A framework for energy services within Product Service Systems classification

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Abstract: In recent years, 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, has forced Western manufacturing industries to rethink their approach to sustainability. 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, it has also ended up in a more focused attention to energy efficiency, 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 framework is proposed to classify and map different types of energy services, based on existing classifications 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 general classification for energy services, discussed separately and fragmentary so far in literature.

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. Since the process is very fast, a proper and complete classification of Energy Services has only partially been given so far, and it is typically very tied to particular and contingent contractual forms and situations, lacking in generality. For this reason, after a brief overview of existing classifications of Energy Services and Product-Service Systems, in this paper a new classification of Energy Services is proposed, based on PSS’ existing classifications, highlighting the tight connection between these two business models and being general and widely applicable.

2. Literature review

In this paragraph, a brief overview of both Energy Services’ and Product-Service Systems’ literature is given, aiming at providing a general background on these two business models 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 (Introna et al., 2014).

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. (2006) 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 (2007) 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 services according to the aforementioned definitions, can be provided by many different companies, including
machinery vendors as well as specialised companies, 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 (differentiation already introduced by Bertoldi et al. (2006) and Pätäri and Sinkkonen (2014)).

2.2.1 Classifications of Energy Services

Sorrell (2007) 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 (2003) and Bertoldi et al. (2006) classified Energy Services into two main categories, based on the economic risk associated to the contract and assumed by the three main shareholders (i.e. the customer, the ESCO and the Lander/Investor). This classification is summarized in Figure 1.

![Figure 1: Shared and Guaranteed savings Energy Service Contracts (Dreessen, 2003)](image)

Pätäri and Sinkkonen (2014) used a similar but more general risk-based classification, naming 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 (2014) and Duplessis et al. (2014) focused on the definition and discussion of Shared savings contracts and EPC (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 servitisation trend in manufacturing has created new connection between these two concepts as, according to Neely, 2009. The term Product-Service Systems (PSS) was first introduced by Goedkoop et al. (1999) who defined it as “a marketable set of products and services capable of jointly fulfilling a user's need”. Therefore, this implied that more traditional material intensive ways of product utilisation are replaced by the possibility to fulfil consumers’ needs through the provision of more dematerialised 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 (Mont, 2002).

Several classifications for PSS have been proposed by several authors, which will be presented in the following section.

2.2.1 Classifications of Product Service Systems

Roy (2000) 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. It is related to reduction of material intensity of existing systems.
- **Shared utilisation 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 utilisation 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 in order to increase their useful life, thus reducing the amount of energy and resources required to provide a given function.
- **Demand side management** (or least-cost planning or integrated resource management) 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. It involves: energy conservation; switching to alternative fuels such as gas; or buying in electricity generated from renewable sources.

Mont (2002) stated that a PSS comprises products, services or their combinations and classified the services forming a PSS as:
- **Services at the point of sale**, those related to marketing, acquisition support or explanations of use of products,
- **Services related to product use**, either use-oriented or results oriented, depending on whether the user or the provider is extracting product utility respectively,
- **Services prolonging product life cycle**, such as maintenance or upgrading services,
- **Revalorisation services**, related to products end-of-life and consisting of reverse logistics, reuse or recycling of products or their parts.

Oliva and Kallenberg (2003) proposed the service space where different types of services can be considered according to two drivers: (i) whether the services are related to a product or to end-user's process; (ii) whether the service is based on transactions or on relationships. Figure 2 presents the service space where the four types of services are identified as “Basic services”, “Maintenance services”, “Professional services” and “Operational services”.
Different types for the following types:

In relation to the use-oriented PSS category, he proposed phase.

factory logistics related to product location during its use regarding different aspects such as team structure or advice in order to improve efficiency during product use.

Product-related advice /consultancy. The provider gives spare parts, upgrading or take-back agreements.

end-of-life product life cycle phases, such as maintenance, also offers services that are needed during the use and or Product-related services. The provider sells a product but PSS category:

Two types were identified within the product-oriented and relationship-oriented PSS.

