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End Use Energy Services Framework Co-Creation with Multiple Stakeholders—A Living Lab-Based Case Study

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Abstract: End use energy services have an important role in the ongoing energy transition process by improving the value proposition to the customer through better needs fulfillment and experience and providing system value to the energy system. This study presents a framework for end use energy services, developed as a result of co-creation with multiple stakeholders for a case study in a living lab context. The framework has been co-created using the principles of systems thinking to identify and map both existing and emerging elements and interactions within the energy system and customers. The framework is organized to include aspects from energy system and human system perspectives and divides the energy services development process into three distinct stages. The development stages comprise the strategic planning stage, service design stage, and solution stage. Key considerations are provided for each stage to develop a clearer understanding of the overall end use energy service process.

Keywords: energy services; energy transition; customer value proposition; servitization; framework; end use system; human system; service design

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1. Introduction

The energy sector is undergoing a rapid transition driven by digitalization, climate change concerns, market liberalization policies, and the entrance of new actors. The energy transition process has often been described as driven by decarbonization, decentralization, and digitalization [1]. This transition requires the development of new effective methods, tools, and frameworks to facilitate this process. Concepts and technologies such as smart grid, smart cities, smart homes, and energy services promise to enable energy efficiency gains and improve end-user engagement and provide better and tailored user experience and value creation [2–4].

While the notion of "energy as a service" has been discussed as a research theme for several years [5], a lack of suitable digital infrastructure and the prevalence of traditional energy value chains coupled with typically monopoly-based market structures have prevented progress. It is just recently that, with the emergence of technologies such as smart metering, data de-aggregation, big data analytics, peer-to-peer energy trading platforms, blockchain, and IoT-based home energy management systems (HEMS); as well as market liberalization and the entrance of non-traditional market actors, that new down-stream energy services are starting to emerge. This renewed focus on energy service can help provide value towards both the customers as well as the energy systems if implemented correctly [6]. Examples of such new energy services range from energy efficiency services (either through upgrade and/or optimized operation of energy use systems or decision-making tools, remote energy audits) to demand-side management, renewables as a service, and provision of smart electric vehicle charging. Additionally, several services within the portfolio can be bundled along with partners offering to provide a personalized value offering to the customer. One example of such service is “heat as a service”, where the focus moves from purchase of energy vector to an outcome such as a guaranteed thermal comfort [7].

The energy sector is still in a nascent stage of the energy transition, with several actors adopting an exploratory approach toward end use energy services. Moreover, a systems perspective has often been missing in developing such services, thus, leading to silo effects across the energy value chain [8]. This has prevented unlocking large-scale system-wide benefits. This paper addresses these gaps by incorporating a wide range of stakeholders in a co-creation process involving a real-world case study to end use energy services. The effort has been made to combine insights from academic literature with industry know-how on the topic by adopting a co-creation approach. Against this backdrop, this study aims to address the following two research questions:

- RQ1: What key elements need to be considered for End Use Energy Services?
- RQ2: How can energy system and human system perspectives be consolidated into an End Use Energy Services framework?

This paper addresses these research questions by presenting a framework for end use energy services based on a co-creation process with multiple stakeholders at KTH Live-in lab. The framework has been co-created using the principles of systems thinking to identify and map both existing as well as emerging elements and interactions within the energy system and customers. Utilizing the service design principles, the framework looks at a more in-depth analysis of consumers’ needs, providing a better and user-centric framework for energy services while considering the wider energy system elements. Home energy management systems (HEMS) are considered an integrated part of the energy services ecosystem instead of stand-alone or consumer products serving as an important touchpoint between the customer and the energy usage systems (EUS). Additionally, with a customer-centric approach, the paper looks at how the framework can help create a better value proposition for the customers, thus improving user engagement.

The research method for this study involved an initial exploratory stage where experts and existing scientific literature were consulted to formulate and delimit the problem and establish research objectives. KTH Live-in-Lab was chosen as a case study based on the following considerations:

1. Access to various stakeholders and actors, representing the energy system side, end-user side, and building context.
2. The ability to check the reliability of expert judgment by directly studying their R&D portfolio tested in the laboratory.
3. The openness of participants for an iterative process of co-creation (often the process of co-creation brings the questions of openness and ownership, what might become a barrier for taking participation). These questions are not part of this paper’s discussion but are well covered in [9]

A two-step co-creation process followed this with stakeholders, experts, and end users at KTH Live-in-Lab [10,11] to create the framework and verify the final content and structure. The framework thus developed, adopts a two-dimensional approach (energy and human systems), and splits the service design process into three stages i.e., strategic planning stage, service design stage, and solution stage. Key thematic considerations are provided for each stage based on the inputs from the co-creation process.

The paper concludes with a discussion on how the energy service framework can help contribute toward consumer empowerment, energy efficiency, and transition to a more sustainable energy system and help tackle the various challenges within the energy sector.

2. Problem Contextualization and Research Objectives

A key starting point in problem formulation involved the framing of the system to be studied. Using systems thinking principles a simplified systems mapping was developed to understand the key elements and interactions. Figure 1 presents the mapping of the end use energy system comprising of energy usage system (EUS) and human system (HS).

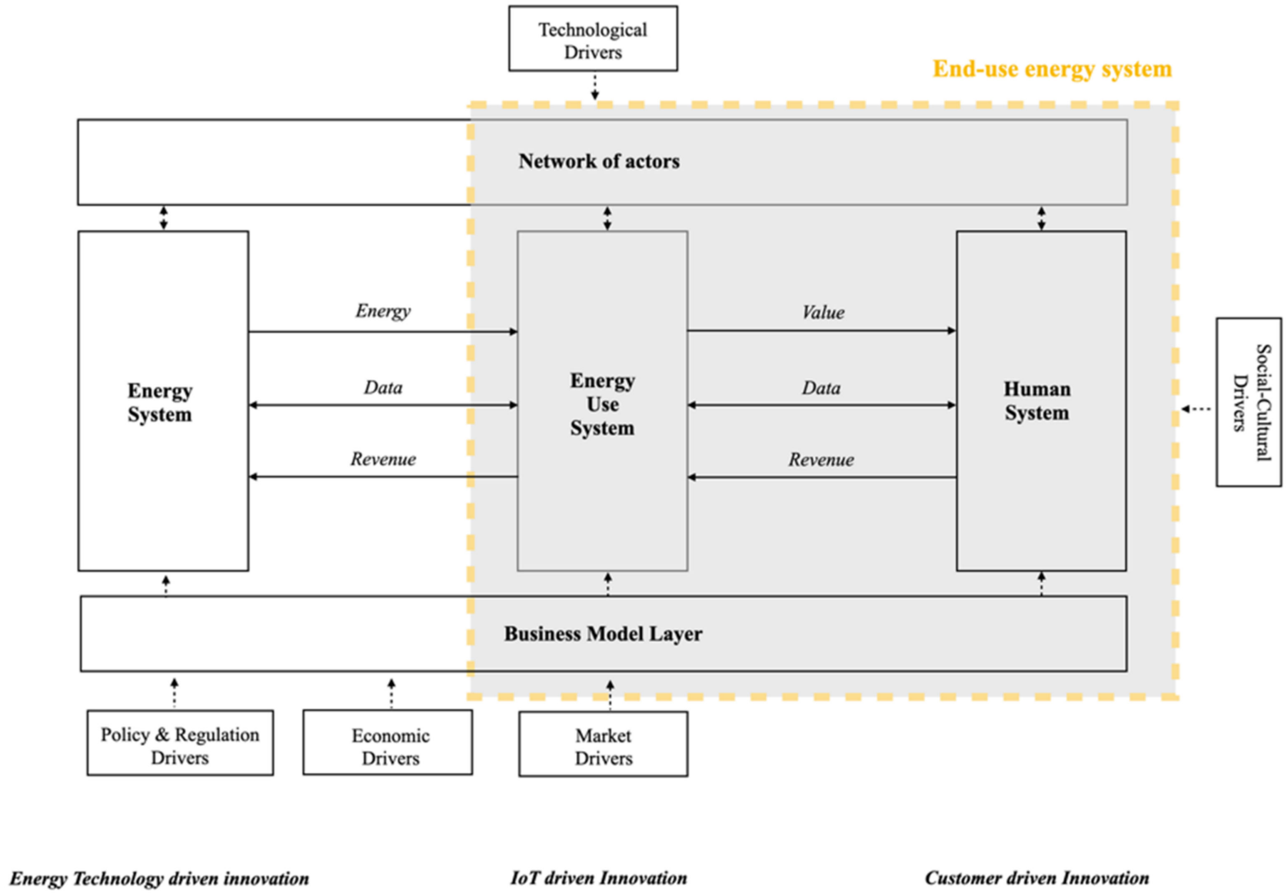

Figure 1. Systems mapping of end use energy system (in yellow dotted area) and interactions with the overall energy value chain.

The two systems interact via the exchange of value (i.e., needs fulfillment), data, and revenues. EUS is defined as the system comprising of end use technologies and equipment that use energy to provide need fulfillment to the human system, e.g., heating systems, cooking equipment, and vehicles. The definition of EUS is based on the work by [10]. The human system is comprised of human activities, behaviors and lifestyles, purchase decisions. The end use energy system interacts with upstream energy systems through energy use, revenues, and data. Network of actors and business model layers influence the system as well as the overall energy system, and various drivers, i.e., socio-cultural, technological, market, economic, and policy regulations, drive the change process in the system. This view of the system served as a frame of reference for the study to examine end use energy services.

As a next step, it was essential to determine a definition for end use energy service (EUES). This was approached from three perspectives, as demonstrated in Figure 2. End user energy services emerge from social, technical, and business perspectives leading to end-user value co-creation and business model innovation.

