, Serbia, and parts of Romania show broad awareness of available solutions, but deployment remains limited, fragmented or project based. Waste heat utilisation provides a clear example. Although repeatedly identified by stakeholders as a high-potential opportunity, its large-scale integration remains rare across the region. Similar patterns can be observed in relation to digital monitoring and optimisation technologies, which are recognised as valuable but often remain confined to isolated projects.

Table 2: Country-specific patterns of district heating transition in the RHE countries

Country	System profile	Technological readiness	Binding governance constraint
Bosnia and Herzegovina	Oversized systems, high losses, fossil dependence	Broad awareness of solutions (geothermal, solar, biomass, heat pumps, digitalization)	Fragmented governance, weak regulation, no unified strategy
Bulgaria	Widespread DH, gas-based cogeneration	Limited renewable integration, minimal waste heat use	Ageing infrastructure, fragmented ownership, regulatory inconsistencies
Croatia	Dense networks, moderate efficiency	Partial renewable integration (biomass)	Institutional fragmentation, regulatory barriers
Hungary	Large, relatively efficient systems	Technologies partly deployed	Fossil dependence, fragmented incentives
Romania	Large, heterogeneous systems	Renewables present, EU funding available	High losses, regulatory instability, weak coordination
Serbia	Extensive systems, formal targets	Recognised modernisation options	Weak enforcement, decentralised pricing, fragmented governance
Slovakia	High penetration, integrated systems	Strong policy alignment	Ageing infrastructure, investment needs
Slovenia	Well-structured systems	Broad technological feasibility	Coordination bottlenecks, administrative complexity

These findings suggest that the main problem is not the complete absence of technological options, rather the challenge lies in translating recognised technologies into coordinated and durable implementation. This points towards the importance of planning capacity, institutional coordination and project preparation as conditions for turning technological feasibility into transition outcomes.

4.4 Financing conditions and limitations

Financial constraints are important, but the evidence suggests that they should not be understood only as a question of whether funding exists. Multiple funding sources are already available across the region, including EU cohesion policy instruments, national support schemes, and international financing mechanisms. EU member states benefit from cohesion-policy funded modernisation programmes, while non-EU countries in the Western Balkans also have access to substantial external financing. In Serbia, the European Bank for Reconstruction and Development approved a €105 million sovereign loan in 2024 for the decarbonisation of the Novi Sad district heating system, complemented by an additional €21 million EU investment grant through the Western Balkans Investment Framework. In the same year, a further €30 million EBRD programme, supported by €12 million in donor funding, was launched to modernise district heating systems in ten Serbian municipalities through renewable heat integration, including solar thermal, geothermal, heat pumps, and industrial waste heat recovery.

However, the availability of funding does not automatically mean that funding is accessible or effectively used. Stakeholder evidence suggests that weak project preparation capacity, fragmented planning responsibilities, regulatory uncertainty and insufficient coordination across institutional levels limit the translation of resources into implementation. Financial constraints therefore appear closely linked to governance and planning capacity. In this sense, finance is not absent, but its effective mobilisation depends on whether actors can prepare, coordinate and implement bankable transition projects.

4.5 Empirical barriers and transition implementation gaps

The survey and gap-analysis evidence provide a more detailed view of how district heating transition barriers appear in practice. The findings do not point to a single dominant obstacle that is identical across all countries. Instead, they reveal a set of recurring barriers through which system complexity, institutional capacity and stakeholder readiness become misaligned. This is important because many of the identified constraints are not purely technical, financial or regulatory in isolation. They emerge at the point where technical system needs have to be translated into coordinated planning, project preparation, financing and implementation. The empirical basis supporting these findings, including synthesised evidence from the stakeholder survey, utility database and project deliverables, is documented in Appendix B.

Table 3 summarises the main barrier dimensions identified from the stakeholder survey and the RHE gap analysis. Table 3 does not rank countries or stakeholder groups. Rather, it shows how repeatedly identified barriers help explain why implementation gaps persist even where technologies and funding are available.

Table 3. Empirical barriers and implementation gaps in district heating transition

Barrier dimension	Evidence from survey / gap analysis	Interpretation for transition	Misalignment mechanism
Outdated infrastructure	Ageing pipes, inefficient networks and underperforming heat generation plants are identified as common regional constraints.	In several systems, the first necessary intervention may not be direct decarbonisation investment, but basic network rehabilitation, loss reduction, metering and controllability improvements. Without these foundations, renewable integration or advanced optimisation may remain technically possible but operationally premature.	System complexity is high, but technical and institutional readiness is still focused on maintaining basic system functionality. The transition agenda therefore arrives before several systems have completed the preconditions for effective decarbonisation.
Fossil fuel dependence	Natural gas and coal remain dominant heat sources in several systems.	Decarbonisation is constrained by legacy lock-in and by the difficulty of integrating renewable and alternative heat sources into existing systems. Fuel switching is therefore not only a	Available low-carbon technologies do not easily match existing fuel structures, regulatory incentives and operational routines. The system requires transformation, while many actors still

Barrier dimension	Evidence from survey / gap analysis	Interpretation for transition	Misalignment mechanism
		technology choice, but also a system-integration and planning challenge.	operate within inherited fossil-based logics.
Fragmented ownership and regulatory barriers	Several countries lack binding national DH strategies, while local implementation remains uneven. Regulatory responsibilities, pricing rules and ownership structures are often divided across governance levels and actors.	The absence of coherent regulation weakens long-term coordination, investment certainty and the preparation of coherent transition pathways. Fragmentation also makes it harder to move from general policy objectives to a structured pipeline of feasible interventions.	Fragmented ownership and regulatory responsibilities make it difficult to build a national-level policy and project pipeline capable of translating strategic objectives into implementable local projects. Multi-actor systems require coordination, but the institutional architecture often produces dispersed responsibility.
Limited financial incentives and project preparation capacity	EU grants and public funding remain important, but diversified funding models, private-sector participation and mature project pipelines remain limited.	Financing problems are not only about the availability of money, but also about accessibility, bankability and project-preparation capacity. Available funding does not automatically become implementable transition investment.	Stakeholder-management capacity remains primarily oriented towards technological operation and everyday service provision. In many utility-centred systems, organisations are led by technical and operational logics, while complex decarbonisation projects require financial, regulatory, EU-project development and stakeholder-management competences that are often less developed.
Data transparency gaps	Many municipalities and utilities lack systematic heat mapping, consumption data, performance monitoring and transparent data-sharing practices.	Weak data limits system optimisation, evidence-based heat planning and credible investment prioritisation. It also makes it difficult to identify whether the first intervention should be rehabilitation, loss reduction, fuel switching or system-level decarbonisation.	Data transparency can create institutional exposure. Making system performance, losses, tariff structures or investment needs visible may generate political pressure, reputational risk or loss of trust. As a result, stakeholders may have weak incentives to disclose the very data required for integrated transition planning.
Planning deficiency	Many cities lack analytical tools and sufficiently specific heat planning capacities.	Planning weakness turns transition into isolated projects rather than system-level change. Even where technologies and funding exist, weak planning capacity reduces the ability to combine them into a coherent pathway.	System-side transition needs exceed local planning and implementation capacity. The result is a project-by-project logic instead of coordinated system transformation.
Low consumer engagement	Low awareness, weak trust and preference for individual heating systems reduce acceptance of district heating investments in several contexts.	Social acceptance, tariff transparency and consumer participation are part of implementation capacity, not only communication issues. Without public trust, even technically sound investments may face resistance or limited support.	Stakeholder alignment is weaker than the level of social coordination required for system transformation. Consumers are affected by transition costs and service changes, but they are often insufficiently integrated into planning and decision-making processes.

