cenex

Assessment of the contribution of charging infrastructure to flexibility, increasing the share of renewable electricity and reducing costs for the electricity system

Q&A session

13th June 2025

Introduction to Cenex

Non-profit consultancy specialising in **low-carbon transport and energy infrastructure**.

- Work with public and private sector clients.
- R&D project development (RTO status).
- Organise Cenex Expo, large net-zero and connected mobility event.

Independent

Not-for-profit

Experts

Contents

1 **Motivation**

What have we analysed and why

2 **Method and key takeaways**

Modelling methodology and snapshot of main results

3 **Results**

Deep dive into individual scenario results

4 **Recommendations**

Recommendations based on results from the simulated scenarios

Background & motivation

- Under Articles 15(3) and 15(4) of the AFIR, EU Member States and regulators must assess how EV chargepoints and bidirectional charging can support energy system **flexibility, cost reduction**, and increased use of **renewable** electricity.
- In Luxembourg, the Ministries of Mobility and Public Works and of the Economy assigned ILR to lead this assessment, with Cenex conducting the study.
- The findings will help guide government actions on the placement and availability of chargepoints and related policies.

cenex

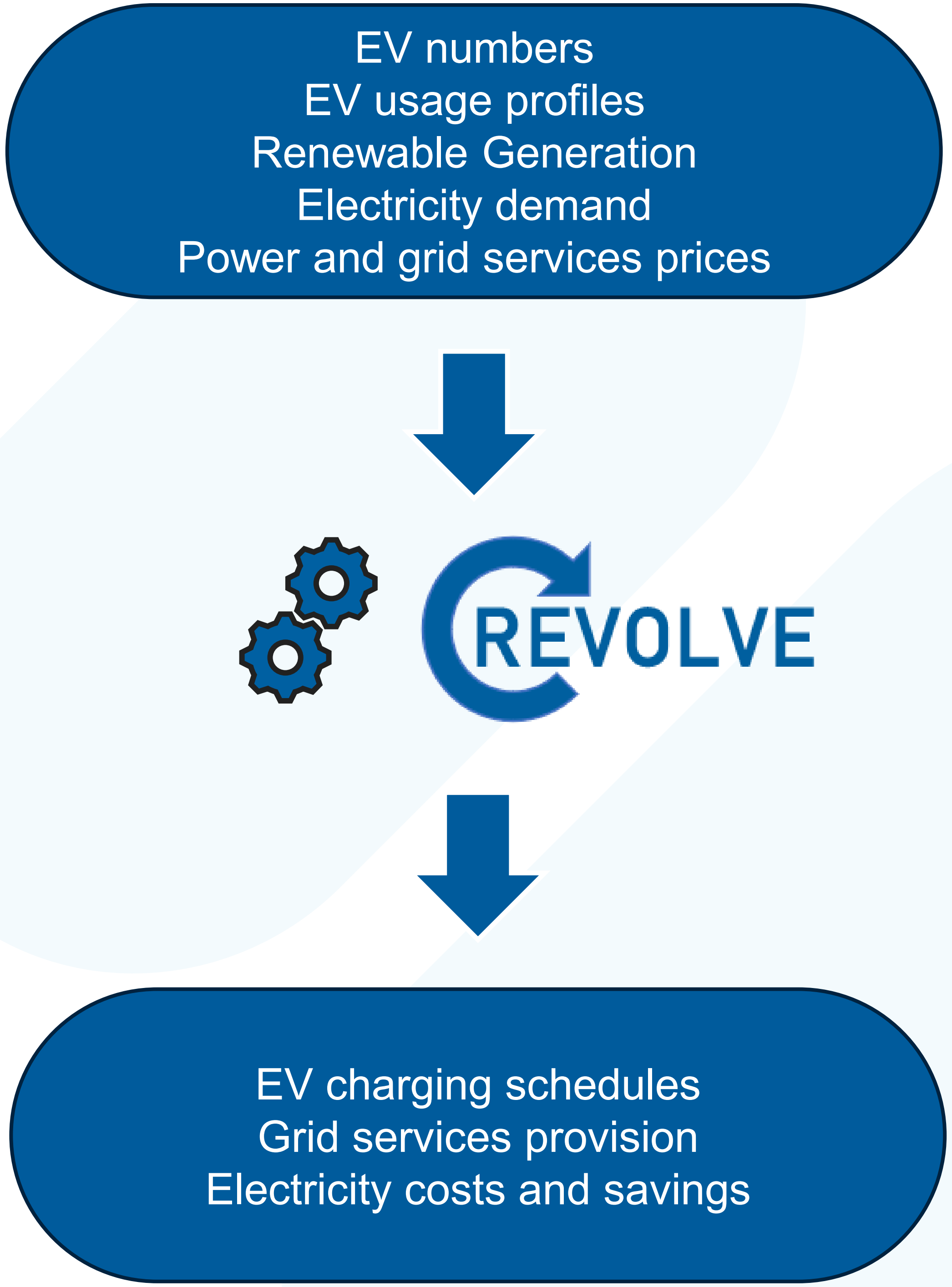
We will pause regularly and ask if you have any questions

