A companion for the design of future-adaptable products for use in circular business models

This is a handbook for manufacturing companies aiming for taking a deliberate big leap towards the circular economy

Brand-used something that has been used but is still brand new to you. https://www.urbandictionary.com/define.php?term=Brand%20used
Today, there are many definitions for a Circular Economy. With more than one hundred different definitions, it can easily result in a “methodology soup”. This makes it difficult for manufacturing firms to set objectives in their approach, in setting metrics, and knowing what route to take to explore business possibilities and risks. Moreover, without implementing CE principles in a specific hierarchical order, there is a risk for circular approaches leads to incremental improvements, just as eco-efficiency approaches have been criticized for.

This companion will focus on how an OEM theoretically can maximize resource productivity and reduce business risks in a stock based Circular Business Model (CBM). The emphasis will be on design strategies for prolonging product life, with the design of products that can adapt to future changes. Such products has a potential to both radically reduce environmental impact, while at the same time retaining or increasing the economic value from a product or system.
In a circular economy, there will be increased incentives to design products with controllable and longer lifespans, and that can be adapted with new service content, keeping the existing hardware at the highest utility.

The CE concept, seen from a resource efficiency perspective is a straightforward way for manufacturing industry to reduce their use of virgin materials radically. Also, from a product design perspective, it is relatively straightforward through already available design tools such as those methods in the Design for X umbrella, which raise awareness and offer support to designers with practical guidelines.

In a CE system there will be incentives to design products fundamentally different to maximize the resource efficiency by extended and controllable product life cycles including reuse, upgrade, remanufacture, and as a last resort material recycle of products.

From a business perspective, such circular products could be offered by value propositions where customers pay for the functions or performance of the products while the OEM keeps the ownership and control of their products and maximize their utility in a so-called product service system (PSS).
Considering severe sustainability challenges from a growing population and increased standard of living with more resource demanding activities, the coming 30-40 years will be critical to not overshoot planetary boundaries with unclear threshold effects on earth overall ecosystem.

Many firms also consider it crucial to explore routes for how they profitably can become more eco-sustainable (Kiron, 2012), and thus increase their resource productivity. In the best of worlds, high resource productivity arises when natural resources are used as efficiently and economically as possible, and seems very well in line with most firms strive to maximize their profits.

For manufacturing firms running linear business models (LBM), profit arises from margins between price and cost for developing, producing and selling products, multiplied by the volume sold. The dominant business logic (DBL) for making such profit is to produce products by the massive use of virgin material resources (often nonrenewable), maximize volumes, minimize costs, and with a product design that makes old products obsolete after a “just right” usage time. To keep up the sales volumes in today’s often saturated and highly competitive markets.
Already in the 1930s, the importance to plan for short product lives to support industry was promoted in the USA. This was successfully implemented in industry by yearly facelifts and with a “design logic” "instilling in the buyer the desire to own something a little newer, a little better, a little sooner than is necessary”. Since then, this idea has been thoroughly implemented in product-design with products reaching functional and aesthetical obsolescence or breakdowns with few possibilities for profitable product recovery, sometimes even prevented by the OEM. Linear Business Models together with planned obsolescence have created a path dependency towards faster replacement cycles, and eco-efficiency efforts are more than offset by increased production volumes and faster product life-cycles.
In a circular business model, in which products are meant to be recirculated over multiple lifecycles, it will be the product owner, i.e., an OEM or a service provider who will be responsible for providing the aesthetics, functions, technology, durability, usage costs that are demanded by customers, as well as the financial risks of products becoming prematurely obsolete. Products thus need to remain attractive to the customers during the period in which the product is offered to the customer.

Product design that allows upgradeability and reuse will then become more critical. It will be supported by continuous maintenance, repair and remanufacturing to provide the function to (different) customer segments over a specific period.

The research field of adaptable design has its base in areas of engineering, with the main focus on strategies for designing alternative product architectures, closely being related to fields as modularization as the primary enabler for allowing components to be assembled, disassembled as well as repaired, remanufactured and upgraded. Uckun et al., (2014), emphasize that adaptable products should be able to respond to changing requirements over a long lifetime, taking into account possible future changes when developing products.
The objective of this “companion” is to provide inspiration for (1) developing circular business models (CBMs) in manufacturing firms AND (2) exploring possible routes for circular product design aimed at extending product life, something that can reduce business risks in CBMs.

In it, we suggest challenging the traditional logic of designing and capturing value from products in a traditional “linear” flow-based business models.

We will start this by inviting you a short thought experiment.....Now, visualize one of your best selling new products or your favorite product...
Now, imagine that new legislation soon will make it illegal to sell (new) products based on virgin materials to customers, and make it compulsory for manufacturers to keep the ownership of their products and their embedded materials.
From a linear business perspective, the business risk for an OEM to keep their products that traditionally have been designed to be sold to customers and to become obsolete by fast fashion and technology changes, will be very high.

Assuming that an incumbent OEM abruptly should abandon already made or planned investments in existing and new technology development, products and production facilities, etc. suggests no less than a revolution! Especially since most incumbent organizations have had plenty of time to optimize their organizations for capturing value from selling goods in fine-tuned flow-based LBMs.

Another aggravating circumstance to changing the BM is that the BM is rarely exposed, appointed responsibility for and changed represented in the organization as for new product design, often being represented in top management (TM), with structured processes, and in large OEMs being coordinated by different departments.

*By leakage we mean systematic reasons for the ingredients in the product to escape from a theoretically closed material flow, as e.g. by off-gassing, dissipative wear, during recycling or by resources used during use as electricity and liquid fuels etc.
This conceptual framework for facilitating organizational learning for circular business models innovation (CBMI) in manufacturing firms is aimed at reducing and circulate material flows by BMI. The framework builds on a line of thoughts, by scholars as c.f. (Simon, 1996; Brown & Martin, 2015, Checkland, 2011), seeing design as a transformational process in changing a current state to a desired one, that in this context, is the outcome of a CBM being based on an existing stock of products. This normative stance is derived from principles for Backcasting (Robinson, 1990; Robert, Holmberg et al,) following described procedures for building awareness about the present problematic situation, setting a challenging vision based on principles, and systematically explore the possibilities and barriers for realizing the vision, and finally deciding and prioritizing possible actions for reaching the vision.

Necessary preparations before starting the CBMI process for those appointed responsibility for, or on own initiative is taking on, the role as a “change manager,” is to get buy-in from the TM, and a commitment that the TM on a regular basis will take an active role in the BMI process. Followed by setting up a separate group “a dedicated team,” consisting of people with necessary competencies and functions from business development and design. A team that has, and is given the prerequisites to distance themselves from the existing DBL in the firm’s current
operations of the “performance engine” c.f. (Govindarajan & Trimble, 2010;). This team can then start to build awareness and understanding about the current (problematic) state embedded in the organizations DBL and the rest of the value chain.
This companion is designed for those who...

- Are already well-informed about that a circular economy is about a radical transformation of industry (given that your company runs a linear business model)
- Have experienced the barriers when changing the existing “performance engine” in incumbent organizations, with Eco-sustainable products and customer offerings
- Think and act like an entrepreneur/designer, in that you consider the future as impossible to predict, but possible to design by a structured approach
- Are highly motivated to facilitate or take part in an intervention in your organization to shift from a linear business model (LBM) to a more circular one (CEM)*.
- Have experiences that CE activities for extending product life are challenging to the existing business model and getting customers to pay for improved longevity, resource efficiency, and flexibility
- Work with business development and design/product development in an OEM or as a consultant
- Have a basic understanding of servitization and product service systems

* A business model represents how an organization creates, delivers, and captures value. We define a LBM as a business model where profit comes from a resource flow; a flow of products while a CEM is a business model where profit comes from a stock of resources, a stock of products.

- This handbook is for those - change agents, entrepreneurs, and designers (and people that hold them accountable) - that is prepared to take on the challenge of designing and implementing a circular business model with adaptable products used in a product service system.
- We hence expect the readers of this book to work with companies’ future businesses and markets and has access and commitment from top management as the business and design managers.
How to use this book
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- If you are responsible for planning and execution of a circular business model intervention, you are advised to read through the whole handbook.
- If you have already have started an intervention in your firm and already established a team that commits the top management, you may focus on the FAD framework section with details on how to set specifications.
- If you facilitate change in other firms as a consultant or researcher, please see this handbook as a way to narrow the discourses of a circular business model and possible to combine with other frameworks and tools.

