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GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

The role of energy storage in power sectors with fossil fuel phase-out

Power sector effects of electric vehicle batteries

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Berlin, 9 October 2020

Future of Fossil Fuels

- Motivation
  - Battery-electric vehicles (BEV): a major strategy to decarbonize transportation, using renewable electricity
  - Two relevant effects of growing BEV fleets on power sector:
    - Growing electricity demand → vRES capacity also needs to increase
    - Potential provision of temporal flexibity → BEV may contribute to vRES integration
    - Trade-off between these two effects
  - Numerical analyses require detailed time series of BEV charging availability and energy demand
    - These are now available thanks to emobpy

- Research question
  - Quantitatively explore the trade off between increasing vRES demand and the provision of temporal flexibility
  - Sensitivity of results to varying assumptions on vehicle charging and V2G
  - Indicators of interest:
    - System costs
    - Capacity effects
    - Dispatch effects
- Special interest of today‘s workshop
  - Effects of BEV on stationary storage

emobpy

- Open-source code tool in Python for e-mobility time-series
- Python Package Index https://pypi.org/project/emobpy/
- Preprint in arXiv https://arxiv.org/abs/2005.02765
- For this project:
  - We created 40 BEV profiles
  - Each profile consists of 3 types of time-series
    - Motor electricity consumption
    - Grid availability
    - Grid electricity demand

4 emobpy: time-series types

(1) + (2)

+

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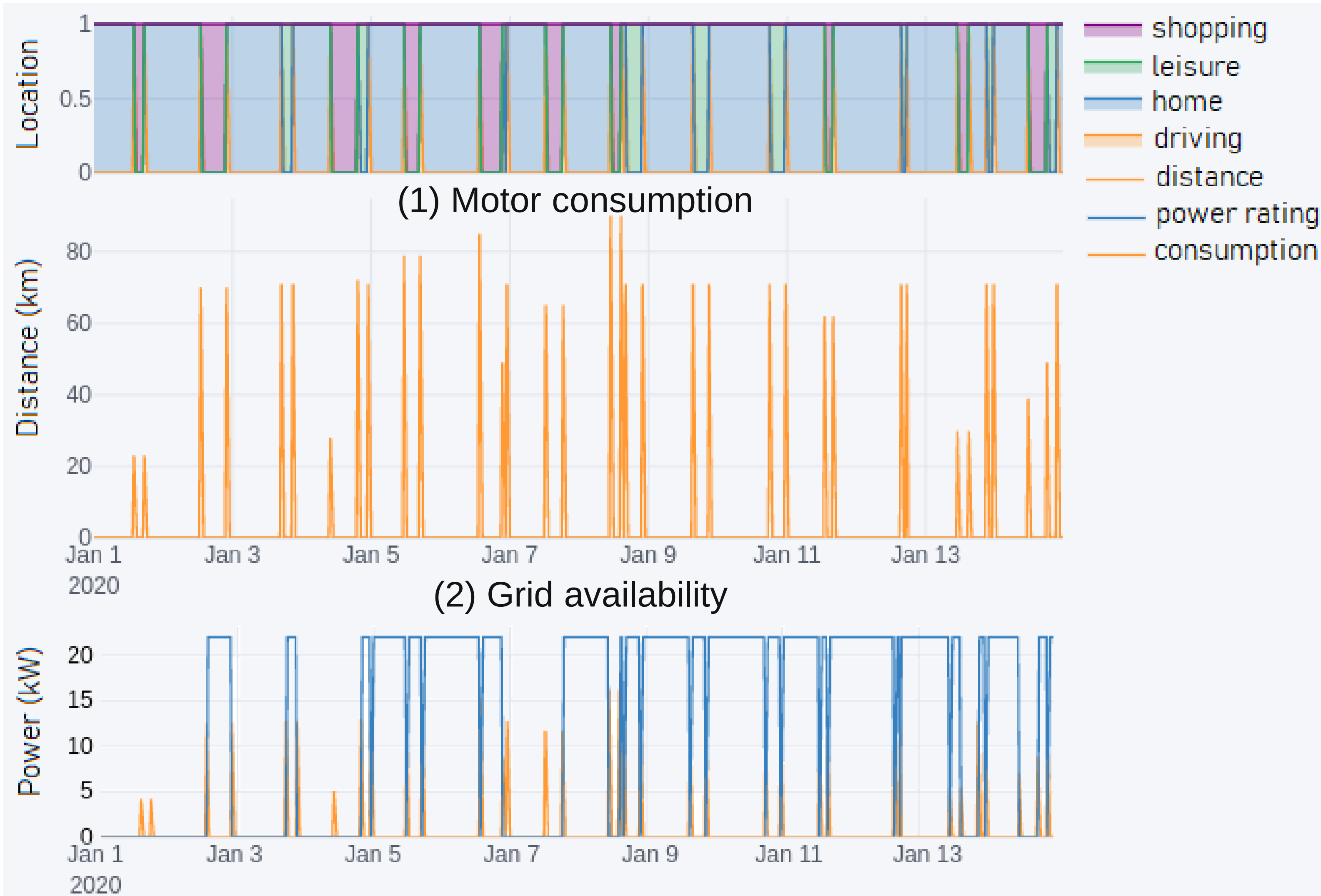
(3)
Grid demand

System Optimized Approach



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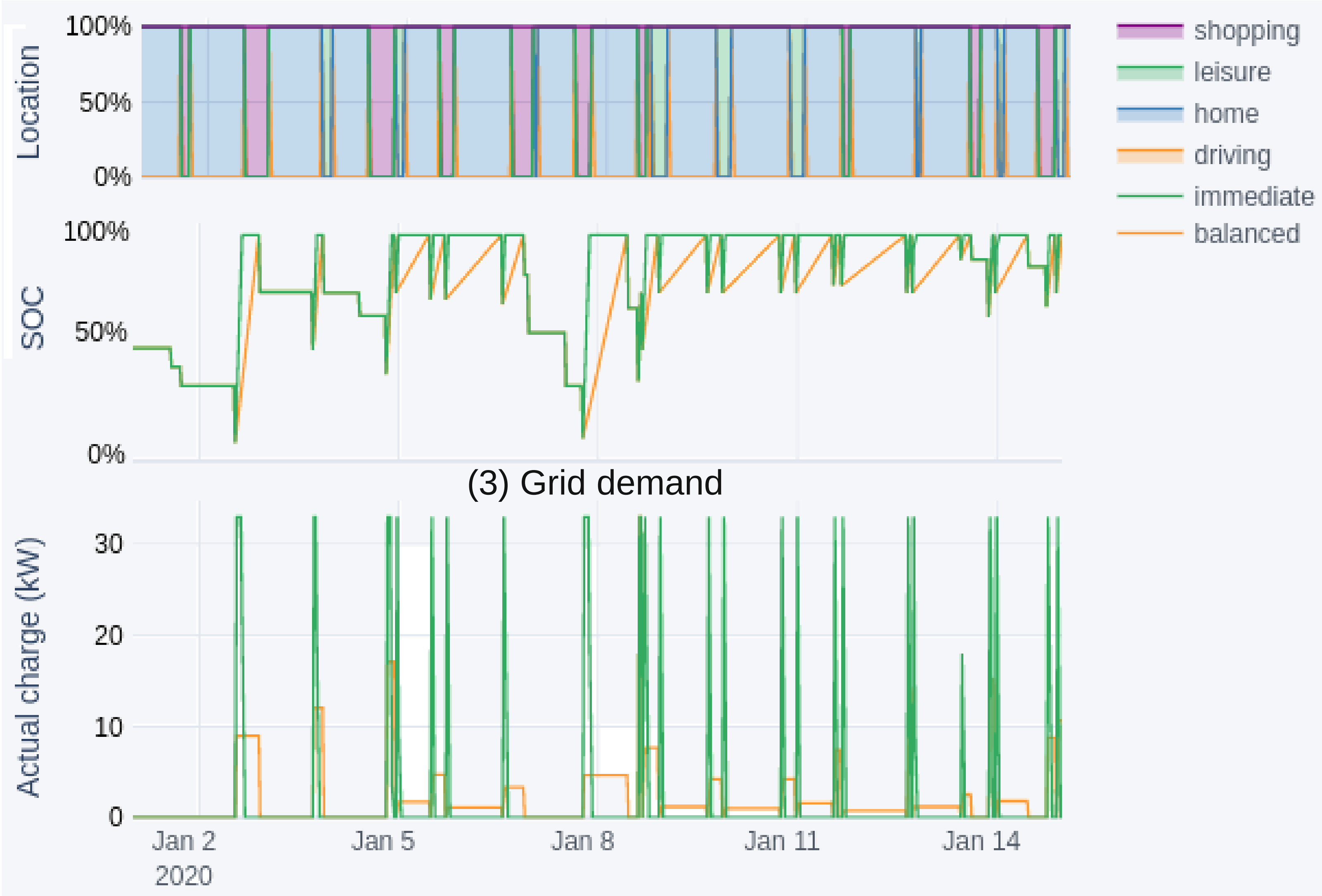
emobpy: time-series types



