

BUSINESS EVOLUTION

Emerging Approaches in Business Model Innovation Relevant to Sustainability and Low-carbon Transitions

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carbon up

carbon down



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Executive Summary

- Businesses are among the most critical actors for achieving greater sustainability and the transition to a low carbon built environment. Business and related activities within the production–consumption system are among the primary causes of sustainability problems. But businesses are also a core source of innovative ideas, not only in reducing pollution and improving the efficiency of our products and production processes, but also in the shaping of ongoing fundamental structural changes in our socio-technical systems.
- The aim of this report is to provide a review of new and emerging approaches used in developing new business models, which might assist in realising and diffusing the technological, social and organisational innovations necessary for sustainability and low-carbon transitions. We also explore some of the limitations of the current conceptualisation of business models and suggest new areas of refinement for these tools to help overcome some of the narrowness of current sustainable business model thinking.
- Business models consist of several components, which together establish the conceptual architecture of businesses. Although these components are referred to using a variety of terms in the literature, fundamentally, business models need to articulate value proposition, target customer, distribution channels, customer relationships, arrangement of activities and resources, core competencies, partner network, cost structure and revenue model. Any novel approach used to develop and/or connect one or more of these components can be defined as business model innovation.
- This report presents nine different approaches used in developing business models that are relevant for creating greater sustainability. These are:
 - Product service systems: where the consumer pays for the services provided by a product rather than buying the product itself. Companies therefore take responsibility for the lifecycle of product, including repair, replacement and disposal.
 - Open innovation: where a company cooperates with other organisations, groups of people or individuals to generate new ideas and commercialise them. Such collaboration is particularly appropriate for dealing with the complex interdependencies that characterise the transition to a more sustainable built environment.
 - Peer-to-peer innovation: innovation rising from cooperation of loosely connected, widely distributed individuals (i.e. peer-to-peer networks) through sharing open-source resources and distributed production capabilities.
 - Closed-loop production: where materials used to create a product are recycled through the production process. It is often characterised as ‘cradle to cradle’ production or ‘industrial symbiosis’.
 - Crowdfunding: a new source of funding for niche innovation, as well as to attract social media attention. It frequently taps into social and community development concerns.
 - Sharing economy: where participatory sharing schemes allow access to resources when needed, enabling a more efficient use of resources that might otherwise sit idle.
 - Social enterprises and benefit corporations: where companies, through participation in certification schemes or under new corporate forms, become legally obliged to pursue social and environmental value in addition to financial (shareholder) value.
 - Gift economy: uses voluntary donations, such as ‘pay as you feel’, and taps into concerns for social sustainability.
 - New manufacturing paradigm: powered by new capabilities associated with additive manufacturing (i.e. 3-D printing), business models that aim to generate greater efficiency in production, enable rapid prototyping, therefore enable faster development and diffusion of new offerings and support peer-to-peer innovation (i.e. makers movement).
- To more systematically explore the qualities and principles that underlie these different sustainable business models, we refer to two recent frameworks that provide some useful insights:
 - Boons and Lüdeke-Freund (2013) identify four fundamental parts of a generic business model, each of which can be a source of greater sustainability: (i) providing a value proposition with measurable and balanced ecological, sociological and economic value, (ii) adopting a more sustainable supply chain, (iii) developing a customer interface that motivates customers to take responsibility for their consumption, and (iv) using a financial model that reflects the appropriate distribution of costs and benefits among actors involved and should account for ecological and social impacts.
 - Wells (2013) identifies six major principles that underpin business models for sustainability: resource efficiency, social relevance, localisation and engagement, longevity, ethical sourcing and work enrichment.
- Given that sustainability issues are complex and cut across several economic, social and natural systems, it is difficult to assess the sustainability of any business model against the above qualities and principles without considering the properties of the wider system within which the new business will be positioned. Accordingly, incorporation of structural and cultural considerations into sustainable business models may be suggested, as well as encouraging companies to take active roles by collaborating with key stakeholders in building more sustainable capabilities within the systems they are part of.
- Refinement of the current conceptualisation of sustainable business models may also be required, as business modelling may be useful for any enterprise offering a sustainable product or service, regardless of whether it is a for-profit business or not.

1. Introduction

In facing the challenge of creating a more sustainable built environment, business plays a double faceted role. On the one hand, business and related activities are at the centre of the production–consumption system that is the major cause of our sustainability problems. On the other hand, the dynamism of modern business and its ability to innovate and generate solutions to current and emerging problems, including those related to sustainability, promises to be one of the primary sources of new ideas and strategies to tackle the sustainability challenges we face.

The changes required of business will be more than incremental process and product innovations. Over the last two decades this focus of sustainability innovation has certainly brought us cleaner and more efficient products and services. However, we also need to make fundamental changes to our business models – and the systems that support them – if we are to meet our current and future sustainability challenges (Gaziulusoy, Boyle & McDowall 2013; Ryan 2013a; Tukker & Tischner 2006; Whiteman, Walker & Perego 2013). Business models have been described as the ‘fundamental structures for how companies create, deliver and capture value’ (Osterwalder & Pigneur 2010); innovation does not necessarily require a new technological product or process, but rather can involve changing aspects (or the entirety) of a value structure around an offering. As the examples in this report will illustrate, such changes can sometimes catalyse broader systems change. Disruptive transformations have occurred in various sectors with the introduction of new business models over the past decades in areas such as retail music, news media and shopping. These highlight the potential risks to business leaders in being complacent about their current business model, which can leave them exposed to new competition and markets.

The aim of this report is two-fold. First, we provide a review of some emerging approaches that influence the development of new business models. This might assist in the conceptualisation, realisation and diffusion of technological, social and organisational

innovations necessary for sustainability and low-carbon transitions in the built environment, and includes looking at some interesting illustrative examples. Secondly, we explore some of the limitations in the way that existing literature on business models is conceptualised and suggest areas for future research.

The concept of a ‘business model’ is a contested one and its application to sustainable development is even more recent. There is, as yet, no consensus framework for business model analysis and the examples of novel business models given in this paper come with insufficient analysis about the likelihood of their future success. However, the concepts we discuss here, and real-world examples provided, can hopefully offer tools and inspiration to think differently about the way we do things in even the most mundane and apparently settled practices and activities.

The outline of this paper is as follows. Section 2 develops the discussion of the emergence of new dynamics for business in response to sustainability challenges. In section 3 we overview some of the new and emerging approaches used in developing business models relevant for sustainability and low carbon transitions. In section 4, we briefly discuss theory on sustainable business models and suggest areas for future research.

2. Emergence of new dynamics for business

Sustainability is recognised as a key driver for innovation in companies (Nidumolu, Prahalad & Rangaswami 2009). The idea that businesses can gain strategic advantage through innovation that aims to address sustainability issues is not new. Michael Porter and Claas van der Linde argued in the mid-1990s that properly designed, stringent environmental regulation would influence and facilitate innovation in companies (Porter & van der Linde 1995). This argument has been supported by a body of empirical research (e.g. Greenstone 2003; Taylor, Rubin & Hounshell 2005). Some of the influences that cause business to shift towards more sustainable practices include regulation and standards, resource limitations, a desire to be a market leader, customer pressure, shareholder and employee pressure, and wider stakeholder pressure such as supply chain actors (e.g. Anton, Deltas, & Khanna 2004; Brown & Wahlers 1998; Charter et al. 2008; González-Benito & González-Benito 2006; Hart 1995; Henriques & Sadosky; 1996; Orsato 2009; Wheale & Hinton 2007).

Business response to sustainability issues has been described using a 'three wave' typology (Dunphy, Griffiths & Benn 2007). According to this, the initial step is mostly forced upon companies by legislation. Therefore, the earliest form of response by companies is a practice of risk management to avoid consequences of non-compliance. In the meantime, they also realise cost-reduction opportunities through process efficiency measures.

The second wave in the typology covers those businesses that realise addressing sustainability issues is a strategic requirement and an opportunity for these companies become aware of the longer-term implications of ever-exacerbating environmental and social problems. Orsato (2009) argued that there is a need to distinguish between competitive advantage based on organisational processes and products/services. He articulated that in addition to strategies focusing on gaining competitive advantage in existing markets (e.g. through eco-efficiency,

beyond-compliance leadership, eco-branding and so on), another approach to strategic management is sustainable value innovation. Sustainable value innovation focuses on the creation of new markets through business model innovation – developing and implementing a unique value proposition that allows companies to reduce both economic costs and environmental impacts, while generating value for customers and for the society as a whole. This portfolio of corporate environmental strategies is referred to as 'win-win' due to the potential of increased environmental protection and profit.