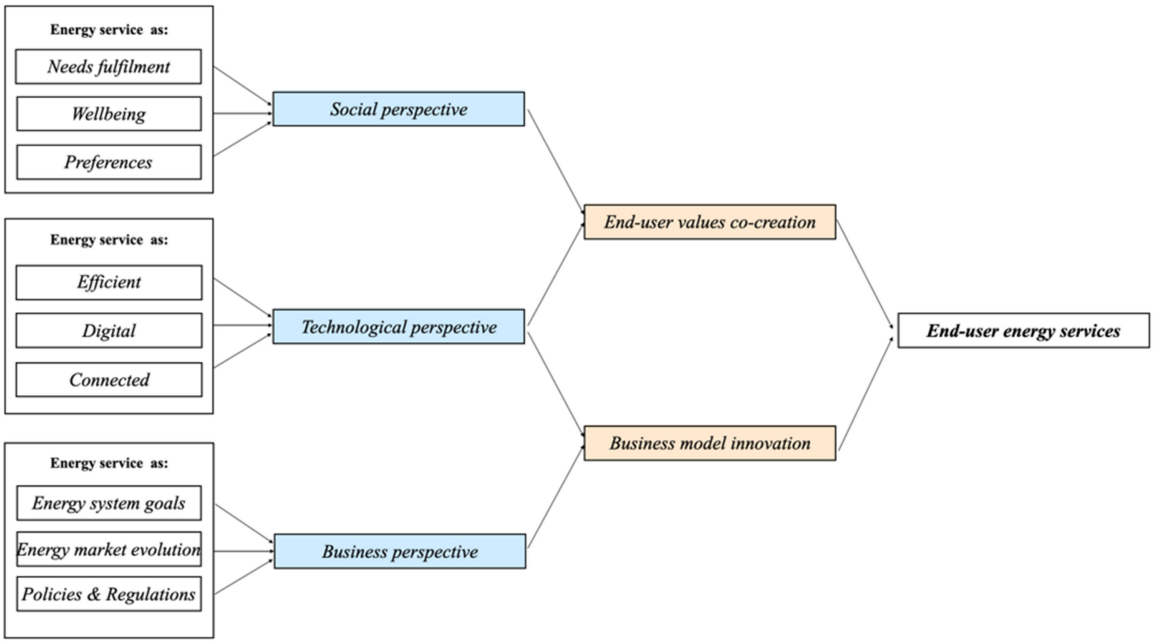

Figure 2. End use energy services perspectives.

Equipped with an initial framing of end use energy services three research objectives were defined for the study that we aim to address with this paper.

1. Understand the state-of-the-art in end user energy services (EUES) based on industry and academic literature. Identify gaps in the current approaches.
2. Using systems thinking and service design principles identify key components needed to create end-use energy services.
3. Create and verify a framework based on co-creation with experts and stakeholders that can be used for future end-use energy services.

3. Energy Services: Highlights from Existing Literature

The topic of energy services is not new and has been considered from different angles in previous studies [5,6,10–16]. Since the topic of this study is energy services focused on the end user, the focus will be to highlight only works that are directly related to the end user. These topics have been divided into four main perspectives: siloed discipline perspective, top-down and bottom-up approaches, business model innovation, and sustainable development.

3.1. Siloed Discipline Perspective

The concept of "energy services" (ES) is used in very different contexts and scientific fields, ranging from environmental and sustainability science to economics and social research. The first observation is that energy services are widely considered either not to need a definition, or in some cases that they may be best "defined" by simply providing a list of examples, such as: "energy service, for example, increase in room temperature, or more generally changes in comfort levels" [5] Reister and Devine [12] identified 15 energy services, which map quite closely onto the most common examples outlined above (their "general energy services are: 'space heating', 'water heating', 'space cooling', 'refrigeration', 'cooking', 'drying', 'lighting', 'electronic services' and 'appliance services'").

Some authors, such as [13–15] discuss the importance of making a distinction between energy services and a more final end service demand: "service demands represent energy-related needs of the end-users" [16]. This approach is the closest to what we characterize as EUES. However, as seen from the definition provided in the previous chapter, this approach lacks the business model component and understanding of how to integrate this concept into the market landscape.

The use of the concept is usually motivated by the recognition that it is generally not energy that is demanded by people, it is services delivered by energy that provide benefits for society and human well-being. Common examples used to illustrate the difference between energy carriers and energy services are heating fuels vs. conditioned living space; electricity vs. illumination; transport fuels vs. mobility [8]. Another issue in the energy service definition is the highly inconsistent way in which energy use is conceptualized. For researchers with an engineering background, who tend to think in terms of energy conversion chains and statistical classifications of energy use, it seems to be straightforward that high-temperature heat, electrochemical applications etc., represent energy services just like residential heating or transport. On the other hand, studies focusing on the wellbeing aspect of energy services often entirely exclude wider aspects of energy use and only consider direct energy consumption at the household level [8].

One of the broadest approaches to define ES was proposed in the paper [5] where it was proposed to look at ES from three perspectives: technical (including energy demand/efficiency), business (including ESCO/supply/billing), and social (including development/social drivers) perspectives. All three categories emphasize the "benefits" to people resulting from energy use. In addition, some literature highlights that low-carbon energy system transformations are usually seen from a technical perspective; the societal dimensions of actors and institutions are widely neglected [17,18].

All of the above directions in the study of energy services indicate rather profound disunity and the lack of a systematic approach to tracking the development of the topic, taking into account both academic and market trends. The complexity of the subject might explain this state of affairs; nevertheless, we see an urgent need for a more united approach to the topic of energy services. The main conclusion from the analyzed literature is that energy utility companies need to realize the importance of transforming their conventional supply chain and take into account the views of their end-users and make sure that they are getting enough value.

3.2. Top-Down and Bottom-Up Approaches

As was highlighted correctly by the author [8], studies related to the energy chain context quite often apply systematic and clearly attributable top-down approaches: total energy use is systematically decomposed to gain insight into (mostly quantitative) relationships between energy consumption and end-use functions. Same author points out that the "well-being context" is dominated by bottom-up perspectives and its main scope may range from functions to benefit specific needs, services, or functions on an individual or household level are usually the starting point for considerations about energy requirements.

Another study focuses primarily on the modelling techniques of end-use energy consumption in the residential sector and highlights that the "top-down models determine the effect on energy consumption due to ongoing long-term changes or transitions within the residential sector, primarily for the purpose of determining supply requirements". Variables that are commonly used by top-down models include macroeconomic indicators (gross domestic product (GDP), employment rates, and price indices), climatic conditions, housing construction/demolition rates, and estimates of appliance ownership and number of units in the residential sector [19]. This perspective shows how granular is the knowledge and understanding of the end-users in this approach. One more important paper is written on the topic of top-bottom and bottom-up approaches that argue that two modelling approaches exist in the domain of energy economics: top-down modelling based on macroeconomic modelling principles and techniques, and bottom-up modelling based on disaggregation and the inclusion of a large number of technical parameters. The different approaches have led to very different properties and model results which in recent years have been most widely noticed in the analyses of CO_2 emissions and mitigation costs [20]. Same author is also bringing a point about bottom-up models as a model, which quite often describes a number of specific energy technologies with both technical and economic parameters: “Both present and future technologies are often included, which means that these models include a description of the change in parameters as, e.g., fuel substitution options based on knowledge of the stage of development of new technologies”.

An extensive portfolio of modelling techniques (bottom-up and top-down) to project energy needs is reviewed in [21]. A bottom-up approach extrapolates the estimated energy consumption of a representative set of individual houses to regional and national levels explaining much better the changes in energy use [21]. Brounen et al. [22], emphasize the importance of social and demographic characteristics of households which are often being ignored by the engineering and energy literature due to lack of detailed data. As stated by [23], energy demand is a crucial point factor in model uncertainties but despite its relevance, medium to long-term studies on energy and climate policy devote little effort and attention to ESD [24,25].

Energy service development requires insights that take both sectoral and technology effects (and their interactions) into account. One of the reviewed papers [26] presents a novel soft-linking method for bridging the gap between sectoral top-down and technology rich bottom-up models and by this motivating us to include technological bottom-up level analysis (solution layer) and top-down layer analysis (strategic planning) into our framework blueprint, which is presented in the Section 5. In our understanding, the process of creating new EUES should include an analysis of both directions: top-down and bottom-up. This conclusion is approved by the authors mentioned above and by most experts from our expert group.

3.3. Business Model Innovation

The topic of servitization and innovation of business models is frequently explored in the literature about energy services. It might be explained by the general trend of industrial servitization in many areas, such as telecom, the Internet of Things, additive manufacturing, etc. Servitization represents a specific form of business model innovation (BMI) [27–30]. It requires the holistic innovation of an organization, where it shifts from selling products to selling services or product-service bundles [31]. The transition from a product-oriented business model based on tangible assets, toward a service-oriented business model based on intangible assets may present great managerial and organizational opportunities. However, BMI, and the servitization of firms, can create significant challenges as well [32,33]. Despite the expected importance of services for utilities, scholars have paid little attention to the challenges of servitizing a utility business model. There are several market barriers related to energy service adaption, such as low energy costs, ambiguous or absent legislative framework, lack or mismatch of financing, perceived business and technical risks, mistrust among actors, and low information levels regarding energy services [34–37]. However, intra-organizational barriers for the servitization of utilities have been hardly addressed and we will try to reflect on them during our framework blueprint development.

Analyzing the difficulties of servitizing a utility BM requires a close look at each of the BM components, such as the value proposition, the customer interface, the infrastructure, and the revenue model [38,39] as well as the dynamics of their interactions, and the relationship between the status quo and the new BM [40,41].

The necessity to establish a service culture or “mindset” and the crucial role of the customer interface has been particularly highlighted by servitization scholars [36,42]. Intangible assets can be a source for sustainable value creation and competitive advantage [43,44]. In this study, we will not delve into the business model innovation domain in detail. Still, we want to note the importance of paying attention to this topic in the general definition of EUES and a more detailed analysis of stakeholders’ considerations related to the business side of the EUES development.

3.4. Sustainable Development

Sustainability has been defined as the extent to which progress and development should meet the needs of the present without compromising the ability of the future generations to meet their own needs [45].

Thus, primary energy saving through better energy services can lead to better environmental sustainability by reducing greenhouse gas pollutant emissions. The usage of prediction models and recommendation engines in energy services can significantly reduce the costs of primary energy sources and decrease their use, which can lead to better economic sustainability. In addition, developing energy services impacts the market maturity, labor quality, and inclusion of diverse specialists into the energy business ecosystem, which impacts social and economic sustainability.

In the paper [46] are highlighted some action areas for energy producers, which reflect very well the interlinkage between energy services and environmental sustainability: management and measurement tools—adopting environmental management systems appropriate for the business; greater eco-efficiency in all aspects of the business; innovation and eco-design rethinking the delivery of "value added" by the business, so that impact reduction and resource efficiency are firmly built in at the design stage; product stewardship—taking the broadest view of "producer responsibility" and working to reduce all the "downstream" effects of products after they have been sold on to customers; openness and transparency—publicly reporting on environmental performance against meaningful targets, actively using clear labels and declarations so that customers are fully informed.

In addition, the topic of energy poverty is playing an important role for global sustainable development. In developing countries, energy is needed to meet basic subsistence needs essential for a minimum level of human comfort. These needs consist of cooking, lighting, space-heating, and the operation of household appliances and devices. Of these, cooking energy needs constitute about 80% of the household energy needs in rural areas.