Methods

- DIETERpy
  - Is a python framework that runs DIETER by using GAMS API
  - Open-source code tool
  - Python package index https://pypi.org/project/dieterpy/
  - Preprint available on https://arxiv.org/abs/2010.00883
  - In this project:
    - Run several scenarios by setting the following configuration:
      - Brownfield - 2030
      - Investment and dispatch model

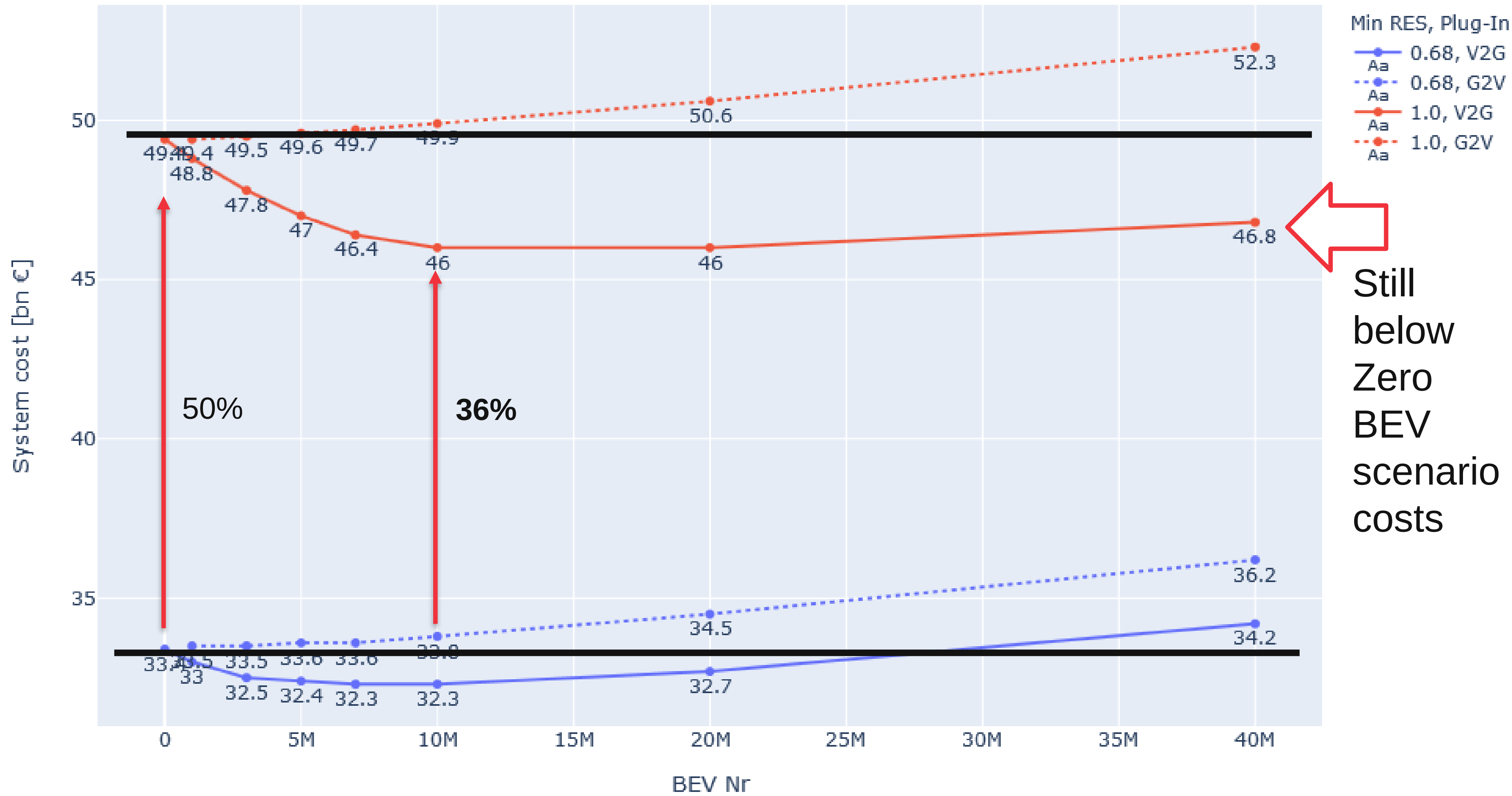
        + Endogenous BEV module

        + Exogenous BEV module (Balanced time series)
      - 0 , 1M, 3M, 5M, 7M, 10M, 20M, 40M BEVs
      - G2V and V2G
      - 68% and 100% Minimum RES constraint

Results

- Total system costs
- Residual load duration curve
- Storage capacity differences
- Hourly charging pattern of BEV

