SITEKIN: Jurnal Sains, Teknologi dan Industri, Vol. 21, No. 2, June 2024, pp.302 - 315
ISSN 2407-0939 print/ISSN 2721-2041 online

A Proposed Business Model of Product-Service Systems for Lighting System

Rangga Primadasa[1], **Sugeng Slamet**[2], **Salman Alfarisi**[3], **Imam Abdul Rozaq**[4], **Akhmad Zidni Hudaya**[5], **Yusuke Tsutsui**[6]

[1,3] Department of Industrial Engineering, Faculty of Engineering, Universitas Muria Kudus
[2,5] Department of Mechanical Engineering, Faculty of Engineering, Universitas Muria Kudus
[4] Department of Electrical Engineering, Faculty of Engineering, Universitas Muria Kudus
Jl. Lkr. Utara, Kayuapu Kulon, Gondangmanis, Kec. Bae, Kabupaten Kudus, Jawa Tengah 59327
Email: rangga.primadasa@umk.ac.id, salman.alfarisi@umk.ac.id, sugeng.slamet@umk.ac.id, akhmad.zidni@umk.ac.id, imam.rozaq@umk.ac.id

[6]Deparment of Systems Engineering Faculty of Computer Science and Systems Engineering, Okayama Prefectural University
111 Kuboki, Soja-shi, Okayama, 719-1197 Japan
Email: tsutsui@cse.oka-pu.ac.jp

ABSTRACT

The growing nature of the business world necessitates continual innovation in business models. In response to the increasing need for sustainable and flexible business practices, Product-Service Systems (PSS) have gained traction across various industries. However, the LED manufacturing industry remains predominantly product-centric. This study investigates the feasibility of transitioning the LED lighting business model to a Product-Services Systems (PSS) approach to fill this gap. This study examines several alternate PSS Lighting System business models using morphological analysis. The Business Model Canvas v2.2 framework is then used to assess these options' acceptability, viability, and feasibility. Selected PSS lighting systems are then detailed within the Business Model Canvas. Four business models for the PSS Lighting System are identified in the study as potentially viable for implementation: product leasing, sharing, pooling, and activity management lighting systems. Additionally, this study advances our theoretical knowledge of PSS, especially concerning the PSS Lighting System business model. Furthermore, this study offers insights into expanding existing business models by integrating multiple lighting system models proposed in this study.

Keywords: *LED Manufacturing, Product-Service Systems, PSS Lighting System, Business Model Canvas.*

Introduction

Economic growth and changes in consumer behavior have pushed companies to look for new ways to provide innovative products and services. One increasingly demanding approach is the Product-Service System (PSS), where companies not only focus on selling products but also provide related services. PSS is an integrated combination of products and services [1]. PSS has been proven to provide many benefits, such as improving environmental sustainability, increasing customer satisfaction, and opening up new market opportunities. PSS can increase revenue if they can meet the exact demand by providing fewer resources and service mixes [2].

The PSS has more significant benefits over its life cycle, such as reducing environmental burden and localizing service needs. [3]PSS is a business model that focuses on providing a set of economically, socially, and environmentally sustainable products or services to meet customer needs. [4]. The PSS has essential points, including changes in consumer attitudes from initially sales-oriented to service-oriented, a repair society rather than a throw-away society, sales of product use rather than product sales, and changes towards a leasing society. [5].

PSS provides benefits for consumers, namely flexible service and continuous improvement of products and services. PSS provides benefits for providers, namely customer loyalty, cost reduction, and resource reduction. PSS delivers benefits for the environment, and services are planned based on the product's life cycle. PSS provides benefits for society, namely by putting public pressure on environmental issues, new services can grow, and new jobs can be encouraged [6].

PSS has a significant impact in encouraging circularity, including the PSS approach, which follows the 6 R's, namely (1) Reduce with the PSS Approach, namely by designing more durable products that have longer lifespans and are energy efficient; (2) Reuse, with the PSS Approach, namely by designing products that can have multiple life cycles and refurbishing or upgrading as needed, (3) Remanufacturing with the PSS Approach, namely by facilitating maintaining ownership of the product and being responsible for its maintenance, (4) Recycle with the PSS Approach namely ensuring products and materials are designed with recyclability in mind, (5) Recover with the PSS Approach, namely looking for innovative ways to recover resources from products and services that are reaching the end of their life, (6) Redistribute with the PSS Approach sharing or leasing products between several users [7].

PSS is generally divided into three categories: product-oriented, use-oriented, and result-oriented, as seen in Figure 1. The first main category of PSS is product-oriented, where the main business sells products but with additional services. Then the second main category is use-oriented, where the focus is on product sales, but ownership of the product still lies with the provider; the third main category is result-oriented services, where the client and provider agree on the results, and no pre-determined product is involved. [8].

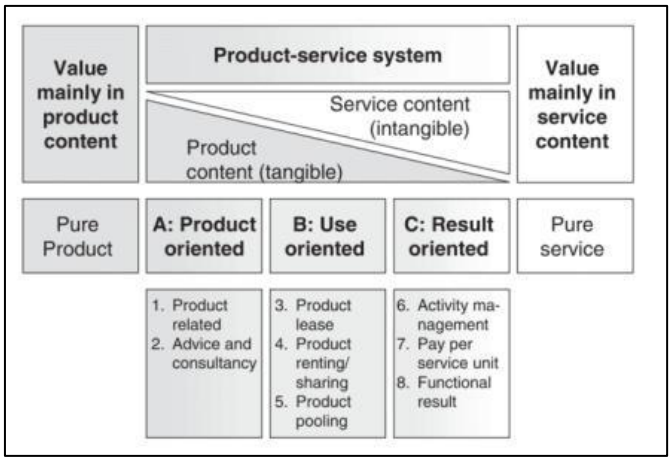

Figure 1. Category and Sub-category PSS, adopted from[8]

