LIVING LAB 'ROTTERDAM TESTS ELECTRIC DRIVING' (FOCUS ON THE MONITORING OF THE IMPACT ON THE ELECTRICITY GRID)

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ABSTRACT

The Dutch government launched a 'Living Lab' 'Electric and Hybrid driving' to facilitate, accelerate and stimulate the innovation and adoption of electric and hybrid vehicles. Part of this program is the living lab 'Rotterdam tests electric driving' or "RTER", which is the largest integral study of EV in the Netherlands so far.
The city of Rotterdam, DNO 'Stedin' and energy supplier 'Eneco' aim to stimulate electric transport, in order to improve air quality, reduce CO_2 emissions and noise nuisance. The objective of the city of Rotterdam is to turn 25% of their own fleet into electric or hybrid vehicles, by the end of 2014. The project is a joint initiative to set up a large-scale test lab to monitor electric vehicles.

Concerning the use of EV, there are still many uncertainties. From april 2012 on, 75 electric or hybrid vehicles are tested. The vehicles are monitored for at least one year on issues like energy consumption, costs (including management and maintenance), charging behavior, environmental issues, user experiences and security. The study ends in 2013. The Belgian research center Laborelec is responsible for analyzing and reporting the data collected. The following research questions are examined:

1. *Understanding the factors that influence the energy consumption of electric vehicles*
2. *Identify the gain of avoided emissions*
3. *Determine the effects of electric driving on the electricity grid*
4. *Summarize the experiences of the users of EV, as to charging behavior in particular*
5. *Determine the impact of electric vehicles on the use of vehicles and the mobility behavior of users of EVs of the city of Rotterdam, Stedin and Eneco*
6. *Define the availability and reliability of electric vehicles*
7. *Determine the economic viability*
8. *Identify the safety of electric vehicles*
9. *Build up project experience in electric mobility*

The paper is focused on research question 3, concerning the impact of electric driving on the electricity grid.

INTRODUCTION

This project subtopic considers the consequences of electric mobility on the existing electricity grid. With this purpose, measured loads in MV/LV distribution substations and load profiles from EVs are combined. This enables an evaluation of the moment, the place and at what level of charging point penetration the grid starts to saturate.
Next, the possibility will be investigated to enhance the number of load cycles by active control of the charging sessions (not included in this paper).

ANALYSIS OF THE CURRENT MV/LV DISTRIBUTION SUBSTATIONS

The simultaneity and the power of the charging sessions are decisive for the number of charging points that can be incorporated into the existing electricity grid.

Most MV/LV distribution substations are not being measured, there is no intelligence or active control present. As a result, the load profiles of these distribution substations and the outgoing feeders are not well known. In order to determine how much remaining capacity the electricity grid has, smart meters are placed in various MV distribution substations. It is important to be able to measure representative distribution substations, in order to do statements for large groups (residential areas/industrial areas/parking places/etc.).

For this research, measuring data from 23 smart meters are supplied from the distribution substations. In that way, 8 different MV/LV distribution substations are being measured, from which in 3 the MV/LV transformer is being measured and in all 8 measured distribution substations one or more feeders are being measured.

From the 23 smart meters, 12 meters measure the load in a city centre and 11 measure the load in a residential area.

There are no measurements in an industrial area or on office locations. In order to have a load profile of an office location, standard profiles of office buildings, known by Laborelec, were used. The smart meter registers the current and voltage per phase per 5 minutes and calculates the 3-phase power. The kWh registry was used in order to determine the average power demand per 5 minutes interval. A geographical overview of the MV/LV distribution substations is shown below.

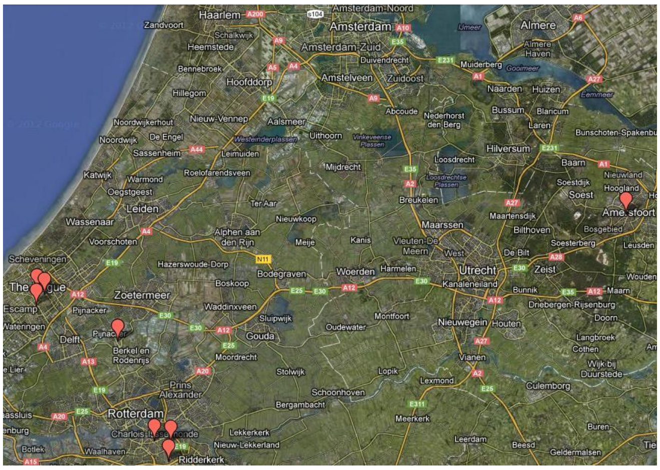

Figure 1: Location of the measured distribution substations (red points)

