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A proposal for Energy Services' classification including a Product Service Systems perspective

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Abstract

Western manufacturing companies have lately started to rethink their approach to sustainability, mainly because of three different issues arising in the international context: the economic and financial crisis that has been slowing down the international markets' growth, the necessity to increase competitiveness and the growing awareness of environmental and energy problems. This process has eventually led to the spread of servitization strategies causing the transformation of several equipment/components manufacturers into service providers, as well as to the creation of the concept of Product-Service Systems (PSS). Furthermore, a more focused attention to energy efficiency has arisen, with the dual objective of both containing costs and meeting international regulations. The intersection of these two development paths is the constant increase in the supply of energy services, which can be marketed together with devices, machines or energy vectors, creating a peculiar form of PSS. In the present work, a new classification is proposed to map different types of energy services, based on existing categorizations of PSS and enriching them with new parameters which are typical of energy services literature, such as the level of risks sharing. The main objective of this work is to highlight the tight connection between the provision of energy services and the concepts of PSS and sustainability, in order to provide a new general classification for energy services, discussed separately and fragmentary so far in literature.

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Keywords: Product-Service Systems; Energy Services; business models

1. Introduction

Servitization strategies have recently been extended to the energy sector, where the spread of Energy Services and Energy Service Companies is rapidly changing the way in which energy is provided, in particular to Western manufacturing industries. This process has been very fast, and existing classifications of Energy Services are generally partial and typically much tied to particular and contingent contractual forms and situations. For this reason, after a brief overview of existing classifications of Energy Services and Product-Service Systems, a new tridimensional classification of Energy Services, general and widely applicable, is proposed in this paper. By highlighting their tight connection and proposing the new classification, this work can be understood as an initial step towards gaining better understanding of how new business models in the energy sector can be configured and innovated. Due to the envisaged benefits for better energy management related to the provision of Energy Services and the claimed linkage between servitization strategies and industrial sustainability, further research on their interrelations could ultimately improve sustainability practices in the manufacturing industry.

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2. Literature review

In this paragraph, a brief overview of both Energy Services' and Product-Service Systems' literature is given, providing a general background on these two business concepts and at describing their existing classifications.

2.1 Energy Services background

Due to the constantly increasing criticality of energy-related issues, energy supply is nowadays no longer considered as a mere fuelling, but always more it is associated to services supply, while consumption reduction has become a key concern for most manufacturing industries in Western countries [1].

In the last decades, this has ended up in the creation of a whole new business model, Energy Services or Energy Service Contracting, whose definition has been given by several authors so far. For example, Bertoldi et al. [2] state that "Energy services include a variety of activities, such as energy analysis and audits, energy management, project design and implementation, maintenance and operation, monitoring and evaluation of savings, property management, and energy and equipment supply", while Sorrell [3] writes: "Energy service contracting involves the outsourcing of one or more energy-related services to a third party. In its simplest form, an energy service contract may guarantee supplies of hot water and/or electricity at reduced cost, but in a more sophisticated form the contract may guarantee particular levels of service provision, such as lighting levels, room temperatures, humidity and 'comfort'. In its most developed form, energy service contracting allows the client to minimize the total bill for the services that energy provides through a single contract with an energy services provider". Both definitions make reference to the conjunct supply of energy and energy-related services and suggest its relevance in terms of energy efficiency, energy savings and therefore of sustainability.

Energy Services, including an incredibly wide range of activities according to the aforementioned definitions, can be provided by many different companies, e.g. including machinery vendors as well as specialized companies, which are generally known as Energy Service Companies (ESCOs) if their remuneration is directly tied to the energy savings achieved, or as Energy Service Provider Companies (ESPCs) if they only provide a service for a fee and therefore take no risk [2, 4].

2.1.1 Classifications of Energy Services

Sorrell [3] proposed one of the most complete classifications of Energy Services, which he characterized by three main variables:

- Scope, i.e. what is included in the contract in terms of energy technologies and systems (the number of useful energy streams and/or final energy services that are wholly or partially under the control of the contractor);

- Depth, i.e. the number of organizational activities required to provide that stream or service that is under the control of the contractor;

- Method of finance, i.e. the source of capital for investment in new energy conversion and control equipment (internal financing, lease financing, third party financing, project financing).

