L'acceptabilité potentielle des voitures électriques : Quelle profitabilité financière pour l'usager privé en Ile-de-France?

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Résumé

Depuis quelques années, le véhicule électrique (VE) suscite un très important regain d’intérêt, au titre de divers enjeux d’ordre aussi bien écologique (qualité de l’air, bruit, émissions de gaz à effet de serre) qu’économique, pour revitaliser l’industrie automobile et à travers elle la production économique générale, ou encor énergétique, pour réduire la dépendance aux carburants importés. C’est pourquoi les pouvoirs publics promeuvent le développement de la mobilité électrique. Les acheteurs de VE bénéficient dès aujourd’hui de réductions de taxes et de fortes subventions à l’achat. Les fournisseurs de l’infrastructure de recharge profitent de nouvelles réglementations et de subventions de la part de l’Etat.

Des prévisions de la demande en VE sont absolument nécessaires pour anticiper les économies d’échelle dans l’industrie et déterminer le prix de vente par voiture, ainsi que pour dimensionner les consommations de ressources. Leur élaboration est soumise à la complexité du système de mobilité électrique, dont les circonstances subissent une évolution permanente et parfois peu prévisible (ex. en ce qui concerne le prix du carburant) ; et aussi parce que la demande en véhicules dépendra fortement des politiques publiques.

Les études antérieures qui explorent la demande en VE masquent souvent cette complexité systémique. L’interrelation entre les politiques publiques et la demande n’est pas prise en compte. Des modèles agrégés sont conçus pour des régions vastes (comme tout un pays) et servent ensuite à établir des prévisions plutôt contestables. Des paramètres désagrégés, tels que les caractéristiques des ménages ou du territoire analysé, restent bien souvent ignorés, alors qu’ils jouent un rôle important dans le bilan financier pour un ménage.

Cette étude a pour but de mieux comprendre l’impact des paramètres désagrégés sur le choix d’équipement des ménages. Nous nous plaçons dans la perspective d’un ménage particulier résidant en Ile-de-France, et nous menons une analyse économique par type de véhicule, thermique ou électrique, en termes de coûts totaux de détention. Le modèle est conçu sous une forme flexible et permet l’analyse de scénarios divers. Nous investiguons les impacts de paramètres désagrégés, de politiques publiques et du développement de marché. De plus, chaque scénario fait l’objet d’une analyse de « point mort »: quel est le kilométrage annuel, et/ou le prix de carburant, nécessaire pour rendre le VE plus avantageux que son concurrent thermique ?

Les résultats démontrent l’importance déterminante des paramètres désagrégés dans la prospection de la demande.

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1. Introduction

1.1 Context

Recent years have been showing rapidly growing public interest in electric vehicles (EVs). Electric mobility is seen as remedy for many current public concerns, be it the sustainable development of our transport systems, the recovery of the automotive sector and the economy in general, or the economy's energy dependency. National governments are therefore on the verge of launching EV supportive policies that aim to promote and push both, the development and the introduction of EVs as well as their necessary infrastructures.
Research has since been focused on technical issues (mainly concerning EV batteries and accompanying infrastructure), on future customer behaviour and EV usage (based on pilot and test projects), and on vehicle demand analyses, which further allow predicting future cost developments and electricity and resource demands.

Making solid demand forecasts is, however, extremely challenging. As is the rule for new technologies, there are many uncertainties that make predictions of prospective customers' choices and resulting future demand very unreliable. In the EVs' case, these uncertainties are mainly threefold. They concern

- *the future offer* of EVs and their recharge infrastructure, above all regarding the performance of the vehicles' batteries defining the driving autonomy as well as the costs of EVs
- *future policy measures* supporting the introduction of EVs - particularly concerning fiscal measures (and less quantifiable incentives) aimed at potential vehicle buyers, measures supporting the installation of recharge infrastructure, and command and control instruments that impact the future vehicle offer
- *future market development* mainly with regard to future oil and electricity prices but also interest rates

In order to overcome the above sketched complexity of demand forecasts, a common hypothesis underlying many existing EV demand analyses is that the key driver of users' acceptance will be the total costs of ownership (TCO) of an EV compared to its conventional counterpart (conventional vehicle - CV). TCO do not only take purchase costs but also vehicle usage costs and all other costs occurring during the ownership period of the vehicle and caused by its ownership into account.

Obviously, vehicle choices will also depend on various other parameters that can not be accounted for in such an economic approach - even more so since many car buyers are not accustomed to evaluating the TCO of their (potential) vehicle. Matters such as vehicle appearance and status, vehicle performance, perceived risk/confidence in a brand, advices from friends or dealers, vehicle comfort etc. often play a decisive role as well.

