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Upcoming Services Innovation for the Home Energy Management System in Korea

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Abstract: Smart grid technology is developed to be commercialized globally, and expected to be utilized at home, named as home energy management system. Despite of its promising marketability, innovative business models are not well-structured and service design methods have limitations on integration for service innovation. Hence, this study employs service-dominant logic to innovate the industry, and introduces the holistic method consisting of service, ecosystem, platform, and strategy. Firstly, it identifies the pain points, and the expected services are arranged using an importance–performance analysis method. Then, the extended ecosystem is defined in three layers perspectives. In addition, the use-case method is used to demonstrate the relationships between the supplier and users on platform. Finally, integrating customers' needs results in two business models: (i) Home Energy management Model and (ii) Home Care Model. This research not only suggests innovative business models in the home energy market, but also supplements the procedure for designing innovative services and applies it with qualitative and quantitative investigation. To the end, it shed light on the direction and way to actualize future Home Energy Management System (HEMS) market.

Keywords: home energy management system; smart home; service innovation; service-dominant logic; sustainable business model

1. Introduction

The accelerating digitalization of the energy industry has caused its integration with core technologies of the Fourth Industrial Revolution, including artificial intelligence (AI), the Internet of things (IoT), cloud, blockchain, and big data [1]. The digitalization of the energy sector is expected to generate "200–500 billion Korean Won worth of economic value annually by 2025" [2]. Major changes are expected in the energy industry ecosystem and consumer-focused platforms [1,3,4].

Against the backdrop of increasing digitalization in the energy sector, the Home Energy Management System (HEMS), which automatically manages home energy consumption, and thus reduces energy usage and greenhouse gas emissions, has become one of the most promising new energy platforms. HEMS offers customers advantages, such as peak power control and energy savings [5].

HEMS, which is an integral part of smart homes having IoT-oriented technology, has grown rapidly; with an average annual growth rate of 26.1%, demand for it is likely to keep increasing because it offers users the ability to directly manage energy efficiency and reduce residential energy consumption [6]. In Korea, the HEMS market is expected to "grow at an annual average rate of 9.8% and increase from KRW 142 billion as of 2014 to KRW 249 billion in 2020" [7]. However, because of Korea's supplier-centered power infrastructure and lower cost of electricity than that of developed countries, consumer demand for HEMS and the growth in the Korean market have been lower than that in the global market [7,8].

Notwithstanding the somewhat adverse influence of these factors on marketability, core HEMS-related technologies are being actively developed in Korea in a variety of ways [9]. Entities in information and communications technology (ICT) and the construction field are developing technologies for use in housing construction, including home network construction, automation, and control technology. In addition, companies in the telecommunications network, software, and platform sectors are competing with one another to grab a share of this growing HEMS market [7–9].

The industry's abiding interest in the HEMS market led the number of studies for business models to have more efficient electricity savings in perspective of technology [5,8,10,11], but there is a lack of studies that propose specific strategic measures necessary for sustained growth in the market [12]. Thus, this study aims to design innovative business models in the HEMS market, and approach in integrated methodologies. Based on service-dominant (S-D) logic, this study began from customer investigation and innovative business models design in order of service, ecosystem, platform, and strategy. Firstly, it initially discovers the pain points of customers in the existing market, devises appropriate services, and evaluates them with related experts. And extended business ecosystem is represented, and mobile platform system is prototyped. Finally, customer type is laddered in accordance with services and customer value and two business models are designed based on previously addressed steps. In the end, it configures the whole process of service innovation and gives implication for HEMS market.

2. Theoretical Background

2.1. Home Energy Management System (HEMS)

Along with research on the commercialization of related technologies, studies on HEMS are proceeding in multiple directions because the industry has continued to garner attention over the last few years. However, few studies examine the structure of the HEMS industry from a microscopic and macroscopic perspective; further, it is even more difficult to find studies that view HEMS from an ecosystem perspective.

Kim et al. [8] presented a micro grid use-case and a business model using KT MEG's infrastructure. However, the study dealt with concepts, such as demand response (DR), block chain transaction, and virtual power plant (VPP), which have not been commercialized. Moreover, it lacked any reference to the HEMS business model.

Shomali and Pinkse [10] examined benefits from smart grid deployment, the conditions under which the emergence of the smart grid will lead to the provision of services, the accelerated growth of new renewable energy and electric vehicles, and the growing role of consumers in the power market. Although the study suggested enabling and constraining factors in terms of value creation, delivery, and capture, a limitation was that a specific business model was not implemented.

Komninos et al. [11] raised issues of privacy and security as the most representative threats to the smart home/smart grid environment. The authors set the following security goals of the smart home/smart grid environment: confidentiality, integrity, availability, authenticity, authorization, and non-repudiation. They also summarized the risks based on possible scenarios. Although the study shed light on the problems that could occur in the implementation of the HEMS, and suggested future research directions, it failed to consider participants outside the industry.

Giordano and Fulli [12] presented a systemic perspective that seeks to improve the business case of smart grid technologies and contribute to a reversal of the consumer-driven paradigm of the electricity sector by providing evidence from applications in the electric vehicle and smart meter ecosystems. The study considered the components of a business model and the stakeholders, and also examined it from the customer's perspective. However, the limitations of the study were the lack of an empirical environment and the fact that a specific business model was not successfully implemented.

To summarize, the majority of the aforementioned studies focused on specific systems or business models from a microscopic perspective. However, to create value in the HEMS market, it is necessary to derive the services desired by potential customers on a macro level. In other words, the roles of the respective entities of the HEMS industry and service itself have been studied, but not in terms of the holistic service innovation process. Therefore, this study investigates HEMS from a service design perspective, and determines a method for the sustained growth of the HEMS market.

