Can Smart Charging Balance the Urban Energy Grid?

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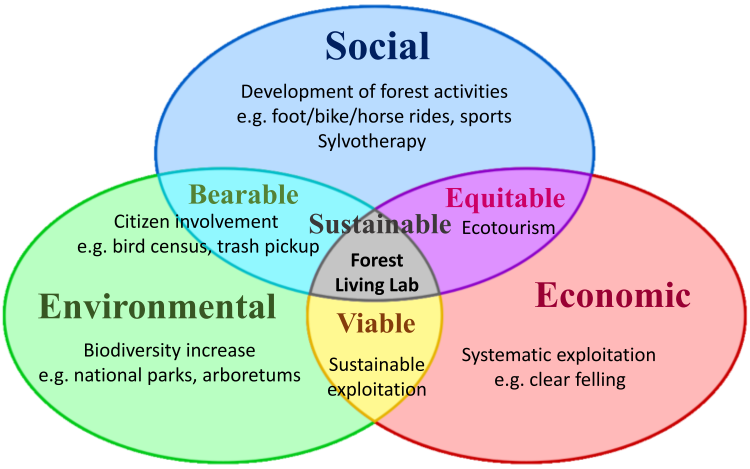

Figure 1: Different means for a sustainable forest.

open to multi-objective/use/purposes, e.g., wood production, water quality, wildlife, recreation, aesthetics and clean air [L3]. Such a multi-use approach is not new but was deployed through a living lab based on the combined methodological experience of two Walloon research centres respectively specialised in information technology and forestry. The strengths and differentiators of our approach are:

- Workshopping activities to bring together people of different backgrounds and identify mutually enriching usage scenarios.
- Multi-objective identification and reasoning using different techniques such as system thinking. This approach can help to pinpoint synergies and barriers, or positive and negative feedback loops, relating to different stakeholders' goals.
- Rapid technical feedback about existing tooling and related constraints, key issues and success factors (e.g., monitoring tools, tracking tools, information channels).
- Easy set-up of experiments involving different types of participant in specific or mixed scenarios.

As an example, participative workshops and online tools supporting collaborative decision making can help to work out how the combined monitoring and recreative functions of the forest might work together. From a technical perspective, useful information is provided by a variety of GIS tools such as WalOnMap [L4]. This helps us assess the potential for a given area to evolve towards more integrated and multiuse management by combining biodiversity, remarkable features (e.g., landscapes, rocks, waterways) and the path/road infrastructure. This approach is proving quite successful and is being applied by CETIC to other ecosystems, such as mobility management to organise ride sharing [3].

Links:

[L1] https://kwz.me/hSW
[L2] http://www.regiowood2.info/en
[L3] https://kwz.me/hSX
[L4] https://kwz.me/hSZ

References:

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[2] A. Kusiak: "Innovation: The Living Laboratory Perspective", CAD & Applications, vol. 4, n°6, 2007.
[3] C. Ponsard: "Building sustainable software for sustainable systems: case study of a shared pick-up and delivery service", GREENS@ICSE 2018.

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Can Smart Charging Balance the Urban Energy Grid?

by Pieter Bons, Robert van den Hoed (Amsterdam University of Applied Sciences) and Nanda Piersma (Amsterdam University of Applied Sciences and CWI)

Smart charging protocols for electric vehicles can help avoid overload and instability in the electrical distribution network and can increase the proportion of locally generated solar energy used for charging. Our results show that the impact of smart charging depends heavily on the technical charging characteristics of the target vehicle.

Electric mobility is developing at a rapid pace, led by a few European countries, including Norway and the Netherlands. The electrification of transport constitutes a considerable additional load for the electricity grid. Electric mobility is estimated to increase the total demand for electricity by 15 to 20%. Given that charging profile of electric vehicles (EVs) tends to overlap with household consumption profiles, the power consumption peaks are likely to significantly increase as a result of EV charging, and limits to grid capacity may be reached [1].

Since May 2019, an experiment known as "Flexpower" has been underway in Amsterdam, with the aim of investigating the technical feasibility and measuring the impact of load shifting on public charging stations under real-world conditions. The project is a collaboration between the Municipality of Amsterdam together with the Amsterdam University of Applied Sciences, charging point operator Vattenfall, grid operator Liander, and knowledge centre ElaadNL.

