Incumbent Perspective to the Sustainability Transitions: District Heating Companies and the Rise of Energy Communities

Marja Heikkinen
Faculty of Information Technology and Communication Sciences
Tampere University
Tampere, Finland
marja.heikkinen@tuni.fi

Tuomas Vanhanen,
Pertti Järventausta
Faculty of Information Technology and Communication Sciences
Tampere University
Tampere, Finland

Jussi Valta
Faculty of Management and Business
Tampere University
Tampere, Finland

***Abstract*— Energy communities and solutions are gaining more attention as a part of the sustainability transition. District heating (DH) companies are not traditionally part of those communities or solutions, although the literature suggests that DH companies should seek to develop prosumer-centric business models.. In this study, four different scenarios are created, each scenario with different involvement of DH company and DH. Four case studies are selected to shed more light on the scenarios and three main topics studied in this paper: Actor network, regulation and policy, and technology and material aspects. This study discusses the role of DH and DH company in energy communities and energy solutions, and how their involvement affects their revenue.**

***Index Terms*—district heating, energy community, energy solution, energy transition, socio-technical transitions**

I. INTRODUCTION

District heating (DH) has garnered increased attention as a vital component of the green transition, given that a considerable share of heating globally is produced with DH, and a substantial portion of DH, in global context, is still produced using fossil fuels. There is also notable potential for DH expansion to help reach the climate goals. [1], [2]

A. The evolving regime of District Heating

The development of DH takes decades. With every new generation of DH technologies, for example, energy efficiency improves, operational temperatures decrease, and the ability to integrate new energy sources increases. [3] In this paper, we consider the 4th generation DH as the state-of-the-art system that further developments are compared to. The new technologies include distributed heat pumps, solar photovoltaics (PV) and solar thermal collectors, which are growing in popularity in both apartment buildings and individual houses.

The change to a more distributed system is driven by climate policy, but also by companies, individual households, and housing companies that want to make their heat production and usage more sustainable and cheaper. This need for new solutions and will for greener heat and energy pushes the concept of energy communities (EC), community energy, and energy sharing. As buildings adopt these technologies and EC models, they may transform into prosumers or disconnect from the district heating network.

A few articles have investigated EC business models in the context of DH. Abugabbara et al. [4] review novel DH business models and find motivation for DH companies to develop prosumer-centric models. González et al. [5] propose a framework for thermal energy EC business models. However, both studies have limited focus on incumbents. On the other hand, recent articles have investigated the perspective of incumbents, such as Scharnigg and Sareen [6], on the diffusion of solar PV, and Shaviv et al. [7], who expect the influence of incumbents to diminish with the shift towards distributed energy systems. However, there is a lack of evidence related to incumbent perspectives on ECs in the DH context. Therefore, we analyze if and under what conditions could the District Heating System Operator (DHSO) play a constructive role in the diffusion of ECs.

B. The research question

This study aims to identify both the barriers and drivers for district heating companies in facilitating ECs and local or distributed energy solutions. We aim to augment the Sustainability Transitions literature by analyzing the state-of-the-art drivers of incumbent energy companies to partake in the development of ECs in the context of DH.

To pursue the goals of this study, our research question is formulated as follows: **What regime-level configurations lead DHSOs to transition towards different EC business models?**

II. THEORETICAL BACKGORUND

A. Socio-technical transitions and incumbents' responses

Wide shifts in the ways of producing, delivering and using energy are oftentimes seen through the lens of socio-technical transitions, and especially the framework of multi-level perspective (MLP) [7]. This framework sees society-wide transitions as an interplay between niche and regime actors who operate under landscape-level pressures. Essentially, regime-level actors operate in the prevailing socio-technical system, which includes stabilizing mechanisms, such as lock-ins to sunk investments and economies of scale. Regimes aim to maintain the status quo institutions or emphasize incremental technological developments instead of more radical ones. Regimes are composed of three elements:

- actors,
- institutions, like regulations and policies, and
- techno-economic elements, such as infrastructures, power plants and fuels [7], [8].