4. Research Methodology

The lack of methodologies enabling the collaborative design of product and service features in an integrated way has been discussed in [47,48]. To develop the methodology, an interactive approach [49], based on the analysis of both available literature and companies' needs, has been performed. In particular, the design research methodology (DRM) framework [50] has been adopted as a primary reference due to its interactive approach. Wrapping up all the principles and steps belonging to the research mentioned above traditions, the design of this research follows the schema traced in detail in Figure 3 and can be described as following. The first phase is the exploration phase, which includes the literature review on the topic and end use energy services definition based on the analyzed literature. The second phase involved formulating the problem based on the energy system value analysis. The third phase, namely framework co-creation, was carried out to co-create a tool for end use energy service (EUES) development with multiple stakeholders from KTH Live-in-Lab, selected as a case study platform for this paper. This phase is described further in detail in Section 5. We decided to make a case study in collaboration with one of the EU living laboratories for easy access to the various actors related directly and indirectly to the built environment context, including the end users. The collaboration with the living lab also has created its limitation. The framework ends at the proof-of-concept stage since most of the projects at living labs are ending in this finalizing. The final phase presents the holistic EUES development framework and limitations and future studies directions.

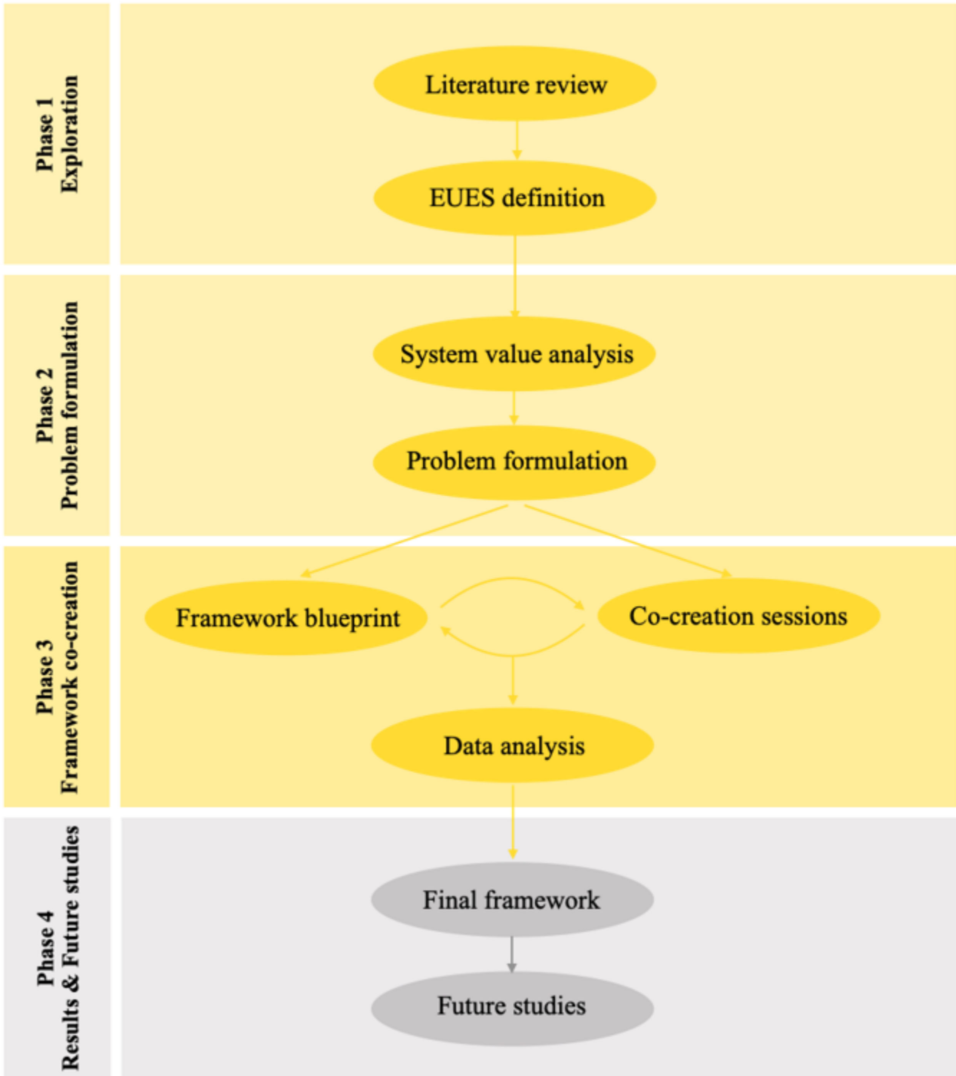

Figure 3. Research methodology for the study showing difference stages and outcomes.

5. EUES Framework Co-Creation with KTH Live-in-Lab Actors

5.1. Living Lab Context

The concept of a living lab refers to the involvement of multiple stakeholders, including users, in the exploration, co-creation, and evaluation of innovations within a realistic setting [51–53]. Living labs offer an easy access to the users and diverse partners and collaborators. As indicated, this familiar context may take the shape of a controlled lab setting which mimics the day-to-day usage context. The environments are selected and managed by living lab practitioners so as to allow the involvement of different types of stakeholders in innovation activities, the introduction of new technologies in realistic circumstances, the monitoring of their acceptance, usage, and effects, and so on [9].

KTH Live-In Lab is a multiple-testbed platform for accelerated innovation in the AEC (architecture, engineering, and construction) industry, and for collaboration between academia and business sectors [54]. Most testbeds in KTH Live-In Lab are operated in real environments for testing and researching new technologies and new methods. The purpose of the KTH Live-In Lab is to reduce the lead times between test/research results and market introduction. In this way, KTH Live-In Lab aims to facilitate the advent of the sustainable and resource-effective buildings of the future. KTH Live-In Lab enables testing of products, services, and methods in real buildings, which results in a well-founded basis for changing structures and rules, and increased use of new innovative technology.

KTH Live-In Lab encompasses a 300-sqm building permit-free innovation environment with alterable student apartments (Testbed KTH), which enables studies on the future's resource-efficient and sustainable student housing. The KTH Live-In Lab also receives property and user data from 305 common student flats owned by Einar Mattsson (Testbed EM) and from the KTH campus education building owned by Akademiska Hus (Testbed AH). Figure 4 presents the KTH Live-In Lab and the configurable student apartments space (courtesy of Semren Månsson Archtitects).

Figure 4. KTH Live-in-Lab: Testbed KTH and Testbed EM. (Design by Semren Månsson).

5.2. Participants Structure

The final list of participants was formed iteratively during the progress of EUES development framework co-creation process. A working group of experts from the building industry, energy industry, and service design were invited on the initial stage of the process. With the help of this small working group, an EUES framework blueprint was co-created and the participants with additional competencies were invited to collaborate. The final participants' selection process was based on the principle of equal representation of each of three organizational levels and energy system/human system perspectives. In addition, experts representing large, medium, and small companies were invited. Moreover, the focus group of end-users (KTH Live-in-Lab tenants) were included into the EUES framework co-creation process. In total, 21 participants were selected and participated in the co-creation sessions. Most of them are directly or indirectly connected to KTH Live-in-Lab. The list of experts and their roles are presented in Table 1.

There are a few reasons why we focused on KTH Live-in-Lab stakeholders and actors: previous experience in participatory sessions and the process of co-creation as a design practice, high motivation to exchange knowledge and readiness to participate in the next phases of the project development. Such focus on the specific project might influence the final outcome, which could become project specific. We are aware about potential biases related to this aspect and plan to discuss it in the discussion part.

Table 1. Participants of the co-creation sessions.

System	Organizational Layer	Number	Role	Background
Energy System	*Strategy*	1	Property manager	Large Scandinavian property development firm
		2	CEO	Building IoT platform
		3	Strategic Assets	Energy Innovation platform (EU supported)
	Design	4	Innovation manager	Home appliances firm
		5	Energy manager	Large Scandinavian property development firm
		6	Architect	Swedish architecture bureau
	Solution	7	R&D manager	Technical consultancy for sustainable buildings
		8	Technical Director	Large Scandinavian property development firm
		9	Solution architect	Home energy management
Human System	*Strategy*	10	Manager Customer IT	Leading European Energy Company
		11	Business Development Manager	Energy utility company
		12	CRM manager	Leading European Energy Company
	Design	13	UX Researcher	Automobile company ∣ EV charging
		14	Service designer	Leading European Energy Company
		15	R&D engineer	Lifestyle app
	Solution	16	Data Scientist	Energy tech start-up
		17	Customer IT support	Energy utility company
		18	Solution architect	Home energy management
	End users	19–21	Tenants at student apartment	Age group 20–27

5.3. EUES Framework Co-Creation Process

5.3.1. Framework Blueprint Design

For a resultful co-creation process, it is important to discuss the discussion with the involved actors. For this purpose, it was decided to design a framework blueprint following a two-steps approach. During the first step, we graphically sketched a core problem. As was highlighted in the previous chapter, the main focus of this study is an analysis of the relationship between the ES and the HS. Therefore, both systems are used as canvas core elements for filling with the actors' considerations. Three test sessions were carried out with energy industry experts to receive their feedback to understand the missing components of the future framework blueprint.

The main suggestion was to add inter-organizational layers to reflect how different roles in the company address the interconnection between ES and HS during the EUES development. This suggestion is aligned with the literature review highlights from Section 3, where we discussed the business model innovation and a need for organizational transformation for the servitization re-orientation of the energy industry. The result of the first step of the EUES framework blueprint design is presented in Figure 5.

An additional comment from our expert group was to include the deliverables for each organizational layer. We clearly understand that different organizations have different structures and terminology for such deliverables, as well as organizational structure layers, but we have aligned the suggestions from our expert group combined with the general organizational management literature and ended up with the final EUES framework blueprint for the co-creative sessions with selected participants. The proposed blueprint includes two vertical canvases (Energy System and Human System) and three horizontal layers (strategic planning stage, service design stage, solution stage). The horizontal layers could be also considered as macro, meso, and micro levels of EUES development process. The deliverable for the strategic planning stage is servitization strategy, which is supposed to include the considerations from both systems: energy system and human system. There are several proposals for what should be included into the servitization strategy, suggested by other authors, but most of them are working with servitization of the manufacturing industry and it might not be fully relevant for the energy industry [55]. The final EUES framework blueprint is presented at Figure 6.