2.2. Service innovation and Service-Dominant Logic

Existing energy industry was a typical one-way market that supplied electric resources in return for payment. However, it has transformed from a manufacturing to a service focused market through its technical development and convergence with ICT for its efficiency and environmental effects [5,13,14]. With continuous growth of the service-oriented economy since the 1990s, the limitation of the goods-dominant logic (GDL) is that it does not work in different market environments [15–17]. In 2004, Service-dominant logic (SDL) was suggested by Vargo and Lusch [17], who argued that the existing GDL cannot explain the components of the upcoming service-dominant economy, that is productivity, quality, and innovation. According to GDL, the core entity that creates the value is the supplier, and the service was treated as secondary for strengthening the value of the goods. Thus, corporations regard the efficiency to produce the goods as the most important factor. However, this has been converted to a service-dominant perspective. Service was treated not as an additional component, but as the application of specialized competences through deeds, processes, and performances for the benefit of the affiliated ecosystem [17].

Until the 1900s, economies had grown with fixed (operand) resources for the competitive advantage of goods, but this changed to a dynamic exchange relationship with intangible and creative (operant) resources such as knowledge and technology [17,18]. Furthermore, the role of corporates is limited in terms of value proposition, and the ultimate value is accomplished with the participation of consumers. This perspective encouraged the paradigm shift that the focus of service should be on the co-creator, that is, the consumer, rather than the supplier. In other words, it emphasized that the key to creating value has shifted from value-in-exchange to value-in-use.

Recently, some related studies have recognized the additional need to consider the ecosystem and the platform. The most representative study is that of Lusch and Nambisan [19], which presented a service innovation tripartite framework from an SDL perspective. Service innovation is defined as a collaborative process occurring in an actor-to-actor (A2A) network to make collaborative profit. Moreover, the service innovation process was divided into three stages: service ecosystem, service platform, and value co-creation. The service ecosystem is a system in which actors create value to exchange services. The service platform is composed of tangible and intangible resources, where actors and resources can interact [20,21]. Value co-creation is defined as the process that underlies the integration of resources within the service ecosystem [22] and the integration of roles between actors. The study is characterized by a platform design method that considers the role of IT; however, it did not present a concrete plan for each stage and lacked a strategic approach.

Even though other studies developed a unified framework of the business model concept in relation to service design [23,24], and examined the relationship between platform and service derivation approached as a conceptual process [25], there was no detailed process, or the ecosystem was completely ignored. Studies on service design can be largely divided into research centered on ecosystem formation and that centered on platform construction. The former has emphasized that services should be designed around relationships among stakeholders within a company or industry [19,26]. On the other hand, the latter has argued that service design must be completed through platform construction because ICT technology is indispensable for organizational or industrial innovation [25,27,28].

As a representative study on service design centered on ecosystem formation, Morelli [26] examined product service systems (PSS). The author presented the concept of service design for service innovation from a PSS perspective, and argued that the society can derive the desired service by identifying the set of actors involved in the industry. In addition, he argued that the flow of services should be expressed using scenarios and use cases and implemented in the form of a platform. However, the ecosystem represented by the network between the actors of the industry had the disadvantage that its elements were simplified; further, it was difficult to reflect the unique characteristics of the industry. Moreover, Antikainen and Valkokari [29] presented a process for service innovation in terms of the circular economy. To this end, they stressed the need to identify factors that can influence service innovation at the ecosystem level. They argued that service innovation can be achieved by understanding the values between stakeholders and partners within the business structure. However, a limitation of this study was that the proposed business model consisted of only nine building blocks.

As a representative study on service design, centered on platform construction, Patrício et al. [27] presented a multi-level service design (MSD), which designed the service concept with the customer value constellation of service offerings. The MSD comprises three levels: new service development, interaction design, and the emerging field of service design. This methodology has the characteristic of deriving services based on customer values. Based on the derived services, the system architecture is structured, and the service blueprint is used to derive the service point of contact. Although this study presented a concrete process for linking services and platforms, it overlooked the ecosystem of a company or industry, and had the disadvantage of not presenting the strategic process. Gawer and Cusumano [28] presented a platform-related service innovation process. Two distinct types of platforms were identified: internal or company-specific platforms, and external or industry-wide platforms. In particular, the external platform was defined as the products, services, or technologies that act as a foundation for the development of complementary products, services, and so on, from the perspective of the business ecosystem. To create corporate innovation, firms need to build and effectively manage the platforms. However, a limitation of this study was that it presented the conceptual contents of services and platforms but lacked a detailed description of the process.

Service innovation in previous studies comprise of four core elements: ecosystems, platforms, services, and strategies for service design. In particular, they suggest that the ecosystem or the platform are important factors for service innovation. However, as shown in Table 1, analyses of previous studies indicate that there is no research that views these factors from an integrated perspective. Service innovation should be centered on customer needs supported from an ecosystem, and platforms should be built as a means to achieve the strategic goal [19,30]. In addition, the service and strategy considering customer values need to be presented together [31,32].

Table 1. Previous studies on service design.

	Ecosystem	**Platform**	**Service**	**Strategy**
Faber et al. [25]		o	o	
Morelli [26]	o	o	o	
Al-Debei and Avison [23]				o
Osterwalder [24]			o	o
Patrico et al. [27]		o	o	
Gawer and Cusmano [28]	o	o		
Lusch and Nambisan [19]	o	o	o	
Antikainen and Valkokari [29]	o			o
Teixeira et al. [33]		o	o	

Therefore, this study suggests the service innovation in the HEMS industry with four core components: service, ecosystem, platform, and strategy. Thus, firstly, services are derived through interviews with customers and experts. Then, to achieve the value for customers and corporates, the ecosystem for implementing specific services and the platform to facilitate it are constructed. Lastly, the most appropriate business models and strategies were constructed and developed. The entire service innovation process is considered using diverse qualitative and quantitative methods to keep the trade-off findings and proofs.

3. Materials and Methods

As this study aims to configure the service innovation process in the energy market with HEMS technology based on S-D logic and adequate business models, services must be designed in terms of the value co-creation [22]. The suggested process is sequenced in the following order: creation, sharing, and connection.

First, creation is a process of "creating" the values desired by the customers of the company or the industry; this will lead to services that include customer values. Next, the value of stakeholders can be shared, creating added value for new industries; this can be identified through specific ecosystem analyses. Last, a platform is needed to facilitate the sharing and integration of value among stakeholders.

