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Can innovative business models overcome resistance to electric vehicles? Better Place and battery electric cars in Denmark

Thomas Budde Christensen [a],*, Peter Wells [b], Liana Cipcigan [c]

[a] Roskilde University, Universitetsvej 1, 4000 Roskilde, Denmark
[b] Cardiff Business School, CF10 3EU, UK
[c] Cardiff School of Engineering, CF10, UK

HIGHLIGHTS

- We explore the context for an innovative emergent business model to deliver battery electric car mobility in Denmark.
- We explore the interplay between battery electric cars, renewable energy generation and smart grids.
- We discuss the integration of electric cars in energy systems based on renewable energy sources.
- We discuss the likely success of the Better Place business model.

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ABSTRACT

This paper explores the geographical and policy context for an emergent business model from Better Place to deliver battery electric car mobility in Denmark. It argues that the combination of radically different technologies and a highly complex multi-agency operating environment theoretically provide the conditions and requirements for such an emergent business model. While focused on battery electric cars, renewable energy generation and smart grids, the paper has wider applicability to an understanding of the interplay between place, innovation and sustainability which suggests that diverse solutions are likely to be the characteristic solution rather than ubiquity and standardization. The paper argues, however, that the innovative business model, the deployment of electric vehicles, and the use of renewable energy systems, in this case largely based on wind power, while mutually supportive and contributing to wider policy aims with respect to the reduction of carbon emissions, may still fail in the face of entrenched practices. At the theoretical level it is concluded that theorization of business models needs a broader perspective beyond the typical 'value creation, value capture' rubric to better understand the wider role such models have in meeting societal goals, and to understand the structural impediments to organizational and technical innovation.

1. Introduction

Research into innovative business models has highlighted the ways in which competitive advantage may be secured by creating new businesses premised on novel structures and approaches, or by re-engineering the architecture of existing businesses. In broad terms, the two primary conditions to allow or promote business model innovation are technological innovations (in the product/service offered or in the underlying business processes) or economic distress under which existing business models are losing their competitive power. Research in this area tends to focus on the innovative cases and on the success stories. In contrast, the ability of entrenched business models or other forces for inertia to resist change tends to be neglected. As this paper argues, the instance of electric vehicles would appear to offer theoretically good reasons to expect that profound technological changes in the nature of the product, allied to repeated economic distress evident in the existing dominant business model for vehicle manufacturing, would yield the perfect opportunity for business model innovation to flourish. Indeed, such innovations in business organization have been claimed to be a pre-requisite for the successful electrification of automobility (Berger, 2011; Wells, 2010a).

According to the Inter-governmental Panel on Climate Change (IPCC) global emissions of CO_2 must be reduced by 50%–85% by 2050 in order to avoid global warming exceeding the 2 °C threshold

* Corresponding author. Tel.: +45 46 74 26 37.
E-mail addresses: tbc@ruc.dk (T. Budde Christensen), wellspe@cardiff.ac.uk (P. Wells), CipciganLM@cardiff.ac.uk (L. Cipcigan).

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temperature for catastrophic climate change (UNFCC, 2011). This reduction target means that the developed countries need to reduce their emissions by 80%–95% by 2050 to counter-balance growing emissions in developing countries (EU, 2011). Two of the main contributors of CO_2 emissions are energy conversion and transport activities. A potential route to climate change mitigation is via the phased substitution of fossil fuels with renewable energy sources such as solar, wind and hydro power. These renewable energy sources all share the same challenge of reconciling fluctuating energy conversion against variable current consumption patterns.

Climate change mitigation in the transport sector has been more challenging as CO_2 emissions caused by transport activities in most countries more or less follow continuing economic growth (EEA, 2010). Private car use is one of the main contributors to CO_2 emissions from the transport sector (EEA, 2010). Incremental achievements in the CO_2 performance of new cars have been achieved in Europe via voluntary action and, more recently, by the direct regulation of CO_2 emissions (EU, 2009a), but more radical solutions are needed (EEA, 2010). One of the most promising radical solutions is that of battery electric vehicles (BEVs; in this paper taken to include plug-in hybrid vehicles as well). BEVs are more energy-efficient than conventional diesel or petrol fuelled combustion engine vehicles and allow the introduction of renewable energy sources in the transport sector if parallel transition is taking place in the energy sector.

There are many potential strategies to reduce the CO_2 emissions from transport, ranging from advanced public transport systems to substitution via increased use of information and communications technologies. However, the combined introduction of electric cars in the transport sector and renewable energy sources in the energy sector via innovative business models is particularly interesting due to the fact that fluctuations in electricity production via renewable energy sources can potentially be managed by so-called intelligent charging of BEVs whereby vehicle charging is controlled and performed according to the actual production patterns in the energy sector in a 'smart grid'. Intelligent charging requires a completely new way of organizing the interface between the transport sector and the energy sector. While much research has identified the technological challenges in terms of vehicle and infrastructure design to achieve the transition to low-carbon mobility (Sperling and Gordon, 2009), rather less attention has been given to the implications for business structure and organization (Wells, 2010b). There is recognition that in broad terms new business models are likely to be a feature of the emergent automotive corporate landscape (Kley et al., 2011; Berger, 2011; Wolfson et al., 2011), and that the technological and business solutions for sustainable mobility are likely to be highly diverse and context-dependent, but in the absence of actual cases there is little understanding of how those innovative business models might be characterized, or how they will relate to and compete against entrenched practices.

This article explores the creation of such a business model by looking at the implementation of BEVs in Denmark by Better Place, a new 'intermediary' interface between BEVs and renewable electric power. We have chosen Better Place Denmark because it is at the forefront of these intertwined technological and corporate changes (Wolfson et al., 2011). Denmark has a high proportion of installed wind power capacity and supportive policy context such that electric cars are expected to penetrate the vehicle fleet faster than elsewhere. The article first reviews the significance of innovative business models in theory, along with the material circumstances of the nascent BEV segment that may allow or even compel organizational innovation. Thereafter, the specific case of Better Place in Denmark is considered. The article concludes with an exploration of the implications of the case study within the wider theme of the quest for sustainable mobility and the potential contribution of business model innovation.

