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Topic – E. MARKET ISSUES/E-1. Introduction & Demonstration

MOBILEL - demonstration of plug-in vehicles in Stockholm (Sweden)

Björn Hugosson
Environment and Health Administration, City of Stockholm
(Clean Vehicles in Stockholm)
P.O. Box 8136, SE-104 20 Stockholm, Sweden
+46 8 508 28 940, bjorn.hugosson@miljo.stockholm.se

Joachim Skoogberg
Fortum
SE-115 77 Stockholm, Sweden
+46 8 671 70 00, joachim.skoogberg@fortum.se

Abstract

MOBILEL is a two-year demonstration project sponsored by the Swedish Energy Agency, the City of Stockholm and FORTUM power and heat company. The main objective for the participation in MOBILEL is to evaluate the feasibility of so called plug-in vehicles, with regards to user aspects, through a field trial. Five Toyota Prius will be equipped with a larger battery pack to increase the driving range in electric vehicle mode. The environmental benefit will be a lower energy consumption, reduced carbon dioxide emissions, less local emissions and less noise. The demonstration will then be assessed considering user requirements, charging infrastructure, environmental effects etc. The Stockholm trial will not lead to an implementation, but serves the important purpose of creating knowledge and debate around plug-in vehicles powered with electricity and demonstrating new technology.

Keywords: Plug-In vehicles, plug-in hybrid vehicles, electric vehicles, PHEV, PEV, EV, demonstration, evaluation, user reactions

Extended abstract

Introduction

Stockholm, as one of Europe's leading cities in renewable fuels/clean vehicles with a total fleet of over 2,500 vehicles, both private and public, has worked with several different clean technologies like ethanol, biogas, electric-hybrid and fuel cells during the last years. There is a cross-party political board exclusively dealing with clean vehicles and with a clear aim to keep Stockholm as a leading clean vehicle city.

During 2008, the City of Stockholm (through the Environment and Health Administration) and Fortum have launched a strategic co-operation, MOBILEL a two-year demonstration project, sponsored by the Swedish Energy Agency. The co-operation focuses on the evaluation of the feasibility of so called plug-in vehicles, with regards to user and infrastructure aspects, and should be seen as a joint learning process to be prepared for challenges of the anticipated growth of plug-in vehicles on the market. Today, 70 per cent of Swedes travel a maximum of 50 kilometres per day, and an electric car can run this distance on just 10 kWh, which is already possible with the current technology.

Fortum as the grid owner in Stockholm needs to know how to meet future challenges on an already strained electrical grid. The city of Stockholm needs to find out how to facilitate an introduction of clean vehicles in order to meet environmental challenges. The project will be performed in close co-operation with TSS, Test Site Sweden, with the aim to demonstrate technologies, methods and tools to increase knowledge about plug-in vehicles and their use.

The project - goal and aim

The main goal of the MOBILEL project is:

> …to demonstrate and evaluate the effectiveness and acceptance of plug-in vehicles to achieve transport goals and reduce the negative environmental impacts, thus meeting the political aim to keep Stockholm as a leading clean vehicle city.

Previous studies have shown that there is a great potential for alternative vehicle technologies, such as battery-electric vehicles and plug-in hybrid electric vehicles to improve the local environment. Today, these plug-in vehicles are not yet obtainable in the public marketplace. Thus, it is uncertain whether or not such systems are considered acceptable by users in terms of e.g. battery capacity etc. Also, it is uncertain what infrastructure upgrades will be needed to accommodate plug-ins.

There are seven major purposes with the realisation of a large-scale field trial:

- To achieve knowledge on the users' understanding of the advantages and the disadvantages of plug-in vehicles but also on the user´s possibility to adapt to the plug-in vehicles
- To achieve knowledge on technical limitations and possibilities in a full implementation (functionality, service needs etc)
- To achieve knowledge on the vehicle's environmental performance and energy consumption
- To achieve knowledge on the charging infrastructure
- To achieve knowledge on legal and safety issues
- To achieve knowledge on the essential technical and infrastructure preconditions for a successful market introduction
- To achieve knowledge on the impacts on environment and safety but also accessibility and transportation costs

It is of great importance to underline that the demonstration in itself does not signify an implementation of plug-in vehicles. The demonstration should be seen as a learning process and a part of a gaining of knowledge to provide objective facts. Also, car manufacturers have announced that plug-in electric vehicles will be introduced to the mass market in a couple of year's time. The City of Stockholm and Fortum need to be prepared for the anticipated growth of plug-in vehicles on the market, why the demonstration constitute an important tool not only to address the technology and infrastructure challenges, but also to steer them.