However, we argue that with the introduction of EVs TCO will become/remain a major key driver of acceptance for the broad mass of private vehicle buyers. Studies based on TCO therefore have the potential to give a first indication of potential demand that, in the following, has to be adjusted to taken assumptions concerning non-economic factors and to existing mobility behaviour.

1.2 Study objectives

The objective of this study is to develop a *TCO model for private vehicle owners in the Paris (Île de France) region*. The study is to comply with the following criteria that literature study (see Funk and Rabl (1999), Carlsson and Johansson-Stenman (2002), Delucci and Lipman (2001), BCG (2009), Becker (2009), Deutsche Bank (2009), EDF (2009), CE Delft (2011), CGDD (2011)) proved to be most important:

(1) Detailed TCO calculation: The study takes a comprehensive TCO approach. Besides vehicle purchase costs and energy costs also costs for maintenance and insurance are accounted for. Residual values and potential usage costs for recharge infrastructure are considered; parameter settings (in particular those of fuel prices) are adjusted throughout the ownership period.

(2) Territorial approach: The study focuses on a sufficiently small geographic area that allows incorporating locally specific parameters (such as parking costs) as well as for sufficient precision (e.g. concerning fuel prices, taxes). The Ile-de-France region is taken as study area. More specifically, Paris, the Petite Couronne and the Grande Couronne area are regarded separately to account for differences in territorial characteristics.

(3) Disaggregate approach: The study acknowledges vehicle owner (and/or household) specifications concerning mobility behaviour and vehicle usage (such as annual driving distances, vehicle usage areas, recharge infrastructure) in order to be able to well reflect possible differences in TCO.

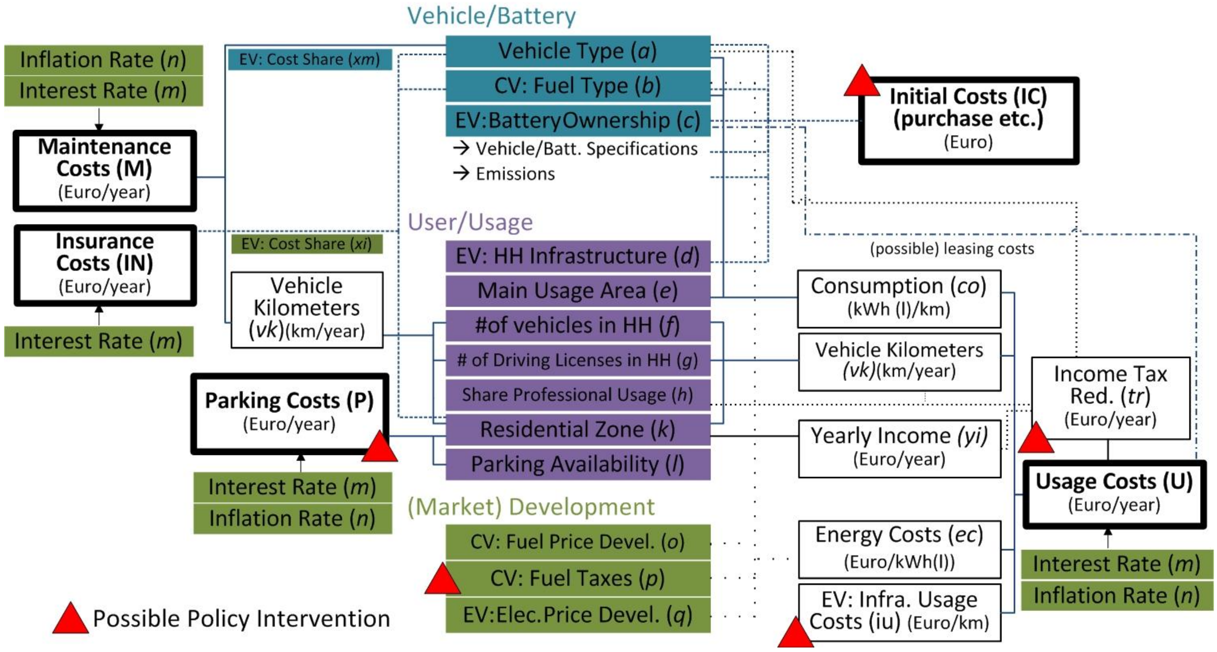
(4) Scenario modelling: In order to account for the complexity of the EV system and the resulting uncertainties concerning many demand influencing issues (see Figure 1) the study explores various potential market development and policy scenarios.