2. Business models in turbulent technological and regulatory contexts

There has been a growing academic and managerial interest in business models over recent years (Baden-Fuller and Morgan, 2010), stemming from a realization in the early period of the 'dot.com' boom of the latter 1990s that innovative business models could offer new ways to create and capture value, and that thereby the traditional market incumbents could to some degree be bypassed (Osterwalder et al., 2005; Osterwalder and Pigneur, 2010; Wirtz et al., 2010). That is to say, such organizational innovation allows the terms of competition to be changed in such a manner that the traditional incumbents find it difficult to respond. Typically but not necessarily, new business models emerge in turbulent technological, economic and regulatory contexts, when new ways of conducting business become possible. Equally, innovative business models can be independent exogenous forces for change—with perhaps The Body Shop as a paradigm example. It is increasingly argued that business model innovation is not only important for the attainment of wider sustainability goals, but also that government should intervene to support such innovation (Birkin et al., 2007). However, where technology is changing quickly, and where the regulatory context is also under change, then traditional barriers to new entrants or novel ways of conducting business may be lowered or disappear altogether. Innovative business models can therefore be deployed to access existing markets, or may be co-emergent with entirely new markets. It is expected, therefore, that a business model is unlikely to be a static 'blueprint' so much as an evolving entity, dynamic and emergently flexible according to internal transformational processes and external stimulus (Demil and Lecocq, 2010). So while the case of Better Place in Denmark is outlined here it may be expected that the business model will change over time, perhaps tending to stability as the wider market becomes more settled.

More fundamentally, as is the case discussed here with Better Place, it might be that innovative technologies that have the potential to meet key sustainability targets are not easily introduced by existing business models within a sector, and that only by changes to the business model would such technologies become commercially viable (Beaume and Midler, 2009). In this sense, innovative business models may be a pre-requisite to the success of new technologies in the market and hence to the contribution such technologies might make to broader environmental targets. Moreover, technological product changes may arise as a response to, but also call for, changes in governmental regulation of the product or the market that the product serves. This in turn can erode the distinctions between sectors, such that the existing boundaries or demarcations of commercial interest become blurred or even disappear. In some respects such a process of boundary erosion has already occurred in the previously distinct sectors of telecommunications and computers, as networked services brought in new entrants (such as Skype) and merged the previously separate interests of computer hardware suppliers and telephone service suppliers. It is pertinent to note that recent theorization on business models has underlined the significance of relationships beyond the boundaries of the firm itself (Zott and Amit, 2010).

In terms of the quest for low-carbon mobility and the use of BEVs a similar type of convergence appears to be underway, with the need to integrate the traditional automotive industry activity of vehicle manufacturing and sales with sectors that have previously been quite distinct (Mitchell et al., 2010; Waller, 2011). This process includes the electricity generators, the electricity distributors (including wholesale supply and purchasers), mobile telecommunications providers, digital mapping and information suppliers, physical infrastructure providers (both of road networks and items such as parking, recharging stations), suppliers new to the automotive industry in respect of novel battery and powertrain systems, local and city authorities concerned with traffic management and related issues, and new 'intermediaries' such as Better Place (Andersen et al., 2009). The deployment of BEVs requires the orchestration of infrastructure provision with new BEV availability such that all of the involved parties are coordinated in order to 'jump start' the new market for electric vehicles. Much of the socio-technical experimentation evident in locations around the world is to do with the desire to trial potential solutions while simultaneously providing a mechanism for cooperation among previous unconnected parties (Accenture, 2011; Charue-Duboc et al., 2011; Harper and Wells, forthcoming; Hildermeier and Villareal, 2011).

Unsurprisingly, even in a world characterized by some as 'flat' or undifferentiated (Friedman, 2005), the unfolding of these intertwined forces for change in terms of technology, regulation, business model, markets, and industrial structures is highly place-specific (Mikler, 2009; Wells, 2010b). Indeed, when the issue of renewable energy is also a key consideration it is obvious that not all places have the same renewable resource endowment or potential, or the same degree of exploitation of the potential. Hence some places, and here notably Denmark, are relatively 'advanced' locations where for a variety of historical and spatially-specific reasons all of the key parameters are thought to be present. While such circumstances are unlikely to be simply replicated elsewhere, the case is indicative of the way in which innovative business models may be developed to create and exploit new opportunities, and hence the principles are relevant to multiple other locations that are also undergoing similar transitions albeit temporally lagging the Denmark case (see Wang and Kimble (2011) for China for example). Better Place as a concept is not confined to Denmark, with experimentation also going on in Israel, Australia California and China for example (Procter, 2011; Better Place, 2011).

In this paper the methodological approach is that of a structured case study that allows an exploratory exposition of the key issues within a specific context, from which more general implications may be tentatively drawn. The primary hypothesis seeks to test which conditions are a necessary prerequisite for business model innovation that allows greater sustainability. In this regard, the research firstly investigates whether Denmark really represents a 'best case' scenario for such business model, and secondly whether such benign conditions are able to counteract the power of the entrenched incumbents and the existing way of doing things. The context for the new business model is investigated by considering government policy for BEVs and for renewable energy production in Denmark. Innovative business models and mobility concepts are thought to need a 'nurturing' environment, at least by the protagonists of strategic niche management. Thereafter, it is necessary to examine the actual Better Place business model with a view to understanding the relationship between this model and the supporting or nurturing environment.

3. Denmark and the policy context for BEVs and renewable electricity production

3.1. Overview

As noted above, regulatory and policy change within a spatial jurisdiction may provide the opportunity for innovative business model design, and indeed protagonists of such organizational innovations may be active in seeking to shape the emergent regulatory environment. Hence in seeking to understand the basis of business model innovation it is pertinent to analyze the policy framework.

The member states of the European Union agreed in 2009 on a renewable energy directive which included EU-wide goals for the implementation of renewable energy sources. The so-called renewable energy sources RES directive (EU, 2009b) calls for the European Union to reach a collective goal of a 20% share of energy from renewable energy sources by 2020 and a 10% share of renewable energy in the transport sector.