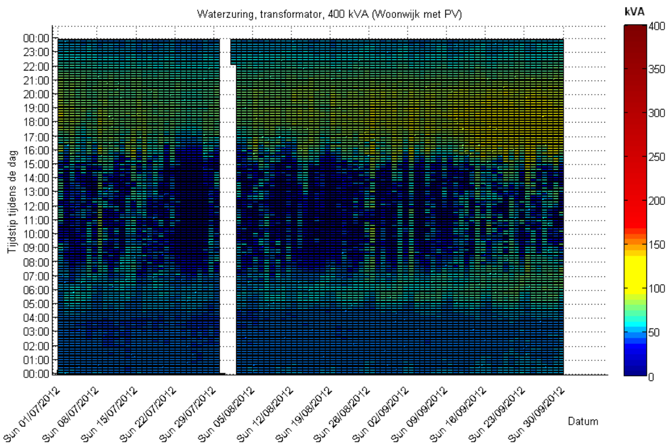

Figure 2: Power supplied to a feeder in a residential area

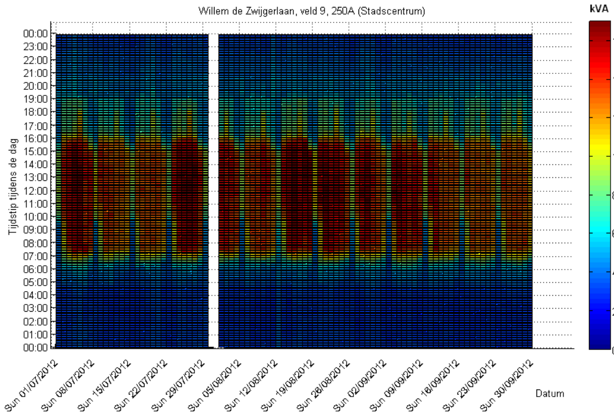

Figure 3: Power supplied to a city center feeder

The load profile of a residential area is determined by the dwellings: a single peak is recognizable in the evening between 5 and 9 pm. The available hosting capacity per substation is variable, but is greater than 45%.

In the city centre, loads are quite constant between 7 am and 4 pm. Outside these periods, consumption is small. Measurements show the available hosting capacity is limited at some places (<20%).

Measurements of a representative office building are similar to the city centre measurements, but over a longer time period: between 6 a.m. and 7 p.m., the loads are quite constant. Between 6 and 9 a.m., a growing phase is present, from 5 to 7 p.m., load level is shrinking. Outside office hours, consumption is low.

ANALYSIS OF THE USED CHARGING POINTS

In this project, only charging points which can charge with 16A or 32A intensity are considered (single or three phase). By analyzing the use of the charging points, conclusions can be drawn about the possibility to fit charging points in the existing electrical infrastructure. In the RTER-project, 20 charging points are equipped with a smart meter.

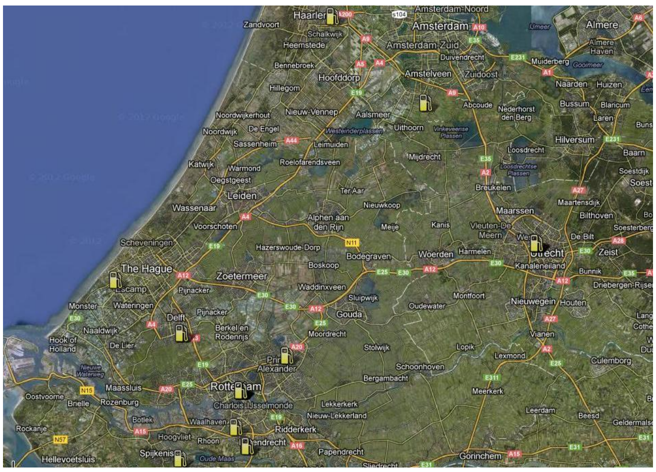

Figure 4: Locations of the measured charging points (yellow pump icons)