(5) Up-to-date: The study uses most recent cost information and EV specifications. Study results and the set up TCO model shall serve for as profound basis for future EV demand analysis in the same study area. TCO are calculated for vehicles acquired in 2011.

2. Methodology and Underlying Data

2.1 Model Overview

Figure 1 underneath gives a very comprehensive overview of the set-up TCO model. The main intention of the Figure is to reveal the dependence of output parameters (the 6 TCO cost components shown in bold) on input attributes (shown in colour), which can be categorized into *vehicle/battery attributes*, *user/usage attributes* and *(market) development attributes*. Intermediate attributes result from input attributes, but mostly rely on supplementary input data. Cost components or attributes that might be (are already) affected by policy intervention are indicated with red triangles.



HH - household

Figure 1: TCO model overview

2.2 Underlying Data and Assumptions

In the following an overview of all data used in order to calculate TCO is given. Some of them had to be based on assumptions, while others could be based on actual/empirical values.

Table 1 gives an overview of all vehicle type specific data used; Table 2 gives information on energy prices per oil/electricity price scenario; Table 3 shows assumptions concerning the vehicle usage in years and kilometers per household characteristics and residential zone; Table 4 gives estimated yearly parking costs and introduces parking related policy scenarios; Table 5 shows additional assumptions made in order to calculated TCO.

	Compact			**Sedane**	
	CV Petrol	***CV Diesel***	***Electric***	***CV Diesel***	***Electric***
Reference Vehicle	Renault CLIO	Renault CLIO	Renault ZOE	Renault Fluence	Renault Fluence Z.E.
			Vehicle/Battery Specifications		
(Costs in €)					
Purchase Price Vehicle (1) (incl taxes)	16,650	17,450	21,000	22,850	26,300
CO2 emission (g/km)	129	115	0	120	0
Pow er (kW)	74	50	60	81	70
Purchase Price Battery (2)	-	-	7,200	-	8,800
kw H Battery	-	-	18	-	22
Costs/kw H Battery	-	-	*400*	-	*400*
Lease Price Battery (per month)	-	-	69	-	79
			Vehicle Registration Costs		
(Costs in €)					
Registration Costs (3)	330	138	-4997	276	-4997
Registration Fee	330	238	3	376	3
Bonus/Malus	0	100	5000	100	5000
			Energy Consumption (4)		
	(l/100km)	*(l/100km)*	*(kWh/100km)*	*(l/100km)*	*(kWh/100km)*
Urbain Use	7.6	5.3	10.1	6	12.4
Pre-Urbain Use	6.5	4.5	12.4	5.4	15.1
Mixed Use	7	4.8	11.3	5.5	13.3
			Insurance Costs (5)		
(Costs in €/year)				*(all -13% if private parking available)*	
Paris/Petite Couronne	616	630	493	630	504
Grande Couronne	494	529	395	529	423
			Maintenance Costs (6)		
(20% EV reduction) *(Costs in c€/km)*	2.72	2.72	2.18	3.26	2.61

(1) Prices/specifications of vehicle types (incl. battery lease prices) obtained from www.renault.com (February 2011). The battery lease price is assumed to be valid for the whole ownership period (so far it has only been guaranteed for a duration of 3 years).

(2) Own estimation based on Renault's battery lease prices and an assumed battery lifetime of 10 years.

(3) French registration fees and bonus/malus system ; values obtained from http://www.ants.interieur.gouv.fr/IMG/pdf/Tableaux_taxes.pdf (October 2010)

(4) Empricial values for Renault CLIO (diesel and petrol) obtained from TheirEarth (2009). For other models values as advertised by Renault: values for urban drive assumed to be valid for mixed use. Other values up- or downscaled. For EV the value varies +/-10% for urban/pre-urbain use due to regenerative breaking.

(5) 20% reduction of insurance costs for EV assumed. Reference values for CV obtained by an online calculation template, see http://www.caradisiac.com/service/assurance-auto/ (November 2010)

(6) Costs for CVs based on a study recording the costs of over 5000 vehicles in France (Carnet d'entretien en ligne, http://www.entretien-auto.com, November 2010). Costs for EVs assumed to be 20% less (according to discussions with Renault).