The collective EU goal, broken down between the member states, and Denmark, is committed to achieving 30% renewable energy target by 2020 relative to 19.7% in 2009 (The Danish Energy Agency, 2010a). The progress in achieving this goal in the RES Directive is monitored via the National Renewable Energy Action Plans (NREAP). The NREAPs includes annual sector targets and details on the technology mix along with a description of policies required to accomplish the respective targets. The share of renewable energy in the transport sector was by 2010 only 1.0%, according the Danish NREAP, primarily achieved through electric trains and a small amount of bioethanol blended in gasoline (Ministry of Climate and Energy, 2010). The 2020 target on 10% renewable energy in the transport sector is planned to be met partly by the use of biofuels and a partly by implementation of electric cars (Ministry of Climate and Energy, 2010).

A new energy agreement was closed in March 2012 covering the period 2012–2020 between the government and the opposition in the parliament. The agreement includes a range of initiatives concerning energy efficiency, renewable energy and the energy system. The expected result of these initiatives is that 50% of the electricity by 2020 will be supplied by wind power and more than 35% of the final energy consumption supplied by renewable energy sources (The Danish Energy Agency, 2012). Promotion of electric cars is also emphasized in the energy agreement.

Implementation of electric cars is an efficient way of reducing CO_2 emissions. There are mainly three reasons for that:

(1) A number of well-to-wheels studies indicate that electric vehicles are more energy efficient than combustion engine cars (van Vliet et al., 2011; Campanari et al., 2009, IEA, 2011; The Danish Energy Agency, 2008) and that adoption of BEVs on behalf of conventional ICEs will result in reduced GHG emission—depending on the configuration of the local energy systems and the vehicle charging conditions (The Danish Energy Agency, 2008; van Vliet et al., 2011).
(2) BEVs charged from the electric grid transfer CO_2 emissions from the transport sector into the energy sector. CO_2 emissions from the energy sector are regulated by the European emission trading system which works as a 'cap and trade' system with maximum limit on CO_2 emissions. Transferring emissions from the transport sector into the energy sector means that the energy sector is forced to implement further energy savings or increase the share of renewable energy sources in order to provide the needed electricity without exceeding the emission cap.
(3) Implementation of electric cars can potentially improve the efficiency of the energy system and improve the economy of renewable energy sources such as wind power. However, that will only be the case if the BEVs are charged intelligently according to the given production and consumptions patterns in the energy sector. We will elaborate more on this aspect later in the article.

Hence, it is clear that at an EU and national (Denmark) level there is a strong presumption in favour of bringing BEVs to market as one key strategy to reduce CO_2 emissions.

4. Wind power in Denmark

Wind power composes an essential element of the Danish energy system. In 2010 there were more than 5100 wind turbines operating in Denmark producing roughly 20% of the domestic electricity supply (The Danish Energy Agency, 2011). The other components in the electricity production are currently, coal (44%), natural gas (10%) and the rest being biomass incineration, waste incineration and oil (The Danish Energy Agency, 2010a). Additional wind power capacity is already planned both onshore and off shore. Fig. 1 illustrates the implementation of wind energy in the Danish energy system.

The total installed wind power capacity in Denmark was 3802 MW in 2010 (relative to an installed capacity in the entire energy system on approximately 13,400 MW). The "energy agreement" from spring 2012 furthermore entail a considerable expansion of the wind power capacity resulting. Approximately 50% the electricity consumption is to be covered by wind power by 2020 (TThe Danish Energy Agency, 2012).

An important problem that arises from the implementation of wind power is the problem related with fluctuations in electricity production caused by changing weather conditions (Hammons, 2008). Such fluctuations are currently managed partly by adjusting production levels of other components in the electricity generation system and partly by the exchange of electricity between domestic energy markets in Northern Europe.

Wind power is introduced on the market at the lowest price due to the low marginal costs of wind power. The wind power thereby prices out the more expensive units such as the oil and gas fuelled power stations (Energianalyse, 2007). The same situation is present on the common Nordic energy markets called Nord Pool where excess capacity of wind power, in periods where favorable weather conditions result in high wind power production, cause hydro power stations in Norway and Sweden to discontinue production and hold back water in reservoirs until the wind power turns down and prices rise again.

Increased amounts of wind power in the energy system result in two types of challenges namely energy security and system sufficiency (Energianalyse, 2007). System security has to deal with the ability of the energy system to adjust to large and abrupt changes for example caused by a storm. When a storm hits, the system needs to be able to absorb huge quantities of electricity and quickly produce the needed electricity again when the storm is over. Energy sufficiency on the other hand has to deal with the ability of the energy system to deliver the needed electricity at any time. What is important to system sufficiency is how much electricity the wind power is able to guarantee when the demand is at its peak. The problems with obtaining energy security and system sufficiency can be reduced if the Northern European energy markets are integrated more closely; if the wind turbines are geographically scattered over a large area or if the demand for electricity is adjusted according to the given energy production levels. Herein, is the potential significance of BEVs that are charged while wind power production peaks (van Vliet et al., 2011). Such a system is required to be managed by what is termed a 'smart grid' (Kempton and Tomic, 2005). Ideally, such a smart grid could provide real-time information on energy supply, demand and prices, and prevent so-called 'uncontrolled' recharging of BEVs (Papadopoulos et al., 2010). Thus the nurturing environment of Denmark clearly includes an opportunity to maximize BEV benefits via the co-management of renewable electricity generation. A business model that in some regards speaks to this opportunity would in theory have a stronger position as a result.

