

Four Business Models for a Fast Commercialization of Plug-in Cars

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Abstract Plug-in vehicles are one important means to lower CO₂ emissions from the transport sector. Despite this, uptake is slow. This can be well explained by theory on social dilemma problems and on diffusion of innovations. The traditional “sell-and-disengage” business model is not suitable for plug-in cars. Using an entrepreneurial business model generation process we have developed four alternative business models that address important factors for the speed of which customers adopt an innovation. The results show that alternative business models are necessary, but they cannot alone ensure a fast, and lasting, commercialization of plug-in cars. As a complement, governments will have to take measures to control external factors that influence the viability of business models for plug-in cars.

Keywords Plug-in car • All-electric car • PHEV • REV • Business model • Social dilemma problem • Diffusion • Innovation

1 Introduction

Plug-in vehicles are seen as one important means to lower CO₂ emissions from the transport sector and to reach a fossil independent vehicle fleet by 2030, a goal set by the Swedish government.¹ The slow commercialization of plug-in vehicles seems to have taken people by surprise.² What is surprising though are the high expectations

¹ See <http://www.regeringen.se/sb/d/15703/a/196433> (read 2013-09-03).

² Illustrations: <http://www.theengineer.co.uk/blog/uk-electric-car-take-up-is-slow-while-carmakers-charge-ahead/1016123.article> or <http://www.bloomberg.com/news/2013-05-27/german-automakers-falter-in-meeting-million-electric-goal.html> or <http://www.gizmodo.com.au/2012/01/electric-cars-off-to-a-slow-start/> (read 2013-09-03).

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of a rapid shift to plug-in cars, and even more surprising is the stubbornness most plug-in carmakers show when sticking to the same business model they use for traditional cars, despite the disappointing sales figures achieved when it is used for plug-in cars. The slow uptake of plug-in cars can be well explained by theory on social dilemma problems and on diffusion of innovations. By building on these two theories, we have developed four alternative business models that address the reasons why the traditional car sale business model is inefficient for plug-in cars. The business models' viability have been tested, and from that, conclusions can be drawn about specific societal support that will be required to avoid the risk of future social dilemma problems that may obstruct a fast introduction of plug-in cars.

The paper is structured as follows. First we set the terminology on plug-in cars used for this chapter. Then a brief description of the business model concept is given. After that we explain why the current business model for cars does not work for plug-in cars, after which we look into what issues a business model for plug-in cars should address. Thereafter follows a description of the business model generation process we have used for developing the four business models, which are then depicted through a common template. We then revisit the social dilemma problem, where governmental intervention is most likely required for a diffusion to take place and then not discontinue. The chapter ends with a concluding section including a description of limitations.

2 Terminology

The terminology for plug-in electric vehicles is not yet well defined. The study behind this chapter has focused on cars, although our findings may be relevant also for other vehicles. With plug-in cars we mean all cars that can be charged from the grid, i.e. both *all-electric* cars, like Nissan LEAF and the Tesla cars, plug-in hybrid (*PHEV*) cars, like Volvo V60 PHEV and Toyota Prius Plug-in, and range extender cars (*REV*), like Opel Ampera and BMW i3 with the range extender option. Since all plug-in cars, except the all-electric cars, can easily replace a traditional internal combustion engine (ICE) car, we have had the all-electric car in focus when designing the alternative business models. The business models should however be applicable, potentially with some adjustments, also to the other types of plug-in cars.

3 What Is a Business Model?

A business model is a description of how a company creates, delivers and captures value [1, 2]. A viable business model must provide value to the customer that is higher than the costs for providing it, and then capture the difference. Business models unleash technologies' inherent value with different degrees of efficiency and with different characteristics [3]. In the most common "sell and disengage" business

model, the ownership of a product, and all its future costs are transferred to the buyer in exchange of money at point of sale, possibly with some warranties included. An alternative business model can be to keep ownership of the product and sell access to it as a subscription, like renting an apartment.

It is the business model that defines what the offering will be compared with. A traditional “sell-and-disengage” business model for plug-in cars will make the established ICE cars the obvious reference point, while a carsharing service like Car2Go can have taxi and public transport as reference points.