The outcomes of core activities are derived from the ecosystem, platform, service, and strategy. First, an ecosystem is defined as an interdependent system that has loosely coupled stakeholders within a particular industry or organization [34]. Basically, ecosystems include the following core concepts: interdependence, symbiosis, coherence, competition, cooperation, value creation, and value sharing among stakeholders. In addition, stakeholders' interactions can lead to co-evolution and innovation [30].

Second, the platform can be defined as a structure in which stakeholders can interact with tangible and intangible resources [19]. The platform enables services to be delivered to customers, and the interactions among the stakeholders on the platform promote co-evolution and innovation. The platform architecture is designed, and a prototype built to embody the structure of the overall platform.

Third, we have the service and the strategy. In terms of S-D logic, a service can be defined as the process of creating a new offering that can provide benefits; a strategy is presented as a means of increasing the success of such a service [17]. New services in new industries must complement existing services and create value; this makes the process very complicated. In this study, service and strategy can be addressed through an industry analysis, problem definition, pain points, and customer segmentation.

3.1. Service

3.1.1. Understanding and Estimating Services

Prior to the customer pain point and expected service questionnaire for HEMS, the literature review and expert focus group interview (FGI) were used to derive the problems in the existing energy management system (EMS) and the expected service offering of HEMS. Two surveys were conducted to identify customer complaints and expected service related to the existing EMS. The survey's target audience was set at users aged 30 years or more to obtain responses from those who actually pay for power usage; a total of 354 users were contacted for the online survey, which consisted of 16 questions about the pain points and expected services for HEMS. The survey was conducted through the professional survey company DOOIT Survey. Multiple answers to questions were allowed, and the criterion for a significant selection was set based on the choice made by the majority of the respondents. The survey results are reported in Table 2.

Table 2. Pain Points of Existing Energy Management System.

Category	Division	Pain Points of Existing Service		Expected Services of HEMS	
Power Consumption Monitoring	**Power Consumption**	Inability to measure power consumption	204 (56.2%)	Real-time power consumption monitor service	207 (55.9%)
		Inability to compare with neighborhood	244 (66.4%)	Power consumption data of respective home appliances	218 (59.6%)
		Inability to measure power consumption in real time	206 (55.4%)		
	Electric Fee	Inability to check the electric fee in real time	188 (51.4%)	Real-time electric fee monitoring	234 (62.7%)
		Inability to check the progressive tax section	294 (79.7%)	Alarm service for progressive tax section	271 (73.2%)
Energy Consumption Control	**Energy Management**	Unknowledge of effective energy saving methods	263 (71.5%)	Auto-control of effective power consumption	246 (67.5%)
		Unknowledge of reducing electric fee	260 (68.9%)	Deterioration detection with energy data	187 (50.8%)
	Standby Power	Inability to cut the non-use standby power from the outside	231 (61.9%)	Auto-control of non-use standby power in absence	249 (66.9%)
		Inability to measure effect of cutting standby power	213 (57.9%)	Saving data of cutting standby power	263 (71.8%)
		Lack of knowledge of appliances' standby power consumption	211 (57.3%)		
	Home Appliances Control	Trouble with remote control with existing system	212 (56.8%)	Total remote power control with mobile apps	301 (80.5%)
		Limited compatibility with appliances	223 (61.0%)	Remote power control of home appliances with mobile apps	213 (57.9%)
Security	**Advanced Metering Infrastructure (AMI) Security**	Data privacy fears regarding smart meters	286 (77.7%)	Smart meter protection solution	248 (67.2%)
		Fear of smart meters being hacked	233 (61.9%)	Personal authentication to energy data	284 (75.4%)
	Energy Data Security	Fear of gateway and smart plug being hacked	290 (77.1%)	Gateway/Smart plug protection solution	311 (84.5%)
		Fear of being hacked to cut electricity	215 (58.2%)	Convenient setting of gateway	196 (52.5%)
Interface	**Display**	Complication of existing energy management system	194 (52.3%)	User-oriented UI/UX	202 (54.2%)
		Burden of expenses for additional displays	221 (59.0%)	One-touch control of main appliances	277 (76.0%)
				On/Off status check service	194 (52.0%)

3.1.2. Service Importance and Urgency

With the pain points and expected service of potential consumers derived from the survey, the following nine HEMS services were selected as candidate services: (1) AI-based personalized automatic control service for home appliances, (2) real-time power consumption monitor service, (3) real-time standby power consumption control and monitor service, (4) remote-controlled service for home appliances, (5) data comparison with neighborhood service, (6) alarm service for progressive tax section, (7) personal authentication service, (8) power consumption data service of respective home appliances, and (9) power consumption and fee estimation service. Subsequently, an importance–performance analysis (IPA) was conducted on the relevant experts to determine the importance and urgency of developing the candidate services. IPA analysis is a marketing valuation technique that is used to prioritize attributes to enhance customer satisfaction and service quality [35–37]. The results of the IPA analysis are shown in Figure 1.

	Service	Importance	Urgency
EMS1	AI-based personalized automatic control service for home appliances	5.54	5.00
EMS2	Real-time power consumption monitor service	5.91	5.73
EMS3	Real-time standby power consumption control and monitor service	5.00	4.82
EMS4	Remote control service for home appliances	5.36	5.00
EMS5	Data comparsion to neighborhood service	5.64	5.09
EMS6	Alarm service for progressive tax section	5.36	5.18
EMS7	Personal Authentication service	5.55	4.64
EMS8	Power consumption data service of respective home appliances	5.00	4.36
EMS9	Power consumption and fee estimation service	5.45	5.00

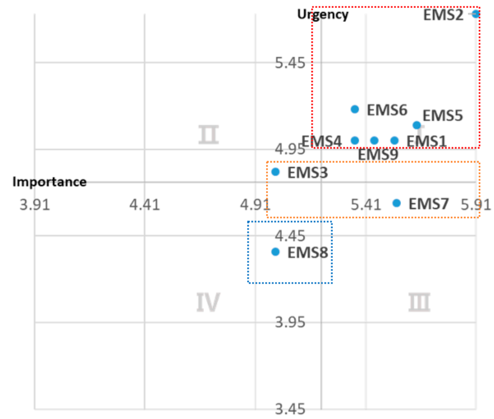

Figure 1. Importance–Performance Analysis (IPA) on Home Energy Management System (HEMS) Services.