8 Total system costs: Minimum RES share – BEV quantity



Still below Zero BEV scenario costs

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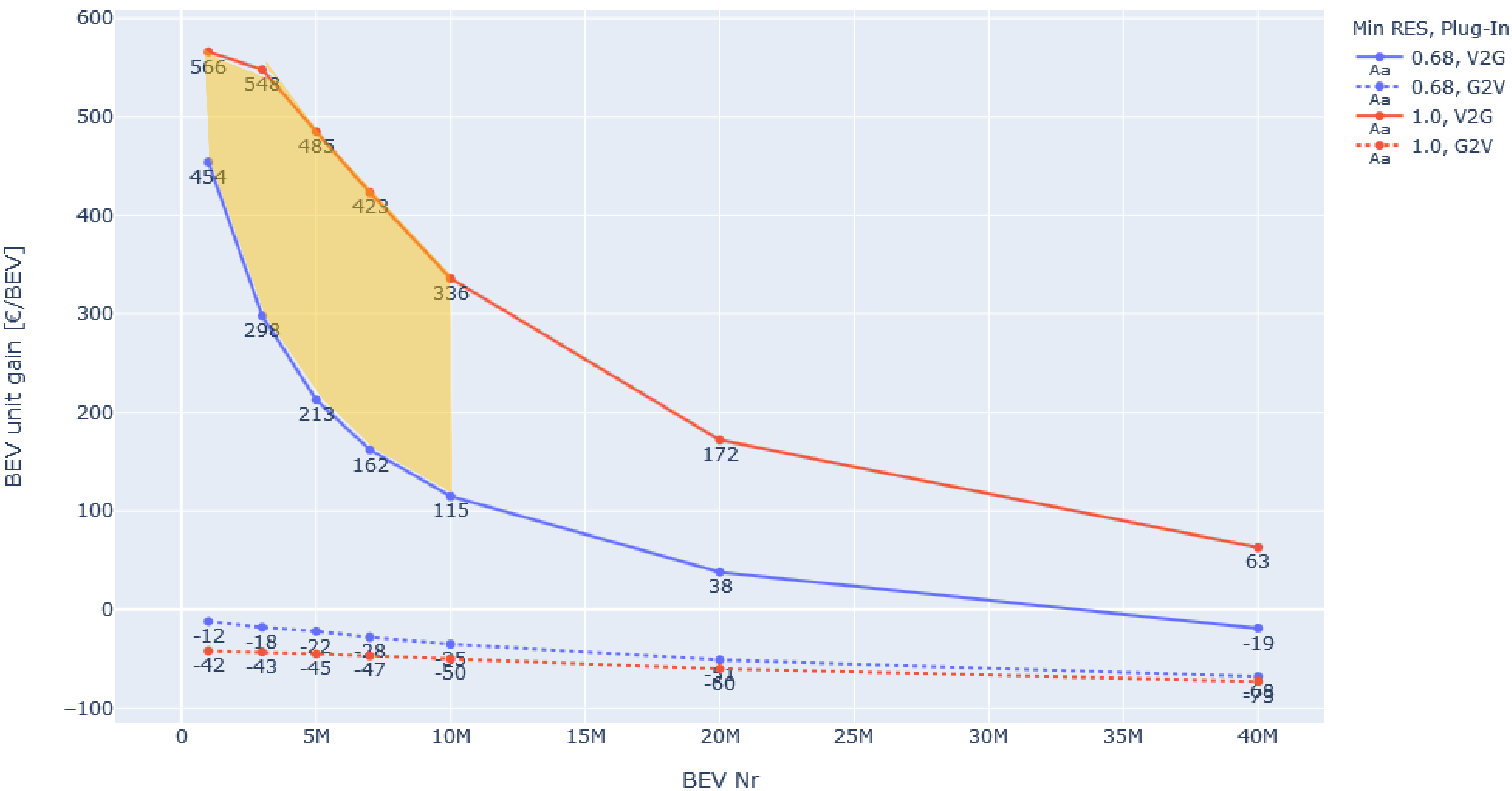