Although 'win-win' strategies are promising in theory, suggesting superior environmental performance can be achieved without any reduction in quality or increase in price, limitations became clear from a wave of product eco-innovation in the 1990s. These problems have been identified by Ryan (2013b) as:

1. Impact reductions in first round of innovation are mostly achieved as a result of eliminating 'bad-design', such as highly toxic materials, which should not have been in the products in the first place, or inefficiencies which could easily be corrected. This means that further improvements (in later product innovations) are marginal;
2. Increased overall consumption has outpaced product efficiency improvements;
3. Improved efficiency and decreased impact often results in 'rebound effects', where improvement in efficiency of products lead to increased spending/consumption in another area (possibly with greater environmental impact).

The third wave of business response to sustainability issues, as the ultimate level of business response in the typology of Dunphy et al. (2007), 'reinterprets the nature of the corporation to an integral self-renewing element of the whole society and its ecological context' (p. 17). In this conceptualisation, business strategies are carried beyond 'win-win' to another level, which advocates putting an emphasis on systems, encouraging companies to see themselves as part of a greater whole

(ecosystems and a social fabric) and acknowledge the limits of a finite planet (e.g. Hawken, Lovins & Lovins 1999; Holmberg, Robèrt & Eriksson 1996).

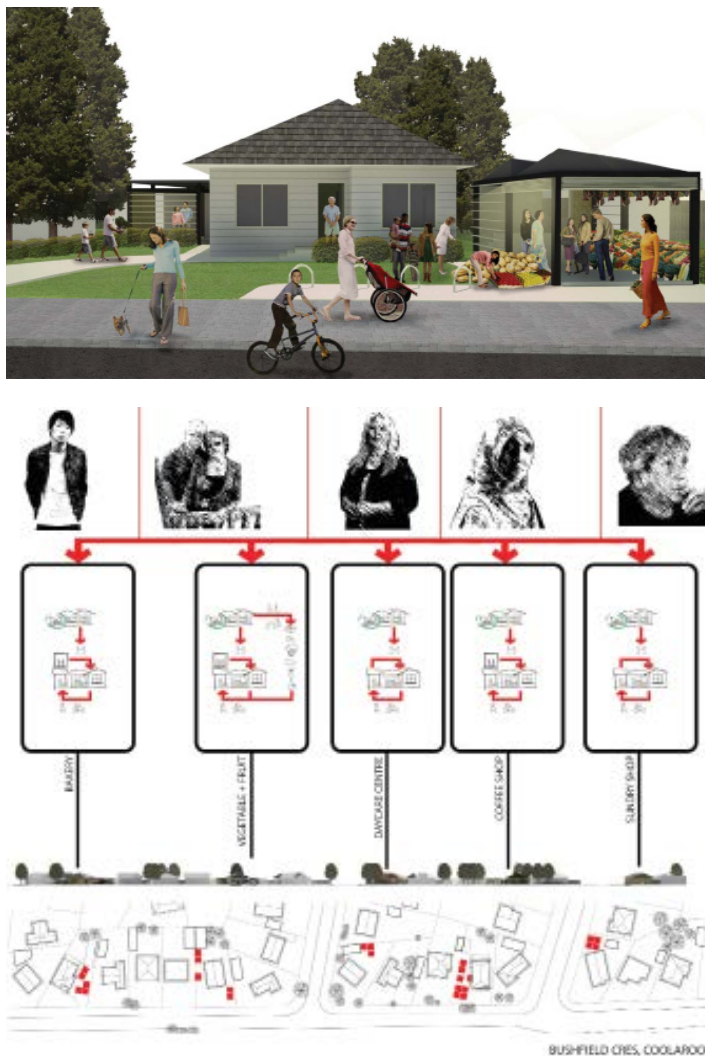
Of course, in order for the third wave to be realised there is a need for fundamental societal change. Our current Western worldview is still dominated by a belief that the ecosphere is there to serve the needs of humankind, with an almost infinite ability to provide resources and absorb waste. Therefore, our relationship with the ecosphere is utilitarian and exploitative. However, while our physical, psychological and economic wellbeing depends on the availability of the services and resources provided by the ecosphere, the ecosphere is not dependent on us. Therefore, the required societal change calls for reinterpretation of the nature of the relationship between society and the ecosphere and the creation of new technological, organisational and social systems that operate in alignment with the limits, processes and structural requirements of the ecosphere. In other words, the current Western worldview needs to be transformed for the third wave of business to be observed at large scale. This is a significant level of change which cannot be achieved in the short term.

Nevertheless, there are signs of change emerging in all levels of the society, including business. In fact, in the past ten years there has been an observable change in the response of business to sustainability and climate change issues. For example, the World Business Council for Sustainable Development (WBCSD), an organisation established and led by its corporate leader members, has a declared aim of galvanising the global business community to create a sustainable future. WBCSD initially promoted product innovation and efficiency as a strategy to address environmental problems (WBCSD 2000). Later, it adopted a more sophisticated perspective acknowledging that sustainability risks are systemic mega-risks that pose unprecedented challenges to companies and government alike (WBCSD 2004). In 2010, the WBCSD proposed a vision for 2050 and a pathway emphasising the need for a new agenda

for business and system innovation and transformation, with a warning that the window of opportunity might be closing (WBCSD 2010).

Other organisations that help business in their sustainability journey have also changed tack. One example of this is Forum for the Future, a UK not-for-profit organisation founded in 1996. It has worked with global brands such as Aviva, Unilever, 3M, Nike, Sainsbury's, Levi Strauss and AkzoNobel, and expanded internationally to cover the United States, Singapore and India. In 2011, Forum for the Future launched its system innovation initiative, branded as 'theBIGshift' campaign as an overarching framework for the Forum's work. Within this initiative, Forum for the Future works with business leaders who acknowledge the inadequacy of incremental change and the need for systems transformation (Forum for the Future 2014).

These changing dynamics in the business environment create a market risk for companies that do not develop strategies for aligning themselves with new systems approaches that could address critical environmental challenges, such as depleting resources, ecological thresholds, changing climatic, economic and demographic conditions (Gaziulusoy et al. 2013; Loorbach & Wijsman 2013; Rockström et al. 2009; Whiteman et al. 2013).



Neighbourhood Micro-Businesses. Image © Yee Hui Xuan, VEIL, 2010.

3. An overview of new and emerging business models relevant for sustainability and low-carbon transitions

There is a lack of an established definition for what makes a sustainable business. This creates a real challenge for identifying specific business models as sustainable or not. In addition, business models are highly contextual; they are unique to the core capabilities of the organisations that create them and respond to particular strategic opportunities within a specific market. This implies a difficulty in identifying generic business models that are readily applicable to other organisations, even within the same sectors. In Box 1 we present an overview of emerging approaches used in business model innovation, referred to in literature and currently implemented in practice as 'promising' approaches from a sustainability point of view.

In our research, we identified nine emerging approaches used in developing business models that are relevant to sustainability and low-carbon transitions. These nine approaches are product-service systems, open innovation, peer-to-peer innovation, closed-loop production, crowdfunding, sharing economy, social enterprises and benefit corporations, gift economy, and business models enabled by the emerging manufacturing paradigm. Among these approaches, product-service systems (PSS), open innovation and approaches that emphasise circular flows have been discussed in the literature in terms of their relevance for achieving sustainability. There is only a limited body of knowledge on the relevance of other approaches to sustainable business and innovation as these have emerged or begun to be used more commonly in the past few years. They include crowdfunding, shared consumption of assets and other approaches based on heterodox economics, such as the gift economy. The emerging manufacturing paradigm, which is based on additive manufacturing, or 3-D printing, has been of interest to governments and businesses alike as it is accepted to be game-changing, with major economic, environmental and social implications.

Box 1 – What is a business model?

A business model can be described as the logic and architecture of economic and societal value creation and value capture that allows a firm to attain a competitive advantage and/or to create a new market (Rohrbeck, Konnertz & Knab, 2013).

Six distinct roles are fulfilled by business models (Baden-Fuller & Morgan 2010; Boons & Lüdeke-Freund 2013; Lehmann-Ortega & Schoettl 2005; Osterwalder et al. 2005). These are:

1. understanding and sharing of business logic as objects of communication
2. assisting in improving, measuring, observing, and comparing the business logic of a company as units of analysis
3. improving the management of the business logic of the firm as blueprints of overall company strategy
4. describing the possible futures for a company as tools for simulation and visioning
5. generating intellectual property for the company as objects which are patentable (in some sectors such as e-commerce)
6. providing competitive advantage by changing the terms of competition as subjects of innovation.