PSS sub-category (1) product-related service from Figure 1 means that the provider not only sells products but also sells services during the product use phase, (2) advice and consultancy means that the provider provides advice on how the product is used efficiently, (3) Lease products mean that there is no change in product ownership, the provider is the product owner and is responsible for maintenance, repair, and control. The lessee pays a regular fee for product use, (4) product rental or sharing, meaning the provider also owns the product, including responsibility for maintenance, repair, and control. The difference with a product lease is that the product lease user has unlimited and individual access, while in product rental, the user does not have the product. (5) Product pooling closely resembles product renting, with the primary distinction being the product's concurrent utilization. Additionally, activity management, or outsourcing, includes the delegation of specific company functions to a third party, (7) Pay-per-service unit" entails a shift from traditional product buying to the payment based on the usage output of the product, (8) "functional result" involves a contractual agreement between the provider and the client concerning the delivery of the desired outcome, leaving the methodology of achieving declared outcome entirely to the discretion of the provider [8]. Up to now, PSS research has focused chiefly on optimization and comparison studies in a few notable contexts, such as bike and car sharing. PSS car-sharing case studies in Austria and Germany show that the provider's motivation is sustainability, opening new markets, and social reasons. Then, the customers are business and private clients. Meanwhile, consumers' motivation is cost efficiency, convenience, and sustainability. [9].

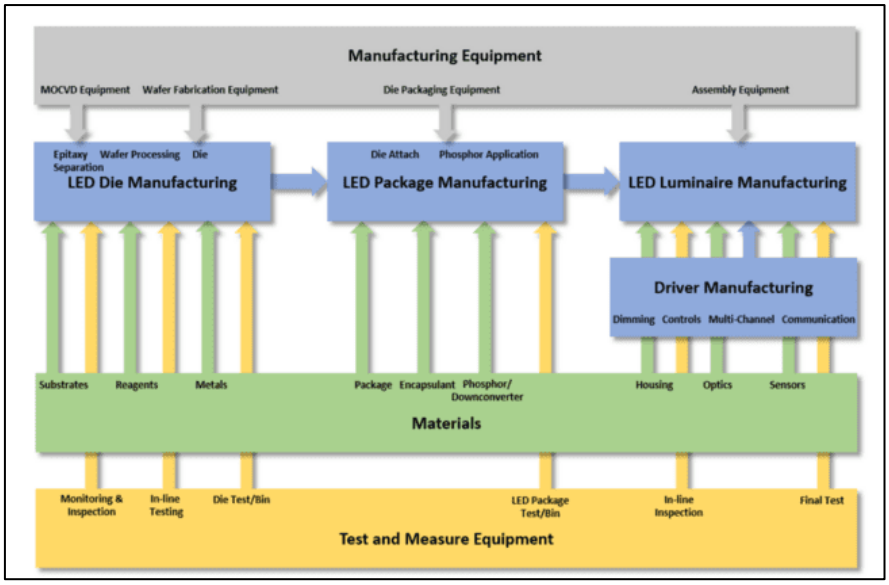

Figure 2. LED Manufacturing Supply Chain, adopted from[10]

Unfortunately, these studies frequently omit several PSS-preferred categories, leading to unexplored and unresearched categories. The lack of detail in initial research concerning the assortment of available categories constitutes a challenge this study aims to address. The LED Manufacturing company is used as a case in this study to address this issue. The Traditional Lighting system business model here is producing and selling LED lamps. As described in Figure 2, the LED Lamp supply chain generally starts with LED Die Manufacturing, then LED Package Manufacturing, and LED Luminaire Manufacturing. [10]. After the LED lamp is produced, it is sent to retail and from retail to final consumers. The current LED Lamp business model is still not PSS-based but a pure product.

Various kinds of research have been carried out regarding the PSS business model, including smart PSS in industrial firms. [11], barriers to the bicycle-sharing system [12], use of design thinking in PSS design [13], PSS-oriented untuk customize production pada healthcare [14], straightforward approach to SME's to design PSS [15], lean and green supply chain for PSS [16]Urban mining as a PSS case [17], the business model configuration of PSS [18], sustainability factors for PSS [19], integration lifecycle thinking into PSS [20]. Other research examines how PSS types with different business models relate to different circularity strategies. [21]. In all previous PSS research, we still haven't found a PSS business model for Lighting Systems.

The morphological analysis method will be used to develop a proposed PSS business model for lighting systems and select feasible proposals. Morphology comes from the Greek, μορφή, morphé = form, used in various scientific disciplines to refer to the study of structural relationships between different aspects of the object of study. [22]. In this research, the PSS lighting system was prepared following the morphology analysis stages, where the components in the morphology chart were integrated with the business model canvas components. In contrast, the business model selection integrated the business design canvas v.2.2. These three methods are incorporated to obtain the best PSS Lighting system business model.

Product-Service System (PSS) Application in the Context of Various Industries

Product-Service System (PSS) is a suite of products, services, support networks, and infrastructure designed to compete, meet customer needs, and have a lower environmental impact than traditional business models. PSS research has developed from various perspectives. The study conducted by [23] Shows that from 1988-2015, research topics regarding PSS were divided into five clusters, namely: (1) the business perspective, (2) the design perspective, (3) the sustainable perspective, (4) the operational perspective, and (5) the decision perspective. Then, in 2016-2022, PSS research topics are also divided into 5 clusters, namely (1) digitalization perspective, (2) circular economy perspective, (3) performance perspective, (4) sustainable design perspective, and (5) diffuse perspective. [23]. This research tries to take a business and performance perspective, where PSS is implemented in traditional LED Manufacturing to create various business models and new revenue opportunities in the developed business model.

PSS has been used in various types of industrial research, including in developing customization in healthcare production to create an alternative business model [14], in small and medium enterprises (SMEs) [15], in urban mining as a segment of the construction equipment industry [17], in the fashion

industry to compare the propensity of customers in Russia and Italy [24], in clothing libraries for women to assess the attractiveness [25], in the plastics industry to design a new business model[26], in the niche clothing industry in Belgium and the Netherlands to assess relational, symbolic, and material work [27]. This research focuses on the servitization of LED manufacturing by developing a PSS lighting system.