BEV unit gain: Minimum RES share – BEV quantity



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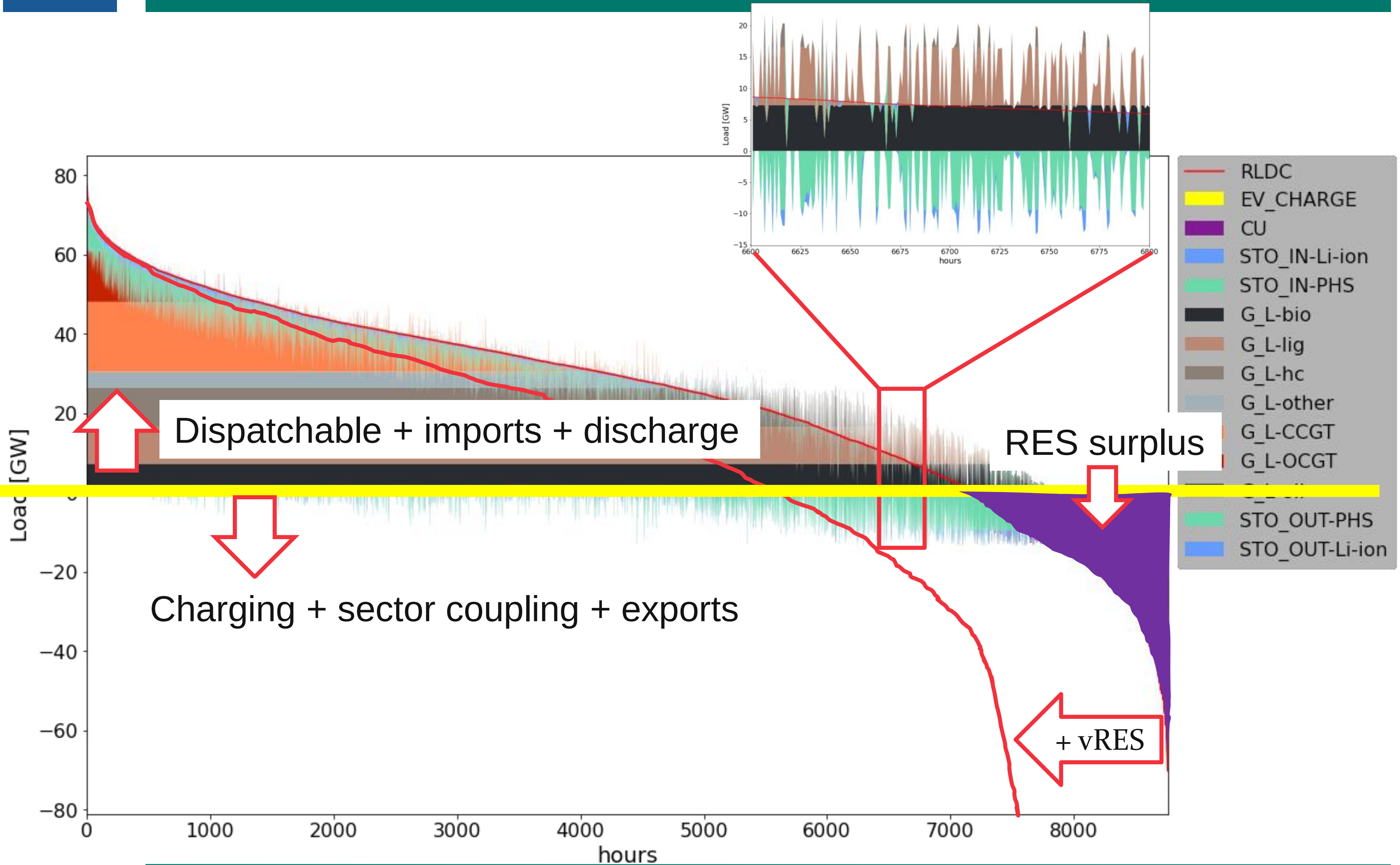
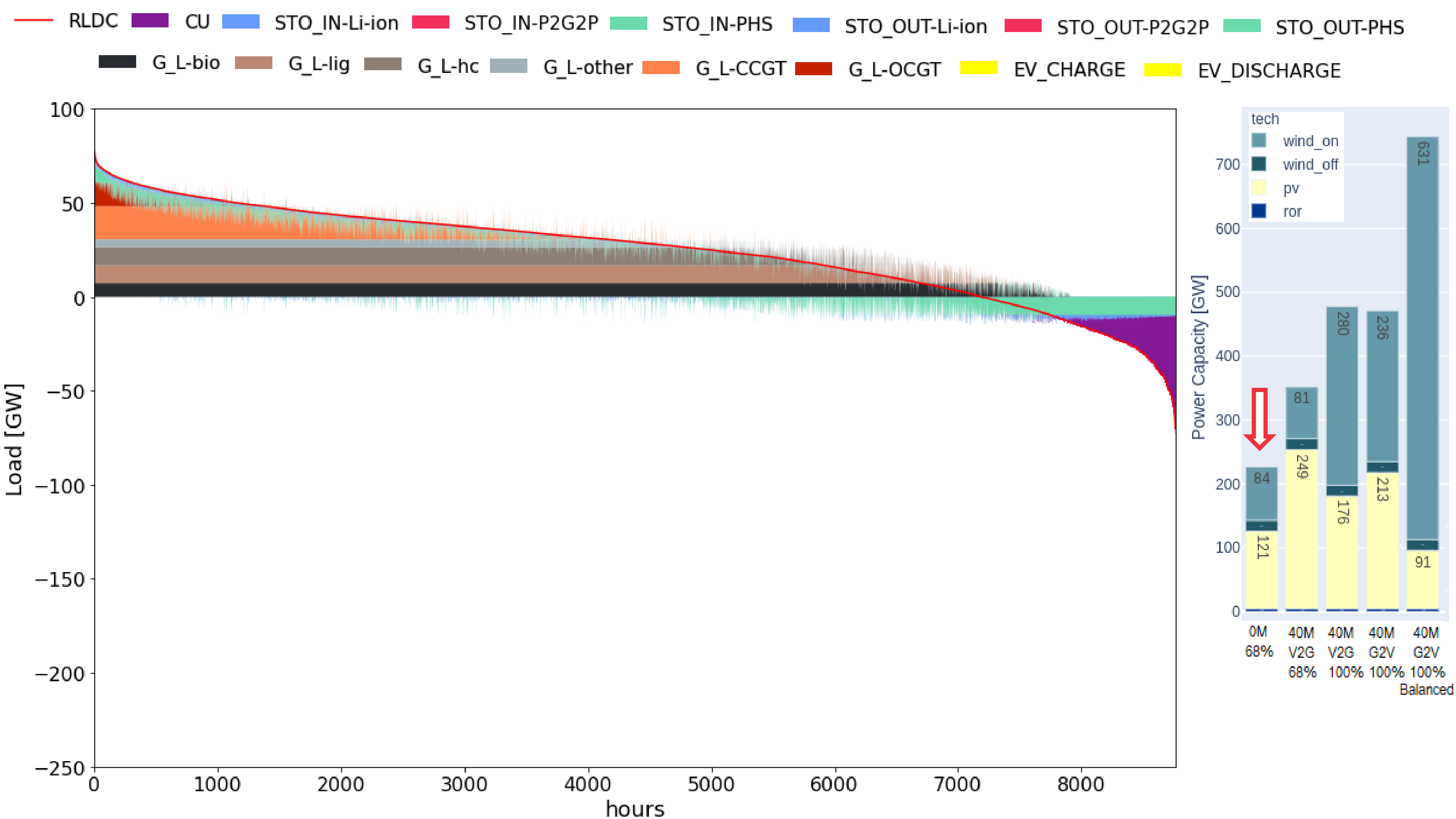
RLDC