DISCLAIMER:
The illustrations we show in this guide are intended as illustrative examples of the different aspects of modularisation we want to show. However, they are mostly not from circular offerings. They are probably mostly unintended and mostly from linear, flow-based business models. Please bare this in mind.
Introduction of central concepts
### Central concepts and abbreviations used in companion

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<th>Acronym</th>
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<tr>
<td>FAD</td>
<td>Future Adaptable Product: A product that can be changed adapted, such as reconfigures and upgrades, during a product operation stage to satisfy different requirements of customers. (Chang et al., 2016)</td>
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<td>PL</td>
<td>Product Life Extension: Progressive changes in use phases for maximizing the product's life cycle, e.g., by presenting product integrity.</td>
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<td>BL</td>
<td>Business Logic: A logic for capture of (economic) values(s).</td>
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<td>DML</td>
<td>Defined (Business) Logic: An (economic) information filter through which managers (in a firm) conceptualize their business and make critical resource allocations decisions. Drawing such data that they are relevant, and ignoring others. Adapted from Prahalad, S. (1999)</td>
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<td>DL</td>
<td>Design Logic: A logic for creating and delivering material and immaterial values in form of physical products, processes, and services. Adapted from (Jones, 2006)</td>
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<td>ES</td>
<td>Eco-sustainability: A capacity of organizations to maintain their essential functions and processes, and retain their biodiversity in full measure over the long-term. <a href="http://www.businessdictionary.com/definition/ecological-sustainability.html">www.businessdictionary.com/definition/ecological-sustainability.html</a></td>
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<td>LBM</td>
<td>A linear business model: A traditional business model, based on using single resources, digested in a linear cascade to generate manufacturing, linear system of &quot;take, make, use and lose&quot;. Adapted from Raworth, (2017)</td>
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<td>BDBM</td>
<td>A stock-based business model: A business model where profit comes from a stock of resources, a stock of products.</td>
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<td>BS</td>
<td>Business and design strategies for a circular economy: Closing, Narrowing and Shifting down resource flows/cycles (Boekh et al., 2019)</td>
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<td>OB</td>
<td>Obsolescence: a measure of a product's loss in value resulting from a reduction in the utility of the product relative to consumer expectations. (Wright and Teppers, 2010)</td>
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<td>RPS</td>
<td>Resource Productivity: The quantity of good or service (outputs) that is obtained through the expenditure of real resources. <a href="https://en.wikipedia.org/wiki/Resource_productivity">https://en.wikipedia.org/wiki/Resource_productivity</a></td>
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Adaptable design can be considered a strategy for improving products overall value by allowing products to adapt to changes in their environment. To be able to design adaptable products that can lower business risks in circular business models we consider some central building blocks as prerequisites for directing thoughts as follows:

**A stock-based business model:**
In all business models, there is a tension between the value to the customer and value to capture for yourself. That tension is managed through the price. You try to capture as much as possible from the value created for the customer, but some additional value must be left for the customer or she will not buy your product. A stock-based business model primarily captures value from YOUR stock of products that you don’t sell. As a manufacturing firm, you are thus incentivized to make products that are attractive for as long time as possible - as long as that lower your cost without lowering the revenue your product brings in. You are incentivized to continuously deliver utility to your customer because only then does it bring in revenue. So, in a stock-based business model, even though you try to capture as much value as possible for yourself through a high customer price, there is no way to “cheat” but to deliver as
much customer utility as possible (= revenue) at as low cost as possible (= costs) continuously – actually in a continuous flow.

**Business model innovation**

As the current business model affect the existing design and decision logic quite effectively, it has to be addressed first in manufacturing companies that want to make significant eco-sustainability improvements (Nyström and Willander, 2013)

**Business and design strategies for a circular economy:**

From a resource flow perspective, a circular economy can be defined by three simple principles: closing, narrowing and slowing resource flows, i.e. with the aim of intentionally creating circular material flows in industrial systems. According to these principles, closing loops are achieved by material recycling and narrowing loops by resource efficiency, such as using fewer resources per product produced, or during usage. Slowing loops can be achieved by reuse and remanufacturing, extending product life to keep products at their highest utility for as long as physically possible. In a stock based circular business model “you” want as slow “flow” of products as possible since “flow” = costs without added revenues. And you want as short (narrow) circular loops as possible – reuse is better than refurbishing, which is better than reman, which is better than recycling because of higher costs and higher lost values the wider the loops are. And you want as closed loops as possible – any leakage is lost value, which you have to compensate by some means = adds cost without any added revenue

**Servitization, a combination of products and services in a system:**

In discourses about BMs that can facilitate a CE, selling services is often being proposed as a business strategy for dematerialization, i.e., reduced requirements for physical materials to fulfill a specific function, for example replacing physical products with digital services. Product - service-system (PSS) is a combination of tangible physical products with intangible services into a customer offering the buyer the utility of a product as a service with access of a specific function (s) or performance. While ownership of the product often is retained by the seller, that also has a high incentive to induct an industrial logic of intentionally close material loops to reduce resource and energy consumption from materials in production and during product use.

**Factors that make products become prematurely obsolete:**

According to Chapman (2005) and Cooper (2004), product durability, (technical lifetime), is often not the main reason for discarding the product as the actual product lifetime largely depends on the user, his or her behavior, and socio-cultural influences. Rai and Terpenny (2008) define
obsolescence, from a product design perspective, as “a measure of a product’s loss in 
value resulting from a reduction in the 
utility of the product relative to consumer expectations”. Kasarda, et al. (2007) states, 
that “product life ends because a product is unable to adapt to change.”. Therefore it 
is fundamental to be aware of the reasons why existing products might become 
premature obsolete by aesthetical, technical, functional and social causes. These 
various drivers for premature obsolescence have to be carefully considered in the 
business model process. Both as these drivers for obsolescence represent possible 
business threats, as well as a set of enablers for delaying obsolescence

Design for an unknown future:
At the moment it is not possible to predict the future, however the desired future can 
be envisioned and created by using an “effectuation” approach (Sarasvathy et al., 
2008). As a guiding principle to setting specifications in adaptive design, the future 
can as proposed by Bakker (2014 p.101) be divided into of three types of “projected 
facts that might happen.” Things that are known to happen, things that are likely to 
occur and downright surprises.”. Things that are known and likely to happen can be 
understood e.g. by studying quality data reclaims, actual product wear for specific 
products. Surprises will be impossible to avoid but can be can be accounted for by 
making usage scenarios and risks analysis based on a normative vision and customer 
hypothesis.

Durability, flexibility and various grades of adaptability
As, making forecasts of possible future needs of products will be difficult, uncertain 
and drive costs, we suggest an approach to 
design physical products to be durable, flexible and modular. Making modules 
durable and upgradable will minimize needs for costly redesigns and in the further 
described FAD framework, support for designing for such future open modularity is 
being proposed.

Radically increased resource productivity
According to OECD (2008 p.23), sustainable resource use is likely to contribute to 
increased resource productivity, i.e. Creating more output or value added per unit 
input of resources.
This handbook, based on theory and empirical findings, take the position that an 
OEM theoretically, can improve resource productivity radically and reduce business 
risks in a stock based CBM, by using design strategies for prolonging product life as 
adaptable design. This has been proposed as the most feasible way to both radically 
reduce environmental impact, while at the same time retaining or increasing the 
economic value from a product or system (den Hollander 2018).
A business model represents how an organization creates, delivers, and captures value.

A Circular Economy (CE) can be defined as a vision of an economic system without waste that runs on renewable energy.

Today’s variety of CE definitions makes it difficult for manufacturing firms to set objectives and explore business possibilities and risks with circular product offerings.

Products that cannot adapt to changes in its environment will become prematurely obsolete.

Adaptable design, therefore, can be considered a strategy for preserving and improving a product’s overall values and thus, extending its lifecycle.

Extending product life can decrease business risks in stock-based CBM by keeping products at their highest utility for an extended period of time.

Servitization is an enabler to keep products attractive over time.

All CE strategies proposed in this companion are already in use in the manufacturing industry, but result mostly in very low resource productivity.
Nothing will stop you now! however...

Where does an established organization as a manufacturing OEM start to dig, if interested in moving in a more circular direction?

What could be challenges and possibilities for an incumbent manufacturing firm to embrace strategies for circularity, as closing, narrowing and slowing down resource flows?

What does a change/design manager need to be aware of when trying to propose an adaptable product for the top management in an incumbent OEM?
Capturing value, along with competencies and technologies the firm should use and develop, and how to sell to which markets, are a few of the key components in what Prahalad & Bettis describe as the “dominant general management logic” of a firm. Prahalad & Bettis first saw this dominant logic as a “knowledge structure and a set of elicited management processes” for how managers (in a firm) conceptualize their business and make critical resource allocations decisions. This view was further evolved into viewing the dominant logic as an information filter, where the managers only filter such data that they see as relevant, and ignore others. Relevant data are then incorporated into the organization’s strategy, values, systems, and routines etc. The result is a resource and capability infrastructure that will influence the firm’s further search for growth, diversification and strategic experimentation.