Integrated Business Model Canvas (BMC) and Morphology Analysis

A business model is a conceptual tool that includes various objects, concepts, and relationships between them to express a particular company's business logic. Therefore, we must consider which concepts and relationships allow simple descriptions and representations of the value delivered to customers, how it is offered, and the financial consequences involved. [28]The business model canvas (BMC) is a tool widely used to create value-based business models. This tool highlights the importance of understanding what customers find valuable and provides users with steps on how to design and deliver that value to their customers.[29]. Many studies using BMC have been carried out, including by [30] To develop BMC-based social enterprises. BMC is also used in developing business models for oil-water separation equipment in restaurants and food-processing factories [31]. It is also used to develop circular business models in electrical and electronic manufacturing. [32]. However, BMC has never been used to develop PSS lighting system models or servitization in LED manufacturing.

Morphology analysis integrated with the business model canvas (BMC) is used to develop a business model, namely mobility-as-a-service as a prominent future passenger transport. [33]. Prototyping business models using morphology analysis was also carried out. [34], where three phases are used, namely determining objectives and identifying potential fields; the second phase is generations of new business models; and the third phase is assessment of the business model. Morphology analysis has also been used to develop digitalization and automation in the transportation sector. [35] Where the attributes of each electric vehicle parameter are developed in the morphological box, this research is the same as previous research, which integrated morphology analysis with BMC, but what makes it different is by integrating again with business design canvas v.2.2. Three parameters are used in design canvas v.2.2 to assess a business model, namely desirability, viability and feasibility. Desirability itself consists of five attributes, namely: target audience; the “job to be done” the audience is carrying out; an observed and evidence-based challenge or problem that is backed by an insight; evidence that is seeking a way to solve the problem or a solution that addresses a specific challenge; what the customer can achieve in the future they can't right now. Then viability also has five assessment attributes, namely: the target audience represents a potential addressable market of x customers; what the customer is willing to give us; the main atomic value swap the opportunity offers them; how the business model creates revenues and profits based on a cost model; Evidence-based projection of when the opportunity will return a profit over time. Finally, feasibility also has 5 assessment attributes, namely: our organization and any partners required for the leanest viable operation; understanding the least amount of work at any time to start to drive repeatable sales; the mixture of customer acquisition, activation, sales, and retention; and efficient and scalable sales growth experimentation framework; the differentiating factor that customers will love that is unique to this Opportunity. [36].

Research Methods

This research uses morphological analysis. Morphology is defined as the study of form or pattern. It intends to understand objects based on typology, which consists of various patterns. [37]. Briefly, this research stage starts by describing the problem, then determining various possible solutions, making a morphological chart to compile various possible PSS Business Models, then selecting a business model with three things: desirability, viability, and feasibility, and finally implementing the solution. In detail, the stages of this research are as follows:

Problem Description

The business model itself is defined as a conceptual tool that consists of several elements and their relationships, which makes it possible to show the business logic of a specific company. This describes the company value offered to consumers. [18]At this stage, case study information was acquired within the premises of an LED light manufacturing industry. Interviews with key stakeholders within the company garnered a thorough comprehension of present circumstances. This approach enabled the synthesis of pertinent information for developing a business model concerning future operational paradigms and pathways.

Possible Solution Analysis

At this stage, various alternative business models for lighting systems are developed while still paying attention to the PSS concept, as described in Figure 1. Each alternative business model was developed from eight PSS business models: PSS model business yaitu product-related, advice and consultancy, product lease, product renting, product pooling, activity management, pay-per-service, and functional result.

Morphological Chart/Matrix Construction

At this stage, a multidimensional matrix is prepared for the current lighting system business model, and various alternative business models are developed. In this way, a comparison of each alternative business model created will be carried out. Bibliographic mapping and analysis related to dimensions and business models of PSS (Product-Service System). The dimensions used are derived from [38], namely revenue structure, value proposition, and several dimensions (41), including customer segments, partners, and leading providers. A value proposition is a bundle of products or services that creates value for specific consumers. [18]. Revenue structure or revenue streams is the way cash is generated from consumers. [18]. Partners or key partnerships are suppliers and partners who make the business model work. [18]The morphological chart prepared at this stage is intended to explore various possibilities for the Business Model Canvas, which will be prepared so that the table is adjusted to that in the BMC.

Solution Selection/Evaluation

At this stage, the PSS model for the lighting system with various alternatives is evaluated, and the most feasible business model is selected for implementation. The evaluation process relies on the expertise of experts who are well-versed in the intricate details of PSS, as proven by their scholarly contributions within the domain. In this research, details of expertise are in Table 1. Moreover, input from pivotal stakeholders was garnered through interviews to enrich the assessment with valuable insights. The synthesis process from each expert is carried out in several stages, namely: first, an explanation of the problem approach, including measurement and scoring indicators, is carried out as shown in Figure 4, then the views of each expert are continued considering the value or score for each indicator in the business design canvas v2.2, each experts are given to express their opinions and points of view without being forced to equalize the score. Then, a consensus session was held to produce a scoring agreement that most experts agreed upon. In general, the stages follow the stages of [39].The analytical structure employed for this evaluation is the Business Model Canvas v2.2, a structured tool renowned for its efficacy in assessing various facets of business design. Each element of inquiry within this framework is meticulously aligned with corresponding templates provided by the Business Model Canvas v2.2, ensuring a systematic and thorough review of pertinent considerations. Calculation of desirability, viability, and feasibility for business design canvas 2.2 from [36] They are used to select a business model that can be implemented.

As described in Figure 4, Within the framework of the Business Model Canvas v2.2, the process of scoring desirability, viability, and feasibility entails an extensive assessment of diverse facets inherent to a proposed business model. The score for each desirability attribute is between 1 and 3, so with 5 characteristics in the desirability parameter, the maximum total score is 15. Desirability measures whether what is being offered is relevant to existing behavioral trends. Do most people want what is being offered? [40]. The score for each feasibility attribute is also 1-3. With 5 attributes, the feasibility has a maximum score of 15. Feasibility encompasses an assessment of whether the intended outcome is technically possible and can utilize resources in the specified time frame [40]. The score for each viability attribute is 1-3. With 5 attributes, the viability has a maximum score of 15. Viability means measuring the likelihood of a business model having a profit potential of the business venture [41]Each criterion is assigned a score between 1 and 15, which provides an objective way to assess the potential performance and feasibility of the evaluated business model.