- 0 BEV – 68% minimum RES – System optimized
- 40M BEV – 68% minimum RES – **V2G** - System optimized
- 40M BEV – 100% minimum RES – **V2G** – System optimized
- 40M BEV – 100% minimum RES – **G2V** - System optimized
- 40M BEV – 100% minimum RES – **G2V** – *Exogenous: Balanced*

RLDC: Zero BEV – 68% minimum RES – System optimized



RLDC: Zero BEV – 68% minimum RES – System optimized



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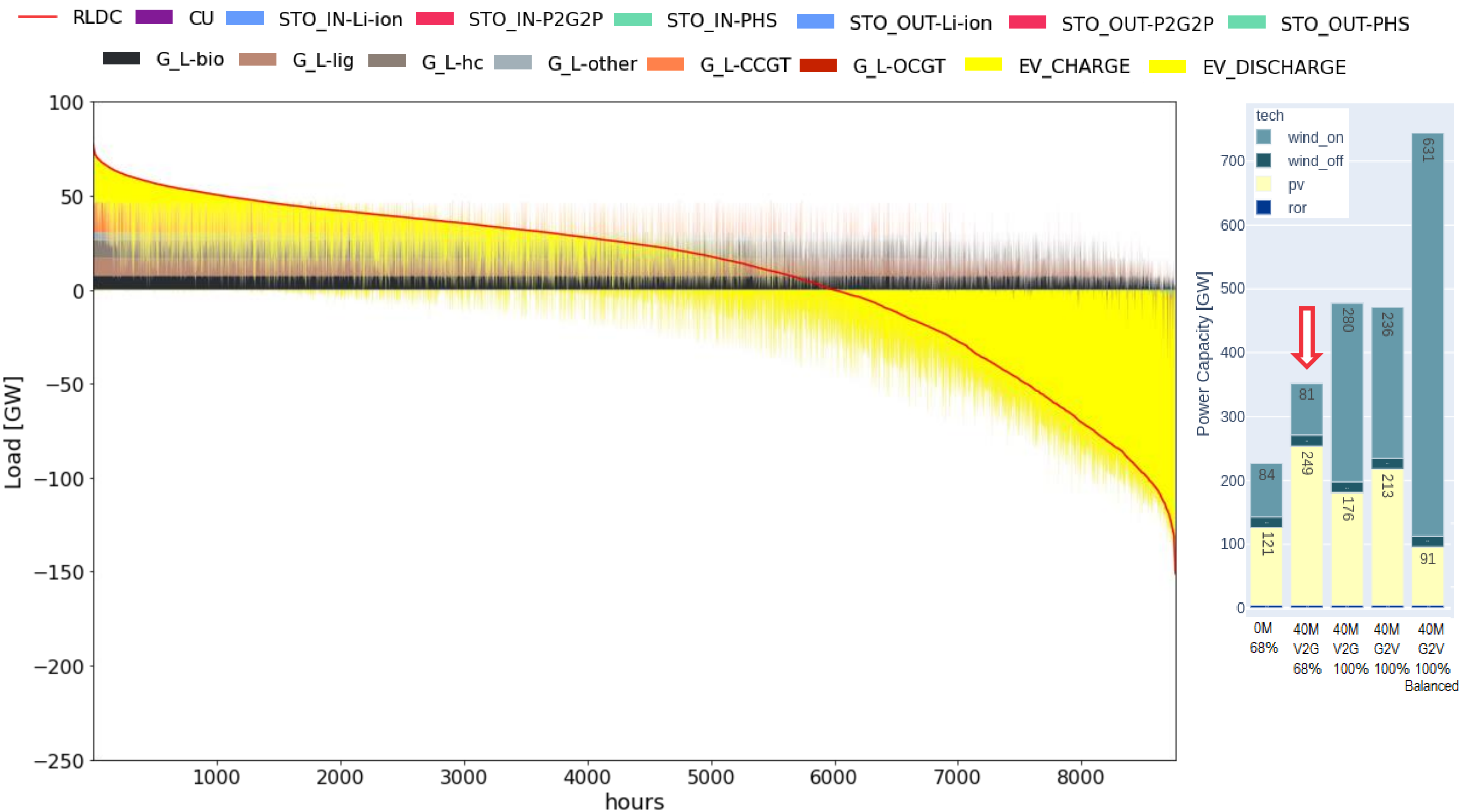
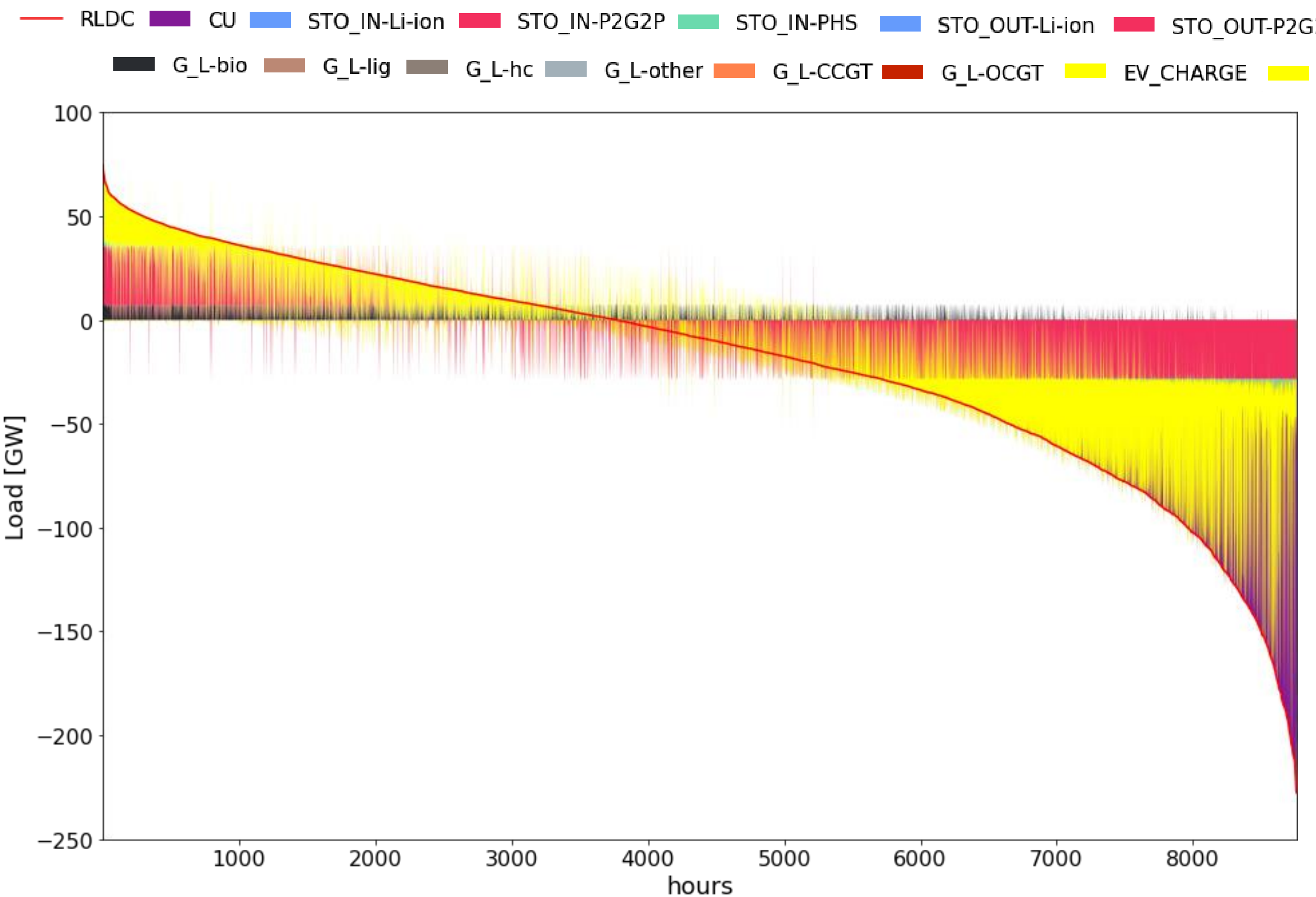
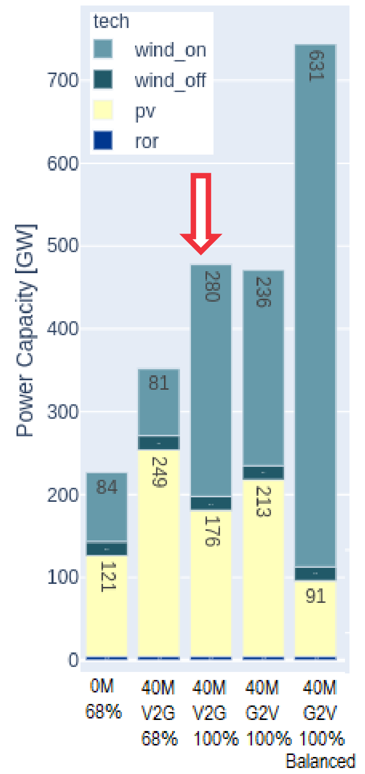
RLDC: 40M BEV – V2G - 68% minimum RES – System optimized