A key to a viable business is the business model owner’s ability to capture the excess value, i.e. the value above the cost for providing it. Since there is limited willingness to pay privately for something that will benefit the commons [4] this is extraordinary challenging when a substantial part of a product’s value is common good and not private good. This will be further discussed in the section on social dilemma problems.

4 Why the Current Business Model for Cars Doesn’t Work for Plug-in Cars

The “sell-and-disengage” business model where the physical product ownership, and hence all risk, is transferred to the buyer at point of sale may work fine for established technologies with low perceived risk, but not for novel technologies, especially not when they are not up to par with the technology they challenge. Using the traditional “sell-and-disengage” business model for plug-in cars encourages customers to use the ICE car as reference, hence giving three issues unnecessary focus; (1) the higher price, (2) the shorter driving range, and (3) the uncertain battery life length. The hesitance this creates among new car buyers becomes also valid for used car buyers, which makes the used car value uncertain.

People use a higher implicit discount rate for technologies that are unfamiliar to them [5], i.e. they demand a lower “price per utility” than from the established technology. Humans also have a nonlinear perception of gains and losses, where we perceive the punishment from losing as bigger than the joy from winning an equal amount of value [6]. This means that when a new technology performs worse than the established technology in any attribute, it will easily be discarded as inferior.

Price versus operating cost also matters. We can learn from behavioral economics that a high initial price but low future operating cost often is perceived as less attractive than a lower initial cost but higher operating cost, even when the total economic impact is exactly the same [6, 7]. Renault’s decision to sell their all-electric cars without the battery and instead sign up the customer on a forcing monthly lease is an example of change in the temporal distribution of financing to make the all-electric car offering price- and cost-wise more similar to prices and costs of ICE cars.

5 Issues to Address for a Successful Diffusion of Plug-in Cars

Innovations are, by definition, new and unfamiliar at the time they start to diffuse among adopters, and this goes for plug-in cars as well. An innovation is an improvement compared to an existing state or practice among the intended adopters. Plug-in cars, and especially the all-electric car, are an illustration of a valuable solution to a problem that is of common responsibility. The private interest to pay is however dependent on the private good the car provides, and this can create a so-called social dilemma problem. Hence, two general issues to consider when trying to commercialize plug-in cars are how innovations are diffused successfully and how to handle social dilemma problems.

5.1 Social Dilemma Problems

A social dilemma problem is when “individuals in interdependent situations face choices in which the maximization of short-term self-interest yields outcomes leaving all participants worse off than feasible alternatives” [8]. The value a technology provides can be split into common value and private value. The value can be positive, like improved mobility, or negative, like noise, accidents and emissions.

Plug-in cars provide more common value (or more precisely, less negative common value) than ICE cars, for instance less noise, local air pollution and tailpipe emissions. On the other hand, they have difficulties in providing the same amount of private value as the ICE car in terms of for instance price, driving range, charging/(refueling) time, and towing capacity, although they often manage to show a lower energy cost. Hence, the slow adoption of plug-in cars can be seen as an illustration of a social dilemma problem. When most car buyers continue to choose the ICE car because of its perceived higher short-term private value, we may all be worse off.³

5.2 Diffusion of Innovations

The relative speed with which intended adopters, like potential car customers adopt an innovation is highly dependent on five factors [9, 10]. There are of course more factors that affect the adoption speed, but these five are considered most important:

³ c.f. the Stern Review on the Economics of Climate Change, executive summary: http://webarchive.nationalarchives.gov.uk/20130129110402/http://www.hm-treasury.gov.uk/d/CLOSED_SHORT_executive_summary.pdf.