Finally, Gebauer (2008) studied different service strategies considering the following four types of services:

- After-sales services, including spare parts, repair / trouble-shooting, basic training, inspection/diagnosis;
- Process-oriented services, regarding maintenance contracts, process optimization, process consulting, advanced operator training;
- Research and development (R&D) services, including design and construction services, process-oriented R&D;
- Operational services, consisting on the provider taking over customers’ maintenance function, operating processes or logistics. Tukker (2004) 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 3): product-oriented, use-oriented and result-oriented PSS. Different types for each category are presented herein.

![Figure 2: Service space (Oliva and Kallenberg, 2003)](image)

![Figure 3: Product-service systems classification (Tukker, 2004)](image)

Two types were identified within the product-oriented PSS category:

Product-related services. The provider sells a product but also offers services that are needed during the use and or end-of-life product life cycle phases, such as maintenance, spare parts, upgrading or take-back agreements.

Product-related advice /consultancy. The provider gives advice in order to improve efficiency during product use regarding different aspects such as team structure or factory logistics related to product location during its use phase.

In relation to the use-oriented PSS category, he proposed the following types:

<table>
<thead>
<tr>
<th>Product-oriented services</th>
<th>End-user’s process-oriented services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transaction-based services</td>
<td>Professional services</td>
</tr>
<tr>
<td>Basic installed new services</td>
<td>Process-oriented engineering</td>
</tr>
<tr>
<td>Documentation</td>
<td>Cost optimization, simulation</td>
</tr>
<tr>
<td>Transport to client</td>
<td>Process-oriented R&amp;D</td>
</tr>
<tr>
<td>Installation/commissioning</td>
<td>Spare parts management</td>
</tr>
<tr>
<td>Product-oriented training</td>
<td>Process-oriented training</td>
</tr>
<tr>
<td>Hot line help desk</td>
<td>Process-oriented consulting</td>
</tr>
<tr>
<td>Inspection and diagnosis</td>
<td>Business-oriented consulting</td>
</tr>
<tr>
<td>Repair/repair parts</td>
<td>Business-oriented consulting</td>
</tr>
<tr>
<td>Product updates/upgrades</td>
<td>Refurbishing</td>
</tr>
<tr>
<td>Relationship-based services</td>
<td>Operational services</td>
</tr>
<tr>
<td>Maintenance services</td>
<td>Preventive maintenance</td>
</tr>
<tr>
<td>Recycle/machine learning</td>
<td>Condition monitoring</td>
</tr>
<tr>
<td>Prevention services</td>
<td>Spare parts management</td>
</tr>
<tr>
<td>Full maintenance contracts</td>
<td>Full maintenance contracts</td>
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</tbody>
</table>

Product lease. The provider keeps product ownership and customers pay a regular fee for the use of the product, having unlimited and individual access to the product. The provider is normally responsible for maintenance, repair and disposal activities related to the leased product.

Product renting or sharing. The provider keeps product ownership and customers pay for the use of the product, not having unlimited and individual access, thus the product is sequentially used by different customers. The provider is responsible for maintenance, repair and disposal activities related to the product.

Product pooling. Similarly to previous one, the provider keeps product ownership and customers pay for the use of the product, but in this case, the product can be simultaneously used by different customers.

Last but not least, three types were suggested regarding the result-oriented PSS category:

Activity management /outsourcing. The provider takes over a customer’s activity. An outsourcing contract is established which includes a set of performance indicators to control the quality of the outsourced activity.

Pay per service unit. Instead of selling the product, the provider sells the output of the product according to the level of use. Customers operate the product, while the provider is responsible of keeping the product function available (i.e. consumables supply, maintenance, repair and replacement activities).

Functional result. The provider agrees with the customer the delivery of a functional result, frequently in abstract terms and not including any predetermined product or technology to be used, thus the provider is free to decide the most effective means to deliver the result.