Table 3 shows that the transition problem is not simply a lack of technology or money. In many cases, the difficulty lies in the sequence and organisation of change. Some systems first need rehabilitation and better data before advanced decarbonisation projects can be implemented effectively. Others need stronger policy coordination, more mature project pipelines or more credible consumer engagement. The same pattern appears across different barrier dimensions: the technical requirements of transition are increasing faster than the institutional and stakeholder capacities needed to manage them. This does not mean that technology and finance are unimportant. On the contrary, both are essential. However, their effectiveness depends on whether they are embedded in a governance environment capable of selecting priorities, preparing projects, coordinating actors and maintaining trust. This evidence provides the empirical basis for the mismatch interpretation developed in the Discussion.

In addition to the barrier synthesis, the gap analysis also provides useful evidence on the types of pilot actions in which stakeholders are willing to participate. The reported motivations follow a recognisable transition logic: reducing greenhouse gas emissions, improving energy security, modernising ageing infrastructure, demonstrating benefits and best practices, facilitating stakeholder cooperation, supporting policy alignment and funding access, and addressing social and economic issues such as energy poverty. This order is important because it shows a practical gap between transition objectives and implementation conditions. Stakeholders clearly recognise the formal decarbonisation agenda, but their motivations are not limited to climate mitigation or technology deployment. They also reflect the practical conditions under which transition can become feasible in the RHE region. Social and economic issues appear as one of the stated motivations, yet in many local contexts they may work as a precondition for implementation rather than as a secondary concern. Where affordability, trust, energy poverty, service reliability and basic infrastructure quality remain unresolved, district heating transition cannot be treated as a simple technology-deployment process.

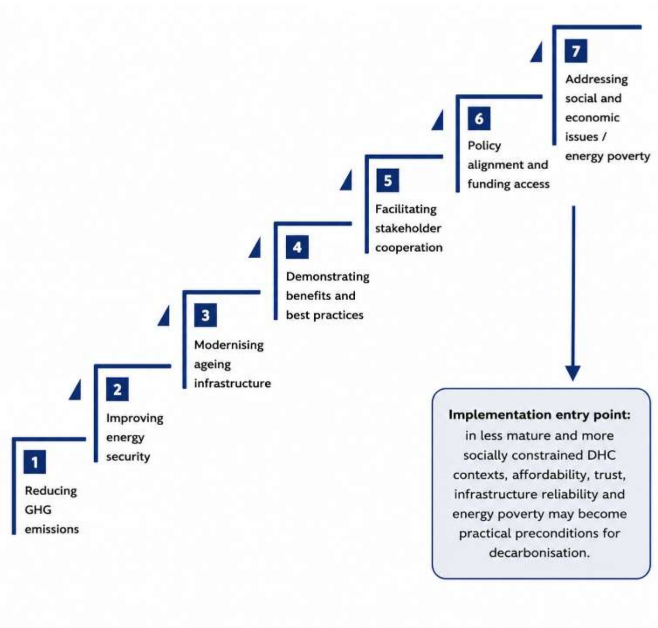

Figure 1. Stakeholder motivations for DHC pilot actions in the RHE region

Source: adapted from REHEATEAST Deliverable 2.1.4. Gap Analysis of Current Practices and Policies [26]

Figure 1 therefore helps explain the gap between declared transition objectives, stakeholder motivations and social expectations. Policy frameworks usually define the transition through decarbonisation, renewable integration and efficiency improvement. Stakeholders, however, often approach pilot actions through a more practical sequence of needs: keeping systems reliable, reducing exposure to imported fuels, modernising ageing assets, demonstrating tangible benefits, accessing finance and maintaining social acceptance. At the same time, households and local communities are likely to judge transition mainly through affordability, service reliability, transparency and trust. This difference does not make decarbonisation less important. Rather, it shows that decarbonisation has to be embedded in locally credible and socially acceptable transition pathways.

4.6 Core empirical finding: governance and coordination as implementation constraints

The preceding results indicate that governance and coordination problems are central to the implementation of district heating transition in the RHE countries. Sections 4.1 and 4.2 showed that the analysed systems differ substantially in penetration, scale, fragmentation and infrastructure legacy. Sections 4.3 and 4.4 showed that technological options and funding sources are present, but their use remains uneven. Section 4.5 further demonstrated that recurring barriers, including outdated infrastructure, fossil fuel dependence, fragmented ownership, weak project preparation, data gaps, planning deficiencies and low consumer engagement, tend to appear at the point where technical system needs have to be translated into coordinated implementation. The barrier synthesis in Section 4.5 further shows that many constraints appear at the interface between technical system needs, planning capacity, institutional coordination and stakeholder readiness.

A recurring pattern across the RHE countries is the absence of integrated heat planning. Although district heating is widely recognised as an important component of decarbonisation, several countries lack binding national strategies, coherent regulatory frameworks or clearly defined implementation pathways. This is particularly visible in Bosnia and Herzegovina, Serbia and Romania, where fragmented institutional structures and weak regulatory coordination limit long-term planning. However, coordination problems are not limited to less advanced systems. Even in countries with more developed district heating sectors, such as Slovenia and Slovakia, administrative complexity, investment needs and divided responsibilities create barriers to implementation.

These findings suggest that governance constraints are not simply background conditions, but directly shape the capacity of district heating systems to move from recognised transition options to implemented projects. Where planning responsibilities are fragmented, utilities and municipalities often lack the institutional support required to prepare mature investment pipelines. This limits the effective use of available financial resources and reduces the capacity to combine different technological options into coherent system-level transition pathways.