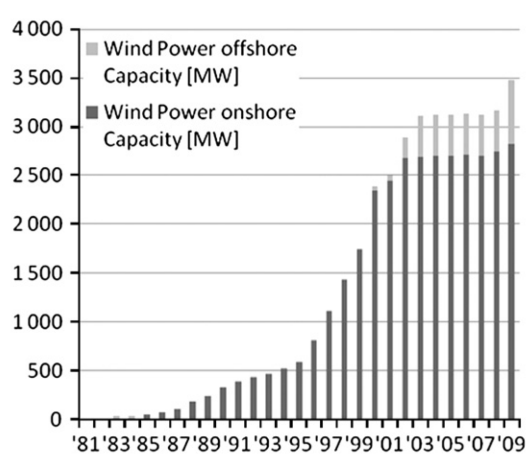

Fig. 1. Installed wind power capacity in Denmark (The Danish Energy Agency, 2010c).

5. The Danish transport sector

In Denmark, the transport sector in 2010 emitted 32.7% of the total CO_2 emissions (The Danish Energy Agency, 2011). Roughly half of these emissions come from petrol and diesel fuelled passenger cars (The Danish Energy Agency, 2011). As a result, energy companies (such as DONG energy), transport companies, regulators and public authorities have pointed at the introduction of electric cars as a way of reducing CO_2 emissions. Conventional petrol or diesel cars are in Denmark subject to a high registration fee. The registration fee is primarily determined by the purchase price of the car. The first 79,000 DKK (€10,590) of the value of the car has a registration fee of 105% and the value that exceeds 79,000 DKK has a 180% registration fee. A small discount is given to energy-efficient cars while inefficient cars on the contrary get a penalty. The high registration fee provides the Danish state budget with around 24 billion DKK, annually (€3.2 billion).

It is well established that as a result of novel technologies, different materials and low production volumes BEVs have a higher retail price than comparable cars with internal combustion engines. Early examples on the market in 2011, such as the Mitsubishi iMieV and the Nissan Leaf have a retail price in the region of €25,000, almost three times the equivalent of comparable conventional cars. Compared with conventional cars, BEVs, therefore, have a high purchase price, but low per-kilometer running costs (approximately 30% of that for conventional cars of a similar size) though precise comparisons are highly dependent upon the price of oil and the level of government incentives (Diem, 2010). Moreover, the performance of such BEVs is not directly comparable to conventional cars: BEVs have stronger initial acceleration, a smoother power delivery, but also lower top speed, long recharging times and much reduced range. BEVs in Denmark are exempt from the registration fee up to 2015 (The Danish Government, 2011). The tax exemption helps close the price gap between conventional cars and BEVs. Once again this suggests that the context for the development of an innovative business model is strong, with the government offering significant incentives for an early consumer take up of BEV ownership and use.

6. Better Place: A case study

As noted above, BEVs represent a rather different proposition to consumers compared with conventional vehicles. Along with the high initial price and low running costs, BEVs also bring a degree of risk in that consumers can be less certain of the performance of such cars over a long time period. Crucially, the battery pack constitutes a high proportion of the extra cost and the technology risk, given that the anticipated useful life of such a pack is eight to ten years. The restricted range also promotes 'range anxiety' in consumers, who do not wish to be stranded in a vehicle where the battery is depleted. Moreover, proper management of the battery in terms of discharge and recharge cycles, slow charging versus fast charging, and other aspects of vehicle use will make a substantial difference to battery performance and durability. Hence, even attempts at assisting BEVs to becoming price competitive with equivalent conventional options, as being undertake in Denmark, may not be sufficient to attract a critical mass of consumers to BEVs. Combine these market concerns with the wider coordination issues noted above in terms of infrastructure deployment, renewable energy use, and vehicle availability, and it is readily appreciated that achieving a substantial proportion of BEV penetration is a significant challenge.

Better Place is an entrepreneurial company that seeks to provide BEV solutions to consumers while simultaneously managing the transition to a BEV fleet. The company is based on a novel business model in which Better Place owns and coordinates the electric car charging infrastructure, including battery ownership, charging facilities and the actual charging of batteries. Consumers purchase an electric vehicle and sign a contract with Better Place by which the consumer leases a battery and subscribes to annual mileage limit. Better Place then provides the consumer with an installed infrastructure such as charging spots and automatic battery switch stations and manages the charging of the battery. Consumers are offered two charging options: they can either plug their BEV into a charging spot or they can chose to use the battery switch stations if they need to drive long distances or need fast recharge. Better Place earns money from battery leasing, coordinating and charging of the batteries and the related infrastructure. Fig. 2 illustrates how Better Place coordinates intelligent charging according to battery level and expected driving pattern of the electric car owners on the one hand and according to price levels on the electricity market on the other hand.

Better Place has developed projects like the one in Denmark described here in other locations including Honolulu, Israel and Canberra Wolfson et al., 2011: 174) claim.

> 'Although Better Place strives to deliver services that will facilitate the confident adoption and use of EVs while optimizing the customers access to and use of energy, it also collaborates with ecosystem players to create a compelling and integrated solution, i.e., a sustainable solution.'

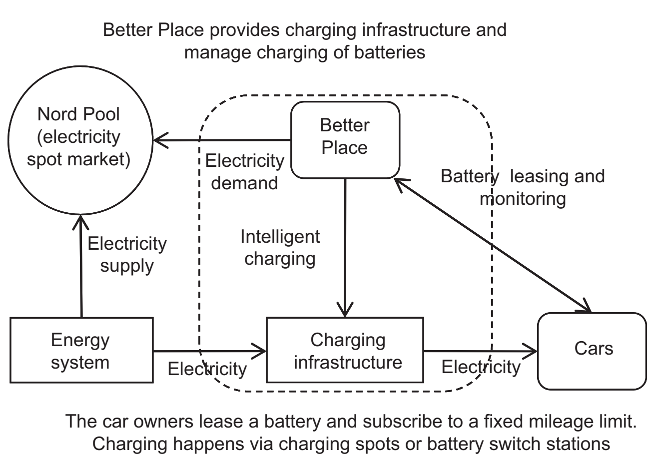

Fig. 2. The Better Place Model (inspired by Andersen, 2010).