cenex

2 Method and key takeaways

Method*

- National and regional modelling of:
  - ✓ EV charging demand
  - ✓ Plug-in times
  - ✓ Renewable generation
  - ✓ Electricity demand
  - ✓ Power prices
  - ✓ Transmission grid constraints
- Cenex's **REVOLVE**: optimisation model simulating (dis)charging behaviour of large numbers of EVs at half hourly granularity against time varying tariffs and grid services
- *Model **caveats***
  - *<u>Perfect foresight</u>: knowledge of future events, including energy demand, prices and vehicle movements*
  - *<u>Price taker</u>: price remains fixed, model changes on electricity demand do not have an impact on prices*



Method cont.

- Data from **2023 baseline and 2030 forecast** scenarios on:
  - ✓ PV and wind generation capacities
  - ✓ Electricity non-EV demand profiles
  - ✓ Numbers of electric cars, vans and HGVs
  - ✓ EV charging demand from all electric cars, vans and HGVs resident in or visiting Luxembourg (incl. hourly plug-in profiles)
  - ✓ Electricity prices for day-ahead market.
  - ✓ Grid services prices for FCR and aFRR (grid services mature in 2030)
- **Four reference days** to spread possible market conditions in which EV flexibility could be demonstrated
  - ✓ Winter High Renewables
  - ✓ Winter Low Renewables
  - ✓ Summer High Renewables
  - ✓ Summer Low Renewables
- **Six grid regions** / nodes: North, East, West, Central, Southeast, Southwest
- **Three EV plug-in scenarios**: Necessary, Current, Incentivised
- **Three EV uptake scenarios**: High (NECP target), Mid, Low (NECP reference)

Key takeaways

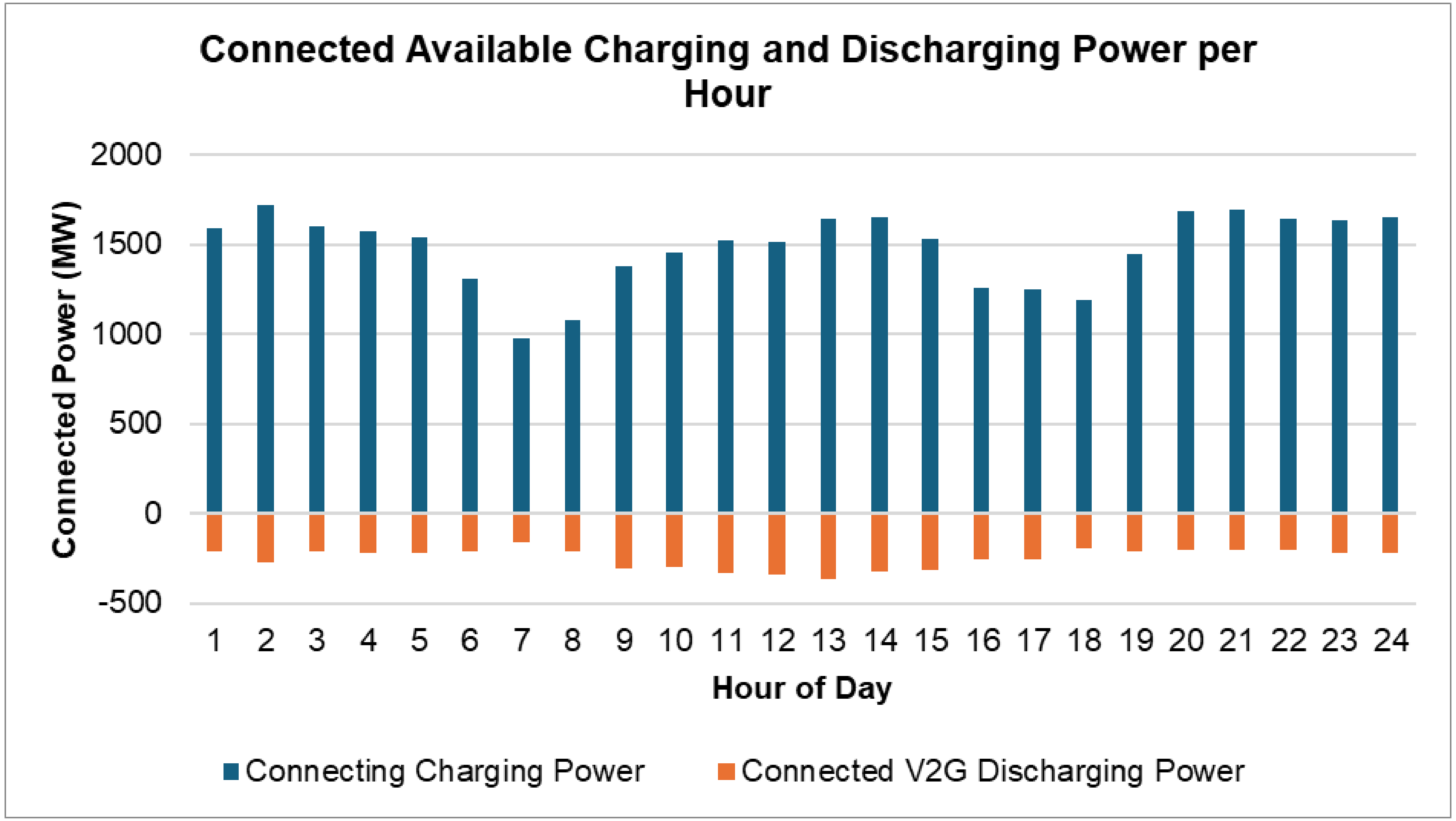
- If the 2030 modelled **costs savings** are split equally across all Luxembourg residents:
  - ✓ Day ahead wholesale energy price optimisation: between **0,19 EUR** and **0,61 EUR / day**
  - ✓ Additional savings from grid service provision: between **0,03 EUR** and **0,08 EUR / day**
  - ✓ From network reinforcement postponement: **0,17 EUR / day**
- Day ahead optimisation and grid services are stackable
- Grid service savings may seem small per resident, but per V2G user: between 1,19 and 2,61 EUR/day
- ***Caveat****: EV charging optimisation to postpone network reinforcement is a different objective vs day ahead and grid services (i.e. non-stackable). Reality will fall somewhere in-between.*
- In 2030 EV charging can contribute up to a maximum additional **renewable energy absorption** of **1,96 GWh / day**, in a maximised renewable capacity scenario.