Kor & Mesko consider the dominant logic a central part in understanding dynamic managerial capabilities, where managers, by their “human capital, social capital, and cognition”, can orchestrate a renewal of a firm for evolutionary fit. The concept of the dominant management logic and the interplay with dynamic managerial capabilities offers an explanation model for what forms a firms decision-making in their ongoing operations, as well as why changing their existing business model is often difficult to achieve.

One of the main assumptions in this handbook is that it is not primarily design-methods or available technologies that are the main challenges for design and production of adaptable and long-lasting products that could perform better over several use cycles. The main barrier is instead, being embedded in the dominant business logic of the firm, with the design logic mostly
being a faithful solution provider for the DBL. The established business logic proven to be profitable will dominate as survival of the firm is crucial. This current business logic in most firms is taken for granted and there is a lack of a well-organized approach to business model innovation compared to well-established structures and practices for product design. This is something we see as a weakness in many firms’ ability to adapt.
The dominant business logic in large incumbent OEMs; the linear business model

The business model of a firm is seen - by several scholars - as an image or a blueprint of the “core” logic of doing business. It reflects the management’s hypothesis about value creation, by solving potential customers wants and needs, and identifying how to organize, get paid, and make a profit for delivering such values c.f. Alternatively, the business model is considered as being a mediating device for capturing latent value(s) from technical innovations, as e.g. illustrated by Chesbrough & Rosenbloom, in which a new business model helped the innovative, but at that time expensive, photocopier technology to diffuse in society. Henry Sloan, the CEO of GM between 1923 and 1946, suggested that: “The business of business is business”, probably with the assumption that the main reason for companies to do business is to earn money and make a profit, and in the process, staying alive on the market.

From the perspective of an incumbent manufacturing firm, the traditional logic of using design since the late 1800s has been as an enabler for the success of the firm’s dominant business logic. It has mostly been associated with decoration (styling) of the mass-produced artifacts aesthetical properties, as e.g. shape and color etc. The potential of design as a solution provider for the dominant business logic became very clear during the 1930s when the US automotive industry by GM introduced...
annual model changes. With intense marketing, GM was able to differentiate themselves in a fierce recession-era business environment. They also started to build what has become a very established consumer culture around individual ownership of cars, where the metric of success for this design-logic has been its contribution to the earning money.

The status quo in this dominant business logic is a design logic that provides solutions “in harmony” with the dominant business logic. Disharmony could, of course, occur when definitions of good work differ between competencies in the organization. A product design could fail by reasons of too little effort spent on aesthetics, wrong aesthetics or functionality, insufficient durability, or a price that’s too high resulting insufficient sales. But the real clashes occur when the design logic starts to challenge the dominant business logic.
The CE concept, seen from a resource efficiency perspective is a straightforward way for manufacturing industry to reduce their use of virgin materials radically. Also, from a product design perspective, it is relatively straightforward through already available design tools as, e.g., for circular design or by methods in the Design for X umbrella (Gatenby, & Foo, 1990), raising awareness and offering support to designers with practical guidelines for designing products for desired characteristics. In such, a CE system there will be incentives to design products fundamentally different to maximize the resource efficiency, by extended and controllable product life cycles by systematically in a sequence be able to, reuse, upgrade, remanufacture, and as a last resort material recycle products.

If further, adding a business perspective such circular products could be offered by value propositions, where customers pay for the functions or performance of the products, and with the OEM keeping the ownership and control of their products and maximize their utility in a product service system (PSS).

From the field of PSS research (Pearce, 2009; Nasr, 2011; Nasr & Thurston, 2006), studies have promised to profitably reduce resource consumption in such systems significantly.

However, from a linear business perspective, the business risk for an OEM to keep
their products that traditionally have been designed to be sold to customers, and to become obsolete by fast fashion and technology changes, will be very high. Then, assuming that a CEO in an incumbent OEM abruptly should abandon already made or planned investments in existing and new technology development, products and production facilities, etc. would be no less than a revolution asked for. Especially, as most incumbent organizations have had plenty of time to optimize their organizations for capturing value from selling goods in fine-tuned flow-based LBMs. Another aggravating circumstance to change the BM is that the BM is rarely exposed, appointed responsibility for (Chesbrough, 2007) and changed represented in the organization as for new product design, often being represented in top management (TM), with structured processes, and in large OEMs being coordinated by different departments.

Applying all three principles/strategies illustrated is considered to have the highest potential for eco-sustainability by prolonging product life and continuously looping product’s back into the system for extended use phases and finally closing the material loops by recycling, at the final end of product life. The Narrowing loop strategy could increase the eco-sustainability potential even more if renewable energy is used for production and during the product’s use phase. This is especially relevant for energy demanding products. However, even if approaching all three strategies for a circular economy has the highest eco-sustainability potential, it will also pose most challenges on the existing linear business model. Compared if the firm only focuses on e.g. closing the loop activities as making their products easier for recycling. Or saving energy or materials in production, by the narrowing loops strategy, that rather support the already established industrial logic of reducing costs.
Two practical examples of the role of the dominant business logic in product design
These examples illustrate two different approaches in which the product design provides a solution for the existing dominant business logic/business model. In the case of Fairphone model 2, it has a design for an estimated life-length of five years, by easily exchangeable modules and with the intention that end-customers themselves can disassemble and exchange modules that are broken. This modularity and design for repair are supported by a business logic that encourages customers to repair by-offer spare parts at a low cost. Such a long-planned life expectancy is considerably longer than for the average usage time of smartphones today, which can have a significant eco-sustainability potential depending on the energy usage during the use phase. Of course, actual consumer behavior, such as the consumer’s willingness to upgrade the operating system, and the mere availability of what is required to do an upgrade, such as the support from Google of old Android operating systems, affects the actual life-length in the end. In order to address this, Fairphone is exploring possibilities to develop their business model even further, providing the phones as a service and retain ownership. This strategy would then enable Fairphone to control both the hardware and software upgrades on the stock of phones being in use, and thus minimize the risks of customers not upgrading their phones as needed and then deeming their phones to be obsolete prematurely. By doing these activities Fairphone illustrates a dominant business logic that embraces all three circular strategies, for
closing, narrowing and slowing down resource loops.

The TILE tracker, on the other hand, is designed for a fixed life-length of one year. Even if it would be technically feasible to use Tiles for additional use cycles, they have- for safety, environmental, reliability concerns and to keep up with fast changes in new technology (according to Tile) - a sealed design. This disallows simple battery change and runs counter to many other small consumer electronics (many watches, music devices, lighting etc) that allow customers or other actors access to change batteries and make other small repairs. The result of such a design for premature product obsolescence, is the generation of a lot of electronic-waste, as TILE themselves claim to have sold more than 10 million products and has no take-back system for used Tiles. Instead, customers are encouraged to send their technological obsolete Tiles for “proper recycling”, that in practice will result in various types of recycling depending on the geographical market. The design logic described here exemplifies a linear business and design logic that is common for many other consumer electronic products, increasing the growing global E-waste stream of small electronic equipment.
So, if the dominant business logic is ruling product design, who can change it? and how can it be altered to foster a circular business logic?
Although all firms, either articulated or not, employ a specific business model, it is often taken for granted and seen as implicit in the organization. As an effect, business model innovation in incumbent firms is rarely objectified, and responsibility is rarely appointed for in the same structured way as other innovation and product development activities. In large OEMs, this way of organizing has been described as “machine bureaucracies”, that has become “fine-tuned to run as integrated, regulated machines”, performing repetitively standardized operating tasks like designing, producing and selling physical products. Design and product development activities in these organizations are often run as a recurring and cyclical process that uses a natural science-based approach of experimentation and testing that is owned by individuals and departments set-up specifically for these tasks. This process is carried out in detailed stages. From the very early stages of a conceptual design coordinated by advanced engineering and design departments to industrialization by product development and production departments. These activities are combined with, often deeply-rooted structures for aftermarket operations as resellers of products, spare parts, and service etc..

As these machine bureaucracies are designed and optimized for specific purposes, they are also extremely difficult to reorganize and change when conditions change.
According to Mintzberg, organizational charts like the one in Figure 1. can be used to reveal current positions and functions in a firm and how these positions are grouped into unit/departments, as well as illustrating flows of formal authority between them.

Without a formalized authority for business model innovation, as often is the case in incumbent firms in early development phases, any change to the business model (depending on how much a new business model will challenge the dominant business logic) has to be referred back up to the top management. This can result in a delay even when more radical business model innovation is warranted, for example when disruptive competitors, changing customer demands or, as this paper addresses, when implementation towards circular economy principles is initiated.
Changing the dominant linear business logic with business model innovation
Regardless of who is responsible for the business model innovation process, it can be, according to Osterwalder & Pigneur’s popular Business Model Canvas, viewed as a “kneading” - within and/or between one or several of the “building blocks” in the business model.