Business models consist of several components, which together establish the conceptual architecture of businesses. Although these components are referred to using a variety of terms in the literature, fundamentally business models need to articulate value proposition, target customer, distribution channels, customer relationships, arrangement of activities and resources, core competencies, partner network, cost structure and revenue model (Morris, Schindehutte & Allen 2005; Osterwalder et al. 2005). Osterwalder et al. (2005) identify four pillars of business models that should be addressed by articulation of these components. These are product (i.e. offering), customer interface, infrastructure management and financial aspects. Casadeus-Masanell and Ricart (2010), on the other hand, identify three core parameters through which business models should be understood: policies (i.e. operational attitudes of the company), assets (i.e. what is done within the company and what is outsourced) and governance (i.e. nature of relationships of the company in value creation).

These approaches are generally used in combination with one another to develop new business models that are innovative and relevant to sustainability and low-carbon transitions in the following ways:

1. Designing products, services and associated industrial and organisational processes as whole systems, thus potentially reducing the overall impact of the production-consumption system.
2. Financing niche innovations and start-up companies in ways alternative to venture capitalism, thus overcoming financial barriers to development and market entry.

3. Introducing new models of social, structural and legal organisation across innovation networks, thus enabling knowledge sharing and accelerating the pace of innovation.
4. Experimenting with new models of economic exchange, thus enabling institutional change and societal reflection on the role, purpose and meaning of business.
5. Promoting adoption and use of new technologies thus facilitating development and widespread diffusion of new technological and organisational capabilities.

3.1 Product-service systems (PSS)

PSS have been discussed in the literature on design and innovation for sustainability as a promising approach for sustainability for more than a decade. A product-service system is a set of products and services capable of jointly fulfilling a user's need (Goedkoop et al. 1999; Mont 2000). PSS can help companies to expand their role in the market to better coordinate and control the mix of products and services to meet needs of people while lowering overall environmental and social impact (Tischner, Ryan & Vezzoli 2009). Tukker (2004) identifies eight archetypal PSS categories:

1. Product-related service,
2. Advice and consultancy,
3. Product lease,
4. Product renting or sharing,
5. Product pooling,
6. Activity management/outsourcing,
7. Pay per service unit,
8. Provision of functional results.

Tischner et al. (2009) identify five starting points for companies to deliver PSS:

1. Adding services to a product – Typical examples include adding repair, maintenance, user advice/education services, refurbishment and extending the functional range of products;
2. Providing 'the use of a product' for the customer – Typical examples include hiring, renting and leasing of products such as cars, washing machines and furniture, renting fully-equipped shared office space;
3. Facilitating the shared use of products – Typical examples include platforms enabling shared use of products such as cars, tools and bicycles (also see Section 3.5);
4. Delivering 'functional results' to a customer – Typical examples include selling 'thermal comfort' instead of heating/cooling equipment, a 'guaranteed minimum percentage of yield' instead of pesticides, or copied documents instead of photocopiers;
5. Replacing products with information services – Typical examples include online booking or payment systems, digital music and electronic books.

to different models of businesses or stakeholder collaboration (Keskin, Brezet & Diehl 2009; Van der Zwan & Bhamra 2003; Williams 2007). Therefore, development of functional PSS might influence mindset change in companies.

However, even though PSS corresponds to a shift from product focus to service/system focus (Brezet 1997), there are few studies considering PSS in the context of system level innovation (e.g. see Ceschin 2012; Keskin et al. 2009). A critical issue about successful implementation of functional PSS is the need to address the symbolic meaning of products, mostly neglected in the mainstream PSS literature. Scholl (2008) highlights that through a symbolic (as opposed to a functional) perspective of PSS, it is revealed that shifting from ownership to usership requires far-reaching change in current consumption patterns. Therefore, the potential innovation and implementation success will depend on the availability of institutional and organisational incentives, as well as the development of strategies to recover symbolic meaning that is lost as a result of giving up ownership.

These five starting points are not mutually exclusive ways of offering PSS, and are often combined in business models. Three examples of PSS are given in Box 2.

While all PSS represents a shift from product focus to system focus, only those based on delivering functional results to customers are promising in terms of shifting socio-technical systems, while the rest generate only marginal sustainability benefits (Tukker 2004). In functional PSS, the PSS provider promises to deliver a particular 'outcome' or meet a 'function', as shown in Box 2. Functional PSS is also referred to as function (or functional) innovation in eco-design terminology (Brezet 1997; Halila & Hörte 2006). Functional PSS applications not only challenge existing product concepts and consumption patterns through alternative ways of function fulfilment, but also give way



Paris bike share stand. Photo by [mariordo59](#) via Flickr [CC BY-SA 2.0](#)

Box 2 – Examples of Product-Service Systems (PSS)

SolarCity – Solar leasing

The major barrier to adopting solar energy solutions for homeowners, as well as businesses, is the associated high upfront cost of solar panels. Solar leasing business models aim to address this barrier by distributing the upfront cost across many years through long-term service contracts. SolarCity is one such company, which is distinguished by an integrated delivery of service that includes the design, finance and installation of solar energy systems (SolarCity Company Profile 2014). The company was founded in 2006 and in 2013 was the second top solar installation company in the United States (Solar Power World 2014). SolarCity provides an example of how business model innovation can actually be the determining factor in achieving success. While many solar panel manufacturers in the United States went bankrupt when prices dropped significantly due to cheap imports from Asia, SolarCity used existing technology within an innovative business model to overcome the major adoption barrier of upfront costs. SolarCity provides performance guarantee for the systems installed, assuring customers save money with the aid of their monitoring systems which generate data on how similar systems perform (Bullis 2012). Although currently a successful example of product-service system, due to reliance on governmental subsidies and finance from external funders, the future of SolarCity is not certain and depends on institutional change to take place so that the sector becomes self-sufficient.

Vector SunGenie – Distributed energy services

In New Zealand, Vector Limited, an electricity network operator, is trialling an innovative energy distribution business model that may challenge the traditional remote generation and transmission model employed by utilities for over a century. Their SunGenie service bundles rooftop solar PV, battery storage and smart controls into one package for households that can be leased on a fixed-price monthly basis. By selling a service through leasing contracts, the customer avoids the relatively high upfront investment cost of the system and the burden of owning the systems themselves, while having more active management of their energy generation and usage.

The business model has arisen from the emergence of new electricity generation and demand management technologies that signal a move towards a more decentralised energy generation paradigm. In this new world, as Vector CEO Simon MacKenzie argues, 'it's not a case anymore of distribution companies bringing energy from central generation sources to homes; the generation sources are at the home, so the whole architecture and business models, the thinking for distribution companies, need to change in order to recognise the fact that their role has shifted significantly' (La Valle 2013).

Flexicar – An access-based mobility solution

Flexicar is a car-sharing system operating in Melbourne's inner suburbs. The company was established in 2004 by a group of university friends as a start-up with the vision of providing an alternative to car ownership (Flexicar 2014). Flexicar is a membership-based, use-oriented product-service system; the members of the system pay for the amount of car use by the hour through monthly bills. Currently Flexicar has around 200 cars, each parked in a dedicated parking space from which the user takes and leaves the car. Bookings are managed via a website and once booked, users access the car using a swipe card sent to them after they join. Flexicar has received several business and environmental awards and was purchased by Hertz car rental in 2010.

Flexicar has borrowed its business model from its counterpart in the United States, Zipcar. The origins of car sharing date back 20 years when the first systems were offered in Europe (Katzev 2003). Car sharing was first analysed in the Netherlands by Meijkamp (1999). In the last decade it has become a popular alternative to car ownership and has demonstrated considerable growth. In 2009, in the United States revenue from car-sharing systems was US\$253 million and is forecast to rise to US\$3.3 billion in 2016 (Florida 2011). Although access-based consumption has been perceived as inferior historically, the politics of consumption are changing and companies are finding ways to monetise this pervasive phenomenon (Bardhi & Eckhardt 2012).

3.2 Open innovation

The traditional 'closed' approach to innovation has been a model of strong self-reliance by companies in carrying out R&D, generating ideas, making investment decisions, developing, financing and marketing new products/services/technologies through systems of intellectual property protection, control and confidentiality. Nevertheless, a strictly closed approach to innovation is not strategically the most effective way to innovate and generate value, especially when there is both high market and high technical uncertainty (Chesbrough 2004). Powered and facilitated by broader changes taking place in society, such as the democratisation of knowledge, the open source movement, the open science movement and widespread diffusion of information-communication technologies, open innovation is suggested as a new paradigm of innovation, in both established and in niche markets.