Any questions so far?

3 Results

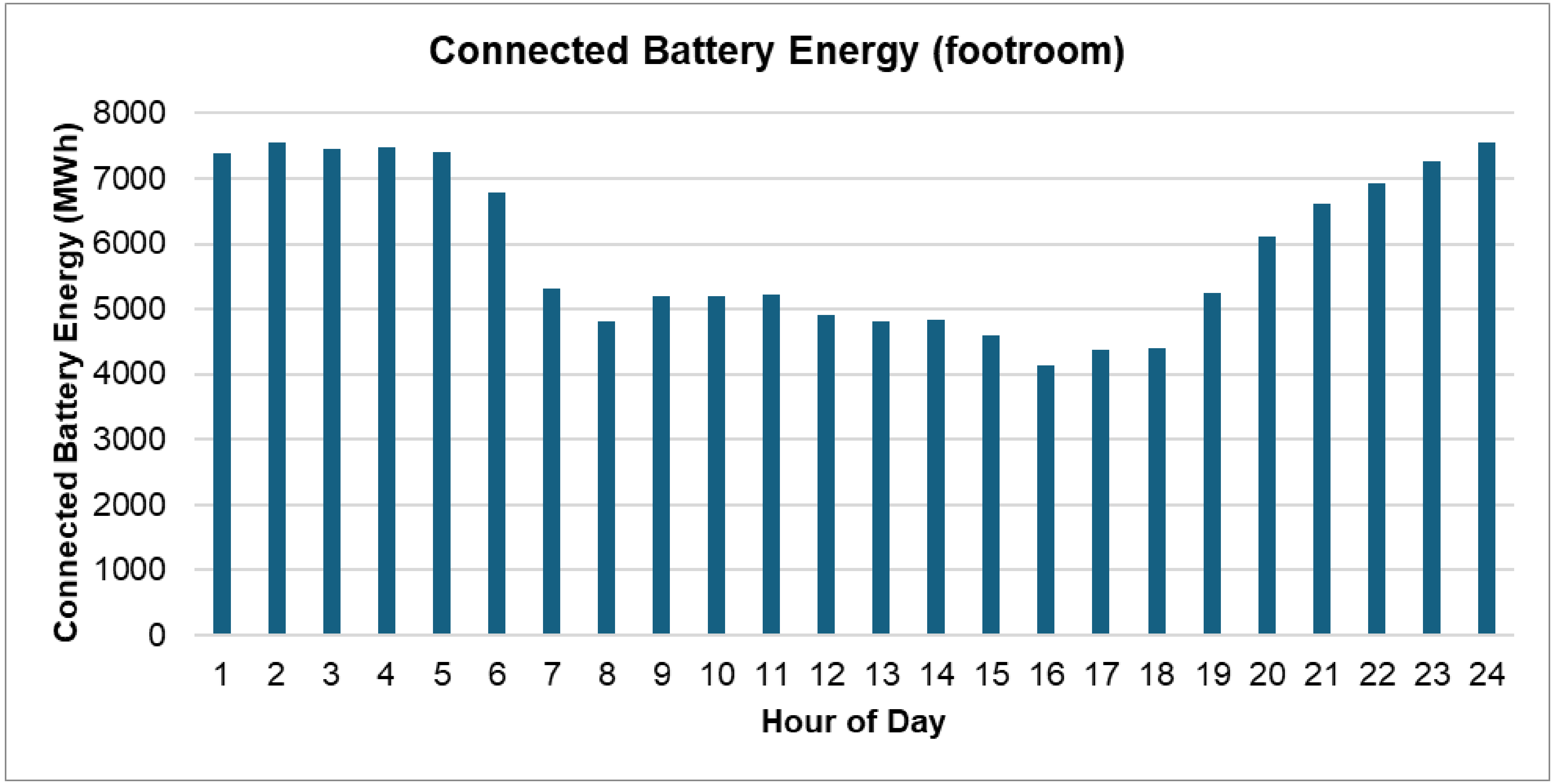
2030 EV Connected Power

- Cars, vans, and HGVs simulated to plug in to different charger powers according to vehicle type, plug-in location, and plug-in schedule
- Based on rated charger power for each chargepoint and does not account for the State of Charge (SOC) present in each vehicle battery at the time of connection



