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Sociotechnical imaginaries of resident roles: Insights from future workshops with Danish district heating professionals

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ABSTRACT

Technical research indicates that buildings can be used for short-term heat storage to peak-shave daily profiles in district heating. Increasing the energy flexibility of buildings implies new relations between demand and production – newly defined roles between residents and heating professionals. Heating professionals' understanding of residents is an important precondition for how these roles can be changed. To investigate this empirically, this paper reports from three future workshops where professionals from Danish district heating utilities, municipalities, energy companies and housing organisations discuss possibilities for including residents more actively in flexibility generation and more generally in district heating systems operation. The analysis focuses on the importance professionals ascribe to residents compared to other actors, the vocabulary professionals use to describe residents, and, most importantly, the rationales professionals ascribe to residents. Inspired by the notion of sociotechnical imaginaries, our analysis shows how the professionals imagine residents and ascribe rationales of autonomy, economy, comfort, involvement and sustainability to them. The professionals emphasise the first three rationales in particular. The conclusion points to the negative consequences such imaginaries may have for the future development of flexible district heating and proposes experimenting with various collaborative forms for engaging residents and professionals.

1. Introduction

A cornerstone of decarbonising energy systems is an increased use of renewable energy, notably solar and wind energy. Yet increased reliance on these intermittent energy sources complicates power system operation, as supply can no longer simply follow demand. Sector integration – the electrification of heating (and transport) – is considered an important means for real-time balancing of power systems, i.e. for providing the necessary system flexibility [1,2]. One way to generate this flexibility is to install large-scale heat pumps in the district heating (DH) system that utilise excess "green" electricity to produce heat. This means DH production will to some extent fluctuate with electricity production, calling for flexibility in the provision and use of DH.

The issue of system flexibility has been widely analysed in the context of electricity [3–5], and there is a growing body of literature quantifying the benefits of end-user flexibility in district heating [6]. An extensive review of the demand side management techniques in the DH networks has shown that the end-user flexibility has potential for reducing the peak load up to 30% as well as reducing emissions and costs up to 10% (strongly dependent on the system characteristics) while also reducing primary energy needs up to 5% [6]. Studies modelling the potential of building flexibility in Danish DH networks have shown that end-user flexibility has potential for economic savings in operational costs between 0.7% and 4.6% in a small city's, Sønderborg, DH [7]; for energy cost saving up to 11% for the customers in DH in Nordhavn, a neighborhood in Copenhagen [8]; energy reduction of 5.2% and 4.3%,

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respectively during morning and afternoon peak in DH in the city of Aarhus [9]; and energy reduction during heating season by 11% in Great Copenhagen DH [10].

The promising results of these quantitative studies notwithstanding, relatively little attention has been given to qualitatively explore the role DH consumers have in producing and storing heat or shifting their heat consumption according to the fluctuating availability of energy in the DH network [11]. According to studies [12,13], consumers of DH – buildings and their residents – should modulate their energy use based on the network status: the building should be able to use more energy when there is an excess of renewable energy production, and vice versa in the case of energy shortage. This means that in the periods of surplus energy from renewable sources, the building is in preheating mode, i.e. heat consumption from DH is higher than the heat demand necessary to meet residents' thermal comfort requirements, and the surplus heat is stored in the structural thermal mass of the building [14,15]. In the opposite situation, when the building is in discharging mode, no or very little heat is consumed from the DH grid and the heat demand necessary to maintain thermal comfort is met by utilising the heat stored in the buildings' thermal mass. However, the system flexibility buildings can provide depends on several things, i.e. location and climate, architectural qualities, age and characteristics of DH technologies, and infrastructure. It is also affected by the practices of the people occupying the buildings, i.e. the socio-temporal dynamics of their everyday lives as well as their willingness to activate the building [13,16,17]. Furthermore, undetected faults and errors may seriously affect system flexibility [18].

Visions regarding the role buildings and residents can play in providing the needed flexibility for decarbonising the energy system can be considered 'sociotechnical imaginaries' – widely espoused desirable futures based on shared understandings of what is scientifically and technologically possible [19]. Sociotechnical imaginaries are, however, entangled with social norms and expectations of what the future should bring. Many of the energy system imaginaries in circulation have been proposed by energy professionals, e.g. energy researchers, energy providers and policy makers. These imaginaries highlight increasing use of large-scale heat pumps in combined heat and power plants, developing low-temperature heating/distribution systems, controlling building heat use and peak shaving, minimising grid losses, etc. [20–22]. Implicit in these energy system imaginaries, however, are also certain expectations as to how residents will act and react to these possible futures. These expectations are important. Not only do they influence how technologies and policies are designed, they are also likely to affect how energy professionals interact with residents, which, in turn, can also affect how energy transitions occur.

Against this backdrop, this paper explores how key proponents of such energy system imaginaries envision residents in DH in the future. Professional actors' expectations regarding imagined residents, including how they are conceived of and how their rationales are understood, are likely to influence what roles professionals ascribe to residents. Accordingly, this paper seeks to answer the following questions:

- How are residents denominated by professionals engaged in the district heating sector?
- How do the professionals understand rationales of residents in the transition to a green and intermittent district heating system?
- What implications can such understandings have for the shaping of resident involvement in the future DH grid?

In what follows, we begin with a brief review of the literature on imaginaries of residents in energy systems. The following section introduces the methods of the future workshops (FW), and the main part of the paper presents our analysis and the discussion leading to our conclusions.