7. The cars

Better Place has so far only managed to sign an agreement with one vehicle manufacturer namely Renault which offers their Ranault Fluence ZE to Better Place's consumers. The Renault Fluence ZE is a five-seat sedan that looks similar to the conventionally-powered Renault Fluence. The car has a peak power of 70 kW at 11,000 rpm and a maximum torque on 226 Nm. The top speed is 135 km/h and the 270 kg lithium ion battery offers a range of 185 km in mixed driving when fully charged, according to Renault. A full charge will take approximately 6–8 h. The car is offered to consumers in Denmark for 205,000 DKK (€27,480) without the battery. Renault will offer a small city vehicle called Renault ZOE and a Kangoo car-derived van by autumn 2012.

The fact that only Renault is offering cars within the Better Place system is a major disadvantage for Better Place. Currently, the number of BEVs offered is limited but in the near future Opel, Peugeot, Citroën and Nissan will be offering BEVs as well. Consumers that prefer a vehicle other than that from Renault will have to buy it outside the Better Place system. Better Place will on the other hand have the first-mover advantage and furthermore be able to provide consumers with an installed infrastructure including the battery switch stations. Better Place is negotiating with other vehicle manufacturers but the Better Place model requires that vehicle manufacturers design their vehicles to fit the system. That means that they will have to design their cars to fit the battery switch stations developed by Renault and onboard electronics designed by Better Place. Especially the battery part is complicated as battery technology is perceived as a core technology in the car industry. A standardized interface between the switch station and the vehicles would inevitably restrict the design freedom and provide Renault with a first mover advantage. It is therefore unlikely that other vehicle manufacturers will introduced in the Better Place system unless the business model with the switch stations becomes such a big success that it forces other vehicle manufacturers to accept the standard. It is possible that weaker new-entrants might be more inclined to subscribe to the Better Place system, and in this regard vehicle manufacturers from countries such as China or India that currently lack an EU market presence might align their offerings with Better Place.

8. The batteries

As noted above, in this business model the batteries are owned by Better Place and leased to the customers. Current prices for batteries are in the range of 2250–4000 DKK per kW h (€302–536 per kW h) (The Danish Energy Agency, 2010b) which means that the price of a 22 kW h lithium-ion battery for the Renault Fluence ZE will be between 49,500–88,000 DKK (€6635–11,796).

The customer does therefore not need to pay the initial purchase price for the battery. Instead the battery is financed by Better Place via the subscription fee. The leasing model places the technological risk associated with the batteries at Better Place but also of course the capital cost invested in the required stock of batteries. Of necessity given recharging times and the locations of the recharging stations a buffer stock of batteries is required such that a recharged battery will always be available when a customer needs it, further multiplying the number of batteries in which Better Place has to invest. Fast charging at the battery switch stations (full charge in less than one hour) means that each station has to stock at least 12 batteries. Interestingly, the system will also allow Better Place two other potential advantages. First, as battery technologies develop they can be released into use with the existing fleet, so long as the size and interfaces match with the

Better Place specification—thereby 'future proofing' the technology somewhat for customers. Second, Better Place will ultimately have a stock of used batteries to dispose of, but these can be used in less demanding applications including temporary energy storage of the kind that is useful in power grids with a high proportion of renewable energy sources assuming bi-directional power interfaces are available.

9. Intelligent charging

In effect, the business model from Better Place hinges on the ability of the company to act as a smart grid operator. The charging spots are connected directly to the grid and contain a smart meter and a control device that manage the charging of the vehicle. The battery switch stations automatically switch the batteries within 3 to 5 min.

When charging the cars Better Place acts as a broker between the vehicle owner and the energy market. The vehicles are expected to be plugged into the grid for a longer time than it actually takes to charge the battery. A full charge of the Renault Fluence vehicle will take approximately 6–8 h but the average distance that Danes travel per day is less than 40 km (Jensen, 2009). The average vehicles will therefore only need around 20% charge to be fully charged equivalent to 1–2 h of charging per day. This provides flexibility for Better Place to charge batteries while energy prices on the spot market are low which typically coincides with high amounts of wind power in the system.

The intelligent charging is from an energy system perspective crucial. The demand curve is typically falling during night and peaks in the late afternoon around 6 pm when consumers return from work and switch on appliances in the households. Fig. 3 illustrates an example of the energy consumption in Western Denmark during a week in May 2011. The figure also illustrates the production of wind power in the western part of Denmark where the majority of Danish wind turbines are installed.

If the charging of electric vehicles is not intelligently controlled then vehicle owners are likely to return from home and plug-in their vehicles and begin charging when the demand is already at its peak. That will cause capacity problems in the energy system and lead to higher prices. The implementation of renewable energy sources will furthermore be complicated as both high peaks in demand and fluctuations caused by renewable energy sources necessitate high-price back up capacity. That would ultimately lead to a less efficient energy system and higher energy prices for the consumers. The Danish Energy Authority has calculated that if 200,000 electric vehicles are deployed by 2020 then they can be charged during night without adding extra capacity. If charged during peak hours via uncontrolled charging then an additional capacity on 250–300 MW is needed (The Danish Energy Agency, 2010b).

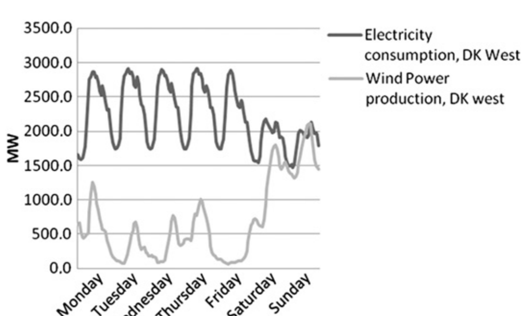

Fig. 3. Electricity consumption and wind power production during the first week of May 2011 (Energinet, 2011).

Night time charging would improve the economy of wind power installations and at the same time provide a more efficient energy system (The Danish Energy Agency, 2010b) with less strain on the grid, although localized clustering of recharging vehicles may cause hotspots that overload the low-voltage distribution system.

Another reason for intelligent charging is that electric grid, more specifically the distribution part of the electric grid, only has capacity to charge a certain amount of vehicles. The load on the grid follows the demand curve and is therefore lower during night hours. Night time charging will therefore place less strain on the distribution grid (The Danish Energy Agency, 2010b).