- (1) *Its relative advantage* in terms of economy, initial cost, comfort, social prestige, time and effort saving, and immediacy of rewards. Here, plug-in cars hardly provide clear benefits. Its costs relative the ICE technology are uncertain. Comfort and prestige may be similar to those of ICE cars while time and effort savings depend on its use. It can be better in commuting situations where charging takes place at home and/or at work and hence is more effortless than refueling at a gas station, but it is worse at long-distance driving, even when fast-charging.
- (2) *Its compatibility* with sociocultural values and beliefs, with the technology it is compared against, and with potential customers' need for the innovation. Here, plug-in cars fit well with contemporary values and beliefs in Sweden. The compatibility with ICE cars is insufficient. All-electric cars cannot replace ICE cars to 100 %. Many car owners/users are quite happy with their ICE cars and don't see the plug-in car as delivering innovations they personally have been missing.
- (3) *Its complexity*, i.e. how difficult it is perceived to understand and use. Here, plug-in cars *can* be easy to use and understand, but are not on par with ICE cars, for instance in providing understandable, reliable and consistent driving range predictions, which are crucial to support range anxious drivers.
- (4) *Its trialability*, i.e. if it can be tested on a limited basis. Many auto dealers do not even have plug-in cars in their showrooms, and those who have, offer the same level of testing as for ICE cars. This means you can test drive the car for a while, but not really evaluate it to see if the car really fits in your daily life.
- (5) *Its observability*, i.e. its visibility to others. Many plug-in cars are variants of ICE cars, which make them difficult to distinguish from their more common car cousins. This makes them relatively unobservable in the streets, which in addition makes them difficult for potential owners to use as identity markers.

In summary, plug-in cars have had difficulties in providing sufficiently convincing personal advantages for potential customers. However, the business models used for diffusing plug-in cars do not seem to have addressed the above five factors in order to achieve a successful diffusion.

6 The Business Model Generation Process

A look at the Swedish plug-in car market revealed an astonishing lack of alternatives to the traditional sell-and-disengage business model. In order to appraise alternative business models, which were lacking in reality, a project was set up where the objective was to create four alternative business models and validate them in accordance with recommendations from successful serial entrepreneurs. It was decided to follow an entrepreneurial Customer Discovery business model generation procedure [11–14] where an initial business model hypothesis evolves through a refinement procedure with tests against the assumed customer segment,

financial calculations, and so forth. The hypothesis is refined in cycles until there is an offer that actually is sold to members of the final customer segment.

The alternative business models to be developed should assume plug-in cars maintain the attributes they have today and hence focus on use-cases and customer segments in which the unfavorable attributes of plug-in cars mattered less and the favorable attributes could be emphasized. The business models should also consider the most important five factors for successful diffusion of innovations and try to deal with the social dilemma problem of many plug-in cars.

Initially, 17 business model hypotheses were generated, discussed, compared, combined and briefly checked, either against potential customers or in discussions with companies in similar businesses. They were then reduced in a combination-selection process, inspired by the Pugh Concept Selection Method [15] until four business models remained.

The four business models have not been validated as far as to actual sales since the project was without commercialization intent. However, each business model was refined to the point where potential customers showed substantial interest in the value propositions at prices and costs that were judged as realistic by the companies in similar businesses we used as reviewers of the business models. Reviewers were typically car rental companies, car leasing companies and carsharing companies. The customers that the business models were tested against were first chosen according to each business model's customer segment hypothesis, and then found in our network of friends and friends' friends in the Gothenburg region in Sweden. Interviewers were selected so that no interviewer had previously met or talked to the interviewee.

7 Business Model Descriptions

The business models will be described using a specific structure. Each description starts with *the initial idea* where the initial hypothesis is briefly depicted. *How it works* describe the final business model's function. *Diffusion strengths* highlight the most important strengths among the previously described five diffusion factors, relative to the sell-and-disengage business model. Finally, *viability factors* describe the top most important factors we identified that economically break or make the business case for the business model.

7.1 Conditions

The business models have been developed with all-electric cars in mind, although they might be of value also for plug-in hybrid electric cars and range extenders. Calculations for all four business models (which are available upon request) are

Table 1 Reference cars

Car attribute	Nissan Leaf	VW Golf 1.6 TDI BMT
Electricity consumption (kWh/km)	0.173	n/a
Diesel consumption (l/10 km)	n/a	0.38
Tailpipe emissions (CO ₂ g/km)	0	99

based on an interest rate of 4 %, a fuel price of €1.59/l petrol or diesel, and an electricity price of €0.1225/kWh.⁴

We have used the Nissan Leaf and a Volkswagen Golf as reference cars in business models BM1, BM3 and BM4, their attributes are specified in Table 1. A Volvo V60 Drive Momentum and a broader range of plug-in cars are used as references in BM2 due to a significant difference in customer segment preferences.

