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Obstacle 1: Capturing the experiences of Swedish electric vehicle users

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Abstract

The Swedish National Procurement of Electric Vehicles and Plug-in Hybrids scheme is a technology procurement project aimed at facilitating a market introduction and market expansion in Sweden. The paper describes the development of the data collection method over the course of the project, with the aim of contributing to more efficient evaluations of demonstration fleets of electric vehicles. Combining multiple sources of data may enable a socio-technical understanding of electric vehicle operations. The methods used for data collection in the project are vehicle logbooks, GPS equipment, questionnaires and interviews. Focus groups have been carried out to validate the socio-technical findings. The paper will describe the method development process and the lessons learned are divided into three categories: avoiding misunderstandings, time-saving measures and increasing engagement.

Keywords: Battery electric vehicles, Plug-in hybrid vehicles, Demonstration

1 Introduction

Globally, 98% of the transport sector is dependent on fossil fuels and the transition to renewable fuels is moving more slowly in the transport sector than in the stationary energy sector [1]. The share of electric vehicles in European urban areas is increasing, hence the benefits of both energy-efficient and local emission-free operation [2].

The Swedish National Procurement of Electric Vehicles and Plug-in Hybrids scheme is an on-going project where the City of Stockholm, together with utility company Vattenfall, is coordinating a joint procurement with the aim of facilitating a market introduction and market expansion in Sweden. The public-private partnership project consists of three phases, each with different objectives:

1. The demonstration phase – the establishment of the demonstration fleet, data collection and method development, August – December 2011.
   30 organisations, both public and private actors, participated and endorsed 50 electric vehicles for use in their normal activities
2. Procurement process. Framework agreement established in October 2011
3. The procurement phase – vehicles called-off in the procurement join the demonstration fleet, data collection, January 2012 – December 2013.
   296 organisations, both public and private, are drafted to participate.