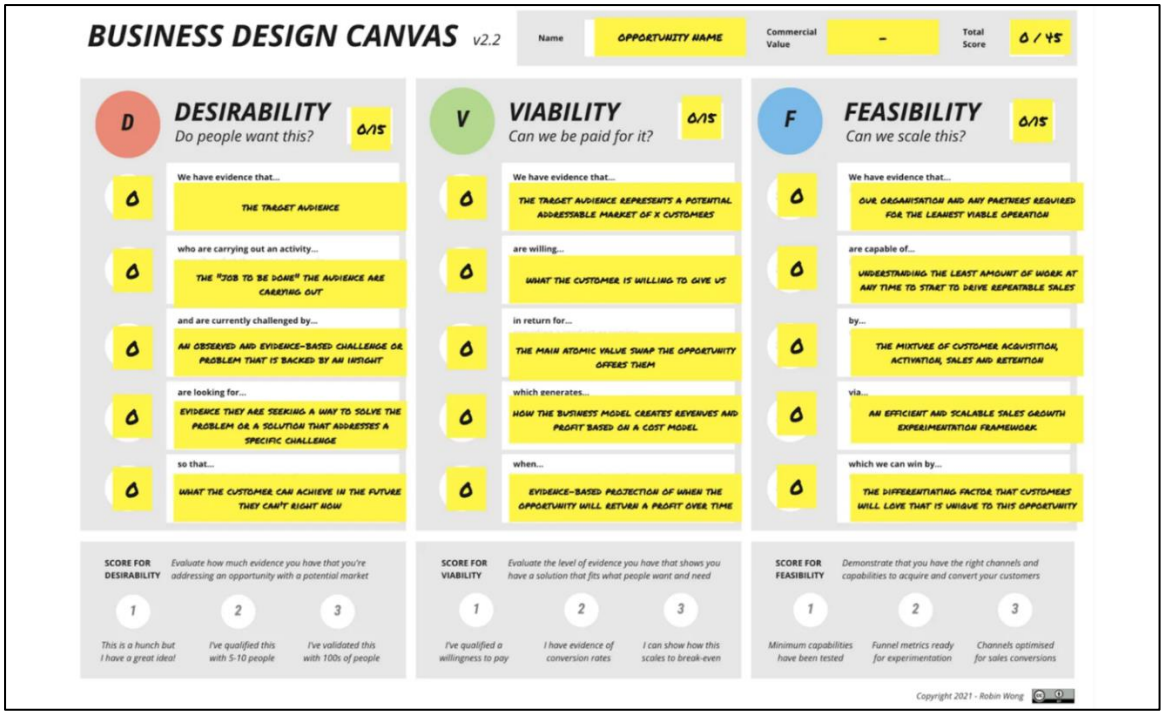

Figure 3. Scoring Desirability, Viability, Feasibility Business Design Canvas V.22 (adopted from[36])

Table 1. Team of Expertise

Expert	Status	Position	Education	Work	Field of Expertise
A	Practitioner	Sales and Operation	Bachelor	5 Years	Product-Service System
B	Practitioner	Manager	Bachelor	5 Years	Product-Service System
C	Academics	Lecturer and Researcher	Master	5 Years	Product-Service System
D	Academics	Lecturer and Researcher	Doctor	6 Years	Product-Service System
E	Academics	Lecturer and Researcher	Doctor	7 Years	Product-Service System

Applying Solution

At this stage, the selected solution is proposed to the lighting system company as an alternative to be implemented. The proposal is made by compiling a comprehensive business model canvas (BMC) for the selected business model. Business Model Canvas contains key partners, key activities, value propositions, essential resources, customer relationships, channels, customer segments, cost structure, and revenue streams. [42].

Result And Discussion

Problem Description

LED manufacturing is a pure product and is not yet PSS-based; the leading provider in this business is still the LED Manufacturing Company. Business partners are still raw materials suppliers, with customers being individual LED light buyers. The revenue structure is still from selling LED light products only. The value proposition defines the business model's value for consumers and shows the difference from competitors. [43]The value proposition for LED Manufacturing is still pure energy-saving and environmentally friendly LED lighting products. To expand the scope of the traditional LED manufacturing business, new business models with new consumer targets and revenue streams need to be developed.

Possible Solution

Possible solutions that can be offered for the PSS Business Model for Lighting Systems are 8 business models in PSS including (1) product related to lighting systems, (2) advice and consultancy for lighting systems, (3) product lease for lighting systems, (4)) product renting/sharing for lighting systems, (5) product pooling for lighting systems, (6) activity management for lighting systems, (7) pay per service unit for lighting systems, (8) functional units for lighting systems. All of these business models are derived from [8]This solution offers eight PSS business models for lighting systems, allowing them to be oriented toward what is more prospective for future implementation.

Morphological matrix

The morphological matrix for the PSS Lighting System consists of eight business models with five dimensions: provider, partner, customer, value proposition, and complete revenue structure, as shown in Table 2.

Table 2. Morphological matrix for PSS business model to implement for lighting system

PSS-Business model	Main Provider	Partners	Customer	Value Proposition	Revenue Structure
Product related	LED Manufacturing Company	Suppliers' materials	corporate	Selling LED lights with high energy efficiency, good lighting quality, easy installation and maintenance, + special installation services for IoT integration	Revenue from 2 things: (1) sales of LED lights, (2) IoT integrated LED installation services.
Advice and consultancy	Lighting System Consultant	LED Manufacturing Company	Building developer	It provides advice and consultation from experts to determine the type and number of LED lights suitable for the building, which will be and is being built in accordance with the space designation.	Revenue from 2 things: (1) fees for advice services on selecting LED lights, quantities, and installation suggestions, and (2) tips from LED manufacturing for selling lights to clients.
Product lease	Lighting System Provider	LED Manufacturing Company	Event Organizer	Always get the latest lighting technology for the events being held, always provide lighting technology according to the event concept, and always get lighting technology according to safety	Revenue is obtained from (1) Subscription fees to use lighting system services for several events held within a month or a year, depending on the subscription length.