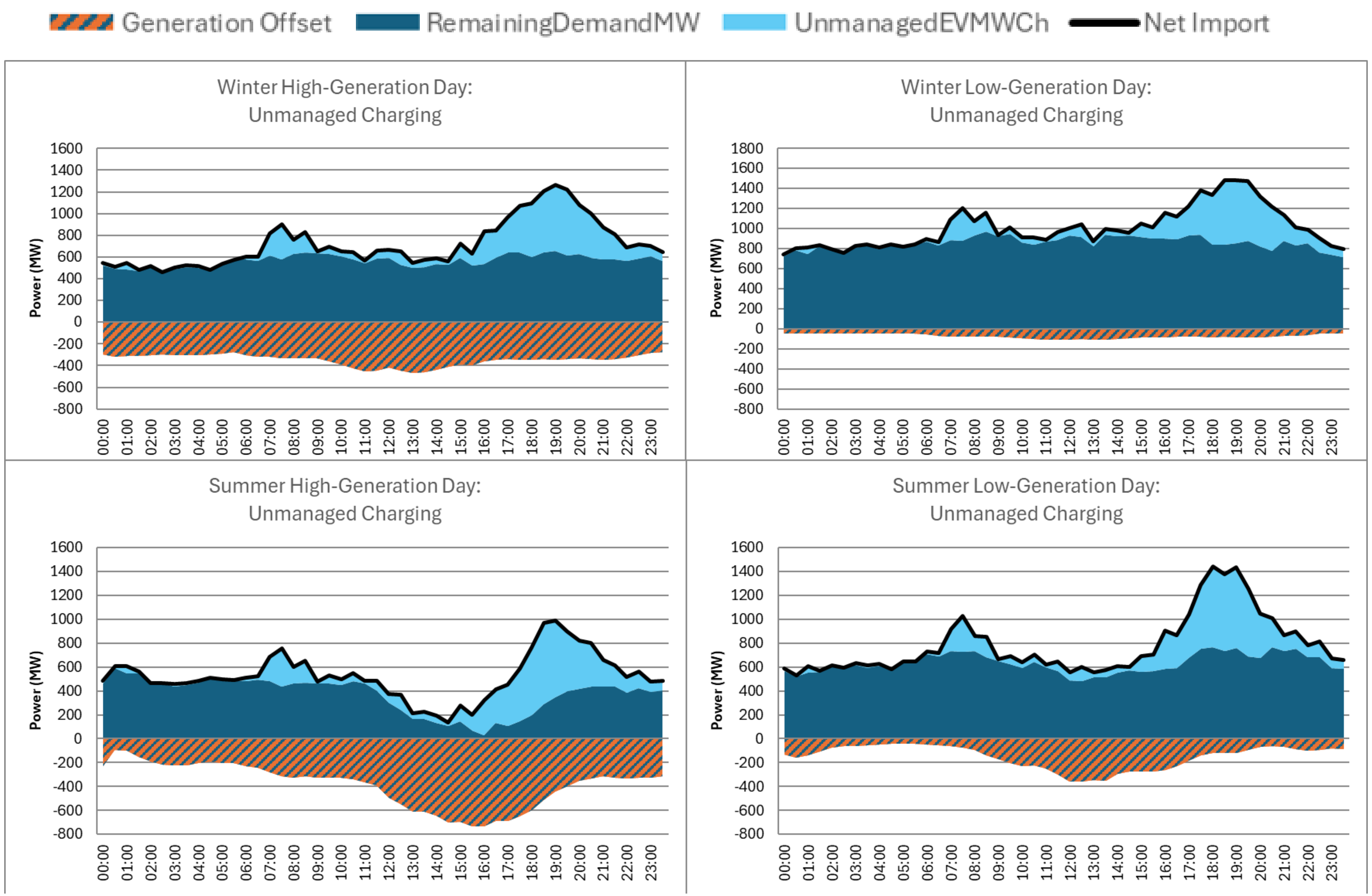
2030 EV Connected Energy

- SOC of each EV at each hour of the day was considered to plot this graph, assuming vehicles charge in an unmanaged way: charging at chargepoint's rated power until the battery is full.
- 20% SOC buffer to consider that users would not allow their batteries to discharge under that value.
- Assumed that average battery capacity will increase by 20% by 2030



