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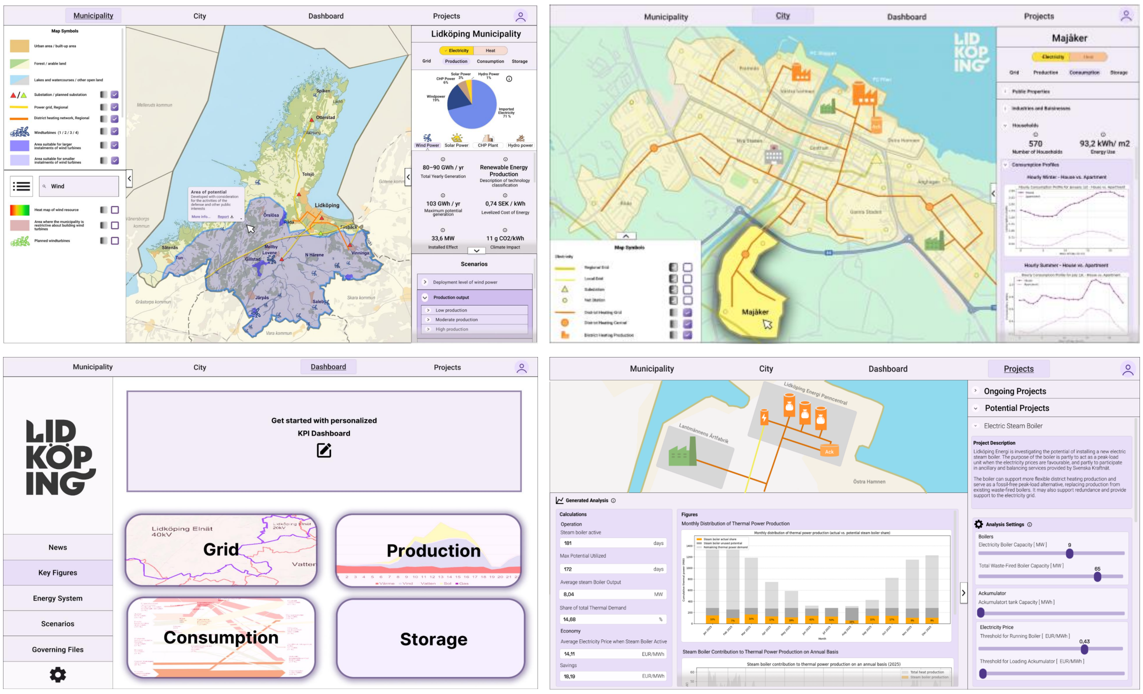

Collaborative Planning of Local Energy Systems: Exploring the Need for a Digital Support Platform

An Investigation of Current Planning Practices, Stakeholder Challenges, and Conceptual Platform Design

Master’s thesis in Sustainable Energy Systems

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Cover: Conceptual model images, developed during this thesis.

Abstract

The accelerating energy transition and increasing geopolitical uncertainty are placing new pressures on municipalities and other stakeholders to coordinate and plan the development of local energy systems more effectively and responsibly. To investigate solutions in aiding planning processes, this study aimed to address a research gap on the practical planning processes and tools used between key stakeholders as well as the challenges involved in collaborative local energy systems planning. Additionally, the demand for a digital platform that can act as a tool to support collaborative planning and decision-making processes was investigated. Another major part of this study included the identification of platform specifications and development of a conceptual model of such a platform.

Through a qualitative interview study with 14 representatives spanning municipalities, energy companies, grid owners, and housing companies, current planning practices, challenges, and attitudes toward a new digital tool were examined. Based on these findings, platform specifications and a conceptual model of a possible user interface was developed, grounded in a case study of Lidköping municipality.

The results showed that planning of local energy systems is largely conducted in parallel by separate actors, with limited transparency and fragmented data exchange between them. Key challenges include: managing complexity and uncertainty; navigating conflicting interests; and overcoming structural barriers related to data confidentiality and political instability. Furthermore, respondents were generally positive toward a new digital tool to support collaborative planning processes, which currently is supported by manual and project-specific analytical tools. There was an expressed demand for a simple, shared tool that could provide an overview of the energy system, support scenario exploration, and facilitate more informed discussions between stakeholders.

A conceptual model was developed and resulted in four digital images representing a suggested user interface, aimed to collectively address the identified platform specifications. The study concluded that while a digital platform is not a standalone solution to the governance and coordination challenges identified, it can serve as a valuable complementary tool, supporting transparency, shared understanding, and more collaborative planning processes.

This study further concluded that there are several important aspects to consider if the platform suggested in this study were to be practically implemented. This includes interdependent technical, organisational, and legal constraints such as confidential data, ownership of the platform, and software and system architecture development.

Keywords: Local Energy Systems, Collaborative Local Energy System Planning, Digital Tool, Conceptual Model

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Definitions

Local Energy System (LES) – A structured network of actors, including energy producers, consumers, distributors, and governing/regulating bodies (e.g. a municipality), and energy-related technologies or infrastructure within a defined local area. Interrelations and interactions between actors impact the coordination of the generation, distribution, storage, regulation and management of energy carriers.

Local Energy System Planning (LESP) – Involves processes through which stakeholders plan and make decisions regarding the development, operation, and management of the local energy system. The term encompasses concepts such as local energy planning, municipal energy planning, grid development planning, forecasting future energy demand, developing infrastructure plans, setting targets, etc.

Collaborative Local Energy System Planning (CLESP) – emphasises the collaborative and multi-stakeholder approach of local energy system planning. It includes processes in which multiple stakeholders actively engage in coordinated planning and decision-making of energy-related issues, with the aim of achieving system-wide outcomes and shared goals.

1
Introduction

Sweden, like many countries worldwide, is currently undergoing major transitions in its energy system. These transitions are driven by the urgency to meet global climate goals and supporting large scale electrification of fossil-dependent sectors, all while navigating a geopolitical landscape that is increasingly destabilizing long-term planning conditions [1]. The Swedish Parliament has established energy policy targets, including a long-term target of achieving net-zero emissions by 2045, along with two milestone targets for 2030 and 2040. Additional objectives relate to system planning and security of supply which in summary aim to ensure that the electricity system should create the conditions necessary for increased electrification and the green transition, while guaranteeing that electricity is delivered in the required quantity at the time in a socioeconomically sustainable manner [2]. In order to achieve these goals, major transformations in the structure, governance, operations, and socio-economic aspects of the country's energy system are expected [3]. Achieving this place high requirements on how energy system developments are planned in practice.

Traditionally, energy system planning has been performed at the national level, supported by centralized energy production. However, the energy system has been gaining more complexity with growing decentralization [4]. Thus, even though several climate and energy issues are decided at governance levels beyond municipal control, municipalities' decision-making can achieve high impact on the local level [5, 6]. Given that municipalities play a central role in Local Energy System Planning (LESP), they should, in order to effectively achieve the energy transition, (1) set targets and communicate future visions (2) utilize existing tools for community planning and integrate them with energy planning, (3) collaborate and unify stakeholders through leadership, and (4) ensure secure energy supply [7].

LESP is inherently challenging given that Local Energy Systems (LESs) are complex systems involving multiple stakeholders with multiple administrative levels, goals and values; fragmented governance and regulatory responsibilities among stakeholders; financial, geophysical and spatial constraints; constantly evolving market and technological contexts; and political and social influences. These factors create several uncertainties, interdependencies and lock-in mechanisms that can obstruct progress in planning for the energy transition [8, 9].

In response to these challenges, enhanced collaboration at the municipal level, along with the integration of energy planning with spatial planning, has emerged as a key approach to making cost-optimal and efficient decisions and ultimately accelerating local energy transitions. However, exactly how urban energy planning processes should be integrated and made participatory remains an active area of research [10, 11]. Another finding from scientific literature is the focus on available analytical tools and a recognized gap between their intended benefit and practical needs of local stakeholders.

In a study by Buow et. al. [12], there is a recognized need for exploring a solution for simple and effective planning tools that can support local stakeholders in accelerating the energy transition.

Collectively, this background forms the foundation of this study, which aims to investigate how a digital platform could be designed to support Collaborative Local Energy System Planning (CLESP) in practice.

1.2 Purpose

The purpose of this study is to investigate practical planning processes for local energy systems, with a particular focus on challenges related to collaboration, uncertainty management, analytical and modelling tools, and data sharing among stakeholders.

To explore a solution for collaborative approaches for planning processes of local energy systems, the study also assesses the demand for a digital platform that can support collaborative local energy system planning. Ultimately, the platform aims to facilitate more efficient, collaborative, and informed planning processes for local energy systems, thereby contributing to a clearer understanding of how stakeholders can address the energy transition.

Furthermore, the study seeks to develop specifications and a conceptual model of such a platform, including relevant content and functionalities, through the synthesis of identified planning practices, existing challenges, and stakeholder needs. The conceptual model, based on the Swedish municipality of Lidköping, is intended to illustrate how a digital planning support tool could contribute to a more informed, efficient, and collaborative local energy system planning in the context of the energy transition and other energy-related issues.

1.4 Research Questions

Three research questions were developed to address the study’s purpose:

- How are local energy systems planned in practice, and what challenges are there regarding collaboration, managing uncertainties, the use of analytical/modelling tools and sharing data?
- What is the demand for a digital platform as a tool to support Collaborative Local Energy System Planning (CLESP)?
- How can insights from current planning practices and challenges be synthesised into specifications and a conceptual model of a digital platform aimed at supporting Collaborative Local Energy System Planning (CLESP)?

2

Literature Review

A selective literature study was conducted as an initial step in the research process to build a theoretical and contextual foundation for the study. The purpose of the review was to identify existing knowledge gaps within LESP, and to define relevant system characteristics, challenges, and potential requirements for a digital platform. The review combined academic literature with policy documents, technical reports, and municipal planning documents, with a focus on the role of municipalities in LESP, the challenges they face, and the research gap this study aims to bridge.

2.1 Swedish Municipalities' Role in Planning and Developing LESs

Through formal responsibilities, Swedish municipalities play a central role in influencing how LESs are planned and developed. Their influence extends across several dimensions. As public authorities, municipalities are responsible for permits, local policies, and regulatory processes. They act as information providers and advisors by sharing information, visions, and plans which can guide other stakeholders in decision-making regarding the LESs. As owners of property and land as well as being spatial planning authorities they influence the use and development of land and infrastructure. A final example is that municipalities often own municipal energy and grid companies, which gives them direct influence over energy supply, distribution systems, and infrastructure investments. [13, 6].

Municipal energy planning, as defined by the Swedish Energy Agency, is a statutory activity carried out by municipalities. They are, in accordance with the Municipal Energy Planning Act (MEPA), required to plan for the supply, distribution, and use of energy within their municipal boundaries and communicate this through a formal document known as an Energy Plan. Furthermore, the MEPA also specifies that municipalities are required to examine opportunities for collaboration and to consider measures related to the sufficiency, security, and cost-effectiveness of energy supply [14, 15]. Since the development of national energy policies focused on climate change mitigation and the transition to renewable energy sources, municipal energy planning has expanded to incorporate climate adaptation measures. This has led municipalities to frequently integrate energy and climate plans into a single, so-called energy and climate plan, rather than separating them. Complementary and voluntary activities related to municipal energy planning include creating strategies and action plans [14, 16].

Moreover, given that municipalities hold a high degree of autonomy over local spatial planning under the Planning and Building Act, they can shape the land use and infrastructure development within their borders, and thus, the planning and development of LESs [13, 14, 15]. Under this act, municipalities are required to adopt statutory Comprehensive Plans which concern spatial planning over the next 10-20 years and Detailed Development Plans which are legally binding plans which confirm actual development [14, 15]. For example, this includes claiming or approving land-use for energy infrastructure and setting conditions for establishing energy-intensive activities [16].

Another statutory planning activity within LESP are Network Development Plans, which are indirect responsibilities of municipalities considering the fact that 129 of 170 electricity distribution companies in Sweden are owned by municipalities [17]. The network development plans are created by the electricity distribution companies to increase transparency regarding future development of grid-capacity demand with considerations to potential grid flexibility over a five- to ten-year horizon. These plans were introduced in 1997 and have been modified to aid rapid electrification and to achieve national energy and climate targets [18].

Taken together, the statutory responsibilities and governance roles held by municipalities make them a key stakeholder in influencing the planning and development of LESs. Beyond this, complementary and voluntary initiatives can further impact the direction and speed of development. Overall, it is highlighted by the Swedish Energy Agency that it is necessary for energy plans to be integrated with spatial planning as well as other planning domains to coordinate efforts and achieve effective implementation [16]. However, the inherent complexity of managing these responsibilities and achieving efficient cross-sectoral integration gives rise to several practical challenges. This demands municipalities to handle these effectively in terms of maintaining a comprehensive overview of their LES, coordinating multiple actors, and relying on appropriate analytical tools.

2.2 Current LESP Challenges

This section identifies key challenges related to the planning activities within LESs based on previous research. LESP is becoming increasingly complex due to the growing number of actors, technologies, and sector couplings involved, which makes it more difficult to maintain a shared and coherent understanding of the system. As a result, there is a growing need to connect energy plans with other urban planning processes, such as industrial expansion and residential development, to better capture potential system synergies [19, 20]. However, current planning practices and existing tools often struggle to support this type of system-oriented and collaborative approach, as they are not always designed to handle the level of complexity and interdependence that characterises today's LESs. This points to a need for decision-support tools that are usable in practice and that can also support collaboration and shared system understanding between actors involved in the planning process [4].

2.2.1 Overview and Data Challenges

LESs consist of complex networks of interconnected actors, energy carriers, and technological couplings. For municipalities and energy companies, developing a holistic understanding of these systems is important for long-term planning and decision-making. However, achieving such an integrated overview in practice is difficult, partly due to a lack of suitable digital tools and access to reliable system data [4].

Without detailed information about their LESs, municipalities and utilities face increased uncertainty, which can lead to unexpected system failures or unplanned economic burdens. This lack of detailed data also affects how grid capacity is assessed in planning processes. In some cases, it results in over-dimensioning, which increases costs for end users, while in other cases planned developments are rejected due to perceived capacity limitations [21]. There are also examples where housing projects have been delayed or stopped entirely because of such uncertainties [22]. In addition, planners often require more detailed data than annual energy consumption, such as peak load profiles, as these are necessary for system dimensioning and for understanding the potential role of flexibility solutions [23].

Another aspect highlighted is the difference in time horizons between sectors. Industrial actors can often adjust operations or investments within relatively short timeframes, whereas the development of transmission infrastructure typically takes more than ten years [24]. When these timelines are not aligned, there is a risk that new buildings or developments are completed without sufficient energy capacity being available at the right time [22].

The literature further emphasises the importance of access to reliable and shared data as a foundation for effective LESP [4]. In district heating systems, for example, there are challenges in predicting how energy carriers will be distributed in new residential areas, since the choice between electricity-based heating and district heating has major implications for both grid and thermal infrastructure [23]. This lack of shared information increases the risk of suboptimal prioritisation, which can affect both security of supply and the economic efficiency of the energy transition [20, 22].

At the same time, these challenges are not only related to technical data availability, but also to how different actors interact within the system [25]. This connects to broader issues of collaboration and coordination in LESP.

2.2.2 Collaboration and Coordination Challenges

This section focuses on challenges related to collaboration and coordination between actors involved in LESP, complementing the previous discussion on system understanding and data-related challenges. The literature highlights a recurring lack of coordination, cooperation, and alignment between actors [4, 26]. In systems involving multiple stakeholders, such as municipalities, grid operators, energy companies, industries, and property owners, maintaining a shared understanding of system conditions and agreeing on future priorities becomes difficult [23].

Communication between these actors is important for aligning needs and enabling more efficient use of resources and knowledge [8]. However, collaboration tends to vary across different stages of the planning processes. Interaction may work relatively well in more detailed or project-specific or detailed phases, while it is often weaker in early strategic stages where long-term system decisions are made. This is partly linked to differences in roles and responsibilities, where municipalities typically take on a coordinating or facilitating role, while energy companies and grid operators tend to be involved later in the process. As a result, opportunities for early alignment between spatial planning and energy system development are often limited [27].

The development of municipal energy and climate plans, as well as network development plans, is further complicated by actors operating with different time horizons and strategic objectives, making coordination more difficult. [26]. A central bottleneck for proactive electrification is limited data sharing between actors, where information on industrial expansions and future power demand is often restricted due to confidentiality or commercial interests. This creates gaps in the information available to municipalities when planning infrastructure in time [22, 26]. Without clear structures for coordination and long-term alignment, there is a risk that investments are made too early, too late, or in the wrong location which can delay local development, or in some cases, prevent it altogether [22].

An additional and ongoing challenge for energy system development is the difficulty of sharing data between actors. This issue is reinforced by cybersecurity legislation, market regulations and safety regulations, which define strict boundaries for what energy system information can be shared [25]. Since energy supply is a part of critical infrastructure, detailed grid data and customer-specific information are often confidential and cannot be included in publicly available material. This means that municipalities, grid companies, and energy producers often must plan based on fragmented information. Without structured ways of sharing sensitive data, it becomes more difficult to plan for future energy demand, which can contribute to unexpected capacity constraints and increased infrastructure costs [22].

When a shared system vision is missing, important synergies within the LES may be overlooked [19]. For example, actors may fail to identify how district heating could function as a flexible alternative to costly grid reinforcements [22]. Within the district heating sector, a related challenge is limited communication between municipalities and building developers. Developers need to be integrated early in the planning processes, in collaboration with municipalities, to ensure that district heating systems are properly incorporated into new developments and contribute to overall system stability. However, municipalities often lack consistent interaction with these stakeholders, resulting in fragmented collaboration and actors working in isolation from one another [28]. This fragmentation reinforces siloed planning approaches, where energy carriers are managed separately, increasing the risk of suboptimization [22].

Although municipalities are part of larger regional energy systems, planning processes often remain isolated due to the absence of formal requirements for cooperation in energy planning. This can result in different interpretations among municipal and regional actors regarding grid capacity and accessibility. The situation is further complicated by the fact that regional and local grids are often owned by different organisations, which limits the availability of a fully integrated system overview. In addition, restricted information flows mean that actors may not be aware of parallel developments, which can delay infrastructure projects and broader regional development processes [29].