Stakeholder coordination represents a further constraint. District heating transition requires alignment between municipalities, utilities, regulators, financing institutions, technology providers and consumers. In practice, this alignment is often weak or project based. Stakeholder evidence points to problems of coordination, data transparency, regulatory uncertainty and limited consumer engagement. These issues are closely connected: weak data limits planning, weak planning reduces project quality, and low trust makes implementation more difficult.

Consumer trust and social acceptance are especially important because district heating transition affects tariffs, service quality and household-level decisions. In several contexts, consumers are sceptical of district heating systems because of previous experiences with high prices, low transparency or unreliable services. This means that consumer engagement cannot be treated only as a communication issue. It is part of the governance capacity required to implement transition successfully.

Overall, the results indicate that the main implementation problem is not the isolated absence of technology or finance. The challenge lies in aligning technological options, financial resources, institutional responsibilities and stakeholder expectations.

4.7 Synthesis

The results show that district heating transition is shaped by the interaction between system characteristics and governance capacity. Structural differences between systems are significant, but do not explain transition outcomes on their own. Instead, implementation depends on the ability of institutional systems to align policy design, planning, financing, coordination, and stakeholder engagement. The transition challenge is therefore not primarily technological or financial, but also organisational and institutional.

These patterns, summarised in Table 4, illustrate how increasing system complexity consistently outpaces governance and coordination capacity, resulting in fragmented and project-based transition pathways.

Table 4: Structural gaps underlying the system–stakeholder mismatch in district heating transition

Gap dimension	Key manifestations	System-level effect	Governance implication	Link to mismatch
Outdated infrastructure	Ageing networks, high losses	Limits RES integration	Short-term focus	Complexity exceeds capacity
Fossil dominance	Continued gas/coal reliance	Low-carbon options underused	Lock-in effects	Governance favours status quo
Fragmented ownership	Split responsibilities	Uneven development	Weak coordination	Multi-actor misalignment
Weak project pipelines	Dependence on grants	Underused investment potential	Limited capacity	Funding not translated
Planning deficiency	Lack of data/tools	Ad hoc development	Weak planning capacity	Capacity lag
Low engagement	Low trust, resistance	Weak demand-side integration	Limited social acceptance	Coordination failure

To make this relationship more explicit, the observed patterns can be interpreted as a system–stakeholder mismatch, as synthesised in Table 5. The relationship can be expressed in a heuristic simplified form as:

$$M = f[(TI + SI + LI) - (IC + PC + FC + DC + EC)]$$

where TI refers to technological intensity, SI to structural system characteristics, and LI to legacy lock-in effects, while IC captures institutional capacity, PC planning capacity, FC financial coordination capacity, DC data availability, and EC stakeholder engagement. The mismatch increases where system requirements exceed the capacity of governance and coordination structures.

Table 5: Governance constraints underlying the system-stakeholder mismatch (empirical synthesis)

Dimension	Empirical evidence (RHE data)	System-side pressure *(TI, SI, LI)*	Governance capacity gap *(IC, PC, FC, DC, EC)*	Mismatch mechanism
Strategic planning	Lack of national DH strategies; no long-term pathways in BiH, Serbia, Romania	SI + LI: Large, legacy systems require long-term transformation planning	PC ↓ / IC ↓: Weak planning competence and institutional anchoring	Complex systems operate without strategic direction
Regulatory framework	Fragmented or non-binding regulation; inconsistent tariff and RES integration rules	TI + SI: Integration of RES and new technologies require stable regulation	IC ↓: Weak regulatory coherence and enforcement	Technological options exist but cannot scale
Institutional coordination	Survey shows weak alignment between municipalities, utilities, regulators	SI + TI: Multi-actor, multi-technology systems require coordination	IC ↓ / EC ↓: Fragmented governance and stakeholder misalignment	System complexity exceeds coordination capacity
Project development / financing	Under-developed project pipelines despite EU funding availability	TI: Capital-intensive upgrades and RES integration	FC ↓ / PC ↓: Weak financial coordination and project preparation	Funding exists but is not translated into projects
Data and planning tools	Limited heat mapping, weak data availability	TI + SI: System optimisation requires detailed operational data	DC ↓ / PC ↓: Insufficient data systems and analytical capacity	Decisions made without system-level optimisation
Stakeholder engagement	Low consumer trust and participation (survey evidence)	SI: System transformation requires demand-side alignment	EC ↓: Weak engagement and social acceptance	Social dimension under-mines implementation
Incentive structures / lock-in	Continued fossil dependence despite available alternatives	LI: Strong legacy dependence on gas/coal systems	IC ↓ / FC ↓: Misaligned incentives and regulatory signals	Governance reinforces existing system inertia

Note: Arrows indicate the direction of capacity gaps. Downward arrows (↓) denote insufficient governance and coordination capacity relative to system-side pressures.

5. Discussion and policy implications

The results provide a basis for reinterpreting the drivers of district heating transition across the RHE countries. A wide range of technological solutions – biomass, geothermal energy, solar applications, heat pumps, digitalisation, and system optimisation – is already available and, in many cases, partially implemented. Financial resources are also present across most countries, particularly through EU cohesion policy, EIB instruments, and related funding schemes, although their accessibility and effective use vary across contexts. However, the availability of funding does not automatically mean that these resources are accessible or can be effectively mobilised for concrete district heating projects. Instead, persistent weaknesses in governance, planning, and coordination continue to limit implementation. Fragmented policy frameworks, weak or non-binding regulation, limited enforcement, insufficient municipal planning capacity, and poor coordination across stakeholders all contribute to this gap. As a result, system-level transition pathways remain fragmented and largely project-based.

A central issue is the absence of integrated and enforceable heat planning frameworks. In several countries – particularly Bosnia and Herzegovina, Serbia, and Romania – district heating systems operate without comprehensive national strategies or clearly defined long-term decarbonisation pathways. At the same time, municipalities often lack the tools, data, and institutional capacity needed for effective planning. Investment decisions therefore tend to be reactive and isolated, rather than part of coordinated system development. This suggests that planning limitations are not merely technical but reflect deeper governance deficits.

Weak multi-level coordination emerges as another key constraint. District heating transition requires alignment across municipalities, utilities, regulators, financial institutions, and consumers. In practice, coordination mechanisms are often weak or rely on ad hoc arrangements, frequently linked to externally funded projects. Importantly, this is not only a feature of less developed governance contexts. While fragmentation is particularly visible in Bosnia and Herzegovina and Serbia, coordination challenges also exist in more advanced systems, such as Slovenia, where administrative complexity and divided responsibilities limit effective alignment.

