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NOTE:

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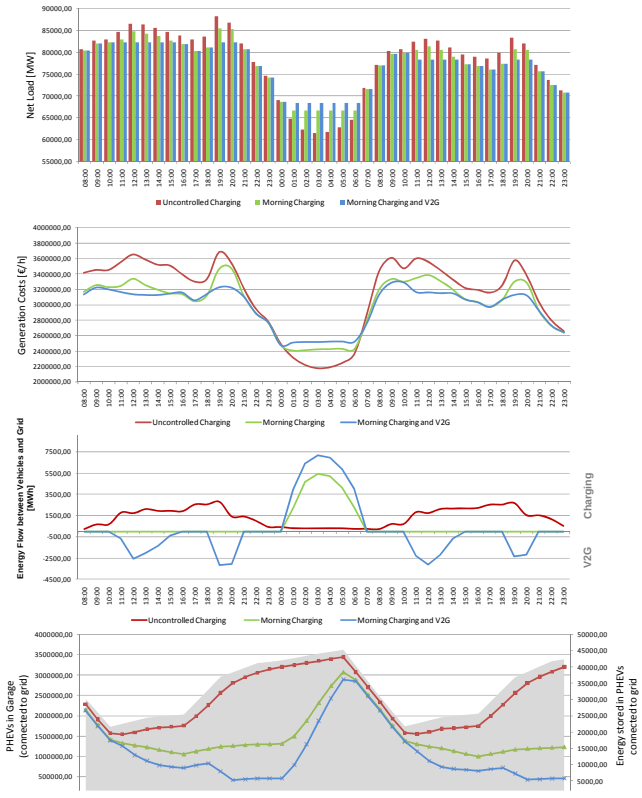
ASSESSING THE POWER SECTOR-RELATED ENVIRONMENTAL AND COST IMPACTS OF PLUG-IN HYBRID ELECTRIC VEHICLES IN GERMANY

Motivation

Plug-in Hybrid Electric Vehicles (PHEVs) are expected to decrease both the fuel costs for households and total emissions, and to enable an individual transport service that is less dependent on fossil fuels. Nevertheless, the diffusion of PHEVs will induce additional demand for electricity, which has to be supplied by the electricity producers, and can be expected to significantly affect total daily net load. In this study, we investigate the expected **environmental and cost impacts of different charging regimes**, including the influence of vehicle-to-grid (V2G).



Net load, generation costs, energy flow and stored PHEV energy by charging regimes (4,000,000 PHEV-60km)

Research focus

Modeling and simulation of the impact of PHEV diffusion(4,000,000 vehicles) with regard to Germany's energy mix in power generation and different charging regimes (scenarios) on:

- Power plant deployment,
- Generation emission and cost,
- PHEV emission and input fuel cost.

Comparison of results with the power generation mix after a **nuclear phase-out and** a **nuclear-intensive power generation** mix ('French mix').

Methodology

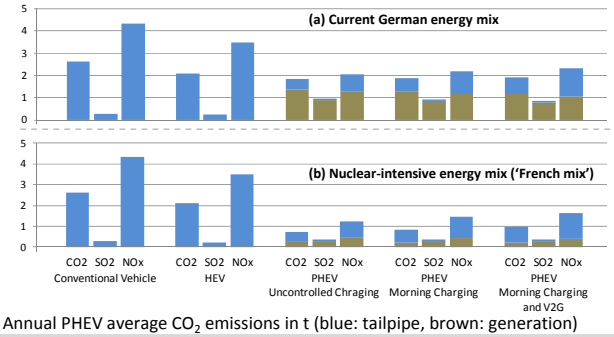
For each hour of simulation, a **mixed-integer linear programming (MILP)** approach is utilized in order to determine the **cost-minimizing deployment of generators**. Additionally, based on mobility data we develop heuristics for simulating the number of vehicles connected to the grid and their energy stored depending on the different charging regimes: **(1) Uncontrolled Charging; (2) Controlled Morning Charging and (3) Controlled Morning Charging with V2G**. The program is written in Matlab, the MILP solver used is lp_solver.

Data

We reproduce **Germany's power generation mix** with the different types of plants. In each charging regime/scenario, the **hourly generator deployment and hourly PHEV usage patterns for one year** are simulated (8,740 hours in total). For the net load demand curve and wind load supply curve, **real data from 2008** was utilized. The availability of PHEVs and their storage was derived from the study 'Mobility in Germany' (DIW, 2003). The simulation output is hourly deployment data of each generator, air pollutant emissions (CO_2, SO_2, NO_x), and power generation and PHEV fuel cost.

Main results

- Controlled Charging leads to more steady use of coal-fired power plants
- Generation costs are the highest for Uncontrolled Charging
- **Generation emissions increase with Controlled Charging** and V2G
- The effect of Controlled Charging on generation emissions and costs is likely to be significantly lower in Germany than in France.
- PHEVs in Germany will **emit not much less CO_2** than conventional vehicles
- %age of distance in All-Electric mode decreases with Controlled Charging
- PHEV emissions increase under Controlled Charging regime
- PHEV fuel costs increase under Controlled Charging regime



Annual PHEV average CO_2 emissions in t (blue: tailpipe, brown: generation)

Selected references

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