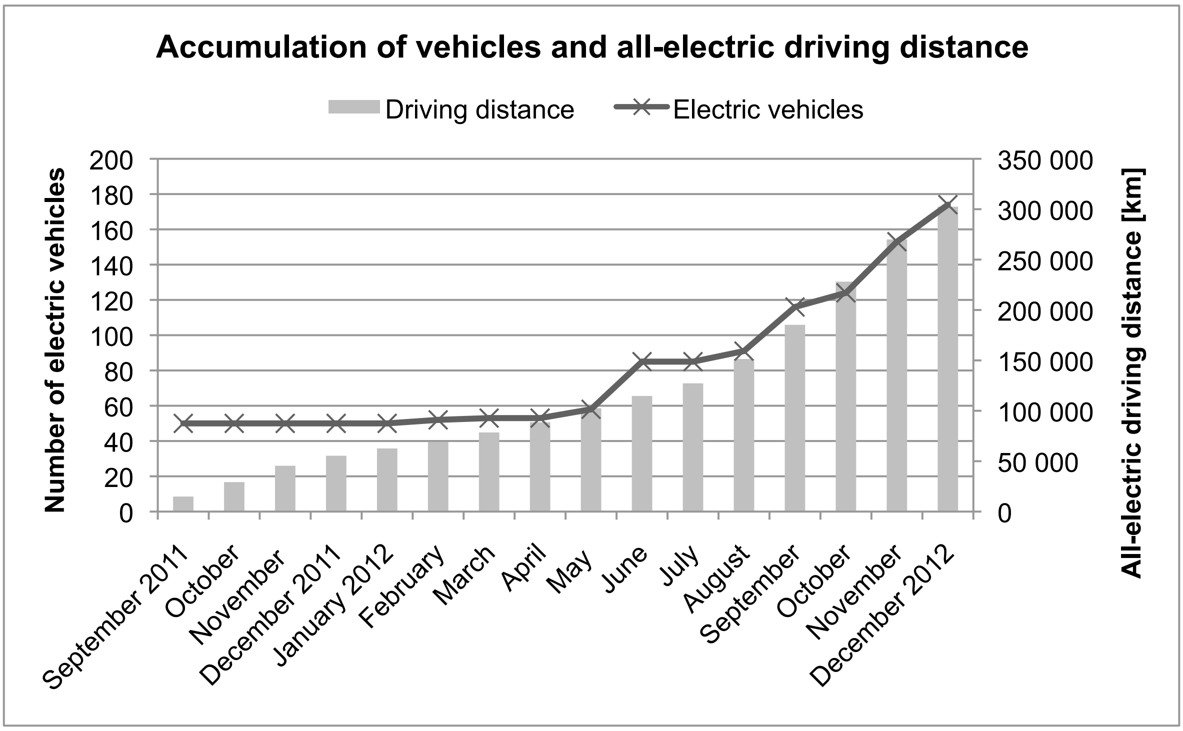


Figure 1: Accumulation of electric vehicles and driving distance between September 2011 and December 2012

This paper describes the method development process of the data collection during the project, with the aim of contributing to more efficient evaluations of demonstration fleets of electric vehicles. A standard method of evaluating electric vehicles is by using technical equipment to gather the data of interest. Other studies [3] emphasise the importance of user engagement, hence this project aims to study both the actions of the electric vehicles and also continuously obtain user feedback. To achieve this socio-technical understanding, the methods used in the project are logbooks, questionnaires and interviews. The amount of data collected was extensive; a total of 174 electric vehicles have been included in the project so far.

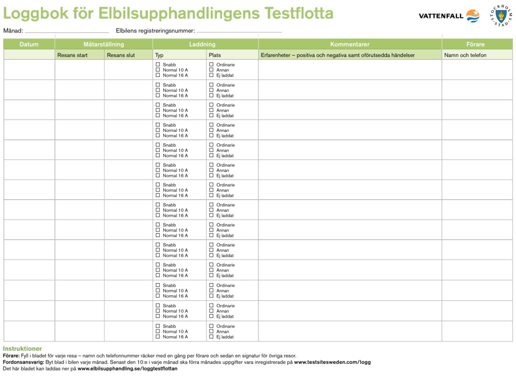
2 Background

To illustrate the extent of the data collection, figure 1 shows the expansion of the vehicle fleet. In December 2012, the fleet comprised 174 vehicles, distributed between 12 Chevrolet Volt, 13 Citroën C-Zero, 14 Fiat 500 EV, 32 Mitsubishi i-MiEV, 3 Peugeot i-On, 98 Renault Kangoo ZE and two Volvo C30 Electric. Figure 1 also visualises the fleet's accumulated driving distance between September 2011 and December 2012. PHEVs were used but only their all-electric driving distance is included in this figure. By the end of December 2012, approximately 302,000 electric kilometres had been driven.

This section describes the five methods used during the project. The combination of methods, technical as well as from the social sciences, aims to understand both the actions of the vehicles and the user experiences during operation. Understanding the user's perspective may be vital to facilitate a large-scale introduction of electric vehicles. Within the Swedish National Procurement of Electric Vehicles and Plug-in Hybrids scheme, the aim is to further understand the users of electric vehicle in commercial vehicle fleets. In Sweden, commercial actors account for 60% of new car sales [4] and all governmental vehicle acquisitions are highly influenced by the environmental policies. Technology procurement may function as a non-market based local public policy instrument, complementary to national policies. In its White Paper on Transport [5], the European Commission emphasises the role of technology procurement to ensure rapid up take of new energy efficient vehicle technologies.

2.1 Vehicle logbook

In Sweden, the Swedish Tax Agency expects all commercial vehicles to keep vehicle logbooks to monitor their whereabouts. A cost-efficient measure was therefore to expand the existing logbook template, with all information required by the Tax Authority, to include questions about charging. An example of the vehicle logbook is shown in figure 2.