10. The finances

The customer in the Better Place system does not pay directly for the electricity consumed while charging but pays according to a fixed number of kilometers. Customers are offered five different packages with 10,000, 15,000, 20,000, 30,000 or more than 40,000 km per year. If the customer drives more than the package allows then a fixed price per kilometer balances the payment. Charging is managed by Better Place while the vehicle is connected to the charging station. The customer is equipped with an identity card (ID) card and that allows the customer to use any Better Place charging station.

When signing the contract with Better Place each customer pays a subscription fee of 9995 DKK (€1340) which partly covers the installation of a charging spot at a location chosen by the customer (typically at the home or work place). Better Place plans to have around 7–800 public charging spots installed by the end of 2012. Approximately 200 public charging spots (plus 230 charging spots at private BP costumers) were installed by May 2012. The price of the charging spots varies according to the distance to the electric grid and the specific soil characteristics. There is no official price for the charging spots but an estimated price is around 20,000 DKK (€2680). According to Williams (2008), the business model has been well received by entities such as Deutsche Bank, who believe that the BEVs under this model will be competitive on price with traditional cars.

An innovative element in the Better Place business model is the battery switch stations. The first 4 stations will be opened to the public in mid-2012 and Better Place expects to have 20 stations in operation by the end of 2012. The price of the battery switch stations is estimated at around €2 million.

A combination of the sunk costs in batteries and those associated with the recharging and battery swap infrastructure means that Better Place is based on a capital intensive business model. In early 2010, Better Place secured investment from a consortium of UK investors, led by HSBC, which invested US$350m, thereby increasing the valuation of the business to US$1.25 billion. Along with HSBC investing US$125m new investors included Morgan Stanley Investment Management and Lazard Asset Management. These investors joined existing investors including Israel Corp, VantagePoint Venture Partners, Ofer Hi-Tech Holdings, Morgan Stanley Principal Investments, and Maniv Energy Capital, among others, as shareholders of Better Place. Under the agreement, HSBC took a 10% holding in Better Place. Better Place require this capital to finance the installation of charging stations, the installation of automatic battery switch stations, development of technical infrastructure to control charging of batteries and communication with electric car owners and energy producers. Better Place furthermore has to finance the actual charging of the vehicles. This is done in a complex computer system that coordinates charging profiles for each individual vehicle owner, local grid capabilities and energy prices.

Predicting the location and characteristics of BEV loads is an important new requirement to managing the overall system load (Papadopoulos et al., 2011). All these investments are financed by the monthly fee paid by the vehicle users and partly by the subscription fee. The business model therefore requires a critical mass of customers in order to reach economic break-even. In this respect, a key weakness of the business model is that it still faces a 'chicken and the egg' situation where a critical mass of vehicle owners are needed to cover infrastructure costs while installed infrastructure at the same time is needed upfront in order to attract potential vehicle owners.

Better Place together with the shareholder DONG Energy initially announced that they aimed at 500,000 electric vehicles in Denmark by 2020. This number was in summer 2010 reduced to 20,000–100,000 but currently there exists no official number by which Better Place will reach economic break-even. The numbers should be seen in the light of the current number (spring 2012) of electric vehicles of less than 1000 units and a total vehicle fleet of 2 million cars.

11. Analysis and conclusions: Innovative business models as a vector for sustainable mobility?

The research has shown firstly that Denmark does indeed offer an incredibly supportive setting in which to establish an innovative business model and thereby establish a more sustainable form of automobility. Indeed, few other locations could offer such an opportunity, particularly as it is combined with a broadly supportive cultural setting (Denmark has often taken the lead on a wide range of environmental issues), a broadly supportive economic setting, and a firm commitment from government to pursue the low-carbon agenda in all areas including transport. The research has also shown that Better Place has created a business model and product-service offering that is indeed innovative and which attempts to address perceived problematic aspects of electric vehicle ownership. Yet, as of spring 2012, Better Place has been vanishingly insignificant compared to volume of cars provided by the established mainstream automotive industry and the culturally embedded approach to personal automobility. It might be thought that innovative business models would allow the conventional auto-industry business model to be circumvented, but to date that does not seem to have happened.

Business model innovation is likely to be easier for new entrants than for incumbent entities that have deeply established practices, procedures and operational norms. Indeed, the literature on business models is often concerned with the difficulty of significant transformations in existing businesses with existing models (Chesbrough., 2010). If Better Place is successful with this business model, it is going to be extremely difficult for other businesses such as vehicle manufacturers or electricity suppliers to compete. From the perspective of sustainability, however, the survival of the new business model in competition is but one consideration. Such survival is a necessary but insufficient condition of meeting the test: is personal mobility more sustainable as a result of this business model? If the model remains small, with just a few hundred BEVs in circulation, then it is likely to fail as a business but also will be insignificant as a contribution to more sustainable mobility.

At this stage it is not possible to calculate the CO_2 emissions reductions that could arise from the widespread adoption of BEVs in Denmark using a high proportion of renewable energy to generate the electricity. However, the case does illustrate that business models need to embrace the internal and external relations of the business, and that such models are not just narrowly about how value is created and captured by the firm, so much as how the interlinked network of firms and other agencies benefit. Hence, the long-run evaluation of the success or otherwise of the Better Place business model needs to account for, say, the extent to which BEV's are implemented without having to increase capacity (insofar as the increased capacity can be attributed to BEV charging). In some respects, therefore, a full evaluation would require tools and data more akin to those developed in industrial ecology than the traditional metrics of business evaluation. Around the world there are a great many initiatives under way with government support to encourage the adoption of BEVs (Williams, 2009; Procter, 2011; IEA, 2011). The major economies have declared that they aim at reaching an annual sales target on 7 million BEV's by 2020 (IEA, 2011). However, many of initiatives appear premised on a largely unchanged automotive industry and without the intervention of new intermediaries such as Better Place. It is perhaps significant that the locations chosen by Better Place are rather conspicuous for their lack of a significant incumbent vehicle manufacturer, for their small scale, and for the opportunity to use renewable energy to generate the electricity required. This all suggests that the Better Place solution may remain a niche rather than mainstream business, and hence, that its contribution to sustainable mobility, while valuable on a local scale, may not be replicated more generally. Either way, on the evidence to date it would appear that an innovative business model allied to novel technology and a supportive context are still insufficient to make a substantial difference to the entrenched practice. In turn, this means that some of the more optimistic expectations for business model innovation may need to be tempered by an understanding of how, in particular sectors or areas of activity, the barriers to change are truly formidable.