Additional business model information such as descriptive folders, storyboards, and short illustrative videos can be found at <http://www.viktoria.se/projects/believe>.

8 Four Alternative Business Models

Here follows a description of each of the four business models that were created by the project using the business model generation process.

8.1 *BM1: Free-Floating All-Electric City Cars*

8.1.1 The Initial Idea

The inspiration for this business model was the fact that more than half of the world population now lives in cities and that it will be more or less impossible for cities of the future to carry the load of today's car density per citizen. Hence, the initial idea was to provide all-electric car based service, providing personal mobility as flexible and as private as a personal car, but with more convenience and less hassle than private car ownership in a city. The idea was also to offer a range of all-electric cars, from vans to Tesla Roadster, so that almost any mobility need or desire could be met.

8.1.2 How It Works

You go by taxi but you are the driver. That is how free floating carsharing works. As user, you pay per minute of use, and that's it. The typical customer is a city dweller who finds it increasingly annoying to own a car in the city but still wants

⁴ These are valid amounts as of June 2013 in Sweden at an exchange rate of 9.10 SEK per €.

personal mobility beyond what public transport and taxis can provide. With free-floating all-electric city cars, you don't have to pre-book, stick to a certain time interval or leave the car where you took it. It's as a taxi, but you drive yourself.

A free-floating carsharing service is established within a designated city zone. Within this area, users may pick up and return the cars at any public parking spot. The user pays per minute of use. Electric energy, maintenance, road tolls etc. are included. The customers are believed to be both private persons and employees on business errands. Typical private customers are people who have no car or families who use the service instead of owning a second car. It is a flexible complement to public transport, just as a taxi is. For people living in city centers it is an added benefit not having to bother about parking. Companies may also benefit from using the all-electric carsharing service instead of compensating employees for driving their own cars and having parking places for them.

Customers book and have contact with the service through a smartphone, tablet or computer, showing where cars are located. The idea is that there should always be enough cars available for the users to mostly book just before use, i.e. the cars are not supposed to be reserved until shortly before they are used. In this business model, it is assumed that the city contributes with free parking if the cars are all-electric. Firstly because an all-electric car doesn't contribute to local air pollution and secondly because a carsharing car replaces 9–13 privately owned cars [16] and hence the service can help reduce car density per citizen. The combination of free-floating carsharing service with all-electric cars is hence superior to a similar ICE solution both for society and for users.

8.1.3 Diffusion Strengths

This business model completely avoids the ICE car as reference point and any car attribute comparison, since it provides a service that rather competes with taxi and public transport. Relative to them, this service costs more than public transport but is more flexible, private and convenient while it costs less than taxi but requires the customer to drive and park.

The strengths relative to the sell-and-disengage business model are:

Relative advantage: It provides access rather than ownership, and 2–3 times higher car utilization than privately owned cars.

Compatibility with sociocultural values and beliefs: It supports the general trend where the interest in owning a car is decreasing [17] and where people move to cities.

Complexity/simplicity: Given that one has a smartphone, which is required to use the service and locate the cars, the service is very simple.

Trialability: The service can be tried out easily and without any long-time commitment. One only pays for the time the car is used.

Observability: It is the visibility of the service rather than the cars' make and model that matters here. Striped⁵ cars at the required density within a designated city zone will ensure a continuous high visibility within that zone.

8.1.4 Viability Factors

A high utilization of these cars is the main tool to make a service like this better with all-electric cars than with ICE cars. The lower mileage cost will offset the higher price.

However, the current battery warranty conditions show to be the main financial constraint since we have to expect a car's residual value to be almost zero when the battery warranty ends.

The second most important factor for the profitability of this business model is that the city can provide low-cost or free parking for electric cars.

A drawback of this business model is that it requires many cars at launch. Customers will only be satisfied if they can easily find a car within a reasonable distance, typically about 200–300 m, and that the designated area is not too small. This can easily sum up to a need of several hundred cars, i.e. a significant investment and hence business risk.

8.2 BM2: Plug-in Cars as Company Cars

8.2.1 The Initial Idea

Company cars, cars provided by the employer for employees to use as their own private cars, are common in Sweden. About 25 % of all new car sales in Sweden are company cars used for this purpose.⁶ Hence, by making plug-in cars attractive as company cars a significant part of the Swedish new car market will be available.