Financial constraints are closely intertwined with these governance conditions. Although EU funding and national support schemes are widely available, their utilisation is often constrained by weak project pipelines, limited administrative capacity, and regulatory uncertainty. Private investment is similarly restricted – not by a lack of capital, but by perceived risks and unclear policy frameworks. In this sense, financing challenges are better understood as a consequence of governance quality rather than as an independent constraint.

A concrete illustration of this implementation gap can be observed in the case of Tuzla (Bosnia and Herzegovina), where technically viable district heating decarbonisation options – including renewable integration and system modernisation – have been clearly identified and analysed. Despite the availability of solutions and access to potential funding sources, progress remains limited due to fragmented institutional responsibilities, weak coordination mechanisms, and constrained project preparation capacity. The Tuzla case highlights that even where technological pathways are well understood, the absence of coherent governance and planning frameworks can delay or prevent implementation. As such, it illustrates how governance constraints translate directly into stalled transition outcomes.

At the same time, consumer trust and engagement add a further layer of complexity. In several countries, low levels of public trust – combined with concerns over pricing transparency and system performance – reduce the willingness of consumers to support system upgrades. This complicates the implementation of coordinated investment strategies and highlights the social dimension of transition.

The findings point to a structural imbalance between the complexity of district heating systems and the capacity of governance structures to manage their transformation. While structural differences between countries are significant, they do not explain transition outcomes on their own. The decisive factor is the ability of institutional systems to align planning, financing, implementation, and stakeholder cooperation in a coherent and sustained way. This reinterpretation has important implications for European Union policy, particularly in relation to the 2050 climate neutrality objective. Existing frameworks have been effective in mobilising funding and supporting technological development but place less emphasis on governance and coordination capacity. Achieving meaningful progress therefore requires a shift in focus - from technology and investment towards the institutional conditions that enable their effective use.

In this context, the findings provide a set of policy-relevant insights for the 2028-2034 programming period, as summarised in Table 6. The policy implications in Table 6 are derived from the barrier synthesis presented in Section 4.5 and from the additional survey documentation and response distributions reported in Appendix A.

Table 6: Data-anchored policy implications for district heating transition

Empirical finding (Results)	Identified problem	Policy implication (2028–2034)
Weak heat planning capacity (Section 4.6)	Lack of strategic direction	Mandatory integrated heat planning frameworks
Fragmented governance structures (Section 4.6)	Limited coordination	Formal multi-level coordination mechanisms
Underutilised EU funding (Section 4.5)	Weak project pipelines	Ex-ante conditionality linked to governance capacity
Available but underutilised technologies (Section 4.4)	Implementation gap	Focus on deployment and system integration
Low consumer trust and engagement (Section 4.6)	Social barriers	Consumer engagement and transparency measures

The key challenge for the next programming period is therefore not the expansion of financial resources, but the conditions under which these resources are accessed and used. Stronger ex-ante conditionalities linked to planning and governance capacity could significantly improve the effectiveness of EU-funded interventions. This is particularly relevant in Western Balkan accession countries, where funding opportunities exist but access depends not only project availability, but also on institutional capacity and project-preparation quality.

Overall, the findings point towards a more coordination-oriented policy approach. This would place greater emphasis on aligning strategic planning, institutional capacity, and implementation mechanisms. Importantly, such an approach does not replace technological or financial instruments but ensures that they are used more effectively within a coherent framework.

In this paper, the system-stakeholder mismatch refers to the situation in which the technical and organisational complexity of district heating transition exceeds the capacity of institutions and stakeholders to plan, coordinate and implement change in an aligned way. The concept does not describe governance weakness in general, nor does it imply that stakeholders ignore the transition or consider it unimportant. Rather, it captures the specific misalignment between what the system requires - long-term heat planning, infrastructure modernisation, coordinated investment, consumer engagement and regulatory stability - and what the stakeholder environment is able to deliver in practice.

This misalignment may result not only from limited capacity, but also from different stakeholder priorities, mandates, risk perceptions and time horizons. Utilities may prioritise operational reliability, municipalities may focus on affordability and political feasibility, investors may require bankable projects, while consumers may judge transition mainly through price, transparency and service quality. These priorities are individually understandable, but they do not automatically combine into an integrated transition pathway that is coherent, implementable and acceptable to all major actors. The system-stakeholder mismatch therefore helps explain why technically feasible and financially supported transition options may remain under-implemented even when the transition itself is widely recognised as necessary. Although developed here in the context of district heating transition, the perspective may also be relevant for other infrastructure transitions where technological complexity, multi-actor coordination and implementation capacity have to be aligned.