Open innovation is an innovation paradigm that puts emphasis on using external ideas as well as internal ideas, and internal and external paths to market through collaborative networks involving private and public organisations, as well as individuals or groups of people (Chesbrough 2003; Tapscott & Williams 2006). A UK-based open innovation agency – 100%Open – defines open innovation as 'innovating in partnership with those outside your company by sharing the risks and rewards of the outcome and process' (100%Open 2014). The open innovation model is a less linear and more dynamic approach through which companies cooperate to source and generate knowledge in order to create new ideas and commercialise them in shorter periods of time (OECD 2008). It utilises both technology-push and market-pull mechanisms to generate and diffuse innovation.

Open innovation is definitely a trend in innovation and business, and even traditionally closed businesses, such as pharmaceutical companies and academic research, are adopting a more networked, open approach to innovation (Rodriguez & Solomon 2007). For example, in early 2013 The European Lead Factory

project was launched as the largest public-private partnership in Europe, fostering collaborative pharmaceutical research with 30 partners (Della Peruta 2013). The aim of the consortium is to generate 'unprecedented opportunities for the discovery of new medicines by providing public partners with an industry-like discovery platform to translate cutting-edge academic research into high-quality drug lead molecules on a scale and speed that was not possible previously.' Open innovation is also enabling development and commercialisation of new technologies that require simultaneous development of supporting systems to become operational such as the case of third generation (3G) mobile technology (Maula, Keil & Salminen 2008). With a similar spirit, in June 2014 Tesla Motors announced that it opened up patents to accelerate the development of electric vehicles through collaboration (Musk 2014).

While in some cases open innovation takes place through collaboration of partners from private and/or public sectors, in other cases it happens through collaboration of companies and individuals or groups of individuals through online crowdsourcing platforms. For example, IDEO, the well-known design agency that popularised design thinking as a strategic orientation in business, established the OpenIDEO platform in 2010 to facilitate collaborative innovation aimed at addressing social, environmental and economic issues (OpenIDEO 2014). As of 2014 the platform has close to 60 000 members from across the world who have collaborated with IDEO designers in idea generation, selection, development and implementation to address 21 challenges that were also collaboratively identified. Open innovation challenges are presented by institutions or companies and are generally open to any individual or group, including other companies, NGOs, experts and students. One very famous and earlier example of open innovation challenges was by the mining company Goldcorp. In 2000 it was on the verge of closing because the mine was old, there was no evidence of substantial gold deposits remaining and any search for new deposits by company geologists required substantial

investment and time (Tapscott & Williams 2006). Although traditionally propriety data would never be given away, Goldcorp revealed all information about their 55-acre property on their company website and started a competition for the best methods and estimates, offering prize money of \$575,000. As a result, the contestants identified 110 targets on the property, 50% of which had not been identified by Goldcorp before; 80% of these new locations yielded substantial quantities of gold.

Box 3 – Open Innovation Challenges for Energy Systems

One urban support system in need of urgent and major change is the energy system. Forces driving this change include the requirement of decarbonising the energy sector, emerging technologies such as the Smart Grid, and the shift to distributed generation, which includes individuals and communities seeking to generate their own power. Open innovation challenges may assist with systemic innovation and sectorial transformation by facilitating generation and execution of innovative ideas collaboratively.

Dynamic Demand Challenge by NESTA

A current example of an open innovation challenge is the Dynamic Demand Challenge by UK's innovation foundation Nesta (Dynamic Demand 2014). The challenge has been presented in collaboration with National Grid, the UK's grid operator, and other partners focusing on demand side response. The challenge was to 'Create a new product, technology or service that utilises data to significantly improve the ability of households or small businesses to demonstrate measurable reduction in carbon emissions by shifting energy demand to off peak times or towards excess renewable generation'. Below are the ideas of the five finalists, from 76 submissions, each explained by the teams that proposed them:

1. thEnergy (technology): Thermal Accumulator is a hardware that transforms buildings into dynamic sources of Energy. Energy Storage will change the way we see buildings from energy sinks to active and intelligent energy managers. It will lead to the emergence of buildings as grid players, able to react to spot pricing, reducing electricity use, saving energy and generating income from balancing the grid.
2. Upside (product): Many small businesses use a UPS (interruptible power supply) to run computers and related equipment. In essence, the computers are powered by a high-capacity battery which is constantly recharged from the grid. UPS are generally quite smart devices, e.g. they can recognise that grid power has failed and signal the attached computers to shut down gracefully before the battery is drained. Thus it would be feasible to extend UPS' capabilities such that they cease taking power from the grid when it is under high load and/or using non-renewable generation capacity, and then recharge at times of lower demand.
3. Powervault (product): The Powervault device was created to allow households with Solar Panels to store the excess electricity generated on their rooftop during the day and allow them to use it when they actually need it. By shifting a proportion of the self-generated electricity to a time where owners want to use it, the Powervault device allows them to use more of their own green power. Plugging the device into a convenient socket and linking electricity usage sensors to existing WiFi takes around 10 minutes. Future generations of the device will be capable of remote dispatch by utilities to reduce peak demand.
4. Demand shaper (technology): To gain universal acceptance, a dynamic demand scheme must influence electricity use rather than directly control it. We all have times when we need an appliance to run now! This idea combines a 'smart home' technology that can influence demand while responding to user needs and a signalling protocol that interacts with electricity retailers and Distribution Network Operators (DNOs). This system allows aggregate demand to be shaped, taking account of the interests of consumers, retailers and DNOs, so that best use is made both of renewable energy generation and the capacity of distribution networks.
5. Community substation challenges (technology): This idea provides communities with simple, low-cost, radio-connected 'fridge magnet' energy displays. Using these displays the network operator can run 'substation challenges' that signal local grid conditions and reward the community collectively for manually responding to those conditions. At the beginning of each season each community (all the houses attached to a substation) is given a set of credits that are lost as electricity is used during 'peak' and 'trough' periods of the day, as measured at the substation. Credits are lost faster during 'peak' times than 'trough' periods. At the end of the season the remaining credits are converted into a financial reward for the community.

3.3. Peer-to-peer innovation

In addition to the now 'traditional' model of open innovation, which involves a company or consortium tapping into the wisdom of crowd through idea challenges, innovation generated by peer-to-peer networks through open-source resources and distributed production capabilities is even more ground-breaking in terms of its implications for business and society. Peer-to-peer innovation is based on cooperation of loosely connected, widely distributed individuals who share resources and outcomes without relying on market signals or top-down commands in hierarchical firm structures (Benkler 2006). The early examples of intentional open peer production were observed in software development from the early 1980s. The emergence of peer production in software development makes a lot of sense as there was no cost associated with the logistics of information-sharing across a distributed network. The open-source software movement found its icon in the launch of the GNU/Linux operating system in 1991, which is now powering servers, desktop computers, super computers and even the New York Stock Exchange. In 2008, a report published by the Linux Foundation estimated that the development of Linux Fedora (a GNU/Linux-based operating system) alone under proprietary models would cost US\$10.8 billion (McPherson, Proffitt & Hale-Evans 2008).

More recently, in addition to software, peer production has begun to be observed in hardware through the diffusion of micro-manufacturing methods, such as 3-D printing, within globally connected micro-communities, the majority of which are currently in North America and Europe (Moilanen 2012). Although it is yet uncertain whether hardware-focused peer production will have a significant influence on society similar to open source software or whether it will remain within a technologically savvy and enthusiastic subculture, it is worth noting developments in this area. Centralised systems of provision are vulnerable due to expected infrastructure failures, increasing demand and increasing costs of maintenance and development (Biggs, Ryan

Box 4 – Towards Peer Production Innovations In Systems Of Provision

Hepburn Wind

Hepburn Wind (Victoria) is the owner and operator of Australia's first community owned wind-farm established in 2007 as a cooperative (Hepburn Wind 2014). The wind-farm has two turbines with a total capacity of 4.1 MW and is estimated to generate 12,200 MWh of energy annually, equivalent to the consumption within 2300 homes. Although this amount is higher than the demand of the local community, due to institutional barriers currently 100% of the energy generated is purchased by Red Energy and fed into the national grid. Nevertheless, Red Energy offers all residents of Victoria the option of 100% renewable electricity product (i.e. Community Saver) at competitive pricing. In addition, for each customer on the Community Saver plan who pays their bill on time, Red Energy contributes a certain agreed amount to the Hepburn Wind Community Fund on a quarterly basis. The Community Fund is an important element of 'Hepburn Model' as it will provide a significant amount of financial support for local sustainability projects, which is projected to be over \$1 million in the coming 25 years. Hepburn Wind Farm shares knowledge and a best-practice toolkit with other communities that would like to adapt and scale-up the 'Hepburn Model' in collaboration with Embark which is a non-profit organisation aiming to overcome barriers for the growth of renewable energy sector in Australia (Embark 2014).