RLDC: 40M BEV – V2G - 100% minimum RES – System optimized





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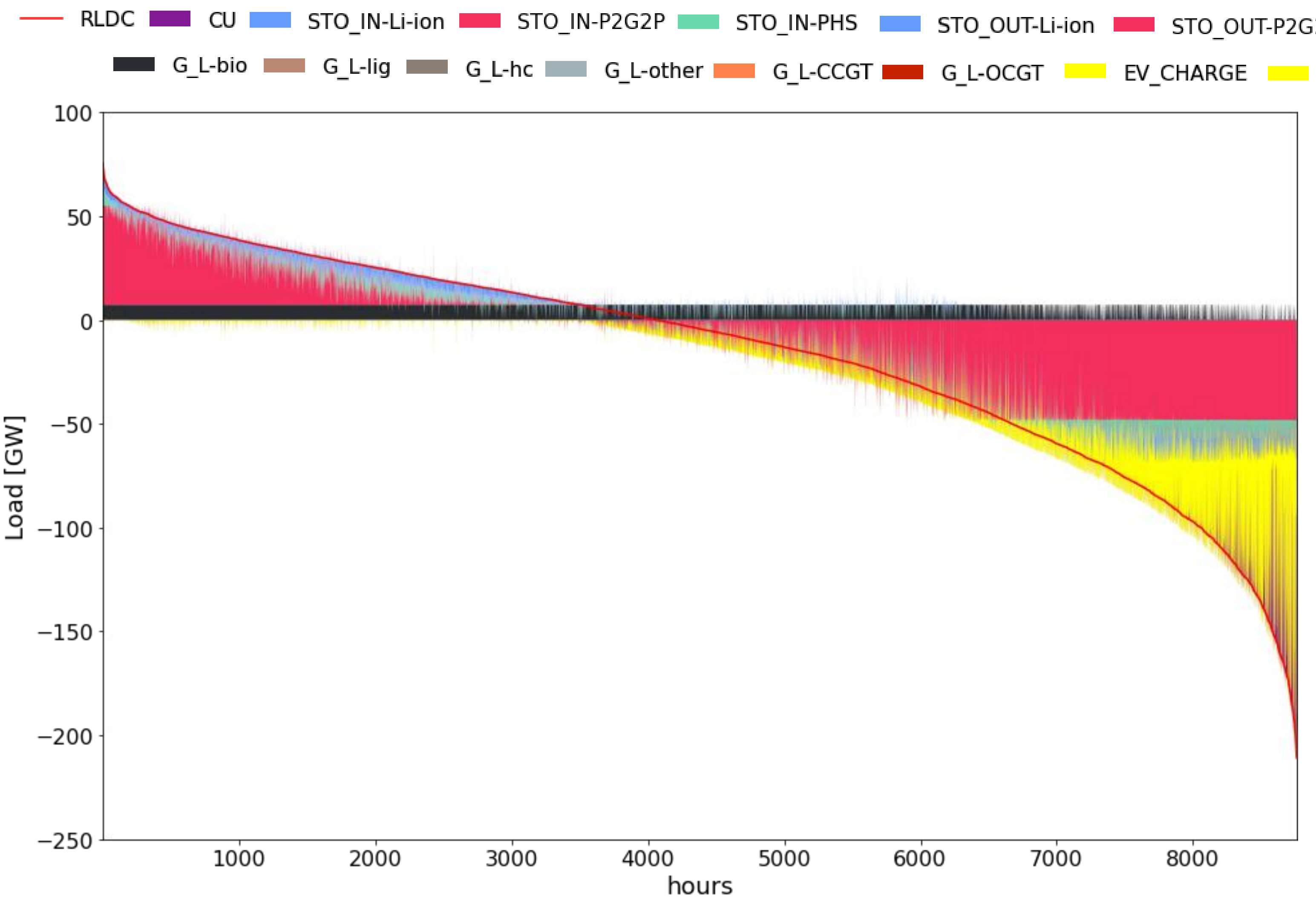
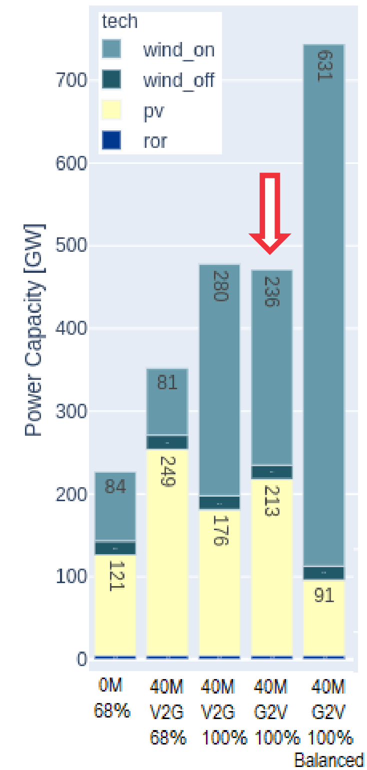
RLDC: 40M BEV – G2V - 100% minimum RES – System optimized





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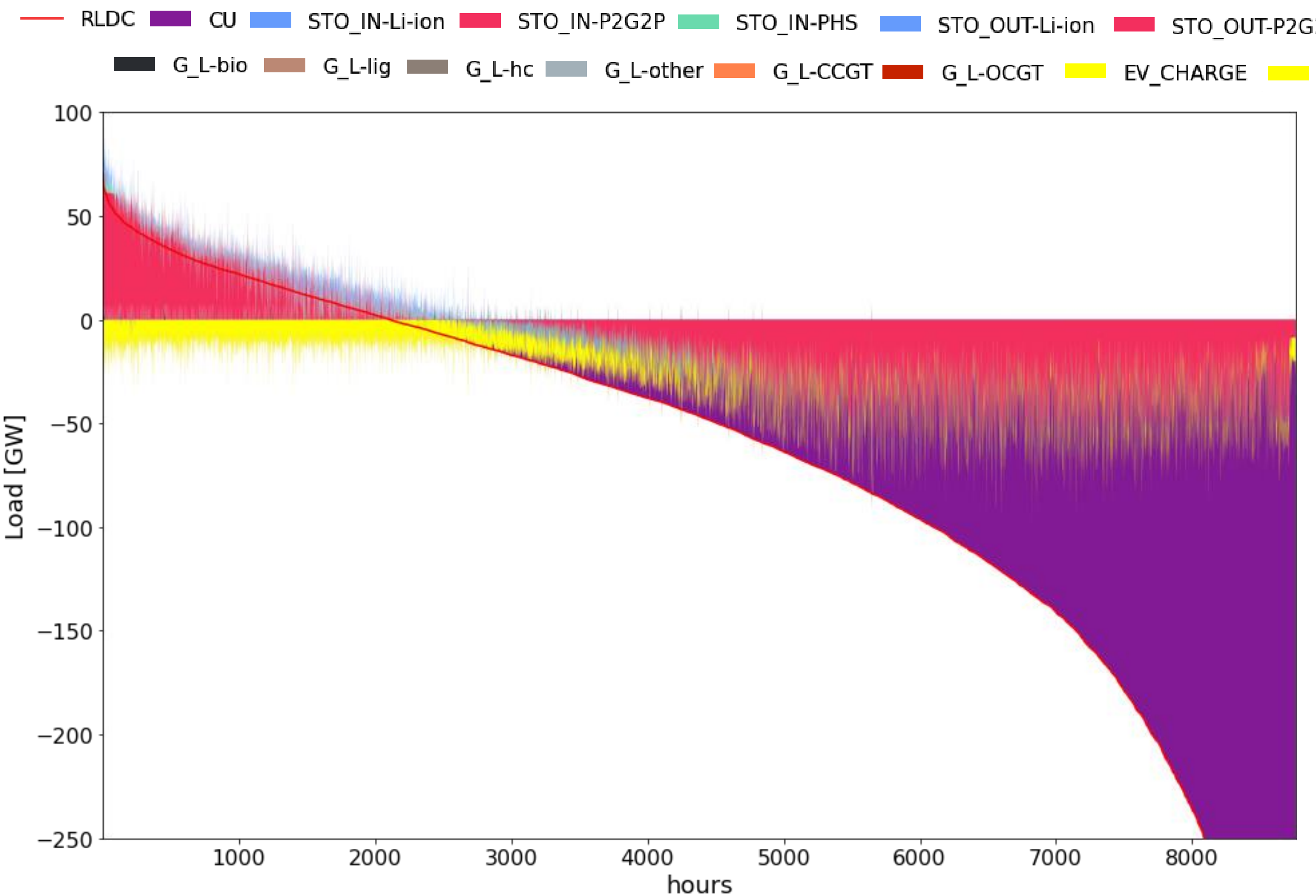
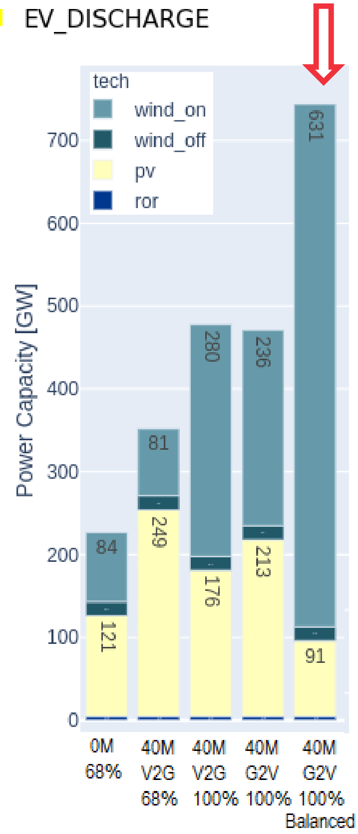
RLDC: 40M BEV – G2V - 100% minimum RES – Immediate balanced