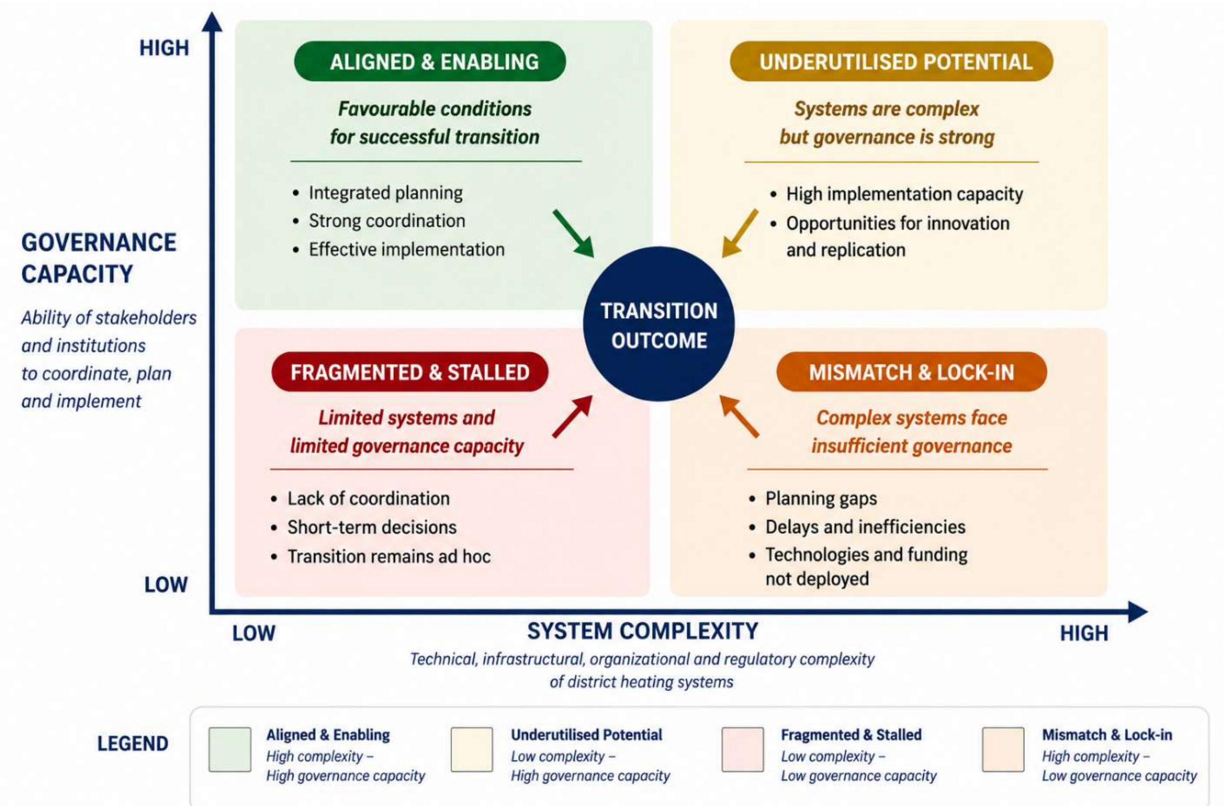

Figure 2: System-stakeholder mismatch in district heating transition

Figure 2 illustrates district heating transition as a function of the alignment between system complexity and governance capacity. Where institutional capacity matches system requirements, transition can proceed effectively. Where it does not, the mismatch leads to fragmented planning, suboptimal investment, and limited implementation. A key implication is that governance constraints act not only as background conditions, but as direct barriers within planning processes. In fragmented and uncertain environments, planning horizons shorten, long-term investments are delayed, and decision-making becomes reactive. This leads to incremental, project-based interventions rather than coherent system-level strategies. In this sense, governance weaknesses can be understood as planning-failure mechanisms, shaping both the direction and effectiveness of transition.

The findings also suggest a broader policy implication. Future district heating transition programmes would benefit less from additional sector-specific strategies than from an EU-supported District

Heating Transition Governance Framework linked to the preparation and implementation of major district heating investments. Unlike existing national district heating decarbonisation strategies, which primarily focus on achieving climate and renewable energy objectives, such a framework would provide an integrated transition roadmap combining technical modernisation, governance reform, financing, regulatory development and stakeholder coordination within a single implementation process. The stakeholder evidence presented in this study indicates that district heating transition should not be organised around a single dominant objective, such as decarbonisation alone. Instead, successful transition requires a phased roadmap that recognises the different priorities, capacities and implementation horizons of governments, regulators, district heating utilities, municipalities, technology providers, financial institutions and consumers. The proposed framework should therefore define integrated transition stages, clarify institutional responsibilities and coordination mechanisms, and specify how the needs and expectations of each stakeholder group will be addressed throughout the implementation process rather than only at its outcome.

The survey findings further suggest that consumer trust and social acceptance should be treated as integral components of transition governance rather than as communication issues addressed after investment decisions have already been made. The proposed Governance Framework should therefore include a dedicated consumer pathway alongside the technical, financial and institutional dimensions of transition. This pathway should establish minimum requirements for transparent tariff communication, affordability considerations, structured stakeholder participation and regular public consultation, allowing consumers to understand how the transition affects service quality, costs and long-term benefits at each implementation stage. Such an approach could strengthen public confidence, reduce resistance to change and improve the social legitimacy of district heating transition.

Finally, the proposed District Heating Transition Governance Framework could serve as a practical programming and implementation guide accompanying European and national funding instruments. Linking major public investment to a common governance methodology and multi-stakeholder transition roadmap could improve the effective use of available decarbonisation resources, reduce institutional fragmentation and directly address the system-stakeholder mismatch identified in this paper.

6. Conclusion

This paper set out to understand why district heating transition across the RHE countries remains uneven despite the growing availability of technologies and funding. The analysis shows that the main barriers cannot be explained by the absence of technological options or financial resources alone. Across the region, viable solutions already exist, and substantial resources are available. Yet these do not consistently translate into real-world outcomes. The supplementary empirical material supporting these conclusions is available in Appendix B.

The analysis shows that the core issue lies in a persistent mismatch between the complexity of district heating systems and the capacity of institutions to manage their transformation. Fragmented governance structures, weak planning frameworks, and limited coordination prevent available tools and resources from being used effectively. As a result, transition processes remain partial, fragmented, and often confined to isolated projects rather than coherent system-level change. This helps explain why progress continues to diverge across countries, even under broadly similar structural conditions.

At the same time, recent geopolitical developments are reshaping the economic context of the transition. The reduction and gradual exclusion of Russian fossil fuel imports have increased pressure on district heating systems to diversify energy sources, while also improving the relative economic viability of renewable and alternative heat solutions. This shift creates a window of opportunity but also increases the urgency of transition. Without adequate governance and planning capacity, even these favourable conditions may fail to translate into effective system transformation.

The implications are therefore direct. If district heating is to play its expected role in achieving the European Union's 2050 climate neutrality objective, the focus of policy must shift. Expanding funding or refining technologies will not be sufficient on their own. What is needed is stronger institutional capacity: integrated heat planning, stable and enforceable regulatory frameworks, and effective coordination across actors and governance levels. The 2028-2034 programming period provides a critical opportunity to embed these priorities more firmly into EU cohesion and energy policy.

At its core, the transition of district heating systems is not primarily a question of what can be built, but of what can be organised and implemented. Without addressing governance fragmentation, planning gaps, and coordination weaknesses, there is a real risk that existing and future investments will continue to deliver uneven and suboptimal results – even in a context where economic and technological conditions are increasingly favourable.

Seen in this light, district heating transition is not only an energy and financial challenge, but an institutional one. Recognising and addressing this reality is essential if decarbonisation efforts are to move beyond isolated improvements and achieve consistent, large-scale impact across the region.

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The content of this publication reflects the author's views only, and the programme authorities are not responsible for any use that may be made of the information contained therein.

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Appendix A

Stakeholder Survey Instrument

The empirical findings presented in this study are based on the stakeholder survey conducted within the RHE project. To ensure full transparency and reproducibility, the complete stakeholder-specific survey questionnaires are publicly available in RHE Project Deliverable D1.1.2 - *Joint Stakeholder Survey Analysis and Methodology* (Annexes 2-6). The questionnaires were jointly developed by the RHE consortium for five stakeholder groups: energy stakeholders, public authorities, technology providers, financial institutions and consumers. Although several stakeholder-specific questions were adapted to reflect the responsibilities of each group, all questionnaire versions followed a common analytical structure, enabling consistent comparison across stakeholder groups and participating countries. The survey combined structured questions with open-ended questions. While the structured questions provided contextual information on district heating systems, the open-ended questions generated the qualitative evidence analysed in this study. Responses were coded thematically and synthesised at both national and cross-country levels. Tables A1-A3 summarise the survey structure, stakeholder-specific focus and examples of the original survey questions.