The results indicated that the six services in the first quadrant were classified as those that should be developed first; the two services in the second and fourth quadrants were classified into two candidate groups. "Power consumption data service of respective home appliances" in the third quadrant was included in the subordinate development group.

3.2. *Ecosystem*

The HEMS industry is a new industry that adds service value to the basic energy supply market, which is based on the supply and demand for public resources. Therefore, to provide new services, it is necessary to produce additional value through the convergence of direct stakeholders and related industries. This study defines the value delivery flow through the service value network of the HEMS industry and presents a macroeconomic ecosystem model that includes the value chain.

3.2.1. Service Value Network of HEMS

Basole and Rouse [38] proposed a service value network concept by arguing that services and products should no longer be distinguished. Because products should be treated as services rather than a separate medium for delivering services, a service ecosystem that encompasses services and products must be presented on the service value network [39]. This network refers to the value-creating environment of entities providing various services; such entities consist of consumers, service supplier, tier 1, tier 2, and auxiliary enablers. The network is also influenced by external factors in the social, technical, political, and economic environment. The service value network of HEMS is shown in Figure 2.

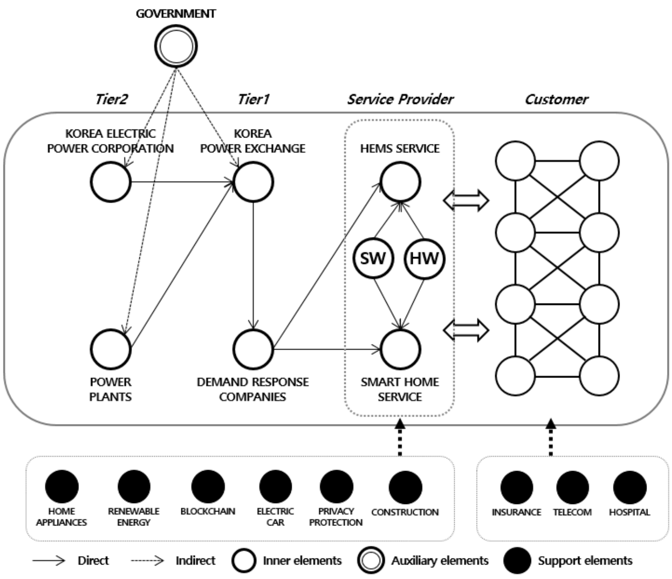

Figure 2. Service Value Network of HEMS.

The Tier 2 enabler area, which supplies power, the raw material for the HEMS market, includes Korea Electric Power Corporation (KEPCO) and the various other power plants in charge of supplying power in Korea. The Tier 1 enabler area includes HEMS service providers that directly serve customers, and entities responsible for the power distribution between smart home service providers and power suppliers. Korea Power Exchange is responsible for the transparency in power trading, which includes pricing, payment, and so on. The demand management provider manages and responds to demand by companies and delivers emergency instructions when necessary. HEMS services and smart home providers work in direct contact with customers, and provide services to customers, in conjunction with energy data analysis software technology companies and the data acquisition hardware.

The government plays the role of the auxiliary enabler in providing HEMS services. To implement HEMS, various types of infrastructure have to be constructed; further, owing to the high initial investment costs, various incentives may have to be offered to induce stakeholders to the HEMS ecosystem [7].

In addition, although home appliance production, renewable energy, blockchain technology, electric vehicles, personal information security, and construction companies are not directly involved in the HEMS market, they are part of the future HEMS service value network, or act as service enablers that collaborate with current service providers. In partnership with HEMS, insurers, telecommunications companies, and medical institutions are expected to take on the role of other service enablers to provide new benefits to customers.

3.2.2. Service Ecosystem of HEMS

Betz [40] proposed a service system modeling concept that integrates Porter's [41] study, which proposed the value chain concept, and Forrester's [42] system dynamics study. Betz [40,43] presented a support plane leading the continuous improvements in service maintenance, and a control plane representing the flow of services moving the industry; it is based on the transformation plane that represents the process from production to product sales. Kwon [31] revised and applied the aforementioned study to propose a logical, a physical, and a network platform to design a platform for realizing the shared value of the industry. In addition, Kwon et al. [44] analyzed the 3D printing industry from an ecological perspective by dividing it into domains of convergence with other fields, indirect support of related technologies, and external control through institutional devices.

Therefore, this study borrowed the 3-layer model framework of Kwon et al. [44] and constructed the ecosystem of the HEMS industry. Located at the center, the convergence domain represents the value chain of the HEMS industry, based on the service value network. The simple power supply, in connection with other industries, is sold as a service with the value of power usage efficiency. On top of that, there is a support domain that contains technologies for maintaining and developing HEMS services, such as AI, automatic control, data analysis, and personal information security; below it is the control domain that represents the institutional devices for market developments and service proliferation. The 3-layer ecosystem of the HEMS industry is presented in Figure 3.

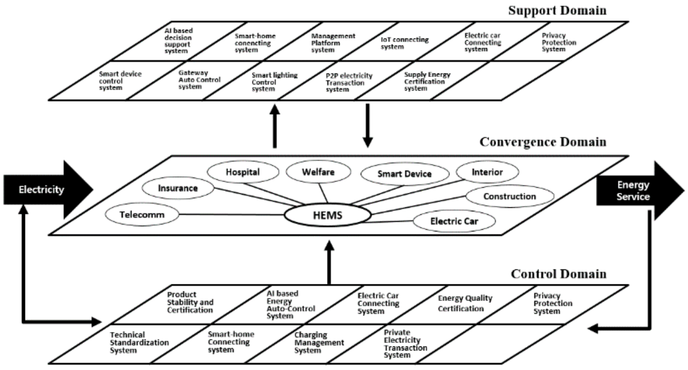

Figure 3. HEMS Industry Ecosystem.