					standards. You can subscribe to get cheaper prices.	
Product renting/sharing	Lighting Provider	System	LED Manufacturing Company	Event Organizer	Flexible rental contracts according to lighting needs for events	Revenue is obtained from (1) rental fees for the use of lighting system rentals for events
Product pooling	Lighting Provider	System	LED Manufacturing Company	shared logistics warehouse	Able to split lighting costs between multiple users as needed	Revenue is obtained from (1) subscription fees for each customer who shares the costs
Activity management	Lighting Provider	System	LED Manufacturing Company	corporate	Able to use lighting according to the needs of each activity without the need for direct involvement.	Revenue is obtained from the cost of each lighting activity package.
Pay per service unit	Lighting Provider	System	LED Manufacturing Company	corporate	Able to use lighting according to lux requirements at a low per-lux cost, without the need to buy lamps and supporting equipment, free of maintenance costs	Revenue is obtained from the cost per lux for each facility used
Functional result	Lighting Provider	System	LED Manufacturing Company	corporate	Able to meet lighting needs according to the desired function	Revenue is obtained from the lighting costs for each package

Table 2 shows that the customer for each business model only focuses on one consumer to concentrate on each PSS Lighting System Business Model. Main Providers and partners are only given one choice for each proposed business model, simply so that the business model offered has greater focus and differentiation. The leading provider for most of the business models offered is the Lighting System Provider; only 2 are different: the product-related lighting system, which is the leading provider, is the LED Manufacturing Company, and the Advice and Product Consultancy Lighting system, which is the leading provider is the Lighting system consultant.

Solution Selection

Interviews and Focus Group Discussions from experts in PSS business models were then carried out to fill in the desirability, viability, and feasibility scores of the proposed business model from Table 2. The results of the expert assessment were then displayed in Table 3. The results were then used as a basis for determining the business model selected to be proposed. The highest value of the total desirability, viability, and feasibility score is proposed for implementation.

Table 3. Score Desirability, Viability, Feasibility

PSS-Business model	Desirability	Viability	Feasibility	Total
Product related	12	10	10	32
Advice and consultancy	12	11	10	33
Product lease	10	11	13	34
Product renting/sharing	10	11	13	34
Product pooling	10	11	13	34
Activity management	9	12	13	34
Pay per service unit	9	11	13	33
Functional result	9	11	13	33

Applying solution

After assessing the desirability, viability, and feasibility of the existing alternatives, 4 proposed PSS Lighting System business models were selected that were most feasible to be implemented, namely (1) product lease for the lighting system, (2) product renting/sharing for the lighting system, (3) product pooling for lighting systems, (4) activity management for lighting systems. The four business models each received a total score of 34 out of 45 maximum scores.

Product lease for the lighting system

PSS to Original Equipment Manufacturers (OEMs)/service providers provides services in the form of a service agreement, including providing preventative maintenance at specified intervals [44] Meanwhile, in the business model offered here, the product lease for lighting systems also provides overall maintenance services during the subscription for all events served by the service provider. In product leases for clothing rental, consumers pay a membership or subscription fee to access the wardrobe or garment for a specific time, usually one month. [45] Meanwhile, in the product lease for lighting systems offered here, consumers pay a subscription fee to access all types of lighting owned by the provider for several events for a month or a year. In developing the lighting system's business model canvas (BMC), the market segment was expanded to event organizers and corporate and high-rise building operators/owners. Then, long-term relationships with customers became a priority in operations. BMC details of the product lease for the lighting system can be seen in Table 4.

This model involves leasing lighting systems to customers instead of selling them outright, providing a cost-effective and sustainable solution. This model is potential because of the demand for energy-efficient lighting solutions, the trend towards leasing rather than owning, and the potential for long-term customer relationships through lease agreements

Table 4. Business Model Canvas Product Lease Lighting System

BMC Product Lease Lighting System

Key Partners	**Key Activities**	**Value Propositions**	**Customer Relationships**	**Customer Segments**
LED Manufacturing Company	Provide lighting subscription services for general corporate purposes, multi-story buildings, and even event organizers **Key Resources** - Human resources - Lighting system technology	New Technologies for the lighting system Affordable Subscription Fee High Safety Standards Flexible Range of Subscription Free Maintenance	Longterm relationship **Channels** Websites Social Media Call center Email	Event Organizer Corporate High-rise building operators/owner Public sector
Cost Structure			**Revenue Streams**	
- Cost of providing the entire lighting system - Installation fee - Preventive maintenance and curative maintenance costs			The subscription fee is monthly, annually, or according to the contract.	

- Overall service provider employee costs
- Partnership costs
- Promotion costs

Product renting/sharing for the lighting system

In product renting or sharing for clothing sharing, the provider maintains ownership, and customers pay-per-use for each garment or wardrobe used in a short period of time, between 2 and 14 days. [45]. Meanwhile, in the product rental for lighting systems offered here, consumers pay for lighting system services for a short time according to the length of the event, between 1 and 7 days. However, holding long events for up to one month is also possible. This product rental for lighting systems is included in the Use-focused PSS type. Consumers do not pay for the product or system but pay a variable fee that depends on the usage of the product, in this case, the length of time for renting a lighting system. Please note that the payback period for the value provided may be longer than for businesses with traditional schemes. [46]. At BMC's product-sharing lighting system, customers are not only event organizers but also corporations in general. BMC details of product renting/sharing are presented in Table 5

Customers can rent or share lighting systems in this model, promoting resource efficiency and flexibility. There is a potential market because of the sharing economy trends, customers' willingness to rent lighting systems, and the competitive landscape in the lighting industry for such services. The market has potential because of the demand for outsourced lighting management services, the competitive landscape for service providers, and the potential for value-added services in lighting.