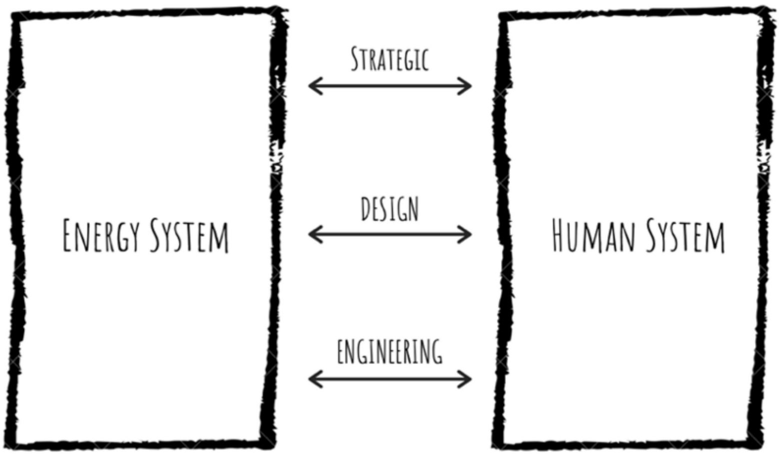

Figure 5. EUES framework sketch.

Figure 6. EUES Framework blueprint for co-creation workshops.

5.3.2. Co-Creation Sessions

The co-creation process was based on the basic principles of participatory design, namely the active involvement of each participant equally, the ability to refine the answers after the session, and feedback and discussion of the results. In our case, each session began with a general introduction of the interlocutor into a discussion on a given topic, identifying the participant's involvement in each topic and determining from what point they would be most comfortable to start the discussion. Typically, each participant chose to start blueprinting from the exact spot that most closely reflected their competence and experience. When the part of the blueprint where the participant felt the greatest competence was filled, they moved first horizontally to the adjacent system. Only then the discussion moved vertically, that is, between organizational layers. During discussing and filling out the blueprint, neither the participants nor we had any problems with the format or the conduct of the discussion. Most of the participants had knowledge and opinions in their specialized field and willingly shared their experience of how certain processes occur in their organization at other organizational levels. Thus, after connecting all the answers, the blueprint developed by us was uniformly filled. It is worth noting that conversation at the strategic levels was easy for all participants, while discussion at the design level, and especially at the solution level, was more difficult for participants outside these competencies.

5.3.3. Data Analysis

We analyzed the co-creation session outcomes by applying a category system derived from clustering theory and frame analysis in order to identify the key considerations and their thematic clusters. The data analysis was based on open coding content analysis. Headings (i.e., codes) were written into the transcriptions based on the participants' quotes and content they addressed [56]. The codes were combined into first-order categories, which described the main considerations of respondents about a specific part of the EUES framework blueprint in their own words. The first-order categories were analyzed for links and patterns and then grouped into distinct clusters (second-order themes). Preliminary clustering results were shared among several participants to provide validation and further development. The clusters' categories have become a foundation for the final EUES framework structure, which is presented and discussed in the next chapter.

6. Results

6.1. Co-Creation Sessions' Results

This section presents the results from the co-creation sessions conducted with the KTH live-in lab stakeholders. Table 1 provides the list of engaged stakeholders. The stakeholders were selected to cover a range of expertise and represent the various levels of organizational hierarchies. This was done to ensure that the diversity of experience is objectively reflected by the resulting framework. The considerations brought up from all the workshops were then thematically clustered and the results are presented based on three distinct stages of end use energy services.

6.1.1. Strategic Planning Stage

The strategic planning stage was discussed from both energy systems and human systems perspective. Figure 7 presents the summary of the key considerations as discussed by the stakeholders from the energy systems perspective. The considerations were then thematically clustered into six categories.

Figure 7. Summary of energy system considerations for strategic planning phase.

- *Meta trends:* This category represents the meta trends that the stakeholders considered as significant drivers toward a shift toward servitization-based portfolio development toward the customers. One of the key trends was new non-energy actors' entering the market and the fear of missing out on the opportunities. Digitalization was a significant enabler leading to new possibilities beyond the meter interaction with the customer. Market liberalization and evolving regulatory landscape pose potential risks for the market position for incumbents. Finally, growing climate change concerns have put pressure on companies to focus on green branding and develop sustainability KPIs with a broader shift toward environmental, social, and corporate governance (ESG) issues and subsequent requirements for investments in new initiatives.
- *Organizational competence:* This category presents considerations around organizational and cultural factors that need to be considered to move toward servitized offerings for customers. Especially for incumbent actors with complex corporate structures, it was identified as a major challenge. Evaluating organizational structures' fit with the future strategy and identifying competency gaps were the first considerations mentioned. Strategy development for utilizing third-party competence to fill the gaps should be developed. Shifting toward a more agile approach and working across internal silo structures to maximize value toward the customer were also considerations brought up by the stakeholders. Organizational culture should also incentivize a two-way flow of ideas, and new models of collaboration need to be implemented.
- *Partnership ecosystem:* In the partnership cluster, stakeholders emphasized the need for setting up new partnerships (e.g., with SMEs, OEMs, and start-ups) and that it can lead to access data and insights sharing and better positioning in the market. Access to new market segments through partnerships was discussed. Revenue sharing models, trust for data sharing, and issues around conflicting goals were some of the aspects stakeholders considered. Finally, cost-benefit analysis of developing competence in-house vs. partnership was a key consideration, especially for larger organizations.

- *Business model:* In terms of the business models, key considerations mentioned by the stakeholders were the need to diversify offerings and revenue streams, cost optimization (built environment), cannibalization of the existing core business, and revenue risks. Exploring the possibilities for multi-sides revenue streams, especially with new market structures around flexibility and grid stability, was mentioned. Finally, the need to incentivize customers to participate was brought up as an essential consideration.
- *Infrastructure:* In terms of infrastructure considerations, stakeholders increased complexity due to diverse assets in the portfolio, the need for systems to communicate with each other, and the need for standardized protocols. Additionally, the importance of different lifespans of building systems in relation to IT and control systems ought to be considered. Finally, the building systems need to be made ready for digitalization to support services, and the capability needs both for the present, and the future should be evaluated. Access to reliable energy data in a fragmented market was a significant challenge.
- *Energy market analysis:* Stakeholders considered electrification (heating and transport) as well as unbundling across the energy value chain as both key opportunities for new services as well as challenges to tackle. A key focus area was meeting energy efficiency goals from the built environment sector and assessing if energy vector substitution is a possibility. New and open markets can enable new services with frequency containment reserve (FCR) market, and flexibility trading markets were mentioned. These markets can also be leveraged to provide upstream value toward the energy system and assist with energy transition challenges. Energy stakeholders mentioned the need to localize the energy services to specific needs and regulations and presented legacy systems as a challenge.

The human system considerations for the strategic planning stage were clustered into six main themes around developing a high-level understanding of customers and their needs. A summary is presented in Figure 8.

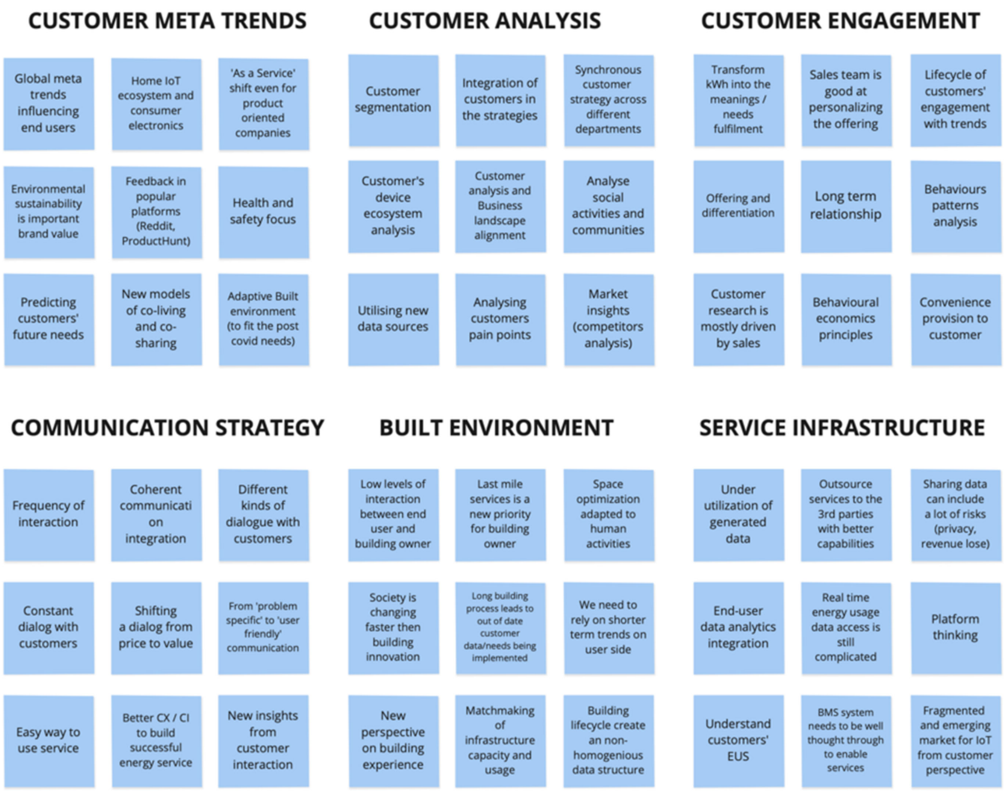

Figure 8. Summary of human system considerations for strategic planning phase.

- *Customer meta-trends:* Stakeholders discussed the need to keep pace with the global consumer meta-trends as this can significantly impact purchase decisions, engagement, and branding. It is therefore important to be able to move quickly to adapt to the trends. Home IoT, HEMs, as well as new ways of interaction with EUS need to be considered. There is a shift toward servitization, especially from OEMs which can be integrated into new energy services. New channels of customer engagement, e.g., social media and review forums, are becoming increasingly important. Additionally, because of the pandemic, health and safety are becoming significant concerns along with the need to adapt the built environment to the post-pandemic landscape.
- *Customer analysis:* Effective customer segmentation was highlighted as an important step, and this should include utilizing new data sources to develop better customer insights. Customer analysis should be aligned with the business landscape, and the customer strategy should be synchronized across different departments. Finally, understanding customers' EUS and devices ecosystem, their pain points, and social and community aspects are essential.
- *Customer engagement:* Stakeholders discussed the importance of transforming energy insights (e.g., energy consumption in kWh) to meaningful insights and needs fulfillment for the customers. A key focus should be seamless convenience for the customer. Sales teams should be good at providing personalized offerings that match the customers' needs. Building long-term relationships and customer loyalty should be a priority, and the various stages of the customer engagement lifecycle should be considered and aligned with the market trends. Behavior patterns analysis should be incorporated along with sales and market analysis. Behavioral economics principles should be utilized to increase engagement.
- *Communication strategy:* Communication strategy should aim at shifting the dialogue from price toward value communication: should go beyond simply customer support to other forms and channels. This can lead to new insights for future service design. The communication strategy should be synchronized and coherent across the portfolio, with well-designed CX/CI aspects fully integrated.
- *Service infrastructure:* Stakeholders mentioned that there is an un-der-utilization of data to gain better insights into customers' needs. Having a platform thinking and bundling third parties' services for a better customer experience was discussed by experts. Data privacy risks should be considered. Working across a fragmented IoT market can be a challenge for the customers. Additionally, real-time access to energy usage data can be complicated and can require additional investments in infrastructure. Having a good understanding of customers' EUS and designing the BMS/HEMS to enable a service layer should be prioritized.
- *Built environment context:* Within the built environment context, increasing the interaction between building owners and end users should be encouraged. Last-mile (meter) services are emerging as a new priority, and buildings need to be adapted toward that. Space utilization needs to be adapted to human activities and the shorter-term trends from the user side to improve the building experience. A relatively long building process and lifecycle can often lead to users' needs not being incorporated into the building design, thus leading to costly retrofits.