2.2.3 Scenario Modelling and Existing Analytical Tools

As part of the municipal energy planning process, the ability to envision and work toward desired futures requires having a clear understanding of the current LES and how it is affected in different scenarios. This is essential for planning, decision-making, developing policies, and setting goals. Establishing this understanding can be supported by existing analytical tools that visualize, describe, and/or model energy systems in their current state or under future scenarios [8, 30].

A central problem in current planning contexts is the uncertainty around the future levels and rates of energy demand growth, especially with planning horizons stretching between 10 to 50 years in the future. Computational tools are often required to manage the high level of complexity in modelling scenarios [31]. However, existing scenario modelling tools are rarely suitable for municipal energy planning due to the low level of detail, lack of adaptation to the local context, as well as consideration to social contextual factors [4, 12]. Following an upsurge in electrification and changing consumption patterns linked to the energy transition, the demand for electricity has accelerated to unexpected levels. Along with changes in the electricity production with more renewable energy sources with intermittent production patterns, there are growing concerns regarding whether power grids can support these changes. Not only may shortages be caused by accelerated demand, but also because of insufficient forecasting and planning, which is particularly relevant for power grid companies [22, 29]. A challenge relating to this includes the lack of standardized methods for forecasting future power needs, a problem that is particularly acute for utilities in smaller municipalities [22, 23]. Consequently, disclosed in a collaborative study between four large County Administrative Boards (Länsstyrelser in Swedish) on the power capacity situation, many stakeholders are calling for increased transparency and a shared situational picture [24].

Furthermore, in a study made by Grundel et al. [8], which included surveys with 95 representatives from 29 municipalities regarding municipal energy planning facing the energy transition, it was revealed that relatively little work has been done on scenarios exploring radically different energy futures, and that such efforts are primarily undertaken by larger municipalities that can afford having such expertise. Furthermore, keeping up to date on existing technology and understanding the available tools is often experienced as complex. Some representatives express the need for socio-economic calculation tools to support the implementation of stringent energy transition policies [8, 22]. Uncertainties, lack of a comprehensive and shared understanding of the energy system can risk sub-optimised decisions, lock-ins and path-dependence, and ultimately delay the energy transition [8, 22].

Moreover, there exists several analytical tools, both open- or restricted-access, including databases, map-based services, and websites to provide information related to energy systems on different geographical scales. Several tools contain interactive maps that visualize the structure and dynamics of electricity systems. Overall, there is a considerable diversity when it comes to the level of detail, time resolution, type of data used, target group, and other aspects. However, many tools often have a low level of integration of different energy carriers, consideration to sector coupling, consideration to social contextual factors, and usage of real-time data. In addition, larger geographical systems, such as regions or countries, are often modelled rather than LESs [32-53].

2.3 Research Gap

A systematic review of research on 'local energy planning' reveals that much of the literature focuses on the development of technical analytical tools and technocratic planning approaches. However, there exists limited evidence of the use of tools in the practical environment, especially regarding creating energy plans. Additional results indicate that there is limited research involving several stakeholders, evaluation of plan outcomes, and examination of challenges connected to implementation of plans [54]. Overall, this points to a knowledge gap in research regarding a deeper understanding for LESP occurs in practice.

Against these findings, this study aims to contribute to the research field by investigating the practical planning processes and challenges in several contexts between stakeholders in five Swedish municipalities. Through a qualitative study approach containing interviews with several stakeholder representatives, it explores how coordination, data sharing, and decision-making processes function in practice, which tools are used to support planning, as well as what barriers hinder effective collaboration.

3

Methodology

The methodology is structured into three main parts: the research design; the interview study; and the identification of platform specifications and the development of a conceptual model. The first section presents the overarching rationale for how this study was designed. The second section describes the methods used for the interview study, which constitutes the first results-generating part of the study. Finally, the third section describes the methods used to develop the platform specifications and conceptual model, synthesising results from the interview study alongside other data collection methods.

3.1 Research Design

A systems thinking approach was applied during this study to develop an overarching understanding of the LESs of interest and the dynamics among key stakeholders. This approach is described as adopting a holistic perspective when analysing and interpreting complex systems. It is useful in contexts where systems consist of multiple interrelated components that interact in dynamic ways [7].

This study was conducted as an explorative pre-study, employing primarily a qualitative research design. This was valuable to collect subjective experiences, provide insights for the realities of energy planning, and facilitate interpretation of the requirements for a digital platform that could be used in a collaborative energy planning context.

To address the first and second research questions, a deductive approach was adopted, guided by key themes identified from the literature review. Qualitative data were collected through an interview study involving representatives engaged in LESP across multiple stakeholders and municipalities. The gathered empirical material was subsequently structured based on a thematic analysis method, which provided a framework for how the findings were presented.

Regarding addressing the third research question, specifications as well as a conceptual model of a platform that can support CLESP were developed using an abductive approach. This approach is characterised by an iterative process in which empirical findings from the interview analysis and literature review were interpreted and translated into overall platform specifications. Subsequently, by integrating qualitative and quantitative data from a case study of the municipality Lidköping, a conceptual model representing the platform's user interface was constructed.

3.2 Interview study

To address the first and second research questions from multiple perspectives, an interview study was conducted with several stakeholder representatives from five different LESs. Including multiple perspectives strengthened the validity of the findings, as it enabled comparisons between different stakeholder experiences and contributed to a more comprehensive understanding of current LESP practices. The material from the interviews was later analysed thematically, where recurring patterns and key themes were identified across the interviews.

3.2.1 Interview Design and Execution

Interviews were conducted with representatives engaged in LESP with experience from different LESs, with the aim of capturing different municipal contexts. Interview participants were selected based on their professional involvement and experience in LESP activities. Consequently, the interviews included individuals holding current or previous strategic, business development, or managerial positions within municipalities, energy companies (including grid owners), and housing companies.

The purpose of the interviews was to capture multiple practical insights into how LESP is currently conducted, as well as to identify existing challenges related to CLESP. To better understand collaborative dynamics, the study aimed to include representatives from several stakeholder groups within the same LES. Five municipalities were selected based on the presence of energy companies, grid owners, and housing companies owned by the municipality. This selection enabled the possibility to examine contexts in which collaboration between municipally owned subsidiaries is necessary to align operational and strategic goals and priorities. As a result, the interviews provided valuable insights into the dynamics and challenges associated with CLESP.

An overview of the interview participants, including their professional roles, organisations, date, and duration of the interviews, is provided in a table found under *Appendix A.1.* All personal names appearing in this report have been replaced with pseudonyms to ensure confidentiality and protect participants' identities.

The interviews were held in a semi-structured format that was chosen to allow flexibility in the discussions while still maintaining a consistent thematic structure across interviews. An interview guide was developed based on the research questions and insights gained from the literature review, where key themes were identified. More specifically, the literature informed the formulation of interview themes and questions by highlighting recurring challenges such as coordination between actors, data accessibility, uncertainty in planning, and the use of digital tools. These themes formed the basis for the interview questions, but the format also allowed respondents to elaborate on additional issues they found relevant in their daily work. The full interview guides are provided in *Appendix A.2,3,4* which include tailored questions for different stakeholder groups.

Regarding gathering data for the second research question, which investigates the demand for a new digital tool to support CLESP, a ranking exercise was introduced at the end of the interviews, as seen in the interview guides. This exercise included suggested categories and potential features related to LESP activities as a complement to follow up questions concerning the demand for a digital tool to support certain planning activities or challenges. Since there was no predefined specification for the platform's content or functionality, the exercise was designed to stimulate reflection and encourage participants to discuss potential needs and ideas for such a tool. The table for the exercise can be found in *Appendix D.1*.

To improve reliability and depth, most interviews were conducted with two interviewers present, allowing both to ask follow-up questions and seek clarification. The interviews were carried out digitally via Microsoft Teams and lasted approximately 60 minutes (apart from one lasting 30 minutes). All interviews were recorded and transcribed within one week to ensure accurate representation of the responses.

3.2.2 Thematic Analysis of Interviews

Thematic analysis was used as a method to interpret and structure findings from the interview study. This method followed an iterative process beginning with repeated reading of the transcripts to gain familiarity with the material. Initial themes and sub-themes were generated, guided by those pre-identified from the literature review, such as within the theme of current practices related to stakeholder coordination, subthemes include data sharing and collaborative decision-making. Concurrently, new sub-themes emerged from the material which were used to review and revise the broader themes. This ensured that there was enough empirical data to sufficiently support the identified themes. Throughout the process, the themes were continuously aligned with the research questions to ensure analytical relevance. At the same time, this allowed for further clarification of the research questions themselves as the patterns in the data became clearer.

3.3 Identifying Specifications for the Digital Platform and Constructing a of Conceptual Model

To address the third research question, which focused on identifying platform specifications and designing a conceptual model through the synthesis of previous data collected, the two objectives were approached iteratively in an analytical method including a value creation design process. The process began with an initial identification of platform specification based on findings from the interview study and the literature review. The specifications provided guidance for the developing the conceptual model. To complement this foundation, additional qualitative and quantitative data from a case study of a LES were collected to support the model development and enable the use of relevant existing analyses and materials applicable to LESP. Following the case study, a conceptual model of a suggested platform was developed, consisting of digital images representing a possible user interface.

3.3.1 Analytical Method: Value Creation Design Process

With respect to digital platforms, their value lies in their capacity to provide, process, analyse, and visualize data. Real benefits can be realised by enriching the consumer experience by creating functional, monetary, informational, emotional, and social value. For example, monetary value creation can be created by saving time and enabling wider access to services. However, creating value is faced by high levels of uncertainty and what proves to be valuable between consumers can vary greatly. To mitigate risks when developing a platform which lacks unique value it is important to gather comprehensive knowledge about the potential consumers [55].

In figure 1 the analytical method including a value creation design process is visualised that was used to identify platform specifications and a conceptual model. This process is inspired by a value propositioning cycle developed by Jaworski [55].

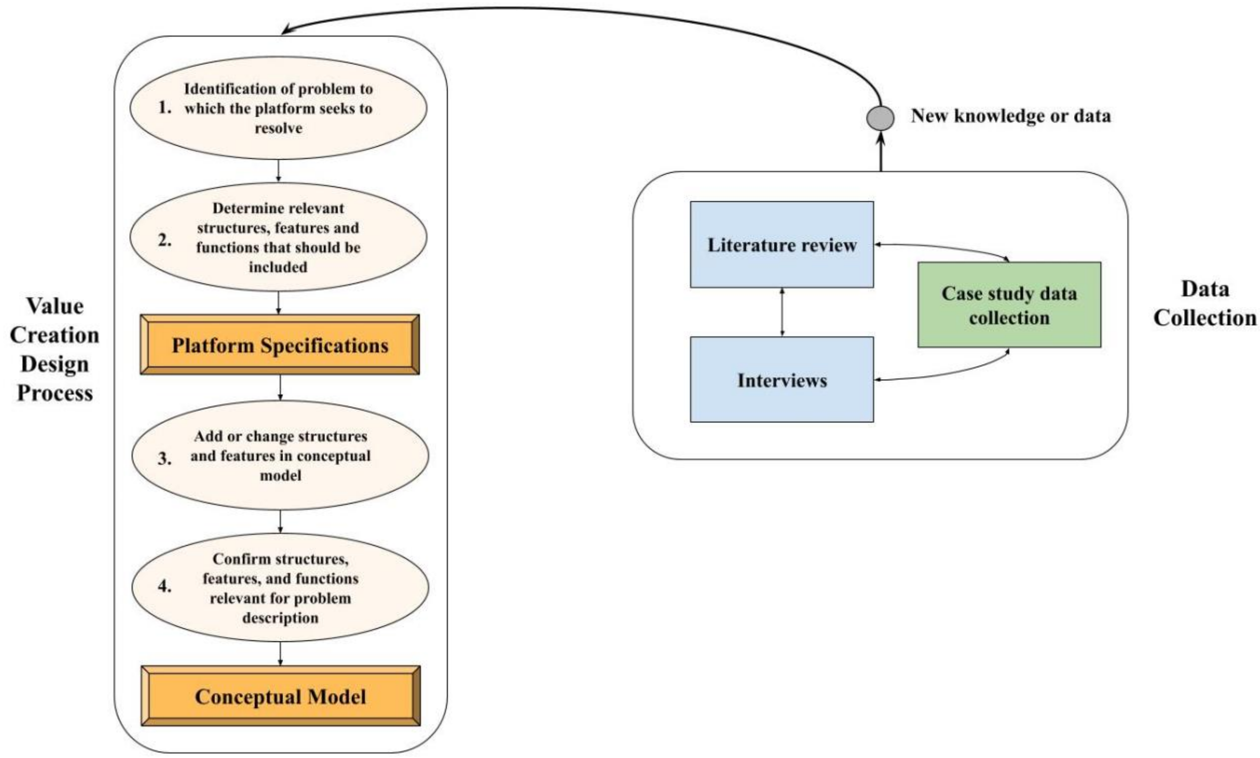

Figure 1: Value creation design process used to develop the conceptual model for the platform

The overarching purpose of this method was to use new knowledge or data gathered throughout the study to develop an understanding of the value that a digital platform designed to support CLESP could provide. This understanding served as the basis for identifying platform specifications and ultimately constructing a conceptual model. The analytical method was iterative, meaning that the platform specifications and the conceptual model were developed and refined continuously throughout the project's duration. This supported the development of specifications and a model that could be aligned with stakeholder demands.

New knowledge and data were collected through multiple methods, including a literature review, interview study, and case study. Within the data collection box, there was an interaction between these data collection methods which describes that as new knowledge was found in each method, this could in turn influence the direction of search in another method. As new knowledge or data was found, it was analysed in a value creation design process. The value creation process describes a linear process, yet new knowledge or data could enter any step to gain an understanding of what is valued by potential consumers of the platform. All new knowledge and data eventually built an understanding for what is valued and contributed to constructing the conceptual model.

3.3.2 Case study

To ground the conceptual model, a specific case was selected to provide an evidence-based example of how a digital platform could be applied within CLESP settings regarding a specific LES. The case study focused on Lidköping municipality, which was selected due to a broad representation of stakeholder groups from the interview study. By investigating this case within its real-world context, the study aimed to provide a concrete example of how a future platform could be applied for a specific LES. A single case was particularly suitable for this research as it enabled a deeper exploration of LES dynamics and operational realities in practice [56].

3.3.2.1 Data Collection and Analysis

Qualitative and quantitative data were collected from multiple sources to gather technical material for the conceptual model. A large part of the foundational data was gathered from municipal energy and climate plans, the network development plan from Lidköping Elnät AB, as well as comprehensive plans. The data collected from these documents includes maps, diagrams, analysis, and key metrics, explaining or showing LES characteristics and components. In addition, data from publicly available reports and studies on different energy carriers was gathered to complement data found unavailable.

A key part of the quantitative data collected was obtained from Lidköping Energi and used in relation to a current investment project they are currently working on, an electric steam-boiler. This included a data file consisting of district heating power a single time for every day of the year. Prior to analysing the data and developing a Python-based program to simulate the operation of the electric steam-boiler, electricity price data was collected from the ENTSO-E Transparency Platform to support assumptions related to electricity market conditions. The diagrams created to plot the results of the simulation can be found in *Appendix B.3*.

3.4.2 Constructing the Conceptual Model

The aim of the conceptual model was to serve as a visual concept of a digital platform that could support CLESP, consisting of static digital images representing the proposed platform's user interface. The primary goal was to use available data to propose potential features and functions, rather than to optimise experience or be an interactive model. Consequently, strategic suggestions and qualitative examples of how the platform could support specific aspects of CLESP were presented alongside each image to explain the depicted features and functions.

To construct the conceptual model, the graphic design tool Figma was used to create digital images by assembling different shapes, icons, data visualisations, and other material gathered throughout the data collection. The use of Figma enabled illustration of how different functions, information flows, and system components could be structured and presented in practice. Some key metrics and system characteristics were based on assumptions or complemented with general data gathered from scientific reports.

4

Interview Results

This section presents results from the semi-structured interviews conducted with stakeholder representatives with experience in LESP across different municipalities. Most respondents were currently or previously employed within energy companies, but the sample also included representatives from grid companies, municipalities, and housing companies, thereby capturing their perspectives as well. Further details on the interviewees can be found in *Appendix A.1*, where roles and organisation for each respondent can be found. The findings are structured thematically, covering current planning practices, perceived challenges, and the demand for a digital support tool for CLESP. Accordingly, results addressing the first research question are presented in sections 4.1 and 4.2, while results addressing the second research question are presented in section 4.3. The third research question is later addressed under section 5.

4.1 Current Practices for LESP

Respondents described that planning of LESs occurs across multiple organisational, spatial, and temporal levels, resulting in stakeholders holding separate responsibilities. Municipalities primarily work on municipal energy and climate plans which set political goals but are not comprehensive and require separate implementation efforts. Grid owners are responsible for capacity-related inquiries for grid-connections and long-term grid-development by forecasting power demand development. Energy companies often support the work on energy plans and are responsible for energy supply to new establishments. In general, planning activities are driven by signals from national goals, customer demand, expansion plans, and other development projects.

One distinction, supported by a claim made by Ronald and reflected in how respondents discussed planning, is that between strategic and operational planning activities. Strategic planning involves long term commitments, goal setting and system-level consideration, whereas operational planning focuses on project implementation or maintenance of existing systems. Furthermore, Lana and Victor described an ongoing transition from traditional planning approaches, historically characterized by simplified assumptions and expectations of predictable development. In response to contemporary national policies and a rapidly changing energy landscape, stakeholders are instead seeking to address energy-related issues through long-term, calculated, collaborative, and increasingly integrated approaches.

Despite varying municipal conditions and specific local challenges, the respondents described that planners currently face several common energy-related issues, such as managing an increasing power demand, capacity shortages, improving energy efficiency, and the need to ensure a robust and resilient energy system. Amid ongoing establishment projects, new forms of electricity use, such as data centres, add further complexity through their high electricity demand and generation surplus heat, which can affect overall system balance.