At the niche-level, new emerging technologies and business models are developed within markets that are unique or protected through regulation. Niches develop through building actor networks, learning processes, and articulation of expectations [9]. Naturally, these processes are interlinked, and, e.g., the composition of actors affects the articulation of expectations. Landscape pressures are exogenous forces (e.g., wars, climate change, and economic cycles) that create changes for these two lower levels. Typically, incumbents are seen as actors who resist change [3]. However, they can have multiple roles in transition [10].

As mentioned, incumbents can react to transitions in very different ways, and there are different transition pathways that they have different roles [11]. Depending on the pressure of landscape-level changes and the maturity of niche solutions, the transition that the regime faces can be either quick or slow and pose clear competition or, rather, a reconfiguration of regime elements. In a competitive scenario, the existing regime faces a substitute of the dominant technology. One example of this is the transition from internal combustion engines to electric vehicles.[8] In a hybridization scenario, the regime and niche blend together while both are transformed to accommodate the niche. Regime actors may partner with niche actors to gain a competitive advantage in the market and utilize regulatory changes to capture hold in emerging markets [12]. For instance, community-led energy initiatives typically adopt business-oriented practices and increased hierarchical processes as they fulfil, for example, the requirements of demand response markets [13]. In some instances, it is not clear whether the company entering the regime is a niche actor or a regime actor from an adjacent regime. For example, telecommunication and car manufacturing companies have an increasing role in the energy sector. These dynamics can be described as multi-regime interactions [14]. Here, regimes interact on different levels, relationships, intensities and impacts [8], [15].

B. District heating companies amid transition

District heating companies operate in heterogeneous contexts and face different kinds of pressures to change their business models depending on a range of factors, including company ownership and size, local economy and politics, legacy assets, available energy resources and regulatory matters [16]. For instance, the trend in population growth or shrinking affects whether the DH company has a capacity surplus or challenges and how the existing network requires updates. [17] Meanwhile, operating in the electricity markets with CHP units has changed remarkably due to the diffusion of variable renewable energy.

In any case, the sustainability transition forces the DH companies to couple more with other sectors: large heat pumps combine electricity and heating sectors, smaller heat pumps and solar increase building sector role, and demand response creates links to the transportation sector, telecommunications and buildings [18]. An increasing number of stakeholders and manageable resources create complexity and challenge the status quo. Instead of navigating the regime reconfiguration, DH regimes have typically orientated towards more incremental pathways based on centralized production and fuel switching to biomass. [18]

The wide range of systemic linkages the DH regime has implies that changes can have unintended consequences. In Rotterdam, long-term contracts, and investments to carbon-heavy sources for DH may lock in pathways (incl. carbon capture and storage) that contradict with more energy-efficient and renewable solutions. Also, transitioning to another heating source creates negative feedback loops to the replaced regime, which needs to be considered when alleviating energy poverty. In the Rotterdam case, this meant supporting citizens who were transitioning from natural gas to DH [19], but, in principle, the situation is similar in transitions from DH to electrification. Overall, making compromises between different policy goals is a challenge during the transition, and may necessitate policy mixes to answer the different targets [8]. For instance, cities gain economic revenue from the profits DH companies make, making new distributed solutions more problematic for them [18].

III. METHODS

We conducted a qualitative analysis of existing literature, utilizing the multi-level perspective framework, to evaluate four scenarios as described in the following section. We focus on selected case studies that shed light on the scenarios, and that include the perspective of incumbent energy providers and the development of energy communities.

A. Scenarios approach

The scenarios assessed are: A) business-as-usual (BAU) where district heating is the sole provider of heating, B) district heating coupled with building-level photovoltaic (PV) systems, C) a property disconnected from DH, that has established an self-maintained energy community with PV and Ground source heat pump, and D) the same as scenario D but the DHSO operates the energy community.

B. Qualitative analysis

Case studies matching the selected scenarios were picked from two reports (Leppänen and Järventausta [20], and Gollner et. al. [21]) that had a list and short description of energy solution focused case studies and pilots. First selection criteria

focused on the short description, and if the description included mentioning of district heating, ground-source heat pumps, energy community, PV or PVT, heat pumps or being an energy self-sufficient.

From the Leppänen and Järventausta report six case studies and from the Gollner et. al. report 16 case studies were chosen. From these 22 case studies four were selected for the evaluation. The four case studies were selected, because information and scientific articles were available from them, and the case studies aligned well with our scenarios.