6.1.2. Service Design Stage

Following the strategic planning stage, the service design stage was discussed from both energy systems and human systems perspective. Figure 9 presents the summary of the key considerations as discussed by the stakeholders from the energy systems perspective. The considerations were thematically clustered into six categories covering key aspects of service design.

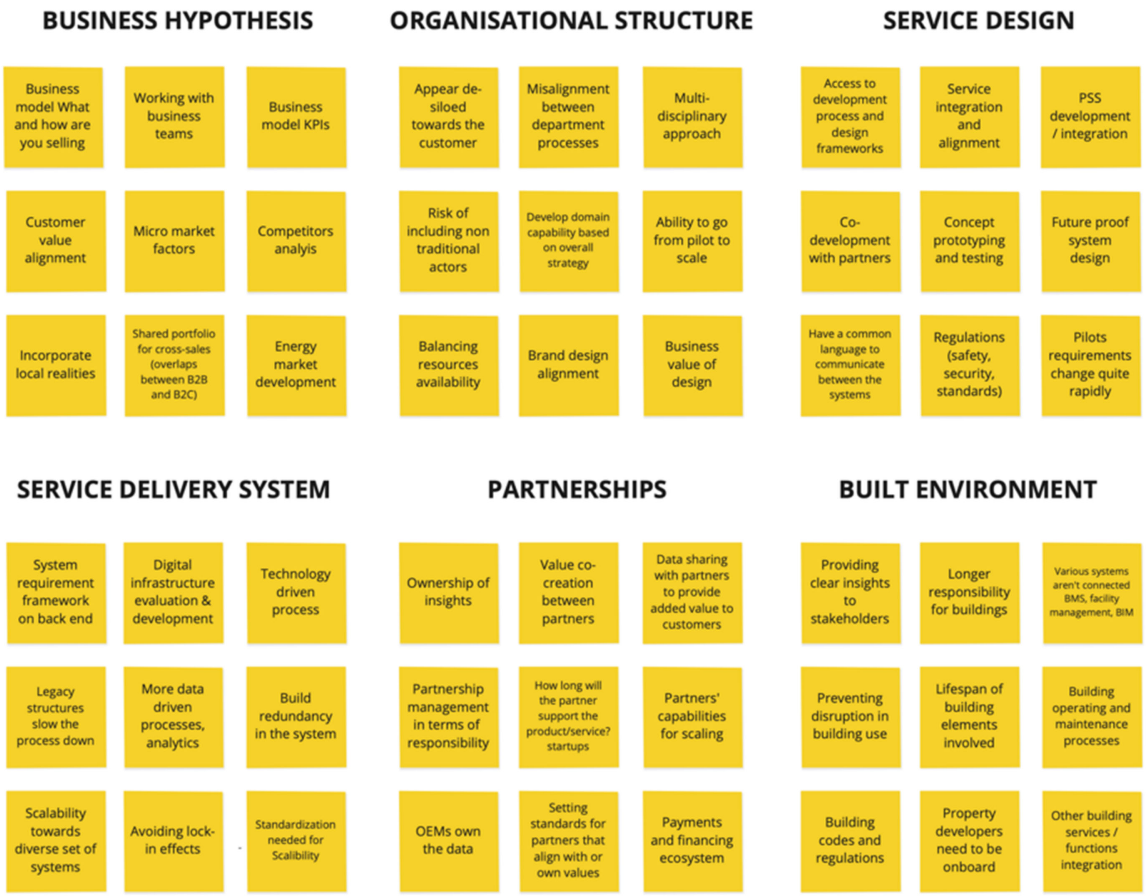

Figure 9. Summary of energy system considerations for service design phase.

- *Business hypothesis:* Stakeholders mentioned working with a business development team, developing business model KPIs, and conducting competitor analysis. Micro market trends and local realities should be considered, e.g., geographical preferences and cultural preferences. The customer value proposition needs to be evaluated against business cases. For businesses with an extensive range of offerings, cross-sales can be leveraged. Finally, the impact of energy prices and market developments needs to be considered.
- *Organizational structure:* It is crucial to appear de-siloed toward the customers, which required a cross-departmental collaborative approach and removing misalignments between processes. Developing or integration of domain-specific capabilities should be done at this stage. An organization's ability to go from pilot to scale should also be evaluated based on resources availability. The business value of design needs to be emphasized, and the design should be alighted with the overall branding strategy.
- *Service design considerations:* The design process and design frameworks should be developed. Product service systems (PSS) development and integration and service integration should be planned. It is important to have a common language to communicate between the systems to facilitate seamless integration. Service design should be future proofed with necessary provisions for eventual needs. Co-design with partners and stakeholders should be included in the process, and concept prototypes and thorough testing should be done. Compliance with present and upcoming regulations should be evaluated.
- *Service delivery system:* Service delivery system development is primarily technology driven. System requirement frameworks for the back end should be developed, followed by digital infrastructure evaluation and development. Data analytics necessary to support other processes should be designed and deployed. Systems with legacy

elements (e.g., controls on the customer side or upstream on the energy value chain) can add complexity, and interoperability issues should be considered. System stability, especially for critical functions, should be prioritized with necessary redundancies built in it. Diversity of connected assets can result in scalability issues, and therefore, standardization can contribute toward better integration. Furthermore, lock-in effects should be considered when deciding on a particular technology.

- *Partnerships:* In terms of partnerships, defining the ownership of data and insights are important in a data-sharing arrangement. Data sharing from partners can be utilized for better value creation for the customers. Responsibilities should be defined with the partners, and their ability to support the product/service and for scaling should be determined. The payment and financing ecosystem for customers should be determined. Partners should be involved in the co-creation process.
- *Built environment:* The building's operation and maintenance processes should be factored into the service design, and other building services and functions should be integrated in terms of the built environment. Preventing/minimizing the disruption of regular use should be prioritized. Building codes and regulations compliance should be considered. Experts also discussed the long cycle of building elements and the various systems not being connected to each other.

The human system considerations for the service design stage were clustered into six main themes. A summary is presented in Figure 10.

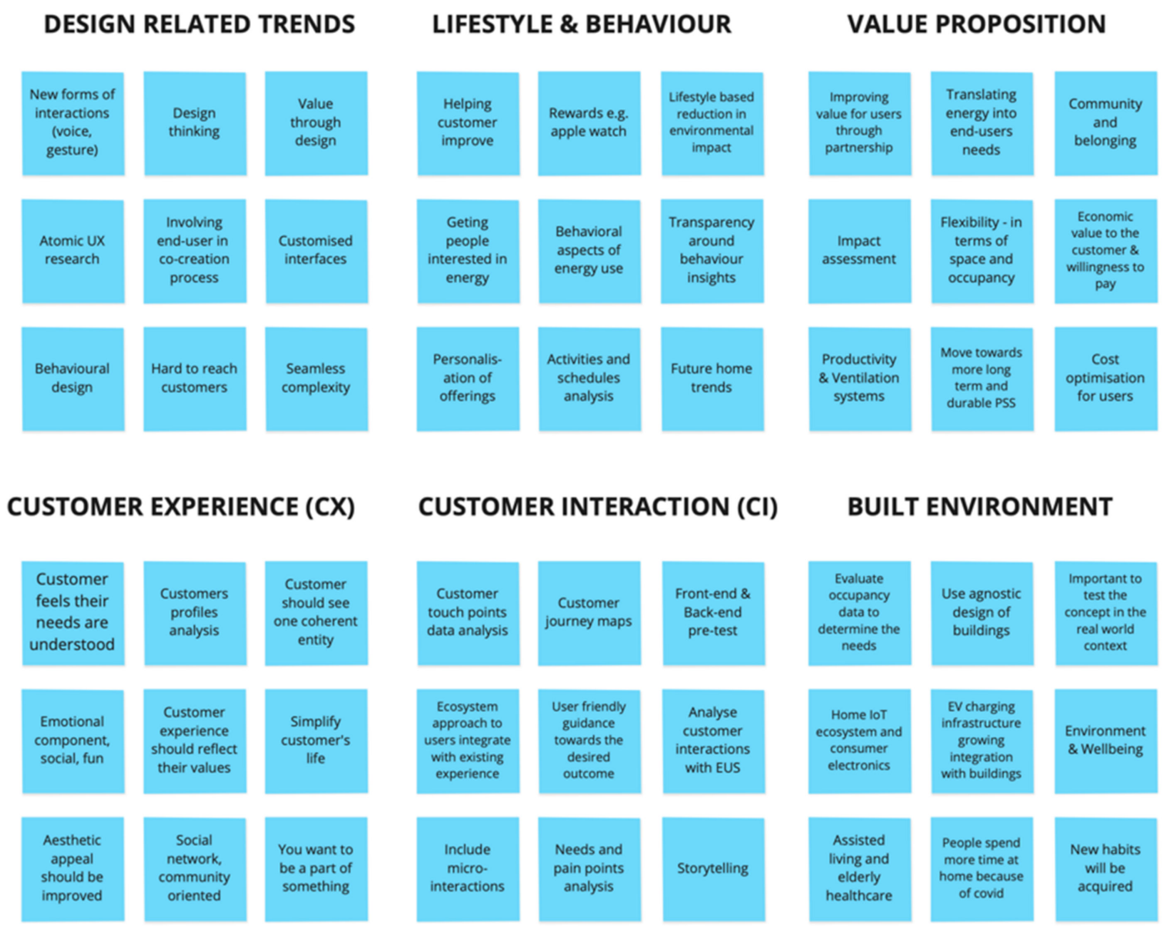

Figure 10. Summary of human system considerations for service design phase.