Table 5. Business Model Canvas Product Sharing/Renting Lighting System

<table>
<tr><td colspan="5">BMC Product Sharing Lighting System</td></tr>
<tr><td>Key Partners</td><td>Key Activities</td><td>Value Propositions</td><td>Customer Relationships</td><td>Customer Segments</td></tr>
<tr><td rowspan="2">LED Manufacturing Company</td><td>Renting lighting systems for general corporate purposes and also events
Key Resources
- Lighting System Technology
- Human Resources</td><td>The latest and environmentally friendly lighting system technology
- Flexible rental contracts according to corporate or event needs
- Technical team available during the rental period</td><td>Longterm relationship
Channels
Social Media
Website
Email
Call Center</td><td>- Event organizer
- Corporate
- Public Sector</td></tr>
<tr><td colspan="2">Cost Structure
- Maintenance costs before and after rental
- Cost of providing lighting system technology
- Technical team costs during rental
- Employee costs
- Promotion and Partnership Costs</td><td colspan="2">Revenue Streams
Lighting system rental costs during the event or the tenant's corporate needs according to the rental contract</td></tr>
</table>

Product pooling for the lighting system

In carpooling or ridesharing, the driver with one or several riders shares parts from the same destination using the car owned by the driver. [47]While product pooling for lighting systems is offered here, several consumers jointly use lighting system services for bonded warehouses. Costs borne by consumers for carpooling and product pooling for lighting systems can be shared between consumers. At BMC, product pooling lighting system consumers are not only in bonded warehouses but can also be used for corporate purposes in general. BMC details of the product pooling lighting system can be seen in Table 6.

Product pooling involves multiple customers sharing the same lighting system, optimizing resource utilization, and reducing costs. The market has potential because of the scalability of this model,

the potential for collaborative consumption in the lighting sector, and the regulatory environment for shared resource initiatives.

Table 6. Business Model Canvas Product Pooling Lighting System

BMC Product Pooling Lighting System				
Key Partners	**Key Activities**	**Value Propositions**	**Customer Relationships**	**Customer Segments**
LED Manufacturing Company	Renting lighting systems for groups of users at affordable costs - Key Resources - Human Resources - Lighting System	Sharing lighting system rental costs The latest lighting system technology that is environmentally friendly and high safety	Longterm relationship **Channels** Social Media Website Call Center	- Shared bonded warehouse - Corporate - Public Sector
Cost Structure - Employee costs - Maintenance costs before and after rental - Technical team costs during rental - Promotion and partnership costs			**Revenue Streams** Rental fees are based on the usage portion of group rentals.	

Activity management for the lighting system.

Fleet maintenance under smart PSS to reduce damage and downtime from public transportation is an example of activity management-based PSS where consumers pay for total systemized maintenance services. [48]. Meanwhile, activity management for lighting systems offers total lighting services for all company facilities that need lighting. Company consumers only pay the lighting system service package once for the entire lighting system service received from the provider. This activity management lighting system is an outcome-focused business PSS type. In this type of business, consumers do not buy a product or system but pay a fee that depends on the achievements or results of the contract or the outcome of using the services provided. [46]. Activity Management Lighting Systems are paid based on the outcome of the lighting system services provided to consumers. PSS Strategy alignment from [49] It can be used to transition towards a manageable PSS. BMC details of the activity management lighting system can be seen in Table 6.

This model focuses on managing lighting systems for customers, offering a hassle-free solution and ensuring optimal performance.

Table 6. Business Model Canvas Activity Management Lighting System

BMC Activity Management Lighting System				
Key Partners	**Key Activities**	**Value Propositions**	**Customer Relationships**	**Customer Segments**
LED Manufacturing Company	Providing lighting system services based on the output desired by consumers **Key Resources** - Lighting system - Human resources	Fees according to agreed usage output New technology in the lighting system Consumers are not involved in the process of providing services. Just accept the results	Longterm relationship **Channels** Social media Email Call center	- Corporate - Public Sector
Cost Structure - Installation fees - Employee costs			**Revenue Streams** Fees are based on the lighting system's output (the lux level of light used every	

- Maintenance costs during service - Promotion costs - Partnership costs	week, month, or year) according to the agreed-upon output contract.

Conclusion

The LED Manufacturing business model can be further developed into various types of PSS business models, including in this paper 8 PSS Lighting System models have been developed through a morphological analysis process. The selection process used Business Design Canvas v.22, namely by assessing desirability, viability, and feasibility; four PSS business models for lighting systems were selected with a total score of 34, namely product lease for the lighting system, product pooling for the lighting system, activity management for the lighting system. These four business models are offered for implementation in this research. Implementing Product-Service Systems (PSS) for lighting systems can lead to a more sustainable approach in the LED manufacturing industry by shifting from a product-centric to a service-oriented model. This transition aligns with the growing need for sustainable and flexible business practices. The proposed PSS Lighting System business models, such as product leasing, sharing, pooling, and activity management, offer opportunities to optimize resource utilization, reduce waste, and promote circular economy principles. By focusing on services rather than products, the models can encourage longevity, repairability, and efficient use of lighting systems, ultimately reducing environmental impact. Integrating multiple lighting system models within the PSS framework can enhance resource efficiency, promote energy conservation, and reduce the overall carbon footprint. This holistic approach to lighting system management can contribute to long-term sustainability goals and support environmental stewardship in the LED industry.

This research provides an overview of the Managerial Structure of LED Manufacturing so that you can consider developing its business model not only as a pure product but also by creating a Lighting System Provider subsidiary that still collaborates with the main LED Manufacturing business. This Lighting System Provider can be developed into four PSS business models selected in this research: product leasing for lighting systems, product pooling for lighting systems, and activity for lighting systems. These four-business model offers need further elaboration before they can be executed, especially regarding the technical details.

This research illustrates that the PSS business model can also be developed for lighting systems. The business models developed in this paper can be discussed with other PSS business models, especially their implementation potential. By advancing theoretical knowledge of PSS and expanding existing business models through innovative approaches, the proposed PSS Lighting System models pave the way for continuous improvement in sustainability practices within the LED manufacturing sector. This evolution towards more sustainable business models can have a lasting positive impact on environmental preservation and resource conservation.

References

[1] T. S. Baines *et al.*, “State-of-the-art in product service-systems,” *J. Eng. Manuf.*, vol. 221, pp. 1–11, 2007, doi: 10.1243/09544054JEM858.