Table 1: Data specific to vehicle types

Energy Prices								
	Fuel Price (€/l) (1)						Electricity Price (€/kWh) (2)	
Scenario	Low Oil Price		Medium Oil Price		High Oil Price		Medium	High
	Petrol	Diesel	Petrol	Diesel	Petrol	Diesel	*(+4%/year)*	*(+7%/year)*
2011	1.44	1.26	1.36	1.17	1.69	1.53	0.11	0.11
2012	1.43	1.24	1.40	1.21	1.86	1.71	0.11	0.12
2013	1.43	1.24	1.43	1.24	2.01	1.87	0.12	0.13
2014	1.43	1.24	1.46	1.28	2.18	2.06	0.12	0.13
2015	1.43	1.24	1.49	1.31	2.30	2.18	0.13	0.14
2016	1.44	1.26	1.53	1.35	2.41	2.31	0.13	0.15
2017	1.46	1.27	1.56	1.38	2.52	2.42	0.14	0.17
2018	1.47	1.28	1.59	1.41	2.60	2.51	0.14	0.18
2019	1.48	1.30	1.62	1.45	2.66	2.58	0.15	0.19
2020	1.50	1.31	1.66	1.48	2.70	2.63	0.16	0.20

(1) Fuel prices comprise fuel tax forecast (estimation based on regression analysis of past development); fuel price forecasts are based on oil price scenarios estimated by the U.S. Energy Information Administration (see EIA (2010))

(2) Electricity prices contain current French tax levels. Medium scenario follows the trend of the past 10 years (including inflation). High scenario assumes increasing demand of electricity due to increasing penetration of EVs.

Table 2: Forecasts of energy prices per scenario

Usage Period of Vehicle	
1-10 years	(depending on scenario setting)

Yearly driven distance (km) (1)				
		Residential Zone		
HH Characteristics		*Paris*	*Petite Couronne*	*Grande Couronne*
# Licenses in HH	*# vehicles in HH*			
1	1	12,000	11,500	15,000
1	2	14,000	13,500	17,000
2	1	15,000	14,500	16,000
2	2	17,000	16,500	18,000
3	1	16,000	15,000	17,000
3	2	18,000	17,000	19,000
4	1	17,000	17,000	18,000
4	2	19,000	19,000	20,000

(1) Distances by household characteristics and residential zone of the household derived from the Enquête Globale de Transport 2001 – A transport survey carried out for the Île-de-France region. Stated values based on general findings/tendencies observed (due to lack of observations for some categories).

Table 3: Usage of vehicle (in years and kms)

Parking Costs (1)			
(Costs in €/year)	Policy Scenario		
	No Policy	Policy Sc. 1	Policy Sc. 2
	-	Free Public Parking for EVs	Free Public AND Overnight Parking for Evs (incl. possibility for overnight charging)
EV - private parking not available			
Paris/Petite Couronne	2,485	1,440	0
Grande Couronne	1,001	780	0
EV - private parking available			
Paris/Petite Couronne	1,045	0	0
Grande Couronne	221	0	0
CV - private parking not available			
Paris/Petite Couronne	1,045	1,045	1,045
Grande Couronne	221	221	221
CV - private parking available			
Paris/Petite Couronne	1,045	1,045	1,045
Grande Couronne	221	221	221

(1) Based on own estimates and parking tariffs in the ÎDF region; Policy Scenario 1 describes rather possible parking measures, Scenario 2 simulates a very extreme case: Households without private parking facilities can park their EVs for free on public grounds equipped with recharge infrastructure.

Table 4: Parking costs

Other	
Infrastructure Usage Costs (1)	0,48 cEUR/km
Infrastructure Installation Costs (2)	€ 1,350
Discount Rate (3)	nominal: 6,5 ‘ real: 4,8%
Yearly Income (Euro) (4)	Paris/Petite Couronne: 25 643 Grance Couronne: 23 854
Depreciation Costs/Residual Value (5)	not considered (assumed to be the same for CV and EV)

(1) Sole costs for infrastructure usage in order to compensate public investments, own estimations based on the announced BetterPlace price of 6-8c$ for their package offering (including costs for battery, recharging, electricity and profit).
(2) In accordance with TfL (2010) and Autoactu (2011)
(3) Nominal rate: Based on the costs of a 5-year 10.000 Euro loan, simulated on December 20, 2010, on https://particuliers.societegenerale.fr/emprunter/prets_vehicule/pret_expresso_auto.html; Real rate equals the nominal discount rate minus the inflation rate (assumed to be 1.7% - the average over the past 20 years).
(4) Average salaries in the IDF region for the year 2008, INSEE (2009).
(5) According to Renault these assumptions are in line with their reasoning.