Table A1. Main thematic structure of the REHEATEAST stakeholder survey

Survey section	Purpose
Stakeholder profile	Identify the respondent and organisational background
Current district heating situation	Assess the current status and key challenges of district heating systems
Technical barriers	Identify technical constraints affecting system modernisation and renewable energy integration
Governance and regulation	Examine institutional, planning and regulatory barriers
Financing	Identify investment barriers and financing needs
Future transition priorities	Identify strategic priorities supporting district heating transition
Good practices	Collect examples of successful projects and transferable experience

Note: All stakeholder questionnaires followed the same overall analytical structure while incorporating stakeholder-specific questions where appropriate.

Table A2. Stakeholder-specific questionnaire focus

Stakeholder group	Main thematic focus
Energy stakeholders (utilities and heat producers)	Technical operation, infrastructure modernisation, renewable energy integration and operational challenges
Public authorities and regulators	Strategic planning, governance, legislation, institutional coordination and policy implementation
Technology providers and contractors	Technology deployment, innovation barriers, implementation experience and market conditions
Financial institutions and investors	Investment conditions, financing mechanisms and financial risks
Consumers and end users	Service quality, affordability, public awareness and public acceptance

Table A3. Examples of original survey questions included in the REHEATEAST stakeholder questionnaires

Analytical theme	Original survey question
Technical barriers	„Name the most significant barriers to adopting new technologies in the DH sector."
Future strategies	„What strategies are envisioned for adapting the DHC infrastructure to accommodate forthcoming technological advancements?"
Regulatory framework	„Is there a need for regulatory or legislative support to accommodate the future expansion of the DHC sector? Please describe."
Financial incentives	„Is there a need for additional incentive mechanisms for DHC? If the answer is yes, what form should these mechanisms take?"
Monitoring and metering	„How is heat consumption measured and monitored within the DH network? To what extent is the accuracy of heat metering ensured, and how transparent is the billing process for customers? Are there ongoing initiatives aimed at enhancing these aspects?"
Digital technologies	„How are digital technologies utilised for system monitoring, control, and optimisation?"
Knowledge and capacities	„Is there sufficient knowledge and capacities for successful development of DH? If the answer is no, what specific skills need to be developed?"
Future developments	„What advancements do you anticipate in DH within your company's operations? (you can mark more than one)"

Note: The complete stakeholder-specific questionnaires are reproduced in Annexes 2-6 of the REHEATEAST Project Deliverable D1.1.2. The questions presented above are reproduced from the original survey instruments (Annex 2, survey for energy stakeholders) and illustrate the main analytical themes addressed across stakeholder groups.

Appendix A References

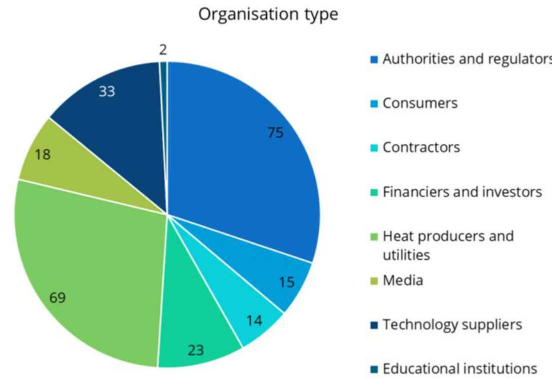
REHEATEAST Consortium. *Joint Stakeholder Survey Analysis and Methodology* (Deliverable D1.1.2). Available through the REHEATEAST Project Library: https://interreg-danube.eu/projects/reheateast/library?page=1

Appendix B

Supplementary empirical evidence

This appendix provides supplementary material supporting the empirical basis of the study. It complements the methodological description presented in the main text by documenting the geographical coverage and stakeholder composition of the survey, and by providing additional evidence underlying the main analytical findings.

Figure B1. Distribution of stakeholder organisations by stakeholder category



Source: REHEATEAST Project Deliverable D1.1.2, Joint Stakeholder Survey Analysis and Methodology Figure 4 (publicly available project report).

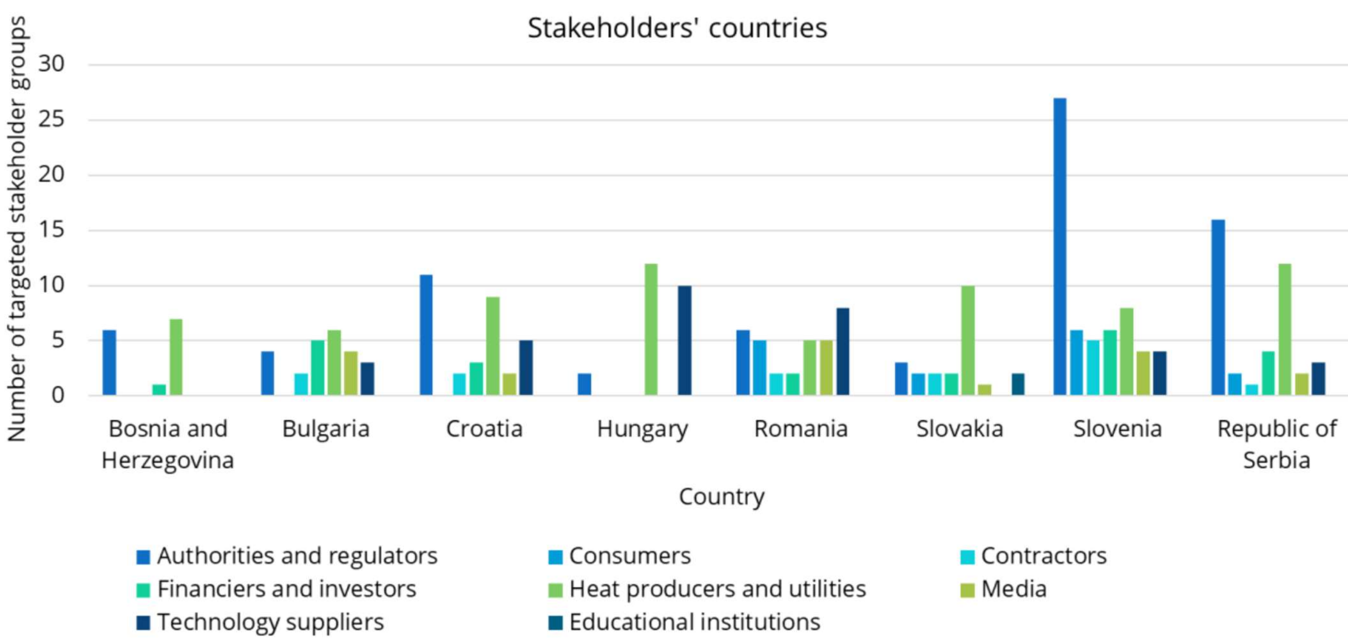


Figure B2. Stakeholder organisations participating in the REHEATEAST survey by country and stakeholder category

Source: REHEATEAST Project Deliverable D1.1.2, Joint Stakeholder Survey Analysis and Methodology Figure 3 (publicly available project report).

