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"Upgradable PSS": Clarifying a new concept of sustainable consumption/production based on upgradablility

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ABSTRACT

Confronted with the accelerated product obsolescence and the resulting waste of materials, the concept of "optimised/increased/hybridised upgradability" is considered. In the literature, upgradability is used to respond to local technical problems (updating norms, update because of a broken component etc.) or as an end-of-life option. In our view however, it constitutes the heart of a new and promising paradigm of production/consumption. This paper proposes to consider hybrid systems that are called "Upgradable Product Service System (Up-PSS)" combining upgradability with optimised maintenance, with valorisation of end-of-life parts and with the servicisation of the offer. The promises of increasing attractiveness for clients, new businesses for manufacturers and a host of environmental benefits make this new concept highly pertinent compared to known models of production/consumption such as remanufacturable products, easily recyclable products, PSS, optimal maintenance products or basic upgrade products. Moreover, Up-PSS is a new opportunity to switch to offers without ownership transfer that facilitates the implementation of circular economy. In order to shed light on the field of Up-PSS and investigate the boundaries of this new paradigm, three actions are carried out: (1) focus groups with consumers and workshops with two manufacturers (2) on the upgradability of real products and (3) on the changes in business models. Our action research approach resulted in clarifying this new concept of the product by defining key ideas based on three keystones: (i) upgrades should be scheduled according to regular cycles of successive lines of functional improvements to satisfy the following themes of value creation: utilitarian, emotional, ethical, and service-oriented. There should also be specific upgrades chosen from a catalogue; (ii) the effects are strong environmental gains from multiple principles of rationalisation materials use but also by encouraging users to eco-friendly usage of their products; this is formalised by an eco-score to which both users and producers are committed. (iii) The above are accompanied by continuous interaction between clients and manufacturers through a web platform, offers of upgradable systems that would integrate bundles of services resulting in the system's growing attractiveness in the eyes of clients. This in turn would set in motion new modes of contracts, offering manufacturers new and more frequent ways of earning revenue; this would be conditional on setting up an upgradability support service that would be attractive to clients as well as reorganising the value chain with the participation of new partners. This transformation of the value network over time implies developing new development paths for business models to facilitate the transition from current economic models centred on material goods to models that are more service oriented.

1. Introduction: from static, passive, throwaway objects to a new category of sustainable systems with multiple upgrade cycles

Our society has become more and more preoccupied with environmental issues. The accelerating rhythm of product renewal results in materials and energy being exploited ever more rapidly.

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Today, with an annual consumption of raw materials at about 60 billion tonnes (SERI Research center, 2009), the world's population consumes about 50% more natural resources than 30 years ago (Commissariat général au Développement durable, 2010). In OECD countries,[1] the volume of household waste flows increased by 40% between 1980 and 1997 (Commission of the European Communities, 2006).

The current mode of mass consumption and production that is called the "Accelerated Process of Renewal of New Throwaway Products" (APRNTP) is no longer compatible with sustainable development (World Commission on Environment and Development, 1987). Finding a solution requires to imagine new models of production and consumption.

To support the idea of sustainability, another mode of consumption/production could be considered: the "Dynamic of Continuous Upgrades Integrated into Sustainable Products" (DCUISP), in other words a product whose end-of-life would be projected over a longer term through optimal modularity. With such products, any technical, functional or visual improvement could be "easily" integrated, and could even depend on the changing needs of each user. The optimisation of modules' lifespan would rationalise the use of materials and the most efficient technologies in terms of energy could be put to use at any time. This ideal picture is however difficult to achieve for many reasons. Notably, the "flexible structure" it implies could make certain changes in the modules, but it would be difficult to alter interfaces between modules or their basic form. Similarly, a system with a certain size can be hard to miniaturize: downsizing suggests the design of a system as a whole (Carey et al., 2011). More generally, changes resulting from breakthroughs of technology or usage are difficult to anticipate.

Between these two models (no evolution in APRNTP and continuous evolution in DCUISP), is suggested a middle way that considers products with certain fixed structural characteristics which discontinuously evolve through the integration of functional changes one, two, three or even four times during their life.