References

Accenture. 2011. Changing the game: plug-in hybrid electric vehicle pilots, London: Accenture. Copy obtained from 〈http://www.accenture.com/us-en/Pages/insight-changing-game-plug-in-electric-vehicle-pilots.aspx〉, 14th April 2011.

Andersen, P.H., Mathews, J.A., Rask, M., 2009. Integrating private transport into renewable energy policy: the strategy of creating intelligent recharging grids for electric vehicles. Energy Policy 37 (2009) 2481–248.

Andersen T. 2010. Better Place løsningen I Denmark (The Better Place Solution in Denmark). Presentation held in the Council for Sustainable Traffic, 23. March 2010. Copy obtained from 〈http://www.baeredygtigtrafik.dk/betterplace2010.pdf〉 on 2nd of May 2012.

Baden-Fuller, C., Morgan, M.S., 2010. Business models as models. Long Range Planning 43, 156–171, http://dx.doi.org/10.1016/j.lrp.2010.02.005.

Beaume, R., Midler, C., 2009. From technology competition to reinventing individual ecomobility: new design strategies for electric vehicles. International Journal of Automotive Technology and Management 9 (2), 174–186.

Better Place. 2011. Better Place, China Southern Grid Strategic Agreement Centered on Battery Switch Model, Press Release 27 April 2011, Copy obtained from 〈http://www.betterplace.com/the-company-pressroom-pressreleases-detail/index/id/better-place-china-southern-grid-sign-strategic-agreement-centered-on-battery-switch-model〉 (30 June 2011).

Birkin, F., Cashman, A., Koh, S.C.L., Liu, Z., 2007. New sustainable business models in China. Business Strategy and the Environment 18, 64–77, http://dx.doi.org/10.1002/bse.568.

Campanari S., Manzolini G. and de la Iglesia F.G. 2009. Energy analysis of electric vehicles using batteries or fuel cells through well-to-wheel driving cycle simulations, Journal of Power Sources, 186: 464-477. Copy obtained from http://dx.doi.org/10.1016/j.jpowsour.2008.09.115.

Charue-Duboc F., Midler, C. and Maniak R. 2011. The role of experimentations in managing electric vehicle deployment. Paper Presented at the 19th International Gerpisa Colloquium on 'Is the Second Automobile Revolution on the Way? 8th to 10th June, Paris.

Chesbrough., H., 2010. Business model innovation: opportunities and barriers. Long Range Planning 43, 354–363, http://dx.doi.org/10.1016/j.lrp.2009.07.010.

The Danish Energy Agency. 2012. Accelerating Green Energy Towards 2020. The Danish Energy Agreement of March 2012. Copenhagen: Ministry of Climate, Energy and Building. Copy obtained from 〈http://www.ens.dk/Documents/Netboghandel%20-%20publikationer/2012/accelerating_green_energy_towards_2020.pdf〉, 1st of May 2012.

The Danish Energy Agency. 2011. Energy statistics 2010, Copenhagen: The Danish Energy Agency, Ministry of Climate and Energy, (www.ens.dk).

The Danish Energy Agency. 2010a. Energy statistics 2009, Copenhagen: The Danish Energy Agency, Ministry of Climate and Energy, (www.ens.dk).

The Danish Energy Agency. 2010b. El-og hybridbiler—samspil med elsystemet, Copenhagen: The Danish Energy Agency, Ministry of Climate and Energy, (www.ens.dk).

The Danish Energy Agency. 2010c. Raw Data Obtained from 〈http://www.ens.dk/da-DK/Info/TalOgKort/Statistik_og_noegletal/Aarsstatistik/Sider/Forside.aspx〉, 22nd June 2011.

The Danish Energy Agency. 2008. Alternative Drivmidler I Transportsektoren, Copenhagen: Danish Energy Agency, Ministry of Climate and Energy.

The Danish Government. 2011. Our Energy (Vores Energi), Copenhagen: Ministry of Climate and Energy, November 2011.

Demil, B., Lecocq, X., 2010. Business model evolution: in search of dynamic consistency. Long Range Planning 43, 227–246, http://dx.doi.org/10.1016/j.lrp.2010.02.004.

Diem W. 2010. The future for electro-mobility, automotiveworld.com. Copy obtained from 〈http://www.automotiveworld.com/news/powertrain/83306-the-future-of-electro-mobility?highlight=denmark〉, 18th June 2011.

E.A. Energianalyse. 2007. 50 pct. vindkraft i Danmark i 2025—en teknisk-økonomisk analyse, Copenhagen: EA Energianalyse. A/s Copy obtained from 〈http://www.windpower.org/download/105/50_pct_vind_EA_Energianalyse.PDF〉, 22nd June 2011.

EEA. 2010. Towards a resource-efficient transport system, TERM 2009: indicators tracking transport and environment in the European Union, European Environmental Agency, EEA Technical Report no. 2/2010.

Energinet.d.k. 2011. Data Obtained from 〈http://energinet.dk/DA/El/Engrosmarked/Udtraek-af-markedsdata/Sider/default.aspx〉, 22nd June 2011.

EU. 2009a. Regulation (EC) No. 443/2009 of the European Parliament and of the Council of 23 April 2009 Setting Emission Performance Standards for New Passenger Cars As Part of the Community's Integrated Approach to Reduce CO_2 Emissions From Light-Duty Vehicle, Official Journal of the European Union, 5.6.2009.

EU. 2009b. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 On the Promotion of the Use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC, Official Journal of the European Union, 5.6.2009.