& Wiseman 2010). Increasing resilience of energy, food and water provision is fundamental in transitioning to low-carbon and sustainable futures. Peer production is increasingly observed within communities that would like to meet their needs without relying on centralised systems of provision.

All forms of open innovation discussed in Sections 3.2 and 3.3 are relevant to sustainability and low-carbon transitions

Open Food Foundation

Open Food Foundation was established in 2012 to develop free and open software to support fair and sustainable food systems (Open Food Foundation 2014). The Foundation's flagship open source project is the Open Food Network, an online marketplace and logistics platforms that connects local producers with local consumers. It is a disruptive innovation aimed squarely at market concentration in food supply networks. It provides an easy way for enterprises to find and trade with farmers and consumers and run their operations, reducing barriers to entry for community and ethical enterprises. The core defining feature is transparency: end consumers can see who grew their food and how and how much they were paid. Open Food Network is currently being trialled with food hubs in a closed beta phase (Open Food Network 2014). The source code for Open Food Network is stored on GitHub, an online platform supporting peer production of software (GitHub 2014).

in urban environments because systems of provision and patterns of consumption have complex interdependencies and sectoral or company-based, proprietary and closed innovation approaches are not likely to be fully effective for transitioning to low-carbon futures. For example, reducing emissions caused by urban energy system at levels necessary to avoid dangerous climate change requires innovations in many sectors including those that develop energy generation technologies, those that

generate and supply energy, those providing mobility solutions, those developing residential and commercial property, and so on. In addition to companies in these sectors, interventions are necessary at a policy level to regulate the industry, as well as to influence the consumption behaviour of end-users. It is argued that through tools of open innovation, opening closed and linear urban planning processes to include company representatives and citizens in the decision-making process can foster bottom-up energy transformation (Arnold & Barth 2012). Since radical innovations and the creation of new markets to achieve sustainability and low-carbon transitions cannot be achieved within a single organisation (de Boer & van Bergen 2012), a willingness to adopt and support open innovation is a fundamental requirement for generation of systemic business models and disruptive innovations to transform existing systems (Rohrbeck et al. 2013; Maula et al. 2008).

3.4. Closed-loop production

The premise of circular models is minimising or eliminating waste and maximising resource efficiency in production–consumption systems. It is argued that this can be achieved by closing material cycles in manufactured products through design, an idea popularised as ‘cradle-to-cradle’ by McDonough and Braungart (2002) (although the term has been in wide use in eco-design research since the mid 1990s), or by building symbiotic networks of companies within which waste from one company is used as raw material by another, referred to as ‘industrial ecology’ (Ayres & Ayres 2002; Frosch & Gallopoulos 1989), or ‘industrial symbiosis’ (Chertow & Ehrenfeld 2012). Although among the scientific community there is a consensus that industrial ecology will have a significant influence on sustainability, the fundamental proof of this is still missing (von Hauff & Wilderer 2008). In an assessment of eco-parks, which are built upon principles of industrial ecology, it became clear that top-down public programs

could not facilitate the formation of collaborative networks to make eco-parks successful in a business sense (Orsato 2009). This indicates that institutional changes are necessary if industrial ecology is to play a role in transitions.

Box 5 – Mission Zero: Zero Negative Impact by 2020

An iconic example of successfully ‘closing the loops’ as a single company through business model innovation is Interface Inc., founded by Ray Anderson in 1973 to manufacture modular office carpets (Interface 2014a). Starting from 1994, following the exposure of Ray Anderson to ideas of Paul Hawken and others, Interface Inc. changed its business model from a linear model of manufacturing and selling carpet tiles to a cyclic model of ‘delivering floor-covering service’ (Stubbs & Cocklin 2008). Interface focused on design of its processes and products to support its new business model in which tiles are leased, continuously recycled into new tiles and only damaged parts of coverings in offices are replaced instead of the whole floor cover; in this sense it is often highlighted as a successful PSS business. The company has the ultimate vision of becoming the first company with zero negative impact by 2020 (Interface 2014b).

3.5 Crowdfunding

Crowdfunding (also known as crowd financing and crowd investing) can be defined as the process of a party requesting and acquiring financial or other resources from many individuals with the purpose of realising a specific project. Investors are offered some kind of return on, or reward for, their investment, which may or may not be financial (Mollick 2014; Vorbraak 2011). Crowdfunding is generally mediated through online platforms.

A fundamental element in sustainability and low-carbon transitions is niche innovations, as these, if successful, can disrupt the mainstream dynamics of business, change the rules of competition and replace incumbent technologies or social practices (Geels 2005). Aligned with this theoretical insight, a recent report published by strategic business advisory firm SustainAbility, which analysed 100 companies with disruptive innovations relevant to sustainability, found that three-quarters of such companies were implementing entirely new business models rather than modifying existing ones (Clinton & Whisnant 2014). Nevertheless, the availability of venture capital and angel investment for niche innovations is limited, especially following the financial crisis of 2008. Crowdfunding makes it possible for niche innovators to turn their innovation ideas into businesses facilitated by information and communication technologies and online social media. For example, US-based company Solar Mosaic Inc. connects individual investors with solar projects needing investment and enables collection of repayments with interest once the project starts to generate profit from renewable energy through an online marketplace (Solar Mosaic 2014).

Crowdfunding as an alternative financing mechanism is becoming increasingly popular, both as a source of venture capital and an investment opportunity (Tomczak & Brem 2013). In 2011, US\$1.5 billion was raised over one million campaigns (Crowdfunding Industry Report 2012). Crowdfunding is not only an alternative financing approach, but it also has broader implications on the generation of business models. In contrast to keeping ideas and

development processes commercial secrets, innovators expose their ideas publicly, build their supply chains and engage with their customers in the early phases of development. In addition to the potential of crowdfunding as an alternative financing approach for start-up companies, it is also becoming popular among communities and local governments as a way of financing major public projects when government policy or funding fails to deliver what citizens desire. As a result, crowdfunding also signals a potential in facilitating institutional change in which power becomes more distributed, decisions on public spending become more democratised and participatory, and local governments develop their own 'business models' for increased self-reliance rather than relying on central government funding.



Luchtsingel bridge under construction. Photo by [AgainErick](#) via Wikimedia Commons [CC BY-SA 3.0](#)

Box 6 – Towards New Business Models for Building Public Infrastructure

Tapping into voluntary financial contribution of the citizens for major construction or infrastructure projects has existed since ancient times. Nevertheless, with increasing costs and decreasing funding for local governments, and facilitated by the wider movement of crowdfunding project investment, crowdfunding public projects is becoming increasingly mainstream. Some of these projects are initiated by the local public authorities, while others are initiated by communities that would like to improve their locality. There are also crowdfunded public infrastructure projects undertaken by private companies. Most well-known examples of crowdfunding platforms for public projects include Citizeninvestor and Neighborly. Both of these platforms emerged from and currently serve the United States. In the Citizeninvestor platform any government entity or official partner can initiate a campaign to raise funds from other users for pre-approved government projects (Citizeninvestor 2014). Meanwhile, Neighborly is a platform that aims to enable the funding of public projects, regardless of the type of body pledging for funding, as long as the project is for public infrastructure, thus enabling collaborative partnerships along the public-private spectrum (Neighborly 2014). Other crowdfunding platforms that specifically cater for public projects include Projexity in the United States and SpaceHive in the UK. The number of such platforms is likely to increase. Some examples of crowdfunded public infrastructure projects include the pedestrian bridge Luchtsingel in Rotterdam, a 66-storey skyscraper in Bogota, and +pool in New York. Currently, there is a crowdfunding campaign to pay for the renewal of the tiles on the outside of the Sydney Opera House.

3.6 Sharing economy

In addition to crowdfunding, which provides an alternative approach to financing private and public projects alike without reliance on angel investors or venture capitalists, the sharing economy as an emerging social movement, again facilitated by information and communication technologies and online social media, provides some new business models with the potential for disruptive innovation. While 'sharing' can be considered one of the domains of PSS development, it is worthy of discussion in its own right.

Profit-centred traditional business practice operating within a classical market economy requires companies to continuously increase the sale of material goods – one of the main drivers of ubiquitous consumption and throw-away culture (Mont & Power 2009). The idea of sharing as a (re)emerging economic model has recently been popularised by Botsman and Rogers (2010). Sharing blurs the boundary of possession and includes voluntary lending, pooling and allocation of resources and authorised use of public and private property, but not contractual renting, leasing or unauthorised use of property (Belk 2007). Therefore, it is related to, but distinct from, access-based consumption (Bardhi & Eckhardt 2012) as exemplified in Box 2.