According to Birkinshaw & Shazansari, there are three main challenges for business model innovation: (1) The inertia caused by the existing business model, (2) the complexity of complementary elements and (3) how to establish and maintain coherence among business model elements. They exemplify these challenges by a framework (Table 1) dimensionalizing business model changes according to a depth dimension with incremental to radical changes and a breadth dimension, wherein business model innovation can be modular, when some of the building blocks in the business model are changed) or architectural,when most of the building blocks are changed).
Modular and incremental changes in this model are described as small adjustments to the firms existing business model, such as adding new offerings to the firm’s
existing products. This can be exemplified by an automotive OEM introducing a new
financial leasing offering for cars. Modular and radical business model changes, on
the other hand, would be if the OEM would add new services to their existing
products, e.g. launching a subscription service of a car and thus creating several
business models that must be managed in parallel or “ambidextrous”, by both selling
cars and selling subscriptions.
Incremental and architectural changes could be exemplified by the OEM designing a
service that enables deliverance of groceries in the trunk of a car in the parking lot
while the owner is at work.
Architectural and radical changes represent the most extreme category as they
demand fundamental change to the current business logic. This category could be
exemplified by an OEM selling uptime instead of selling products, keeping ownership
of produced products in a product service system (PSS) and keeping responsibility for
operations, a responsibility that is currently held by their customers.
The current business logic in most firms, today are taken for granted

There is a lack of a well-organized approach to business model innovation

Established business logic will always dominate as survival of the firm are crucial

Radical product design changes are dependent on radical business model changes

The top management is not only the gatekeepers of the current business model but also for all major business model changes.

The design logic must support the existing BM, either being linear or circular, or it will be dismissed

Radical and architectural BMI will impose TM taking on the suggested role as entrepreneurs, by stepping out into unknown territory, with lack of prior experiences and successful examples to lean on
The CBMI process

General steps to design a stock-based circular business model and adaptable products
This section proposes a conceptual framework for facilitating organisational learning for circular business models innovation (CBMI) in manufacturing firms, with the aim to reduce and circulate material flows by BMI. The framework builds on the previous presented line of thoughts, by scholars as c.f. (Simon; Brown & Martin, 2015, Checkland,), seeing design as a transformational process in changing a current state to a desired one, with a CBM combining all three strategies for a CE (table x). Moreover, also with the assumption that such a CBM will impose both radical and architectural BM changes in which the top management must take a leading role as BM architects or designers in the BMI process, and where the BM and products must be developed in parallel, due to the intertwined relationship between the BM and product design (Teece, Brown & Martin, 2015, Williander? Van Hollander).

The CBMI framework consists of a set of basic principles for accomplishing the highest possible grade of circularity from a resource flow perspective, combined with a method for facilitating a transformational design process (figure x).

The proposed CBMI framework shares thoughts with the one proposed by (Bocken et al.), in considering BM development in conjunction with product design towards a vision. However, the CBMI framework puts more emphasis on prerequisites for...
reaching the highest grade of circularity via the waste hierarchy, thus aiming at radically increase resource productivity, compared to if the OEM does a little bit of everything. Hopefully, contributing to manufacturing firms embracing the full potential of a CBM with more predictable and manageable business risks.

3 Steps:

1. Set the normative vision: To run a business in accordance with a circular economy is a normative stand-point that needs to be decided, for instance through backcasting, adoption of principles, f.ex return loop principles (Bocken et al, 2016). The result is a non-negotiable demand that the business model must be circular in its fundamental design

2. Concept development: The business model development is basically run in accordance with the Lean Startup Methodology principles (see Ries, 2011; Blank & Dorf, 2012), with 2 differences:
   1. Pivoting the business model away from circular principles is not allowed (since it violates the vision in 1 above)
   2. The framework principles for business-model driven material flow reduction must be adopted

3. Action plan: Plan for the implementation and scale-up of the circular offering. The challenges in this step have been identified and addressed in others’ research (c.f. Govindarajan & Trimble, 2010; O’Connor, 2008).
As radical and architectural BMI will impose TM taking on the suggested role as entrepreneurs, (Saeby et al.) by stepping out into unknown territory, with lack of prior experiences and successful examples to lean on when developing a CBM and suitable products. The interventional approach in the CBMI process is derived from the methodology for lean startup and customer development (CD) (Ries, 2011; Blank & Dorf, 2012), where the dedicated team learns by doing small-scale and cheap hypothesis testing and iterations, at a high pace, in close contact with potential customers. Such high pace and close customer contact will reveal essential barriers and hopefully make failures come at a low cost and early in the process preventing more expensive failures later on.

Based on theory regarding entrepreneurship, Sarasvathy et al. (2008) proposes three elements for describing boundaries for the “Entrepreneurial Design Space” where they suggest effectuation as a strategy for handle uncertainties of the future. (Sarasvathy et al., 2008 p.337).

1 “Knightian uncertainty”: I.e., it is not possible to calculate probably future consequences
2 “Goal ambiguity”: preferences for the entrepreneurial venture are often not given or well ordered.
3 “Isotropy”: those elements in the environment that the entrepreneur needs to pay attention to and those that can be ignored is not clear

Based on these three types of uncertainty, a structured method for effectuation of the desired future is backcasting (Robinson, 1990), which will be described later.

However, even if the lean startup principles underpin the CBMI frameworks, an essential difference in the CBMI approach compared with CD is that the CBMI process aims to remain locked on the desired future state, based on the business model principles for circularity. This differs from the traditional CD approach, which allows for significant deviations from the original business model idea (pivoting) since they often have to create new markets. In this context, this might result in increased resource use and possible effects regarding eco-sustainability implications, by how to prioritize between, on the one hand, the entrepreneurs own ethical considerations regarding sustainability goals, versus, on the other hand, the need to find customers that have a willingness to pay for the inventions, understanding that the customers might want to use the technology and service for other reasons that first thought of by the entrepreneur.
As this handbook aims to find ways to increase both profitability and resource efficiency, there is a need in the BMI process to build a shared vision of such a desired outcome of increased resource productivity, and here principles of Backcasting are used to work towards a holistic vision of a transformation from an LBM to a CBM, by a set of guiding principles. These principles are used as boundary conditions for the Business Model to focus value-capturing within.

The First principle is the vision of stock or lake based CBM, i.e., that the value creation and delivery shall be based on the existing stock of products. Thus, considering the aftermarket as a “lake” for capturing value, instead of using virgin resources from the earth crust and biosphere.

Secondly, the three CE strategies, closing, narrowing and slowing down resource loops further set the boundaries for running and maintaining the lake based CBM at a high degree of circularity.

The British standard defines Backcasting as “working backward from a desired future state of a process, product, service or organization (or aspects thereof) to determine both its feasibility and what actions need to be taken to reach that state” (BS
From the 1990s, backcasting came to be related with sustainability and creating sustainable futures with the aim to help organizations to focus on their long-term challenges instead of focusing on small incremental improvements. This helps the organization to identify their major gaps towards sustainability, formulating a transformative vision and solutions for systematically moving towards their vision (Holmberg and Robèrt, 2000).

The organization The Natural Step (2016) has developed a general framework and a method for using backcasting in organizations of various sizes and branches; Framework for Strategic Sustainable Development” FSSD, (Figure x ). The process starts by defining a future normative and desired vision. This vision is formulated by the help of guiding system principles setting a boundary for the envisioned outcome. In the second stage, the baseline in the company or organization is analyzed in comparison to system principles or criteria. In the third stage, the design of an operational solution, acting as stepping stones that are needed to reach the outcome are ideated. In the fourth stage, those alternatives that can help the organization in the “right direction” in reaching a sustainable future and have a high degree of flexibility are prioritized in an action plan (Holmberg and Robèrt, 2000).
The lean-startup methodology is a well-proven low-cost learning process for how to develop a value proposition the market wants within a profitable and scalable business model.

It is a general process, i.e. It doesn’t necessarily lead to circular offerings – in fact, most likely not, since the process is non-normative with a focus on the logic for how to make money.

A tool to use when creating a business model is Alexander Osterwalder’s Business Model Canvas presented in Value Proposition Design (VPD). It provides structure and suggestion of tools to use in the development of a value proposition.

VPD can be seen as a sub-process, a section within the iterative Lean Startup learning process suggested by Blank (see next slide). Lean Startup output is a complete, profitable and scalable business model, within which there is a value proposition that attract customers.

So VPD will help with structure and tools for that part of the Lean Startup learning.
process.

One tool is the Value Proposition Canvas, which is used to make sure you understand the customer with its wants and needs.....

...... and how the value proposition can deliver gains and relieve pains the customer experience to get its “job done” without your offering.