Loggbok för Elbilsupphandlingens Testflotta

Månad: ______________ Elbilens registreringsnummer: ______________

Datum	Mätarställning		Laddning		Kommentarer	Förare
	Resans start	Resans slut	Typ	Plats	Erfarenheter – positiva och negativa samt oförutsedda händelser	Namn och telefon
			☐ Snabb ☐ Normal 10 A ☐ Normal 16 A	☐ Ordinarie ☐ Annan ☐ Ej laddat		
			☐ Snabb ☐ Normal 10 A ☐ Normal 16 A	☐ Ordinarie ☐ Annan ☐ Ej laddat		
			☐ Snabb ☐ Normal 10 A ☐ Normal 16 A	☐ Ordinarie ☐ Annan ☐ Ej laddat		
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			☐ Snabb ☐ Normal 10 A ☐ Normal 16 A	☐ Ordinarie ☐ Annan ☐ Ej laddat		

Instruktioner

Förare: Fyll i bladet för varje resa – namn och telefonnummer räcker med en gång per förare och sedan en signatur för övriga resor.

Fordonsansvarig: Byt blad i bilen varje månad. Senast den 10:e i varje månad ska förra månades uppgifter vara inregistrerade på **www.testsitesweden.com/logg**

Det här bladet kan laddas ner på **www.elbilsupphandling.se/loggtestflottan**

Figure 2 The vehicle logbook in 2012

The vehicle logbook used in the scheme not only includes information concerning the physical actions of the journey, i.e. the distance driven and charging conditions, but the users are also encouraged to provide comments, on a certain trip and/or share their personal general thoughts regarding operating an electric vehicle. Users could include their contact details, which enabled further information exchange as described in section 2.4.

Each electric vehicle generates one logbook per month which, when digitalised as a standardised Excel spreadsheet, is submitted through a web page and collected into a database hosted by Test Site Sweden (TSS). TSS has been a partner in the project and is a national, publicly funded, resource for demonstrations and validation of research results. Each electric vehicle has a vehicle manager, who is responsible for accurate submission of logbooks and functions as a communication hub, linking researchers with vehicle users. The reliability of the data depends on the engagement of the users. This will be discussed later in the paper.

2.2 GPS equipment

A more detailed analysis of the vehicles' actions is possible if the are equipped with GPS (Global Positioning System). GPS data automatically generates technical information such as speed and acceleration.

GPS equipment is expensive, which limited the number of vehicles studied. The extent of the GPS data collection is not robust enough to draw any general conclusions about the scheme or commercial vehicle fleets, but has provided a detailed description that proved useful when validating data from logbooks.

2.3 Questionnaire

Questionnaires are a simple and popular method to gather and compile data from a large number of respondents [6]. Users of electric vehicles within the scheme complete three questionnaires: the first when entering the scheme (Q1), then after a futher year (Q2) and the final questionnaire again after a year (Q3). The recurring questionnaires aim to follow general attitudes towards electric vehicles. The questionnaire was developed by a social scientist at the University of Gävle and is distributed to all projects funded by the Swedish Energy Agency. This enables comparisons to be made between several electric vehicle demonstration projects.

2.4 Interviews

Approximately 40 interviews have been carried out within the scheme and have mainly focused on ensuring accurate interpretation of logbooks. The interviews had a structured approach but they also opened up for additional interviewee comments. The interviews enabled more in-depth information to be gathered about a user's particular experiences and contributed to greater understanding about electric vehicle operation in commercial vehicle fleets.

2.5 Focus groups

The information from the vehicle logbooks, the GPS data, the results from the questionnaires and the insights from the interviews together showed several general findings concerning the operation of electric vehicles in commercial vehicle fleets. Since the findings are interpretations of the collected socio-technical data, validation with focus groups strengthened the results. The focus group is a qualitative research method where a group of participants elaborate on a particular issue under the guidance of a moderator [7].