Company car holders are taxed based on the value of the car. For plug-in cars taxation is calculated on a reduced value of the car, making it advantageous for the employee to choose a plug-in car as a company car.

8.2.2 How It Works

The setup for company cars in Sweden ranges from financing models where the employer pays for all costs of the car and the employee is just taxed for the benefit, to financing models where the employee pays for all costs of the car with a gross salary deduction.

⁵ Made unique in appearance with for example color and/or sticker film, see for example <http://www.carscoops.com/2008/04/volvo-launches-new-personalized-sticker.html> (read 2013-10-11).

⁶ <http://www.tjanstebilsfakta.se/artiklar/nyheter/?page=article&nid=827> (read 2013-10-10).

A growing number of companies offer company cars of the latter model, which is cost-neutral to the company. For the employee the cost for such a company car is somewhat lower than if he or she would have bought the same car privately.

For plug-in cars the financing model that is cost-neutral for the company is the worst-case scenario for the employee. The higher price of the plug-in car has to be covered by the employee through a higher gross salary deduction, which in turn needs to be offset by the lower taxation for the car and the lower mileage cost in order for the plug-in car to be competitive relative to an ICE car. Our calculations show that plug-in cars mostly cost the employee less per month than a comparable ICE car. This cost difference increases with increased driving.

In cases where the employer takes all or some of the costs for the company car a plug-in car can be an expensive alternative for the company. Normally, only the employee benefits from the lower tax and the lower mileage costs of the plug-in car, while the employer is affected by the higher purchase price. To make the plug-in car an attractive alternative to both parties, the idea is that the employer, through an additional gross salary deduction gets a share of the benefits which compensates for the higher price of the plug-in car. Even though the full benefits of the plug-in car in this case do not reach the employee, the plug-in car can still be a competitive alternative to an ICE car.

Company cars in Sweden are often used as the family's first car. The car is hence expected to be able to take the whole family and luggage on holiday trips etc. Many company car holders also use their car a lot for business travelling, driving long distances. For these reasons all-electric cars might not be the primary choice as a company car. However, if the employer offers, for example, a car swapping service among colleagues, for use when the all-electric car is insufficient, some of these difficulties might be overcome.

8.2.3 Diffusion Strengths

The main strength of this business model is solidly shown in the fact that such a substantial share of all new car sales in Sweden are company cars. Some diffusion issues are however worth discussing:

Relative advantage: Compared to other company cars, both PHEV and REV cars show to be less costly while they also are 100 % replacements of ICE cars. This should put them on many employees' consideration list if they only are aware of their existence.

Compatibility with sociocultural values and beliefs: PHEV and REV offer the customer a solution that is as convenient as, less costly than, and more environmentally-friendly than a comparable ICE car, which is in line with current Swedish values and beliefs.

Complexity/simplicity: No major difference to private car ownership.

Trialability: This is the weak spot compared to many leasing schemes. This lease is on 60 months, which may be perceived as a significant commitment compared to

the 36 months used for many ICE cars. 60 months is required to get a sufficiently long depreciation time and still have a lower monthly cost. The alternative would be a high used-car market risk, which most likely would make the business case unprofitable for the customer.

Observability: No major difference to private car ownership.

8.2.4 Viability Factors

The most important viability factor for this business model is the Swedish tax regulations for company cars. The reduction of taxation for plug-in cars is however only temporary, and for this business model to be viable it has to be extended, and in the future even adjusted to compensate for the expected decrease of difference between running costs for plug-in cars and ICE cars.

The second most important viability factor is the value of the car on the used-car market. A higher used-car value would further improve the business case of plug-in company cars and/or enable a shorter (more competitive) leasing period.

8.3 BM3: All-Electric Car Subscription

8.3.1 The Initial Idea

This business model is an attempt to increase the utilization degree of cars owned by private persons. The calculus for the all-electric car requires high utilization of the car for it to be competitive compared to a corresponding ICE car. The average privately owned car in Sweden is driven only 11,820 km/year,⁷ corresponding to 32 km/day, which is not even a quarter of the maximum range of a normal all-electric car. Based on these figures we saw great potential in utilizing the cars more, hereby achieving a more competitive cost structure for the all-electric car. The initial idea was inspired by consumer-to-consumer carsharing and when combined with the social trend of decreasing interest in car ownership the result became a carsharing service suitable for car commuters.