4.1.1 Collaboration and Sharing Data

Interviewees were asked to share their experiences of collaborating with other individuals within and outside of their organisations across various planning activities, including the development of the municipal energy plan, network development plan, and other ongoing activities they are currently involved in.

Overall, a recurring theme which was especially highlighted by Sean, is the existence of legal and organisational boundaries between stakeholders within the LES. These boundaries were described as structuring how tasks are divided across stakeholders and influences the extent of information exchanged between them. Several respondents noted that belonging to the same municipal group created greater expectations of and opportunities for closer collaboration. However, Ronald described that strategic planning activities involving oversight, particularly in relation to stakeholders outside of the group, as limited or even obsolete.

Regardless, the information exchange that occurs between municipal representatives and companies was described as serving several purposes and is quite regular given that they are owned by the municipality. This included communication of regulatory updates, involvement in expansion projects, and requests for advice, data, and forecasts for the development of energy and climate plans. The latter was highlighted as particularly important due to a described lack of sufficient internal energy expertise within municipalities.

The process of developing climate and energy plans was described as both time-consuming and organisationally complex by Lana, involving mapping the existing energy system, identifying major energy users, climate impacts, scenario development, and formulating goals based on this. Lana and Ava described the process as striving to be highly collaborative, involving dialogue with municipal energy companies, industries, property owners, civil society organisations, and other stakeholders. As a result of the extensive coordination and analytical work involved, Lana mentioned that consultants are often hired to support several parts of the planning process.

Regarding sharing information and communicating future energy and development plans within the municipal group, Ralph stated that *"The municipality plays a central role by sharing future plans, especially in early stages such as detailed planning, which allows us to prepare for new projects. We also have a very close collaboration with the municipality; we are involved and know what plans they have. They are communicated, but it doesn't always get through."* This suggests that there is a lack of alignment of planning objectives across stakeholders, indicating a tension between the formal intention of the plans and their practical implementation.

When asked about examples of coordinated planning activities, few examples of formal and regular processes were discussed in further detail. In most cases, coordinated efforts occurred in connection with specific projects, where holistic overview is often outsourced to a dedicated project organisation

/ project leader organisation. One notable exception, described as successful, was highlighted by representatives from Lidköping. Lana described a new structured initiative established in 2025 as an effort to manage implementation efforts according to the energy and climate Plan, with nine different work groups, each with their own area of responsibility. For example, one group involved representatives from companies in the municipal group to meet once a month to discuss potential construction projects. Other examples included one group's responsibility for communication, and another for creation of a new energy system. According to the members of this group, this process has helped save time, accelerate decision-making, and foster a better understanding of each other's perspectives on the issues involved.

Another noteworthy aspect described by respondents was that information and expertise are shared through industry forums for the energy companies. Through these forums, participants can also engage with local and regional politicians. Representatives from energy companies can support each other with various issues and matters, for example energy and climate plans, particularly to ensure they are reasonable and feasible, according to Sean.

4.1.2 Existing Tools

Within their own organisations, planning activities were often distributed across different departments, creating a shared responsibility among several units. Melinda described how larger companies rely on specialised departments with access to different skills, tools, and information, requiring *"linking arms"* with certain individuals across departments to access relevant knowledge and data. Existing tools are optimized for technical analysis and operational optimization at a high level of detail, which often requires specialized expertise. The level of automation varies significantly, often depending on the actors' competence, ambition, and available resources. As stated by Melinda, *"Since they are so large and complex, one may not master five different systems well enough to get [the information] one wants."*

There were many tools mentioned during the interviews and are listed in *Appendix C*. Many relied on their own-built analytical files that manage and analyse data in Excel or Power BI for example. The simulation tools that exist are often separated by individual energy carriers and specific to various stakeholders: district heating has one tool, electricity has another, housing companies have their own. Smaller municipalities may lack analytical tools altogether, relying heavily on manual work.

Ronald explained that *"In general, it is the case that those who calculate profitability rely much more on calculation programs than those who look at system benefits. Both system benefits and climate benefits are probably handled more schematically and less technical with calculations."* He argued that tools that various energy companies have are often very detailed but lack an overall oversight of the whole energy systems. Dan believed that there are generally different software solutions for different niche issues. Some tools may be automated, while others are not, depending on development, ambition, and available resources within the organisation, he explained.

4.2 Identified LESP Challenges from the Interview Study

A recurring theme in the interviews was that planning of LESs is characterized by both high complexity and significant uncertainty. Several respondents described how energy planning can no longer be based on simple or linear assumptions, but instead requires a systems perspective where multiple layers, actors, infrastructures and interdependencies must be considered simultaneously.

4.2.1 Complexity and Uncertainty

The complexity of the energy system was described from several perspectives. Melinda explained that the complexity consists of many different aspects, including operating within large organisations, managing extensive infrastructure and dealing with long-term investments. The complexity was therefore not described as one isolated issue, but rather as a combination of technical, organisational and strategic challenges that interact with one another. Similarly, Lana described how organisations struggle to keep up with how quickly the energy system is changing. Even though actors continuously try to adapt, developments happen rapidly, and planning processes are perceived as constantly falling behind. She described it as always feeling "one step behind".

Another aspect raised in the interviews concerned complex sector couplings and the difficulty of understanding how different parts of the system affect one another. Ronald described the challenge of connecting strategic planning with operational implementation. This became particularly clear in discussions regarding new establishments and infrastructure investments, where solutions that may be beneficial from a system perspective are not always prioritised in practice. District heating was mentioned as one example, where it may provide benefits for the wider energy system, but is still not always selected as the preferred option in individual projects or developments.

Uncertainty was also described as a major challenge by several respondents. A central issue concerned the difficulty of planning for the future and understanding how ongoing developments may affect the energy system over time. Ronald explained that considering future developments is one of the most important aspects of energy planning, while at the same time being one of the most difficult. Planning therefore becomes a continuous effort to understand what changes may occur and how the system should adapt to them. Lana further described how difficult long-term planning has become in today's context: "*In a way, we cannot work on these long-term plans anymore, because we do not know what will happen at the end of the week.*"

Her statement reflected the uncertainty several respondents described regarding rapid technological development, changing political conditions and new types of energy demands. One example frequently mentioned in the interviews was the increasing interest in data centres. These establishments require large amounts of electricity, and several energy companies described difficulties in understanding where such facilities should be located and how they should be integrated into existing energy systems. Respondents also discussed the uncertainty regarding the potential impacts these establishments may have on local infrastructure and system capacity.

Several respondents, including Lana, also described how municipalities increasingly receive requests regarding new energy-related developments such as solar parks, wind power and other large-scale investments. Keeping up with these developments and understanding their long-term implications was described as difficult. Ronald further discussed the uncertainty surrounding new technologies and future investments, particularly regarding storage solutions, flexibility measures and future heating systems. Questions were raised whether municipalities and energy companies should invest in solar power, flexibility solutions, large heat pumps or biofuels, and how these different choices may affect the wider system over time.

Another aspect raised by Nathan and Dan, who work with consulting municipalities and their energy planning, concerns the differences in capacity between stakeholders when it comes to managing energy-related challenges and uncertainty. Smaller municipalities were described as having more limited resources for conducting studies, developing forecasts and scenarios, and managing risks connected to future energy developments. Nathan explained how larger companies may have specific R&D departments dedicated to analysing these types of questions continuously, while smaller municipalities often lacked both the time and resources to work in the same way. As a result, smaller actors may struggle to keep up with ongoing developments and rapid changes within the energy sector.

4.2.2 Conflicting Interests

Another central challenge identified in the interviews concerns conflicts of interest between actors involved in local energy planning. Even when actors share broader goals related to climate transition and local development, their business logic, incentives and organisational responsibilities are described as divided. The result is that actors often optimise based on their own organisational perspective rather than from the perspective of the energy system as a whole.

Sean explained that in the work with developing energy and climate plans, there are continuous discussions regarding the future of the entire LES in Lidköping. However, both Sean and Harry described how a major challenge lies in the fact that several different organisations, each with their own goals, responsibilities and positions, are expected to collaborate around one shared energy system. Even if the actors are interconnected through the system itself, they still operate based on different organisational conditions and priorities.

To address this, the Lidköping municipality had established recurring discussion groups where actors involved in local energy planning meet and discuss ongoing challenges and future developments, as mentioned under *section 4.1.1*. According to both Sean and Harry, these meetings have contributed to a greater understanding of each other's perspectives, constraints and organisational priorities. Jennifer, who also participates in these discussions, described how the actors gradually developed a better understanding of each other's businesses and business plans, which in turn have improved the quality and effectiveness of discussions regarding the energy system.

Lana similarly described how municipalities may share common long-term goals, while still having different views regarding how those goals should be achieved in practice. She explained that during the planning process they realised that even though actors formally work towards the same objectives, they are often not moving in the same direction operationally. This has created a need for more open discussions regarding disagreements and conflicting priorities within the municipality itself.

One conflict highlighted in interviews concerns the relationship between the housing company and the district heating company in one of the municipalities. Jennifer explained how emissions connected to district heating production negatively affect the housing company's emission figures, despite the housing company not directly producing those emissions itself. At the same time, district heating production is also described as providing an important service to society through waste management and energy recovery. The situation described how different actors may be affected differently by the same system, depending on how responsibilities and performance indicators are distributed. Several respondents described the importance of understanding each other's conditions, responsibilities and consequences to better manage these types of conflicts within CLESP.

4.2.3 Structural Barriers

The last category of challenges identified in the interviews concerns structural barriers. These barriers are connected to confidentiality and data sharing, political instability, technical regulations, and external system limitations. Unlike the previous themes, these challenges are often outside the direct control of the individual actors and instead relate to institutional structures, regulations, and the broader surrounding environment.

One major challenge raised by several respondents was confidentiality and limited access to data. LESP was described as becoming increasingly difficult because important information cannot easily be shared between actors, organisations, or even departments within the same organisation. Lana expressed this frustration clearly when saying: "*How are we supposed to work with energy planning when everything is confidential?*" She described how LESP often relies on simplified maps and visualisations, but that they are restricted in what they are allowed to share. According to Lana, even simplified visualisations such as Sankey diagrams or capacity maps can become difficult to access due to confidentiality concerns.

Several respondents described similar issues. Melinda explained that even internally, within organisations, access to information is restricted because of security classification. She described how her department does not have access to certain planning tools or infrastructure information, despite working with related planning questions. At the same time, she also explained that the level of confidentiality often depends on the level of detail in the data: "*If it starts to get more detailed, we do not share it in the same way as when it is more general.*" It was described as overview-level information may still be possible to share, while detailed infrastructure data becomes sensitive due to security and integrity concerns.

Another important structural barrier concerns political instability and changing regulations. Several respondents described how rapidly changing political decisions and policy directions make long-term planning difficult. LESP often involves large infrastructure investments with very long lifetimes, while policies, taxes, subsidies, and regulations may change within only a few years. Ralph described how decisions are introduced and then later withdrawn, making it difficult to plan energy systems over longer time horizons. He pointed to the development of electric vehicles as an example where expectations and planning assumptions changed quickly over time.

A recurring example in the interviews concerned the implementation of capacity tariffs in Sweden. Several energy companies had invested significant resources into adapting systems and preparing for these tariffs after receiving indications that they would become mandatory, only for the policy direction later to become uncertain again. Ralph and Ronalds described the frustration of investing heavily in systems for handling these tariffs while political actors simultaneously discuss removing them, creating uncertainty for the local energy planners.

The broader geopolitical situation was also described as affecting priorities within LESP. Melinda reflected on how changing external conditions influence what is considered important: "*Are the climate goals relevant or should we be building fences around our facilities instead, what is important? An uncertain environment is what increases the complexity.*"

In addition to political uncertainty, respondents also described technical and regulatory system limitations. Several actors explained that technical possibilities may exist in theory, while regulations, grid limitations, or external interests prevent implementation in practice. Ralph described how local electricity grids are often constrained by surrounding regional grids, limiting local development possibilities even when local capacity exists. He further explained that their local grid has relatively high capacity, but they are still limited by surrounding infrastructure operated by larger actors.

4.3 Demand for a Digital Platform to Support CLESP

Interviewees were asked whether they see a demand for a digital platform as a tool that could support them at different stages of their planning process, for example by improving understanding of their energy system, providing decision-support material in discussions, and generating insights or analyses.

Overall, most respondents were generally positive towards the idea that a platform could facilitate a shared understanding of the energy system, thereby supporting dialogue and reducing misunderstandings between stakeholders. They emphasised a preference for a simple and comprehensive tool that can complement existing detailed analytical and computational tools, by providing a sense of the overall dynamics and current state of the LES. The ability to explore scenarios and visualize system effects is also highlighted as central, particularly for understanding consequences of different decisions and identifying synergies within the LES.

At the same time, some critical aspects were expressed regarding the feasibility and usefulness of such a platform. Concerns were raised regarding the challenges of efficiently managing the large amounts of data it may require, as well as how it would handle conflicting interests among stakeholders. Finally, the difficulty of fully specifying their needs in advance was highlighted, partly explained by one respondent because of the uncertainty in knowing what they are missing.

4.3.1 Stakeholder Suggestions and Attitude for a New Digital Tool

Several stakeholders highlighted a potential for a simple tool that could help visualize the energy system and its dynamics to improve understanding and make interdependencies and consequences visible. As Melinda described, *"My department would have liked a tool that didn't give all the details so we could get into it so it wouldn't be too complex, but that also gave us a sense of the greatness in different places."* Dan pointed to a lack of simple dynamic tools that support strategic planning and understanding at a high level or showing the effects of various decisions on the system as a whole. He stated that, *"I think you should start fairly simple, showing things at an overall level - maybe build the municipality as a Sankey diagram instead - and compare two different scenarios so you can see the effects and identify synergies from shared use. Start at a high level so you do not get too bogged down in details."*

Lana described the positive impact of simple diagrams, such as Sankey diagrams or geographically anchored images, noting that they can generate a surprisingly good understanding of the energy system. She provided an example of how a digital platform could support decision-making using visual representations: *"Of course it could be useful if we knew that the electricity grid is constrained in a certain area, and therefore we should expand the district heating network there instead."*

Ava similarly expressed a desire for a more comprehensive overview of infrastructure planning to improve stakeholder coordination and visibility of new residential or business development areas. She stated, *"to be able to see all the land claims, water needs, or whatever it might be to build up this picture would have been very good."* In this quote she suggested visible water flows as an aspect that could be overlooked, but highly relevant given the interdependency between energy consumption, water usage, and wastewater treatment.

A final example in relation to suggested features in a digital platform, building on Ronald's observation of a gap in strategic planning with external stakeholders, he argued that a shared visual "map" could support more proactive and prospective discussions on system development.

Several respondents expressed a need for tools that can help manage complexity and improve understanding for their systems to support decision-making. When reflecting on current practices, Ronald emphasised that *"the uncertainty is a challenge, and then it is probably also a challenge that everything isn't gathered in one place with a common planning tool,"* highlighting the difficulty of locating and being able to access relevant information.

Future development scenarios were seen as important means of addressing uncertainty and understanding the consequences of various developments, and a few stakeholders describe this as a suggestive feature for a tool. The scenarios used by municipalities are often developed at a national or regional level, but it is realized that developing more scenarios using a local-scale perspective would be beneficial. Melinda provided an example: *"If you could go in and vary, for example, fuel, population, and electricity, that would have been really great."* Furthermore, Ava gave another example, highlighting that scenarios for new development projects could be useful, particularly when the eventual end user of the area and their energy consumption are not yet known. In such cases, scenarios representing different consumer types could provide an indication of their potential impact on their LES.

In regard to having a tool that can support managing different interests in discussions, the Lidköping group was asked whether they perceive a need for such a tool or whether discussion alone is sufficient. Overall, they described that their discussions are centred on weighing different costs and benefits of alternatives or decisions within the energy system, such as new construction projects. In response to a new tool, Jennifer stated that: *"It would be super exciting if it were possible to come up with a tool that is linked to highlighting different benefits and what type of benefits [different decisions/alternatives] have for the group in relation to the costs, and where those costs arise."* She added, *"We do not have a tool to fundamentally handle it,"* and further argues that *"sometimes you get stuck not really understanding each other."* She suggested that establishing a shared understanding of the current situation could be supported by *"referring to a tool to be able to forward in a discussion, it would be exciting."*

4.3.2 Critical Aspects

Some stakeholders expressed that digital tools can sometimes create more work than they solve. They argued that tools designed to collect all relevant data in one place and provide multiple scenarios could tend to become highly complex and require large amounts of data. As a result, they experience that managing and maintaining such systems can be time-consuming. For instance, Harry and Sean questioned how a digital system could efficiently produce specific and reliable analysis given the presence of uncertain factors and necessary data. Marcus highlighted the requirement that the platform must deliver a greater value than the costs of maintaining it in a quote: *"If there had been a system that could truly provide us with value, rather than us becoming slaves to the system, it would have been well worth learning."*

Another aspect highlighted by the respondents was uncertainty regarding how digital tools would be able to consider multiple and potentially conflicting inputs in decision-making processes. Regarding the challenge of handling multiple interests Christine expressed an expectation for a simple and straightforward tool but questions its feasibility: *"A tool where you could input data and get output would have been perfect - though that's probably not something you can create either."*

Ralph supported the idea that a long-term energy policy, separate from electoral politics, is an important aspect for managing future uncertainty and enabling stakeholders to make long-term investments. Marcus highlighted another approach, which can manage conflicting interests in the following quote:
"I believe rather in a politically decided framework: in Lidköping to get the right to establish here and build here, it should fulfil some criteria's: jobs, district heating utilization, energy demand, environmental benefit, housing, etc, rather than a digital system as a solution, I think. That would

have been incredible." Together, these perspectives highlight solutions for governance structures as alternative solutions for balancing long-term predictability and stability.

Lana highlighted the difficulty of translating strategic knowledge into practical implementation, referring to their own challenges in turning goals set in their climate and energy plans into actionable measures. She described a context of substantial uncertainty, making it difficult to understand or determine what is required in practice to navigate the ambiguity. Thus, she explained that it was difficult to be able to articulate concrete suggestions as she states, *"I hardly know what I'm missing either in some way."* She further complemented this view by emphasizing that *"We need to collectively be able to articulate what would help us navigate this complex world in which we operate."* Suggesting a deeper collaborative effort to make sense of the uncertainty and identify what tools they need moving forward.