3 Method development

The combination of methods used in the project brings several important new findings regarding further method development. The findings will contribute to more efficient evaluations of electric vehicle demonstration projects and may be divided into three categories:

- Avoiding misunderstandings
- Identifing time saving measures
- Increasing engagement

Avoiding misunderstandings becomes easier with the awareness of the fact that if there is a microscopic chance of misinterpreting information there is an absolute certainty that many will do so. One example is where the logbook requested information about charging current. Given the limited space in the physical logbook, one specified option was *Fast*, an abbreviation of fast-charging – the collective term referring to high-voltage DC charging. Many users interpreted *Fast*, as the time-unit, subsequently checking it when they had charged the electric vehicle for a short period of time. To get the users to consider current, a less well-known concept than the familiar time, the space allocation in the vehicle logbook was reprioritised and *Fast-charging* was printed in full. A user guidance material, describing charging, was also developed and distributed to all associated vehicles. Figure 3 shows the spread of the user guidance material. Information about charging conditions is embedded on the right-hand side.

Vad kul att du kör elbil!

Här kommer lite information om projektet Elbilsupphandlingen och om den utvärdering som genomförs.

Elbilsupphandlingen
är ett samarbete mellan Vattenfall och Stockholms stad, som tillsammans med SKL Kommentus Inköpscentral AB har genomfört en samordnad upphandling av elbilar och laddhybrider. Sammanlagt har 296 organisationer och företag från hela landet anmält intresse att vara med och köpa elfordon. Energimyndigheten stöder Elbilsupphandlingen genom en merkostnadsersättning till alla fordon.

Flera typer av data samlas in från elfordonen som ingår i Elbilsupphandlingen, bl.a. den loggbok du fyller i efter att ha använt elbilen. Information om din körning, men även dina erfarenheter och synpunkter, är viktiga för att förstå hur elbilarna används och fungerar i samhället. Materialet samlas hos Test Site Sweden (TSS) och sammanställs av KTH.

Du kan läsa mer om projektet på www.elbilsupphandling.se

Ditt deltagande är viktigt!

Loggboken ger ett kunskapsunderlag om användandet av elbilar.

Tack!

/Martina (KTH)
och Peter (TSS)

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Att ladda elbilen
Det finns flera typer av laddning Olika elfordon har olika tekniska förutsättningar så samtliga kanske inte är möjliga just för ditt fordon.

Snabbladdning
Avser laddning vid en specifik snabbladdningsstation. Denna infrastruktur är under uppbyggnad och därför ber vi dig att ange vilken snabbladdningsplats du använder.

Det är viktigt i det fortsatta arbetet att förstå behovet av snabbladdning.

Behöver du hjälp att hitta en laddplats, använd gärna:

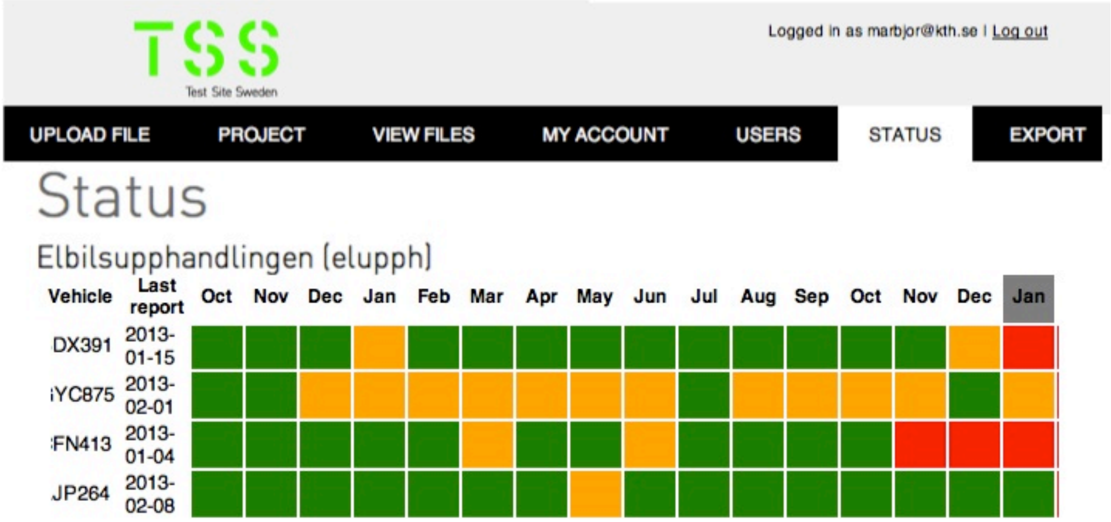
- www.uppladdning.se
- Smartphone- applikationer:
  – Charge and Drive
  – Ladda elbilen (under utveckling)