8.3.2 How It Works

The all-electric car subscription is a carsharing service for frequent users, people who need access to a car more or less every day. For these frequent users today's carsharing services become too expensive to compete with car ownership. The subscription offers access to an all-electric car at an agreed level, at a fixed monthly

⁷ See <http://trafa.se/PageDocuments/2012.xls> (read 2013-09-10).

fee corresponding to the cost of owning a corresponding ICE car. If the subscriber needs to use a car more than agreed in the contract, excess usage will be charged corresponding to fees paid by regular carsharing customers.

The all-electric car subscription allows the subscriber to use an all-electric car for commuting. When the commuter does not use the car it will be available for regular carsharing customers, hence the utilization of the cars is maximized. When using the all-electric car for commuting it is possible to keep the car at home during the night, and as long as it is fully charged in the morning the night hours are free of charge. The subscription includes all costs of the car, even electricity (fuel). The subscriber does not have to worry about services, reparations and maintenance of the car.

All-electric car subscribers also have full access to the regular carsharing service. This gives the subscribers easy access to a conventional car when the all-electric car is not sufficient, for example for longer trips. The subscriber pays the ordinary carsharing service fee for using a conventional car, but has no costs for the subscription during the time and hence no double car costs occur. All car booking is easily handled through an application available for smartphones.

A positive effect of having subscribers commuting by carsharing cars is that they at the same time are moving cars to where the demand for car access is. During the days the cars will be parked in areas where many people work and during the evenings and weekends the subscribers bring the cars to suburbs and areas where many people live. This movement of cars helps extending the market for the carsharing service.

8.3.3 Diffusion Strengths

This business model lowers the threshold for trying an all-electric car for commuting. Since there is no investment to be done, and the subscription does not imply any long-term commitment the risk that the customer takes by trying this service is minimal. By having the customers pay only for their actual usage of the car, the cost is also competitive, compared to owning a car used for the same purpose.

The strengths relative to the sell-and-disengage business model are:

Relative advantage: It provides access rather than ownership, and 2–3 times higher car utilization than privately owned cars.

Compatibility with sociocultural values and beliefs: The business model supports the general trend where the interest in owning a car is decreasing [17]. Driving an all-electric car is also more environmental-friendly than driving a comparable ICE car, which is in line with current Swedish values and beliefs.

Complexity/simplicity: The service is very simple and flexible, hence adapts to the customers' needs. A fixed all-inclusive monthly fee makes it easy for the customers to predict their car costs.

Trialability: The service can be tested without any long-time commitment, and no admission fee is required. The subscription also makes it possible for carsharing operators to include all-electric cars in their range of cars offered to regular car-sharing customers since high utilization of the all-electric cars is necessary to achieve viability. Offering all-electric cars to regular carsharing customers makes it possible for more people to get experience from all-electric cars.

Observability: The visibility of the service could be optimized by using striped⁵ cars and by branding the service as a smart environmental-friendly alternative to owning a car.

8.3.4 Viability Factors

Occupancy rate of the cars is the most critical factor for the viability of this business model. The low operating cost and high purchase price of all-electric cars means that the more the car is used, the better the viability. The usage is however limited by the battery warranty. Since the car is so highly utilized the mileage limit of the warranty is reached rather soon. This severely limits the earning opportunities of the business. If the battery warranty was extended, or if it was concluded that the all-electric cars will be functional even after the warranty has expired, it would have a very positive impact on the viability of this business model.

This business model is easiest to realize as a complement to an existing public carsharing service. This way the existing customer base creates demand for the cars during periods when the subscribers are not using them.

8.4 BM4: Leasing Chain for All-Electric Cars

8.4.1 The Initial Idea

Rental car companies in Sweden annually buy more than 20,000 new cars. These cars are used in the business for about 18 months before they are sold on the used-car market. If plug-in cars could take a substantial share of this flow they would help establish a used-car value, which is important for a rapid commercialization of plug-in cars.