Due to time constraints, the ranking exercise presented under section *3.2.1 Interview Design and Execution* aimed to suggest potential features and functions for a new tool, was only held during five interviews. Throughout the process of evaluating these results, the method was deemed ineffective in generating applicable findings. It was difficult to determine which areas were valued highest and respondents struggled to prioritise their selection. This was due to a limited motivation for their selection, and the categories were somewhat too broad. These results can be found in *Appendix D.2*.

5

The Platform Specifications and Conceptual Model

This section presents the platform specifications and conceptual model developed through a synthesis of the literature review and interview findings. The analysis focused on identifying recurring challenges, needs, and planning practices related to local energy system planning. These findings were translated into overall platform specifications describing the intended content and functionality of a digital support tool. Based on these specifications, a conceptual model was developed and visualised through a set of digital interface representations illustrating how such a platform could support collaborative local energy system planning in practice.

5.1 Overall Specification of the Platforms' Content

As a result of the study, a conceptual model of the platform has been developed. The model is based on both the literature review and the interviews, where needs and challenges in the LESP were identified and translated into specifications for the platform's content and functions.

First, both the literature review and the interviews show that LESs are experienced as complex systems. There are many actors involved, multiple energy carriers, and strong interdependencies between technical, organisational and strategic decisions. Because of this, the platform needs to break down the system into a more understandable structure, making it easier to navigate and interpret. This breakdown is necessary to support more strategic, system-level planning rather than detailed operational work. This also aligns with the interviews, where respondents generally expressed a stronger need for support in long-term and overarching planning rather than day-to-day operational tasks.

Further, the platform is also spatially explicit since many of the planning challenges described in the interviews are closely connected to location and infrastructure. Issues such as new establishments, capacity constraints, sector coupling, and local production all depend on spatial relationships within the LES. A spatially explicit representation of the LES can therefore improve overview, support coordination between actors, and help identify potential opportunities within the system.

Secondly, several interviewees described that there is often no shared understanding of the system, where actors mainly focus on their own part rather than the whole. This makes coordination more difficult and increases the risk of sub-optimisation. The platform therefore aims to function as a shared reference point, bringing together different perspectives and supporting communication across actors. This shared view can also support the identification of synergies, joint opportunities, and potential areas for collaboration across the LES.

The platform also aims to function as a shared information space, where information about the LES is collected and made accessible in one place rather than being fragmented across actors, documents, and systems. In doing so, it not only highlights relevant information and planning material, but also supports the development of plans and strategies. Furthermore, the platform connects to existing data sources and tools, while primarily presenting information at an aggregated and overview level to support strategic decision-making. It also gathers and visualises key indicators that can support these decisions and improve understanding of system-wide effects.

Scenario handling was also highlighted as important for managing the uncertainty that characterises LESP. Future developments are difficult to predict, and many decisions rely on assumptions about demand, electrification, industrial development and future regulations. The platform therefore supports scenario analysis to enable more informed decision-making and collaboration. Apart from scenario handling, the platform also functions as an exploratory tool for future investments and potential projects, allowing users to explore how different technical choices and developments may affect the LES.

Based on these implications, a conceptual model was developed, resulting in four visual representations that illustrate an initial example of what the platform could look like.

5.2 Case Study of Lidköping

The city of Lidköping has been selected as a concrete example of how the platform can support LESP in practice. Located on the southern shore of lake Vänern in southwestern Sweden, Lidköping is a small municipality with ambitions to grow and develop in a sustainable way, which places increasing demands on the LES. Compared to larger cities, Lidköping represents a context where resources and system complexity are more limited, while coordination challenges between actors remain significant [57].

The municipality consists of several actors within the municipal group, including Lidköping municipality, Lidköping Miljö och Teknik, Lidköping Energi, as well as AB Bostäder as a major property owner. These actors have different roles within the planning, development, and operation of the system, but are closely connected, making coordination between them an important aspect of LESP. The municipality also has a well-established district heating system, largely based on waste-fired boilers, which plays a central role in the local energy supply, where Lidköping Energi is responsible for production and distribution, as well as parts of the local energy infrastructure [57, 58].

Lidköping Energi has current plans to construct an electric steam-boiler. This project is used in the conceptual model as an example of how a potential project can be explored within the platform. The initiative was mainly driven by economic considerations, where a nearby pea-processing factory has an increased demand for steam, while revenues from ancillary service markets have made the investment more economically attractive for Lidköping Energi.

5.3 Conceptual Model: 4 Images

Drawing on the identified overall specifications for the platform and usage of available data from Lidköping, four images were developed to illustrate an initial example of a platform’s user interface. Each image represents a different view accessible from a main menu consisting of the following: Municipality, City, Dashboard, and Projects. The following subsections introduce each view, including the intended purpose and user context. Each section presents the corresponding figure, followed by a description of its main components.

5.3.1 Municipality View

The *Municipality view* was developed to establish a geographically anchored overview of the municipality's energy system, in alignment with the platform specification to establish a shared overview map. The intention was to highlight important components within the LES and provide overall analysis linked to the system's parts to contribute to understanding the whole system. Therefore, the municipality view aims to create an overall understanding of the energy system at municipal level. Here, the user could begin in the pursuit of investigating and answering larger planning questions, for example where new wind power or solar power could be established and how different parts of the municipality are affected by such decisions.

Figures 2 and 3 exemplify the user interface of the municipality view and present a context in which the user has an interest in gaining knowledge about the distribution and potential of wind power within the municipality. The relevance of this context is supported by and based on existing analysis conducted by Lidköping Municipality in their thematic addition to the comprehensive plan involving analyses related to wind power potential, referred to as the wind farm plan [59].

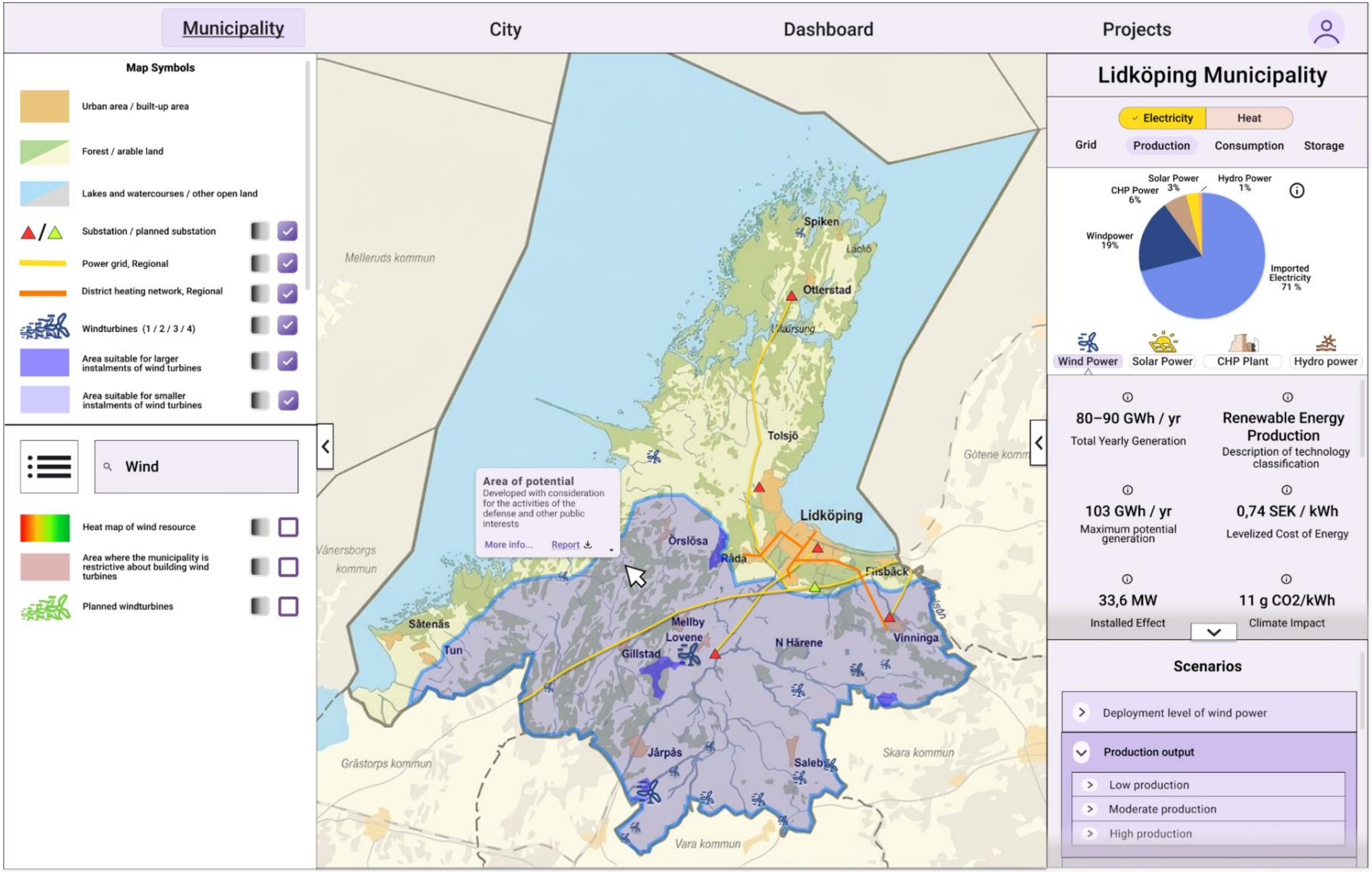

Figure 2: Municipality View

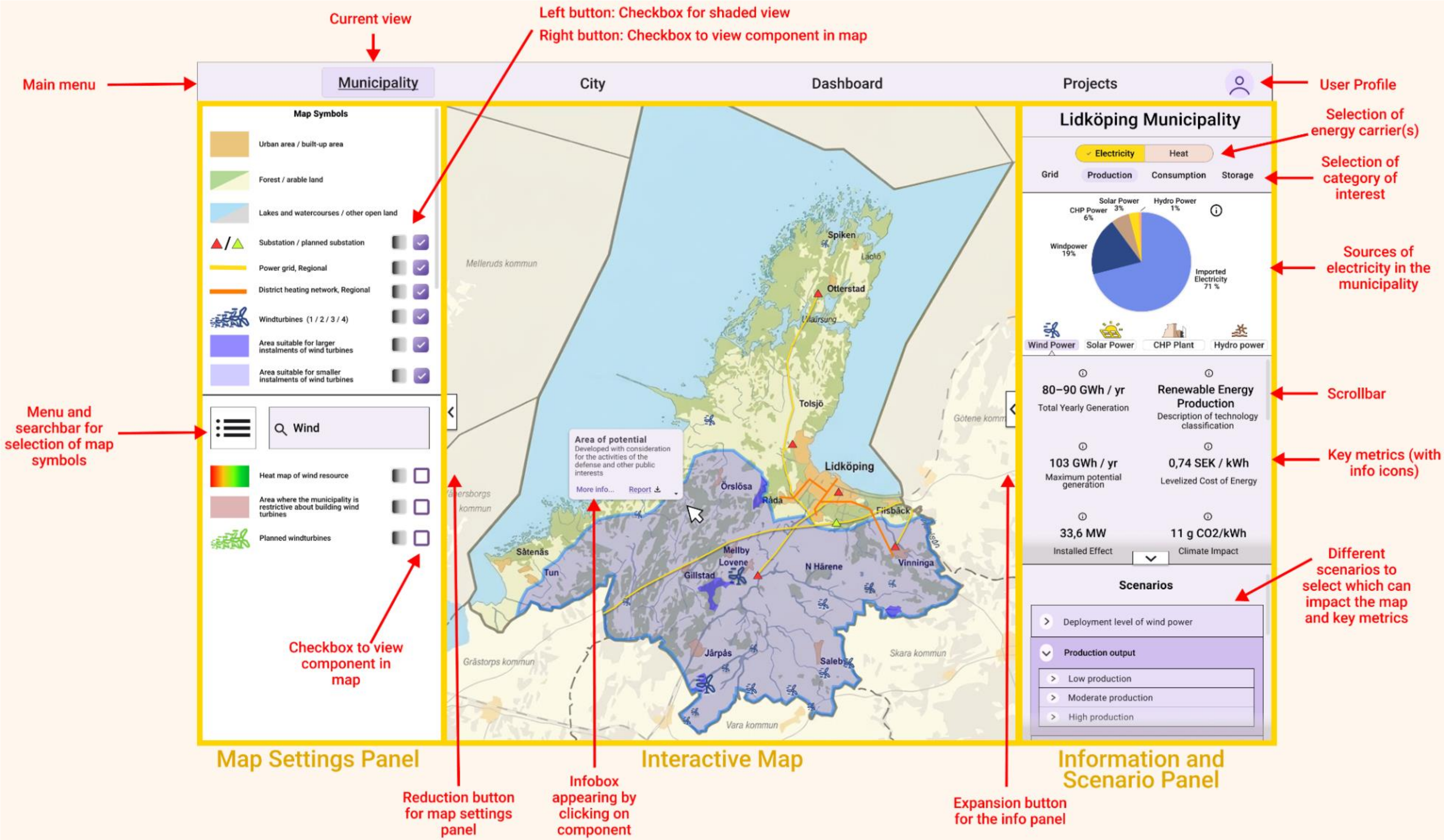

Figure 3: Annotated Version of Municipality View

To describe the components of the proposed user interface, the view can be divided into three main parts as displayed by the yellow boxes in Figure 3: an *Interactive Map*, a *Map Settings Panel*, and an *Information and Scenario Panel*.

The *Interactive Map* is the central component highlighted in Figure 3. As the name suggests, it consists of a map-based interface that is interactive through clickable elements. This feature is intended to give an overview of Lidköping municipality, while linking supplementary information and files that describe key components of the LES. The background map is a photoshopped version of an image sourced from the comprehensive plan made by Lidköping Municipality [60]. The original image can be found in *Appendix B.1*.

The interactable function of the *Interactive Map* is exemplified in figures 6 and 7, where the blue area of the map is selected, as indicated by the mouse pointer icon. As a result, the component is highlighted and an information box appears, providing a description of the area and linking a relevant analysis report. In this example, the blue-shaded area marks an area deemed suitable for smaller instalments of wind turbines, as specified from the thematic addition to comprehensive plan involving analyses related to wind power potential [59].

As shown in the figures, the map includes several symbols in addition to the blue-shaded area, which reflects real data, except from a roughly estimated district heating grid, sourced from Lidköping's Comprehensive Plan as well as the wind farm plan [59, 60]. The user interface component which is intended to help the user manage which symbols that are displayed is the *Map Settings Panel*. There are two types of checkboxes which enable the selection for viewing shaded or fully opaque symbols in the map. The range of available map symbols and layers which can be shown is expected to be limited to location-dependent data on system components.

The final component of the user interface to be described is the *Information and Scenario Panel*. This panel presents key metrics and diagrams intended to convey system magnitudes and includes a scenario function that enables impact analysis of different development options or contextual options. The upper section of this panel allows users to select energy carriers and system-related categories of interest in order to display suggested key figures. As illustrated in the figures, a suggested structure for the selection of 'electricity' and 'production' are selected. First, an aggregated view of the electricity mix is displayed, including different generation sources as well as imported electricity. Below this, a more detailed breakdown of production types is shown. In the current example, wind power is selected, and in turn, key metrics or characteristics of this technology are presented, with information icons included to provide additional explanations of the indicators. The values for total yearly generation and installed effect are sourced from the Lidköping energy and climate plan [57, 58]. Other specific values displayed for the indicators and their source include: the maximum potential generation per year which is an estimated value based on +15% of the total yearly generation; levelized cost of energy from an article from the Swedish Institute for Business Research [61]; and the climate impact from the Swedish Environmental Protection Agency [62].

Finally, the bottom section of the *Information and Scenario Panel* contains a scenario function, introduced in response to the identified requirement for scenario analysis within the platform. In the suggested user interface, available scenarios are displayed based on previous selected options in the panel. In this example, the two suggested scenarios shown in the figures intend to allow the user to adjust the level of wind power deployment and wind power output across different timescales and magnitudes within the municipality. In turn, these parameter changes affect the resulting key metric values. Future development of this function could potentially include visualisation of impacts directly on the map interface. However, the precise design and implementation of such functionality were not explored further in this study.

5.3.2 City View

The *City view* builds on the municipality overview by zooming in to a more detailed level. This view breaks down the city's energy system into a more manageable scale, which was an identified platform specification. The city of Lidköping is visualised in Figures 4 and 5, where it is divided into different areas representing city districts based on Lidköping Municipalities' Comprehensive plan [60]. Each area is interactive and can be selected by the user. By focusing on one area at a time, the system becomes more structured and easier to interpret, while still maintaining its connection to the overall system. Some major consumers in the municipality are represented in the map, as well as major district heating producers. As in the municipality view, the user can also control what type of information is displayed in the map through the *Map Settings Panel*.