The four selected case studies were: the EXCESS project of Kalasatama, Helsinki, Finland [22], Groene Mient area in the Hague, Netherlands [23], MAKING CITY project of Kaukovainio, Oulu, Finland [24], and Zero Emission Building (ZEB) Skarpens Smart Village, Norway [25].

TABLE I. SELECTED CASE STUDIES AND SCENARIOS

Case Study	Scenario
EXCESS project of Kalasatama, Helsinki Finland	C
Groene Mient area, the Hague, Netherlands	C
MAKING CITY project of Kaukovainio, Oulu, Finland	B
Skarpens Smart Village, Norway	C

Table 1 shows which case study represents which scenarios. Kaukovainio case study is part of the MAKING CITY project and includes in the piloted area four residential buildings and a shopping mall. All buildings are connected to the district heating but are all separate systems. Three of the buildings have similar systems, with heat pumps that are run with solar panels and the heat pump system can utilize the exhaust and return heat of DH. 4th building is owned by another company and uses the same heat pump system but does not have PV panels. Shopping mall has a compressor run with electricity that produces heat and cold for the shopping mall and when surplus situation, to the DH. [26], [27]

Kalasatama case study is part of the EXCESS project focusing on Positive Energy Buildings (PEB). This pilot is one building with geothermal energy well with heat pump, PVs, and PVT. [28], [29]

Groene Mient area in The Hague, Netherlands is a "Green Neighborhood" project, ne neighborhood is also used as a living lab. The neighborhood consists of 33 individual houses and a communal garden. The area is not connected to gas grid or district heating. All the houses are equipped with PV panels and some batteries are in place. The neighborhood is connected to the local electricity grid, and it is not operating as an island.

Skarpens Smart Village in Norway is a Zero Emission Building (ZEB) project. In the village five of the single-family houses are detached and working as a zero energy homes. Ground source heat pump (GSHP) covers the demand for heating and domestic hot water (DHW). Each building has also building integrated PV (BIPV) modules. Houses are connected to the electricity grid, and electricity can be sold to the grid and bought from the grid.

The case studies were evaluated by the corresponding scenarios, and three main topics in the evaluation were A) Actor network, B) Regulation and Policy, and C) Technology and material aspects.

IV. RESULTS

The results from evaluating the four case studies are presented in Appendix I. From the four case studies, three were closest to scenario C, and one for scenario B. A corresponding case study for scenario A wasn't found, but as the situation in scenario A is business-as-usual, other literature describing the normal situation was used. The other case studies and scenarios were evaluated against the scenario A. For scenario D a case study couldn't be found, but the evaluated topics are discussed in Appendix I.

The actor network in all the cases varies a lot, but some actors are still presented in almost every case. Actors such as construction company or technical component provider are necessary for property development and new solutions, but their active role might end when the building is done or when the technology is delivered. The actors that are either supporting the community or providing services to them have a more permanent role. In Kaukovainio case service providers have connection with the DHSO, which is also operating the system that the buildings have, having a smart control system for the energy system [26]. For electricity, all case studies are connected to the electricity grid, and that way the electricity market parties, and distribution system operator (DSO) are also considered as relevant actors [22], [30], [31], [32].

From the point of view of who or what started the change to new energy solutions, in the case study environment most of the cases were part of a funded research project, which gave the push to start making concrete actions. The city is also in the Kaukovainio and Kalasatama cases involved in the research. For Kaukovainio, City of Oulu adapted a Sustainable Energy and Climate Action Plan to reduce 20% of Oulu's carbon gas emission by 2020 [21]. Groene Mient is exceptional case compared to the others, as they had the initiative to change form the homeowners. After the neighborhood was build and running, an energy cooperative company and Groene Mient's home owners association (HOA) started to work together, and Groene Mient was used as a living lab for experimenting with smart grid. [33]

Regulation and policies vary across countries, but The Clean Energy Package and opportunities that it had for ZEB's, PEB's and energy communities can be seen from the case studies. In case studies of Kaukovainio, Kalasatama and Skarpens these are brought up as reasons why the energy solutions were made[30], [34], [35]. None of the case studies are classified directly as energy communities, but for Kalasatama case it is a work in progress, as the building in the demo is located nearby a similar demo building [29]. Also, in the Groene Mient's case study, energy community as a term is presented, and the neighborhood operates almost as an energy island. They have not been able to operate the smart grid fully successfully in the area, and the energy cooperative company has stopped working with the demo. [33]