Table 5: Other assumptions necessary for TCO calculations

3 RESULTS

3.1 The Reference Scenario

The reference scenario portrays a random household in the IDF region. The reference scenario can therefore not be seen as ‘average’ household in the IDF which can not be defined. Settings were chosen in such a way that the household showed realistic characteristics (also concerning its infrastructure/equipment and vehicle usage) and that TCO results for the EV and the CV showed similar levels. The settings for the reference scenario are given in Table 6.

Reference Scenario	*Settings*	**Resulting kms/year**	18,000
Household Characteristics		*Household Infrastructure/Equipment*	
		Vehicle Type	**Compact**
# of Vehicles in HH	**2**	Fuel Type	**Benzine**
# of Driving Licences in HH	**2**	Home Installation Costs	**Yes**
Residential Zone	**Grande Couronne**	Private Parking Availability	**Yes**
Vehicle Usage			
Vehicle Ownership (years)	**7**		
Share of Professional Usage (%)	**30**	Main Usage Area	**Pre-urbain**
Market Development			
Oil Price Development	**Medium**	EV Insurance Cost Reduction (%)	**20**
Electricity Price Development	**Medium**	Market Interest Rate (%)	**6.5**
EV Maintenance Costs (in % of the CV counterpart)	**80**	Yearly Inflation Rate (%)	**1.7**
Policy Measures			
EV Purchase Subvention (€)	**5000**	Public Parking Policy	**None**
Increase of TIC by (%)	**0**	Registration Tax Exemption	**Yes**

Table 6: Settings for the reference scenario

The results for the reference scenario are given in Figure 2 underneath. On the left side the repartition of the TCO after 7 years for the EV and the CV are shown. Also the TCO for the EV where the battery is leased (instead of purchased) is shown as alternative. The right side of Figure 2 shows the development of the TCO over time until an ownership period of 10 years. A ‘break-even’ between EV and CV is ‘only’ achieved in year 7 – the year which reflects the end of the modeled ownership period for TCO calculations. In case the battery is leased, the costs of the EV stay underneath the ones of the CV from year 1 onwards.

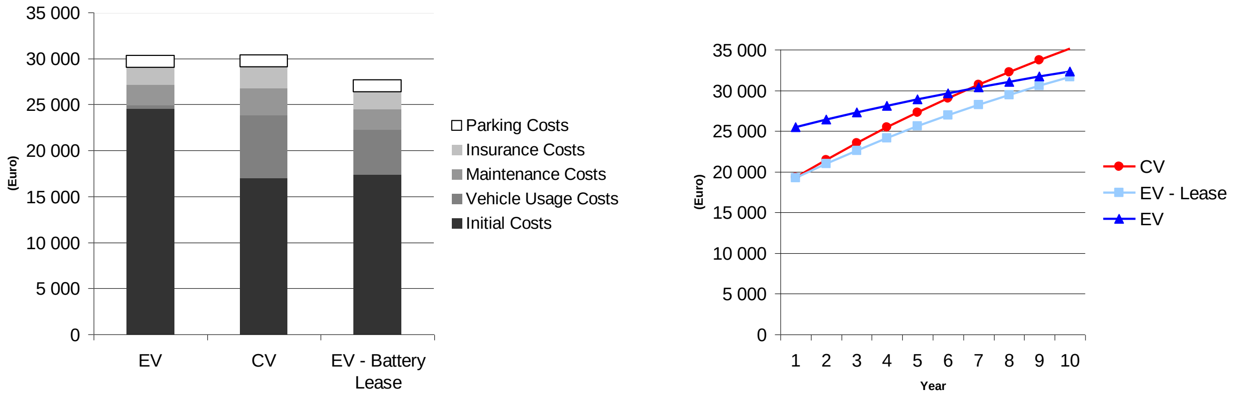


Figure 2: Results for the reference scenario

3.2 Scenario Analysis

Household- and vehicle usage- scenarios

Table 7 gives an overview of the settings of modelled scenarios. The first column shows the reference scenario with regard to the concerned parameters in this section. The subsequent columns show which parameter(s) was(were) changed (and to which value(s)) for constructing the new scenario. Only those parameters that change compared to the reference scenario are shown. For the best/worst scenarios (# 14 and # 15) again all parameter settings are shown.