Neither VPD nor Lean Startup ensure circular offerings – only efficient and effective creation of new markets and offerings
Since radical business model innovations are rare, industry’s capability and experience is often quite limited (c.f. Foss & Sæbø, 2015) the FAD framework includes a process for how to develop circular offerings (that in most firms with a linear business logic will be radical).

- The CBMI process is not a linear one, it is an iterative learning process.
- It follows lean start-up methodology
- It starts by looking at the value proposition based on the vision of a stock based business model.
- Neither VPD nor Lean Startup ensures circular offerings – only efficient and effective creation of new markets and offerings.
- We do not promote any particular method but there are many available tools that can help during the learning CBMI process, with some being suggested in the appendix.
The FAD framework in detail

As presented thus far, the aim with a future adaptable design is to develop products and services that can lower business risks in a stock-based circular business model.

This section will focus on how to develop suitable products that can adapt to a specific degree, based on assumptions drawn in the initial phases in the business modelling.
A stock-based business model will carry a higher business risk than the equivalent linear one since the risk for product obsolescence (carried by the product owner) was transferred to the buyer in the linear model but now is kept by the OEM/service provider.

Adaptable product design can be considered a strategy for mitigating this risk by making products able to adapt to new preferences.
Basic principles for future adaptable design (FAD)
The field of adaptable design has its base in engineering, and is described as a DFX (Design For X) paradigm by Hashemian, (2004 p.4). It has a main focus on strategies for designing product architectures, closely related to modularization, and for allowing components and subsystems to be assembled, disassembled, repaired, remanufactured and upgraded.

Uckun et al., (2014), emphasize that adaptable products should be able to respond to changing requirements over a long lifetime, taking into account possible future changes when developing products.

According to Li et al. (2008), there are three main criteria for adaptable products.

• First, an adaptable product must have the possibility to extend its functions, either obtained within the existing parts or due to the replacement of parts and components.
• Second, new technologies and improved performance should be integrated via upgrades.
• Third, components will have to be customizable to fulfill the needs and requirements of individual customers.

In addition to modularity and changeability, Uckun et al. (2014) argue that adaptability also includes reliability and robustness.
According to Gu and Hashemian (2004), adaptable products can be divided into two different main categories; specific and general.
A specific adaptable product is defined as: “the ability of a product or its design to be adapted for potential applications that can be foreseen at the time the product is initially designed”.
An example of specific adaptability, could be a laptop with the possibility to upgrade with more RAM or s with a larger HDD.

The definition of a general, adaptable product is by Gu Vaguer defined as a product designed to adapt to future unknown needs and requirements. An example could be an aircraft, where physical space and infrastructure has been made reconfigurable to support numerous yet unavailable future systems, i.e. allowing for future changes that are unknown at first launch on the market.
Designing for general adaptability will then require a much more holistic approach, than for specific adaptivity, and will also add more complexity to the design process regarding balancing between present and possible needs.
However as Engel et al., (2017) points out adaptivity can give future benefits if it enables upgrades on an existing product.

There is an important difference between a durable and an adaptable product. Even if a durable product can be used for a long time, it will probably not be resource effective if new technologies and functionalities with better environmental performance cannot be integrated. This is especially relevant for energy-using products as vehicles (Mayyas et al., 2012 p.1849).
Building the adaptable system

Think of:

A system with a product architecture of individual modules (not a product), being separable in interconnected layers.

The different life-lengths of these modules.

What factors that might make modules obsolete?

What will it cost to realize a modularity that is future open?

Who are potential customers for the various modules in a sequence over time?

"An adaptable "whole" (a system) that can survive through time by adapting to changes in its environment"
From the customer perspective, buying a shiny product as a car might be a positive experience. Over its lifecycle, this car will not perform better over time, than from the point of the first sale. On the other hand, it will most probably perform worse from both an Eco-sustainability and user experience perspective, as the wear of the ICE engine and other vehicle components increases. With exceptions from variations in driver behavior, and the type of fuel used.

After some years of usage, the owner or user a might start to consider the car as being outdated, in comparison to new models being launched. This feeling might become even stronger as the depreciation year by year decreases the economic value of the car. As activities for keeping the car from breaking down, the need for yearly services and repairs increases the workshop bills. Finally, when the vehicle is approaching its expected end of life, after being driven more than approx., ten years and 200,000 km. There is, at this point, probably minimal economic and material values left. Considerations at this stage, to refurbish and remanufacture the car back to its original performance, or even retrofit this car to an EV, will be left for tinkering enthusiasts around the world. Being deeply attached to just this specific car, this model, or in adapting to EV technologies. As well as, perhaps interesting in exploring CE principles of product life extension.
Financially grounded modularity/adaptability:
Future-adaptivity through modularisation is generally beneficial because the product can adapt at a lower cost.
But modularisation is not always cost effective since it drives costs – f.ex for interfaces, weight, size, higher MTBF etc.
At some point, an increased modularisation will cost more than the related option value for a future upgradeability.
By financially weighting modularisation costs against real option value, a future-adaptable design is created that is financially grounded

Multi-layered modularity:
Addresses obsolescence by prioritizing exchangeability within layers without affecting other layers. Helps decide where to be modular and to structure for different (obsolescence-driven) frequencies of module replacement needs. Layers are (with association to the human body):Skeleton (fairly stable): Lots of material worth not to be wasted when organs and skin runs obsoleteOrgans (technical obsolescence): Make remanufacturable and upgradeable to minimize cost for delaying obsolescenceSkin (aesthetical obsolescence): Make exchangeable and recyclable and based on recycled materials
Metabolism: Energy and consumables the product needs in the use-phase can play an important role in premature obsolescence. Diesel cars can quickly become unattractive if f.ex. society decides on diesel bans. The metabolism of products is hence important to consider in each layer so that consumables with questionable future is consumed in product modules that can be upgraded in the use phase.

**Future-open modularity:**
A modularisation that allows for efficient disassembly and improvement, but also take into consideration that a module in one product today may be used as module in not-yet-developed products in the future.
In the notion “future-open” lays the view that the modules that constitute a product shall allow the product to upgrade and/or transform to another product, within the limits set by the boundaries of the layered architecture.
An illustration can be LEGO where a “module” (f.ex. a 2*3 plug LEGO piece) not only can be part of a current LEGO kit but in many different kits, both existing and not-yet-invented ones.

**Cascading customer loops**
One way to further decrease the material flow, primarily through a delayed product upgrade, is achieved by identifying and including the innovators, early adopters, early majority, late majority and laggards customer typologies in the business model so that the product (as a carrier of a value proposition) can propagate through the customer typologies before a major product upgrade has to be done.

*Worth noting is that the cascading doesn’t have to be realised for the complete product but fills the purpose of slowing down material flows also by “dissolving” the product into its modules and let different modules continue to deliver utility in new combinations for new customer typologies.*
Designers can only design a potential for extended product lifetime (den Hollander, 2018 p.29), and sooner or later all products will become obsolete based on the previously described drivers for obsolescence (that in reality often are intertwined). It can in many cases be difficult to conclude what made an owner or user by an active choice consider it obsolete, or not (Diener, 2017). It can for example depend on his or her available knowledge, moods, or forced by legislation and so forth.

For example, a skateboard rider considers replacing the metal bearings, with new ones, made of ceramics. Reasons for this could be, both technical as of wear. As well of reasons for wanting to use a more advanced bearing technology, that could minimize friction and promising improved wear resistance and speed. Or, by social reasons as higher status in a specific subgroup of skateboarders. Further, if used in a PSS (Product Service System) skateboard pool, this change to ceramic bearing could be due to lower life cycle costs in the fleet of skateboards (even if the ceramic bearing is more expensive than metal ones per piece).

A starting point in designing products for a CBM is, therefore, to be aware of the reasons why customers and users may consider products become obsolete by aesthetical, technical, functional and social causes. These various reasons for
premature obsolescence have to be carefully considered in the BMI process as drivers for obsolescence represent possible business threats as well as a set of enablers for delaying obsolescence, as being illustrated in

Each of these principles for obsolescence and adaptivity can be looked at as heuristics (ways of working) in conceptualizing a product and the business model.

In the next steps, these principles for future adaptivity are compared with the four modes of obsolescence, forming a matrix of possible ways to identify business risks and find design solutions that can reduce those risks in an iterative search for a well-motivated degree of adaptability.
The FAD framework forms a general 4*4 ideation matrix where the four principles for designing are used to help address the four modes of obsolescence. Each of the 16 cells in the matrix will be of different importance for different business sectors. It is for instance likely that the aesthetical mode of obsolescence is more relevant in the fashion industry than in the heavy construction equipment industry.