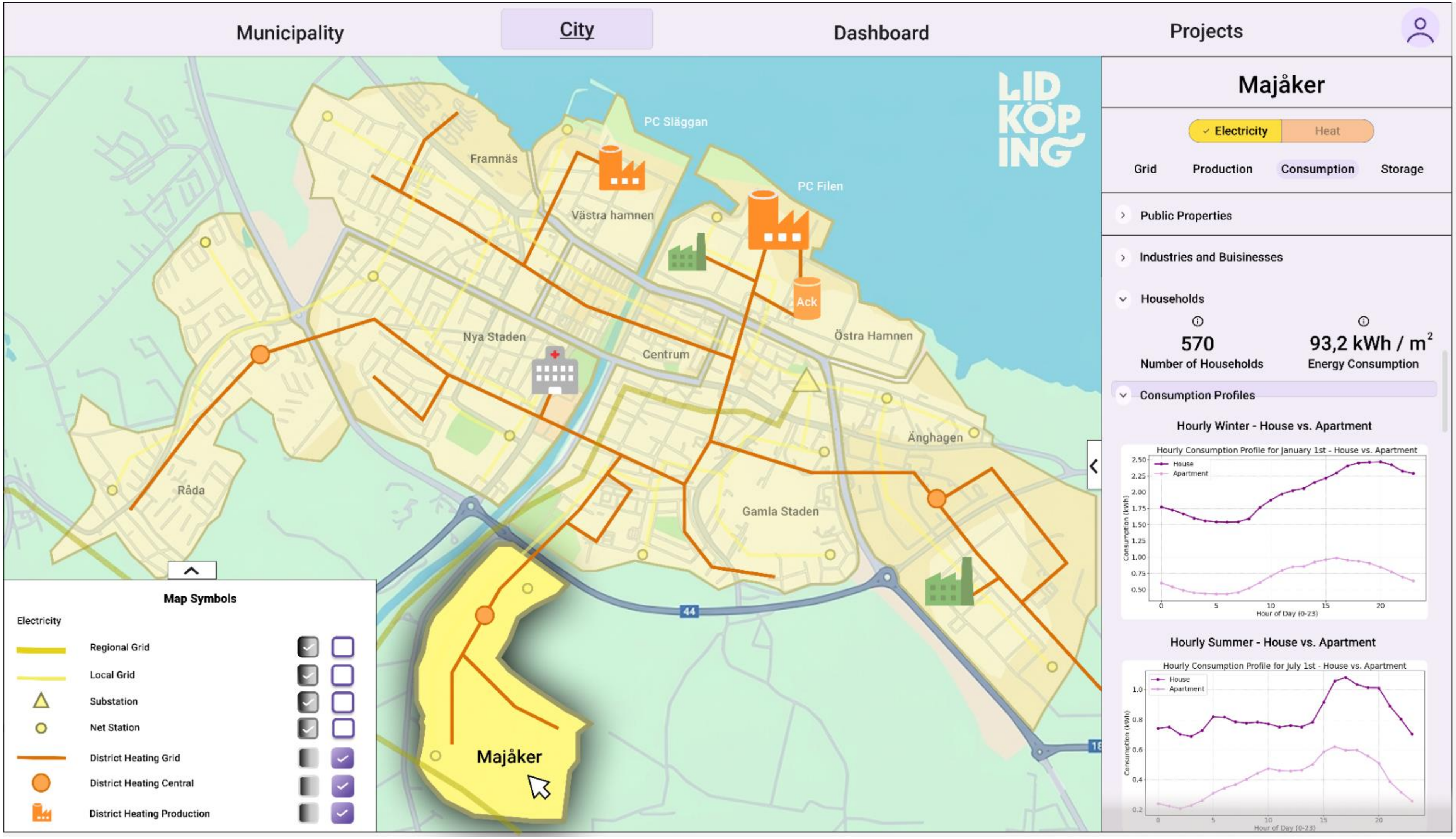

Figure 4: City View
Representation of the user interface when overviewing the energy system of Lidköping City

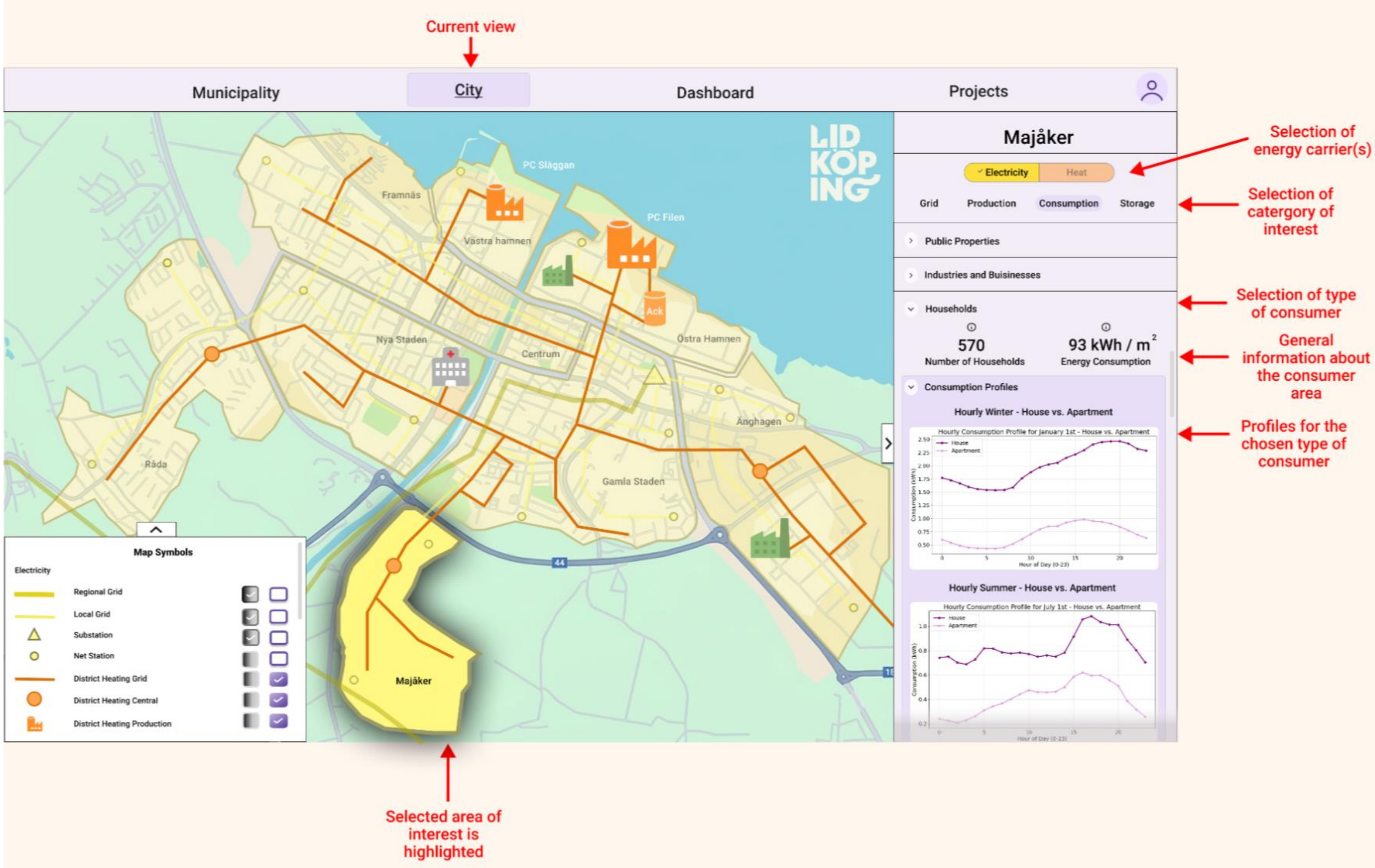

Figure 5: Annotated Version of City View

Figures 4 and 5 illustrate the user interface of the city view and present a context in which the user has an interest in gaining knowledge about the area Majåker. When Majåker is selected as the area of interest, detailed information about the area is displayed in the side panel. This includes, as in the Municipality view, selection of energy carriers and system-related categories of interest. In this case, 'electricity' and 'consumption' are selected and the type of consumers being studied are households. By dividing the consumer types into categories, the information displayed can be adapted depending on the user's focus and the part of the system that is being analysed.

Three types of data are shown in the *Households* category. Firstly, the estimated number of households in Majåker, calculated based on the number of inhabitants in the area divided by the average household size in Sweden [63, 64]. Secondly, energy use per square meter, obtained from the Swedish Energy Agency [65]. Lastly, aggregated consumption data for households and apartments is presented, based on inputs from Mölndal Energi via Chalmers University of Technology. This data is included to provide an understanding of the type of consumers living in the selected area. Presenting data in this way supports exploration of the system at different levels of detail and enables more informed decision-making. The consumption profiles can be found in *Appendix B*.2.

5.3.3 Dashboard View

The *Dashboard view* aims to function as a shared information space where the user can access different types of information, analysis, documentation, and more. The purpose of this is to gather important information in one place and to support a deeper understanding and communication of the system's state.

During the interviews, it became clear that information today is often spread across different organisations, documents, and systems, making it difficult to know where information exists and which information is updated. Therefore, the dashboard view was created as an attempt to create a single access point where, for example, key figures, scenarios, governing documents, and system information can be gathered and accessed in one location.

Figures 6 and 7 represent a suggested user interface for the Dashboard view, where Figure 7 presents an annotated version to explain key components of the interface.

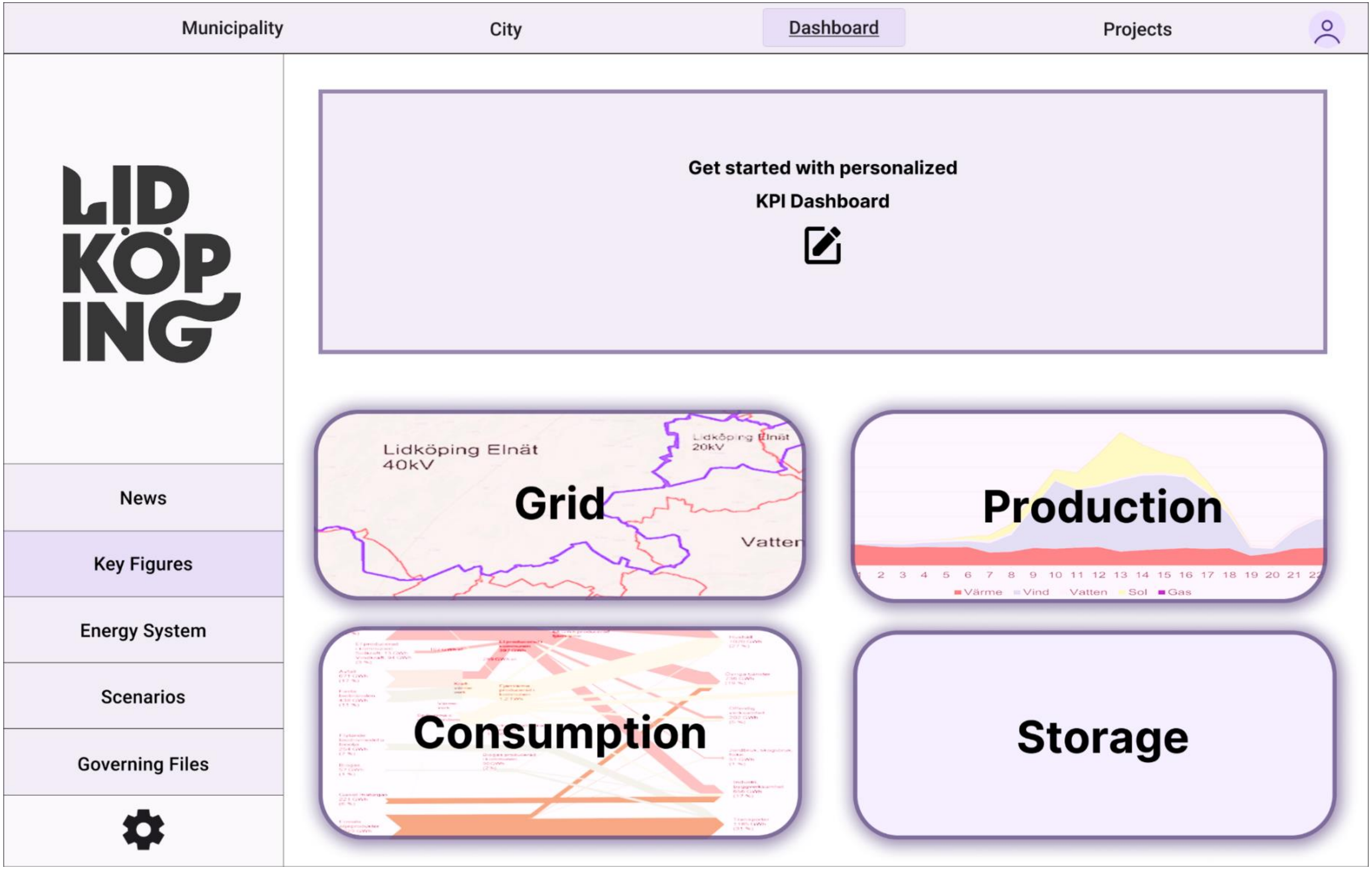

Figure 6: Dashboard View

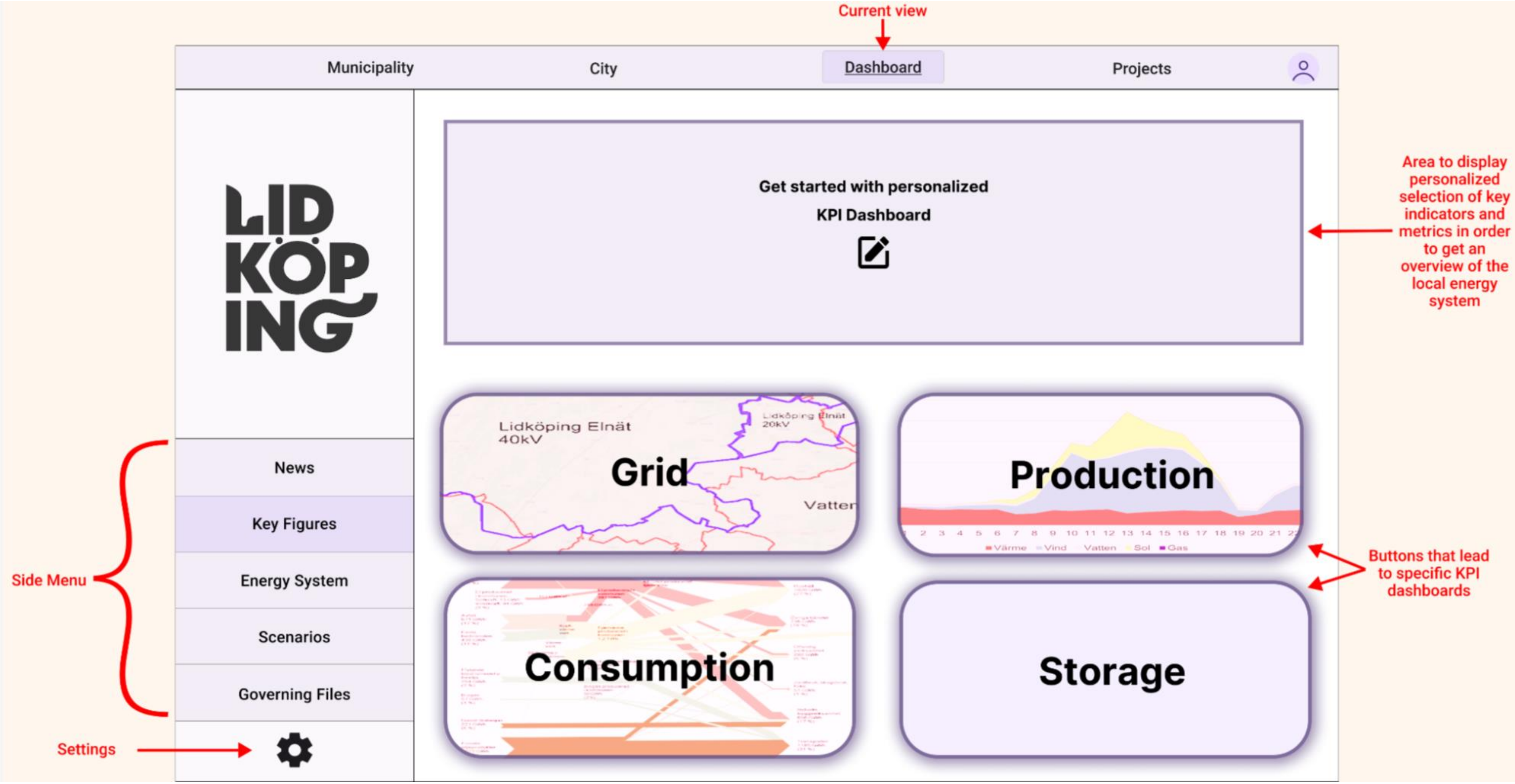

Figure 7: Annotated Version of the Dashboard View

To provide a clearer understanding of the dashboard view shown in Figures 6 and 7, the side menu options, which outlines the suggested content structure, will be described in further detail in the following paragraphs. To give context for Figures 6 and 7, the area to the right of the side menu exemplifies the user interface for the option *Key Figures*. Each side menu option is therefore described in more detail in terms of intended content and function.

The first side menu option, *News,* includes relevant news updates related to the energy system that may affect the conditions for planning and decision-making. This option is included in response to the evolving political landscape and the uncertainty surrounding how specific events or policy changes may affect the LES. Therefore, a suggested feature is to provide complementary explanations or analyses describing how these events and policy changes influence different components of the energy system, and in turn, planning conditions for further operational or development plans.

The second option of the side menu, which is currently exemplified and displayed in Figures 6 and 7 is the *Key Figures* tab. The interview study indicated that system-level Key Performance Indicators (KPIs) are not commonly used in practice but are important to consider for strategic planning and communicating system-level characteristics. Therefore, this side menu option was developed to support an overall understanding of the system's state and its development over time. To begin breaking down the components seen in Figures 6 and 7, the suggested user interface includes at the top, a customizable section with KPIs and graphs. Below this section are four larger buttons, 'Grid', 'Production', 'Consumption', and 'Storage', each leading to alternative views to display relevant KPIs, graphs, and information for the selected category. The images and diagrams seen within these buttons are sourced from Lidköping network development plan and their comprehensive plan [60, 66]

The intention is that the metrics should show comparison to previous years and perhaps be comparable to values in other municipalities to provide more meaningful insights. Relevant KPIs may draw inspiration from those identified by the Swedish Energy Agency [67] or the EU Smart Cities Information System [68] (a project group created by the European Commission) which are intended to serve as a basis for monitoring national energy policy goals or other general sector-related KPIs. Examples include: share of fossil-free energy production; share of renewable energy production; energy consumption in buildings / per person; energy prices for household customers; taxes, fees and subsidies on electricity and heat production. Some additional examples, inspired by the energy-related issues mentioned in the interview study include: degree of self-sufficiency in energy production; order of magnitude of unused waste heat or curtailed energy; and flexible capacity utilized versus unutilized.