2. State of the art: mobilising residents in future energy systems

The future figures prominently in the literature on sustainable transition, e.g. in the narratives and tools presented by policy makers, business partners and/or scientific communities [23]. Within the field of Science and Technology Studies (STS), there is a longstanding interest in examining how visions of the future – imaginaries – serve as a means for reinforcing existing as well as creating new expectations regarding not only particular forms of technological development, but also sustainable transitions [23,24]. Work within this field also shows how technological development is shaped based on needs and behaviours ascribed to users by designers and technology developers [25–29]. In other words, future users are implicated in technology development processes even though they may not be actively engaged in these processes. Future users are implicitly included in what Jasanoff and Kim [19,30] have denoted "sociotechnical imaginaries".

Introduced to capture the complex intertwining of the social and the technical, sociotechnical imaginaries are defined as "*collectively held, institutionally stabilized, and publicly performed visions of desirable futures*" [19,p. 4]. The concept underscores how science and technology are co-produced with "*practices, identities, norms, conventions, discourses, instruments and institutions – in short, in all the building blocks of what we term the social*" [31,p.3]. Further, it directs attention to the ideas and ideals as well as the technological and material dimensions of societal transformations. Sociotechnical imaginaries are, however, both descriptive and prescriptive: descriptive in the sense that the desirable futures are tied to developments within science and technology; prescriptive in the sense that the imaginaries influence future practices through the ways in which policy and technology developments are based on particular understandings of technology use. This can lead to a stabilisation of presumed practices, unless users reject the role assigned to them by the technology [25].

The concept has been mobilised in several studies of energy transitions. It has been used as a means for exploring how various actors create visions for the future in the context of autonomous driving [32], the introduction of the smart grid in Norway [33], low-carbon housing and smart homes in the UK [34], the production of energy futures in Thailand [35], and micro smart grids in Germany [36]. Others have explored the energy imaginaries found in serious educational digital games [37]. Disparate as the empirical foci of these studies may be, a recurrent theme is the way in which users are portrayed in expert-based sociotechnical imaginaries through the language, arguments and representations used to describe the imagined users.

2.1. Experiences and imaginaries of flexible residents in the smart grid

Many of the imaginaries related to a sustainable future energy system deal with questions of flexibility. Regarding electricity consumption, experiments and research have shown the extent to which residential electricity consumption is flexible, e.g. several studies have examined time-shifting of practices such as dish washing and doing laundry, as well as cases of controlling electric heating (heat pumps) according to needs of the electric system [38–41]. These studies reveal that while residents may be flexible in some of their practices, the extent varies in accordance with how these practices are entangled with other everyday practices, as well as with peoples' competences and the technological setups.

There have been far fewer experiments and much less research related to district heating systems, although some examples exist [18,42,43]. Despite noticeable differences between electricity and district heating systems, some of the results regarding flexibility in the electric grid may be relevant in a DH context. It should, however, be noted that the relationship between DH utilities and their customers is different from customer-utility relations in the electricity grid. For one thing, DH utilities are local. Customers cannot simply switch to another DH provider, as they can with electricity utilities, who operate in much larger areas. Secondly, the technical options related to flexibility and storage are quite different. This implies that the two forms of energy company differ from each other, as do the challenges they face and their possible solutions. Further, it is worth noticing that demand side experiments with flexibility in the electricity sector began in the 1980s, and feasible solutions are still not at hand. Given this time lag and the urgent need for green transitions, it is thus imperative to test and develop new forms of resident engagement within DH while also learning from experiments in the electric sector.

Studies of (electric) smart grid projects conclude that the roles and visions ascribed to residents vary with local contexts. For instance, a case study by Skjølsvold and Ryghaug [44] compared smart grid approaches in various demonstration projects including summer cottages, newly build high-end smart homes and housing for elderly residents in need of health care services [44]. The study concludes that both residential context, including the type of housing and resident, and technologies already available have great impact on possible roles in delivering flexibility. Studies show that this is not a common perception within the electricity sector, which predominantly portrays residents as either a kind of highly rational, economically motivated ́Resource Man ́ (a term introduced by Yolande Strengers [45]), or as the complete opposite [46,47], as indifferent consumers who are disengaged, lazy, irrational and generally not interested in participating in the smart grid. One study, based on a large-scale Danish smart grid project, reports that the professionals involved generally spoke and acted as if residents were not interested. The potentials to be gained by engaging residents in the smart grid appeared only in political documents [48]. This suggests that the idea of the rational, active consumer, a Resource Man, is an invention of industry followed up upon in policy. A paper analysing communication from the European Commission explores the different visions expressed as well as the origins of these visions [49]. Analysis of both policy documents and the types of knowledge referenced in these documents shows a lack of scientific input. Instead, they build upon or align with industry discourses in which smart grid and smart technology are heralded as the way to address a variety of problems, including economic growth, sustainability and energy security [49]. It has also been shown that smart home technology developers generally have low expectations regarding resident interests in the energy efficiency aspects of smart home technologies. Instead, they see convenience, atmosphere and aesthetics as sales arguments [50].

These social science studies researching how smart grid professionals understand residents generally have a critical approach, and some of them also suggest alternative characterisations/conceptualisations, such as Energy Citizens, to describe residents who engage in the smart grid for reasons other than financial gain and efficiency [51,52]. Examples of this include smart grid projects where people engage because of issues such as local interest and sustainability [52]. One article also reports that residents identified as prosumers, rather than consumers, become more engaged in transforming their everyday practices to ensure a low-carbon transition [53]. These findings resemble those of how liberalisation of energy and water provision provides utilities with opportunities for differentiating their services and for moving from “captive consumers towards customers, co-providers and citizen-consumers” [54].