Dreessen [5] and Bertoldi et al. [2] classified Energy Services into two main categories based on the economic risk associated to the contract and assumed by the three main stakeholders (i.e. the customer, the ESCO and the Lander/Investor). The classification is summarized in Figure 1.

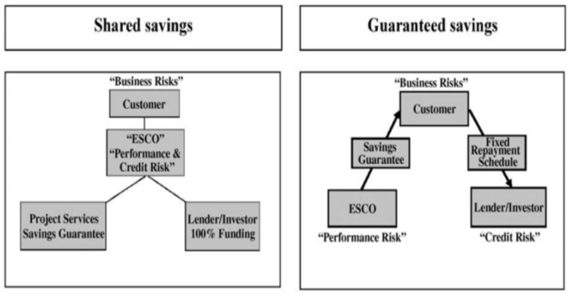

Figure 1: Shared and Guaranteed savings Energy Service Contracts [5]

Pätäri and Sinkkonen [4] used a similar but more general risk-based classification: Energy Performance Contracting (EPCs) contracts, involving high risk level for the supplier; and Energy Supply Contracting (ESCs) contracts, involving low risk level for the supplier.

At last, both Qian and Guo [6] and Duplessis et al. [7] focused on the definition and discussion of shared savings contracts and EPCs (the most risky contract forms from the supplier point of view, that are recently spreading), also listing useful classification parameters (like contract period, revenue-sharing ratio, energy prices, etc.).

2.2 Product-Service Systems background

In traditional business configurations, production and services are viewed as independent, unrelated concepts. The servitization trend in manufacturing has created new connections between these two concepts [8]. The term Product-Service Systems (PSS) was first introduced by Goedkoop et al. [9] who defined it as "a marketable set of products and services capable of jointly fulfilling a user's needs". Therefore, more traditional material intensive ways of product utilization are replaced by the possibility to fulfil consumers' needs through the provision of more dematerialized services, which are also often associated with changes in the ownership structure. In this regard, PSS can be seen as a possible answer to the sustainability challenge [10].

2.2.1 Classifications of Product Service Systems

Roy [11] proposed a categorization consisting of four types of PSS: *Result services* (or demand services or service products) where the service provider is responsible of all physical aspects of the system, providing a 'result' instead of a product; *Shared utilization services* (or product use services or community products) consist of sharing products among different users or a community of users in order to increase their utilization rate; *Product-life extension services (or duration products)* where the service provider is responsible of the maintenance, repair, reuse and recycling activities related to products to increase their useful life; and *Demand side management* (or least-cost planning or integrated resource management), which was originated in the field of energy supply in US as an evolution of the idea that it was often more economical to reduce energy demand than build more generating capacity. The latter involves energy conservation switching to alternative fuels or buying in electricity generated from renewable sources.

Mont [10] stated that a PSS comprises products, services or their combinations and classified the services forming a PSS from the product life cycle perspective as *Services at the point of sale*, *Services related to product use*, *Services prolonging product life cycle* and *Revalorization services*, which refer to products end-of-life and consisting of reverse logistics, reuse or recycling of products or their parts.

Oliva and Kallenberg [12] proposed the service space where different types of services can be considered according to two drivers: whether the services are related to a product or to end-user's process and whether the service is based on transactions or on relationships.

Tukker [13] proposed a quite complete and extended classification, which, due to its completeness and wide applicability, is taken as a basis for the present work. He built his eight-type PSS classification on three general categories of PSS (Figure 2): *product-oriented*, *use-oriented* and *result-oriented* PSS.

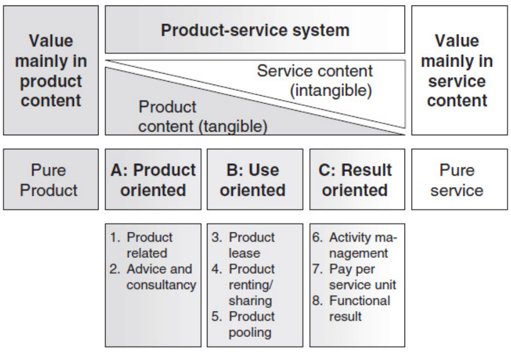

Figure 2: Product-service systems classification [13]

The product-oriented PSS category includes product-related services, offered during the use and/or end-of-life product life cycle phases and product-related advice /consultancy, mainly regarding product use phase.