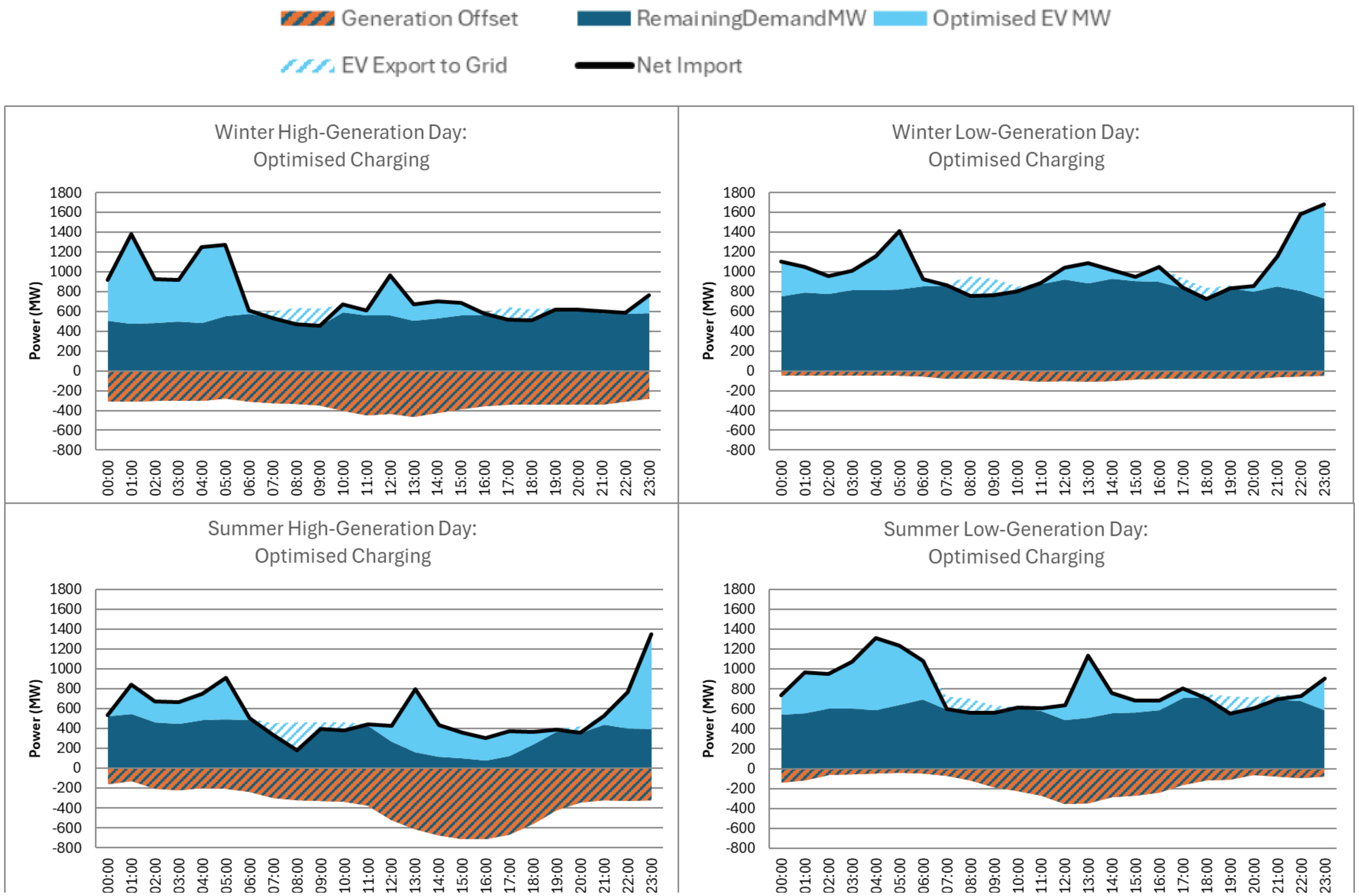
2030 Unmanaged EV Charging

- Charging profiles for incentivised plug-in behaviour (EVs plug-in every day) are presented as the maximum possible impact of the EV parc
- Influence of different charging behaviours and EV uptake rates are detailed in the draft report
- Unmanaged charging significantly increases the peak as large numbers of vehicles return from daily use and plug in.