Figure B2 summarises the composition of the stakeholder survey across the participating countries. Heat producers and utilities, public authorities and regulators, and technology suppliers constitute the largest stakeholder groups, complemented by financial institutions, consumers and media representatives. This composition reflects the multi-actor perspective adopted in the survey and provides the empirical basis for the cross-stakeholder comparisons presented in the main text. Figures B1 and B2 above document the geographical coverage and stakeholder composition of the RHE survey. Tables B1-B6 synthesise the empirical evidence used to support the main findings presented in the article.

Table B1. Cross-country synthesis of governance and implementation barrier categories

Barrier category	BiH	BG	HR	HU	RS	RO	SK	SI	Countries reporting the category
Planning / strategy gaps	✓	✓	✓	-	✓	✓	-	✓	6
Governance / coordination constraints	✓	✓	✓	-	✓	✓	-	✓	6
Regulatory / administrative barriers	✓	✓	✓	✓	✓	✓	✓	✓	8
Financing / investment constraints	✓	✓	✓	✓	✓	✓	✓	✓	8
Consumer / acceptance barriers	✓	✓	✓	✓	✓	✓	✓	✓	8
Data / metering / transparency gaps	✓	✓	✓	✓	✓	✓	-	✓	7
Infrastructure / technical lock-in	✓	✓	✓	✓	✓	✓	✓	✓	8
Barrier categories identified by country	7	7	7	5	7	7	4	7	

Note. A check mark indicates that the issue appears as a distinct barrier category or implementation need in the relevant country-level survey analysis. It does not indicate the number of respondents, the frequency of mentions, or the perceived importance of the issue (as the number of respondents are not identical in the countries). The final row reports the number of barrier categories identified for each country; the final column reports the number of countries in which each barrier category was identified.

Source: Author's synthesis based on the REHEATEAST stakeholder survey results and country-level analyses.

Table B2. Country-level synthesis of stakeholder identified barriers to district heating transition

Country	Technical barriers	Regulatory and governance barriers	Financial barriers	Market and social barriers
Bosnia and Herzegovina	Ageing infrastructure; inefficient heat production and distribution; very limited renewable energy integration; high dependence on coal and natural gas.	Lack of comprehensive policies promoting renewable energy integration and district heating modernisation.	Weak financing mechanisms; limited access to investment and public funding.	Low public awareness and limited acceptance of district heating modernisation.
Bulgaria	Outdated technologies; limited modernisation; difficulties integrating renewable energy sources.	Regulatory inconsistencies and delayed alignment with EU energy policy.	High upfront investment costs; limited private-sector participation.	Low consumer trust, limited transparency and low public awareness.
Croatia	Infrastructure upgrading challenges; limited integration of renewable heat technologies.	Limited policy incentives for decentralised district heating, particularly in smaller and rural systems.	High investment costs; limited local financing opportunities.	Consumer preference for individual heating systems and resistance to tariff increases.
Hungary	High-temperature legacy systems limiting renewable energy integration; continued dependence on natural gas.	Fragmented policy framework; inconsistent implementation; weak stakeholder coordination.	Lack of innovative financing models for district heating modernisation.	Limited collaboration among utilities, regulators and consumers.
Romania	Ageing systems; high network losses; inadequate infrastructure maintenance.	Weak policies supporting renewable energy and waste heat utilisation; poor alignment of heat planning with EU objectives.	Limited public funding and inefficient utilisation of EU financial resources.	Declining consumer base associated with poor service quality.
Serbia	Heavy dependence on fossil fuels; limited renewable energy integration.	Insufficient policies supporting renewable energy, waste heat utilisation and cross-sectoral integration.	Strong dependence on public funding; limited private investment.	High heat prices, unreliable service quality and low public trust.

Country	Technical barriers	Regulatory and governance barriers	Financial barriers	Market and social barriers
Slovakia	Limited waste heat utilisation; absence of modern low-temperature district heating networks.	Weak strategic planning for renewable energy and waste heat integration.	Financial constraints affecting the retrofit of ageing systems.	Consumer mistrust of pricing mechanisms and limited awareness of district heating benefits.
Slovenia	Predominance of second-generation district heating systems; limited renewable energy and waste heat utilisation.	Weak implementation of local energy planning; insufficient technical and institutional capacity.	High infrastructure investment costs; limited financial support mechanisms.	Limited stakeholder and end-user awareness of district heating benefits.

Note: The table summarises the principal transition barriers identified from stakeholders' open-ended survey responses and the accompanying national qualitative assessments prepared within the REHEATEAST project. The barriers were grouped into four analytical dimensions (technical; regulatory and governance; financial; and market and social) to facilitate cross-country comparison. The table represents a qualitative synthesis of stakeholder evidence rather than the frequency or intensity of responses.

Source: Adapted from the REHEATEAST *Comparative Analysis of the Institutional, Legal, and Financial Status Quo of DHC* (Table 8.).

Table B3. Comparative severity of district heating transition barriers across REHEATEAST countries

Barrier category	BiH	BG	HR	HU	RO	SRB	SK	SLO
Policy and regulation	3	3	2	2	3	3	2	2
Financial barriers	4	3	3	2	4	4	3	2
Technical barriers	4	3	3	3	3	4	2	2
Reliance on fossil fuels	4	4	3	2	4	4	3	3
Market barriers	2	3	2	2	3	2	2	2
Economic constraints	4	3	3	3	3	3	2	2
Awareness and knowledge	4	3	3	3	4	3	3	3
Social acceptance and consumer resistance	3	3	3	2	2	3	3	3

Note: Barrier severity was assessed within the REHEATEAST project using a four-level expert scoring framework (4 = severe barrier; 3 = high barrier; 2 = moderate barrier; 1 = low barrier). Scores represent expert synthesis based on national gap analyses rather than direct stakeholder survey frequencies.

