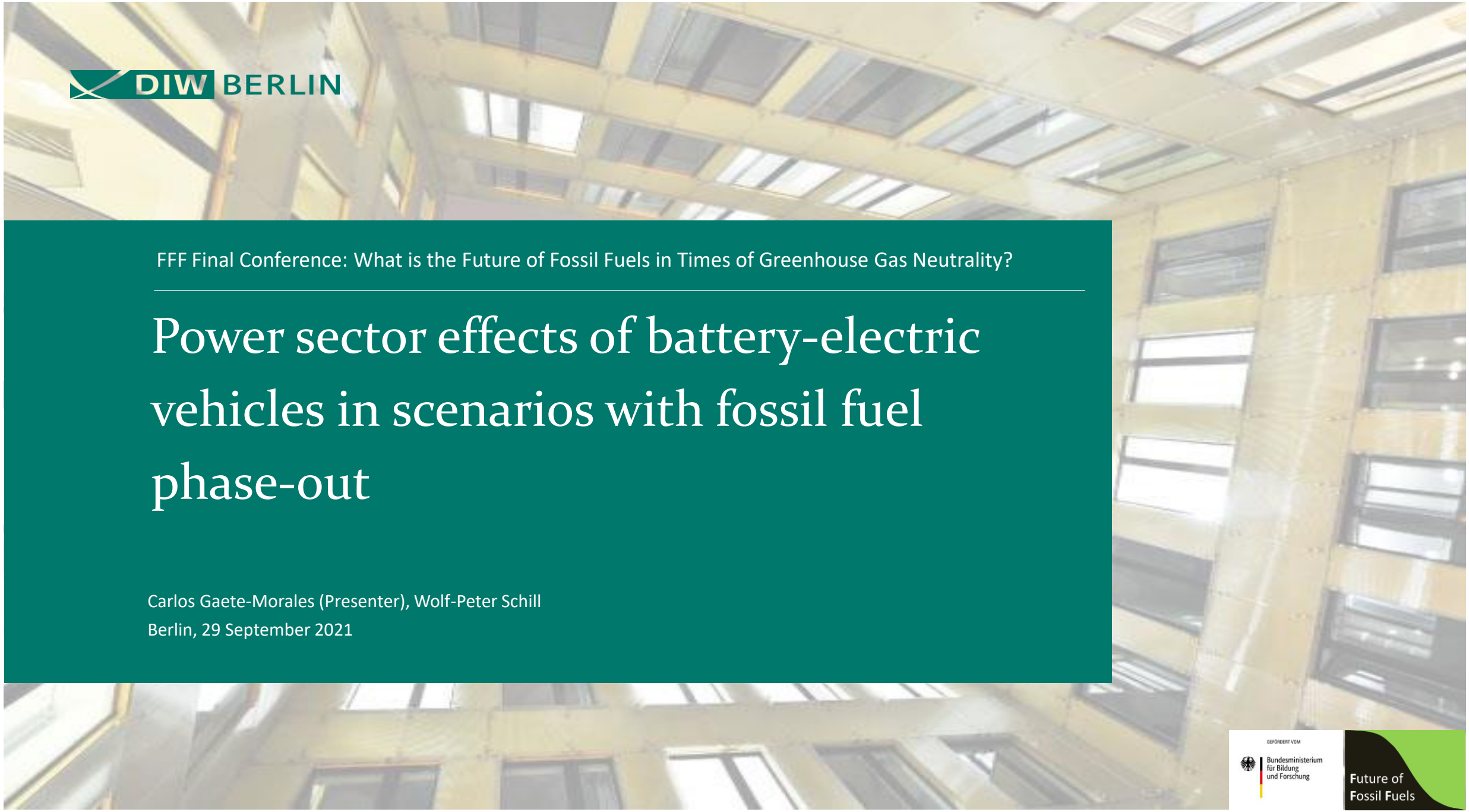


DIW BERLIN

FFF Final Conference: What is the Future of Fossil Fuels in Times of Greenhouse Gas Neutrality?

Power sector effects of battery-electric vehicles in scenarios with fossil fuel phase-out

Carlos Gaete-Morales (Presenter), Wolf-Peter Schill

Berlin, 29 September 2021

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung
Future of Fossil Fuels

INTRODUCTION

- Background
  - There are a various options for power system flexibility and sector coupling
  - Battery-electric vehicles (BEV) are special:
    new (flexible) demand, but also potential grid storage via Vehicle-to-Grid (V2G)

- Research questions
  - Power sector effects of BEV in scenarios with medium or high RES shares?
  - What dominates: additional demand, or additional supply of flexibility?
  - Which role may V2G play?