- *Design trends:* New forms of interaction (e.g., voice assistants and gesture control) should be incorporated based on users' preferences. Design thinking should be incorporated throughout the process. UX frameworks like "Atomic UX" should be integrated. It is vital to involve the end-user in the co-creation process, and behavioral design insights should be considered. Customizable interfaces for better personalization can add value. Complexity should be presented in a seamless way to the user.

- *Lifestyle and behavior:* Behavior insights can be integrated to help customers improve their performance (e.g., lowering consumption, healthy lifestyle, and environmental impact); however, these should be built around transparency and accurate benchmarks. Rewards and behavioral economics principles can be utilized to encourage engagement. Activities and lifestyle analysis should be conducted, and personalization of services should be considered.
- *Value proposition:* Value proposition from the energy services to the customer should determine economic value and willingness to pay as well as wellbeing and quality of life improvements. Community and belonging aspects should be considered. Moving toward a long-term PSS relationship can help provide an outcome-based value proposition by translating energy use into end-user needs fulfillment. Additionally, partnerships-based bundling can be utilized for improving the value proposition.
- *Customer experience (CX):* Customers should feel that their needs are being understood, and the service should simplify their life. It is important in a multi-portfolio setting that the customer sees a coherent, unified entity. Additionally, the customer experience should reflect their value set with social and community aspects incorporated in the experience. Finally, aesthetical aspects should be considered and evolve with the trends.
- *Customer interaction (CI):* Customer touchpoints and customer journey maps should be thoroughly analyzed. This should include customer interactions with the EUS and how the service can facilitate that. Customer needs and pain points should be integrated into the design, and micro-interactions should be optimized. An ecosystem approach can help integrate the service with customers' existing experience. Finally, effective storytelling should be integrated into the customer interaction, and user-friendly guidance should lead the customer toward the desired outcome.
- *Built environment:* In the built environment context, experts highlighted evaluating occupancy data to determine end-user needs. It is also important to test the contexts in a real-world context to establish viability for scaling. Home IoT ecosystems and consumer electronics trends should be considered. Environmental and wellbeing concerns are expanding in scope, and service providers need to consider these in the design. Assisted living and elderly-friendly built environments are increasing in demand and should be included in the design for new services.

6.1.3. Solution Stage

Following the strategic planning and service design phases, the solution stage was discussed in the context of energy and human systems. Clustering of the considerations was carried out based on the inputs provided by the stakeholders. Compared to the strategic planning and service design phases, the solution layer had more overlaps, however, an effort was made to distinguish the considerations from both the energy and human system side. Figure 11 presents a summary of the considerations from an energy system perspective. Five thematic clusters were created which are discussed below.

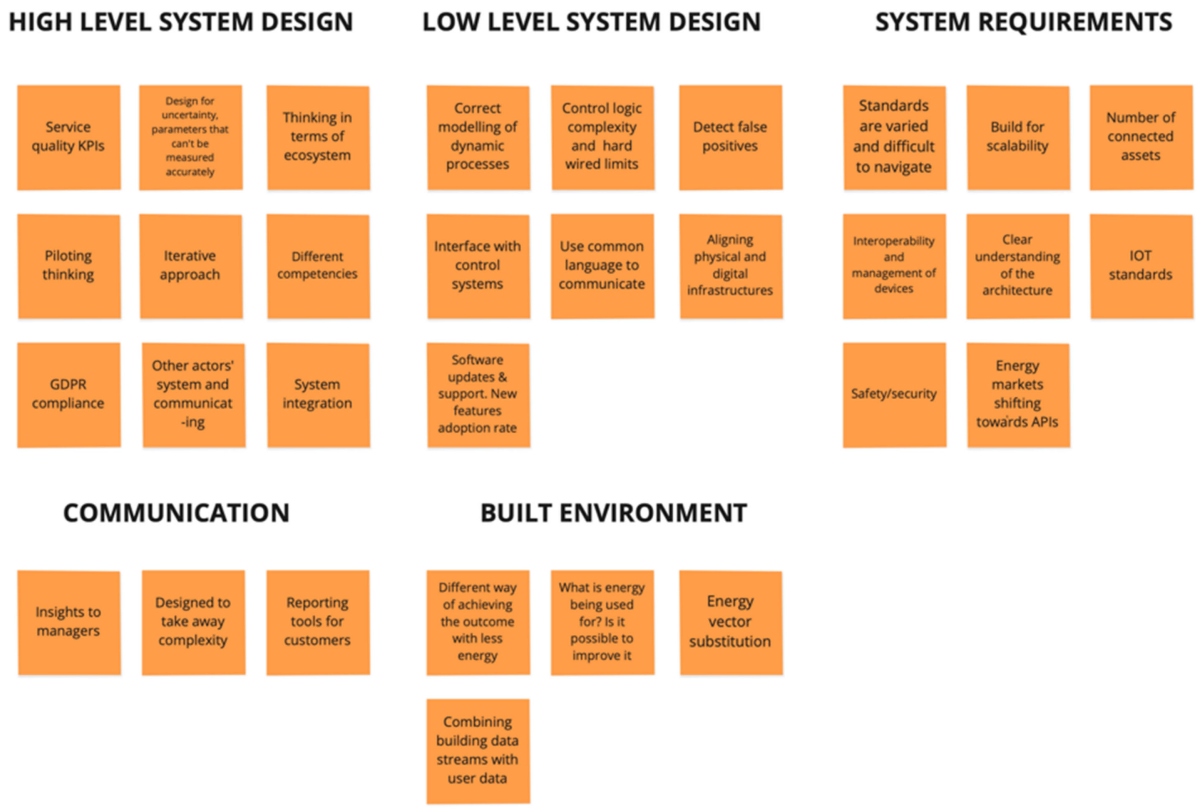

Figure 11. Summary of energy system considerations for solution phase.

- *High-level system design:* Experts stressed the need to develop and monitor service quality KPIs and design the systems with uncertainty factors in mind. Adopting an iterative approach with piloting thinking as well and incorporating ecosystem aspects were stressed by the stakeholders. Understanding other actors' systems and their communication protocols are essential. Finally, issues such as GDPR and regulatory compliances should be considered.
- *Low-level system design:* In terms of low-level design, the process should start with aligning physical and digital infrastructure. Dynamic processes should be modeled correctly and verified. Control logic of the connected systems, system complexity, and hard-wired limits of the equipment should be considered with mechanisms in place to detect false positives. Interfaces should be developed with control systems using a common language to communicate. Lastly, software upgrade and support processes should be established, and the adoption rate for new features should be monitored.
- *System requirements:* Experts pointed out the need for a clear understanding of system architecture. The number and diversity of connected assets can add a considerable amount of complexity, especially due to varying standards of communication. New IoT standards need to be considered. Therefore, interoperability and management of assets need to be considered, and the system should be built for scaling. A shift toward APIs in energy markets is taking place and should be considered in system design. Finally, safety and security issues for the connected assets should be included in the design.
- *Communication:* The system should provide meaningful insights to the managers, and the level of complexity of the information provided should be reduced. Reporting tools for customers should be developed.
- *Built environment:* In the context of the built environment, it is important to understand what energy is being used for and the possibilities of achieving the same outcome with less energy. Energy vector (fuel) substitution possibilities, if they better suit the

overall objectives, should be evaluated. Lastly, building systems (EUS) data should be collated with user data to provide more efficient operational strategies.

Finally, from the human systems side, four thematic clusters were developed from the considerations provided by the stakeholders. These are summarized in Figure 12 and are discussed below.

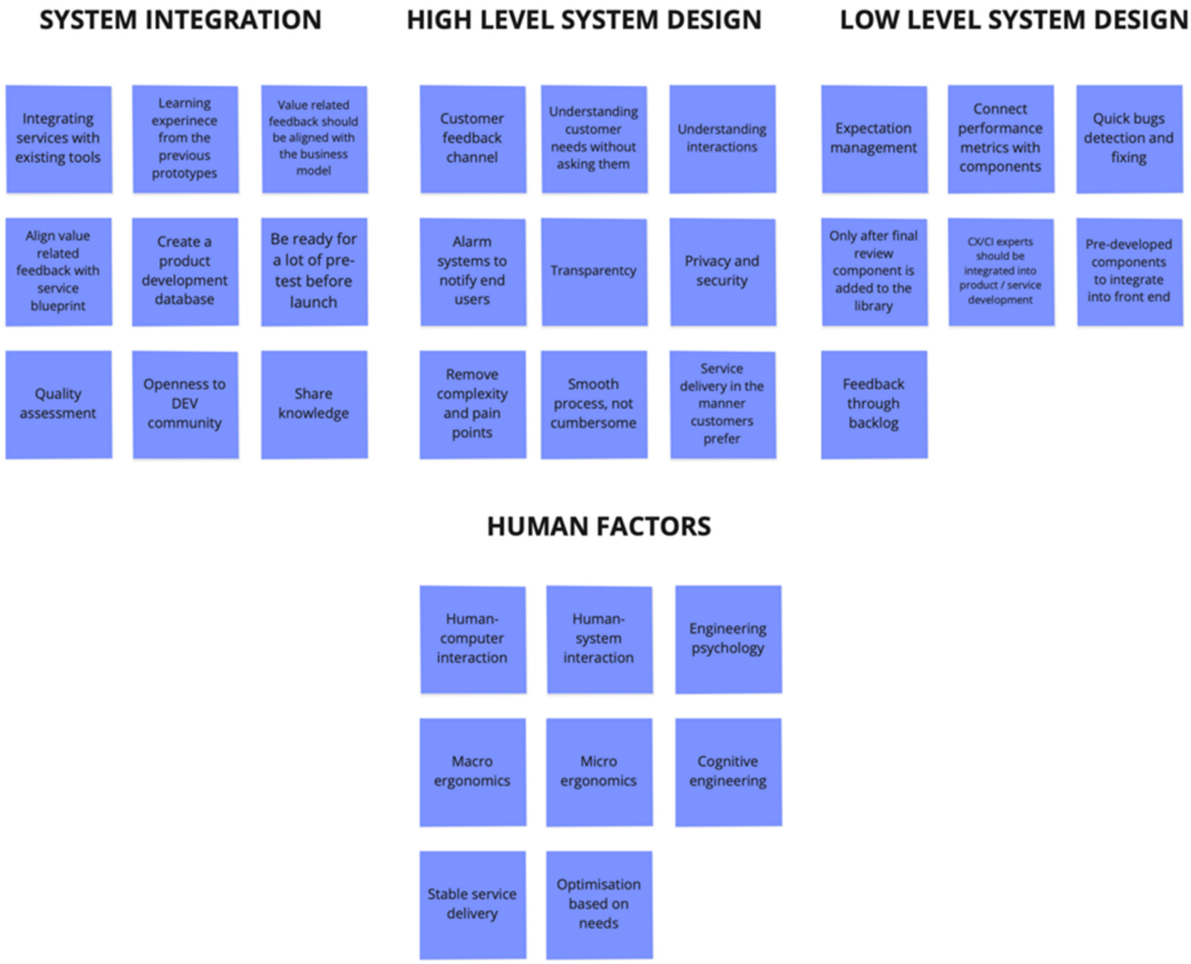

Figure 12. Summary of human system considerations for solution phase.