Source: Adapted from the REHEATEAST Comparative Analysis of the Institutional, Legal, and Financial Status Quo of DHC (Table 9.).

Table B4. Strength of regulatory support for district heating development across the REHEATEAST countries

Country	Regulatory support	Main characteristics
Bosnia and Herzegovina	Weak	Fossil-fuel-oriented regulatory framework with limited incentives for renewable energy integration.
Bulgaria	Moderate	EU-driven regulatory framework promoting CHP, while support for biomass and geothermal energy remains limited.
Croatia	Moderate	Strong alignment with EU energy policy, supporting CHP, geothermal energy and increasing biomass utilisation.
Hungary	Moderate	Stable regulatory framework supported by national subsidies and policies promoting decarbonisation and renewable heat integration.
Romania	Weak - moderate	Ongoing regulatory development supported by EU funding, with increasing emphasis on district heating modernisation and renewable energy.
Serbia	Weak	Regulatory framework primarily focused on affordability and maintaining existing fossil-fuel-based systems, with limited support for renewable technologies.
Slovakia	Progressive	Advanced regulatory framework promoting renewable energy sources, waste heat utilisation and low-carbon district heating.
Slovenia	Progressive	Well-developed EU-aligned regulatory framework encouraging renewable energy integration and sustainable district heating development.

Note: Regulatory support levels are based on the comparative assessment developed within the REHEATEAST project and reflect the overall maturity of national district heating policy frameworks rather than formal legislative compliance alone.

Source: Adapted from the REHEATEAST Comparative Analysis of the Institutional, Legal, and Financial Status Quo of DHC (Table 10.).

Table B5. Current regulatory priorities for district heating transition in the REHEATEAST countries

Country	Main regulatory priorities
Bosnia and Herzegovina	Strengthen the renewable energy policy framework; modernise ageing fossil-fuel-based district heating systems; introduce stronger incentives for biomass and other renewable heat sources.
Bulgaria	Continue support for combined heat and power (CHP); expand biomass and geothermal integration; strengthen regulatory incentives for renewable energy deployment.
Croatia	Promote CHP, geothermal energy, solar thermal and biomass; further align national regulation with EU climate and energy objectives through the National Recovery and Resilience Plan.
Hungary	Accelerate decarbonisation through geothermal energy and biomass; reduce natural gas dependence; strengthen incentives for renewable heat integration and district heating deployment in suitable urban developments.
Romania	Modernise district heating infrastructure using EU funding; improve regulatory support for renewable energy integration; strengthen long-term planning and investment frameworks.
Serbia	Diversify energy sources beyond fossil fuels; promote renewable energy and waste heat utilisation; strengthen the regulatory framework for cross-sectoral energy integration and modern district heating technologies.
Slovakia	Increase the utilisation of renewable energy and waste heat; support the transition towards low-temperature district heating systems; reinforce strategic planning at the local level.
Slovenia	Increase renewable and waste heat utilisation; strengthen local energy planning capacities; improve financial and technical support mechanisms for district heating modernisation.

Note: The table summarises the principal regulatory priorities identified in the national gap analyses conducted within the REHEATEAST project. The priorities reflect country-specific policy directions rather than mandatory legislative requirements.

Source: Adapted from the REHEATEAST Comparative Analysis of the Institutional, Legal, and Financial Status Quo of DHC (Table 11.).

Table B6. Governance and local planning frameworks supporting district heating transition across the REHEATEAST countries

Country	Stakeholder coordination characteristics
Bosnia and Herzegovina	Coordination among national, entity and municipal institutions remains fragmented, limiting integrated planning and slowing the implementation of district heating modernisation projects.
Bulgaria	Coordination between government institutions, district heating utilities and regulatory authorities has improved, although stronger engagement of private actors and municipalities remains necessary.
Croatia	Stakeholder collaboration is generally effective in larger cities but remains uneven across smaller municipalities, where institutional capacity and inter-organisational cooperation are more limited.
Hungary	Coordination is largely driven through central government programmes and district heating operators, while collaboration among municipalities, utilities and other stakeholders remains relatively limited.
Romania	Institutional coordination has improved through EU-funded projects, but fragmented responsibilities and inconsistent cooperation continue to constrain implementation.
Serbia	District heating development is primarily utility-led, with relatively weak coordination between energy, environmental and local development institutions and limited involvement of external stakeholders.
Slovakia	Well-established cooperation between municipalities, utilities and regulatory institutions provides favourable conditions for coordinated district heating planning and implementation.
Slovenia	Strong municipal leadership and close cooperation among local authorities, utilities and energy agencies support integrated planning and the implementation of renewable district heating solutions.

Note: The table summarises the main patterns of stakeholder coordination identified in the comparative REHEATEAST assessment. It reflects the overall quality of institutional collaboration supporting district heating transition rather than formal governance arrangements alone.

Source: Adapted from the REHEATEAST Comparative Analysis of the Institutional, Legal, and Financial Status Quo of DHC. (Stakeholder coordination assessment, Table 14.).

Appendix B References

The supplementary material presented in this appendix is based on empirical evidence generated within the REHEATEAST project. The appendix combines reproduced figures, adapted project outputs and original cross-country syntheses using the REHEATEAST stakeholder survey, national gap analyses and comparative status quo assessment. All underlying project deliverables are publicly available.

REHEATEAST project deliverables used in Appendix B

- REHEATEAST Consortium. *District heating and cooling stakeholder survey and analysis of result. Deliverable 1.1.5*. Available at: https://interreg-danube.eu/storage/media/01JENSHPH28E4ZYGKB3B3ED3CR.pdf
- REHEATEAST Consortium. *Gap Analysis of current practices and policies. Deliverable 2.1.4*. Available at: https://interreg-danube.eu/storage/media/01KKV71X43C55T2QGR0CVKMZV9.pdf
- REHEATEAST Consortium. *Analysis of Challenges, Gaps and Good Practices in District Heating and Cooling Deliverable 1.2.1.* Available at: https://interreg-danube.eu/storage/media/01JFCWJG5F7KEZHAM89Z9MGQKC.pdf
- REHEATEAST Consortium. Comparative Analysis of the Institutional, Legal, and Financial Status Quo of DHC – Insights from the REHEATEAST Countries. Available at: https://interreg-danube.eu/storage/media/01JY3SJ9P1T1HMGY9NK4JBECE3.pdf

Additional REHEATEAST project deliverables and supporting documentation are publicly available through the REHEATEAST Project Library: https://interreg-danube.eu/projects/reheateast/library?page=1

Project information is available at: https://interreg-danube.eu/projects/reheateast