Parallel to these differing views is the terminology smart grid professionals use when referring to residents. One paper reports how electricity utilities once spoke about residents as “load units”, but have since changed and begun talking about them as “customers”, “resource units” and sometimes even “prosumers” [50]. The terminology used by smart grid professionals when referring to people as consumers, customers, users or citizens is not a matter of mere semantics [49]. Such speech acts [55] are an important and significant contribution to the understanding of future residents and what can be expected of them. In the present paper, we use the word resident as a comprehensive term, to denominate the people living in buildings without explicating their role in the energy market as either consumers or customers, or their role related to technology developers as e.g. users or co-developers.

3. Methods

Three future workshops were conducted between September and October 2018, with a total of 36 representatives from municipalities, utilities, housing associations, private companies, universities and technology developers. The aim was to invite central actors within different professional fields of experience and expertise to discuss challenges, potentials and implications for the realisation of a future intermittent district heating system.

The future workshop method, originally developed to support democratic, participative and collective decision making among community groups about a shared future [56], is widely recognised as a method for engaging citizens and other stakeholders in deliberative processes. As we have noted previously [57,58], future workshops have not to our knowledge been applied in the context of DH transition. Moreover, as a “new application” of an existing method [59], we have used the FWs as an inter-professional arena where various professionals within the DH field can express, share and discuss their ideas about future challenges and potentials of DH. Thus, the point of the FWs was to facilitate communication between professionals, not between DH residents.

Given that DH systems vary in size (service area, number and type of customers), age of technology and infrastructure, the workshops were situated in three different locations in Denmark, including the capital, a large provincial city and a smaller city in the countryside. These locations were chosen for their progressive and experimental approach in developing their DH systems. However, the size and types of buildings supplied in each location vary, e.g. more blocks of flats in the cities and more detached houses in the countryside. The method for selecting participants within each of the three DH systems was based on asking local actors to identify participants who are interested or engaged in DH transition. We augmented their suggestions with our own, based on our knowledge of relevant stakeholders within DH. Thus, the FW participants were not chosen to be representative of all actors in Denmark related to DH, but to represent a variance in DH actors among those generally considered to be at the forefront of developing new solutions. The authors of this paper participated in the FWs (as did two of our research partners). The researchers' role in the FW was to facilitate the discussions and keep them on track – in accordance with the FW activities. Results from these FWs have been previously published in two publications [57,58]. One paper, [57], provides a broad introduction to the project and its aim, and highlights some preliminary conclusions from the FWs, while the other, [58], uses the FWs to discuss the role of middle actors in the green transition. Although these two papers report on the same empirical material as this paper, their foci differ.

We have used the term sociotechnical imaginaries [19] in this article to argue that energy system imaginaries, and how these are constructed by various actors, have implications for future actions, as the imaginaries will also include certain expectations of the residents and the role they can play. In our study, the FW serves as a practical context for studying how the participants verbalise different visions for residents in DH. In this study, FW data gives us an opportunity to investigate shared and/or individual imaginaries in relation to (imagined) resident desires and rationales. The FW participants articulated the imaginaries as they engaged with each other's arguments while collaboratively developing visions for the future.

Our specific FW design is inspired by the ACTVOD-future workshop model [60], which comprises an explorative, normative and solution-oriented approach. Each workshop lasted 3 h and consisted of three phases outlined in Table 1. First, the participants were asked to identify and then prioritise which actors, technologies and infrastructures they considered the most important in transitioning to a more flexible DH system. Second, they were asked to visualise how to accommodate major challenges to ensuring DH flexibility. Finally, they were asked to discuss their visions for the future. The FW design did not call specific attention

Table 1
Instructions given to participants in each FW phase.

FW phases	Activities (Participants work in groups of 4–6)
Phase 1: mapping, identifying and prioritizing actors	Participants were instructed to: 1. brainstorm individually about key actors needed to realise a transition to a more flexible district heating system (each actor written down on a separate card). 2. map and prioritise actors on a concentric circle according to their importance and role in realising a future intermittent district heating system. The innermost circle represented the highest priority, and the outermost represented the lowest priority (see Fig. 1). 3. attach small post-it notes to each actor describing what they perceived to be central challenges for the specific actor in relation to the realisation of a future intermittent district heating system.
Phase 2: visualisation of visions	Participants were asked to: 1. identify and describe two significant challenges among the challenges they encountered in phase 1. 2. draw visions for how to accommodate these two challenges in a possible future.
Phase 3: critical discussion of visions	Participants were asked to: 1. present their visions in plenum among all groups. 2. discuss in plenum the feasibility, challenges and potentials of the presented visions and implications for future actions.

to residents or any other group of actors. Instead, it was up to the FW participants to decide which actors and technologies would be relevant in the future transitioning of DH. Methodologically, this implies that the design makes it possible to investigate how residents are understood by DH professionals when imagining and discussing the future(s) of DH.