3.3. Platform

In the business ecosystem, the platform is an essential collaborative space for various stakeholders, including users and suppliers, to ensure the expansion and development of the entire ecosystem [31,45,46]. In this study, an application platform was designed to connect the user of HEMS service to this service; it is presented by using the use-case method, as shown in Figure 4.

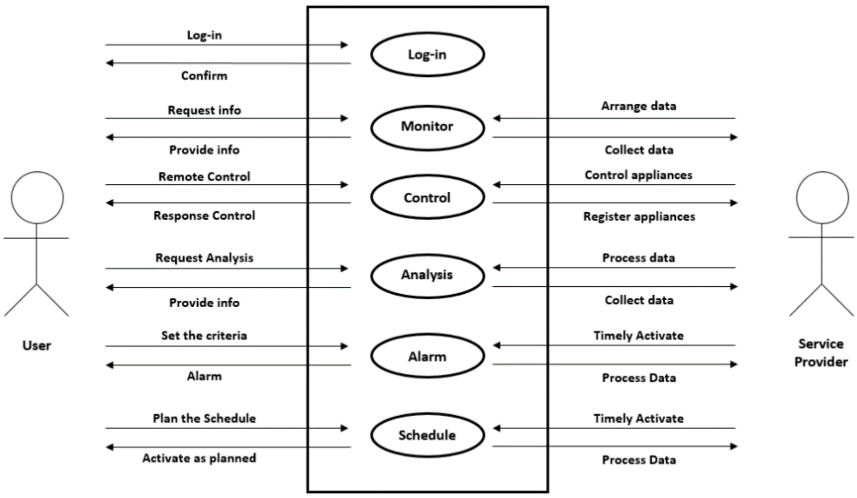

Figure 4. Use Case of HEMS Platform.

Additionally, this study constructed a platform application with the functions shown in the use-case in a prototype form, as shown in Figure 5; this was done to look into the actual users' convenience levels.

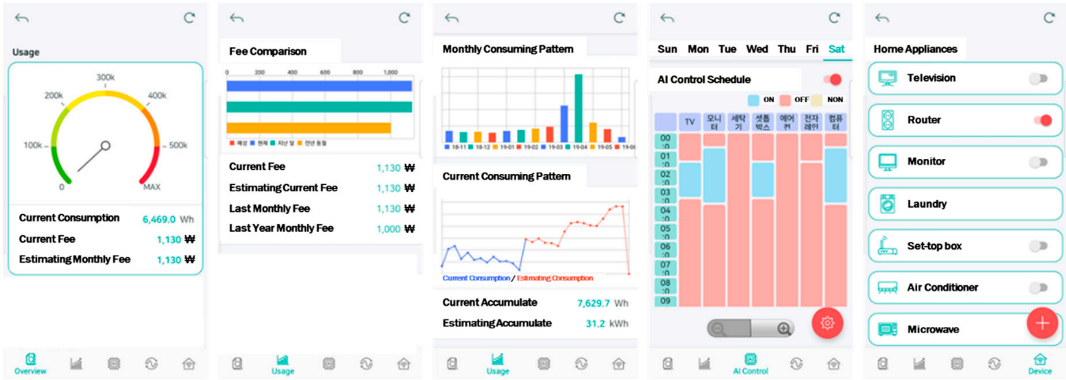

Figure 5. Application Prototype of HEMS Service.

The service is equipped with real-time monitoring, monthly fee comparison, graph-based usage pattern, scheduling, and remote control, and allows users to access the system by logging into the application. This prototype service is being pilot tested in 15 randomly selected households. Through this, the user interface and user experience of the application were evaluated, along with functional tests, such as actual energy saving efficiency and control operation of the service.

3.4. *Strategy*

Customer Segmentation

Prior to presenting the business model, this study segmented the values pursued by potential HEMS consumers on the basis of the means-end chain theory. This is a methodology used to reveal the consumers' value structure by analyzing the connection between the "attributes" of the product that consumers consider when purchasing products and services, the "consequence" or the resulting outcome and the "value" they ultimately seek [47–49]. Face-to-face interviews with six experts and seven potential customers were held according to the existing customer pain points to derive the attribute-consequence-value items of service using the soft laddering method. In addition, robust ladders were discovered using the hard-laddering method in the form of a survey of 330 adults aged 20 years or more; the attributes, consequences, and values were derived through the professional survey company DOOIT Survey [50]. The hierarchical value maps (HVMs), which represent Korea's HEMS consumer value structure, found through the laddering analysis are presented in Figure 6.

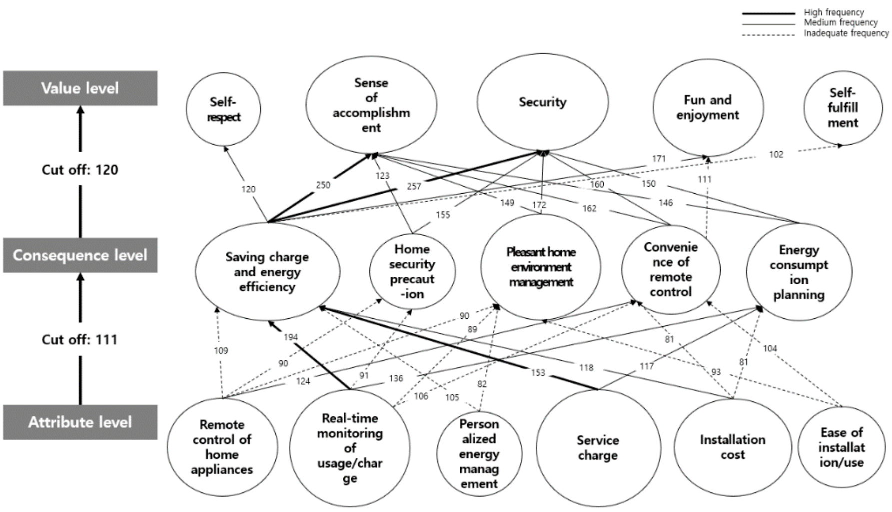

Figure 6. Hierarchical value maps (HVMs) for HEMS services of consumers.