By clicking on any of the (i) buttons, you will find an illustration of a product design that is more robust to that mode of obsolescence and sometimes also an example of non-robustness.
Principle A: Multilayered modularity

Different parts of the product are affected by different drivers of obsolescence (aesthetics, technology, functionality, and social) and with different frequencies – different replacement paces.

The principle for multi-layered modularity aims to provide a structure for how the product can meet different obsolescence-driven frequencies of module replacement needs.
Multi-layered modularity is a FAD principle that gives you a visual structure for address obsolescence by prioritizing exchangeability investments within a specific layers, without affecting other layers. Helps decide where to be modular and to structure for different (obsolescence-driven) frequencies of module replacement needs. Layers are (with association to the human body. The basic idea is to think in layers, and try to structure the different parts of the product (referring to the human body) i.e. a skeleton, organs, skin and metabolism.

Modularisation within layers is fine while modularisation across layers may force more frequent module updates because of the different frequency of obsolescence between layers.

Skeleton:
The skeleton layer represents a supportive structure that should be relatively stable over the whole products useful life and designed to keep the desired functionality. It should also allow for continuous upgrades in the other layers. The skeleton layer will have high embedded values that should be kept unaffected when other layers become obsolete. Examples could be alloys that resist corrosion or safety structures that protect the users.
Organ:
The organ layer represents components or subsystems that maintain specific functions as communication, movement, braking, energy storage, etc. Organs become primarily technically and functionally outdated and should be designed to be upgradeable and possible to remanufacture, to minimize the cost of delaying product obsolescence.

Skin:
The skin layer represents physical surfaces and touch points between the user and the product. It can for example be the shape of outer surfaces, color and textile patterns. But also communication interfaces as for example visual displays or audio communication or service touchpoints as a personal meeting with a service technician.
The physical skin layer primarily risks becoming aesthetically outdated and should be designed to be interchangeable, recyclable and produced from already recycled content as the change pace could be fast if fashion changes are important to follow to keep the product contemporary.

Metabolism:
This layer represents the energy, propellant and consumables the product needs during usage, maintenance, upgrades and remanufacturing, etc. These metabolic factors can play an important role for product risks of obsolescence as e.g. with diesel cars being under increased pressure of emission legislation or local diesel bans in city centers, etc.
The metabolic constraints have to be carefully considered, regarding risks for banned propellants or consumables in the future. One may want to make it possible to change organs in the future resulting in a changed metabolism as e.g. upgrading an ICE to a BEV.
Failures of multi-layered modularisation:

- **Aesthetic:** The uni-body structure creates both the car's shape and its crash properties, i.e. it becomes almost impossible to change aesthetic appearance after production.

- **Technical:** In Google’s ARA concept for a modular smartphone, the chipset was integrated into the skeleton of the phone, with the result that the skeleton had to be scrapped if the chipset broke or became obsolete.

- **Functional:** The hardware in a vehicle that carried Spotify and other apps were forced to remove Spotify when Spotify was upgraded and the hardware in the vehicle could not be upgraded with a new version.

- **Social:** A boycott of leather seats by vegans will hit all already produced cars since the seat’s surface layer isn’t modularised to be easily replaced.
Success of multi-layered modularisation:

Aesthetic: Race cars often are designed with a tube frame, onto which a fiberglass shell is mounted, separating the shapes of the body exterior from the crash safety structure.[1]

Technical: The modular smartphone Fairphone 2 can be upgraded with a camera module after the sale, providing a higher resolution.[2]

Functional: This concept for a bicycle lock by Seth Chiam, provides multifunctionality, by providing both protection against theft an luggage support as a carrier.[3]

Social: These chairs from Gärsnäs can easily be upgraded after the sale with acoustic panels, being mounted under the seat. This reduce noise in public spaces as e.g. canteens or other noisy environments.[4]
FAD tool: The product architectural layer model

Ask yourself:

How can the architecture of the product be divided into separable layers according to its necessary functions?

How can these layers be interconnected without hindering upgrades in the layers?

For example, how could the organ layer in a vehicle, e.g. being represented by the powertrain, allow easy upgrades or retrofits of new propulsion technologies, as changing from an ICE to and BEV powertrain within the same overall product architecture?
Principle B: Future open modularity

Different components in the product system are affected by the various pace of changes. The principle for future open modularity identifies these various need for change over adaptable products usage cycles.
Selling products designed for extended life can be challenging as a general assumption is that customers expect innovation continuously to stay loyal to a brand, and initially such products could be much more expensive due to a more complex development, more durable materials, and need for more extended durability testing. Also, as for all radical innovations, there is difficult to predict the market potential for a new revolutionary technology that might not exist.

A layer based modularization give technical possibilities for systematically and cost effective upgrades but there is also possibilities that parts and modules in an existing products can become relevant to use in another products that has not yet been created.

The future open modularity approach open up for preserving embedded product values by making scenarios for an extended life of specific components or systems that has high embedded material and immaterial values.

**FAD principle B: Future-open modularity**

**Aim:** Specifying required major overhauls and future upgrades during a product lifecycle

**Description:**
Provide a visual structure of the "lock-cycles" of each architectural layer, with planned exchanges and upgrades of components

**Activity:**
Set an expected life length based on the desired economic and environmental scenario

**Outcome:**
A visual representation of a scenario for upgrades of the minimum viable product (MVP) product concept being developed

**Tools:**
Lifecycle upgrade scenario

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**Consider**

*In what stage of maturity is a specific product or technology, from an aesthetical, technological, functional and social perspective?*

*Are the aesthetics of the desired product affected by fast fashion trends or represent a classic design that are more stable over time?*

*Is the technology used in the product under fast development or well established?*

*Will new functionality, risk making the whole product architecture obsolete?*

*Social changes, will the technologies used be affected by coming legislation or new customer/user behavior?*
Time has an essential role for all modes of product obsolescence as time influences all that humans create and all that we do (Thompson et al., 2011), and knowledge about current life length and planning for an extended usage time of products will thus play an important role when designing for resisting obsolescence. Once upon a time, design and production were done in the individual craftsman’s pace (Thorpe, 2007), where large and complex projects like cathedrals could take decades or even centuries to complete, but today, efficient production methods and digitalization have reduced the time from idea to market rapidly.

In the fashion industry, some brands have reduced this process down to months or even days. It takes the fashion company, Zara, approximately 15 days to get from a design concept to a product in the store, where the average time to market is six months! Within the automotive industry, development cycles are much slower where the development of a car or construction equipment could range from 3 - 7 years. During that development time, a lot can change regarding technology, aesthetics, etc.
FAD tool: Lifecycle & upgrade scenario

Ask yourself:

- How will the product architecture be affected by aesthetic, technical, functional and social drivers of obsolescence?
- How often various modules that build up the product architecture need to be maintained, remanufactured and upgraded, to keep the utility of the product over time?
- How can a scenario of various activities for the maintenance and exchange of modules give input to the cost side in the business model canvas?
Principle C: Cascading customer loops

While modularity focuses on the product, the concept of cascading products considers how an offering (a product) could be shifted to different customer groups, based on varying customer groups' wants and needs.
One further reduce material flow and economic risks, is to postpone future expensive product upgrades by systematically design for multiple customer segments with cascading value propositions, cascading potential users in multiple use phases. This approach are based on the well-established "Technology adoption lifecycle" concept (see, for example, Rogers, 1995; Moore, 2002) in the selection of customer segments. By this approach the business model are designed to in sequence serve "customer segments"; innovators, early adopters, early majority, late majority, and laggards, meeting their preferences for aesthetic, technological, functional, social and economical features, before major product upgrades or remanufacturing is carried out.

This approach will be especially relevant for product segments with fast changing fashion and technologies as e.g. with fast changing consumer electronics. Expensive components that could be reused into other application are for example EV batteries, electrical motors, processor units.
Aesthetical enablers: Lamino, launched in 1956, has worked its way through customer typologies not only one loop but several – which is kind of “natural” for objects that become “classical”. Classical = after having reached the laggards and even they tend to discard them, they become re-appreciated by earlier customer typologies because of the product’s inherent and time-independent beauty and function. Appreciated and attractive but now for somewhat different reasons than previously.

Technical enablers: Virrvarr: A design pattern by Sigvard Bernadotte designed in the 1950ies, easily hide the negative impressions from scratches, thus helping to reduce the need to replace surfaces for esthetical reasons.

Functional: A smartphone can become a security camera, with features that have a substantial worth (in terms of what such a surveillance camera cost). A battery in an electric bus, can when it is no longer fulfilling the requirements in the adaptable product be given a second life in a building as e.g cutting voltage peaks in the electrical grid and so forth.