3.1. Data and methods for analysis

The participants' (group) discussions were audio- and video-recorded and have subsequently been transcribed into more than 540 pages. The following analysis is based on the transcripts and on the visuals of the participants' mapping of DH actors (see Fig. 1). The data has been coded based on open- and axial coding from a Grounded Theory approach [61]. In order to understand how professionals related to the district heating sector conceive of residents, and how professionals understand their rationales and ascribe agency to residents in transiting to an intermittent DH system, we used open coding on all transcripts. Based on the process of open coding, we identified five recurring rationales, namely autonomy, economy, comfort, involvement and sustainability, as well as approximately 21 ways of denoting residents. Through a process of axial coding, we developed sub-categories not only to understand different levels, or nuances, within the rationales, but also to understand their interconnectivity: how the rationales were connected and sometimes overlapping. In coding the data based on a Grounded Theory approach, we allowed the data to guide us inductively rather than forcing a perspective onto the data.

The coding system Nvivo was used to identify the most prevalent terms and wordings used by the workshop participants. The programme automatically creates a numerical overview of the references (or statements) that have been coded into a category. As such, the analysis has both a qualitative and quantitative side, in the sense that the numerical value also gives an indication of the importance of certain terms and understandings.

In what follows, we use abbreviations containing workshop number (I, II and III), field of participants (municipalities (M), social housing (S), private companies (P), utilities (U) and “others” (O) (encompassing sustainability representatives, sustainability managers, “green change agents”, etc.)) and participant number (1–26). A full list of FW participant reference abbreviations can be found in Appendix A.

4. Analysis

The analysis includes multiple steps. First, we briefly report on how the FW groups rated residents in terms of importance and we analyse the vocabulary used to describe residents. Following this, the main part of the analysis explores the rationales ascribed to residents.

4.1. Importance and denomination of the residents

The FW participants were asked to identify and rank the most important actors for realising the intermittent DH system. The findings show that six of seven groups rank two types of actors as most important, namely utilities and national politicians/authorities. Additionally, four groups rank two other categories of actors as most important, namely providers of housing (such as housing associations) and residents. Other actors identified – approximately 50 different actor types, including janitors, tech companies and researchers – are all considered to be of less importance. Thus, while professionals in the FWs generally view residents as important for realising an intermittent DH system, they are considered less important than utilities and politicians & public authorities.

When referring to residents, participants use various referential terms such as users, citizens, customers, households or residents. These terms are not neutral or innocent, because they have implications for the

Fig. 1. Concentric circles used by participants in phase 1 to map and prioritise actors as well as associated challenges on post-its. These photos have been previously published in [57,58].

Table 2
Denominations used by FW participants to describe residents and their frequency of usage in all FWs.

Resident denominations	Frequency
Consumers	80
Customers	53
Users	38
Residents	30
People	18
House-owner	17
End-users	14
Landlord	13
Housing association	11
Citizen	9
Tenant	8
Building owner	7
Homeowner	7
Danes	6
Owner	5
Household	4
"Champion"	4
Detatched house owner	2

Table 3
Overview of FWs' participants denomination of actors according to profession.

	Consumer	Customer	User	Resident
Utilities	20	24	12	0
Municipality	7	9	0	7
Private company	18	13	12	1
Social housing	14	3	9	9
Others	21	4	5	13
Total	80	53	38	30

professionals' understanding of whom the DH system serves as well as for their understanding of the relations between professionals and non-professionals in the DH system.

In the FW transcripts, a total of 21 denominations have been identified. The most frequently mentioned denominations are *consumers*, *customers*, *users* and *residents*, all of which are mentioned more than 30 times by workshop participants (see Table 2). Other terms such as *people*, *end-users*, *landlord*, *citizen*, *tenant*, *household* and *end-consumers*, are mentioned 18 times or fewer. Several other descriptions are used only once or twice.

Table 3 gives an overview of the four most frequent denominations, their frequency and the professional field of the participants providing the denominations.[1] The utility professionals included employees from engineering, management, sales and services departments. The professionals from the municipalities included energy planners, municipality consultants and building constructors. Private company representatives included energy & QMS managers and technical consultants. The social housing companies were represented by managers and coordinators. Finally, the group of other-professions includes NGO-representatives as well as climate, energy and sustainability consultants. For a full list, see Appendix A.

With 80 mentions in the workshop transcriptions, *consumers* is the most widely used term, and most readily used by participants from the utilities and from the group of "others". The second most frequently mentioned denomination is *customer*, which was also most commonly mentioned by the utility professionals and private company professionals. *Users* is the third most employed denomination and is used equally often by the utilities and private company professionals. No professionals from the municipalities mention users. Social housing representatives and others mostly use the term residents.

It is worth noticing that the two most common terms; consumer and customer, both indicate a market-relation where processes of selling, buying and consuming (heat) are central. In contrast, the term citizen, which indicates rights and responsibilities in a community, is used much less frequently. However, it should be added that the terms consumer, customer, user and resident also seem to be used somewhat interchangeably. The terms may thus cover processes of buying and paying, but also actions in the home such as opening windows or fiddling with the ventilation system. Very strict correlations between denominations and specific actions or processes performed cannot be observed.

The analysis also shows that the individual FW participants at times adopt the terms employed by others in the interactional exchange. Thus it appears that workshop participants may be influenced by each other. If one participant defines a resident as a consumer, other participants will use a similar term, as illustrated below.

II.P.15	That was also the **customers**
II.U.3	That was the **customers**
II.P.14	That was the **customers** (..) archi (.) okay so we divide them into architects and building constructors (writes on card)

Although continuing to use the resident denomination previously introduced in the exchange was common, this wasn't always the case, i.e. participants would sometimes change the denomination, as illustrated below:

III.O.25	So, your **consumers** actually have the overall power
III.S.22	In principle, the **residents** decide what is going to happen […]

This example suggests that not all participants are influenced by each other's descriptions over the course of the conversational exchange. Furthermore, there are instances where FW participants attempt to influence the remaining workshop participants so as to ensure overall common understanding, e.g. when one workshop participant asks if residents can be defined as "consumers" (III.M.11).

