Dynamic Grid Fees for Congestion Management in Low-Voltage Grids

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Objective

Grid Energy Community Coordination:
Reduce congestion (overloading of network components) in a LV-grid

- Coordinate controllable loads
- Scarcity pricing as signal for controllable loads (via HEMS)

→ dynamic grid fee (DGF)

Optimization

- Self-sufficiency: $\min_{P_{flex}} \sum_t^{t+h} c_d\left(P_{\text{flex},t} + P_{\text{base},t}\right) - c_g P_{\text{PV},t}$
- DGF: $\min_{P_{flex}} \sum_t^{t+h} c_d P_{\text{base},t} + (c_d + \lambda_t) P_{\text{flex},t} - c_g P_{\text{PV},t} + 0.1(P_{\text{flex},t} - \hat{P}_{\text{flex},t})$

With $\lambda_t = \begin{cases} 0.66 & P_{\text{Trafo}} \geq P_{\max} \\ -0.33 & \text{for } P_{\text{Trafo}} \leq -P_{\max,} \\ 0 & \text{else} \end{cases}$ $\quad c_d = 0.66, \quad c_g = 0.3, \quad \hat{P}$: scheduled load

KPIs

- Maximum power on highest loaded feeder $P_{\max}$
- ratio of time steps with congestion $n_t = \frac{N_c}{N_S} = \frac{N_c^+ + N_c^-}{N_S}$
- Congestion Energy: $E_c = (|P_t| - P_{\max}) \cdot \Delta t$

Scenarios

Based on the network development plan 2025

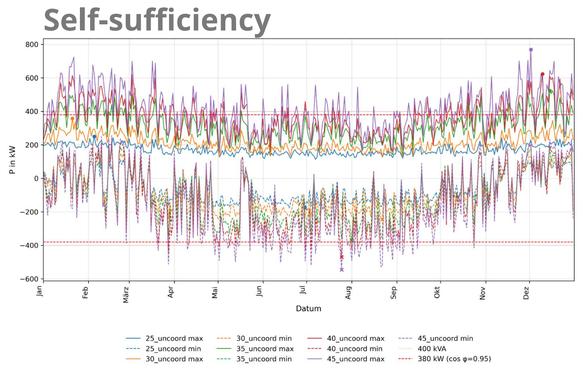
Year	EV	HP	BSS	PV
2025	55	171	200	284
2030	165	274	254	391
2035	363	326	333	554
2040	484	349	392	672
2045	572	404	442	781