Firstly, the concept of upgradability (functional improvements brought to a system over time) is considered as the foundation of a new paradigm of consumption/production (CP/P) that would satisfy at the same time the Environmental sustainability notably due to the rationalisation of materials use over time and the added value of such systems both for clients and producers.

Secondly, the assumption is made that it is necessary to hybridize (1) various strategies for rationalising materials use and (2) value creation in order to maximise the potential of upgradable systems in terms of environmental sustainability and added value. In this spirit of multi-solutions that are flexible over time through upgrades, it can be considered:

(1) Different strategies for rationalising materials use exist; they are centred on loops of material flows at end-of-life, the extension of lifespan or the creation of dematerialised value.
(2) Different strategies of value creation exist, from selling products to selling services.

The aim of this paper is not to demonstrate the quantitative superiority of this new mode of CP/P based on upgradability, but to characterise certain promises, define a perimeter of success and clarify certain aspects to show that such a concept is pertinent.

In order to shed light on the potential, the perimeters and some of the ways of implementing this new paradigm based on upgradability (introduced in section 1), Section 2 shows the real need for product upgradability, lays out the original positioning, promises and opportunities of our approach compared to alternative modes of CP/P proposed in the literature and the key questions defining the boundaries of upgradable offers. Section 3 presents the three actions undertaken to determine the characteristics of an upgradable system: (1) focus groups with consumers and (2) workshops with two industrial actors on the upgradability of real products and (3) on the change in business models to understand their different points of view. Section 4 highlights what is learnt from the results, leading to a proposal for three keystone principles of our new concept of CP/P based on upgrades (section 5) with a view to economic growth freed from consumption of resources.

2. Issues about upgradable systems

2.1. Need for upgradable systems

The upgradability of an artefact is defined as "*an artefact that can upgrade its functionality during operation (like software) and/or at remanufacturing stage*" (Shimomura et al., 1999). Upgradability offers flexibility in terms of adapting to change (changing needs, wear, obsolescence etc.) that is promising for the consumer (attractiveness and system usability), for industrial actors (business loyalty) and for the environment. To remain rooted in reality and take what at this stage is only a theoretical projection further, it is necessary to confirm the potential need for systems upgradability in the field, with the stakeholders involved. A concrete study was carried out with multi-national (France, Germany and Spain) viewpoints on a specific type of product: electrical household appliances (Pialot and Millet, 2014).

The results show:

- For the vacuum cleaner and the expresso machine, more than 50% of products are thrown away, even if they still work (Fig. 1: left). Functional improvements could thus respond to this dissatisfaction in order to extend product lifetimes.
- The problems that lead to end of use are distributed unevenly (Fig. 1: center). Each of these problems is important in its own way. The accumulation of problems is an important issue: nearly 50% of products accumulate 3 problems or more (Fig. 1: right). The concept of integrated functional improvements seems a good way to counter dissatisfaction as early as possible.

2.2. Towards sustainable Upgradable-PSS, a new paradigm for consumption/production (CP/P)

The quantitative study showed strong potential for applying the concept of upgradability. Upgradability must be put into perspective with new alternative paradigms of CP/P proposed in the literature, such as "Post Mass Production" (Umeda et al., 2000) or the "parsimony" paradigm (Cucuzzella, 2009). The analysis of these alternatives shows that they are associated with three main principles of rationalisation of materials use (MRPr.) if the ratio "value of the system over Time/Material consumed" is considered: increased Time, Value and Material unchanged (MRPr.1); increased Value, Time and Material unchanged (MRPr.2); reduction of Material consumed, Value and Time unchanged (MRPr.3). Fig. 2 presents these three principles of rationalisation of materials use and links each of them with the existing models of CP/P in order to compare concrete elements.

These different modes of CP/P (Remanufacturing, Recycling, Maintenance, Upgrading, Product-oriented PSS, PSS related to continued use and PSS related to intermittent/one-shot use) materialising the different principles of rationalisation of materials

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