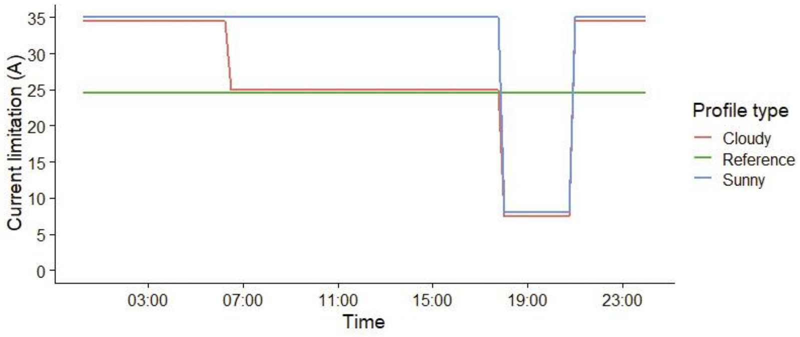

Figure 1: The time-dependent current profile deployed on the selected Flexpower charging stations under sunny and cloudy conditions compared to the current limit on a regular public charging station in Amsterdam.

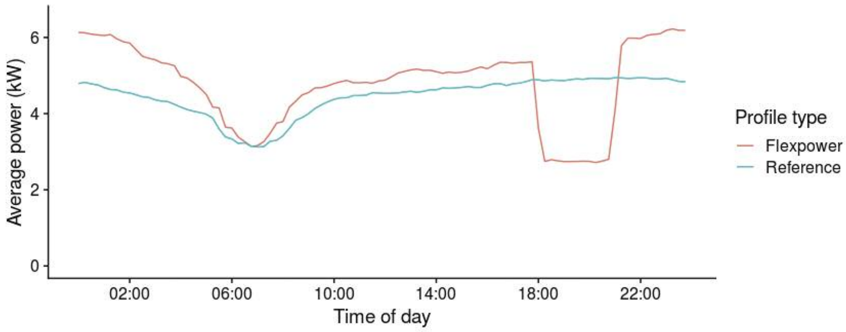

Figure 2: Charging power averaged over all active sessions as a function of the time of day,. The resolution of the graph is 15 minutes, which is limited by the resolution of the data.

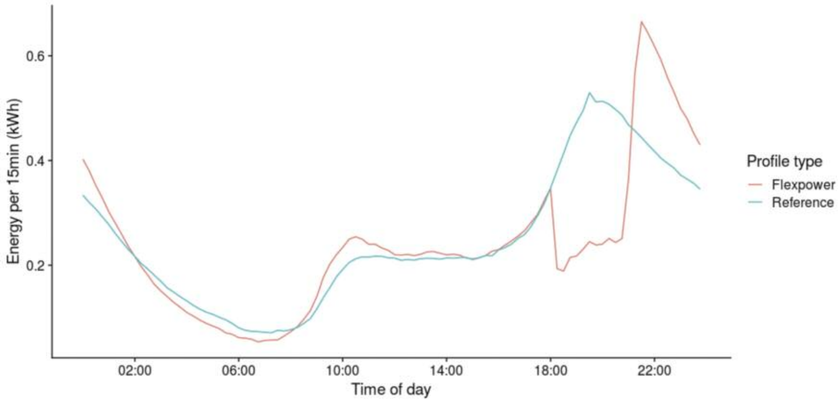

Figure 3: Average energy volume per charging socket per 15-minute interval. During each 15-minute interval of the day, a share of charging stations is distributing energy while the remaining stations are idle. The value plotted in this figure is the total amount of energy charged during this 15-minute interval divided by the total number of stations and averaged over the duration of the experiment.

Out of the 2,100 public charging stations in the city, 450 were selected to deploy a time-dependent current limit, with a higher limit during sunny conditions and greater restrictions during cloudy conditions and household peak-use times (Figure 1). During this pilot, data was collected from about 40,000 users, responsible for approximately 450,000 unique charging transactions. The data contained information on the start time, end time, amount of energy, charge point, payment ID as well as smart meter information at 15-minute intervals. The dataset contains transactions of battery electric vehicles (BEVs; all-electric vehicle) as well as plug-in hybrid electric vehicles (PHEVs; cars with dual fuel systems) since these share the same public charging infrastructure. The type of EV is not known in the data, but a classification is inferred based on the charging behavior over multiple sessions of a payment ID.

During the operational pilot, multiple key performance indicators (KPIs) were monitored to evaluate the effects of the smart charging profiles. These KPIs represent the interest of the different stakeholders involved in EV charging:

1. Effective charging power (kW) as a function of time of day,
2. Average amount of charged energy (kWh) per charging socket as a function of time of day,
3. Number of positively/negatively affected sessions in terms of amount of charged energy per transaction.