Social: By considering basic human needs and how these have been fulfilled over...
time, ideas for biking has been around for hundred plus years and the risks that people stop seeing biking as efficient for communication and for their leisure, will be rather low. However, bike technology develops with new application areas and suitable products. Heavy trucks in dense city areas face higher social barriers regarding emission legislation, congestion, and acceptance from people living and commuting through these areas.
Cascading customer loops, some supportive tools

There are a wide variety of available tools to identify customer segments and identify possible needs and wants.

One tool is the Value Proposition Designer, which is used to make sure you understand the customer with its wants and needs, and how the value proposition can deliver gains and relieve pains the customer experience to get its "job done" without your offering.

Making hypothetical persona descriptions based on real empirical data, provide a rich picture of potential customer segments.

Customer journey maps are often used as a tool in service design and can be helpful for identifying how new service content can be added in an adaptable product service system.
Principle D: Financially grounded adaptability
Designing a product to be future adaptable will require careful considerations regarding choices of materials, production technologies and technologies that can make the product to resist premature obsolescence.

Based on early considerations in the design team regarding things that are known and probable to happen during product usage in combination with making scenarios that can help identify risks for surprises, risks of too low quality, premature visual and technical wear, and dimensioning can be identified early in the design process. Here, benchmarking could be done with products known to be durable with a long useful life, from various product categories.

Alternative materials for vehicles like composites, stainless steel, ceramics, and aluminum are alternatives has been in many applications e.g. in the aerospace industry with old composites airplanes still in the air for many years, or in plastic boats still in use since the sixties. Another option is ceramic bearings that can reduce rolling resistance with 50-70% and that can last 4-8 times longer than steel bearings (Danish energy analysis, 2013) However, many manufacturers still consider materials like ceramics and composites as too expensive and difficult to use.
An exception is BMW that with its model I3 has demonstrated that carbon fiber is possible to use in a mass production car, but it has taken great efforts in building new production facilities, training and new ways to design components. Even though carbon fiber composite does not corrode as fast as steel, they could degenerate due to sunlight and get internally damaged due to accidents during the use phase.

Alternative materials to low-quality steel are needed if a long lifetime shall be possible to predict. More expensive materials and dimensions could save money in the end. This has been shown in a remanufacturing study where the increased thickness of the goods in a cylinder head can make it possible to remanufacture the engine several times.
Modularization has been considered as a strong enabler for adaptivity, if giving possibilities to change a product at a lower cost. But modularization is not always cost effective because it also drives costs (for example, interface, weight, size, increased error risk, etc.). However, at some point, additional modularization costs will exceed the value of the market for future upgrades. By building on financial market principles for economic option values, modularization costs can be weighted against costs for aesthetical to social upgradeability, thus future adaptivity can be considered as an economic option and an optimized "architecture adaptability value (AAV)" as developed by Engel, et al. (2017: 875) where cost for various grades of adaptivity can be calculated and included in the business modeling at an early stage.
Notes on Basic principles for future adaptable design (FAD)

✓ Products can become obsolete by aesthetical, technical, functional and social reasons.
✓ Premature obsolescence creates a value gap between the expected value by owner and the actual lifetime.
✓ The future consist of things that are known or likely to happened, and surprises.
✓ Designers can only design a potential for extended product lifetime, whereas a future adaptable design aims at make a product survive through time by consider possible surprises.
✓ Durability and flexibility are two basic features of an adaptable product, being either specific or general adaptable.
✓ We propose four FAD principles that can enable longevity: (1) Multi-layered modularity, (2) Future open modularity, (3) Cascading customer loops and (4) Financial grounded adaptability.
✓ These four FAD principles, combined with the four drivers for obsolescence, will form a (morphologic) matrix of 4x4 intersection points, that can be explored for possible barriers and possibilities for a future adaptable product concept.
The potential for eco-sustainability by future adaptable products
In principle, eco-effective life extension is facilitated by FAD because a traditional vehicle often degrades (both relative to itself and contemporaries) over time while an FA vehicle is upgraded.
As stated earlier, future adaptability can extend product lifetime and thus can reduce business risk for firms that sell product function or availability instead of the products themselves. When it comes to environmental impacts, extending a product's life is, in principle, a good thing. However, this is not always true. There are a few factors that determine environmental viability of extending product life.

How can one assess the eco-effectiveness of life extension? How does FAD facilitate this? These questions are answered here.

Note: The relationship provided here is simplified. For example, the end-of-use outcome of the products can be also included. In many cases, the New outcome could count a credit for recycling or energy recovery reducing its environmental impact. Likewise, the Adapted outcome could result in credit for components or modules recycled or reused in another application, something that FAD could also facilitate.
How can one assess the eco-effectiveness of life extension? How does FAD facilitate this? These questions are answered here.

Note: The relationship provided here is simplified. For example, the end-of-use outcome of the products can be also included. In many cases, the New outcome could count a credit for recycling or energy recovery reducing its environmental impact. Likewise, the Adapted outcome could result in credit for components or modules recycled or reused in another application, something that FAD could also facilitate.
What is the relevance of this example?

While this example (of the E-type), is arguably focused on a small niche market and is possibly not replacing other vehicle purchases, it represents an instance in which adaptability (even without planned FA design) is achieving energy and GHG reductions for that vehicle’s life cycle (in comparison to if the vehicle were to continue to be run with an internal combustion engine).

A comparable vehicle designed with FA principles would hypothetically facilitate cost-effective upgrades like the one exemplified here and possibly offer a more economic alternative to replacing a vehicle with an electric vehicle (while achieving a comparable environmental impact outcome). Such a path could contribute to electrification of the world’s fleet, which could lag in some regions that may receive second-hand vehicles from Western European markets and where economic constraints may hamper electrification. This is important since globally, electric vehicles (EVs) represent less than 0.5% of the total passenger vehicle fleet but should reach 10% by 2030 and 60% by 2060 if the 2-degree goal of the Paris Agreement is to be met (IEA 2017). Considering this ambition, meeting these goals require many paths to electrification.
Since GHGs emitted during use and fuel production can be between 2 and 15 times as much as for an electric vehicle (depending on electricity mix used to charge the battery), retrofitting a traditional vehicle with an electric drivetrain can make a big difference. As seen below, two outcomes of doubling the life of a traditional vehicle, keeping combustion engine vs. electrifying (US electricity mix).
Conclusions & summary
Today's approaches to minimize environmental impacts by eco-efficiency is insufficient to meet sustainability challenges.

A circular economy could in its purest form be seen as a vision of an economic system without waste that runs on renewable energy and has been proposed as a way for the industry to profitable go green.

A circular business logic of preserving added value and reducing operating costs for a stock of products and services leads to a logic to increase resource productivity. ....

That drives ....

... a circular design logic, where products used being optimized for preserving embedded values by reuse, upgrades remanufacturing and recovery of materials reduces business risk that results in

... A potential for improved resource efficiency by reduced Co2E, less energy use during product usage phases, Improved material and water health, less chemical use and better control of critical materials embedded in products used.
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Today there is a growing body of knowledge regarding CE with a vast amount of definitions (ref), frameworks for implementation, methods, and tools for circular design and product development, as well as established practices in the industry. All put together, this can be seen as islands of knowledge and excellence applicable for developing products suitable for “effectuation” of circular business models. However, in most examples and research areas, the main focus has been on approaching CE with an eco-efficiency approach as more efficient production, or use, and not from the CE perspective of extending product life. Available methods and tools, e.g., for adaptable design also have a theoretical and technical focus, lacking alignment between business and design logic, making them difficult to use for practitioners within business and design. This companion has hopefully contributed to nuance the discourses about a Circular Economy, in highlighting the role of the dominant business logic and how different approaches to circular design will challenge Business Model innovation by either incremental or radically changes to the current linear one.
This scenario includes possible features and functionality as:

- Tires re-treaded 3 times, with updated rolling resistance before being exchanged.
- Body structure and panel with integrated sensors for health detection.
- Batteries exchanged to 50% lighter and more efficient battery pack 2026 & 2036.
- The Aluminium frame is original from 2020.
- Range extender, upgraded from ICE to fuel cell 2019. Fuel cell remanufactured in 2031.
- Infotainment system display updated 2025.
- Updated for wireless and electric road charging 2022.
- Material embedded sensors added for predictive information of body in 2020.
- Carbon fiber body repaired for minor damage, 2018.
- The steering wheel is vintage and from a BMW M1, 1972.
- New, 30% lighter body with thermoplastic & lignin-based carbon fiber in 2026.
- Communication unit exchanged 2025, 2030, 2035.
- Suspension updated with new sensors and functionality 2026.
- Improved user experiences by Co-creation with car owners, where services are added for stronger customer/product attachments.
- Seats remanufactured 2030. With new retro design upholstery.
• A “regenerative” functionality is included in the customer offering. The owner & OEM has during 20 years invested in and produced renewable energy. Where revenues from energy production reduce running costs and are invested in a maintenance fund for the owner, creating incentives to keep the vehicle relevant over time.
How to get started!
Just prepare it,

Establish a commitment from top management to explore the possibilities for circular business models in your firm.