4.2. *Rationales ascribed to residents*

While workshop participants repeatedly discussed the role of the residents in an intermittent DH system, they also talked about what the residents' future needs and desires might be. In these discussions, different understandings of residents are expressed: how they think, what they care about, and what concerns and needs they may have. We label these understandings rationales. Although they vary individually among the FW participants, some patterns in the participants' understandings of residents can be observed. The rationales were identified inductively based on workshop participants' statements about the residents. Thus, the analysis did not proceed from rationales predefined by the researchers but has inductively sought to identify the rationales articulated by the professionals in the FWs.

In the course of the open coding process, five key rationales were identified: *autonomy*, *economy*, *comfort*, *involvement* and *sustainability*.

Table 4 gives an overview of the (numerical) frequency of each rationale. It shows that the autonomy rationale is the most frequently invoked, while the sustainability rationale is discussed less frequently. This observation does not imply that the first rationale is more important than the latter, but it is an indication of FW participants' focus. It is also worth noticing that some rationales are addressed at several workshops, while others, particularly sustainability, are only addressed in three workshops.

4.2.1. *The rationales of residents as perceived by the professionals: autonomy*

The *autonomy* rationale refers to statements in which the residents are seen as concerned about others using their data because it may rob

[1] The counting reflects the number of times a participant uses a certain term. Thus, when a participant uses the same term several times within one turn (or reference in Nvivo), it is only counted once in order to give an appropriate overview of the terms' frequency across the whole FW interaction. Moreover, we have not counted researcher-statements from the workshops.

Table 4
Numerical frequency of rationales at the 7 workshops.

Rationale	No. of workshops where discussed	Number of references
Autonomy	6	23
Economy	6	13
Comfort	5	12
Involvement	4	12
Sustainability	3	4

them of their autonomy and individuality. Recurrent issues pertain to private data and ownership, how others should use the data, and the means to act independently as an individual. There is also a single reference to surveillance.

The autonomy rationale refers to two overall aspects: acceptance of control and acceptance of change. The former is by far the most frequently discussed, and the key issue is how residents would react to having e.g. their indoor climate controlled by others. As one participant put it:

> "*But I think the other big challenge is that the end-user has to accept that they will be remote-controlled.*"
>
> (III.O.25)

Several other participants had the same expectation. This expectation is argued with reference to the participants' experiences with resistance to outside control:

> "*You already have a hard time accepting that there is someone from the outside of your home controlling something in my house.*"
>
> (III.O.25)

The other aspect of the autonomy rationale, acceptance of change, centres on the idea that residents need to be persuaded to accept changes that would reduce their autonomy, because as one participant argued:

> "*there is a limit to what they* [the residents] *will accept*"
>
> (II.O.24)

Another maintained that lack of information and proper communication about the changes would result in "outcries" from the residents (III.S.20).

The two aspects of the rationale overlap when the workshop participants discuss data ownership and what residents are willing to share. A utility representative contends:

> "*it is not necessarily that you collect data, it is more the question of who has access to that data if you only have [inaudible] if you have your own data and someone can see something there and then you yourself choose which you want to share.*"
>
> (II.U.5)

According to a participant from social housing, residents would not be keen to have others view their data because the viewer would be able to deduce "something" from it. As another participant describes it, being able to view residents' data may enable them to

> "*... see where they are growing pot* [skunk]"
>
> (I.S.17)

The autonomy rationale is the most frequently expressed rationale in the workshops. In all but one of the seven groups, the workshop participants articulate the autonomy rationale in one form or another.

4.2.2. The rationales of residents as perceived by the professionals: economy

The *economy* rationale contains statements in which the workshop participants expect the residents to be focused on their private economy, concerned about energy bills and motivated by price measures. For example, it is suggested:

> "*if the consumer saves 10 % of their heating-bill, it will be beneficial for them financially, yes, however, then we have a [inaudible] that they are happy to live with us because we are also interested in providing them with cheap district heating*"
>
> (II.S.18)

This participant expresses an expectation of what residents desire and what it would take to create a favourable environment for them to live in. Many of the other statements regarding the economic aspects show a similar pattern but vary in terms of what the FW participants expect the residents to desire. Some participants believe that residents have explicit financial desires, as indicated in the quote above. Others state that incentives – "carrots" – are, in general, more desirable. A "carrot" represents a financial benefit to motivate residents to allow remote-control of their heating so as to enable e.g. heat storage. The workshop participants expect that the carrot will be necessary for residents to be motivated and cooperative. As a municipal participant exemplifies:

> "*Yes, yes, but um, he owns the building yes and he is the one who rents it (.) but he needs to have a carrot and that is the economy.*"
>
> (III.M.11)

Many FW participants refer to experiences with residents who have been frustrated or confused about their bills and payments.

The economy rationale is expressed with different degrees of strength. Thus, it ranges from being described as the most important issue for residents, to being modified as important "often" or "for some" residents. When articulated, it is mainly ascribed a high degree of importance, and it is one of the most frequently used rationales in the workshops. It is articulated at six out of seven tables during the workshops.