Energy System is the third option of the side menu. The intended content includes displaying organisational information in the purpose of allowing the user to learn more about the interdependencies and connections within the energy system. This may include stakeholder information, a modelled actor network illustrating relations and connections, organisational schemes. This option was developed to support a greater understanding of the system structure and how different components interact, without necessarily requiring geographical anchoring.

The fourth option in the side menu is *Scenarios*, which features an extended version of the scenario function introduced in the Municipality view. It provides a dedicated space which allows users to analyse baseline forecasts as well as creating and comparing results from alternative scenarios by adjusting key parameters. To give some examples of parameters based on possible developments: energy demand growth or population growth, degree of electrification, renewable deployment, and efficiency measures. Results from these scenarios should include graphs and key metrics that can display and convey effects of the results, such as those related to energy balances, total emissions, grid utilization, etc.

The final option in the side menu is called *Governing Files,* and serves as a repository for relevant documents, such as official planning documents, technical specifications for components in the energy system, and other regulatory material. Given the relevance of these formal, technical, or legal documents for understanding strategic objectives and accessing technical or legal information necessary for operational planning, this option was developed to gather such information in one accessible location.

5.3.4 Project View

The *Project view* was developed to support early-stage evaluation of potential projects and enables analysis of system effects and consequences of different choices. The view is based on insights from interviews with Sean from Lidköping Energi, where the investment project of an electric steam-boiler was used as a reference case. A key finding is that there is a lack of tools supporting exploration of new projects under uncertainty, particularly in the early phases before decisions are finalised. At this stage, many parameters remain uncertain and different alternatives need to be compared prior to implementation. The project view is designed to support this stage of planning. Figures 8 and 9 represent a suggested user interface for the Project view, where Figure 9 presents an annotated version to explain key components of the interface.

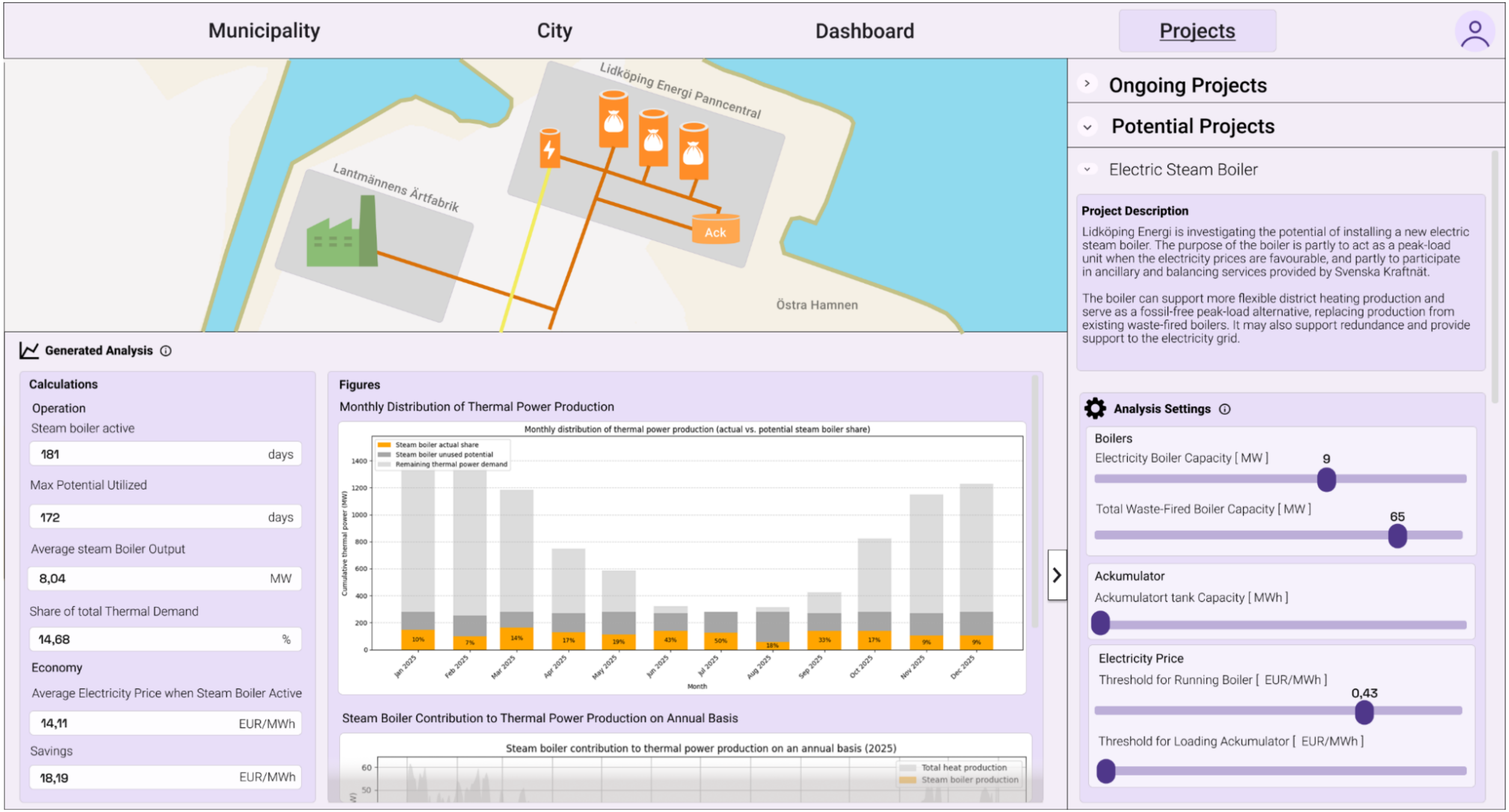

Figure 8: Project View

Representation of the user interface when overviewing the projects

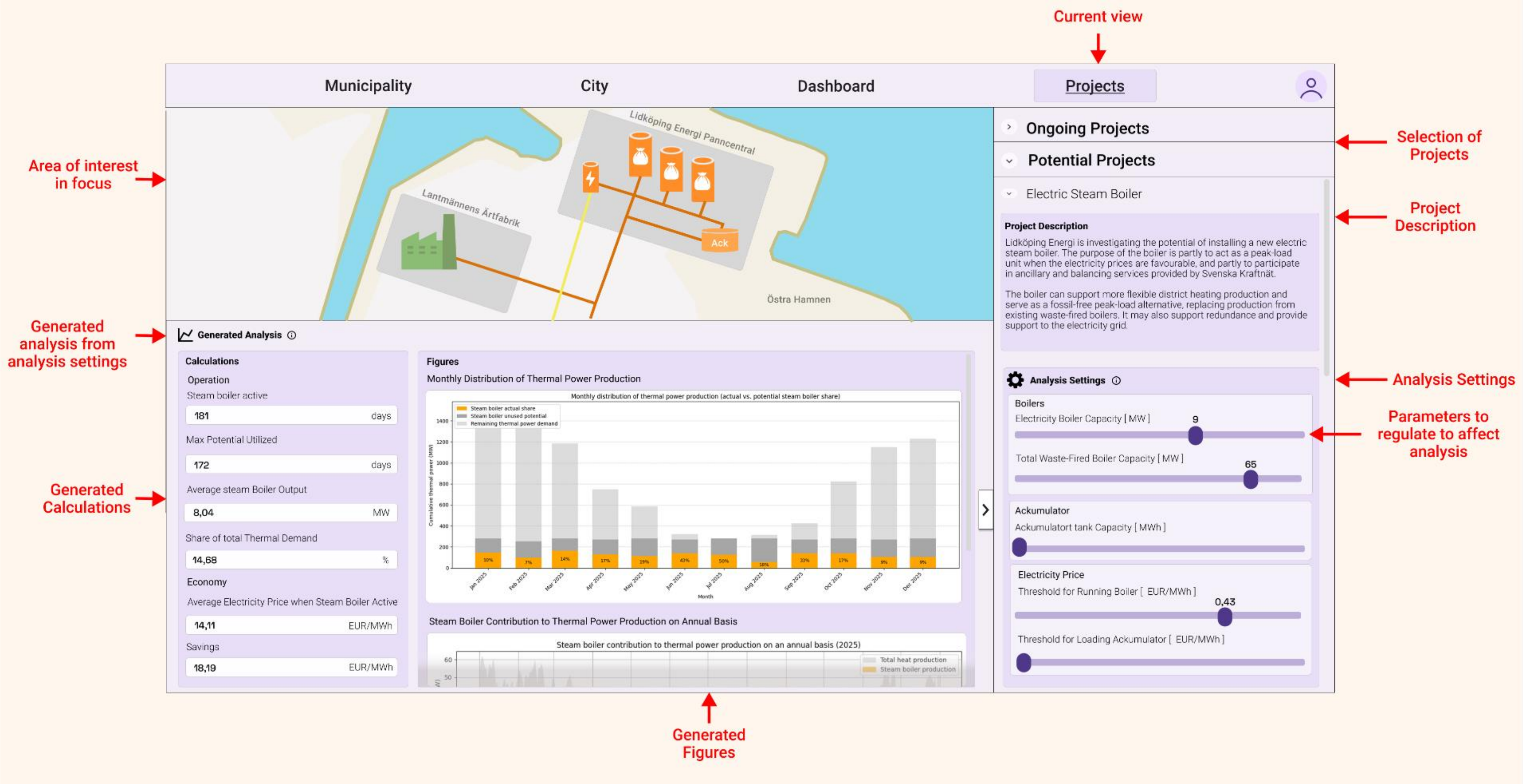

Figure 9: Annotated Version of Project View

The area of interest section visualises the physical context of the system, including the three existing waste-fired steam-boilers, an accumulator tank, the potential electric steam-boiler, and the industrial user. This type of spatial representation was highlighted in the interviews as important for creating a shared understanding between actors when discussing new investments. The view also distinguishes between potential projects and ongoing projects, where early-stage ideas can be explored before being developed into implemented projects.

In addition to the spatial representation, the Project view includes a *Project description* that summarises the main motivations behind the potential investment. These include revenues from ancillary services, avoided emissions, and system related benefits such as increased flexibility. The purpose is to provide an overview of both economic and system-level implications.

The view includes *Analysis settings* with adjustable parameters such as steam-boiler capacity, storage capacity and electricity price. These parameters enable scenario-based analysis where different assumptions can be tested. Results are visualised in the *Generated Analysis* section through key figures and graphs. In this example, the graph illustrates how much of the annual heat demand can be covered by the electric steam-boiler under the selected parameter values. The data used in the model is based on input from Lidköping Energi and has been further processed and simulated to generate the resulting outputs. By allowing users to adjust parameters and immediately observe system effects, the Project view enables comparison between different design options and helps link technical decisions to broader system consequences.

Overall, this view aims to support a shared understanding of projects, connects technical choices to system impacts, and supports discussion and decision-making in early planning stages.

6

Discussion

This chapter discusses the findings of the study in relation to previous research and the identified research gap. It focuses on current planning practices and challenges in LESP, together with the potential role of a digital platform for supporting collaborative planning processes. The chapter also reflects on the conceptual model developed in the study, including both its possibilities and limitations, as well as considerations related to implementation, methodology, and further research.

6.1 Contribution to Research Gap and A Reflection of Current Planning Practices and Challenges

In the pursuit of answering the first research question, this study aimed to address a research gap on practical processes in LESP to complement findings from the literature review. Overall, the results provide multiple perspectives and contexts regarding CLESP practices across five LESs. The findings particularly contribute to insights into stakeholder coordination, real world tool use, and the challenges connected to managing complexity, navigating conflicts of interest, and overcoming structural barriers. However, many of these findings are consistent with existing literature on data sharing, confidentiality barriers, and the limited fit of available tools for local planning contexts.

The main contribution of this study lies in the empirical depth and relational dynamics described in the interview results. By interviewing multiple stakeholder types within the same LESs, the study was able to capture practical interactions, which is less common in previous research. At the same time, the variation in respondents' roles and contexts made it difficult to identify any patterns in their responses, limiting their comparability. However, one area where results are somewhat thinner relative to the gap is the evaluation of plan outcomes. Much of the interviews were more centred on how plans are developed and what barriers there exist in relation to creating them, but limited in-depth evidence exists on processes of translating the plans into concrete actions.

A key finding from the interview study is that although LESP and development inherently requires collaboration between several stakeholders, structured and formally coordinated strategic planning activities remain rare in practice. The results indicate that planning efforts are to a large extent still characterized by separate planning processes among key stakeholders, with limited transparency and data exchange between them. A central explanation for this is that stakeholders tend to operate within their own organisational logics and mandates, planning based on their own responsibilities and goals rather than from a long-term and holistic perspective of the energy system as a whole. This, in turn, risks the development of LES becoming predominantly reactive rather than proactive, due to the lack of emphasis on strategic planning compared to operational priorities. Not to mention, this challenge is further aggravated by the perceived lack of system-level competence among stakeholders, particularly in smaller municipalities, especially in relation to managing complex, cross-sectoral energy issues.

However, this tendency is understandable given the persistence of traditional planning practices, existing structural barriers, and uncertainty within the political climate. Nevertheless, as highlighted in the literature review, collaborative planning processes can facilitate greater synergies and more efficient use of resources, both of which are essential for a successful energy transition, along with a greater understanding of systemic consequences. Consequently, stronger and more clearly defined responsibilities for collaborative strategic planning are suggested as necessary to support sustainable long-term development of LESs.

The municipality holds the clearest responsibility for engaging in strategic planning and facilitating CLESP activities, given its strong influence over the planning and development of LESs as emphasised in the literature review. This does not imply they are solely responsible for the energy transition, rather, they hold a unique position to act as a key enabler of collaborative and coordinated processes. For example, the initiative introduced by Lidköping municipality, involving work groups dedicated to managing implementation efforts of their energy and climate Plan, is a clear example of how CLESP can support a better understanding of stakeholder perspectives and help accelerate decision-making.

At the same time, the results indicate that stakeholders still face difficulties in navigating conflicting interests and the uncertainties related to future development. This highlights the need for new approaches or solutions to strengthen CLESP processes. In this context, the question arises whether a new digital platform aimed at supporting CLESP processes could help address some of these challenges, which is discussed further in the following section.

6.2 Assessing the Demand for a Digital Platform that can Support CLESP

Overall, the results indicated a generally positive reaction towards the platform concept, although some scepticism was also expressed. While no significant opposition to the platform concept emerged, the scepticism expressed by some respondents reveals what conditions that would need to be fulfilled in order for the platform to be attractive and useful to use. In particular, the platform would need to provide clear added value that justifies the time, resources, and efforts required to create it.

Much of the demand for the platform was not always expressed directly, but rather implied or interpreted from the current practices and problems that the interviewees expressed. For example, when the interviewees were asked directly whether they could envision a platform supporting CLESP, interviewees expressed a desire for something that could address fragmented information, the absence of a shared situational picture, and navigate conflicting interests. However, some answers carried more direct implications, such as the recurring need for clearer overview of the current system, for example, through a geographically anchored visualization.

Another point of discussion regards the presumption that organisational sizes and capabilities can influence the demand for this platform. Smaller organisations may already have a higher level of internal coordination and familiarity with their own energy systems, potentially reducing their need for an external tool. In contrast, larger organisations, facing higher degrees of complexity in their system, may stand to benefit more. Nevertheless, the platform could still be potentially relevant to smaller organisations, as it could offer meaningful support in areas where they could lack capabilities. Particularly in providing data analytics, scenario modelling, and project evaluation.

Underlying this discussion is the question of whether other types of solutions are needed to complement or address other challenges and needs identified. For example, some interviewees mentioned the demand for a type of decision-making framework to evaluate different parameters, clearer energy-related goals, or the establishment of more long-term energy policies. These are needs that extend beyond what a digital platform alone can provide. Perhaps what is needed are more structured arenas in which actors can engage in formalized collective planning to facilitate CLESP.

Taking this into account, the platform may not act as a standalone solution to the challenges related to coordinated planning of LESs. However, it can be an important tool among several, to act as a complementary solution to clearer governance structures, goals, and dedicated arenas for collaboration.

6.3 The Conceptual Model

The conceptual model was developed based on the idea that the LESs are often perceived as complex and difficult to oversee. In practice, actors frequently work with several separate tools, maps, and documents, which makes it difficult to create a shared understanding of the system. The model therefore attempts to gather relevant information within one common interface while also breaking the system down into a more manageable level. By allowing the user to choose which information and energy carriers should be displayed, the platform can be adapted depending on the question and the specific need. In this way, the model aims to provide an overall picture of the energy system while also showing simpler relationships between different parts of the system.

6.3.1 Possibilities

The municipality view aims to create an overall understanding of the energy system at municipal level. Here, the user can explore broader planning questions, for example where new wind power or solar power could be established and how different parts of the municipality may be affected by such decisions. Since different energy carriers can be selected depending on what is being investigated, the complexity of the system can be adjusted depending on the context. At this stage, the model only includes heat and electricity, but the structure could be expanded into additional energy carriers such as cooling mediums, gases, and transportation fuel.

By visualising information from different parts of the LES within one shared interface, information may become more accessible compared to when it is fragmented across multiple tools and documents. This can help reduce uncertainty in early planning phases and create better conditions for discussing different possible future developments and support systems thinking. As a potential future application, the platform could also support the development of statutory energy-related plans by collecting relevant planning material and system information in one place. In this way, actors may gain a better understanding of how the LES is evolving and how different parts of the system are connected over time.

The city view instead enables a more detailed analysis of specific areas of the city. In the conceptual model, this is represented through interactive city districts that the user can select to access more detailed information. Several interviewees described that it is difficult to know where new establishments should be located, for example residential areas, industries, or data centres. In the model, electricity consumption profiles are visualised for a specific area, which can contribute to a better understanding of how the load is distributed and what conditions exist in different parts of the city. At the same time, larger producers and consumers are displayed on the map to create a clearer connection to the actual energy system.

Collecting information in one place also becomes important since several respondents described that a large amount of time today is spent searching for information or trying to keep track of documents and material spread across different locations. When information is fragmented, it becomes more difficult to create an overview and quickly access the material needed in planning and decision-making processes. By collecting information in one common interface, the work can therefore become more efficient and less dependent on individuals knowing where different documents or data are stored. It can also contribute to creating a more natural place for information management within organisations and contribute to increased transparency. If relevant information already exists within the platform, it may become more natural for new material and documentation to be added there. In this way, the dashboard view could not only store information, but also create better conditions for overview, information sharing, and shared understanding regarding the energy system and its development.