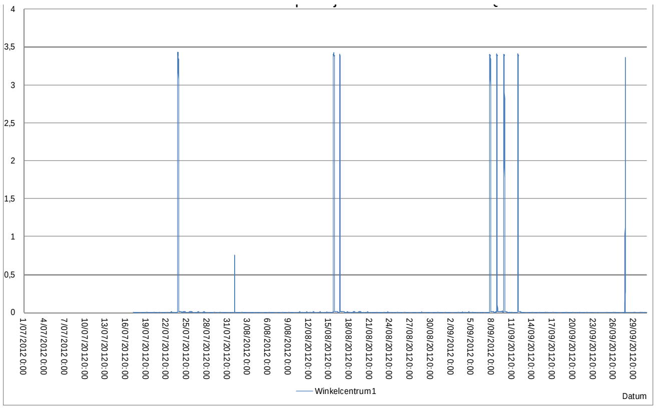

Figure 5: Activity profile of a charging point next to a shopping mall

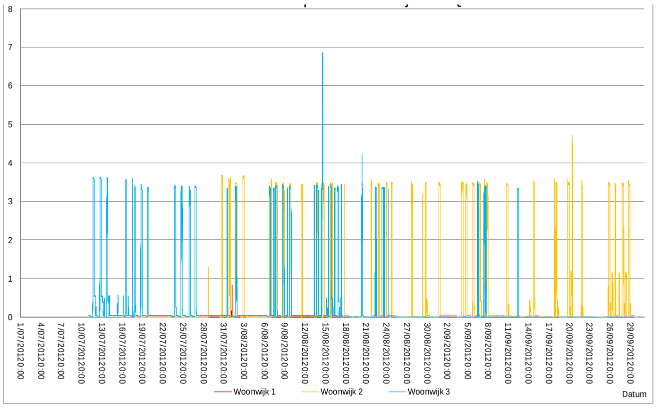

Figure 6: Activity profile of 3 charging points in 3 different residential areas

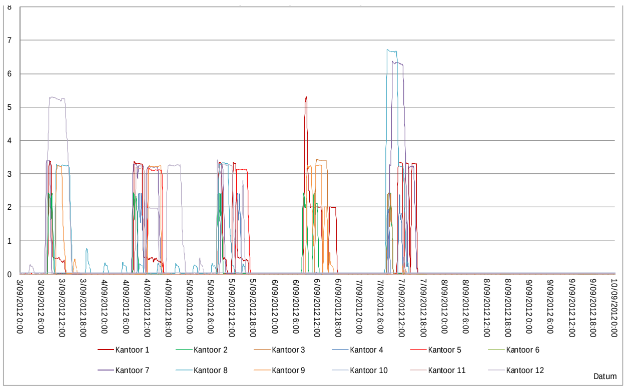

Figure 7: Activity profile of 12 charging points around office locations during 1 week

The measured charging point near a shopping mall is, contra-intuitively, not used by the shopping public.

The measurements show that the charging points in residential areas are mainly used between 5 and 11 p.m. on working days. Average charging time is 3 to 4 hours, with an intensity of 3,5 kW. These charging points are used only once a day.

Charging points near offices are only used during office hours, between 6 a.m. and 6 p.m. These charging points are also only used once a day, although charging time is only lasting for some hours, on average. The charging point is occupied by the same EV for a longer period, parked there for the day. The simultaneity of charging is important near office and just after the noon. Also between 8 and 10 a.m., simultaneity is important.

DETERMINING THE THEORETICAL NUMBER OF CHARGING POINTS

The study determined based on the former chapter "standard usage profiles" for charging points. Applying these profiles on the grid gives a first insight considering the impact of large numbers of charging points in the grid.

From the DSO-perspective the analysis has delivered the following important results:

- Both in residential areas as in city centres, there is room for the installation of charging points. In the considered residential areas, up to 1 out of 2 households can be equipped with a charging point as far as capacity is concerned. See Figure 8. Note that left and right Y-axis are not identical, to point out the simultaneity of charging sessions.
- The peak load of the grid will rise when connecting the charging points. Since the charging sessions have a high simultaneity AND coincide with the period of the current peak load of the present grid, the remaining grid capacity will decrease, making earlier replacement investments needed.
- The marginal costs by connecting additional charging points are greater than the extra income from the DSO/TSO tariffs. This might pose a negative business case from DSO-perspective; this has to be elaborated.

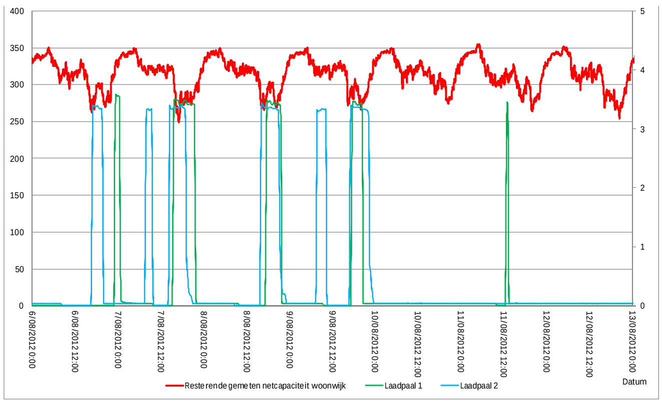

Figure 8: Grid capacity of a residential area and 2 charging points

CONCLUSIONS

It is necessary to examine well the possibilities of active control, in order to make possible large-scale electric mobility at the lowest possible societal costs.

With active control from the DSO, it is possible to double the number of charging poles on office locations, provided the EVs stay connected to the charging point for 8 hours and charge for 4 hours. In the analyzed residential areas, at least a doubling of the number of charging cycles can be achieved by active control. Smart active control, which means that also charging cycles are being divided and distributed in time, can still increase the number of charging cycles but deserves further research.

ACKNOWLEDGEMENT

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