4.2.3. The rationales of residents as perceived by the professionals: comfort

The *comfort* rationale is expressed in statements about residents' presumed need for a desirable indoor climate. Most statements concern the idea that residents feel a need to have a certain temperature in their homes to feel comfortable, and the statements are often expressed in relation to control. As an example, a participant from social housing states:

> "*We have a ventilation system with heat recovery (.) the residents that are not satisfied will cover it [the ventilation-system] with tape (.) so they are broken.*"
>
> (I.S.17)

This quote exemplifies how dissatisfied residents may intervene and even sabotage heating technology. In keeping with this view, another FW participant noted how users need to have autonomy and control of their indoor temperature, otherwise they will simply open the windows (III.O.27). By opening the window, residents are taking ventilation into their own hands, but according to several participants, this is likely to cause a temperature decrease that may affect the heat- and ventilation system. Thus, according to some participants, the practice of opening the window is undesirable.

Other FW participants simply state that

> "*the indoor climate has to be good*"
>
> (I.U.2)

without any further description as to why or what the consequences may be if the climate is not "good".

However, for the most part, the issue of comfort is related to either having a "good" indoor climate or being in control of it. Comfort is related to other priorities in only one instance: according to one utility-manager, when asked whether they would prefer to invest in a new kitchen or to invest in environmental measures to meet the newest energy standards

"*they [the residents] would rather have a new kitchen*"

(III.U.6)

In terms of frequency, comfort is a key rationale, and is mentioned/ discussed in five of the seven workshop groups.

4.2.4. The rationales of residents as perceived by the professionals: involvement

The *involvement* rationale has to do with the interest of residents in being involved in the development of energy-related and environmental measurements. Many of the FW participants share their experiences with users who

"*do not want to be involved*"

(I.U.2)

The same utility participant concludes:

"*we [they] simply do not have the interest, that is what I want to say (.) if we could get them to be involved (.) especially about energy use*"

(I.U.2)

Similarly, another participant contends that residents have no interest in energy and in optimising the operation (I.M.7). When involvement is discussed, most of the participants agree that residents are just not interested in being involved. However, there are exceptions: one participant suggested that if residents had the opportunity to log into a website and view the details of their estate and energy use, then they would perhaps be more inclined to be involved since they would not have to

"*go down to the basement and polish his glasses to look at some form of metre*"

(I.P.12)

Thus, resident involvement is seen as partially dependent on communication technology.

Highly engaged and passionate residents are another exception mentioned by a few participants.

Involvement is discussed at four out of seven tables, which leaves involvement the second-least frequently mentioned rationale in the transcripts.

4.2.5. The rationales of residents as perceived by the professionals: sustainability

The rationale *sustainability* covers statements regarding residents' motivation to be more environmentally considerate and sustainable in their living quarters. Perhaps surprisingly, this rationale is the least frequently discussed of the five rationales and it is always discussed in relation to other rationales, particularly economy and involvement. The participants express scepticism about residents' environmental motivation when it comes to changing the DH system. For example, as one claims:

"*Homeowners do not want to take risks, why would they unless they are green all the way through*"

(III.O.26)

On the other hand, residents are also said to generally be in favour of green measures:

"*… completely regular people who (.) who has an economy just like the rest of us also sit and think (.) well it is not because I have anything against being green, I would really like to be green.*"

(III.S.21)

This allows room to address the environmental benefits when communicating with residents about DH changes:

"*and here the argument has to be, of course, first of all the price will be lowered and secondly we will have a better environment*"

(III.O.25)

This also illustrates how the sustainability rationale is co-articulated with the economy rationale. Similar discussions regarding whether residents must be financially compensated in order to accept new environmental measurements, or whether differentiated electricity fees would further environmental measures, indicate that the workshop participants expect residents to be more willing to accept new environmental measures if they are financially compensated. Sustainability is, however, the least frequently invoked rationale.

This overview has shown how DH professionals cast building residents as consumers, customers, users and residents who are subject to different rationales – autonomy, economy, comfort, involvement and sustainability. Unlike the other rationales, involvement is fairly straightforward: while economy, autonomy, comfort and sustainability are considered rationales that may or may not drive residents, involvement is generally considered something residents do not want.

5. Discussion

We have analysed and identified the most common rationales ascribed by DH professionals to residents concerning their engagement in a future intermittent district heating system. In the ensuing discussion we focus on how the different understandings of resident rationales are likely to include certain ideas of a future DH grid and exclude others. Further, we discuss how our findings relate to other studies of future users' engagement with infrastructural systems, e.g. the smart grid.

Our findings on stakeholder perceptions of resident rationales are in line with other studies. Research on smart grids reports on several of the rationales we have identified [46,47,52]. We augment this work by documenting that these rationales are also found within DH, i.e. within another infrastructural domain. Further, what is different in our approach and analysis is that we juxtapose rationales by looking at what is expressed across a large group of actors with different professional backgrounds. We have been able to identify differences in the professionals' perception of resident rationales. It is nonetheless striking how the five rationales and the views they represent on resident engagement are rather similar across different professions and rather firmly anchored in certain understandings and views. If one considers current practices, as well as future practices, to be affected by the sociotechnical imaginaries in circulation, then rationales about users and how these are constructed by different actors have important implications for the design and politics of future energy systems – with regard to both how these are constructed and which roles residents are assigned in such a future [19,30]. In the following we highlight central aspects of firmly anchored views on resident engagement across professions and discusses their implications.

In the FWs, the involvement rationale is mainly considered in terms of residents' lack of interest in being involved in DH changes. They are assumed to have limited or no interest in energy itself or in system operation. Many of the professionals report on their own disappointing experiences with resident involvement. In a few instances, residents are imagined as being interested in information on their consumption if it were easily accessible through communication technology. This is in keeping with many of the information campaigns utilities have developed to encourage residents to operate their heating systems more efficiently to reduce temperature levels and enable load shifting.