The project view was developed through dialogue with Lidköping Energi and focuses on early stages of project development. The interviews indicated that there is often a lack of tools that support exploration of new project ideas and help actors understand how different technical choices may affect the LES as a whole. Several respondents described that planning processes are frequently characterised by uncertainty and estimations, which can make it difficult to determine which investments or initiatives should be prioritised. The project view is therefore intended to support exploratory discussions in situations where future conditions and consequences remain uncertain.

In the conceptual model, the investment project of an electric steam-boiler is used as an example. By allowing the user to adjust different parameters, for example steam-boiler capacity and storage possibilities, system impacts of various selections can be understood through simpler analyses and visualisations. The intention is not to create exact forecasts, but rather to make it possible to explore different alternatives and ask questions such as “what happens if we do it this way instead?” In this way, the model can be used to compare different solutions and connect technical choices to system effects.

A central idea behind the project view is also that it should function as a shared arena for discussion between actors. The interviews highlighted that stakeholders often work from their own organisational perspectives and responsibilities, which can make it difficult to understand how decisions affect other parts of the system. This creates risks of suboptimization seen from a wider system perspective, where local decisions may contribute to less efficient outcomes. By visualising possible system effects and consequences, the project view could contribute to a more shared understanding around projects and investments that otherwise risk being evaluated too narrowly. This becomes especially relevant in projects where actors are affected differently and where system-wide benefits do not necessarily align with benefits for individual actors.

Several respondents highlighted that visualisations and images make it easier to discuss complex questions compared to working with only text or numbers. The project view therefore aims to function as an exploratory forum where different alternatives can be discussed jointly and used as a common reference point between actors. This is particularly important since actors often operate from different perspectives and goals, which can make it difficult to establish a shared understanding of projects and their system effects. Even though the exemplified analyses are based on limited data and simplified assumptions, this reflects real planning situations where decisions must often be made under uncertainty and with incomplete information. In this sense, the model is not intended to eliminate uncertainty, but rather to support discussion by clarifying possible risks and opportunities and thereby encouraging early-stage exploration of new projects.

Overall, the goal of the conceptual model has been to suggest an interface that is relatively simple and intuitive to use. The intention is that the model should be usable both for people with technical expertise and for actors working more generally with energy and planning issues. At the same time, there should be opportunities to explore different parts of the system in more depth depending on the level of information needed by the user. Since the conceptual model is exploratory, there are also many possible directions for further development depending on user needs, available data, and future planning contexts.

6.3.2 Limitations

The conceptual model is largely based on limited data and rough assumptions rather than detailed and verified system data. As a result, certain parts of the model rely on assumptions and simplifications rather than exact representations of reality. For example, visualisations of the electricity grid and district heating network are partly based on estimations and schematic illustrations, since detailed infrastructure data is confidential and could not be shared within the scope of the study. Limited access to data may therefore have affected both which functions were developed and how the system was visualised. The model should therefore not be seen as an exact representation of the energy system, but rather as an example of how relevant information and system relationships could be visualised and structured.

The model also only includes electricity and district heating. Other important parts of the energy system, such as transport, cooling, gas, and other sector couplings, have not been included. This means that the model only visualises part of the LES and therefore does not capture all dependencies and relationships that exist. At the same time, narrowing the scope made the model more manageable within the timeframe of the study.

Another limitation is the risk of oversimplification. Since one of the intentions of the platform was to make the energy system more accessible and easier to overview, there is a risk that important technical, organisational, and economic relationships could become simplified to a degree where vital interactions are lost. LESs contains many interdependent processes and system interactions that can be difficult to visualise in a simplified interface without reducing analytical depth. The conceptual model may therefore be too simplified to suggest how the platform can support certain advanced analytical tasks or detailed system analysis.

The scenario functions also involve limitations. Results from scenarios are highly dependent on the data and assumptions used. Since future development is uncertain, there are also limitations regarding the reliability of such analyses. The scenarios should therefore mainly be viewed as support for discussion and exploration rather than as highly precise forecasts.

In the interviews, it was also difficult to identify exact specifications regarding what functions a platform should contain. Many of the conclusions are therefore based on interpretations of problems, needs, and frustrations expressed by the respondents rather than clear requirement specifications. This means that several functions in the model are based on our own interpretations of what could be useful in planning contexts.

Finally, the model does not solve the organisational and institutional challenges that exist for LESP. The model is not intended to eliminate uncertainty, but rather to lower the threshold for taking new initiatives or investments. The platform can function as support for discussion, analysis, and information sharing, but it does not in itself change the incentives, goal conflicts, and organisational structures that affect planning processes.

6.4 Important Considerations for Practical Implementation

There are important factors to consider for the proposed digital platform intended to support CLESP to be implemented in practice. This includes managing and defining interdependent technical, organisational, and legal constraints. These constraints establish boundaries for what the platform could realistically provide.

One of the most central issues concerns data privacy, confidentiality, and other legal restrictions governing what types and levels of energy system data can be shared. As established in the literature review under the section regarding collaboration and coordination challenges, critical infrastructure is subject to strict regulatory frameworks that significantly limit data exchange. Additional constraints include security requirements and market regulation measures between stakeholders. These limitations were highlighted as a major challenge in the interview study, where stakeholders described significant difficulties associated with sharing data and noted that, in practice, only very limited data can currently be shared between them. As a result, certain stakeholders, such as grid owners, may not be able to disclose detailed network-level information.

These legal constraints directly influence how the platform can be designed. It is therefore important to identify what types of functionalities and information the platform can include while remaining compliant with existing regulations. One solution, as mentioned in the platform specifications, is relying on aggregated and anonymised data, as well as simplified schematic representations rather than direct source-level information. Although this creates a technical compromise and partly contradicts the aim of increasing transparency between stakeholders, it is a prerequisite for protecting sensitive information, maintaining integrity of the system, and establishing stakeholder trust. Nevertheless, the approach of using aggregated and simplified data was identified as a requested aspect and can still provide meaningful analytical value.

Even with these measures, however, some stakeholders may remain reluctant to share data due to uncertainty, perceived risks of safety breaches, or concerns related to strategic and business-sensitive information. Therefore, these non-legal constraints should also be considered when designing the platform.

Related to the question of how data should be managed and sourced is the question concerning platform ownership, maintenance responsibility, and access control. Clear role definitions and governance structures must be established to ensure that data is effectively sourced, maintained, validated, and distributed among stakeholders with different access rights and responsibilities. Maintaining updated data was highlighted in the interview study as one of the most important aspects to ensuring platform usefulness. Without establishing clear accountability for how this can be managed, the practical value and legitimacy of the platform can risk being undermined. Whether the platform is owned and operated by a third-party actor or, for example the municipality, each arrangement presents various advantages and disadvantages, including variations in technical competence and economic incentives. Regarding access control, there is an understanding that more detailed information can likely be shared among stakeholders within a municipal group than with external stakeholders, given stronger shared governance frameworks within the group. This can further limit the extent of data and functionality available in the platform. At the same time, this distinction should not solely be viewed as a limitation. There is an opportunity to explore more adaptive access control structures that can better reflect varying degrees of trust, responsibility, and regulatory alignment.

The scope of the conceptual model did not include any software engineering considerations related to technical implementation, such as frontend and backend architecture, system integration, or data management processes. These technical aspects therefore require further investigation to develop a functioning and interactive platform. The design of the platform's technical architecture is essential not only for making it functional, but also for ensuring secure, effective, and reliable data management. For example, from an analytical perspective, the usefulness of the platform’s scenario functionality is heavily dependent on the availability and quality of energy system models, particularly those adapted to local scales. Energy system models are essential for generating analytical outputs based on different data inputs and thereby supporting understanding for impacts of future developments or policy decisions. This can require specialised expertise as well as reliable data input.

Finally, the conceptual model should be understood primarily as an illustrative example of how the user interface of such a platform could be designed. Further refinement of the concept should be achieved through testing the design or a functioning prototype with potential end users. An important consideration is that a single design of the platform may not serve all actors equally well. organisations differ in size, technical capacity, and have different planning responsibilities, meaning that the platform's interface, functionality, and complexity may need to be adaptable to different user contexts and levels of expertise.

6.5 Method

The study is partly based on interpretations of interview responses regarding challenges that actors experience in local energy planning, which were then translated into specifications for the platform's content and functionality. The interviews were therefore not primarily intended to collect direct requirements for a digital platform, but rather to understand existing practices, challenges, and practical needs related to LESP. As a result, the functions included in the conceptual model are not direct requests from the interviewees, but interpretations of what could support the issues and barriers identified throughout the study.

This introduces a risk of bias, since the design of the platform was influenced by the authors' own interpretations and assumptions regarding which challenges were most important and which types of functionalities could be valuable in practice. The platform concept was also part of the study from an early stage, which may have influenced how interview responses were interpreted and connected to possible platform solutions.

To identify which functions and themes were perceived as most important, a ranking system was created where the interviewees were asked to prioritise different needs and functions. However, this did not fully work as intended, since many respondents experienced that several areas were equally important. This may partly be because it was not made sufficiently clear that the prioritisation needed to be relative between options. At the same time, it may also indicate that there are needs across several parts of local energy planning, and that many of the issues are perceived as important simultaneously.

The platform concept was presented to different respondents in varying levels of detail due to different interests and understanding of the study. This may have influenced how they responded and which types of functions they reflected on. The respondents also had different roles and responsibilities, which likely influenced which problems and needs they highlighted. This may have influenced which needs were emphasised rather than providing a balanced view of priorities in local energy planning. Many of the responses therefore reflect the specific issues and challenges that the respondents deal with in their daily work rather than a general view of local energy planning.

Since the study from the beginning was based on the idea of investigating a digital platform, there is also a risk of confirmation bias. This means that the interview responses may have been interpreted in a way that supports the idea of a platform as a solution, rather than critically examining whether other types of approaches, processes, or policy instruments could have been more relevant for addressing the identified problems.

Another limitation is that the study did not include a systematic review or comparison of existing digital planning tools and platforms. Although existing tools were discussed in both the literature review and interviews, the primary focus of the study was instead to investigate planning challenges and explore how a conceptual platform could support planning processes in practice. A more structured mapping of existing tools could have contributed to a clearer understanding of which functionalities are already available, and which gaps remain insufficiently addressed.

The conceptual model was also not tested with end users or implemented in a practical planning context. As a result, the usability and practical relevance of the platform could not be evaluated. User testing and iterative feedback would likely have contributed to further refinement of both the platform's functionality and interface design.

6.6 Further Research

Based on the discussion above, several areas are identified as relevant for further research. The following section introduces a few additional perspectives to practical implementation considerations already mentioned connected to further development of the platform or other analytical tools.

As mentioned in the previous section, a key limitation of the methodology was that the conceptual model was not tested with stakeholder representatives. Future research could therefore complement and extend this work by applying an iterative and participatory process to further refine the platform concept through stakeholder testing. This approach would enable a validation or revision of platform specifications and features in the conceptual model by gaining stakeholder feedback on their perceived usefulness and suitability.

The study mainly focused on technical and organisational challenges in local energy planning, while, for example, planning theory, governance theory, and decision-making theory were not used as analytical frameworks. Including such perspectives could have contributed to a deeper understanding of how responsibility, coordination, and decision-making are handled between different actors and thereby further strengthened the analysis. In addition, further research could also investigate how planning practices might be strengthened through the application of planning and decision-making theory, with a certain focus on identifying which analytical methods, decision-making frameworks, and information which would be most effective in supporting CLESP.

7

Conclusions

In summary, local energy system planning is a complex and interdependent process involving many actors with different goals and responsibilities. Planning is characterised by uncertainty regarding future energy demand, technological development, regulatory frameworks, and market changes. Actors often work from their own organisational perspectives rather than a shared system perspective, which creates a risk of sub-optimisation of the system.

Among the actors, there is a clear need for more strategic and collaborative planning processes. Since LES involves many interconnected actors, infrastructures, and long-term investments, decisions taken by one actor often affect other parts of the system. Without a more coordinated and long-term perspective, there is a risk that actors optimise based on their own organisational goals rather than the needs of the system. The demand is therefore not primarily related to operational control or detailed technical management, but rather to a shared understanding of the system, scenario work, coordination, and improved decision-making support.

The tools currently used in practice show several limitations, especially related to system overview, scenario handling, integration of different energy carriers, and support for collaboration. It is also highlighted that confidentiality and organisational boundaries restrict data sharing between actors, which makes it more difficult to achieve an optimal energy system.

When it comes to a potential digital platform as a tool to support collaborative planning processes, the demand is mainly expressed in contexts where complexity is high, many actors are involved, the future is uncertain, and strategic decisions need to be made. However, there are also limitations, and a certain level of scepticism related to confidentiality, data quality, and the feasibility of collecting all relevant information in one system.

Insights from the interviews and literature have been translated into overarching specifications for a conceptual platform. The platform, intended for this type of strategic and coordinating purpose, should be geographically anchored, create a shared situational awareness, support scenario handling, visualise system relationships and synergies, and gather relevant information and key indicators. Overall, rather than functioning as a detailed analytical tool, it should act as an exploratory support tool that supports system thinking. As a result, it should work with aggregated and high-level data rather than detailed operational data, mainly due to confidentiality and practical constraints.

A central part of the results includes the conceptual model that was developed, illustrating how such a tool could potentially support local energy planning processes. However, the conceptual model remains exploratory and would benefit from further development and validation in practical contexts. Future research should therefore focus on validating and testing the concept in real-world settings, as well as further investigating implementation aspects such as organisational requirements, data governance, and user needs in practice.

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Appendix

A. Interviews

A.1 Interview Details

Interview number	Interviewee(s)	Professional role(s)	Company(s)	Date	Duration
1	Ralph	Project Management	Trelleborg Energi	25-02-2026	1 h
2	Melinda	R&D Management	Tekniska Verken	26-02-2026	1 h
3	Christine	Executive Management	Lidköping Miljö och Teknik	27-02-2026	1 h
	Harry	Business Development	Lidköping Miljö och Teknik		
	Marcus	Senior Management	Lidköping Miljö och Teknik		
	Jennifer	Executive Management	AB Bostäder		
	Sean	Executive Management	Lidköping Energi		
4	Lana	Strategic Role (focus on sustainability and environment)	Lidköping Kommun	03-03-2026	1 h
5	Victor	Business Development	Mölndal Energi	05-03-2026	1 h
6	Simon	Strategic Role (focus on energy and technology)	Helsingborgshem	06-03-2026	1 h
7	Sean	Executive Management	Lidköping Energi	10-03-2026	1 h
	Harry	Business Development	Lidköping Miljö och Teknik		
9	Ronald	Strategic Role (focus on energy and urban development)	Öresundskraft AB	13-03-2026	1 h
10	Dan	Business Development (previous experience includes roles in Executive Management)	Rejlers (previous companies include Mölndal Energi, Borås Energi och	23-03-2026	1 h

			Miljö AB, FordonsGas Sverige AB)		
11	Nathan	Business Development (previous experience includes roles in Senior Management with focus on energy)	Rejlers (previous company AFRY)	26-03-2026	1 h
12	Ava	Strategic Role (focus on sustainability and environment)	Helsingborgs Kommun	27-03-2026	0.5 h

Interviewed people, their professional position, company, date of interview and duration length of interview.

A.2 General Questions for Stakeholder Representatives

General Questions About Energy Planning

1. What does energy planning mean to you?
2. Which other people and departments do you collaborate with regarding energy planning?
3. What goals and challenges do you see in the municipality's energy system?
4. How do you work to achieve these goals and manage these challenges?
    a. For example, do you have any coordinated processes with other actors?
5. What types of planning material or supporting data do you use in energy planning?
6. How do you follow up on goals?
7. In summary, what do you see as the main barriers and opportunities for achieving effective energy planning?

Existing Planning and Analysis Tools

8. Do you currently use any physical or digital planning or analysis tools that support your work?
9. More specifically, how do these tools support your energy planning work?
10. Is there a good overview of electricity, heating, and gas within the same tool?
11. What level of detail does the tools provide?
12. Do you get an overview of projects?
13. Do you get a good overview of facilities, including their components?
14. Is there a shared place for important documentation?
15. How up-to-date is the data?
16. Is there support for:
    1. Forecasting?
    2. Scenario modelling?
    3. Simulations?
17. Are specific key indicators used?

18. Who has access to the tools?
19. Do you have an example of how you use the tools to work with a challenge or follow up on a goal?
20. Is there anything you feel is missing in the tools?
21. What has been most important in the tools according to you?

Questions Regarding Grid Development Plans and Energy Plans

22. How involved are you and the energy company in developing these plans?
23. What does the process of developing these plans look like?
24. How do you collect information and build supporting material for the plans?
25. What type of data is relevant when developing the plans?
26. What does collaboration look like when developing the plans?
27. Are urban planners, property owners or industries included?
28. What difficulties have you encountered in developing the plans?
29. To what extent are the plans used as decision-support during implementation?
30. How much of the plans are usually implemented?
31. How are the plans and goals followed up?

Questions Regarding Specific Decisions and Plans

32. What types of decisions or plans are you currently working with?
33. Is there any type of information that would help you make that you currently do not have access to?
34. What constitutes good decision-support for achieving one of the goals/challenges you face?

Evaluation of Thematic Categories

35. Preparedness Planning
36. Flexibility in the Energy System
37. Maintenance and Status
38. Consumption
39. Production
40. New Construction and Decommissioning

Questions About Collaboration, Data Sharing and Flexibility

41. To what extent can or do you want to collaborate with other actors to improve the development of the energy system?
42. Are there any existing collaborations?
43. Do you have examples of projects where actors made joint investments? How did that process work, and what information needed to be shared?

44. Are there any decisions or plans you would like to be involved in but currently do not have responsibility for?

Flexibility and Transparency

45. Do you have an understanding of other actors' room for manoeuvre or future plans?
46. Their limitations and opportunities to influence the energy transition?
47. For example, is there an understanding of citizens' energy consumption patterns to identify flexibility potential in the energy system?
48. How do you manage the need to protect sensitive information while still maintaining transparency regarding the energy system?
49. What type of data would you be willing or able to share on a neutral platform if cybersecurity could be guaranteed?
50. How is the energy supply for new residential or business areas planned?
51. How do you believe flexibility can be created in your local energy system, and what room for action exists connected to this?