Scenario Type	Ref.	HH Caracteristics			HH Infra./Equipment				Vehicle Usage							
Scenario	Reference Scenario - (Ref)	Small Household	HH Location: Paris	HH Location: PC	Vehicle Type: Sedane	Fuel: Diesel	EV Infra: Available	Private Parking: Not Available	Veh. Ownership: 5 years	Veh. Ownership: 10 years	Prof. Usage: High (50%)	Prof. Usage: Low (0%)	Vehicle Usage: Urban	Vehicle Usage: Mixed	Best User/Usage Scenario	Worst User/Usage Scenario
Parameters / Scenario #	Ref	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
# of Vehicles	2	1													2	1
# of Driving Licenses	2	1													2	1
Residential zone	GC		Paris	PC											GC	PC
Vehicle Type	Compact				Sedane										Compact	Sedane
Fuel Type	Benzine				Diesel	Diesel									Benzine	Diesel
Home Installation Costs	Yes						No								No	Yes
Private Parking Availability	Yes							No							Yes	No
Vehicle Ownership (years)	7								5	10					10	5
Share Prof. Usage (%)	30										50	0			10	50
Main Usage Area	Pre-urbain												Urbain	Mixed	Urban	Pre-urbain

Table 7: Overview of household/vehicle usage scenario settings

Figure 3 gives the TCO results for the best and worst case user/usage scenario. Values for the EV, the EV with battery lease option and the CV are shown. The values underneath the bars give results of 'break-even' analyses: The first number (brown – 'B/E Distance') gives the minimum yearly distance necessary in order to even out TCO between EV (battery purchase option) and CV within the modelled ownership period. The second number, the 'B/E Fuel Price', gives the minimum fuel price in 2020 necessary to even out costs within the modelled ownership period (assuming a linear fuel price increase over time). The third number, 'Payback', gives the minimum ownership period necessary in order to even out the TCO – all other settings being kept equal.

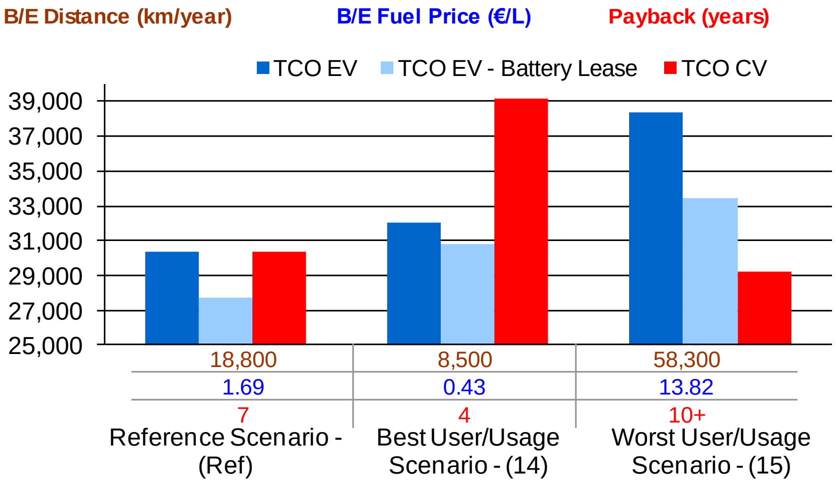


Figure 3: Results for household and vehicle usage scenarios – Extreme cases

Results show that household characteristics can play an important role for the profitability of an EV compared to a CV. An 'average' scenario that can well reflect the characteristics of single households and that is valid for the whole region can not be determined. EV demand analyses that are based on alleged 'average' scenarios do not have the potential to be very reliable. The difference in TCO between the extreme case scenarios shows that neglecting household and vehicle user specific characteristics necessarily need to be taken into account when wanting to predict the EV acceptance of private households.

Market development scenarios

As before, Table 8 gives first an overview of modelled market development scenarios. Figure 4 gives then the TCO results for the modelled scenarios. All parameters that are not shown in Table 10 remain the same as in the reference scenario (see Table 6).

Parameters	Scenario / Scenario #	Reference Scenario - (Ref)	High Oil Price - (1)	Low Oil Price - (2)	High Electricity Price - (3)	EV Maintenance Costs: 100% - (4)	EV Insurance Reduction: 0% - (5)	Interest Rate +1% - (6)	Inflation Rate +1% - (7)
		Ref	1	2	3	4	5	6	7
Oil Price Development		Medium	High	Low					
Electricity Price Development		Medium			High				
EV Maintenance Cost Share (%)		80				100			
EV Insurance Cost Reduction (%)		20					0		
Market Interest Rate (%)		6,5						7,5	
Yearly Inflation Rate (%)		1,7							2,7