[2] C. Vezzoli, F. Ceschin, J. C. Diehl, and C. Kohtala, “New Design Challenges to Widely Implement ‘ Sustainable Product-Service Systems.’”

[3] F. Tonelli, P. Taticchi, and E. S. Sue, “A Framework for Assessment and Implementation of Product-Service Systems Strategies : Learning From an Action Research in the Health-Care Sector .,” *WSEAS Trans. Bus. Econ.*, vol. 6, no. 7, pp. 303–319, 2009.

[4] A. Annarelli, C. Battistella, and F. Nonino, “Product service system : A conceptual framework from a systematic review,” *J. Clean. Prod.*, vol. 139, pp. 1011–1032, 2016.

[5] O. Mont, “Clarifying the concept of Product-Service System,” *J. Clean. Prod.*, 2001, doi: 10.1016/S0959-6526(01)00039-7.

[6] T. A. Tran and J. Y. Park, “Development of integrated design methodology for various product – service systems,” *J. Comput. Des. Eng.*, vol. 1, no. 1, pp. 37–47, 2014, doi: 10.7315/JCDE.2014.004.

[7] D. Demyanova, M. Colucci, E. Sirimal, and A. Vecchi, “Assessing consumers ’ propensity towards product-service systems in the fashion industry : A cross-national comparison between Russia and Italy,” *J. Clean. Prod.*, vol. 428, no. February, p. 139302, 2023, doi: 10.1016/j.jclepro.2023.139302.

[8] A. Tukker, "Eight Types Of Product – Service System : Eight Ways To Sustainability ? Experinces From Suspronet," *Bus. Strateg. Environmet*, vol. 260, pp. 246–260, 2004.
[9] K. Waldhör, "Towards an Ownerless Consumption in Western Europe- - - The Main Drivers for the Usage of (S) PSS on the Basis of Car Sharing Master ' s Thesis," 2014.
[10] K. Lee, V. Nubbe, B. Rego, M. Hansen, and M. Pattison, "2020 LED Manufacturing Supply Chain," 2021.
[11] S. Chowdhury, D. Haftor, and N. Pashkevich, "Smart Product-Service Systems (Smart PSS) in Industrial Firms : A Literature Review," *Procedia CIRP*, vol. 73, no. May 2018, pp. 26–31, 2018, doi: 10.1016/j.procir.2018.03.333.
[12] S. R. Moro, A. C. Imhof, D. C. Fettermann, and P. A. Cauchick-miguel, "Barriers to bicycle sharing systems implementation : analysis of two unsuccessful PSS," *Procedia CIRP*, vol. 73, pp. 191–196, 2018, doi: 10.1016/j.procir.2018.03.312.
[13] J. Ost, A. Paula, J. Luis, D. Ribeiro, and G. Pezzotta, "Product-Service System (PSS) design : using Design Thinking and Business Analytics to improve PSS design," *Procedia CIRP*, vol. 47, pp. 341–346, 2016, doi: 10.1016/j.procir.2016.03.062.
[14] G. Pourabdollahian and G. Copani, "Development of a PSS-oriented business model for customized production in healthcare," *Procedia CIRP*, vol. 30, pp. 492–497, 2015, doi: 10.1016/j.procir.2015.02.158.
[15] A. Rondini, J. Matschewsky, G. Pezzotta, and M. Bertoni, "A simplified approach towards customer and provider value in PSS for small and medium-sized enterprises," *Procedia CIRP*, vol. 73, no. May 2018, pp. 61–66, 2018, doi: 10.1016/j.procir.2018.03.330.
[16] A. Q. Li and P. Found, "Lean and Green Supply Chain for the Product-Services System (PSS): The Literature Review and A Conceptual Framework," *Procedia CIRP*, vol. 47, pp. 162–167, 2016, doi: 10.1016/j.procir.2016.03.057.
[17] C. Johansson, J. Elfsberg, T. C. Larsson, M. Frank, L. J. Leifer, and V. Söderberg, "Urban Mining as a Case for PSS," *Procedia CIRP*, vol. 47, pp. 460–465, 2016, doi: 10.1016/j.procir.2016.03.089.
[18] M. Orellano, G. Neubert, L. Gzara, and M. Le-dain, "Business Model configuration for PSS : An explorative study," *Procedia CIRP*, vol. 64, pp. 97–102, 2017, doi: 10.1016/j.procir.2017.03.008.
[19] A. Paula, J. Seidel, G. Seliger, and H. Kohl, "Sustainability factors for PSS business models," *Procedia CIRP*, vol. 47, pp. 436–441, 2016, doi: 10.1016/j.procir.2016.03.021.
[20] M. Orellano, C. Lambey-checchin, K. Medini, and G. Neubert, "Towards an integration of lifecycle thinking into PSS business models," *Procedia CIRP*, vol. 73, no. May 2018, pp. 291–296, 2018, doi: 10.1016/j.procir.2018.04.017.
[21] M. De Pádua, F. Blomsma, T. C. Mcaloone, and D. C. A. Pigosso, "Enabling circular strategies with different types of product / service-systems," *Procedia CIRP*, vol. 73, no. May 2018, pp. 179–184, 2018, doi: 10.1016/j.procir.2018.03.327.
[22] T. Ritchey, "Applications of General Morphological Analysis," vol. 4, no. 1, pp. 1–40, 2015.
[23] E. Kohlbeck, P. A. Cauchick-miguel, G. Henrique, and D. S. Mendes, "A Longitudinal History-Based Review of the Product-Service System : Past , Present , and Future," *Sustainability*, pp. 1–23, 2023.
[24] D. Demyanova, M. Colucci, E. Sirimal, and A. Vecchi, "Assessing consumers ' propensity towards product-service systems in the fashion industry : A cross-national comparison between Russia and Italy," *J. Clean. Prod.*, vol. 428, no. February, 2023.
[25] C. Muylaert, V. S. C. Tunn, and K. Mar, "On the attractiveness of clothing libraries for women : Investigating the adoption of product-service systems from a practice-based perspective," *Sustain. Prod. Consum.*, vol. 45, no. October 2023, pp. 359–370, 2024, doi: 10.1016/j.spc.2024.01.012.
[26] M. Salwin and A. Kraslawski, "Product-Service System business model for plastics industry," *J. Clean. Prod.*, vol. 451, no. February, p. 141874, 2024, doi: 10.1016/j.jclepro.2024.141874.
[27] J. Van Gaubergen, E. Paredis, and T. Block, "' Fit-to-transform ' : An institutional perspective on the empowerment of clothing product-service systems," *Environ. Innov. Soc. Transitions*, vol. 49, no. February, p. 100781, 2023, doi: 10.1016/j.eist.2023.100781.
[28] A. Osterwalder and Y. Pigneur, "Clarifying Business Models : Origins , Present , And Future Of The Concept Clarifying Business Models : Origins , Present , And Future Of The Concept," *Commun. Assoc. Inf. Syst.*, vol. 15, no. May, 2005.
[29] J. Sibalija, D. Barrett, M. Subasri, L. Bitacola, and R. B. Kim, "Understanding value in a healthcare setting : An application of the business model canvas," *Methodol. Innov.*, 2021, doi: 10.1177/20597991211050477.