Figure 3: Developed guidance material

Early in the project, no clear definitions of the different electric vehicle techniques had been established throughout the project associates. The terms used were: EV (electric vehicle), BEV (battery electric vehicle), PEV (plug-in electric vehicle) and PHEV (plug-in hybrid electric vehicle). To avoid misunderstandings, harmonising measures were made in both internal and external communications. EV and PEV were recognized to describe the general concept of electric vehicles with the possibility to charge them from the electricity grid. BEV and PHEV were used to separate the different electric vehicle powertrain systems. Establishing a joint definition framework early in a project might sound simple enough but is often neglected and a common concept consensus taken for granted.

Managing a large number of electric vehicles and ensuring vehicle logbook submission may imply a lot of work. The development of time-saving measures in the handling were prioritised over continuous data synthesis during the demonstration phase. The most fundamental measure was to automatically categorize submitted logbooks. Initially, submitted logbooks were given a name that each vehicle manager had chosen and all logbooks were bundled together, without any internal relation. Most logbooks were given the original name of logbook_ev. The result was a large number of uncategorised logbooks, which made it difficult to follow up on the monthly data submission. Identifying missing logbooks and consequently reminding the vehicle managers concerned required manual intervention. By altering the submission process on the website, the vehicle manager chooses, from a drop-down menu, the specific vehicle the logbook concerned (several managers manage more than one vehicle) and states which month, also this from an drop-down menu. This generated a list of the vehicles, presented per month and the measure allowed many possibilities: a visual interface displaying the status of the submitted logbooks with the possibility to detect missing vehicles and with the feature to subsequently automatically generate a reminder to these vehicle managers. Figure 4 is an example of how this status looked at the beginning of February 2013. Green indicates a submitted logbook, complete with all requested information. Yellow denotes a submitted logbook but with key information missing. Red visualises a logbook that has not been submitted.

Other studies have emphasised the need to engage the users within a technical demonstration project [3]. Engagement from the users will generate more correct data and the desire to contribute to the research project. These theories where combined with the process of constructing the user guidance material resulting in a general information material about the project and the participating researchers, see the left-hand side in figure 3.



Status

Elbilsupphandlingen (elupph)

Vehicle	Last report	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
DX391	2013-01-15	🟩	🟩	🟩	🟧	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟧	🟥
YC875	2013-02-01	🟩	🟩	🟧	🟧	🟧	🟧	🟧	🟧	🟧	🟩	🟧	🟧	🟧	🟧	🟩	🟧
FN413	2013-01-04	🟩	🟩	🟩	🟩	🟩	🟧	🟩	🟩	🟧	🟩	🟩	🟩	🟩	🟥	🟥	🟥
JP264	2013-02-08	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟧	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩

Figure 4: Visual tool to monitor the submission of vehicle logbooks.

The project has developed the data collection measures to avoid misunderstandings, to save time and to increase engagement among the electric vehicle users. The data collection will continue until December 2013 and the method development will proceed but this paper hopes to contribute to more efficient evaluations of demonstration fleets with electric vehicles.

Acknowledgments

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