- *System integration:* Experts stressed the need for integrating services with the tools used and preferred by the customers. There should be a learning process in place from previous pilots to guide future development processes. Value-related feedback from the customers should be aligned with the business model and incorporated into the service blueprints. Extensive pre-testing with users should be carried out before the launch. Quality assessments should be done with the users' inputs taken into consideration.
- *High-level design:* Customer feedback channels should be developed and must align with the users' preferences. Service delivery should meet customers' preferences. Onboarding of customers should be a smooth process and avoid cumbersome steps. Transparency and focus on privacy and security help build customers' trust. Alarm systems should be built to keep customers notified. Finally, understanding customer interactions and removing complexity and pain points should be the key focus.
- *Low-level design:* CX/CI expertise should be incorporated into the processes. Components should be connected with various performance metrics and should be monitored. There should be a quick bug fixing and detection process in place. A thorough review

should take place before components are added to the library and deployed. Customer expectations should be considered.

- *Human factors:* Experts mentioned various considerations around bringing the human factor into the design process. Human-machine interaction, psychological and cognitive factors, and optimization based on needs were mentioned. Both macro and micro ergonomic aspects should be considered.

6.2. Final EUES Framework Structure

The co-creation sessions generated a rich corpus of data which was clustered into themes as presented in Section 6.1. The initial thematic clusters provided a preliminary structure for the framework. This preliminary framework was then shared among a selected group of participants to provide validation and finalization of the framework. Based on the two-step co-creation process, the final version of the framework is presented in Figure 13. The initial structure proposed in Figure 6 has been maintained with three stages i.e., strategic planning stage, design stage, and solution stage in order to streamline the processes at different organizational levels and the themes have been divided into energy system and human system sides. Three deliverables have been defined for each stage i.e., servitization strategy, service design blueprint, and service proof-of-concept. While there is some convergence of themes at the solution level however, they are depicted separately to include specific considerations from both energy system and human systems as described in Section 6.1.3.

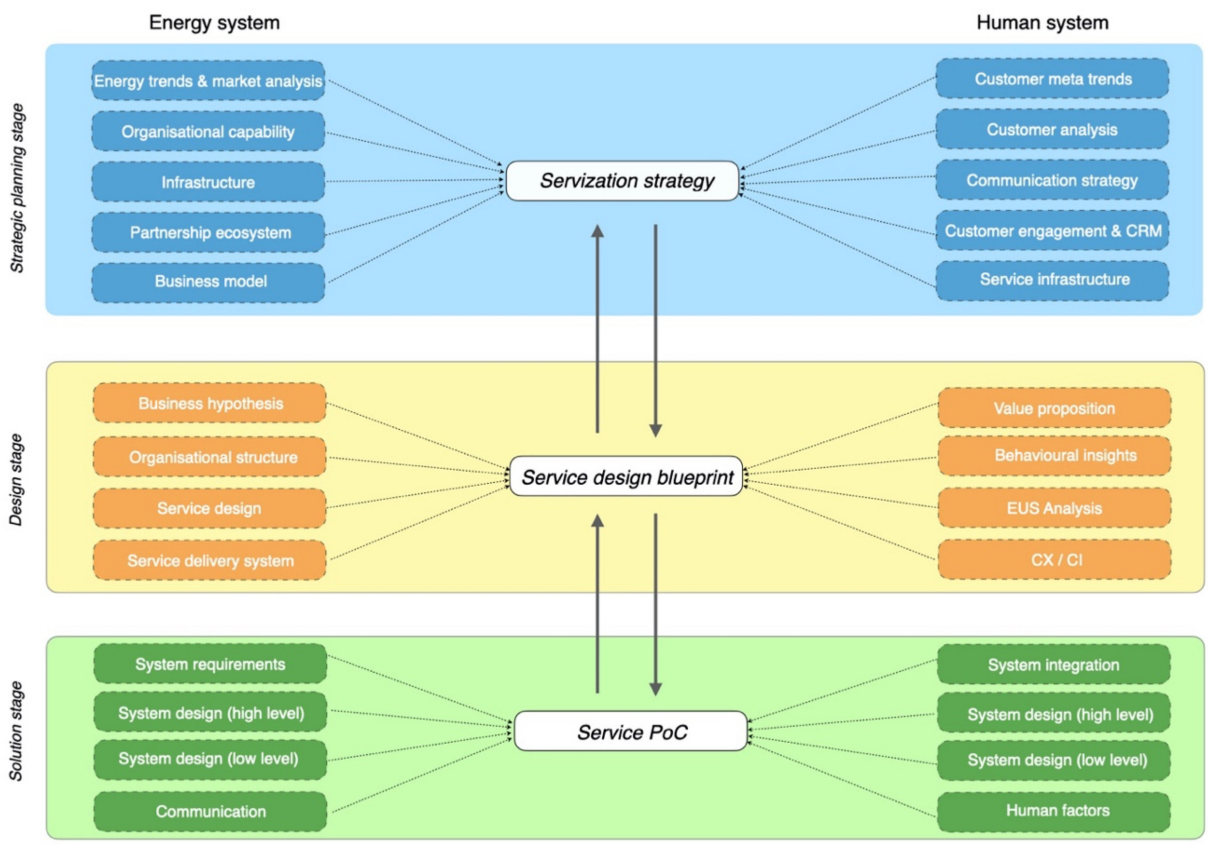

Figure 13. End use energy services (EUES) framework.

7. Discussion and Conclusions

The results from this co-creation process brought meaningful insights about the process, and key considerations at each stage of end use energy services development. Based on the research questions initially defined, key elements for end use energy services were identified (RQ1) and were subsequently structured into a framework (RQ2). The resulting framework addresses some gaps in existing research by providing a broader understanding of energy services beyond the siloes quite often encountered in the domain of energy services [8]. Additionally, by identifying three distinct stages, the framework facilitates the energy services development process by identifying friction layers at various organizational levels. It was possible to incorporate both a top-down and a bottom-up perspective by utilizing the systems thinking approach. In addition to the final framework, a rich corpus of data was generated that can provide a deep understanding of each element within the framework. It will serve as a starting point for our future work on the topic.

The co-creation methodology adopted for this study allowed for engaging a diverse team of experts with competencies specific to various stages of the service design process, and therefore, a holistic picture was developed. It also allowed for consolidating academic knowledge of the topic through literature review and analysis with industry expertise from practitioners.

While the list of considerations reflects the experience of the experts consulted and can certainly be expanded, the resulting framework provided a good overview of the overall structure needed for end use energy services. The two-dimensional approach involving energy and human systems can help provide value to both customers as well as to the energy systems and, therefore, generate “system value” in line with the energy transition process as discussed by [6]. By bringing energy usage system (EUS) (as described by [10]) analysis as an intermediary between the human system and the upstream energy system into the energy services process, various sustainability benefits [50] can be achieved.

By contextualizing the research in the living lab settings, access to a large group of stakeholders as well as end users was possible. It should also be noted that the innovation fostering and exploratory environment of the living lab setup provides unique possibilities to test out energy services concepts that can be scaled up to the broader society [56].

While some of the built environment-specific aspects have been excluded from the framework so as to keep inapplicable to other types of end use energy services, it formed a significant part of the dialogue with the experts. Selection of target building segment(s) and their buildings characteristics and having scenarios for different types of building stock i.e., newly built, renovations stock, and historical buildings was discussed. Evolving space utilization trends such as co-working, work from home require adopting new approaches. Determination of buildings’ capabilities to participate in energy services requires an evaluation and accurate benchmarking. Building ownership and operation structures can help aim the incentives correctly. Finally, a balance needs to be achieved between energy system goals and the wellbeing and comfort of the users.

It is also important to point out some of the limitations of this study. Since the work was centered around a living lab context, the framework defines the proof of concept as its final stage, which, while logical in the research context, needs to be expanded to service delivery and service management stages in the future. In terms of the stakeholders consulted, most of them connected to the energy or the built environment sector. Therefore, the analysis and the resulting framework can be further enrichened by bringing in experts from other fields where servitization is at a more mature stage. Additionally, despite the efforts to reduce bias in the results from specific stakeholders, there are possibilities that some bias might be reflected. This can be augmented by testing the framework with a broader range of experts and future case studies where the framework is applied.

The framework presented in this paper is intended for energy services designers and practitioners in both industries as well as academia. As with any research, this is the first step toward understanding end-use energy services. The future phases of the research will involve designing tools around the framework that can complement the framework and facilitate the development process for end-use energy services. Additionally, further case studies will be conducted to test the framework in real-world use cases to continue the development and provide additional validation.