The MOBILEL technical solution

The technology used in the demonstrations is a fully functional PHEV system, which contains all the functionality of a future operational and market introduced PHEV, except payment:

Five Toyota Prius, which are owned by Fortum and used on a daily basis by Fortum staff, will be equipped with a larger battery pack to increase the driving range in electric vehicle mode.

Picture 1: The FORTUM-owned Toyota Prius vehicles before conversion..

Picture 2: A Fortum PHEV test car after conversion.

The vehicles will be recharged by simply being plugged into the wall. The battery contains 22 NiMH-cells and is manufactured by the Swedish-American company NILAR. The system solution and software originates from the American company Plug-in Conversions. This conversion to plug-in extend the original Toyota electricity performance in low speeds (up to 50 km/h) and as long as the battery is charged and it makes it possible to rely much more on the electric motor.

Picture 3: The NILAR battery and the in-vehicle charger.

Picture 4: The dashboard graphic service. display.

For the purpose of the project, each vehicle will also be equipped with a log system, which will continuously log information about system performance, location and time. A main issue is to extract data so that the energy flows between the different power sources can be studied and illustrated. Another is to achieve data on how much energy will derive from petrol-powered motoring, brake regenerated electricity and how much from electric-powered motoring. The log system, the so called ARDAQ (Argonne Real-time data AcQuisition system) is developed and delivered by the Argonne National Laboratory in USA, and it provides onboard data collection and diagnostics of the PHEV. The ARDAQ is based on Controller Area Network (CAN) information collected on two separate CAN nodes. It is also possible to use GPS and simultaneously collect moment-by-moment data on vehicle performance measures (including driving and engine speed; fuel flow, use and economy; hybrid battery current; frequency of battery charge; hybrid watt-hours per mile; PHEV watt-hours per mile; and length and distance of trip).

Evaluation

To be able to address the challenges of the anticipated growth of plug-in vehicles in Stockholm, a number of questions need to be put forward and answered. The major evaluation issue is to study the user reactions, but the project will also investigate, among other issues, what the introduction of plug-in vehicles will require from the infrastructure, if a fast market introduction would put

too much pressure on the already strained electrical grid, what kind of technologies are available for both the cars and charging poles, how they function in every-day use, and what happens to them in the Nordic winter conditions. These questions will to a large part be addressed within the project by practical tests.

Guided by previous test results and experiences, a number of possible demonstration outcomes and hypotheses have been discussed within the project, but also with other experts related to the project. These hypotheses are to be tested in the demonstration and have therefore been given priority in the design of the evaluation. A number of other aspects will also be evaluated using evaluation methods such as interviews, logging of system performance and driving patterns but also calculations. The field trial hypotheses have been divided into these four categories:

- hypotheses on the user (acceptance towards the PHEV)
- hypotheses on the vehicles (attitudes and system performance)
- hypotheses on the charging stations (system performance)
- hypotheses on demonstration impacts (effects on environment, safety etc)

and hence, the project will be evaluated from three angles, in order to be able to either confirm or contest the hypotheses at the end of the demonstration. Guided by the hypotheses, a list of some 40-50 indicators have been proposed to measure user reactions, technical issues and environmental and safety demonstration impacts.

A number of surveys will be performed. The result will be combined with log data from the vehicles and other data if needed. A main task in the evaluation of the road-user is to measure how acceptance and self-reported behavior is changes over time, why the test drivers will be inquired before mounting (preconceived notions), after half the trial period (first impression and habit) and after finished trial (reflection).