Based on the cut-off criteria presented in herein, the ladders that have the strongest impact are: (1) usage/rate real time monitoring-rate saving and energy efficiency-safety, (2) usage/rate real-time monitoring-rate saving and energy efficiency-achievement, (3) service charge-saving and energy efficiency-safety, and (4) service charge-saving and energy efficiency-achievement. In addition, a total of 18 ladders showed significant results, as shown in Table 3. The results were classified into the following groups based on each value pursued by the HEMS consumers: "life quality-oriented," "innovation-oriented," "convenience-oriented," and "eco-friendly-oriented."

Table 3. Ladder Structure of HEMS consumers.

Ladder	Attributes	Consequence	Values	Ladder	Attributes	Consequence	Values
Ladder 1	Remote control of home appliances	Convenience of remote control	Sense of accomplishment	Ladder 10	Remote control of home appliances	Convenience of remote control	Security
Ladder 2	Real-time monitoring of usage/charge	Saving charge and energy efficiency	Sense of accomplishment	Ladder 11	Real-time monitoring of usage/charge	Saving charge and energy efficiency	Security
Ladder 3	Real-time monitoring of usage/charge	Energy consumption planning	Sense of accomplishment	Ladder 12	Installation cost	Saving charge and energy efficiency	Security
Ladder 4	Service charge	Saving charge and energy efficiency	Sense of accomplishment	Ladder 13	Real-time monitoring of usage/charge	Energy consumption planning	Security
Ladder 5	Service charge	Energy consumption planning	Sense of accomplishment	Ladder 14	Installation cost	Saving charge and energy efficiency	Security
Ladder 6	Installation cost	Saving charge and energy efficiency	Sense of accomplishment	Ladder 15	Service charge	Saving charge and energy efficiency	Security
Ladder 7	Service charge	Saving charge and energy efficiency	Fun and enjoyment	Ladder 16	Real-time monitoring of usage/charge	Saving charge and energy efficiency	Self-respect
Ladder 8	Real-time monitoring of usage/charge	Saving charge and energy efficiency	Fun and enjoyment	Ladder 17	Service charge	Saving charge and energy efficiency	Self-respect
Ladder 9	Installation cost	Saving charge and energy efficiency	Fun and enjoyment	Ladder 18	Installation cost	Saving charge and energy efficiency	Self-respect

The "life quality-oriented" type is a group that pursues a sense of accomplishment and feels satisfied by consuming energy efficiently through the HEMS service. The "innovation-oriented" type pursues fun and enjoyment and has the characteristic of enjoying new technologies through the efficient consumption of energy via the HEMS service. The "convenience-oriented" type pursues safety and aims to secure energy consumption or the prevention of safety accidents through the HEMS service. Finally, the "Eco-friendly-oriented" type is a group characterized by its desire to contribute to the environment through energy-efficient use of the HEMS service.

4. Results

Given the aforementioned, this study designed two HEMS business models that capture the existing state of affairs considering Korean domestic market, infrastructure, and potential customers.

4.1. HEMS B2C Model

First, the HEMS B2C model is a business model for the general household and places of business of small business owners; it is suitable for the "life quality-oriented" and the "Eco-friendly-oriented" types found through the laddering method. The model offers the optimal cost reduction and safety in power consumption by collaborating with smart device manufacturers and stakeholders who provide the living space and the necessary infrastructure. The conceptual diagram of the business model is shown in Figure 7.

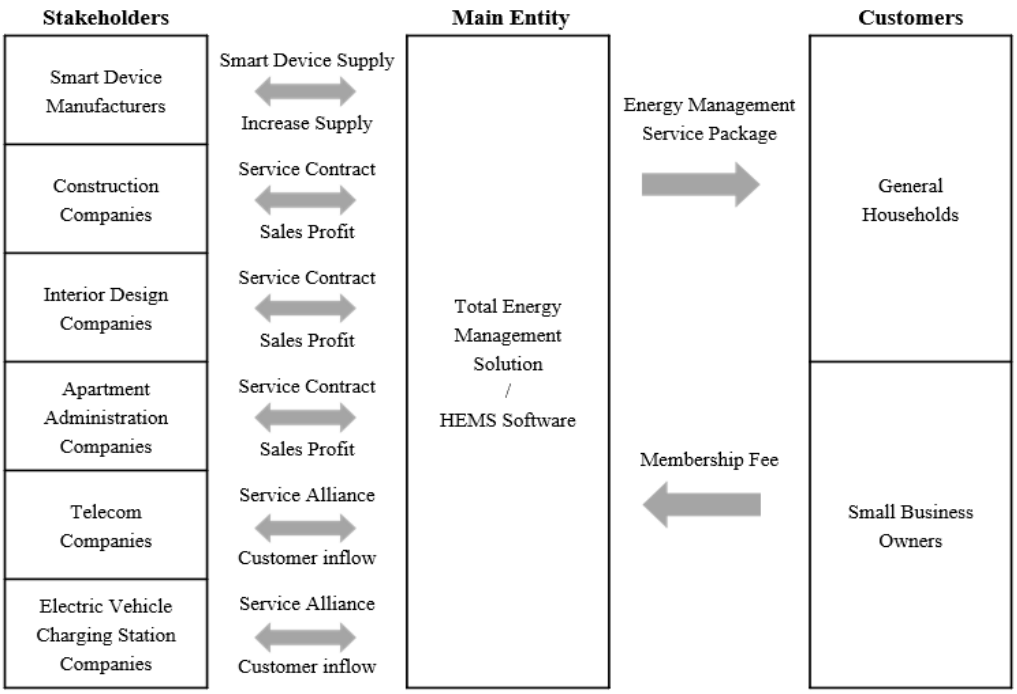

Figure 7. Business Conceptual Map of HEMS B2C Model.

Economies of scale can be achieved through collaborative relationships with the installation operators, who consist of smart device manufacturers, construction companies, interior design companies, and apartment administration companies. Service linkages can be made through alliances with telecom companies, and information can be shared with electric vehicle charging station companies to expand the service scope. The specific business model is presented in Figure 8 through the Business Model Canvas technique, which is a visual modeling method for explaining the principle and process of profit generation, and consists of nine blocks [24,51].