The use-oriented PSS category considers different types of services where the provider keeps product ownership. The customer can access the product in three different ways, i.e. through three types of services: Product lease, Product renting or sharing and Product pooling.

Last but not least, three types were suggested regarding the result-oriented PSS category: Activity management/ outsourcing, where the provider takes over a customer's activity; Pay per service unit, which consists on selling product output according to the level of use; Functional result, where the provider delivers a functional result, frequently in abstract terms and not including any predetermined product or technology to be used.

3. Mapping Energy Services within Product-Service Systems

Energy Services are undoubtedly closely related to Product-Service Systems, these two emerging and promising business concepts presenting many common features and attributes. In literature, their closeness has been more or less explicitly underlined by several authors, who have alternately considered Energy Services as a peculiar form of PSS or as an independent but comparable business model.

For example Mont [10], while discussing the general connection between PSS and sustainability, clearly includes Energy Services within PSS by pointing them out as an example of how PSS allow gaining profits "not through sales but through efficiency provision".

Maxwell and van der Vorst [14] introduce and give different examples of Environmentally Superior Products (ESP), that are defined as products providing a reduced environmental impact without compromising functionality, quality, ability to manufacture or cost. They highlight how ESP can be part of a PSS offering, and energy efficiency is mentioned as a result of a combined ESP-PSS contract.

Lay et al. [15] introduce a set of parameters used to describe new business concepts, linking these parameters to each of them. Energy service contracts and PSS are here referred to as separate models, but the authors underline that they definitely share several key parameters, such as "Ownership", "Production personnel", "Maintenance" and "Payment". Conversely, other parameters seem more specific either to the Energy services or PSS: "Financing" seems to characterize Energy service contracts only, while "Number of customers" and "Retrieval, recycling" are associated to Product-Service Systems alone.

In addition, both PSS's and Energy Services' literatures address common problems and issues, such as provider-client relationship [3, 15], payment and financing methodologies [3, 13], service gain (basic conditions for a client to enter into a service contract, discussed both by Sorrell [3] and Colen and Lambrecht [16]) and risk sharing and management [2, 13].

As stated previously, Tukker's PSS classification is by far the most complete among those proposed in literature, as well as the one that gives a more general and complete overview on PSS categories. For this reasons, it has been taken as a reference to frame Energy Services within PSS, its generality allowing an easy combination of these two business concepts.

Energy Services	PSS CATEGORIES							
	Product Oriented		Use Oriented			Result Oriented		
	Product related	Advice and consultancy	Product lease	Product renting/sharing	Product pooling	Activity management	Pay per service unit	Functional result
Steam	*	*	*	*	*	*	*	+
Hot water	*	*	*	*		*		
Electricity	*	*	*	*	*	*	*	*
Coolant	*	*	+	+	+	*	*	*
Industrial gases	*	*	*	*	+	*	*	*
Heating	*	*	*	*		*		+
Ventilation	*	*	*	*		*		+
Lighting	*	*	*			*		*
Compressed air	*	*	*	*		+	+	
Process heat	*	*	*	*		*		
Refrigeration	*	*	*	*		*		+
Motive power	*	*	*	*		*		*

Table 1: Application of Tukker's PSS categories to different Energy Services

A matrix has been created (Table 1), the columns being Tukker's PSS categories described in paragraph 2.2.1 and the rows being the various energy vectors or services commonly required in industrial plants, according to Sorrell [3]. The matrix has been completed by linking PSS category and energy vectors/services (illustrated in Table 1 by the symbol *), according to both an analysis of several providers' commercial offers (a selection of providers has been previously made on the basis of their commercial web sites' frequency of visualization, and then their offers have been explored by both browsing their web pages and contacting them) and a direct verification of contractual conditions and common practices within industrial plants (through surveys and inspections of different sites).