Put together a cross-functional team of business developers, designers and other relevant functions as from environmental affairs.

Define the goal

- Define a vision based on a stock-based circular business model based on business and design strategies for closing, narrowing and slowing down resource flows.

Compare with today

- What is the current baseline in your firm regarding circular activities?
- What is the major gap between a circular vision and today’s baseline?
Starting the Circular Business Modeling Innovation Process

- Start with the vision and the identified gap between today's activities that can be considered to be circular.
- Investigate if some existing products & components could be suitable to use in the CBM, as they are or with minor modifications.
- Design an initial value proposition in the form of a system of products and services considering possible customer segments and their needs, pains and gains.
- Do small-scale market experiments at a high pace to learn about the potential customer's interest in the circular value proposition.
- Design a business model based on existing products based on existing knowledge of longevity, maintenance costs, willingness to pay etc. and continue market tests.
- Consider and make a hypothesis about factors that might make the existing products obsolete by aesthetical, technical, functional and social reasons and estimate the economic consequences of these risks are realized.
- Make a hypothesis about potential customers for the various modules in a sequence of usage scenarios over the complete lifecycle.
- Estimate costs for realizing scenarios of future open modularity with cascading customer loops.
- By using the lean startup approach work in small steps of continuous market experimentation.
Just do it
Start the circular business modeling, by analyze the existing products and plan for redesigns

- Based on the vision and identified gap, identify required functions that provide the intended outcomes of the CBM
- Design a conceptual system of physical products and services with product architecture based on individual modules (not a product) being separable in inter-connected layers
- Consider and plan for different life-lengths of these modules over time
- Make scenarios for how modules can be designed to avoid premature obsolescence (identified in Business Modeling)
- Search for possibilities where services can prolong the longevity of physical products and minimize resource usage by adding customer value without needing upgrades or new products
- Make a hypothesis about potential customers for the various modules in a sequence of usage scenarios over the complete lifecycle
- Estimate cost for realizing scenarios of future product adaptivity with cascading customer loops
- Compare the product service concept with the vision to identify such deviations that risk to lead away from circularity. (see check questions page 75)
- If the PSS concept developed has deviated from the vision, iterate back and make adjustments in service content, product features and the building blocks of the business model until aligned to the vision
- If the PSS concept aligns with the set vision continue with market experimentation with minimum viable prototypes of the adaptable product service system, and continue with making an action plan for implementation
Ask yourself:

- Do you know (roughly) which existing products in the portfolio that are durable and adaptable?
- Do you know how durable components are and how durability can be managed over time?
- Is there a modular design, that is open for upgrades with new functions or aesthetics?
- What are the risks for modules and the overall product becoming premature obsolete?
- Have the risks for premature obsolescence been addressed in the PSS concept?
- Do you know what customers that might be interested in buying function or performance in a CBM?
- Will there be a business case for using existing products in a stocked based Business Model and PSS?
- Will customers be satisfied with planned for upgrades?
- Is there a plan for cascading customer segments that can prolong the usage time of products without needs for upgrades and remanufacturing?
- Would the PSS still be competitive without a yearly facelift of products used?
- How expensive is the physical products in the PSS to maintain and upgrade?
- Is it expensive or to repair, and are spare parts expensive or not existing?
- Are bio-based and “technical” materials in the product separated?
- Is material used safe for the users and the environment, if leakage occur?
- Is the concept based on recycled ingredients and possible to recover after usage?
- Is it using renewable energy for production and usage?
- Will the cost for the PSS be met by customers willing to pay in the hypothetical value proposition?

Just check it,

Does your existing products used in a CBM lead to the vision of a stock based business model that results in high resource productivity?
Just check it,
Does your redesigned or new developed adaptable products in a PSS lead to the vision of a stock-based business model that results in high resource productivity?

- Ask yourself
- Do you know existing products in the portfolio that are durable and adaptable?
- Do you know how what durability that are needed?
- What are the risks for modules and the overall product becoming premature obsolete?
- Have the risks for premature obsolescence been addressed in the adaptable product concept by a design that can resist visual and technical wear over the planned for usage time?
- Is there a modular design, that is open for upgraded with new functions or aesthetics?
- Is there a scenario for the overall product lifecycle divided into several usage phases?
- Is there a scenario for maintenance, overhauls and upgrade activities over time?
- Is there a plan for cascading customer segments that prolong the usage time of products without needs for upgrades and remanufacturing?
- How expensive will the adaptive product concept become with the desired grade of future open modularity?
- Is the product designed for maintenance, repair, upgradability, remanufacturability, and recyclability, that is
- Are access to spare parts planned for over the intended lifecycle?
- Are bio-based and "technical" materials in the product separated?
- Is material used safe for the users and the environment, if leakage occur?
- Is the concept based on recycled ingredients and possible to recover after usage?
- Is it using renewable energy for production and usage?
- Will the cost for the PSS be met by customers willing to pay in the hypothetical value proposition?
Ask yourself

- What business hypothesis and PSS concepts shall we use to move forward to implement into further market experiments?
- Are these concept(s) leading in the desired direction towards the vision?
- Is this concept(s) a flexible platform, i.e. how costly is there to change the path if we proved to be wrong about customer acceptance?
- What is the return on needed investments for developing new products and keeping produced one in the stock?
- What are indicators for measure progress and deviations for reaching the vision?
- What are the main barriers for reaching the vision?
- What organizational barriers need to be overcome?
- Is there a time plan for stepwise implementation
Some supportive tools with suggested further reading
Methods and tools underpinning the CBMI and FAD frameworks

- Principles for a circular economy
- Design as a change process
- Backcasting
- Lean start-up methodology
- Business model innovation
- Adaptable design

Tools to further support detailed development of adaptable products & services

- Design for X
- NPD methodologies
- Circular design
- Design for PSS
Design for future adaptable products will most certainly challenge designers, engineers and business developers, not only to identify today’s users’ needs, but also to broaden imagination about future needs that can make the product obsolete and thus increase business risks for the product owner in a circular business model. By using the FAD framework, the NPD process will become much more complex, and potentially much more costly due to that. However, nothing is hindering the use of e.g. agile NPD tools – on the contrary. And design-for-X tools are encouraged since considerations such as disassembly, remanufacturing, repair, upgrades etc. are at the core of FAD. Each of this set of enablers in the framework represent fields of knowledge that in many cases are well-developed regarding methods and tools as e.g. within the Design for x (DFX), that is an umbrella term that comprises many design philosophies and practices (Gatenby, & Foo, 1990) as well methodologies with the aim to help of raise designers’ awareness of the characteristics that are most important in the finished product as for example quality, modularization, assembly, disassembly, manufacturability, reliability, environment etc. Hashemian (2004 p.4) describe DFX as a design paradigm, being a theoretical framework for design activities, including rules, guidelines, specific procedures and software tools.
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<td>See for example <a href="https://www.bizonline.com/story/10-10906/1591045.2016-1172124">Boxen et al., 2016</a></td>
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<td>Future adoptability for more energy-efficient Mobility the study report</td>
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<td>Circular Design</td>
<td>The circular design guide from [IMMEX](<a href="http://www.immex">http://www.immex</a> latinoamerica.com)</td>
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<td>Design as a change process</td>
<td>SBDI Swedish Industrial Design Foundation</td>
<td><a href="http://www.svd.se/en">http://www.svd.se/en</a></td>
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The Pearl Harbor model of change

“In his State of the Union address on January 6, 1942, one month after the bombing of Pearl Harbor, President Franklin D. Roosevelt announced the country’s arms production goals. Public skepticism was widespread. But Roosevelt and his colleagues realized that the world’s largest concentration of industrial power at that time was in the U.S. automobile industry.

Roosevelt met with auto industry leaders and told them that the country would rely heavily on them to reach these arms production goals.

Initially they wanted to continue making cars and simply add on the production of armaments.
What they did not yet know was that the sale of new cars would soon be banned.

From early February 1942 through the end of 1944, nearly three years, essentially no cars were produced in the Unit-ed States. (Brown, 2009 p. 260)
Acknowledgments

This guide is a result of the research project Future-adaptability for more energy efficient vehicles, carried out at RISE Viktoria within the research group Sustainable Business between 2016-2018.

The authors would like to thank the participating organizations, companies, and individuals, for participation and valuable support during this research study:

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More information available at: www.viktoria.se/application-areas/sustainable-business
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Thank you for reading to this last page

We hope you found this companion worthwhile. (Take it with you)

Please feel free to contact us on any matter related to circular business models and adpatable design

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