In general, residents are understood as receivers of information, technologies, systems and energy rather than as actual or potential partners. This one-way directionality is underpinned by the most frequent denomination of residents across all seven workshops as either 'consumers' or 'customers'. This indicates that market relations are central in the relation between DH professionals and residents, as is also seen in the electric grid [49]. Residents are, thus, considered receivers of what the market and energy/heating system has to offer, which excludes a view of residents as individuals with diverse and individual practices, routines and rationales. Furthermore, residents are also considered direct obstacles for developing a more flexible DH system in the future. This view of residents as receivers, consumers and customers appears to limit more active forms of resident engagement in the development and strategic planning of future systems [52]. We see this as problematic, since a lack of user engagement and user participation in system development has historically led to misuse, rejection or workarounds of the technical systems, consequently resulting in a failure to realise energy saving potentials [62].

What is important to highlight here, however, is that even though the professionals at the FWs acknowledge the need for engagement, their view of engagement is as something that is directed from one actor to someone else, and not as two-way collaboration. This is apparent in the FW participants' discussions of how frustrating or difficult resident involvement is, due to residents' lack of interest, motivation and knowledge about systems. Resident motivation is often coupled to price/monetary measures (e.g. differentiated tariffs). These are considered 'carrots' that can provide residents with a financial incentive to allow remote-control of their heating and heat storage. This is considered a necessity in order for residents to be motivated and cooperative. Again, this represents a perception of motivation as something that opens the door for allowing specific deliverables to be implemented or controlled from the production side. As such, engagement is achieved through economic incentives. In other instances, economic considerations are seen as unimportant or not interesting for residents. These findings are in line with current literature focusing on the electric grid that reports that residents are understood either as a kind of highly rational, economically motivated Resource Man′ [45] or, in complete contrast, as indifferent consumers who are disengaged, lazy, irrational and generally not interested in participating in the smart grid [46,48]. We argue, however, that the rationales for engagement related to motivation, economy etc. need to be more nuanced in future imaginaries in order to promote and articulate the diversity of resident rationales rather than perpetuate black and white propositions. Research shows, for example, that questions of economy and sustainability are interwoven and always contextual [38,53]. Such understandings are imperative to include in the future, because ensuring DH flexibility is likely to call for resident engagement rather than passivity. Although information and financial campaigns are important means for optimising resident behaviour in accordance with energy system requirements, these measures do little to change existing practices [63]. Developing and designing more diverse formats for resident engagement through e.g. gamification [37,64], living labs [65] and co-design [66] may have the potential to solicit more engagement (rather than just acceptance). This can, in turn, lead to changes in practices that are supportive of the systems changes needed. Future modes of resident engagement, solutions and systems need to match residents' situated contexts and diverse motivational structures.

The discussions about the autonomy rationale in the FW refers to two overall aspects: acceptance of control and acceptance of change. In several instances, residents are seen as reluctant or unwilling to allow their indoor climate to be remotely controlled, and their acceptance of change is considered limited. This centres on the idea that residents need to be persuaded before accepting a change that implies a reduction in their autonomy. It is also noted how a lack of information, or poor communication about changes, is likely to result in "outcries" from the residents. Taken together, this suggests an understanding of resident engagement as something that must be initiated by the production side, through persuasion and/or the right information, in order to reach and engage with the consumption side. These findings are comparable to results from research on smart home technology developers, and how they generally regard residents' interest in the energy efficiency aspects of smart home technologies as low. Instead, they see convenience, atmosphere and aesthetics as sales arguments [50].

The comfort rationales ascribed to residents revolve around their need to have a certain temperature in their homes to feel comfortable and are often expressed in terms of being in control. The participants also draw attention to how residents may intervene to disable heating technologies if they do not feel satisfied with the indoor climate these technologies provide. In a sense, residents are understood as quite engaged when it comes to home comfort, since they can choose to override technology and control their own home environment even if it is at the expense of cost savings. Thus, the professionals express, on one hand an understanding of comfort as a static, objective and measurable state (of temperature) to be delivered, which stands in contrast to an understanding of comfort as a context dependent feeling, where temperature demand varies with materiality, activity, norms and culture [67,68]. On the other hand, the professionals also agree that comfort relates to the ability to be in control, which stands in contrast to a linear objective relation between indoor temperature and comfort [69].

In order to increase the flexibility of DH in the future, it can be argued that a paradigm shift is needed – from production following consumption towards consumption following production. Our findings show that the prevailing understanding of residents and their rationales among the energy professionals at the FWs is consistent with the existing production following consumption paradigm, i.e. where heat is delivered from the system – the utility companies and technology providers – to the residents. However, in realising a future flexible DH system that relies more on consumption following production, it is imperative to test and develop new forms of resident engagement within DH that enable the creation of new understandings and practices. The strategies to activate residents must be tailored to meet the requirements and particularities of both the residents and DH technologies and infrastructure. This may prove difficult, given prevalent views of resident engagement as difficult, disappointing, or something that must be incentivised through economic gains, etc.

As pointed out by Vesnic-Alujevic et al. [49], there seems to be a lack of scientific input and knowledge about residents in political documents related to smart technology and flexibility in energy consumption. We see a similar lack of scientific knowledge or at least a lack of more nuanced knowledge about residents' practices, motivations, rationales and forms of engagement in the discussions among our broad representation of professionals in the FWs. Research about households and how they may be flexible in some of their practices already exists [38–41] as does knowledge about economic rationales, comfort etc. [38,67]. This knowledge needs to be taken into account in the context of flexibility in district heating.