Referring to energy vectors, Product Related PSS are generally represented by the direct sell of machines and equipment that produce the particular energy vector (generators), together with various services providing design support, maintenance, monitoring and other technical features, while Use Oriented PSS are represented by different rental contracts (long-term or short-term period rentals, possibly sharing machines and fares with other companies); Result Oriented PSS are instead represented in the energy sector by contracts where a certain amount per contract period, a certain amount per energy vector unit or a certain service level are fixed.

Some of the Energy Services or Energy Service Contracts proposed are supposedly feasible, but not directly observed nor commonly practiced (yellow colored cells within the table with symbol +).

In the light of such a tight connection between Energy Services and PSS, in next sections a new general classification of Energy Services will be proposed, based on Tukker's PSS categories and completed with parameters that are typical of the Energy Services' literature.

4. Energy Services' classification proposal

The proposed classification of Energy Services is based on the definition of three different dimensions (represented on three different axes on the scheme provided in Figure 3), that are used to define and categorize each Energy Service:

- The first one, axis x, represents the "intangibility" of the contract (whether the value of the contract is mainly in its product or in its service content), which basically corresponds to Tukker's PSS classification;

- The second one, axis z, represents the "scope" as defined in Sorrell's classification;

- The third one, axis y, represents the "risk" accepted by both the client and the service provider, and is the result of the combination of different classification parameters that are typical of Energy Services.

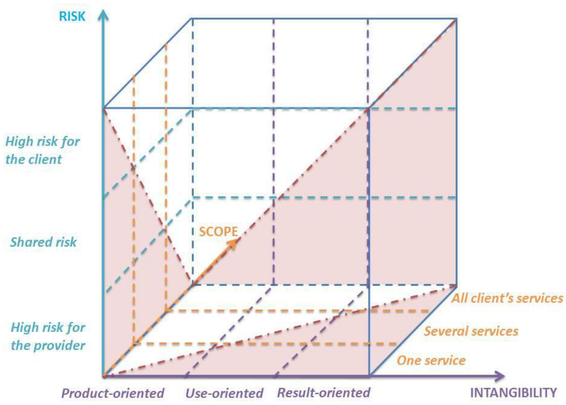

Figure 3: The proposed Energy Services' classification

4.1 The "intangibility" axis

The definition of this axis in built on the results of previous section (Table 1). Given the wide range of existing Energy Service Contracts identified, and considering that they are often the result of a provider-customer negotiation and therefore highly influenced by the contingent situation and conditions, the "intangibility" of the contract is not meant to vary only from one PSS category to the other, but also within a single category, according to the exceptions and constraints fixed within the contract (it means that is shall be considered in a continuous rather than on a discrete scale).

The intangibility axis is therefore intended to be a continuous axis that can be divided into three main segments, corresponding to the three main categories (as done in Figure 3) or even into eight segments, indicating the eight PSS types.

4.2 The "scope" axis

This axis is based on the "scope" parameter defined by Sorrell, and indicates how many energy vectors or services are included into the contract.

In analogy to the first axis, it can be divided into three main segments, as illustrated in Figure 3, considering the options that one, several or all possible energy vectors are included in the contract.

4.3 The "risk" axis

Several Energy Services classification, as already stated, introduce a parameter linked to risk sharing within Energy Service projects [2, 4]. This can be assimilated to the Sorrell's "method of finance", but is much more suitable for a PSS-oriented classification and also much more up-to-date considering the modern Energy Services context.

A "risk" axis has therefore been created in order to take into account this parameter, and it can be divided into three main segments, depending on which player accepts the major risk (it can be the client, the service provider or they can decide to share the risk).

5. Critical analysis of the proposed classification

The tridimensional classification proposed is totally applicable to Energy Services. However, the space defined by the three axes might not to be considered as a domain in which Energy Services exist, i.e. all the possible combinations of risk, intangibility and scope might not be possible nor feasible.

In fact, the wider is the scope, the lower is the probability that a contract with a high risk for the client is stipulated; in addition, the lower is the intangibility of the contract, the lower is the probability that a contract with a high risk for the client is stipulated; eventually, the lower is the intangibility of the contract, the lower is the probability that a contract with a wide scope is stipulated.

According to what previously stated, it is possible to suggest, on the three main plans (risk vs scope, intangibility vs risk, intangibility vs scope), three areas of major existence of Energy Services (represented as red triangles in Figure 3), which in turn define a spatial domain considering the tridimensional nature of the classification (referred to, in the remainder, as Energy Service cube).