[30] S. Sparviero and S. Sparviero, "The Case for a Socially Oriented Business Model Canvas : The Social Enterprise Model Canvas The Case for a Socially Oriented Business Model Canvas : The Social Enterprise Model Canvas," *J. Soc. Entrep.*, vol. 10, no. 2, pp. 232–251, 2019, doi: 10.1080/19420676.2018.1541011.
[31] T. Otsuka, R. Ishizaki, T. Ahamed, and R. Noguchi, "Three-layer business model canvas of oil-water separation equipment in restaurants and food processing factories," *Energy Nexus*, vol. 13, no. December 2023, p. 100273, 2024, doi: 10.1016/j.nexus.2024.100273.
[32] J. Pollard *et al.*, "Implementing a circular economy business model canvas in the electrical and electronic manufacturing sector : A case study approach," *Sustain. Prod.*, vol. 36, pp. 17–31, 2023, doi: 10.1016/j.spc.2022.12.009.
[33] K. Krauss, C. Moll, and K. Jonathan, "Research in Transportation Business & Management Designing mobility-as-a-service business models using morphological analysis," *Res. Transp. Bus. Manag.*, vol. 45, no. June, 2022, doi: 10.1016/j.rtbm.2022.100857.
[34] S. Seidenstricker, S. Scheuerle, and C. Linder, "Business Model Prototyping – Using the Morphological Analysis to Develop New Business Models," *Procedia - Soc. Behav. Sci.*, vol. 148, pp. 102–109, 2014, doi: 10.1016/j.sbspro.2014.07.023.
[35] Z. Raoofi, E. Stenemo, A. Engholm, and A. Pernestål, "How can we structure the future development of automation , How can we structure the future development of automation , electrification , and digitalization in the transportation sector by electrification , and digitalization in the transportation sector ," *Transp. Res. Procedia*, vol. 72, pp. 1808–1815, 2023, doi: 10.1016/j.trpro.2023.11.657.
[36] R. Wong, "Business Design Canvas — v2.2."
[37] J. Hwan and S. Yoo, "A Morphological Approach To Business Model Creation Using Case-Based Reasoning," in *International Conference on Engineering Design, ICED11*, 2011.
[38] G. George and A. J. Bock, "The Business Model in Practice and its Implications for Entrepreneurship Research," *Entrep. Theory Pract.*, vol. 35, no. 1, pp. 83–111, 2011, doi: 10.1111/j.1540-6520.2010.00424.x.
[39] J. Landeta, J. Barrutia, and A. Lertxundi, "Technological Forecasting & Social Change Hybrid Delphi : A methodology to facilitate contribution from experts in professional contexts," *Technol. Forecast. Soc. Chang.*, vol. 78, no. 9, pp. 1629–1641, 2011, doi: 10.1016/j.techfore.2011.03.009.
[40] B. T. Hunsaker and D. E. Thomas, "The Viability Triad : Desirability , Feasibility , and Sustainability as the New Strategic Decision Imperative," vol. 4, no. 2, pp. 1–3, 2017, doi: 10.15640/jeds.v4n2a1.
[41] B. Viability and C. Flow, "Business Viability," *Bus. Organ.*, pp. 1–11.
[42] A. Murray and V. Scuotto, "The Business Model Canvas," pp. 94–109, 2015.
[43] S. R. Moro, P. A. Cauchick-miguel, G. Henrique, and D. S. Mendes, "Literature analysis on product-service systems business model : a promising research field," vol. 19, no. 1, pp. 1–18, 2022.
[44] K. C. Felix Ng, "The Application of Product Service Systems for Hydraulic Excavators," 2016.
[45] E. Johnson, "Product-Service Systems and Sustainability : Analysing the Environmental Impacts of Rental Clothing," *sustainability*, 2021.
[46] F. Adrodegari, A. Alghisi, M. Ardolino, N. Saccani, and X. Boucher, "From ownership to service-oriented business models : a survey in capital goods companies and a PSS typology," *Procedia CIRP*, vol. 30, pp. 245–250, 2015, doi: 10.1016/j.procir.2015.02.105.
[47] H. Huang, D. Bucher, J. Kissling, R. Weibel, and M. Raubal, "Multimodal Route Planning with Public Transport and Carpooling," *IEEE Trans. Intell. Transp. Syst.*, no. November, 2018, doi: 10.1109/TITS.2018.2876570.
[48] H. Husniah, G. G. Rachman, and S. A. Rachman, "Opportunistic Maintenance under Product – Service System for Usage Based Transportation System," in *Proceedings of the 2nd African International Conference on Industrial Engineering and Operations Management Harare, Zimbabwe, December 7-10, 2020*, 2020, pp. 2843–2852.
[49] M. Sholihah, T. Maezono, Y. Mitake, and Y. Shimomura, "PSS Strategic Alignment : Linking Service Transition Strategy with PSS Business Model," pp. 13–15, 2019.