The business models that are emerging from the sharing economy are most interesting in terms of their 'offering' for the end-user. Businesses generally offer platforms for people to share collectively or individually owned assets. Some of these models also offer 'business opportunities' for the end-user, i.e. they become profit-making opportunities for the individuals or collectives that share their assets. These models increase utility per asset, thus helping to dematerialise consumption. They also introduce and normalise social practices based on values such as collaboration, sharing, connecting with one's local community, and so on, challenging values that have been the norm in individualistic societies since the industrial revolution, such as

competition and prioritisation of an individual's wellbeing over that of the community.

Some of these business models have become so successful that they have either opened new markets or started to disrupt existing ones. It is likely that, besides the implications for business, a sharing economy could assist with broader societal change and increase the resilience of communities. For example, San Francisco has launched a plan to deal with disasters using collaborative consumption platforms (Schwartz 2013a).

Box 7 – Peer-to-peer Consumption

Spinlister

Spinlister is an online platform for peer-to-peer bike-sharing that operates in over 100 countries (Spinlister 2014). The online platform of Spinlister connects people who want to rent a bike with members of the platform that have bikes available to rent. The system has built-in security features, such as embedded insurance, peer feedback, and user verification, to ensure financial and physical security for system users. In 2013 Spinlister had around 10 000 users and 2000 bikes listed (Schwartz 2013b).

Potential disruption for traditional hospitality sector: Airbnb

Airbnb is a peer-to-peer accommodation rental platform founded in 2008 in the United States, which currently has more than 500 000 listings in more than 34 000 cities across 192 countries (airbnb 2014). Airbnb is acknowledged as disruptive and potentially poses a substitution threat for the hospitality sector, even for a specialised segment of the market, i.e. luxury hotels (Hemmeter 2013; McCarthy 2014). Airbnb has become so widely diffused that a series of new businesses have emerged as spin-offs to provide complementary services to Airbnb hosts, such as property management services dealing with key exchange and cleaning (Tate 2014).

3.7. Social enterprises and benefit corporations

The most powerful business form in the world today is the shareholder-owned corporation. A key premise of this type of business is that executives are legally obligated to maximise the profit of the company/shareholder. In most legal jurisdictions, the shareholder-wealth-maximisation requirement generally prohibits corporations from acting in ways that benefit, say, local communities or the environment, if that is at the expense of the bottom line. While most shareholder-owned companies can, and often do, engage in *modest social and environmental and philanthropic efforts* without trouble, the underlying rationale should be that it improves the company's fortunes through, for example, a better corporate image and customer relationships – or a 'social license to operate' (corporate social responsibility (CSR)).

In the United States, one of the most famous cases defending this principle was *Dodge v. Ford Motor Company*, in which the Michigan Supreme Court held that Henry Ford owed a duty to the shareholders of the Ford Motor Company to operate his business to profit his shareholders and pay a special dividend, rather than, as Ford was planning to do, invest money on community and employee programs. In a more recent US case, a Delaware court rescinded a decision by majority shareholders and founders of Craigslist Inc, Craig Newmark and James Buckmaster, from enacting a rights plan to defend the frugal, community-centred corporate culture of Craigslist Inc. from the financial profit-oriented strategies being advocated by the minority shareholder Ebay (Strine 2012).

Partly in response to this principle, an influential article by Michael Porter and Mark Kramer in the *Harvard Business Review* in 2011 argued that it is time to redefine the purpose of the corporation to one of creating 'shared value' rather than profit per se. Shared value involves creating value for society by addressing its needs and challenges. They argue that this 'will drive the next wave of innovation and productivity growth in the global economy. It will

also reshape capitalism and its relationship to society. Perhaps most important of all, learning how to create shared value is our best chance to legitimize business again' (Porter & Kramer 2011, p. 65).

The idea of shared value goes beyond conventional CSR, whereby a business monitors and ensures its active compliance with ethical standards and positive social norms. As Parrish (2007) explained, there is 'an important distinction between a sense of duty to act responsibly towards society and the environment as they pursue their private interests, and those enterprises that are driven by a sense of purpose to contribute to sustainable development of the socio-ecological system of which they are part' (Parrish 2007, p. 51).

In recent years, the term 'social enterprise' has been used to describe organisations that trade and operate in business activities with the aim of maximising improvements in human and environmental wellbeing, rather than maximising profits for shareholders. The precise meaning of the term is still being contested, and social enterprises can take many organisational forms, including cooperatives, mutual organisation and incorporated companies. However, they should not be confused with not-for-profit enterprises; distribution of profits or payments to individuals can occur as long as it is consistent with an enterprise's value statement and/or social objectives.

Social enterprises are a thriving area of activity and Social Traders, an Australian social enterprise association, estimates that there are up to 20 000 social enterprises operating in Australia.

Perhaps the most exciting development within the sphere of social enterprises has been the recent development of certification schemes and legislation in a number of regions around the world that are now formalising the status of social enterprises. For example, in the United States, the B-Corp certification scheme (see Box 8), which started in 2007, and in the UK, the Social Enterprise Mark scheme, which started in

2010, offer companies an accreditation process that rigorously examines a company's social, environmental and governance practices against global benchmarks and provides an ongoing assessment that ensures the company is steering along the path to sustainability. Unlike other certification schemes, it applies to the whole business and not just to the products being made.

Simultaneously, a number of the states in the United States and the UK have now introduced changes to company law to formally recognise 'Benefit Corporations' (B-Corp) (USA) and 'Community Interest Companies' (UK) which provide a stronger legal basis for companies to have greater freedom to pursue strategies which they believe benefit society as a whole rather than having to focus exclusively on maximising profits.

In Australia, a handful of small firms have already achieved B-Corp certification status. Some of the benefits quoted by these companies include having a clear, credible and transparent way to let the public know the business's commitment to generate 'profit with purpose', to differentiate themselves from competitors, to attract enthusiastic, committed and fully engaged employees. The rigorous and comprehensive auditing process provides valuable insights into further areas of social and environmental sustainability that the firm can pursue (Pro Bono Australia 2013).

Whether large publicly-listed companies in Australia will attempt to adopt B-Corp or similar social enterprise commitments is likely to depend on the success of the experiences of small and medium-sized enterprises and whether there are legislative changes that support and encourages B-Corp type companies (Pro Bono Australia 2013).

Box 8 – The B-Corporation

A B-Corporation (or B-Corp) is a company that has received a certification issued by B Lab, a US-based non-profit organisation, to meet rigorous standards of social and environmental performance, accountability and transparency. The 'B' stands for benefit or beneficial – social and environmental, as well as financial. B Lab was founded by a group of business people who were frustrated with the traditional shareholder-focused business model that constrained the social and environmental sustainability and accountability of business leaders.

With the first certificate awarded in 2007, as of March 2014 there are 990 certified B-Corps across 60 industries in 27 countries, with over a third outside the United States. Large companies that have received accreditation include ice-cream company Ben and Jerry's and clothing retailer Patagonia.

The process of accreditation is a systematic one that initially requires a minimum score on an online assessment for high social and environmental performance, including impacts on workers,

consumers, suppliers, communities and the environment, followed by a verification process by B Lab representatives. A requirement of the process is that companies integrate their stakeholder commitments into the corporate governing documents. Certification costs up to \$25,000 a year for large companies, though it is much less for start-up companies

As a recent program, it is still too early to determine the social and environmental effectiveness of the scheme. Among concerns, it is not clear to what extent a B-Corp should give standing to other constituencies to sue to enforce the directors' duty to them (Strine 2012). The weight to be given to other constituencies would seem to be a matter entrusted to the judgement of the directors and would be difficult for courts to second guess. Furthermore, the sturdiness of a firm's commitment to social and environmental sustainability remains contingent upon the shareholders of the company, who by electing a new board that supported a change, could presumably always change back the charter of the company to a strictly shareholder value maximisation proposition.

3.8 Gift economy

According to one theoretical and ideological position, the environmental and social problems we face stem from the dominant Western worldview, which has absolute confidence in technology and science, and unquestioned confidence in consumer-oriented and market-driven growth and development (Coates 2006). Associated with this position, and fuelled with well-documented flaws and limitations of that economic system in addressing sustainability issues, there has been increasing reflection on alternative economic systems, either as substitutes or complementary to the mainstream economic paradigm (Söderbaum 2007). The sharing economy, mentioned earlier, is one example. An extreme form of sharing economy is gift economy. A gift economy stands against commodification of resource and labour exchange through monetary transactions, arguing that this creates alienation and an illusion of separation from nature and other human beings (Eisenstein 2011). Some authors have presented theoretical and psychological obstacles for a pure gift economy, especially within economies of scale (Marcoux 2009). Nevertheless, although there are very few examples of business models based on gift economy and it is unclear if these will succeed as niches and become forces of disruptive innovation, it is worth watching these businesses.