It might however, be tricky to create both enough demand for plug-in cars and to achieve a profitable business case for the plug-in cars on the rental market, especially for all-electric cars. This has given birth to the idea of the leasing chain in which the all-electric car is kept until its end of life, hereby eliminating the residual value issue.

This business model was initially focusing on finding a way to use all-electric cars in car rental services, but in the resulting version the first customer in the lease chain might as well be a private household, a carsharing service (see BM1 or BM3), a company car provider (see BM2) as a car rental company.

8.4.2 How It Works

Some claim that all-electric cars already today provide lower total cost of ownership (TCO) than comparable ICE cars for many consumers [18], but this is only the case if seen over the total lifetime of the car. If the car is sold before that, the TCO will highly depend on the used car price when sold. Today, there is a considerable uncertainty about used car prices for plug-in cars. One way to reduce this uncertainty is to own the car until its end of life. Most private households are uninterested in such commitments. In fact, a growing share of households is not interested in owning a car at all, as long as they have access to one [17].

The idea with this business model is to let a leasing company own the car and lease it out to a chain of customers until its end-of-life. The potentially lower TCO can then be shared between the leasing company and its customers, and the residual value risk is significantly reduced. Since all-electric cars are expected to need fewer repairs when getting older compared to ICE cars it may be that only all-electric cars can be considered for a used-car operational lease offer. If so, that can be a significant and lasting advantage for all-electric cars in the lease market.

The leasing chain offers operational lease of all-electric cars in a chain spanning several customers. When the car is new it can be leased by car rental companies, carsharing companies and other new-car leasing customers at about the same price and on the same terms as comparable new ICE cars. In the second, third and possibly fourth leasing scheme, the typical customer segment is two-car households in suburban areas who commute daily by car. The reason to focus on households with two cars is that the ICE car can be used in cases where the all-electric car is not sufficient.

The older the car, the more economical an all-electric car is compared to an ICE car. Through all the leasing chain the value proposition must be compared with ICE lease on a per-km basis since the financial lease cost will be higher for an all-electric car but together with the lower running cost becomes much more comparable, even lower.

8.4.3 Diffusion Strengths

Relative advantage: Operational lease gives customers peace of mind, especially compared to owning an old ICE car. A leasing offer for every car age preference is novel and wanted in Sweden, especially offers for leasing of cars with an age that matches households' view of the second car.

Compatibility with sociocultural values and beliefs: Many suburban car commuters are well aware of their carbon footprint but have difficulties in finding reasonable alternatives to car commuting in their "cash-rich but time-poor" lives. Leasing of an all-electric car could offer a competitive solution to this dilemma.

Complexity/simplicity: All costs and leasing time are pre-known. An all-electric car can often be perceived as simpler to use than an ICE car since it doesn't have to be refueled.

Trialability: The business model provides opportunities to compare how an all-electric car fits with one's lifestyle with a commitment limited to the shortest offered leasing period.

Observability: No major difference to private car ownership.

8.4.4 Viability Factors

The top viability factor in this business model is the distance limitation in the battery warranty. Car commuters typically drive more than 20,000 km/year, which quickly accumulate to distances beyond what's warranted.

The second most important factor is the battery warranty time. Many customers are willing to use cars that are older than what is currently covered by the warranty.

The third most important factor is that the difference in running costs between the all-electric car and an ICE car must cover the price difference. As ICE cars become more fuel-efficient, this cost difference may erode and hence destroys the business case.

9 Social Dilemma Problems Revisited

An economic analysis of the four described business models shows that their viabilities are dependent on four recurring factors, namely:

- The battery warranty conditions
- The energy cost gap per driven km
- The price gap between a plug-in car and a comparable ICE car
- The technology improvement speed.

If we examine these factors further, it can be seen that the causes to these factors are not business model related but rather technology related. The battery warranty conditions set the limit for the accumulated distance that can be driven at low risk; this combined with the lower energy cost per km for plug-in cars can define how much of the price gap can be recovered during use. The technology improvement speed affects the depreciation rate of sold plug-in cars. The speed of technology improvement is often something wanted, while the strategy among customers to wait to purchase because improved technology is around the corner is unwanted, as it delays the diffusion of the technology wanted by society.