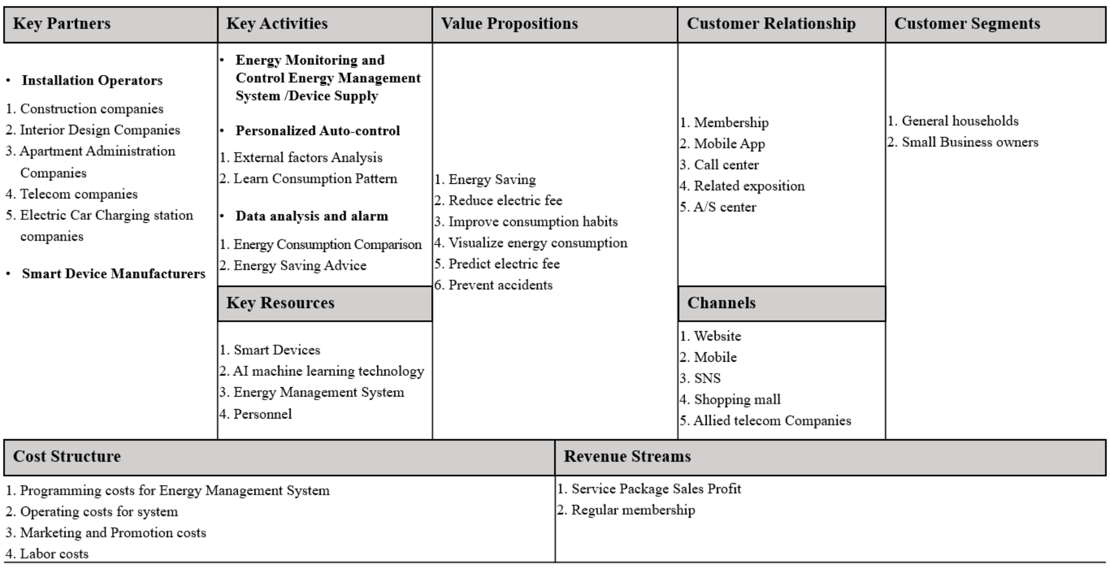

Figure 8. Business Model of HEMS B2C Model

Consumers in this model, that is, the general households and places of business for small business owners, are offered energy savings, lower energy bills, and a variety of benefits through online and offline channels. Suppliers work in cooperation with a variety of stakeholders to provide

AI-based energy data analysis services, invest in service development and promotions, and generate revenues from service sales and usage fees.

4.2. Home Care Model

The Home Care Model is a business model for the "convenience-oriented" type determined through the laddering method; it provides energy management and absolute safety, through the HEMS, mainly for households in which there is no one at home, and those with persons in need of care. The conceptual diagram of this business model is presented in Figure 9.

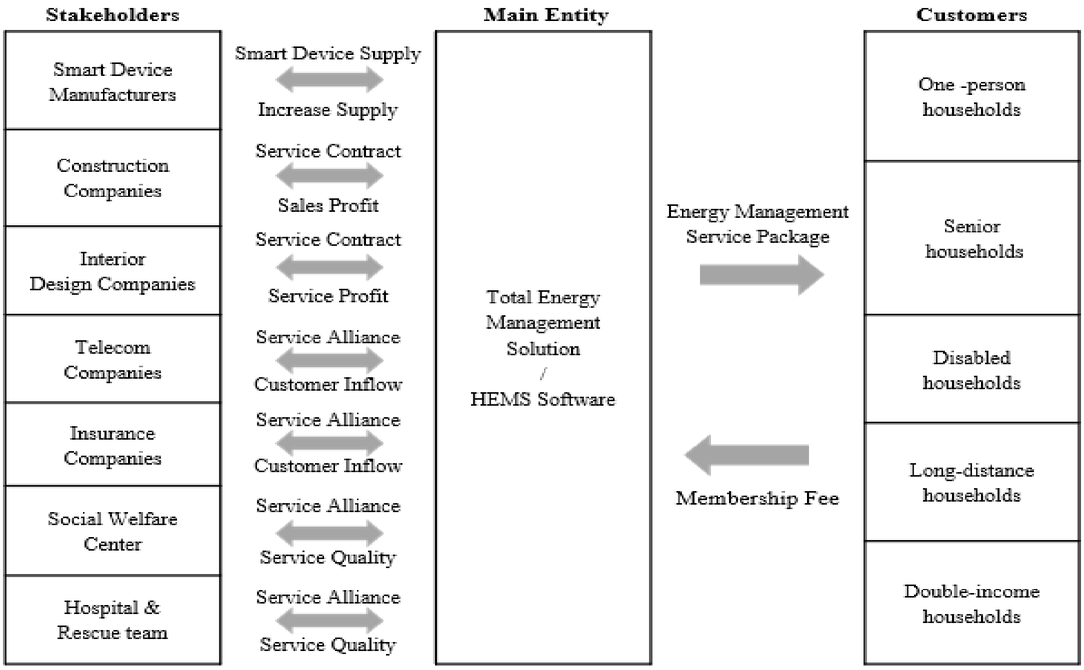

Figure 9. Business Conceptual Map of HEMS Home Care Model.

As in the B2C model, the cooperation of not only the installation operators with the telecom companies, but also of safety-related stakeholders, is required. The safety of service users can be ensured through energy anomaly detection services, in conjunction with immediate actions by medical institutions and welfare centers. Furthermore, insurance benefits for service subscribers can be provided through cooperation with insurance companies.

The HEMS Home Care Model is shown in Figure 10; the consumers in this model include single-person households and vulnerable households, who will be provided with the values of energy savings and security through online and offline channels. Suppliers will work with a variety of installation operators and safety-related stakeholders to provide AI-based energy data analysis services, invest in service development and promotion costs, and generate revenue from service sales and usage fees. The difference from the B2C Model is that the end consumer is an organization or family, such as a vulnerable household, in need of the aforementioned safety services.