3. Framework for 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 (2002), 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 (2003) 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. (2009) introduce a set of parameters used to describe new business concepts, providing a table to link these parameters to each of them. Energy service contracts and PSS are here referred to as separate models, but the table shows that they definitely share several key
parameters, such as “Ownership”, “Production personnel”, “Maintenance” and “Payment” (while “Financing” seems to characterize Energy service contracts only, and “Number of customer” 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 (Sorrell, 2007 and Lay et al., 2009), payment and financing methodologies (Tukker, 2004 and Sorrell, 2007), service gain (basic conditions for a client to enter into a service contract, discussed both by Sorrell, 2007 and Colen and Lambrecht, 2010) and risk sharing and management (Bertoldi et al., 2006 and Tukker, 2004). In the light of such a tight connection between Energy Services and PSS, in next paragraphs Tukker’s PSS categories will be applied to Energy Services in order to better highlight their similarities and differences and also to allow easily classifying them, giving several examples.

3.1 Application of Tukker’s Product-Service Systems classification to Energy Services

As stated in previous paragraphs, 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. 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.

A matrix, showed in Table 1, has been created, the rows being the eight PSS categories described in paragraph 2.2.2 and the columns being the various energy vectors or services commonly required in industrial plants (steam, hot water, electricity, coolant, industrial gases, space heating, ventilation, lighting, compressed air, process heat, refrigeration and motive power). These energy vectors or services have been listed by Sorrell (2007) while giving the definition of his “scope” parameter; Sorrell’s classification has been chosen to help evaluating the applicability of Tukker’s model to Energy Services, trusting its completeness to test the full characterization of the energy sector.

The matrix has been completed by associating to each PSS category and to each energy vector or service considered a different Energy Service or Energy Service Contract. Such association has been made by both analysing 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 directly verifying contractual conditions and common practices within industrial plants (through surveys and inspections of different sites). Some of the Energy Services or Energy Service Contracts proposed are supposedly feasible, but not directly observed nor commonly practiced (yellow coloured cells within the table).

As it was expected, the matrix is not completely full, because some PSS categories do not apply to all energy vectors and services, in particular categories included in use-oriented PSS (because, for example, some machines and devices used to generate or transport energy vectors are either not rentable nor usually rented, or cannot be used simultaneously by more than one customer, like lamps or air conditioning systems, or because some vectors cannot be stocked) and result-oriented PSS (manly because vectors that can be paid per service unit are often not subject to functional result contracts).

As a conclusion, by carefully observing and analysing the presented matrix, it is possible to state that the Tukker’s model is totally applicable to Energy Services, whose characterization is mostly complete, but some improvements can be proposed to enable a more accurate classification of them within the PSS framework.

3.2 Improvement proposals for the classification of Energy Services within Product Service Systems framework

As previously stated, a first finding of this work is that PSS categories seem not applicable to all energy services, in spite of the general formulation of Tukker’s classification.

Besides this partial applicability, the use of Tukker’s classification in the energy context (and in general the application of PSS classifications to Energy Services) presents limitations, mainly due to the fact that it does not take into account some parameters that are critical for Energy Services, and in fact very common in Energy Services’ literature (but not as much as critical nor common in PSS’ literature).

Comparing Tukker’s classification of PSS to Sorrell’s classification of Energy Service Contracts (which is here taken as an example due to the fact that it includes most of the parameters used in other classifications), it appears evident that while the latter puts an accent on the relevance of parameters related to financing (“method of finance”) and to “scope” statement, the former does not focus so much on them, aiming at giving a more general definition of PSS categories.

Regarding the “depth” parameter in Sorrell’s classification, it is possible to partly relate it with the “intangibility” of the contract’s content in Tukker’s classification, affected by whether its value is mainly in product content or in service content. In fact, the larger is the number of organizational activities related to the energy service’s provision that are included in the contract (increasing its depth according to Sorrell’s definition), the more its value will lay in its service content.

Anyway, given the wide range of existing Energy Service Contracts, and considering that they are often the result of a provider-customer negotiation and therefore highly influenced by the contingent situation and conditions, the depth 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).