Table 8: Overview of market development scenario settings

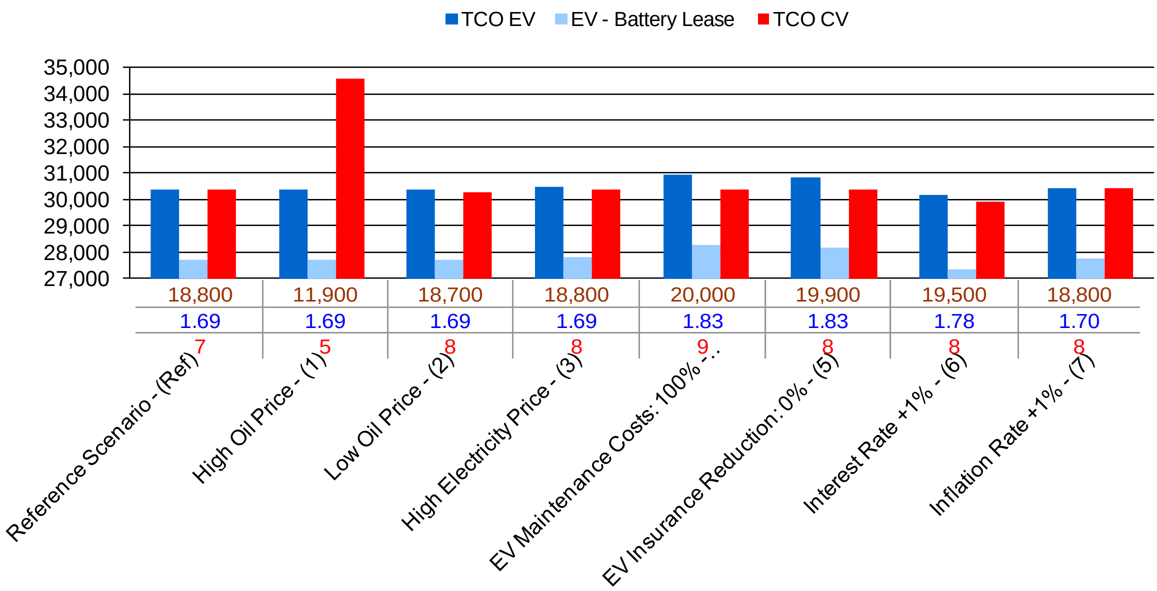


Figure 4: Results for market development scenarios

Modelled scenarios show that mainly the oil price (directly influencing the fuel price) has main impact on the TCO difference between EV and CV (Scenarios 1 and 2). Also the maintenance cost share of EVs shows to be significant (Scenario 4). Concerning this matter real experience could not be gained so far though. The popular assumption that EVs will cause less maintenance costs than CVs due to less moving parts in the engine has not yet been proven. Maintenance costs of EVs might actually turn out to be similar to those of a CV due to increased usage of the braking system (due to higher vehicle weight caused by the heavy battery) and more security checks that also become necessary due to the battery. The impact of electricity prices proves to be negligible (Scenario 3) – at least considering the price change that is modelled here. A higher interest rate gives advantage to the vehicle type for which a higher cost share occurs at later time instants. The CV therefore profits more from a higher interest rate than the EV. The EV with battery lease option profits, however, the most. (Scenario 6)

Policy scenarios

Again, Table 9 gives first an overview of modelled policy scenarios. Figure 5 gives then the TCO results for the modelled scenarios. All parameters that are not shown in Table 9 remain the same as in the reference scenario (see Table 6).

Parameters / Scenario #	Reference Scenario - (Ref) Ref	Subvention 50% - (1) 1	No Subvention - (2) 2	No Reg. Tax Exemption - (3) 3	TIC +10% - (4) 4	TIC -10% - (5) 5	Parking Policy 1 - (6) 6	Parking Policy 2 - (7) 7	No Infrastructure Use Costs - (8) 8	Overall Best Policy - (9) 9	Overall Worst Policy - (10) 10
Purchase Subvention	5,000 €	2,500 €	0 €							5,000 €	0 €
Reg. Tax Exemption	Yes			No						Yes	No
Fuel Taxes (TIC)	+/-0				+ 10%	-10%				+ 10%	-10%
Parking Policy	None						Scen 1*	Scen 2*		Scen 2*	None
Infrastructure Use Costs	0,48c/km								0 c/km	0 c/km	0,48c/km