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Propositions</th><th>Customer Relationship</th><th>Customer Segments</th></tr>
<tr><td rowspan="3">• Installation Operators
1. Construction companies
2. Interior Design Companies
3. Telecom companies

• Smart Device Manufacturers

• Safety-related entities
1. Insurance companies
2. Social Welfare Center
3. Hospitals & Rescue team</td><td>• Personalized Auto-control
1. External factors Analysis
2. Learn Consumption Pattern
• Energy Monitoring and Control
1. Energy Management
2. System/Device Supply
• Ensuring Safety Service
1. Mutual Monitor & Control
2. Alarm to App</td><td rowspan="3">1. Energy Saving
2. Reduce electric fee
3. Mutual Energy Monitor
4. Censoring Energy Abnormal Patterns
5. Special Care for abnormal households</td><td>1. Membership
2. Mobile App
3. Call center
4. Related exposition
5. A/S center</td><td rowspan="3">1. One person Households
2. Senior households
3. Disabled households
4. Long-distance households
5. Double-income households</td></tr>
<tr><th>Key Resources</th><th>Channels</th></tr>
<tr><td>1. Smart Devices
2. AI machine learning technology
3. Energy Management System
4. Personnel</td><td>1. Website
2. Mobile
3. SNS
4. Shopping mall
5. Allied telecom Companies</td></tr>
</table>

Cost Structure	Revenue Streams
1. Programming costs for Energy Management System 2. Operating costs for system 3. Marketing and Promotion costs 4. Labor costs	1. Service Package Sales Profit 2. Regular membership

Figure 10. Business Model of HEMS Home Care Model.

5. Discussion

Two implications could be found in this study for HEMS market industrially and academically. This study reorganizes and supplements the attributes of service innovation suggested in previous studies. Previous studies implemented service innovation in that they treated service innovation partially [19,25–28] or implemented from the point of supply side [25,26,28]. On the contrary, this study derives customer needs and structures the business model co-creating value with customers. Furthermore, it configures the process of the integrated service innovation: understanding customer needs, developing service, organizing the ecosystem, prototyping the platform, and establishing the strategies. Then, it overcomes the simplicity of the business models with describing the roles of stakeholders in the ecosystem [29].

Moreover, it has an industrial implication with finding undiscovered customer value in the HEMS market. Previous studies were limited to understanding of the structure of HEMS industry with the proposal of business model [14], or analyses of environment and the suggestion of business models in the perspective of suppliers [52,53]. However, this study, following S-D logic, prioritizes unveiling hidden pain points of potential customers and finds new customer value. In the end, proposed business models offer not only energy reduction but also a solution for the social problem of single family household through energy consumption data. Additionally, self-fulfillment and self-respect value is not proved significantly, but it could be highly considered in the future as customers perceive eco-friendliness of HEMS.

In addition, it is necessary to recognize the differences between the global HEMS environment and the Korean environment and determine a service strategy suitable for Korean consumers. Currently, the following additional factors need to be considered in Korea: 1) viewing the commercialization of 5G technology, the popularization of smartphones, and the increase in electricity-consuming devices from a technological perspective, 2) examining the rise of single-person households and the aging society from a sociological perspective, and 3) taking the serious environmental problems and other environmental factors into account [8,54,55]. The incorporation of the aforementioned factors into the service strategy will result in a better service strategy and enhanced user loyalty.

As Vargo and Lusch suggested [17,18], the structure of service should be changed to be more relational and customer oriented. Therefore, to fulfill the upcoming customer value, the content of the business model needs to be diversified through convergence with related technologies of the EMS technology, including demand response, energy storage system, virtual power plant, and renewable energy [56]. Hence, it is necessary to quantitatively estimate the energy saving efficiency in the real households with HEMS and evaluate customer loyalty according to several strategies in the future researches.

Finally, even though this study focused on the Korean domestic market, it still has contributions to the global energy market. First, it differentiated service design approach from previous studies, so following studies and businesses could be more customer oriented. Second, this study could be a reference for structuring innovative energy industry ecosystem. Lastly, it gives an insight for related business model innovation.

6. Limitations

It cannot be said that this study identifies all the elements in the HEMS ecosystem. A limitation of this study is that there is a lack of a micro analysis of the detailed relationships among stakeholders. However, this study has implications for the HEMS market in Korea as it presents the following: a visualization of the ecosystem through S-D logic, a classification of potential HEMS users based on the types and the needs of users, and a business model that includes prototype models. It is hoped that this study will lay the foundations for an extensive integrated study in the future, which contains a detailed analysis of the HEMS market in Korea and in other countries, and research on the technologies and services that can be developed further.

7. Conclusions

It is undisputable that the HEMS service will be adapted to many houses in the near future with the development of smart grid and an increase in demand of electricity. Targeted to marketable industry, many studies suggested innovative business strategies and analyses. However, this study, based on S-D logic with an ecological perspective, deals with the provision of services in the Korean HEMS market (Service), ecosystem composition (Ecosystem), platform design (Platform), and business modeling (Strategy); it provides specific clues for innovation in the promising new/renewable energy industry.

It shows that the greatest benefits to Korean customers of the HEMS service are energy savings and efficient use, through service offerings, such as energy consumption monitoring, remote control, power consumption comparison, and billing. However, it is also important to consider the issues of safety and contribution to the environment.

The value-added will not come solely from the combination of electrical power, as a resource, with various services. It is also necessary to combine the various stakeholders, technologies, and institutions. This suggests that the new energy industry should go beyond the primary and secondary industrial characteristics of electricity production and supply and should develop into an ecosystem-based industry that meets the new paradigm of IT convergence [31]. Thus, the mock structure of platform was constructed, and application prototype was also represented to visualize how it comes to customers.

Then, the type of customers' preferences was derived with service hierarchical value maps consisting of attributes, consequences, and value of HEMS service. And, to meet these customer types, this study suggested two business models in the way of service conceptual diagram and business model canvas. Especially, home care model, devised from safety value, could be highly evaluated because it has not been served in Korean domestic industry.

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