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References

1. Di Silvestre, M.L.; Favuzza, S.; Riva Sanseverino, E.R.; Zizzo, G. How Decarbonization, Digitalization and Decentralization Are Changing Key Power Infrastructures. *Renew. Sustain. Energy Rev.* **2018**, *93*, 483–498.
2. Shomali, A.; Pinkse, J. The Consequences of Smart Grids for the Business Model of Electricity Firms. *J. Clean. Prod.* **2016**, *112*, 3830–3841. [CrossRef]
3. Erlinghagen, S.; Markard, J. Smart Grids and the Transformation of the Electricity Sector: ICT Firms as Potential Catalysts for Sectoral Change. *Energy Policy* **2012**, *51*, 895–906. [CrossRef]
4. Smale, R.; van Vliet, B.; Spaargaren, G. When Social Practices Meet Smart Grids: Flexibility, Grid Management, and Domestic Consumption in The Netherlands. *Energy Res. Soc. Sci.* **2017**, *34*, 132–140. [CrossRef]
5. Fell, M.J. Energy Services: A Conceptual Review. *Energy Res. Soc. Sci.* **2017**, *27*, 129–140. [CrossRef]
6. Hiteva, R.; Foxon, T.J. Beware the Value Gap: Creating Value for Users and for the System through Innovation in Digital Energy Services Business Models. *Technol. Forecast. Soc. Chang.* **2021**, *166*, 120525. [CrossRef]
7. Britton, J.; Minas, A.M.; Marques, A.C.; Pourmirza, Z. Exploring the Potential of Heat as a Service in Decarbonization: Evidence Needs and Research Gaps. *Energy Sources Part B Econ. Plan. Policy* **2021**. [CrossRef]
8. Kalt, G.; Wiedenhofer, D.; Görg, C.; Haberl, H. Conceptualizing Energy Services: A Review of Energy and Well-Being along the Energy Service Cascade. *Energy Res. Soc. Sci.* **2019**, *53*, 47–58. [CrossRef]
9. Malakhatka, E.; Sopjani, L.; Lundqvist, P. Co-Creating Service Concepts for the Built Environment Based on the End-User's Daily Activities Analysis: KTH Live-in-Lab Explorative Case Study. *Sustainability* **2021**, *13*, 1942. [CrossRef]
10. Jonsson, D.K.; Gustafsson, S.; Wangel, J.; Höjer, M.; Lundqvist, P.; Svane, Ö. Energy at Your Service: Highlighting Energy Usage Systems in the Context of Energy Efficiency Analysis. *Energy Effic.* **2011**, *4*, 355–369. [CrossRef]
11. KTH Live-in Lab. Available online: https://www.liveinlab.kth.se/en (accessed on 21 May 2021).
12. Reister, D.B.; Devine, W.D. Total Costs of Energy Services. *Energy* **1981**, *6*, 305–315. [CrossRef]
13. Nissing, C.; von Blottnitz, H. An Economic Model for Energisation and Its Integration into the Urban Energy Planning Process. *Energy Policy* **2010**, *38*, 2370–2378. [CrossRef]
14. Haas, R. Energy Efficiency Indicators in the Residential Sector. *Energy Policy* **1997**, *25*, 789–802. [CrossRef]
15. Olerup, B. Energy Services a Smoke Screen. *Energy Policy* **1998**, *26*, 715–724. [CrossRef]
16. Cullen, J.M.; Allwood, J.M. The Efficient Use of Energy: Tracing the Global Flow of Energy from Fuel to Service. *Energy Policy* **2010**, *38*, 75–81. [CrossRef]
17. Schmid, E.; Knopf, B.; Pechan, A. Putting an Energy System Transformation into Practice: The Case of the German Energiewende. *Energy Res. Soc. Sci.* **2016**, *11*, 263–275. [CrossRef]
18. Sovacool, B.K. What Are We Doing Here? Analyzing Fifteen Years of Energy Scholarship and Proposing a Social Science Research Agenda. *Energy Res. Soc. Sci.* **2014**, *1*, 1–29. [CrossRef]
19. Swan, L.G.; Ugursal, V.I. Modeling of End-Use Energy Consumption in the Residential Sector: A Review of Modeling Techniques. *Renew.Sustain. Energy Rev.* **2009**, *13*, 1819–1835. [CrossRef]
20. Klinge Jacobsen, H. Integrating the Bottom-up and Top-down Approach to Energy–Economy Modelling: The Case of Denmark. *Energy Econ.* **1998**, *20*, 443–461. [CrossRef]
21. Sartori, I.; Wachenfeldt, B.J.; Hestnes, A.G. Energy Demand in the Norwegian Building Stock: Scenarios on Potential Reduction. *Energy Policy* **2009**, *37*, 1614–1627. [CrossRef]
22. Brounen, D.; Kok, N.; Quigley, J.M. Residential Energy Use and Conservation: Economics and Demographics. *Eur. Econ. Rev.* **2012**, *56*, 931–945. [CrossRef]
23. Van Ruijven, B.; de Vries, B.; van Vuuren, D.P.; van der Sluijs, J.P. A Global Model for Residential Energy Use: Uncertainty in Calibration to Regional Data. *Energy* **2010**, *35*, 269–282. [CrossRef]

24. Hourcade, J.-C.; Jaccard, M.; Bataille, C.; Ghersi, F. Hybrid Modeling: New Answers to Old Challenges Introduction to the Special Issue of The Energy Journal. *Energy J.* **2006**, *SI2006*, 2006. [CrossRef]
25. Böhringer, C.; Rutherford, T.F. Combining Bottom-up and Top-Down. *Energy Econ.* **2008**, *30*, 574–596. [CrossRef]
26. Kowalska-Pyzalska, A. What Makes Consumers Adopt to Innovative Energy Services in the Energy Market? A Review of Incentives and Barriers. *Renew. Sustain. Energy Rev.* **2018**, *82*, 3570–3581. [CrossRef]
27. Maglio, P.P.; Spohrer, J. A Service Science Perspective on Business Model Innovation. *Ind. Mark. Manag.* **2013**, *42*, 665–670. [CrossRef]
28. Nair, S.; Paulose, H.; Palacios, M.; Tafur, J. Service Orientation: Effectuating Business Model Innovation. *Serv. Ind. J.* **2013**, *33*, 958–975. [CrossRef]
29. Velamuri, V.K.; Bansemir, B.; Neyer, A.-K.; Möslein, K.M. Product Service Systems as a driver for Business Model Innovation: Lessons Learned from the manufacturing industry. *Int. J. Innov. Manag.* **2013**, *17*, 1340004. [CrossRef]
30. Kastalli, I.V.; van Looy, B. Servitization: Disentangling the Impact of Service Business Model Innovation on Manufacturing Firm Performance. *J. Oper. Manag.* **2013**, *31*, 169–180. [CrossRef]
31. Baines, T.S.; Lightfoot, H.W.; Benedettini, O.; Kay, J.M. The Servitization of Manufacturing. *J. Manuf. Technol. Manag.* **2009**, *20*, 547–567. [CrossRef]
32. Gebauer, H.; Fleisch, E.; Friedli, T. Overcoming the Service Paradox in Manufacturing Companies. *Eur. Manag. J.* **2005**, *23*, 14–26. [CrossRef]
33. Kindström, D. Towards a Service-Based Business Model-Key Aspects for Future Competitive Advantage. *Eur. Manag. J.* **2010**, *28*, 479–490. [CrossRef]
34. Hannon, M.J.; Foxon, T.J.; Gale, W.F. The Co-Evolutionary Relationship between Energy Service Companies and the UK Energy System: Implications for a Low-Carbon Transition. *Energy Policy* **2013**, *61*, 1031–1045. [CrossRef]
35. Marino, A.; Bertoldi, P.; Rezessy, S.; Boza-Kiss, B. A Snapshot of the European Energy Service Market in 2010 and Policy Recommendations to Foster a Further Market Development. *Energy Policy* **2011**, *39*, 6190–6198. [CrossRef]
36. Suhonen, N.; Okkonen, L. The Energy Services Company (ESCo) as Business Model for Heat Entrepreneurship-A Case Study of North Karelia, Finland. *Energy Policy* **2013**, *61*, 783–787. [CrossRef]
37. Vine, E. An International Survey of the Energy Service Company (ESCO) Industry. *Energy Policy* **2005**, *33*, 691–704. [CrossRef]
38. Osterwalder, A. The Business Model Ontology a Proposition in a Design Science Approach. Ph.D. Thesis, Universite de Lausanne Ecole des Hautes Etudes Commerciales, Lausanne, Switzerland, 2004.
39. Richter, M. Business Model Innovation for Sustainable Energy: German Utilities and Renewable Energy. *Energy Policy* **2013**, *62*, 1226–1237. [CrossRef]
40. Demil, B.; Lecocq, X. Business Model Evolution: In Search of Dynamic Consistency. *Long Range Plan.* **2010**, *43*, 227–246. [CrossRef]
41. Zott, C.; Amit, R. The Business Model: A Theoretically Anchored Robust Construct for Strategic Analysis. *Strateg. Organ.* **2013**, *11*, 403–411. [CrossRef]
42. Neely, A. Exploring the Financial Consequences of the Servitization of Manufacturing. *Oper. Manag. Res.* **2008**, *1*, 103–118. [CrossRef]
43. Hall, P.A. Policy Paradigms, Social Learning, and the State: The Case of Economic Policymaking in Britain. *Comp. Politics* **1993**, *25*, 275. [CrossRef]
44. Hall, R. The Strategic Analysis of Intangible Resources. *Strateg. Manag. J.* **1992**, *13*, 135–144. [CrossRef]
45. Chichilnisky, G. What Is Sustainable Development? *Land Econ.* **1997**, *73*, 467. [CrossRef]
46. Bocken, N.M.P.; Short, S.W.; Rana, P.; Evans, S. A Literature and Practice Review to Develop Sustainable Business Model Archetypes. *J. Clean. Prod.* **2014**, *65*, 42–56. [CrossRef]
47. Doultsinou, A.; Roy, R.; Baxter, D.; Gao, J.; Mann, A. Developing a Service Knowledge Reuse Framework for Engineering Design. *J. Eng. Des.* **2009**, *20*, 389–411. [CrossRef]
48. Vasantha, G.V.A.; Roy, R.; Lelah, A.; Brissaud, D. A Review of Product–Service Systems Design Methodologies. *J. Eng. Des.* **2012**, *23*, 635–659. [CrossRef]
49. Svensson, L.; Ellström, P.-E.; Brulin, G. Introduction-on Interactive Research. *Int. J. Action Res.* **2007**, *3*, 233–249.
50. Blessing, L.T.M.; Chakrabarti, A. *DRM, a Design Research Methodology*; Springer: London, UK, 2009; ISBN 978-1-84882-586-4.
51. Mensink, W.; Birrer, F.A.J.; Dutilleul, B. Unpacking European Living Labs: Analysing Innovation's Social Dimensions. *Cent. Eur. J. Public Policy* **2010**, *4*, 60–85.
52. Leminen, S.; Westerlund, M.; Nyström, A.-G. Living Labs as Open-Innovation Networks. *Technol. Innov. Manag. Rev.* **2012**, *2*, 6–11. [CrossRef]
53. Ballon, P.; Schuurman, D. Living Labs: Concepts, Tools and Cases. *Info* **2015**, *17*. [CrossRef]
54. KTH Live-in Lab KTH Live-in Lab: Our Value Proposition. Available online: https://www.liveinlab.kth.se/en/om-kth-live-in-lab/vara-vardeerbjudanden-1.894654 (accessed on 22 May 2021).
55. Elo, S.; Kyngäs, H. The Qualitative Content Analysis Process. *J. Adv. Nurs.* **2008**, *62*, 107–115. [CrossRef]
56. Khandkar, S.H. Open Coding. Available online: http://pages.cpsc.ucalgary.ca/~{}saul/wiki/uploads/CPSC681/open-coding.pdf (accessed on 25 May 2021).