Box 9 – Business as Gift Exchange

Lentil as Anything

Lentil as Anything is a 'pay as you feel' vegetarian restaurant chain in Melbourne that has operated for 13 years as a not-for-profit community organisation (Lentil as Anything 2014). The menu at Lentil as Anything does not show any fixed prices and diners are requested to pay as much as they think the whole experience of eating there is worth, considering the overheads associated with staff wages and stock. In 2007, Lentil as Anything won a private ruling with the Australian Tax Office exempting the 'pay as you feel' model from having to pay GST. The founder of Lentil as Anything, Shanaka Fernando, won Australian of the Year – Local Hero award in 2007. Under the current legislative and economic paradigm of business, Lentil as Anything cannot be regarded (and is not defined) as a business. On the other hand, it has an underlying business model that demonstrates the possibility of running a financially viable enterprise without a focus on finances or pricing.

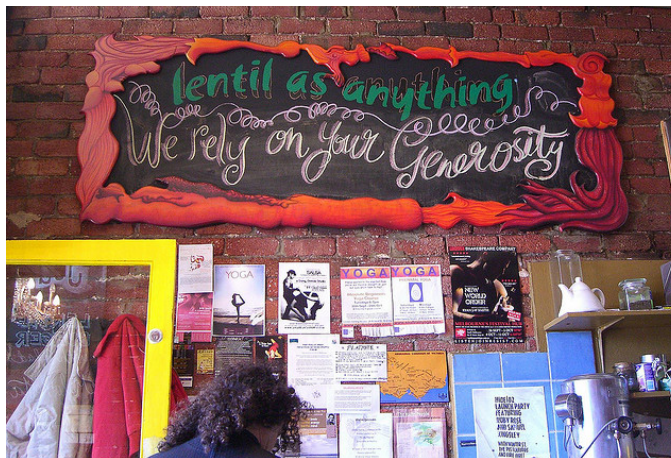


Photo by [Alpha](#) via Flickr [CC BY-SA 2.0](#)

3.9 Business models driven by a new manufacturing paradigm

Additive and digital manufacturing, or as it is more commonly known, 3-D printing, has become a new paradigm for manufacturing. Its potential to be disruptive from an economic point of view is already apparent: In 2013 the market size of 3-D printing was US\$3.1b. Over the next six years this is expected to grow at a rate of 32% per year to reach \$US21b by 2020 (Wohlers Associates 2013). The implications of 3-D printing for sustainability and low-carbon transitions may also be substantial; however, it is still too early to definitively conclude whether the outcomes will always be positive.

3-D printing is a process where a physical object is made from a three-dimensional digital model, typically by laying down many successive thin layers of a material. The 'printing' material may be plastic, metal, ceramics or many other materials. While this form of the technology has been around since the 1980s, it is only in the last few years that lower costs have enabled the technology to move into SMEs and homes (Lipson 2013).

From an environmental perspective, 3-D printing has four main selling points (Kovac 2013). First, there is the potential to reduce waste, particularly when using metal, where the additive approach contrasts with the conventional manufacturing process of cutting away at a solid metal block. Second, the same machine can build many different things, and hence does not require further energy and resources to create or retool specialised machinery for each new object produced. Third, there is the potential for reduced energy and emissions from lower transport costs, as the assumption is that production will be more 'distributed' – closer to points of consumption – and the raw material for printing may be acquired from 'local' sources. Fourth, there are enhanced opportunities to repair products by creating damaged or worn parts (particularly useful if the object is out of mainstream production) and thus help extend the life of products.

Against these potential energy and environmental gains, concerns include the potential for rebound effects (increased consumption resulting from lower prices), the energy efficiency of printers, and end-user waste from failed products or the overproduction of throwaway goods (Sorrell 2007; Kovac 2013; Olson 2013).

New business opportunities provided by 3-D printing include offering new value propositions to customers in terms of user customisable goods where customers can contribute to the design process of a product (e.g. a necklace, headphones, toys) (Gannes 2014). 3-D printing may also provide a revitalised market for repair and aftermarket services for products and a market for waste plastics (e.g. Plastic Bank 2014).

3-D printing may also cause a major disruption to the traditional distribution chains for manufactured objects, with a movement towards a more distributed model and the likely involvement of a range of new actors. Such a change to manufacturing systems has been envisaged as an emerging shift in the business models of future sustainable industry (Evans et al. 2009). Currently there are start-ups in the Netherlands that focus on new waste-to-product systems, taking plastic waste 'in' with small 3-D products 'out' (e.g. Perpetual Plastics Project, 2014) illustrating another way the current linear production-consumption-waste model might shift towards a circular system.

Mainstream 3-D printing services are now available not only in traditional printing shops, but have also begun to move to the high street, with companies such as Asda and Selfridges in the UK offering in-store printing services to customers. Online print-on-demand merchandisers are also emerging. The move to in-home printing is also becoming more possible and in 2013 major retailers such as Amazon, Staples and Matlin all began selling 3-D printers.

Large industrial plants, such as the RedEye in Eden Prairie, Minnesota, United States, are already custom-printing components for the aerospace, medical and defence industries.

Such developments are proposed as new hybrid models for manufacturing, giving hope for the economic revitalisation of industrial cities in decline (Economist 2013). This kind of investment in future manufacturing is seen as much more compatible with mixed-use urban development, particularly supporting creative design and innovation labs and start-ups. In relation to urban development itself, some early work has been carried out in the 3-D printing of houses, suggesting that the business model of existing construction might be affected by the technology.

Perhaps one of the most exciting developments, partly driven by the new possibilities opened by 3-D printing, is the rise of the makers movement. This is a community of craftspeople, tinkerers, hobbyists and inventors who are harnessing the internet and the latest manufacturing technologies and, according to some commentators, may provide a renaissance in product design and business start-ups (Deloitte 2014). Often working in shared community workshops (often referred to as hacker spaces or maker spaces) or for-commercial spaces (e.g. TechShop, Fablabs) and convening in Maker Faires, the maker movement, along with associated developments like crowdfunding, points towards a new type of manufacturing economy; one shaped like the internet itself: bottom-up, broadly distributed and highly entrepreneurial (Deloitte 2014).

A number of sites are now competing to become the iTunes of physical objects. Here designers and makers can list their products and customers can download them for a fee (e.g. Shapeways.com, i.materialize.com). In addition, there is a rapidly growing open-source movement where 3-D designs are available (and available to refine) for free (e.g. Thingiverse).

It is an open question as to whether all these possibilities and developments will be largely limited to niche product areas or whether they will transform whole industries and see the competitive advantage of many current incumbent companies

shift away from the ability to manufacture in high volumes at low cost and move towards other areas of the value chain, such as design or ownership of customer networks (Dante 2014).

Box 10 – Open Source 3-D Printers

Recyclebot

One of the holy grails of 3-D printing, for both environmental and commercial reasons, is to create a self-replicating 3-D printer that uses waste plastics. The RecycleBot, created in 2013 by Joshua Pearce and his team of researchers at Michigan Technological University, is the latest prototype from a group that have been working for years on open-source, environmentally friendly 3-D printers.

'There are large environmental savings when you use recycled plastic. However, the main reason people will want to use recycled filament is the cost,' Pearce said. 'Commercial plastic filament costs about \$35/kg or more – if you make it yourself with a Recyclebot the cost drops to only ten cents per kilogram for the electricity to run it' (Gilpin 2014).

To provide electricity for these printers, and thus make them more accessible in developing countries, the team is now working on printing solar-powered equipment. They are also looking to develop a Recyclebot for recycled metal materials. But their long-term vision is even more grand.

With the new value that can be provided by waste materials and the open possibilities that low cost, self-replicating printers can provide, 'I think open source 3D printing can do a lot to bring us all incredible wealth,' Pearce said. 'It can help everyone in both the developing and developed world alike to print themselves out of poverty' (Gilpin 2014).

4. Discussion

The overview presented in the previous section provided some existing contextual background for business model innovations relevant for sustainability and low-carbon transitions. One question that still has not been answered is whether the general theory on business models is readily applicable to business models specifically developed to deliver and distribute innovations for sustainability and low-carbon transitions. The theoretical contributions in the area of sustainable business models are limited.