2030 EV Charging Optimised for Day Ahead Electricity Prices (inc. FCR, aFRR)

- Cost-optimised V2G simulation: vehicles charged when prices low, V2G-capable vehicles discharged when prices high.
- ***Caveat****: this moves peak EV charge to cheaper times of day (e.g. overnight), which leads to spikes in charging power where prices are low for a short period.*
- **Recommendation**: avoid this by diversification of price signals to EV charging, differing charging objectives, or explicit capacity costing for users.



2030 EV Charging Optimised for Day Ahead Electricity Prices (inc. FCR, aFRR)

cenex

Table 19: Summary of Potential Savings against Unmanaged Charging in EUR, 2030 Incentivised

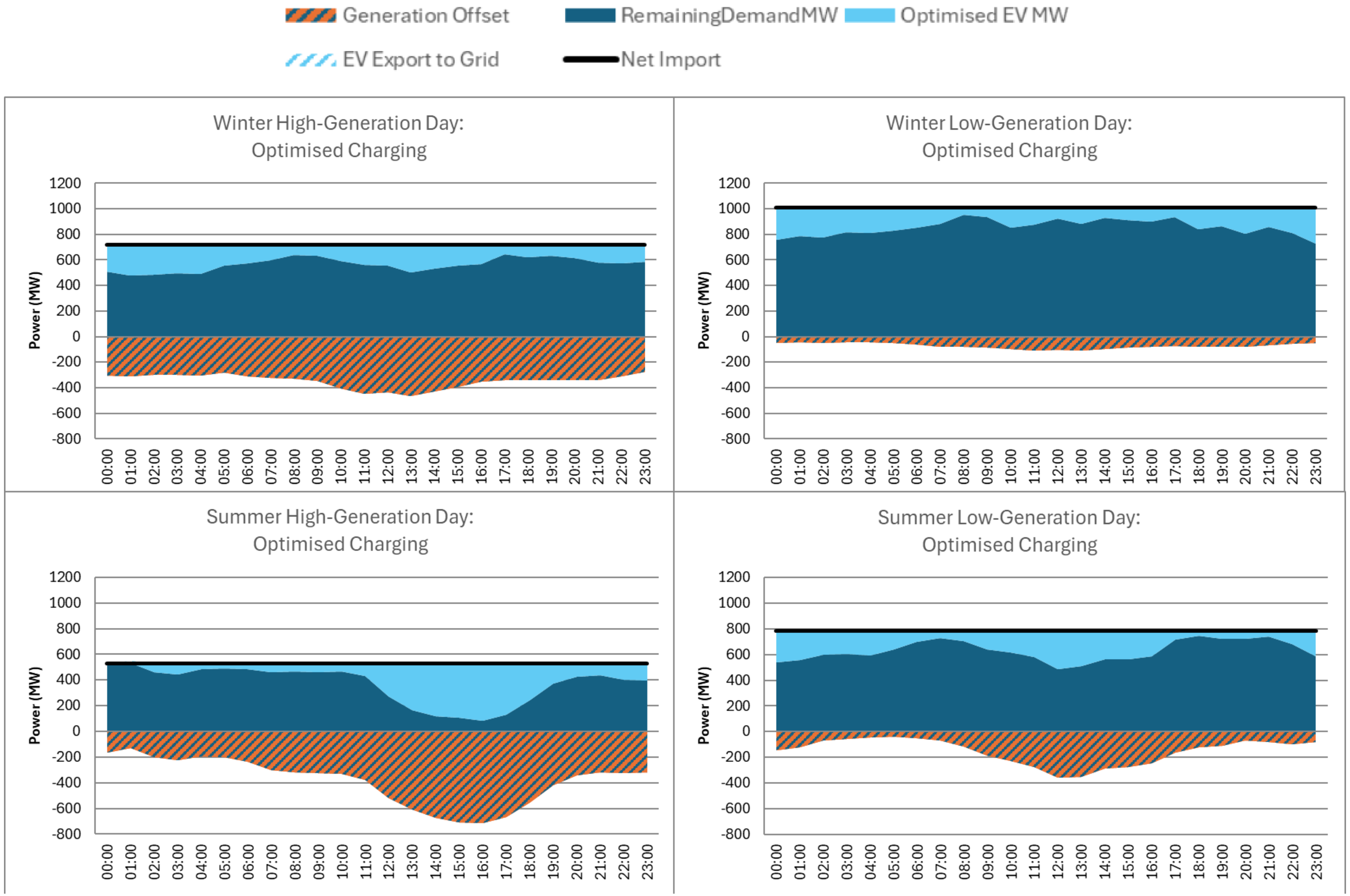
	Reference Day	Winter High-Generation 13 January	Winter Low-Generation 25 January	Summer High-Generation 02 August	Summer Low-Generation 28 August
Incentivised	**Baseline National Consumption Costs at Day-Ahead Pricing (Unmanaged EV Charging)**	**1650k EUR**	**4677k EUR**	**1417k EUR**	**2532k EUR**
	Saving Cost-Optimised Smart Charge	299k EUR	256k EUR	141k EUR	235k EUR
	Saving Cost-Optimised V2G	403k EUR	291k EUR	195k EUR	280k EUR
	Saving Combined Grid Services & Cost Optimised V2G	427k EUR	322k EUR	249k EUR	326k EUR