Other Energy Services classification, as already stated, introduce a parameter linked to risk sharing within Energy Service projects (Bertoldi et al., 2006, Päräni and Sinkkonen, 2014). 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.
### Table 1: Classification of energy services based on PSS categories and energy vectors

<table>
<thead>
<tr>
<th>STEAM</th>
<th>HOT WATER</th>
<th>ELECTRICITY</th>
<th>COOLANT</th>
<th>INDUSTRIAL GASES</th>
<th>SPACE HEATING</th>
<th>VENTILATION</th>
<th>LIGHTING</th>
<th>COMPRESSED AIR</th>
<th>PROCESS HEAT</th>
<th>REFRIGERATION</th>
<th>MOTIVE POWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase of a steam generator, together with technical support and maintenance</td>
<td>Purchase of a hot water generator, together with technical support and maintenance</td>
<td>Purchase of an electricity generator, together with technical support and maintenance</td>
<td>Purchase of a coolant generator, together with technical support and maintenance</td>
<td>Purchase of a gas generator, together with technical support and maintenance</td>
<td>Purchase of a heating system, together with technical support and maintenance</td>
<td>Purchase of lighting systems, together with technical support and maintenance</td>
<td>Purchase of compressors, together with pre-scheduling maintenance, systems checks, troubleshooting, minor repairs and consumptions monitoring</td>
<td>Purchase of heating systems, together with technical support and maintenance</td>
<td>Purchase of refrigeration systems, together with maintenance and technical support</td>
<td>Purchase of refrigeration systems, together with maintenance and technical support</td>
<td>Purchase of motive power systems, together with technical support and maintenance</td>
</tr>
</tbody>
</table>

**PSS CATEGORIES**
- Activity
- Product
- Product
- Product lease
- Pooling
- Renting/sharing
- Consultancy
- Outsourcing
- Cooling
- Electricity
- Steam, irrespective of availability of the level (actual fixed amount per needed steam at a function (paying a fixed amount per contract period))
- Space heating
- Ventilation
- Lighting
- Compressed air
- Process heat
- Refrigeration
- Motive power

**Energy Vectors**
- STEAM
- HOT WATER
- ELECTRICITY
- COOLANT
- INDUSTRIAL GASES
- SPACE HEATING
- VENTILATION
- LIGHTING
- COMPRESSED AIR
- PROCESS HEAT
- REFRIGERATION
- MOTIVE POWER

**Example Entry:**
- **Coolant:** Rental of a coolant tank for a short term period (fill additional needs or emergencies)
- **Electricity:** Purchase of an electricity generator for a short term period (fill additional needs or emergencies)
- **Steam:** Rental of a steam generator for a short term period (fill additional needs or emergencies)

**Product Options:**
- **Activity:** Outsourcing of a service level (actual availability of the electricity, irrespective of the quantity needed, which may vary)
- **Product:** Purchase of a service level (actual availability of the electricity, irrespective of the quantity needed, which may vary)
- **Product Lease:** Purchase of a service level at a fixed amount per period (the generator might or might not be located at the customer’s)
- **Pool:** Purchase of the needed coolant level at a fixed amount per contract period (the generator might or might not be located at the customer’s)
- **Rental:** Purchase of a service level (actual availability of the electricity, irrespective of the quantity needed, which may vary)
In fact, even if it is generally true that risk shifts from client to provider while the latter takes charge partially or completely of the initial investment, it is also true that considering the level of risk accepted rather than the method of finance allows taking into account also the arranged profit distribution method (for example, it can be either a percentage of the customer’s savings or a fixed amount, i.e. “Shared savings” or “Guaranteed saving” according to Bertoldi et al., 2006).

A possible new classification that would combine the convenience of framing Energy Services within PSS with the possibility to also consider parameters that are typical of Energy Services’ literature would be the one here proposed, basing upon three different dimensions (see Figure 4): the “intangibility” of the contract’s content as defined by Tukker, the level of risk accepted by both client and provider (previously discussed), and the “scope” of the contract, as defined by Sorrell.

**Figure 4: Proposed classification of energy services within PSS framework**

### 4. Concluding remarks and future developments

This paper presents a general and widely applicable classification of Energy Services built on PSS literature through the application of Tukker’s categories to the energy sector. In conclusions, a new classification model has been proposed, merging Tukker’s PSS categories with several parameters typical of Energy Services’ literature, as a mean to overcome some of the main difficulties met in extending PSS classifications to Energy Services.

The newly obtained classification model is therefore to be further developed in future works, analysing and discussing the variables here identified and mapping all various Energy Services to verify its effectiveness, also proposing a method to foster the spread of those services that are not implemented in practice, but could contribute to sustainability.

### 5. References