Two systematic contributions proposing qualities and principles for sustainable business models were recently made by Boons and Lüdeke-Freund, and Wells. Boons and Lüdeke-Freund (2013) identified some normative qualities across four components which they distinguish as fundamental parts of a generic business model, i.e. value proposition, supply chain, customer interface and financial model. According to this framework, a sustainable business model should involve a value proposition that provides measurable and balanced ecological, social and economic value. The supply chain should involve suppliers, who are part of a sustainable supply chain and who take responsibility for all stakeholders (direct and indirect). Within this supply chain, no social or ecological burden should be shifted from one point to another along the chain. The business model's customer interface component should motivate customers to take responsibility for their consumption and other stakeholders. The business model should acknowledge and respond to different sustainability challenges in different markets. The financial component of the business model should reflect an appropriate distribution of costs and benefits among actors involved and should account for ecological and social impacts. Wells (2013), on the other hand, identified six major principles that underpin business models for sustainability: resource efficiency, social relevance, localisation and engagement, longevity, ethical sourcing and work enrichment.

Both Boons and Lüdeke-Freund's (2013) normative qualities and Wells' (2013) principles frame 'ideal' sustainable business models. However, a business model cannot be sustainable or even assessed against these qualities and principles without considering the properties of the wider system within which the new business is positioned. Given that sustainability issues are complex, persistent in nature, and, cross-cut several human constructs (e.g. economic systems), as well as natural systems, there is a requirement for new business models to be based on an understanding of the relationship between business, natural environment and society as a whole system (Loorbach & Wijsman 2013). For systemic transformations to take place within the time periods required to avoid system collapse, rather than starting from a preconceived single technological or social innovation idea, it is necessary to develop and act upon a set of diverse interventions that leverage both technological and social change simultaneously (Leach et al. 2012; Manzini 2007; Schaltegger & Wagner 2008; Wüstenhagen et al. 2008). In order to achieve this integrated approach the new business model should be informed by a vision about the desirable future state of the broader system (Gaziulusoy et al. 2013).

Rohrbeck et al. (2013) also point out that many of the required sustainability innovations are radical in nature and cannot be delivered by relying on traditional economic mechanisms or within individual firms. Nevertheless, the mainstream business literature, as well as emerging literature, on innovation for sustainability, base its assessment of success of new business models on the unexamined assumptions of the current economic system, as well as a conventional definition of business (Parrish 2010). There is indeed a need for creating whole new business systems to make these radical innovations work (Johnson & Suskewicz 2009). This requires shifting from the traditional means of competing in a market to working collaboratively with stakeholders, and in some cases with competitors, to

create new technologies and markets (Rohrbeck et al. 2013). The new business models should also include an expression of organisational and cultural changes that are necessary to implement the new business model as part of the business model (Stubbs & Cocklin 2008).

During our research we realised that these new and emerging business models present challenges for research about business and business models for the very reason that they were conceived to address environmental and social problems that stem fundamentally from the flaws of the existing economic system. On the one hand, to be successful, these new models follow the rules and institutions of the existing socio-technical systems, but on the other hand they challenge the rules and institutions of the existing socio-technical systems. Fundamental theories of mainstream business literature were developed following World War II, when economic development through increased production and consumption was the norm and the environmental and social problems created by this mindset were not known. Therefore, we did not find the body of mainstream theory on business and business models helpful for generating insights relating to the potential success and disruptiveness of these new models. This is identified as an area that needs to be investigated through further research. In our research, we also identified that business models can be powerful strategic tools, not only for businesses, but also for a diversity of traditional and emerging types of organisations that aim to deliver sustainable innovations ranging from governmental bodies to peer-to-peer networks. As a result, we also identified a need to expand our focus of research on new business models applications to cover types of organisations that are not traditionally considered as business, but which can benefit from using tools of business in conceiving and delivering low-carbon and sustainable innovations.

5. Conclusions

The design and development of sustainable business models is still in its infancy and this paper has only provided a taste of the types of new business models for sustainability in the built environment that may emerge and generate disruptive change.

In this paper we have also raised questions and presented ideas to help develop the agenda of sustainable business model research. This includes recognising the structural and cultural considerations of business models more explicitly and considering how the business model concept can be refined to be more readily useful beyond for-profit corporations, so as to include other project activities and enterprises.

Some of the real-life examples presented in this report will not gain further traction and some will fail, yet they are seen as inspirational and so might shape other business developments in the future. Experimentation and learning is a central dynamic of the innovation and transition process, and the inevitable failures of some business models will not deter innovative thinking in sustainable business model design.

As stated in the introduction, business as usual supplemented by incremental innovation is not likely to be sufficient in achieving the sustainability changes needed in the built environment. Innovation in all aspects of our lifestyles and social structures is required and will be an ongoing and collective endeavour. The Visions and Pathways 2040 project hopes to contribute towards this goal by developing snapshots and narratives of what the journey and destination of this undertaking may look like. Innovative business models will most likely be a critical element of it.

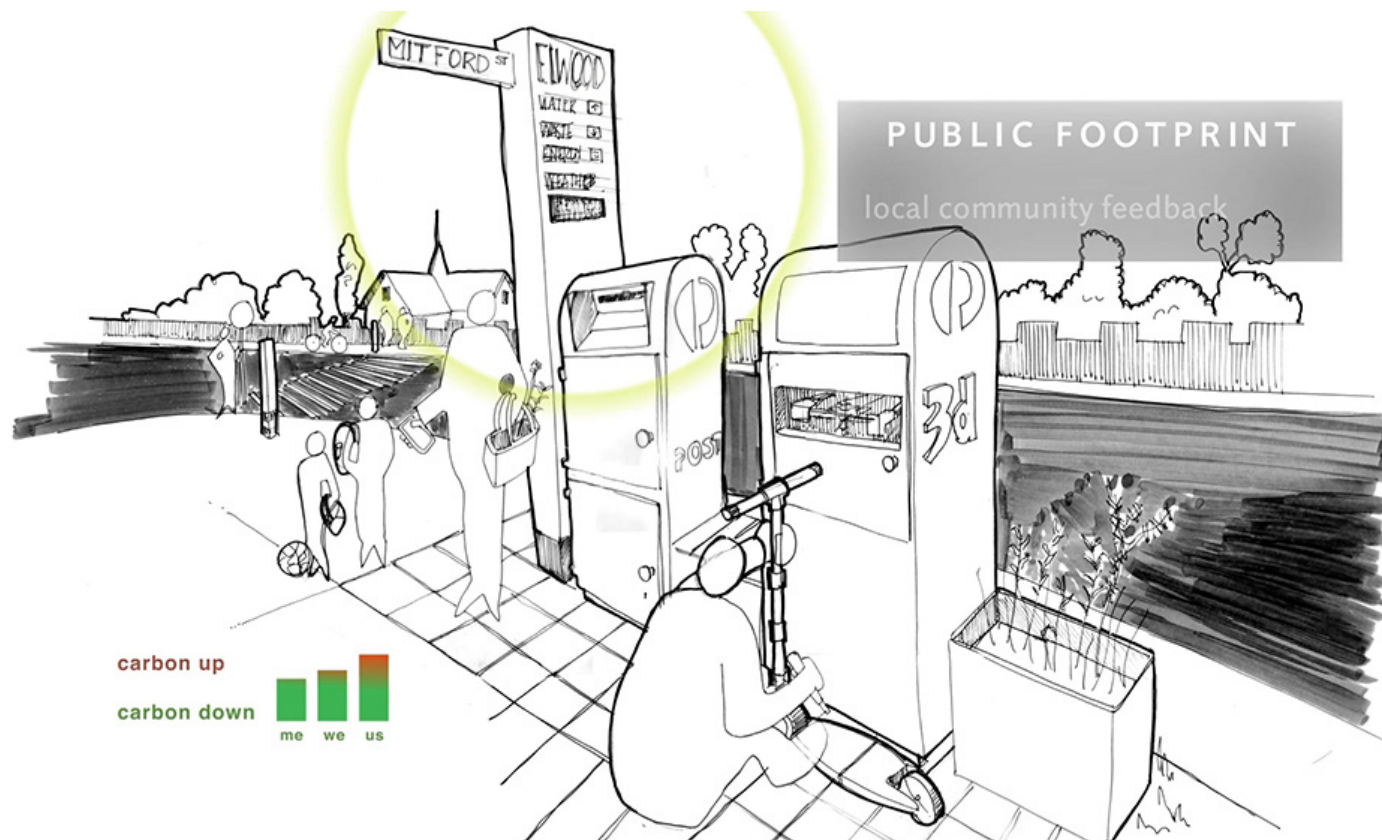


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