

1 ChaProEV: Generating Charging Profiles for Electric 2 Vehicles

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Software

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7 Summary

8 ChaProEV is

9 Statement of need

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

Conceptual innovations: Supporting optimisation models

Basic elements

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

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

$$\underline{E}N_t^{\text{plugged}} N \alpha \leq e_t \leq \bar{E}N_t^{\text{plugged}} N \alpha \quad \forall t \quad (2)$$

$$0 \leq p_t^{G2V} \leq \bar{P}_t^{G2V} N_t^{\text{plugged}} N \alpha \quad \forall t \quad (3)$$

$$0 \leq p_t^{V2G} \leq \bar{P}_t^{V2G} N_t^{\text{plugged}} N \alpha \quad \forall t \quad (4)$$

19 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^{G2V}/p_t^{V2G} (kW) are the power consumed/provided by the EVs from/to the grid. Parameters η^{G2V}/η^{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.

25 Section ?? defines the remaining parameters (profiles).

26 Equation 1–Equation 4 model the demand response provided by controllable EVs through p_t^{G2V} and p_t^{V2G} . The total EV demand d_t^{Tot} (kW), including the non-controllable load, is defined as

$$d_t^{\text{Tot}} = D_t^0 N (1 - \alpha) + p_t^{G2V} - p_t^{V2G} \quad \forall t \quad (5)$$

28 where D_t^0 is the reference (non-demand response) profile given by ChaProEV (see Section ??),
 29 and α is the proportion of vehicles that are optimally providing demand response.

30 Further modelling

31 Software innovations

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

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

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