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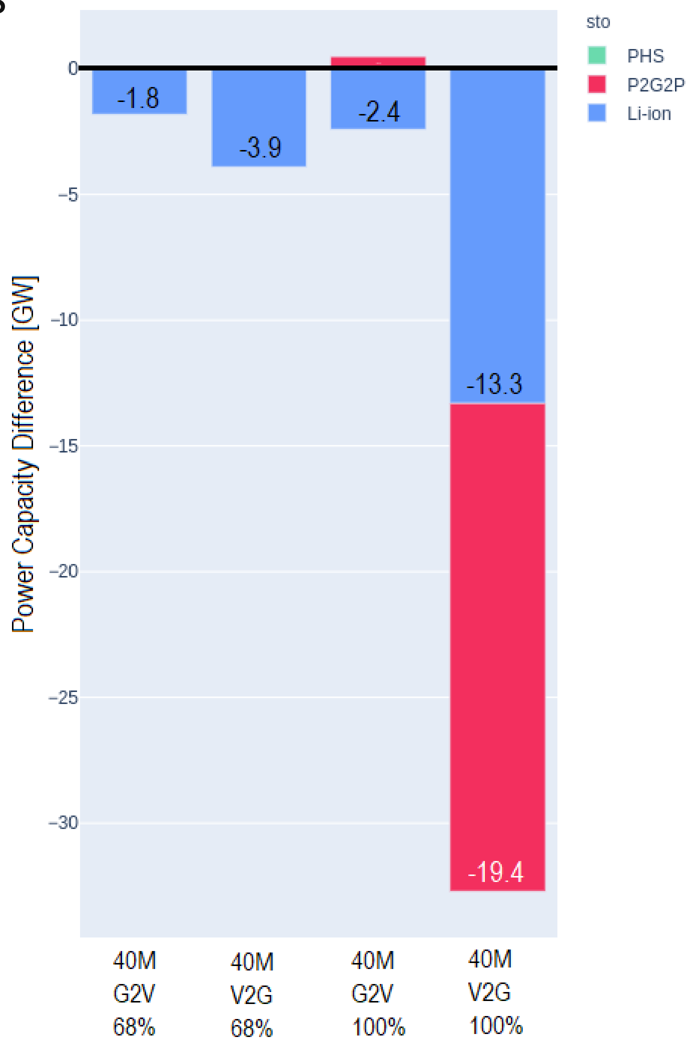
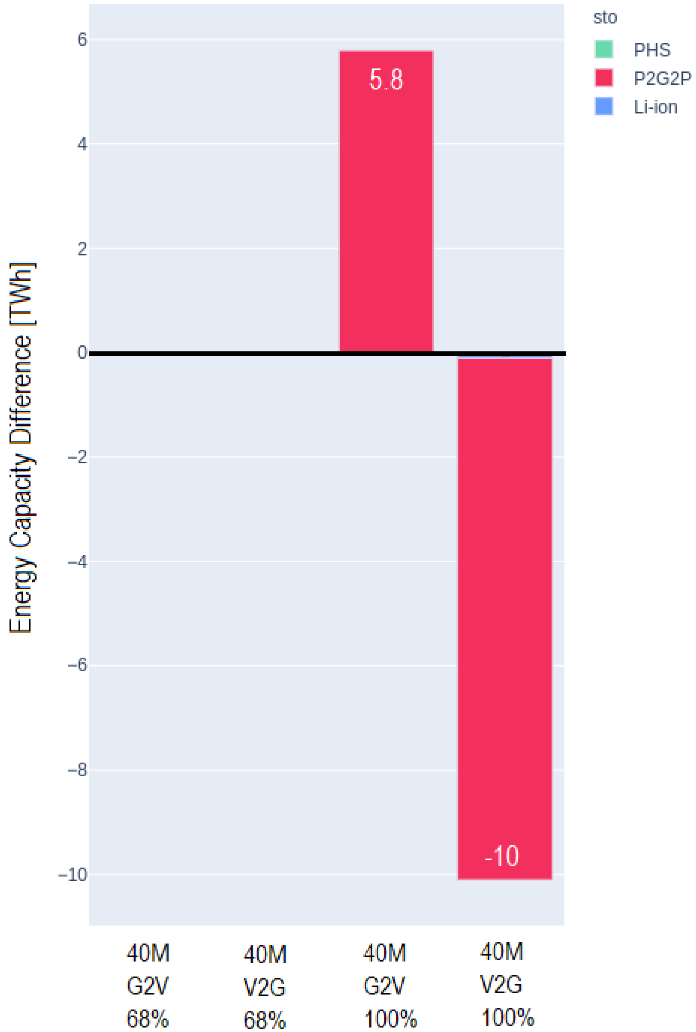
Storage capacity differences: Zero BEV - Reference

