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ChaProEV: Generating Charging Profiles for Electric Vehicles

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Summary

ChaProEV is

Statement of need

- Profiles are good and useful, but optimisation modes might also need soem underlying parameters to do optimisation computations as well
- Provide optimisation models with the boundary conditions they need
- ChaProEV povides the necessary parameters (as explemplified in COMPETES, Mopo/Ines, etc.) in a clear and accessible way, with the also allowing a clear way to modify them without touching code (Sijm et al., 2022)

Conceptual innovations: Supporting optimisation models

Basic elements

A commonly used aggregated EV formulation is (Morales-España et al., 2022):

$$e_t = e_{t-1} + \eta^{\mathrm{G2V}} p_t^{\mathrm{G2V}} \Delta - \frac{p_t^{\mathrm{V2G}}}{\eta^{\mathrm{V2G}}} \Delta - E_t^{\mathrm{drive}} \Delta N \alpha \quad \forall t \tag{1}$$

$$e_t = e_{t-1} + \eta^{\mathrm{G2V}} p_t^{\mathrm{G2V}} \Delta - \frac{p_t^{\mathrm{V2G}}}{\eta^{\mathrm{V2G}}} \Delta - E_t^{\mathrm{drive}} \Delta N \alpha \quad \forall t \tag{2}$$

$$\underline{E} N_t^{\mathrm{plugged}} N \alpha \leq e_t \leq \bar{E} N_t^{\mathrm{plugged}} N \alpha \qquad \forall t \tag{3}$$

$$0 \leq p_t^{\mathrm{G2V}} \leq \bar{P}_t^{\mathrm{G2V}} N_t^{\mathrm{plugged}} N \alpha \qquad \forall t \tag{4}$$

$$0 \leq p_t^{\mathrm{V2G}} \leq \bar{P}_t^{\mathrm{V2G}} N_t^{\mathrm{plugged}} N \alpha \qquad \forall t \tag{5}$$

where t is the time index and parameter Δ (h) is the duration of the time step. Variable e_t (kWh) tracks the total state of charge of the plugged EVs to the grid. Variables $p_t^{\mathrm{G2V}}/p_t^{V2G}$ (kW) are the power consumed/provided by the EVs from/to the grid. Parameters $\eta^{\mathrm{G2V}}/\eta^{\mathrm{V2G}}$ (p.u.) are the charging/discharging efficiencies; $\underline{E}/\bar{E}$ (kWh) are the minimum/maximum storage capacity per vehicle; N is the total number of EVs; and α (p.u.) is the share of controllable EVs providing demand response to the system. Section **??** defines the remaining parameters (profiles).

Equation 2

Further modelling

Software innovations

No code parameters and profiles modification (explain what kind of modifications are possible) Scenarios

1. Demand for next leg (kWh) (from network): The charge that the vehicles leaving in the next time step need to pull from the network for the leg they are about to undertake, corrected by the charger efficiency.
2. Demand for next leg (kWh) (to vehicles): The part of the above that vehicles get. ($\{E_t^{\mathrm{drive}}\}$ in Equation)
3. Connected vehicles:The share of vehicles that are connected to a charger ($\{N_t^{\mathrm{plugged}}\}$ in Equation)
4. *Charging Power from Network (kW):* Maximum power that connected vehicles can potentially draw from the network. ($\{\bar{P}_t^{\mathrm{G2V}}\}$ in Equation)
5. Charging Power to Vehicles (kW): Maximum power that can potentially go to vehicles go to vehicles (i.e. the same as above with a charger efficiency correction).
6. *Vehicle Discharge Power (kW):* The amount of power connected vehicles can discharge to the network.
7. Discharge Power to Network (kW): How much of that discharged power can go to the network. ($\{\bar{P}_t^{\mathrm{V2G}}\}$ in Equation)
8. Effective charging efficiency: Ratio between charging power going to the vehicle and power coming from the network. This can vary in time, as the location of the charging vehicles (and thus the efficiency of the involved chargers) changes as they move around. (η^{G2V} in Equation)
9. Effective discharging efficiency: Same as above, but for discharging (it is the power going out of the vehicles divided by the power going into the network). (η^{V2G} in Equation)

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