** see table 4*

Table 9: Overview of policy scenario settings

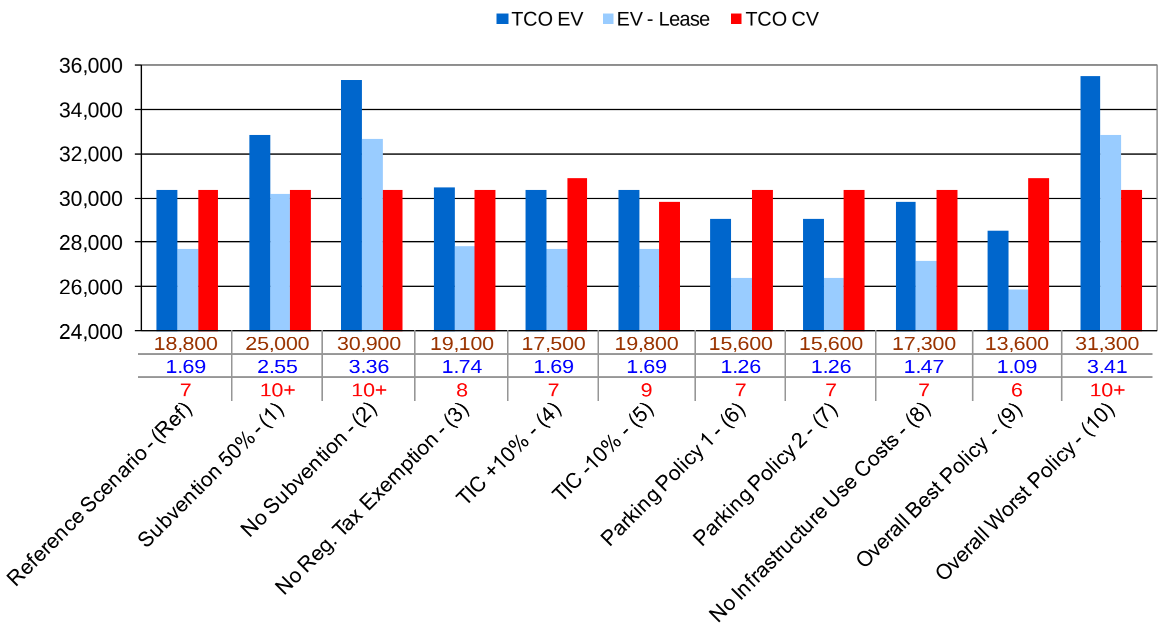


Figure 5: Results for policy scenarios

Scenarios 1 and 2 show the obvious impact of the current purchase subsidy of 5000€. Without this subsidy the reference scenario would not equal out costs between CV and EV. The exemption of registration taxes does not have major impact on the TCO of the EV in the French setting (Scenario 3). Changes in the TIC show expected changes in the TCO of the CV (Scenarios 4 and 5). In order to evoke an impactful change, higher changes in the TIC would be necessary. The parking policy scenarios (Scenarios 6 and 7) prove to be pretty impactful in the Paris region. However, policy scenario 2 does not change compared to policy scenario 1 since the reference scenario models a household with private parking space availability. The supplementary policy measure of guaranteeing free overnight parking facilities equipped with charging infrastructure therefore does not show supplementary impact in this setting. The impact of the policy measure offering free access to public recharge infrastructure proves to be rather low (Scenario 8). However, it has to be said that assumed costs were low. On the other hand, these low costs were applied to each driven km, whereas actual public infrastructure usage might occur very seldom – especially considering households equipped with private parking facilities/recharge facilities.
Overall best/worst policy scenarios (Scenarios 9 and 10) show that policy measures have significant impact on the profitability of an EV compared to a CV. Most impact seems to stem from the direct purchase subsidy. However, also parking policies (whose entire possible impact is not shown here) can have significant impact in Paris region – especially if a household is not equipped with a private parking space.

4 Conclusions

Results prove that due to the influence of vehicle user/usage and territorial characteristics demand forecasts should be based on *disaggregate* TCO models. Average scenarios that are applied to a whole region (or even a whole country) are not valid and bear the great risk to heavily distort demand forecasts. Vehicle user and usage characteristics as well as local policy measures – both heavily dependent on territorial characteristics - show major influence on the profitability of an EV compared to a CV. Households' vehicle choice decisions should therefore not be modelled on aggregate level hereby neglecting the heterogeneity of vehicle users and different territories.

A complementary work (Windisch, Leurent, 2011) based on the National Household Travel Survey (NHTS) in France as of 2007, has investigated the proportion of households within given sets (notably by location and number of cars) such that they fulfil some specified set of disaggregate requirements on the practicality of using an EV: the requirements bear a close relationship to the disaggregate parameters. Work under progress deals with application of the disaggregate TCO model in conjunction with the requirements to the households sampled in the NHTS, so as to yield quantitative results at both disaggregate and aggregate levels.

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