The complex network of technologies behind these four factors is constantly evolving. How the factors develop relative to each other will therefore have a major impact on the size of the social dilemma problem of plug-in cars, and hence have a major impact on the diffusion rate of plug-in cars in society. There is a considerable risk that over time these factors will increase rather than decrease the social

dilemma problem for plug-in cars, but there are steps that governments can take to mitigate these risks:

- The price gap may remain or widen: There is a fierce competition and significant overcapacity in the car industry today while plug-in cars are sold in low volumes, which combined may widen the price gap. In addition, governmental incentives to plug-in car buyers may end. One mitigation option can be a bonus-malus system where buyers of ICE cars with high CO₂ emissions have to pay fees, which then are used as rebates to buyers of less CO₂ emitting cars. Such a bonus-malus system can be designed to be cost neutral for the government and hence be long-lasting.
- ICE cars may become more fuel efficient, not least because of EU's ambition to legislate further CO₂ tailpipe emission reductions for cars. One mitigation option is to increase petrol- and diesel taxes accordingly so that the energy cost gap between ICE and all-electric cars remain or increase.
- The battery warranty/battery life length might not improve: Our analysis suggests that the battery warranty time/distance is more important than driving range. Customer segments can always be found where the current driving range is more than sufficient while the battery warranty time directly affects the depreciation and hence the economic competitiveness across most business models and customer segments. Battery warranties vary between countries and states. Nissan gives a battery warranty of 8 years or 160,000 km in the US while they give 5 years and 100,000 km in Sweden, which seems to be without reason. One way to guide interest into the battery warranty issue can be for governments to legislate minimum warranties, as many governments have done for consumer goods. For instance legislate that the best available global battery warranty must count also in this country.
- The technology speed may induce a waiting strategy among potential customers. Some governments and municipalities, with Norway as a periphrastic example, gives from time to time various forms of incentives to plug-in car buyers, like lower tax, free parking, driving in bus lanes, exemption from congestion charges and so forth. These incentives can not last forever, especially not when the market share of those cars become significant. One way to mitigate the depreciation caused by technology improvement speed can be to let incentives follow the car for its lifetime. By that, older plug-in cars may be valued higher than otherwise if they are accompanied by highly valued incentives.

10 Conclusion

As has been shown here, alternatives to the most common “sell-and-disengage” business model can be designed to provide a more successful diffusion of plug-in cars. This can be done by designing plug-in car based offerings that give the addressed customer segment a reference these offerings can compete with, and then

use available knowledge on how to successfully diffuse innovations when crafting the business model around the offering and its customer segment.

The history of business provides a wealth of business models that have been tested in various businesses and business conditions over the years, while research on entrepreneurs and start-up companies gives a structure for how to validate business models at low cost [11–14, 19]. Combined, they constitute a useful toolbox for anyone who wants to design business models that better fit the potential customer segments for plug-in cars than the sell-and-disengage business model does.

Car manufacturers hold significant business model experience and innovativeness. Despite that, many of them go for the same business model for plug-in cars as for ICE cars. Tesla Motors however, who subsists on making only all-electric cars, show a much higher willingness to develop their business model in accordance to the business model principles and theories that have proven successful for introduction of new technologies, which is rewarded by the market through impressive sales figures.

Plug-in cars provide a lot of social value (common good) for which there is limited private interest to pay (limited private good). Without governance of the four technology-dependent factors we have identified, the diffusion of plug-in cars may not only be weak and delayed, but may also halt once it has started. Governments themselves may be an initiator, for instance through commendable efforts to reduce tailpipe CO₂ emissions from ICE cars.

10.1 Limitations

The four business models that have been described in this chapter have been designed with Sweden in mind, i.e. Swedish tax rules, taxes, prices and costs, the Swedish mentality among potential customers, Swedish commuting distances and so forth. This may not apply to other countries without adjustments or changes.

The business models, although validated to a certain extent, have not been validated to the level where customers actually buy. A considerable remaining business risk should hence be expected in each of the business models.

The cost and price calculations behind each business model have been made with rigor, have been crosschecked and have been discussed with companies in related businesses. However, the business model designers are not professional economists and it can not be expected that external parties would identify all possible flaws or reveal all flaws they possibly would identify.

Despite these limitations, we believe that some interesting analytical generalizations can be made.

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