- If the 2030 modelled costs savings are split equally across all Luxembourg residents:
  - ✓ Day ahead wholesale energy price optimisation: between **0,19 EUR** and **0,61 EUR / day**
  - ✓ Additional savings from grid service provision: between **0,03 EUR** and **0,08 EUR / day**
- ***Caveat****: These are savings for the incentivized plugin behaviour (once everyday) and high EV uptake (NECP target) scenario: upper limit of available savings, but not unrealistic.*
- **Recommendation**: pursue optimised EV charging and V2G charging as it can contribute a net benefit to the electricity system (V2G chargers could pay back within 1 to 4 years). Grid services could be considered, but additional hardware, monitoring and integration costs may challenge economic viability.

Any questions so far?

2030 Postponement of Grid Reinforcements

- Optimisation to use available (dis)charging EV power to minimise daily peak load, with cost optimisation and offers to grid services as a secondary goal.
- The EV parc provides sufficient flexibility in 2030 (incentivised plug-in behaviour) to completely flatten the demand curve.
- ***Caveat**: A single transmission grid constraint is modelled for each region.*



Postponement of grid reinforcements

cenex

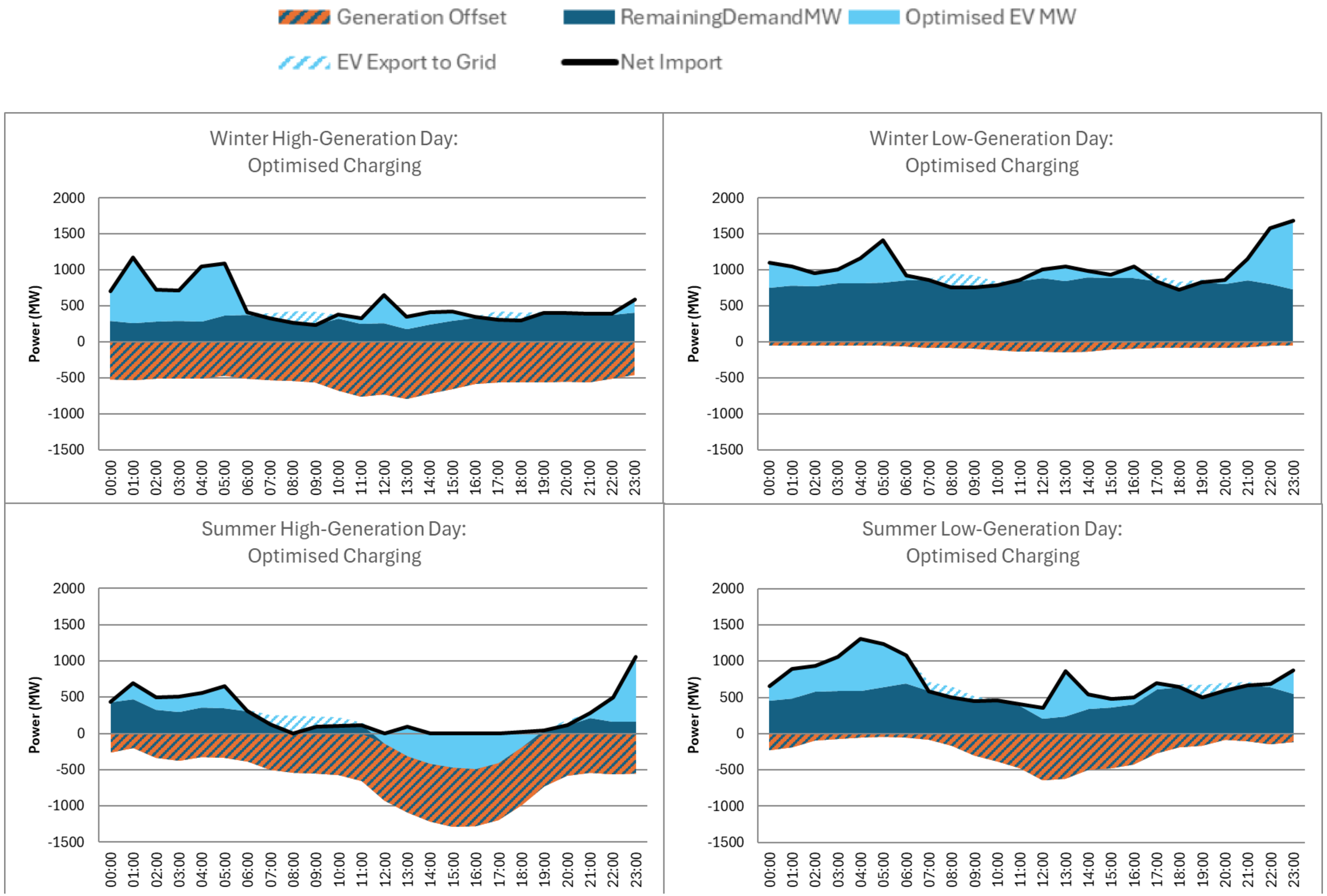
Region	Grid Capacity		Unmanaged Case		Optimised Case	
	2023 Capacity (MW)	Planned 2030 Upgraded Capacity (MW)	Peak Load (MW)	Reinforcement Cost (MEUR)	Peak Load (MW)	Total Savings (MEUR)
Central	330	500	464	221	248	221
North	140	400	200	184	103	184
East	120	250	144	138	75	138
Southeast	140	320	381	51	254	None
West	140	250	141	23	83	23
Southwest	180	320	260	101	225	None
Total				**718**		**566**