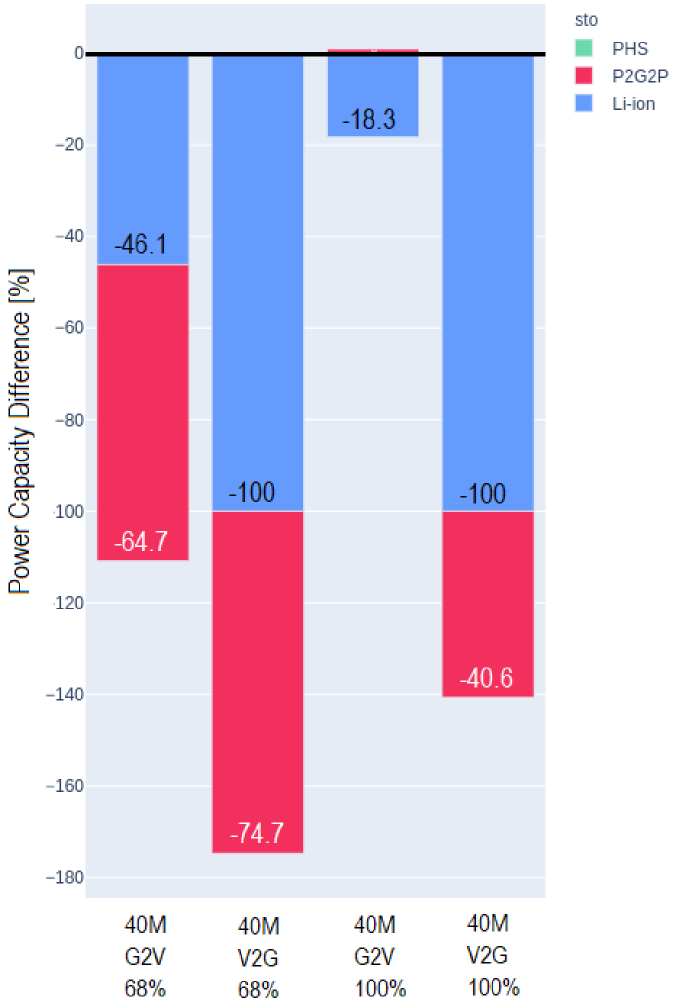
Absolute values

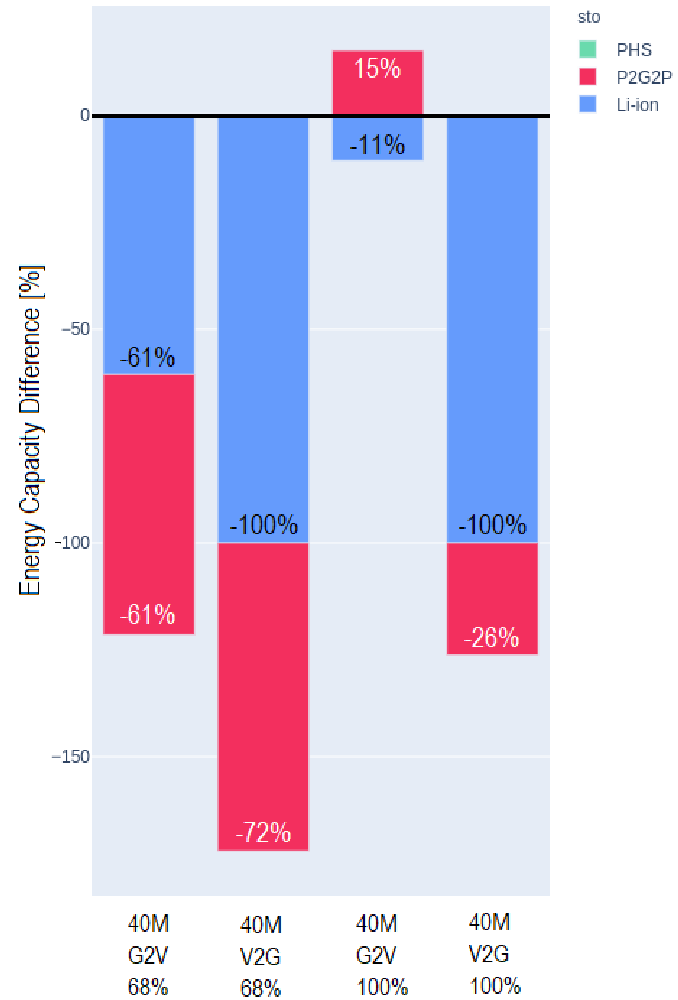




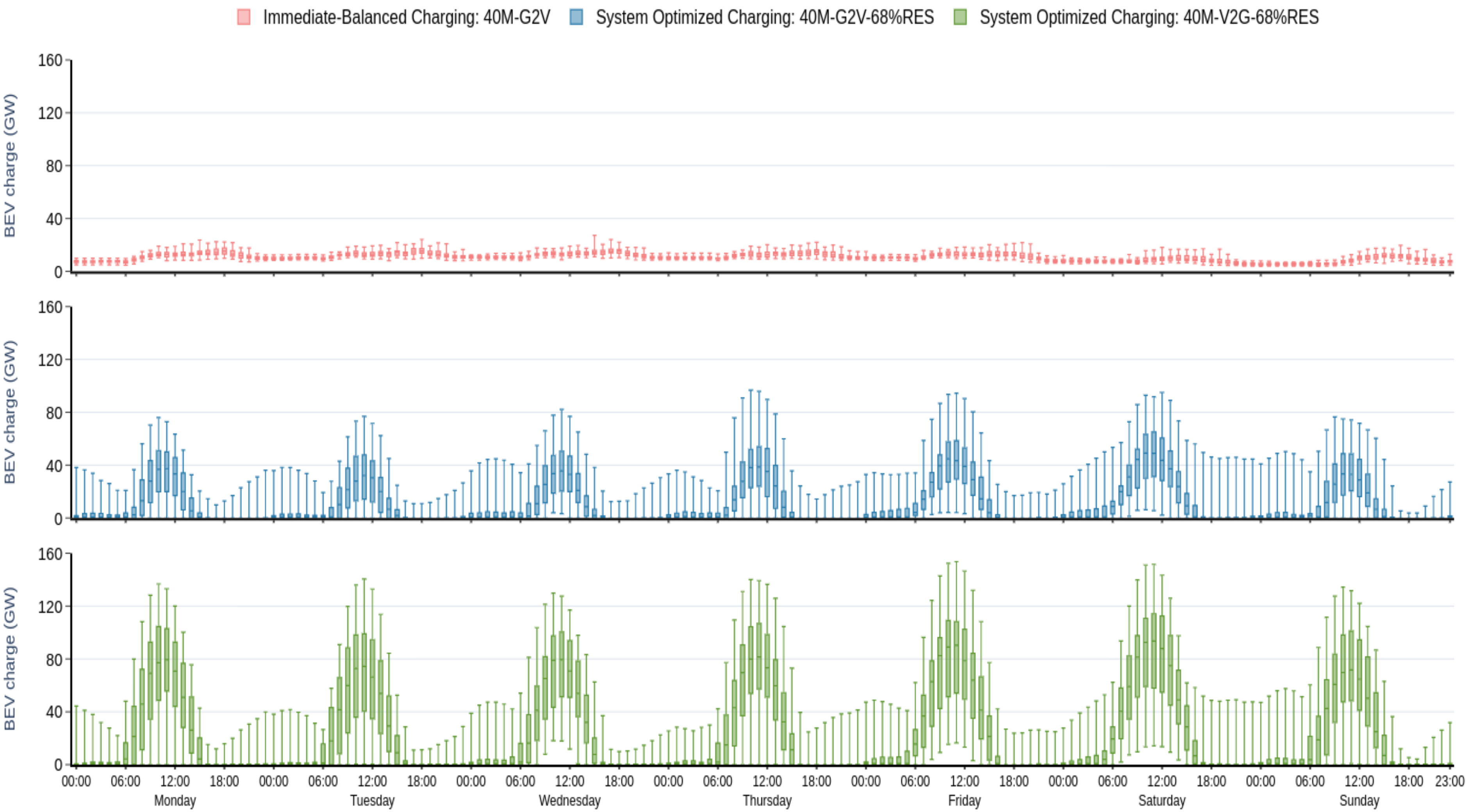
Storage capacity differences: Zero BEV - Reference

Relative values





Hourly charging pattern of BEV



Conclusions

- 100% RES scenarios costs are greater that 68% scenarios (+ 36%)
- V2G shows significant benefits by reducing the system costs, this effect increases when renewables are higher, while the maximum benefit is reached in the range of 7 – 10 M BEV → flexibility effect dominates
- V2G entails BEV unit gains ranging 100 – 500 Euro per BEV-year; benefits could be higher for vehicle profiles with higher flexibility availability
- System optimized approach for charging (discharging) of BEV is largely desirable, either G2V or V2G
- V2G provides provides short-term storage, partially long-term storage and makes an efficient use of vRES
- For larger BEV fleets (+40M), the demand effect dominates
- BEV charging is coupled with solar generation, large load poses several challenges

Vielen Dank für Ihre Aufmerksamkeit.

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