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SOLAR POWERED E-BIKES: MONITORING AND ANALYSIS OF A SUSTAINABLE MOBILITY SYSTEM

BY ANGELE REINDERS

CONTEXT

E-bikes are considered one of the most promising sustainable alternatives to automobile transportation today. These e-bike solves many of the reasons people give for not cycling (distance, hills, physically strenuous) and offers many of the same benefits as the car (range, flexibility, rush-hour speed). In the Netherlands, E-bikes are gaining in popularity, especially among elderly and commuters.

THE SHARE OF E-BIKES IN BIKE SALES HAS RAPIDLY GROWN FROM 10% IN 2008 TO OVER 20% IN 2014.

At the moment, there are over 1.2 million e-bikes in the Netherlands. Recent innovations are the high-speed e-bike, solar charging of e-bikes and the development of the e-solar-bike. Solar charging happens by photovoltaic systems resulting in a twenty-fold lower CO2 emission than charging by

electricity from the grid. This can be done by separate systems, called solar charging stations, or by an integrated design such as solar bikes, which are e-bikes with integrated solar cells, which charge an e-bike's battery during a trip.

To date little is known about the use of different types of e-bikes, their health effects, and the effect they are having on motorized and regular bicycle travel. Therefore most information is highly opinionated, with in particular high expectations about health benefits that are not supported by scientific evidence). Also very little is known about the technical performance and effects of solar charging of e-bikes on mobility patterns and battery charging behavior and hence sustainability effects, even not in the Netherlands, a country which has a strong track record in research in both photovoltaics, mobility and sustainable design. This project proposed for the Living Smart Campus aims therefore to significantly add to this existing and surprising void in knowledge with a high societal relevance.

AIM

The aim of this trans-disciplinary Smart Living Campus project is to collect and analyze data to understand the use patterns of electric bicycles (e-bikes) and their potential benefits as part of a sustainable mobility system. E-bikes are usually charged by electricity from the grid and by human power resulting from pedaling during use. In this project, among others, we like to compare these two modes of charging with charging by solar PV power, before, during and in the middle of trips. At the same time, by exploring this topic with a trans-disciplinary approach, new research methods will be required which can combine end-user studies with the analysis of (big) data of e-bike use variables. The main research question is to examine the efficiency and user satisfaction of different solar charging strategies of e-bikes in three different situations, (1) at the work place (at UT), (2) at the home location, and (3) during travelling.

AMBITIONS & ACTIONS

For each of three situations sketched above clear ambitions exists and actions are being executed and prepared.

1. Solar charging at the work place

The UT's Facility Management is preparing the installation of a solar charging station for the recently started ERA-NET Smart Grids Plus project CESEPS. The station's design has been prepared yet in the past half year and at present the engineering and realization phases have been initiated. The ambition is that this solar charging station which will be able to charge six e-bikes. The station will be installed next to the Spiegel building by the beginning of 2017. This charging station and the e-bikes that will connected to it will be fully monitored and evaluated. An important aim of this activity is to expose the sustainability ambitions of the UT.

2. Solar charging at home

To examine solar charging at home we plan to select 10 UT staff members who will receive a small solar charging kit consisting of a PV module and lead-acid battery to be installed and used at home. This approach is based on previously executed research between UT and University of Waterloo on the design and effectiveness of individual charging kits for e-bikes. The charging kits and the e-bikes connected to them will also be fully monitored and evaluated with the aim to compare these results with central charging at the work place and charging during a trip.

3. Solar charging during a trip

To examine solar charging during a trip, we will use 5 solar-bikes which are been developed at TU-e as part of a 2016 TUE/UT 4TU.Bouw Lighthouse project. The solar bikes are e-bikes with integrated solar cells in their wheels, which can be charged during the trip. The e-solar-bike also allows traditional charging. Also these e-bikes will be fully monitored and evaluated. Adding to the comparison with the two other solar charging modes we will evaluate also in what extent the integrated solar cells expands their range compared to regular e-bikes.

TWENTY E-BIKES USERS (RECRUITED FROM UT STAFF MEMBERS) WILL BE MONITORED, AND USER SURVEYS WILL BE CONDUCTED TO EVALUATE USER NEEDS & SATISFACTION WITH SOLAR CHARGING.

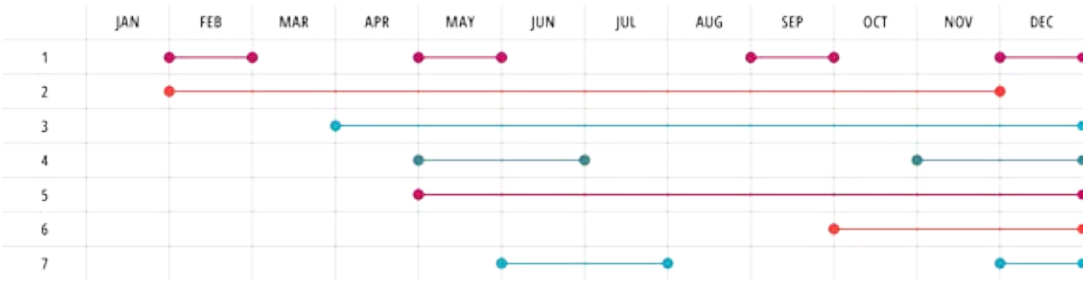
For the monitoring of all e-bikes in this project and collection of data sets, sensor kits will be applied which have been developed and tested yet at University of Waterloo, a long term collaborator of ARISE. See appendix for an overview of the sensors in these kits.

ENFORCING COLLABORATIONS WITH OTHER UNIVERSITIES

This project will strongly enforce ongoing collaboration with University of Waterloo and Technical University of Eindhoven around the theme of solar charging of e-vehicles. For instance at University of Waterloo has ongoing research on e-bikes and has recently submitted an internal proposal with a similar scope like this proposal. By this collaboration we can collect similar data sets with the aim to increase research statistics by repeating tests on different batches of e-bike volunteers by postdoctoral research.

MILESTONES & OUTPUTS

The project has the following milestones (which are indicated in Table I): (1) the start of technical testing of the central solar charging station at UT, (2) the start of technical testing of 10 single charging units at homes of e-bike users that participate in this research, (3) the start of mobile monitoring of 20 e-bikes, (4) the first results of user surveys, (5) the first results of combined user and technical data, (6) the design recommendations for solar charging of e-mobility following from this research project, (7) reporting.



DOCUMENTATION & COMMUNICATION PLAN

The findings of this Living Smart Campus project will be disseminated to a wide public by the demonstrator cases, such as the visibility of the solar charging station on campus and the solar powered e-bikes, and by publications in relevant professional and academic journals. In addition, messages, photos and movies will be posted on social media with support of UT and TU/e. To allow the outcomes of the project to benefit the academic community, results will be described in a conference paper, which will be presented at a conference and later submitted to a journal (December 2017).

APPENDIX: SENSOR KIT FOR E-BIKE MONITORING

The sensor kit that can be used for e-bike monitoring includes a wide range of sensors that can be applied based on the interest of the researcher. Sensors that measure e-bike performance: battery voltage (to measure battery state of charge); battery charge/discharge current (to measure power consumption and state of health); sensors to measure rider behavior for transportation engineering research: a gps sensor to record space and time data (x,y,z,t).

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