EU. 2011. Communication from the Commission to the European Parliament, The Council, the European Economic and Social Committee and the Committee of Regions, A Roadmap for Moving to a Competitive Low Carbon Economy in 2050, Brussels, 8.3.2011.

Friedman T.L. 2005. The world is flat: a brief history of the 21st century, New York: Farrar, Straus and Giroux.

Hammons, T.J., 2008. Integrating renewable energy sources into European grids. International Journal of Electrical Power & Energy Systems. 30 (8), 462–475, http://dx.doi.org/10.1016/j.ijepes.2008.04.010.

Harper G. and Wells P. Forthcoming. Diverse regional sustainability strategies: template for the future or squandered resources? International Journal of Automotive Technology Management.

Hildermeier J. and Villareal A. 2011. Sustainable development as a strategic challenge for OEMs: policies on the battery electric car in Germany and France, Paper presented at the 19th International Gerpisa Colloquium on is the Second Automobile Revolution on the Way? 8th to 10th June, Paris.

IEA. 2011. Clean Energy Progress Report, Update June 2011, International Energy Agency, Paris: International Energy Agency.

Jensen C. 2009. Danskernes transport—hvor meget, hvordan, hvor og hvornår? Paper presented at the conference "Trafikdage på Aalborg Universitet", 24–25th August 2009, Aalborg, Denmark.

Kempton, W., Tomic, J., 2005. Vehicle-to-grid power implementation: from stabilizing the grid to supporting large-scale renewable energy. Journal of Power Sources 144 (1), 280–294, http://dx.doi.org/10.1016/j.jpowsour.2004.12.022.

Kley F., Lerch C., Dallinger. 2011. New business models for electric cars—a holistic approach, Energy Policy 39, 3392–3340.

Mikler, J., 2009. Greening the Car Industry: Varieties of Capitalism and Climate Change. Edward Elgar, Cheltenham.

Ministry of Climate and Energy. 2010. National Action Plan for renewable energy in Denmark, Copenhagen: Ministry of Climate and Energy (www.kemin.dk).

Mitchell, W.J., Borroni-Bird, C.E., Burns, L.D., 2010. Re-inventing the Automobile: Urban Mobility for the 21st Century, Cambridge MA. MIT Press.

Osterwalder A.Y., Pigneur Y. and Tucci C.L. 2005. Clarifying business models: origins, present, and future of the concept, Communications of the Association for Information Systems. 15: 1–40.

Osterwalder A.Y. and Pigneur Y. 2010. Business Model Generation, Available from 〈http://alexosterwalder.com/〉.

Papadopoulos S., Skarvelis-Kazakos S., Grau I., Cipcigan L.M., and Jenkins N. 2010. Predicting electric vehicle impacts on residential distribution networks with distributed generation, IEEE Vehicle Power and Propulsion Conference (VPPC) Lille, France.

Papadopoulos P., Akizu O., Cipcigan L.M., Jenkins N., and Zabala E. (2011). Electricity demand with electric cars in 2030: comparing Great Britain and Spain. Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy (PIA). 225(A): 551–566. DOI: 10.1177/0957650911406343.

Procter, T., 2011. EVs: Energy, Infrastructure and Mobility in the Real World. TrendTracker Ltd, Bath.

Roland Berger. 2011. Automotive Landscape 2025: Opportunities and Challenges Ahead, Copy Obtained from 〈http://www.rolandberger.com/expertise/industries/automotive/2011-02-28-rbsc-pub-Automotive_landscape_2025.html〉, 24th March 2011.

Sperling, D., Gordon, D., 2009. Two Billion Cars; Driving Towards Sustainability. Oxford University Press, Oxford.

UNFCC. 2011. Fact sheet: Climate change science - the status of climate change science today, United Nations Framework Convention on Climate Change, Copy Obtained from 〈http://unfccc.int/press/fact_sheets/items/4987.php〉, 22nd June 2011.

van Vliet, O., Brouwer, A.S., Kuramochi, T., van den Broek, M., Faaij, A., 2011. Energy use, cost and CO_2 emissions of electric cars. Journal of Power Sources 196 (2011), 2298–2310.

Waller B. 2011. Developing a new plug-in electric vehicle ecosystem for automotive distribution, Paper presented at the 19th International Gerpisa Colloquium on is the Second Automobile Revolution on the Way? 8th to 10th June, Paris.

Wang H. and Kimble C. 2011. Business model innovation in the Chinese electric vehicle industry, Paper presented at the 19th International Gerpisa Colloquium on is the Second Automobile Revolution on the way? 8th to 10th June, Paris.

Wells P. 2010a. Creating new value-added configurations in the electric vehicle industry, EVS25 Conference, Chengdu, China, 11th–14th November.

Wells, P., 2010b. The Automotive Industry in an Era of Eco-Austerity. Edward Elgar, Cheltenham.

Williams A. 2008. Project Better Place—the road to an electric future? automotiveworld.com, Copy Obtained from 〈http://www.automotiveworld.com/news/powertrain/69022-project-better-place-the-road-to-an-electric-future?highlight=denmark〉, 18th June 2011.

Williams A. 2009. Supporting low-carbon vehicles: the role of government policies in key global markets, automotiveworld.com. Copy Obtained from 〈http://www.automotiveworld.com/news/powertrain/73915-supporting-low-carbon-vehicles-the-role-of-government-policies-in-key-global-markets?highlight=Better+Place〉, 18th June 2011.

Wirtz, B.W., Schilke, O., Ullrich, S., 2010. Strategic development of business models: implications of the Web 2.0 for creating value on the internet. Long Range Planning 43, 272–290, http://dx.doi.org/10.1016/j.lrp.2010.01.005.

Wolfson, A., Tavor, D., Mark, S., Schermann, M., Kremar, H., 2011. Better Place: a case study of the reciprocal relations between sustainability and service. Service Science 3 (2), 172–181.

Zott, C., Amit, R., 2010. Business model design: an activity system perspective. Long Range Planning 43, 216–226, http://dx.doi.org/10.1016/j.lrp.2009.07.004.