A.3 Questions for Consultant Representatives

Introduction

1. Presentation of ourselves, how we approach the thesis work, and the purpose of the interview.
2. Is it okay if we record the interview?
3. What is your job title, which department do you work in, and could you briefly describe your work tasks?

Background and General

4. How would you describe how energy planning works in practice today?
5. What are the biggest challenges you see when working with different actors in the energy system?
6. How does the dialogue between the municipality, energy companies, and industry look today? Does it work well?

Challenges

7. When you worked as a decision-maker, what would you say was the most difficult part of making decisions related to the energy system?
8. Where do things most often go wrong today?
9. Can you give examples of situations where several representatives from different actors/companies gathered to plan or make decisions regarding a municipality's energy system?

10. Where does collaboration between actors tend to fail?
11. Connected to these challenges, what kind of information or supporting material do you feel is missing when making decisions?
12. What do you feel is missing in today's tools?
13. Are there tools that combine several energy carriers?
14. Is there a good overview of facilities and system components?
15. Are there shared places for important documentation?

Visualisation and Understanding

16. How is a shared understanding of the energy system created today?
17. What is difficult to communicate between actors?

The Platform

18. If you had a tool that provided a shared overview of the energy system, what would be most important to see?
19. What data would be most important to include?
    1. Production profiles?
    2. Consumption profiles?
    3. Consumer categories and types of consumers?
20. What kinds of decisions could such a tool help support?
21. Do you have any real-life examples where a platform like this would have been valuable to use?

The Electric Steam-boiler Project

22. What role did you have in the project?
23. What was the biggest uncertainty in the project?
24. What information would have made decision-making easier in the project?
25. How do you think a platform like this could have supported or simplified the project?
26. Have you heard of many municipalities working with the question of installing electric steam-boilers?
27. Do you have any information or data regarding the project that we could access?

Closing Questions

28. Is there anything important we have not asked about that you think is central when looking at local energy planning?
29. What do you think is most important for us to bring into our work with the platform?
30. What do you think would be required for a platform like this to be used in practice?

A.4 Questions for Further Clarification of Steam-boiler Project

Organisational

1. What stage is the electric steam-boiler project currently in?
2. How did the idea emerge, and what did the process look like to get to where you are today?
3. What type of supporting material has been used in the process, how has the information been collected, and where is it stored?
4. Was there any information missing during the decision-making process?
5. What goals or challenges initiated this project?
6. Were there any alternative solutions that were considered?
7. Which actors are involved in the project?
8. How is the collaboration organised?
9. Which organisations are affected by the decision?
10. Which parts of the energy system are affected?
11. How do you keep track of responsibilities for different parts of the project?
12. How do you follow up on what is happening?

Strategic and System Perspective

13. What kind of system benefit is the project intended to provide?
14. How do you create an understanding of how the district heating system may develop in the future?
15. Are you planning to build more electric steam-boilers?
16. Are older steam-boilers planned to be phased out?

Current System Understanding

17. We would like to understand how you maintain a good overview of your current system. How do you work with creating an understanding of the energy system in Lidköping?
18. Where is information about the current system stored and who has access to it?
19. Composition of production and consumption (profiles)
20. Seasonal variations
21. How many production facilities are there and what capacities do they have?
22. Which fuels are currently used?

Technical Questions Regarding the Electric Steam-boiler

23. What capacity is the unit planned to have?
24. Where in the system is it planned to be located?
25. How will it be integrated into the current system?
26. Is there any surrounding technical system supporting it?

Operational

27. How is the unit intended to operate in relation to the electricity grid and electricity prices?
28. Is it intended to be used continuously and/or for flexibility purposes?
29. Have you estimated the potential for flexible production?

Regulatory

30. Are there any laws or regulations motivating the project?
31. How are these handled?
32. Which permits are required to operate the project?
33. Environmental assessments / permits?
34. How do you handle permit follow-ups?

Scenarios and Forecasts

35. Have you carried out forecasts, scenarios, or simulations directly connected to the project?
36. What do you see as the biggest identified risks connected to the investment?

Regarding the Thesis and Platform Concept

37. Based on what we have discussed today, how could a tool support you in this process?
38. Provide a better overview?
39. Compile answers to the types of questions we discussed today?
40. Gather information in one place?
41. Make it easier to share information with other relevant actors?
42. Is there a possibility to share information or data connected to the project related to what we discussed?

B. Figures Used in the Creation of the Conceptual Model

B.1 Original Map-image of Lidköping Municipality vs. Generated Image by Gemini

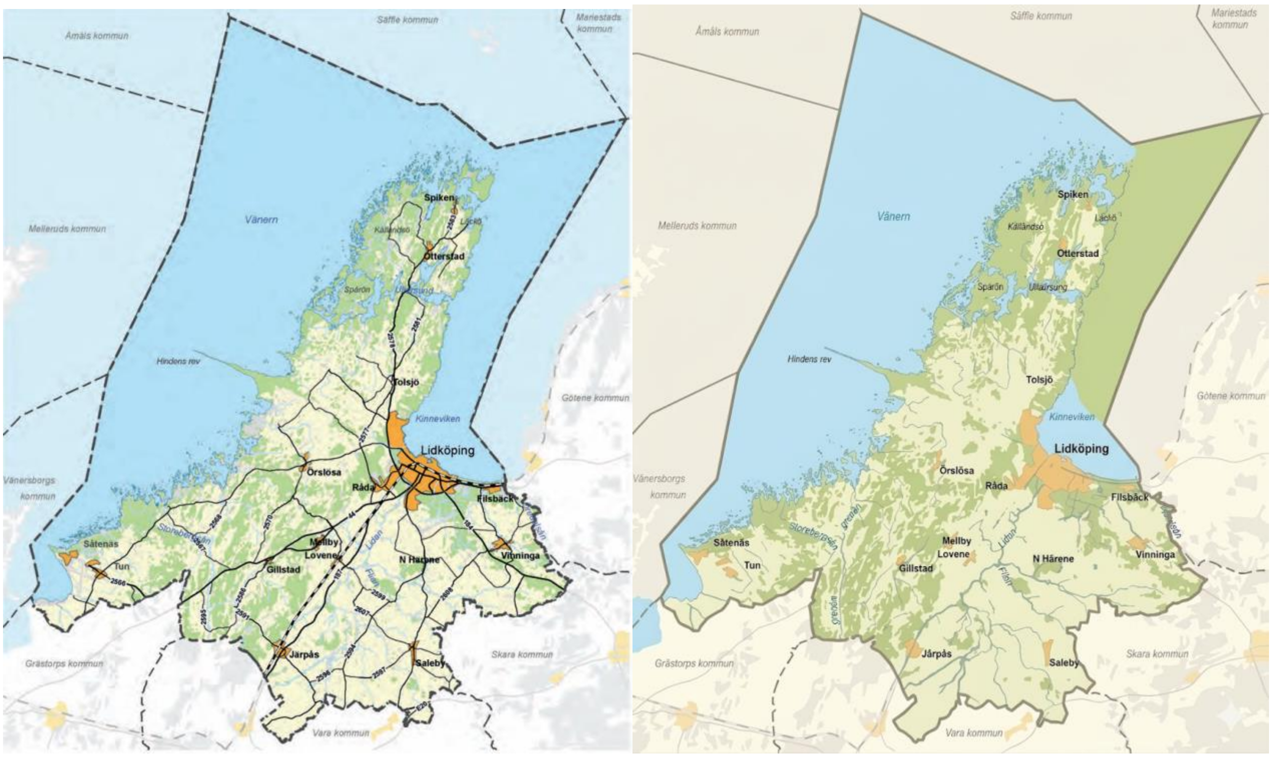

Figure 10: Original image sourced from the Comprehensive Plan of Lidköping (left image) [60] and the generated image created by Google Gemini (right image).

B.2 Household Energy Consumption Graphs

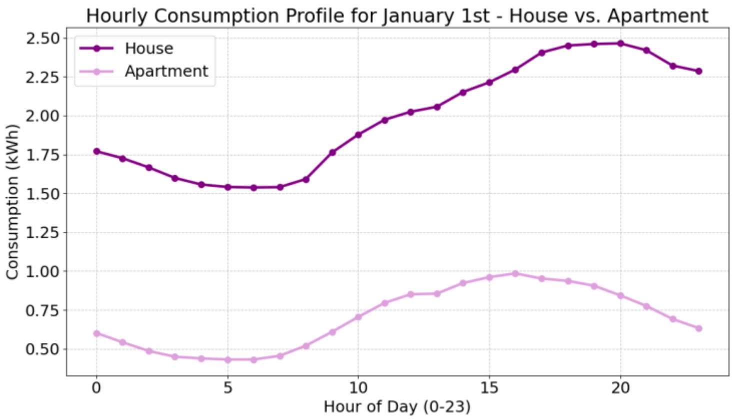

Figure 11: Data for hourly consumption for January 1st from Mölndal Energi via Chalmers University of Technology was used

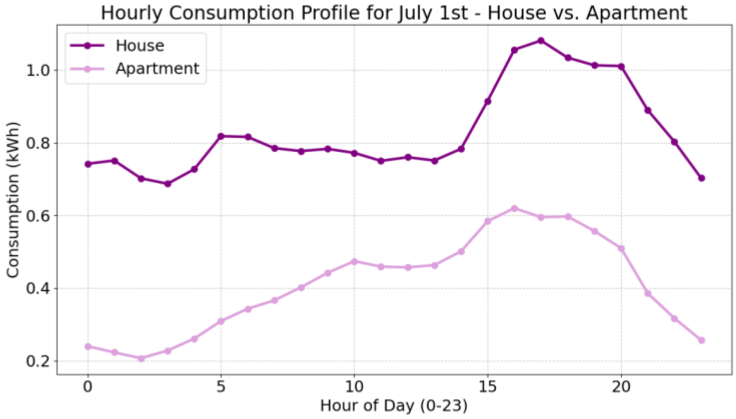

Figure 12: Data for hourly consumption for July 1st from Mölndal Energi via Chalmers University of Technology was used

B.3 Steam-Boiler Graphs

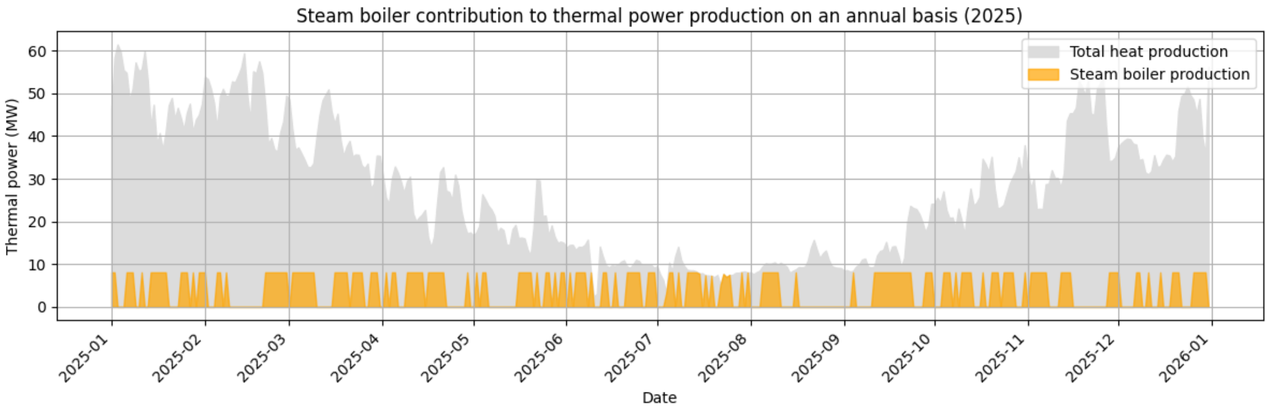

Figure 13: Data for yearly district heating power from Lidköping Energi AB was used to simulate a generated heat production from one of their facilities as well as for an electric steam-boiler with a size of 9 MW.

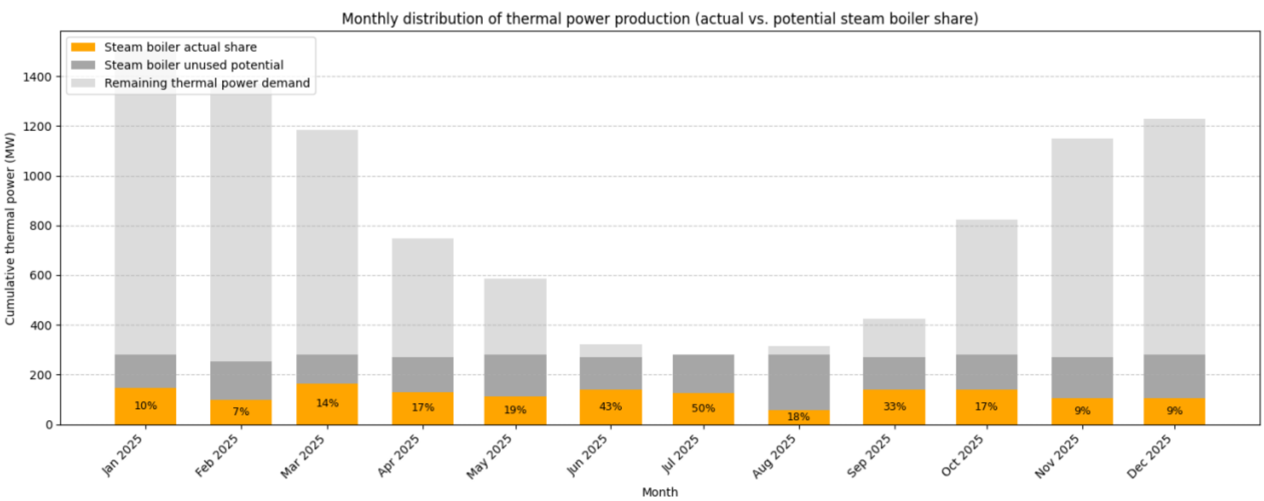

Figure 14: Based on the generated simulation, a monthly distribution of thermal power production was plotted to indicate the share of heat which was produced by the electric steam-boiler.

C. Analytical or Planning Tools Mentioned in Interviews

- Endre Technologies model: Model of a new residential area
- Trimble: Detailed for electricity grids, district heating, water and wastewater. Users often need help from a colleague familiar with the tool, as it is complicated.
- NETSIM: District heating, daily operations
- Quant Insight: Electricity grid. It allows you to input scenarios such as "this residential area will have 30% more solar panels" and assess how a specific substation would be affected.
- Kadra: Design/planning tool
- Emnis: Used by electricity grid companies
- Vitec: Used by housing companies
- Daily operations tools: ABB
- Overview map
- Manual calculations with Excel: values are obtained from meters, for example, and then calculated and analysed
- Power BI: Dan demonstrates a self-developed program for the electricity grid side that visualizes customer categories, consumption, production, and how these relate to each other over time. In addition, it includes simulations and a "heatmap" showing energy use over the year. The tool was intended to support the development of pricing models for capacity tariffs.
- Google Maps has been used in projects to show the geographical location of assets
- Ronald explains his engagement with developing a tool by RISE, "*which helps the city to see or calculate and explore how the waste system and district heating system are connected and how, if people get better at sorting waste, what happens then to emissions and what happens then to the profitability of CCS. If prices for emission allowances go up, what happens to the price of district heating if we do that, or if people become more inclined to choose heat pumps instead of district heating, what happens then? But it is a very limited project where they have chosen a restricted part of the energy system, but it is quite detailed, how large a part of residual waste, different types of garbage, and so on, so it is not a planning tool.*"
- Marcus describes a map to indicate the suitability of different establishments based on power-grid availability as well as estimated investment size for upgrading the availability: *"3 years ago we actually developed a plan that we presented to the Ministry of Public Works: that there is currently this much MW available for consumption in different places in the city, with this level of investment then we had level 2, 3, 4. Do we need to replace switchgear, transformer, build a new distribution station, investments of about 20, 50, 100, 150 million → then we can reach this. That you point out areas in the city where it is appropriate from the electricity grid perspective. Then how the recipient listens to it or where the establishment would prefer to end up, I do not know. We have developed that tool in any case. Tool is far too big a word, it is an overview map that says here it is inappropriate / appropriate. Because here there are approximately this many MW for a reasonable investment."*
- Energy System Models by Energy Modelling Lab that explore scenarios

- Forecasted scenarios developed by Skånes Effektkommission
- Maps of prevalence and potentials for different power generation types found in thematic additions to the comprehensive plan
- MARTES: A detailed calculation program för analysis of district heating and electricity production.

D. Results from Ranking Exercise

D.1 Ranking Exercise

Respondents were asked to give a score for each thematic category in terms of relevant feature or related content in a potential platform. They were asked to score between 1-5, where '1' indicates very uninteresting and '5' as very interesting to get help with from a tool. There was also an option to leave the score blank, as indicated with a '-'

Thematic Categories	**Score / Rank (1-5)**
Flexibility ● Energy storage, Support services, Flexible capacity of actors	
Maintenance ● Maintenance documentation, Repair needs, Spare parts availability	
Production ● Production profiles, Plant documentation/data, Status/Requirements, Potential for production types	
Consumption ● Consumer profiles, Energy demand trends, Opportunity for efficiency improvements	
Contingency planning ● Island operation, Security of supply	
New Construction and Decommissioning ● Detailed plans / planned projects, Project management, Electricity grid change, Spatial analysis	
Future Scenarios ● Population development / Fuel variation / Electricity / Emission prices, Electrification rate	

D.2 Results from Ranking Exercise

Respondent	Ronald	Victor	Lana	Melinda	Ralph
Score for Flexibility	4	5	5	4	4/5
Score for Maintenance	2	4	-	5	5
Score for Production	3	-	5	3	4
Score for Consumption	4	5	5	2	4
Score for Contingency planning	5	4	5	2	3
Score for New Construction and Decommissionin g	4	-	5	4	3
Score for Future Scenarios	4	5	5	5	4

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