in kW

Results

Time series

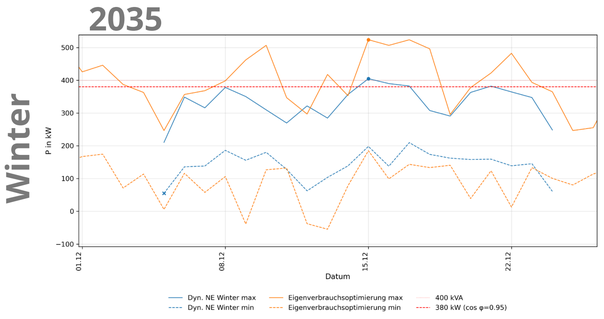
Self-sufficiency



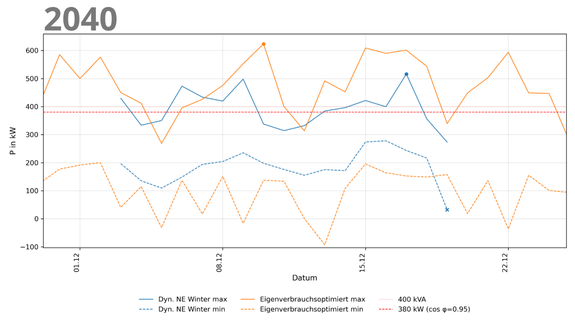
→ Congestion from 2035 on

Winter

2035



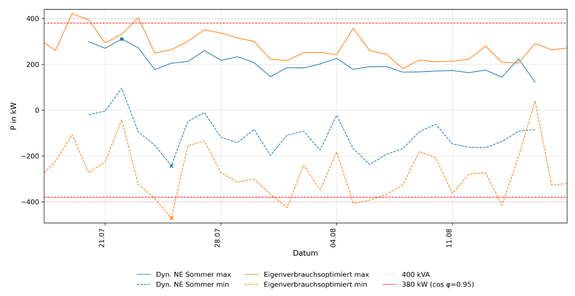
2040

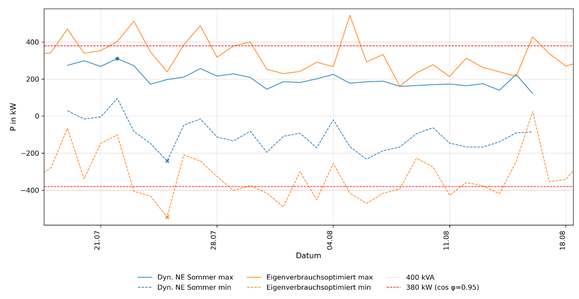


2045

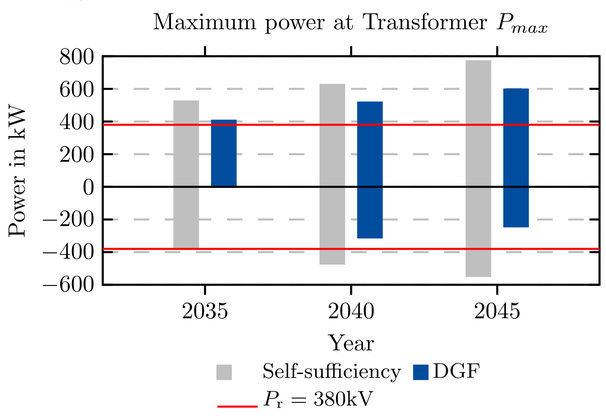
Summer

No congestion

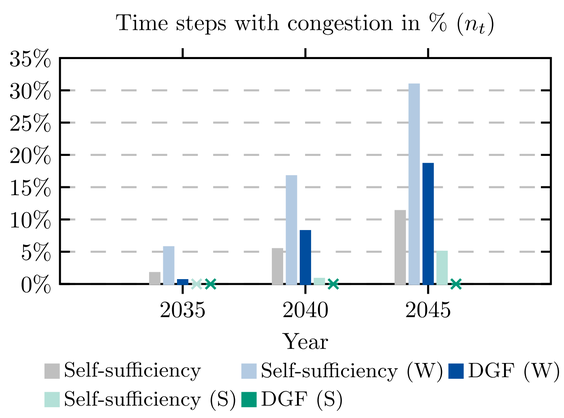




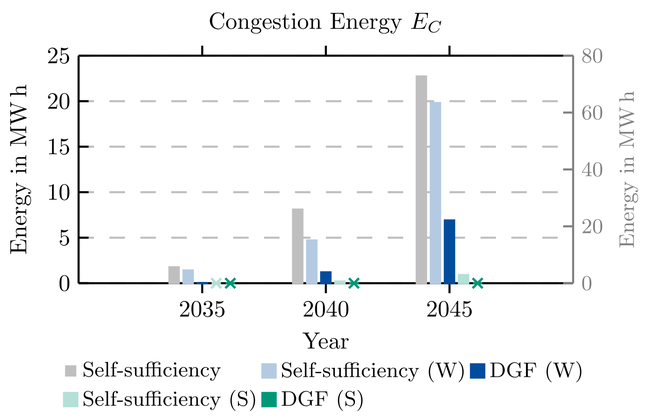
KPIs



→ Significant reduction of maximum power:
- possibly no transformer update needed for 2035
- no additional transformer update from 2040 to 2045



→ Significant reduction of time steps with congestion:
- no congestion from feed-in in 2035 and 2040
- no additional transformer update from 2040 to 2045



→ Significant reduction congestion energy:
- Negligible for 2035 → no transformer update necessary

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