Technological solutions are quite similar in all the case studies. To achieve PEB or ZEB type of buildings, they need to have some kind of electricity production. In all the cases, production came from PV. To addition to PV, also thermal PV collectors were installed. In the Skarpens' case study, a Building Integrated Photovoltaic (BIPV) was introduced [30]. In Kaukovainio case study PV's are used to run the HP's and excess energy can be fed to the DH grid and electricity grid [32]. Kalasatama case study has a semi-deep geothermal energy well combined with heat pumps, which is run with the electricity from PV. Excess electricity can be shared with the residents of the building and someday also with the neighboring demo building, as the energy community will be in place. [29]. Groene Mient's energy solution is more focused on electrifying everything, as the gas grid connection is more popular solution in the Netherlands. As the houses were build, owners were able to choose from three different energy solutions for their house. Every house has as a standard PV panels, but extra panels, HPs and solar collectors could be chosen. [36] In Skarpens case study the main goal was to cover the heat demand with BIVP system, and the electricity can be sold to the electricity grid [30]. Kaukovainio's case is the closest present of the 5th generation district heating and cooling (5GDHC) system, as the low temperature DH network is working in the area and the Kaukovainio's technology is build based on that [32], [37].

An additional note to the case studies is that the EXCESS project with a PEB is part of a bigger project of Smart Kalasatama, which is a larger piloting and development area in Helsinki, Finland [38]. The energy community that is mentioned with Kalasatama case study is under planning with another demo building in the Kalasatama area. It must be noted that bigger energy communities could also be formed in the area.

As previously stated, the regulations and policies vary, but in the case studies the role of municipalities is not brought up in most of the cases. In the Groene Mient case study they have mentioned that municipalities are involved, and an exemption for them have been made concerning the microgrid in the area [33].

The scenario D is constructed with the idea of DH company being involved in the energy solution, and it addresses some of the concerns that rise from the other scenarios form the DH company's side.

V. DISCUSSION

This study aimed to identify both the barriers and drivers for DH companies in engaging in ECs business models and local or distributed energy solutions. With a multiple-case method we find that DHSOs or other incumbent utility companies for that matter typically do not take an active role in EC developments. If they do, they seek to engage in an incremental development where their foothold of the regime remains strong.

External regulations, policy targets and strategic plans of companies such as property developers are among key drivers for DHSOs to take part in ECs. Rinne [26] notes that in the Case in Oulu, there is no regulation that would force new construction to connect to the local DH network. According to Billerbeck et al. [39] the regulation of DH varies between countries, and the policy framework of DH in Finland is more relaxed than in Case countries Norway and the Netherland. In the Kaukovainio Case, Finland, the local DHSO finds it beneficial to allow for a hybrid system where the customer uses only the low temperature return pipeline, due to benefits to the DH system. This allows for the property developers and the city organization to attain their PED goals and seek novel solutions and business models, while the DHSO still has a role to play in the development.

The initiative for energy solution seem to come more often from the construction company, or the property developer if they are not the same company. Two of the selected case studies are funded research demo projects, and thus do not represent in the same way how and who is the driver for the new energy solutions. In the Groene Meint Case initiative is from the people, and other actors have been collected around them, but as DH is not as popular in the Netherlands, the fact that DHSO is not mentioned in the studies is not surprising.

The link between electricity EC and the selected case studies is different for each case. Heat and DH solutions are not directly part of any EC, and because the systems are different, the communication between them is challenging. EC can be a good starting point for an energy solution, but as in Groene Mient's case, the regulation about energy communities has only come available since the neighborhood has been operating for a while. In the Kalasatama case a PEB is pursued in the project, and the idea of energy community has risen afterwards, as it is studied in [29].