Results

Figure 2 shows the average power of all active sessions over the course of the day. The charging power on Flexpower stations is higher during the daytime and lower during peak times, which is exactly the intended effect for grid balancing in relation to household energy usage and availability of solar energy.

However, the charging volumes shown in Figure 3 (amount of charged energy) show no significant increase during the daytime, and a delayed peak in charging volume just after the evening peak. This shows that during the day the energy demand does not increase along with the higher power. Vehicles can charge faster but will finish the session earlier with the same net amount of charged energy. Without extra incentives to increase daytime demand, the current time-dependent profile does not result in more solar energy being utilised by EVs. The fact that there is a rebound peak directly after limitations are lifted proves that the Flexpower infrastructure can deliver higher energy volumes if there is outstanding demand.

An important finding of this study is that a determining factor of the effects of a flexible charging profile are the charging characteristics of the EV itself. There are many different EV models on the market with different charging characteristics. The number of phases that a vehicle uses to charge can differ (there are 1-phase, 2-phase and 3-phase models) as well as the maximum current at which the vehicle can charge (16A, 25A and 32A). Full electric cars tend to have larger batteries that require higher charging powers (3-phase charging at up to 32A), PHEVs generally use 1-phase charging at 16A. The effects of a flexible current limit depend heavily on the type of EV that is charging.

In total, 5% of all transactions on Flexpower stations received a lower average power than on reference stations, which represents a negative impact on EV users. It should be noted, however, that PHEVs dominated these negatively affected sessions. As such, although there will be a slight reduction in zero-emissions kilometres driven by these users, it is unlikely that they will be impacted by range anxiety.

In total, 4% of the sessions were positively affected, owing largely to vehicles that were technically able to profit from higher current during off-peak hours. This category of vehicles is dominated by full electric vehicles, which are more dependent on a full charge. For this category, the Flexpower profile provides a significant improvement.

The results of this experiment show that smart profiles on charging stations can suppress charging volumes during a designated time window without large implications for EV drivers. The possibility of increasing charging volumes during the day is limited by the level of demand and technical limitations of most EVs currently on the market. More advanced battery electric vehicles are increasing in popularity in the major European markets for EVs, so the percentage of positively affected users is likely to increase rapidly in the near future.

Link:
[L1] https://kwz.me/h4C

Reference:

[1] García-Villalobos, Javier, et al.: "Plug-in electric vehicles in electric distribution networks: A review of smart charging approaches", Renewable and Sustainable Energy Reviews 38 (2014): 717-731.

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Grid-friendly Sustainable Local Energy Communities

by Michael Kaisers (CWI), Matthias Klein and Alexander Klauer (Fraunhofer ITWM)

New software and algorithms are being developed to help communities become less dependent on the electricity grid and less of a burden on it. This decoupling is an important step towards improving sustainability without compromising on affordability, comfort and efficiency of the overall system. Experience from pilot projects provides key insights into the management of the challenges that arise.

The transition towards (fluctuating) renewable electricity generation requires increased flexibility to use energy when available, either by shifting time of use or by storing energy. This capacity to be flexible is referred to as demand response. Such demand response is possible given decreasing storage prices, flexible thermal loads, electric vehicle charging schedules etc., but it requires intelligent coordination. The project "Demand response for grid-friendly quasi-autarkic energy cooperatives (Grid-Friends)" [L1] has developed and evaluated solutions that aim to achieve cost efficiency and maximum autarky by shared exploitation of storage and other flexible energy resources within communities.

The coordination challenge has been addressed with both fundamental and applied research, published in scientific conferences and journals. The research output can be roughly divided into three main directions. First, automated negotiation based on user preference models enables decentralised coordination of flexibilities within energy communities [1]. Second, fundamental research on reinforcement learning highlights how individual agents can learn to optimise their strategy in order to best respond within a collective of autonomous decision makers with potentially mixed interests, using methods such as opponent modelling [2]. Finally, future scenarios have been investigated that allow for the between-community exchange of flexibilities on regional energy markets [3]. Overall, the project resulted in 26 peer reviewed publications, and consortium members contributed to the discussions and policy briefs of several working groups within the knowledge community of the funding programme (ERA-Net Smart Grids Plus).

Practical challenges have been addressed with new software components and algorithms, added to the myPowerGrid internet platform [L2] and the local Amperix® energy management system, providing synergetic new capabilities across three interconnected sectors (electricity, eHeat and eMobility). Offered services include load-based dynamic power control of photovoltaic (PV) systems, curtailment event reduction by active scheduling of