Although one could contend that professional opinions and articulations may have changed since we conducted our study, our emphasis has been on documenting the *shared* imaginaries of resident roles and rationales that district heating professionals developed in conversations about the challenges associated with engaging residents in increasing system flexibility. Such collectively developed understandings are, however, less likely than individual opinions to change over a relatively short span of years. Substantial changes in the roles residents can have in the district heating system have yet to be seen, further suggesting the significance of the imaginaries.

As such, we see a need for further research that can help articulate, use and promote alternative sociotechnical imaginaries among energy professionals and politicians. These additional imaginaries need to represent residents as individuals with complex social practices and rationales. Although there are studies documenting this (in contexts other than DH), more work is needed on introducing these insights to energy professionals. The goal of promoting additional and more nuanced imaginaries should be to offer a contrast to the currently dominant expert-based sociotechnical imaginaries [30,32,33,37]. As argued, how we talk about residents is not just a question of semantics. Since imaginaries, and as such the ways in which these are constructed, contain both ideational and material dimensions, they simultaneously emphasise ways in which the desired future(s) can be achieved [19], based on shared understandings of what is scientifically and technologically possible. From the FWs it is clear that it is important to engage residents. They are, however, considered in a specific way, namely as gatekeepers to change, who might reject or accept, engage with or destroy what the DH system offers, and/or act rationally or irrationally to new possibilities.

6. Conclusion

This article set out to investigate how professionals in the field of DH view residents as users of DH. The empirical basis is a series of future workshops with DH professionals at different locations in Denmark. The findings show that the participating professionals generally consider residents important for realising a flexible DH system, although they are considered to be less important than utilities, politicians and government authorities. Residents are seen as essential primarily in the sense that they have the potential to disturb new DH initiatives.

Secondly, the analysis shows that DH professionals use different terms when denominating the residents, and that these terms vary somewhat with interactional context, i.e. the term used by the previous speaker. At the same time, it is evident that the terms ‘consumers’ and ‘customers’ are the most dominant denominations of the residents. Both terms indicate that market relations are central in mediating the relation between DH professionals and residents.

Thirdly, the analysis identifies different rationales that DH professionals ascribe to residents with respect to DH. The rationales autonomy, economy and comfort are the ones most frequently ascribed to the residents. Less frequent rationales are sustainability and involvement. This indicates that the professionals perceive residents as concerned primarily with maintaining autonomy over their household heating, saving money or at least not having extra costs because of system-related changes, and ensuring a pleasant indoor temperature. Concerns about sustainability or the environment are mentioned in the FWs, but they are not seen as strong drivers for residents, but rather as something that may strengthen other drivers. Moreover, the involvement rationale is mainly used to characterise residents' lack of interest in being involved in DH changes. Combined with the findings on the importance of residents, this leads us to conclude that the professionals do not view residents as potential partners in developing a flexible DH system, but rather as an obstacle to realising it.

Previous studies within energy systems have included analyses of resident rationales [47–50]. This paper, however, contributes to these discussions by considering these different rationales and their interplay, and by extending this kind of analysis to another empirical domain, the DH sector, rather than focusing on the electrical grid. Given that new roles for the production and consumption side are essential for the realisation of a future flexible DH system, these rationales and imaginaries circulating among energy professionals may hinder the envisioning of other modes of engagement, thus limiting the development of future relations and technical systems in DH. Based on the analysis in this paper it can thus be recommended to start experimenting with new ways of involving not only residents, but also various professionals in thinking about and practicing flexibility in residential heating in different ways.

Declaration of competing interest

I hereby declare that none of the authors have any conflicts of interest related to this publication.

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Appendix A

	Workshop number	Participant definition	Participant number	Reference
Utilities	I	Utility manager	1	I.U.1
	I	Utility-chief engineer	2	I.U.2
	II	Utility manager, sales & service	3	II.U.3
	II	Utility manager	4	II.U.4
	II	Utility-IT team coordinator	5	II.U.5
	III	Utility manager	6	III.U.6
Municipality	I	Municipality-climate secretariat-energy planner	7	I.M.7
	III	Municipality planner	8	III.M.8
	III	Municipality property consultant	9	III.M.9
	III	Municipality-building constructor	10	III.M.10
	III	Municipality-architect	11	III.M.11
Private company	I	Private company-district heating & energy planning expert	12	I.P.12
	II	Private company head of energy systems department	13	II.P.13
	II	Private company-environment, energy & QMS manager	14	II.P.14
	II	Private company-technical director	15	II.P.15
	III	Private company technical consultant	16	III.P.16
Social housing	I	Social housing consultant	17	I.S.17
	II	Social housing project manager	18	II.S.18
	II	Social housing representative	19	II.S.19
	III	Social housing manager	20	III.S.20
	III	Social housing building coordinator	21	III.S.21
	III	Social housing-technical manager	22	III.S.22
Others	I	NGO climate & energy specialist	23	I.O.23
	II	Energy consultant manager	24	II.O.24

(*continued on next page*)

(*continued*)

	Workshop number	Participant definition	Participant number	Reference
	III	PPPsustainability-representative	25	III.O.25
	III	PPPsustainability manager	26	III.O.26
	III	PPPsustainability-citizen engagement expert	27	III.O.27

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