In Case Kalasatama, the legislative framework in Finland changed during the project execution: from 2008 the city planners had the power to determine in the city plan if a property should connect to DH or include other energy technologies. The law MRL 57a was repealed in 2018. The Finnish Energy Industries advocacy organization commented on the proposal to repeal the law like this: "…it can be concluded that the [DHSO] companies do not consider the obligation to join necessary and often it is perceived as downright harmful for the image of DH." [40]

The transition to more distributed energy system and EC business models may encounter resistance from incumbents within the energy sector. This could be the case even if the incumbents could benefit from the transition themselves. For instance, Lygnerud et al. [41] showed that in Sweden DHSOs tend to see heat pumps (HPs) as competition rather than opportunity for the DH, although cost and efficiency gains would be gained by investing in HPs also for the DH system.

We argue that the DHSOs would be better off investigating the possibility of EC business models to maintain their relevance among those customers and shareholders who actively pursue novel smart solutions. Moreover, as the newly revised Energy Performance of Buildings Directive pushes buildings to integrate solar PV in their energy systems, the property developers might look into HPs instead of DH for the most lucrative concept, as seen in the case of Kalasatama. If a DHSO is not ready to take a role in EC developments, they risk losing market share and not being involved in the actor networks (incl. architects, financiers, insurance companies) developing the future solutions. Furthermore, such changes

could impact national and local government finances through reduced tax revenues and DHSOs dividends, as many of the DHSOs are owned by municipalities. If the District Heating System Operators' (DHSO) customer base would diminish it would lead to revenue losses and apply pressure to raise end customer heat prices, since the infrastructure cost would be distributed with less customers.

Future research could further investigate the revenue losses that DH companies might face if they are not involved in the energy community, and if the involvement would make up those losses.

VI. CONCLUSIONS

The involvement of DH and DH companies varies a lot between the cases. The availability of DH is not even discussed in some cases, and in others it is dismissed as the energy solution is sufficient to provide needed energy for the building or area. District heating is not typically seen as a part of the new energy solution or energy community, which complicates the study conducted on the matter.

For future research, the possibility of 5GDHC as a part of energy communities should be researched. Also, for the future research the role of DH companies in energy communities should be researched from the economical perspective.

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APPENDIX I. TABLE OF SELECTED CASE STUDIES AND SCENARIOS

Scenario	Country	Actor network		Regulation and policy		Technology and material aspects	
		Which actors are participating?	***What or who started the change?***	***How is heating or construction regulated in the cases?***	***What strategic objectives and policy targets guide the development?***	***Surrounding energy mix and infra***	***Production, distribution, storing, and consumption solutions?***
A		Property developer, Construction company, DHSO	No change	Typically, no obligation to join DH network. Minimum level energy efficiency requirements.	The Clean Energy Package, Energy Performance of Buildings Directive.	The availability of DH depends on the country and region.	No additional solutions.
B (Kaukovainio)	Finalnd	Construction company, DHSO, the City, technical component provider	A funded research and piloting project, the City Council	DH connection is voluntary for buildings.	Research results, proof-of-concept, climate action plans	DH, low temperature DH	Centralized HP, PV, two-way DH connection
C (Kalasatama)	Finalnd	Construction company, property developer a research institute, tehcnical componen provider	A funded research and piloting project, property developer, a research institute	Heating is not regulated. City plan required solar PV. Smart monitoring and control required in land transfer.	Local incumbent utility had carbon neutral target by 2050; societal pressure towards low carbon solutions.	Borehole flied, HP, large scale heat storage	Semi-deep geothermal energy well, HP, PV, PVT
C (Groene Mient)	The Netherland	Home owners association (HOA), energy cooperation, technical component provider	HOA, residents	No references about DH connection as an option, exemption of an electricity act	Environmental living	Gas grid, no mention about DH	Microgrid, PV, HP
C (Skarpens)	Norway	Construction company, property developer, technical component provider	Property developer, a research institute	No references about DH connection as an option, Norway's Passive House Standard	To stay at the forefront of development.	No mention about DH	PV, HP, BIPV, GSHP
D		DHSO as the EC operator or participant.	DHSO has an active role as an initiator, offering EC model to property developers.	No obligation to join DH. Low carbon construction materials become central in regulation.	ZEB framework, strong sustainability targets, smart solutions that enable digital ECs.	DH could still be used to provide peak demand or as a low temperature (return pipe) source for HPs.	Microgrid, PV, GSHP, alternative to use DH in smaller role.