- Reinforcement cost from Creos data on planned upgrades to the grid by 2030
- **Central, North, East and West** regions are all able to defer their planned reinforcement costs with peak loading reduced by up to 50%
- Unable to say for how long the investment may be deferred, but if cost is spread over 20 years (of customers' bills) at 4% discount rate, this equates to **0,17 EUR/day per resident**
- **Recommendation:** although savings are smaller than via price optimisation, a co-optimisation combining wholesale energy costs and minimising peak capacity is the likely highest value solution (competing objectives, hence co-optimisation required).

Any questions so far?

2030 optimisation for renewable energy absorption

- To understand how much EV flexibility can increase renewable share of energy consumed
- RE maximised by simulating increase in the installed capacity of PV and Wind until national-level export is reached
- ***Caveat****: Calculating a limit based on the addition of marginally economic renewable generation is beyond the scope, so a simple limit was chosen to estimate when the grid begins to fail to fully absorb renewable energy.*



2030 optimisation for renewable energy absorption

cenex

Table 30: NECP Target and Maximised Renewables Share for 2030 Reference Days

	Summer Low Generation 28/08	Summer High Generation 02/08	Winter Low Generation 25/01	Winter High Generation 13/01
Daily Total Demand (Upscaled Creos + Sotel Grid + EV Charging) MWh	**22.408**	**21.767**	**25.984**	**25.631**
NECP Target Renewables, Unmanaged	14,6%	39,6%	4,1%	31,1%
Increased Renewables, Unmanaged[42]	24,6%	64,5%	4,7%	53,1%
Increased Renewables, Optimised for Absorption	25,4%	73,5%	4,9%	55,6%

- EV charging used to absorb generated energy that would otherwise have been exported or otherwise curtailed.
- Optimised use of the EV parc could allow for a greater share of renewables, **raising the renewables share by 9% of the demand** on the highest generation reference day. Equivalent to an additional 1,96 GWh of renewable energy absorbed.
- Again, this scenario was run independently to cost optimisation and grid reinforcement scenarios, so reality will fall in-between the three situations. A co-optimisation solution would be required.

Any questions so far?

4 Recommendations

Recommendations

- **We recommend pursuing optimised EV charging due to the multiple possible benefits for the electricity system.**
  - Significant energy costs reduction, grid upgrade postponement and renewable energy absorption are possible as demonstrated in this study.
- **We recommend that V2G charging is pursued as it can contribute a net benefit to the electricity system.**
  - V2G charging provides between 0,8 and 2,3 EUR / day additional saving for V2G capable EVs
- **Grid services (specifically aFRR and FCR) could be considered within an optimised EV charging solution.**
  - However, additional hardware, monitoring and integration costs to facilitate grid service provision may challenge economic viability.

Recommendations cont.

- **We recommend actions to avoid the possibility of wholesale cost charging optimisation creating secondary demand peaks.**
  - Initiatives such as diversification of price signals to EV charging, differing charging objectives (co-optimisation for price and grid), or explicit capacity costing for users may help.
- **We recommend actions to encourage EV owners to plug-in EVs more frequently where a dedicated charger for the EV exists.**
  - This could be done via the customer value proposition to EV/chargepoint users.
- **There are no clear recommendations currently between AC and DC V2G technology solutions.**
  - It is not yet clear which V2G technology will win out, as this is still dependent upon vehicle OEMs and how interoperable different solutions become.

Thank you for your time

Any more questions?

cenex

Transport

Energy Infrastructure

Knowledge & Enterprise

www.cenex.co.uk