The vertexes of the Energy Service cube (as well as relevant spaces obtained from the interceptions of axes and planes) have subsequently been analyzed in order to identify contract typologies that are well known in literature, and are represented in Figure 4.

The point identified with number 3 in Figure 4 represents the existing contract typology that is known as Energy Global Service (the provider takes the whole risk, the contract is result-oriented and involves all the services needed by the client; it is typical of Energy Service Companies, offering clients to take care of the entirety of their energy demands and needs and concluding favorable agreements with different energy producers thanks to scale economies), while point 4 is a contract based on a Service Level Agreement between the provider and the client on a single service (for example, client and provider agree on a certain level of comfort in lighting); point 5 represents the direct buy of an energy vector or of an energy production machine by the client, while point 6 is to be considered a feasible but not so common contract typology (at least with a single provider, as it might be convenient to stipulate a Service Level Agreement if so many energy vectors are involved); eventually, point 9 represents a kind of contract that is usually stipulated when the provider is a company of the same group of the client (for example, the purchase of compressed air produced by high-efficiency compressors owned by the provider at a fixed amount per m^3).

The point (and then the contract typology) identified with number 1 in Figure 4 is not an already well-known contract typology and could probably be hardly realized (it is product-oriented, so the client will most likely take the whole risk), as well as point 2 (considering a large scope and a provider willing to take the risk, the contract will not probably be referred to a product-oriented PSS), 7 and 8 (result-oriented contracts are not compatible with high risk for the client category, and in addition it is rare to have such a contract for just an energy service). These options are to be further tested in the future through some empirical research as they could be found unfeasible.

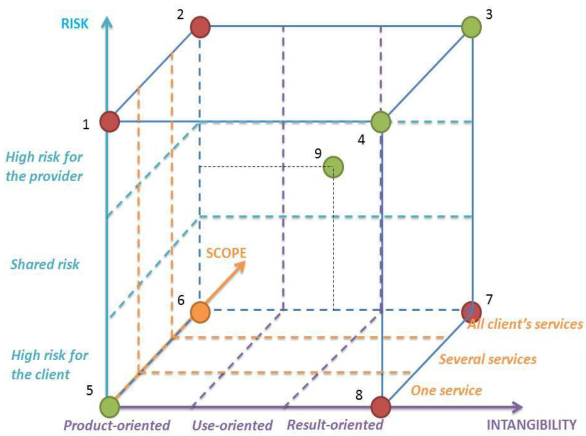

Figure 4: Relevant points of the spatial domain analyzed by means of the Energy Service Cube proposed by this paper

6. Concluding remarks and future development

In the present paper, a new classification of Energy Services has been proposed, based on parameters suggested in Tukker's PSS and on various Energy Services' classifications.

The presented classification has been analyzed in order to find whether all possible combinations of the three defined dimensions' values are possible and feasible, and a spatial domain of existence of Energy Services has been defined.

Eventually, relevant spaces and axes interceptions have been analyzed in order to frame into the defined classification existing contract typologies.

The classification here proposed is to be further developed in the future. In particular, it will be worth testing its applicability to all Energy Services (as well as its usefulness for Energy Service Companies and its suitability to assess their maturity), carrying on the analysis of existent contracts' typologies and developing a more accurate definition of the "risk" axis (it is possible to further deploy the "risk" concept by considering, for example, differences between Guaranteed Savings and Shared Savings contracts, already introduced in literature).

Once obtained a more robust classification, next steps will be to evaluate, through surveys and interviews, the evolution of the contractual forms of Energy Services in different industries during the last years, and to identify the most suitable contract typologies for different industries and companies of different dimensions.

Furthermore, performing a set of selected key case studies could be adequate for different purposes. First of all, the case studies will help to validate the classification itself as a "tool" to study, map and, finally, interpret different business models for energy services. Further on, the classification would become an aid to study the motives for innovation in company's business models and contribute to the analysis on the evolution of Energy Services, their potential benefits and main challenges for all stakeholders involved. This research will additionally support the description of diverse pathways for innovating business models in the energy sector.

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