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Concept study – using a hybrid vehicle as a CHP plant

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Introduction

Decentralisation and increasing energy efficiency are factors of success of the 'Energiewende'. Sensible interlinking of various energy markets will support and speed up the energy system transformation process. This concept study looks at and discusses an innovative approach to integrate power, heat and the mobility market using hybrid vehicles. Automobile electrification is steadily rising and goes hand-in-hand with qualitative (larger energy storage options) and quantitative storage capacity (much more hybrid vehicles) [1], [8]. Further utilisation options of electrical storage units in e-vehicles for intermediate storage to compensate volatile renewable energy sources are being discussed and tested. The innovative approach of integrating future full-hybrid vehicles with the principle of 'combined heat and power' [2], [3] to supply energy to buildings is not being pursued in depth, or even at all. In this approach both the electrical and also the thermal energy produced would be used as supply sources for the building.

Main part, discussion

Triggered by statutory regulations, the increase in the electrification of vehicle technology allows new ways of thinking about how to use one's own vehicle. In addition to the central issue of increasing mobility efficiency, hybridisation of vehicle technology allows this equipment to also be used for other energy markets, e.g. to supply heat and power to buildings or to generate capacities for the electricity grid. Central factors for the efficient use of a vehicle as a source of energy are the performance of the combustion engine, the e-machine, the storage capacity, a mobile thermal storage unit that is as compact as possible and existing interfaces to feed the energy into the building network. This promising combination exists, in particular in vehicles with range extender aggregates, because there is already an electrical interface in the vehicle. For this reason, any further theoretical considerations will be based on the technical data of the BMW i3 [6], and the range extender aggregate of the KSPG AG [4]. The quantities of energy required to supply a building were determined using the VDI 4655 [5] and compared to the output that could be generated in the vehicle by both systems, on a thermal and also electrical basis. This comparison examines three system utilisation scenarios and assesses them as realistically as possible. The following comparisons are carried out: daily mileage (duration) to work; average annual mileage of the vehicle; and the flexible use-independent production of heat and power. All three scenarios afford a good and secure supply of energy. Depending on the examined case, back-up boilers also need to be considered on cold energy-intensive winter days to cover the additional thermal output.
In addition to the use of the hybrid vehicle for mobility and as a building supply source, a further business model is the participation in the Electricity Balancing Market as part of a virtual grid. Calculations using the latest figures in combination with the projected number and assumed future performance capability of hybrid and electric vehicles result in a storage capacity of 3.1GWh (approx. 7,8% of the pump-storage hydropower plant capacity of Germany) for the year 2020 and a power plant capacity via the existing range extender combustion engines of up to 40 GW (approx. 40x1000MW power plants), plus a 33.6GWh storage capacity (approx. 84%) and a power plant capacity of approx. 100GW (approx. 100x1000MW power plants) for the year 2030. In relation to188 GWh [7] required to store one production hour of the current power plant output, this results in a coverage of the total storage capacity of almost 20% for the year 2030; in the field of output supply, the capacities are already more than adequate in the year 2030. Even when only 30% of the cars are available for storage or energy production, this approach will solve the needed flexibility in storage and production to integrate the further increase of the volatile renewable energy sources for the future. With this innovative approach, the so-called 'Energiewende' can be further accelerated by improving efficiency with decentralised storage and power plant capacities through hybrid vehicles.

Conclusion and outlook

The investigation shows that significant synergies can be utilised by optimising the crosslinking of the mobility, power and thermal energy markets. The required energy volumes in detached homes or smaller apartment complexes will be more or less covered. In particular, the integration of hybrid vehicles in other energy markets will allow the efficiency of these vehicles to be increased. In a further step, the theoretical examinations can be explored and developed in greater depth by means of detailed examinations of the various energy systems, specific interface analyses and economic efficiency calculations. Finally, steps also need to be taken at the political level to create a statutory framework to combine all three energy markets.

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