- Contribution
  - Use of empirically-founded BEV time series, generated with open-source tool *emobpy*
  - Use of open-source power sector model with new Python wrapper *DIETERpy*

https://doi.org/10.1038/s41597-021-00932-9

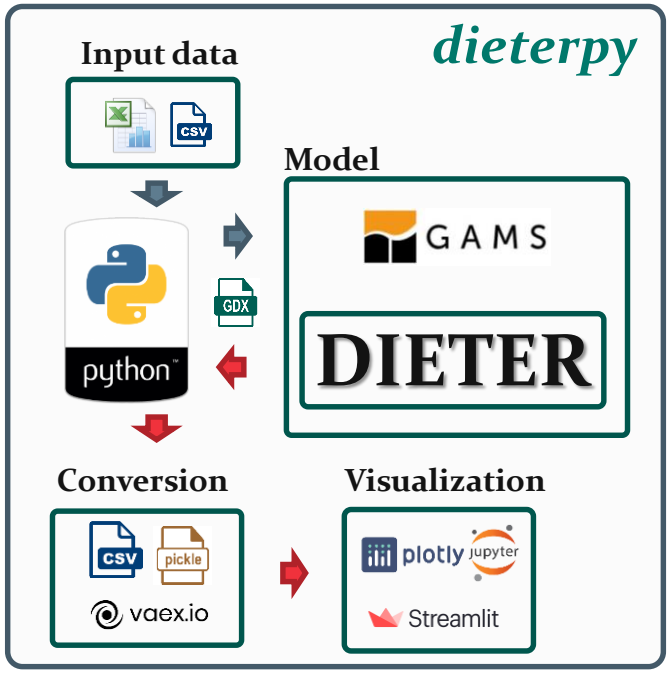
emobpy

- Mobility
- Driving consumption
- Charging availability
- Grid demand

+

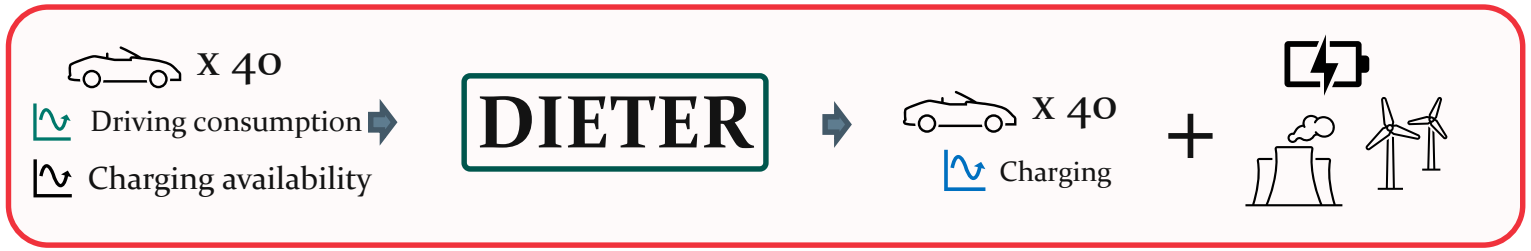
https://doi.org/10.1016/j.softx.2021.100784

dieterpy

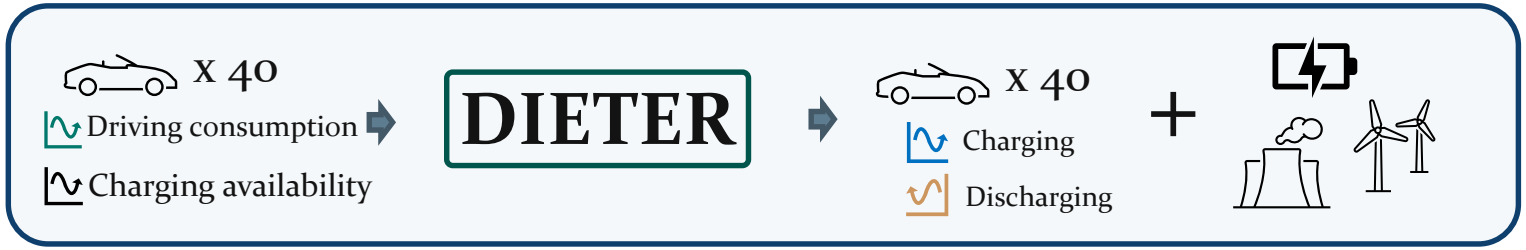


Feature: **Inflexible BEV**

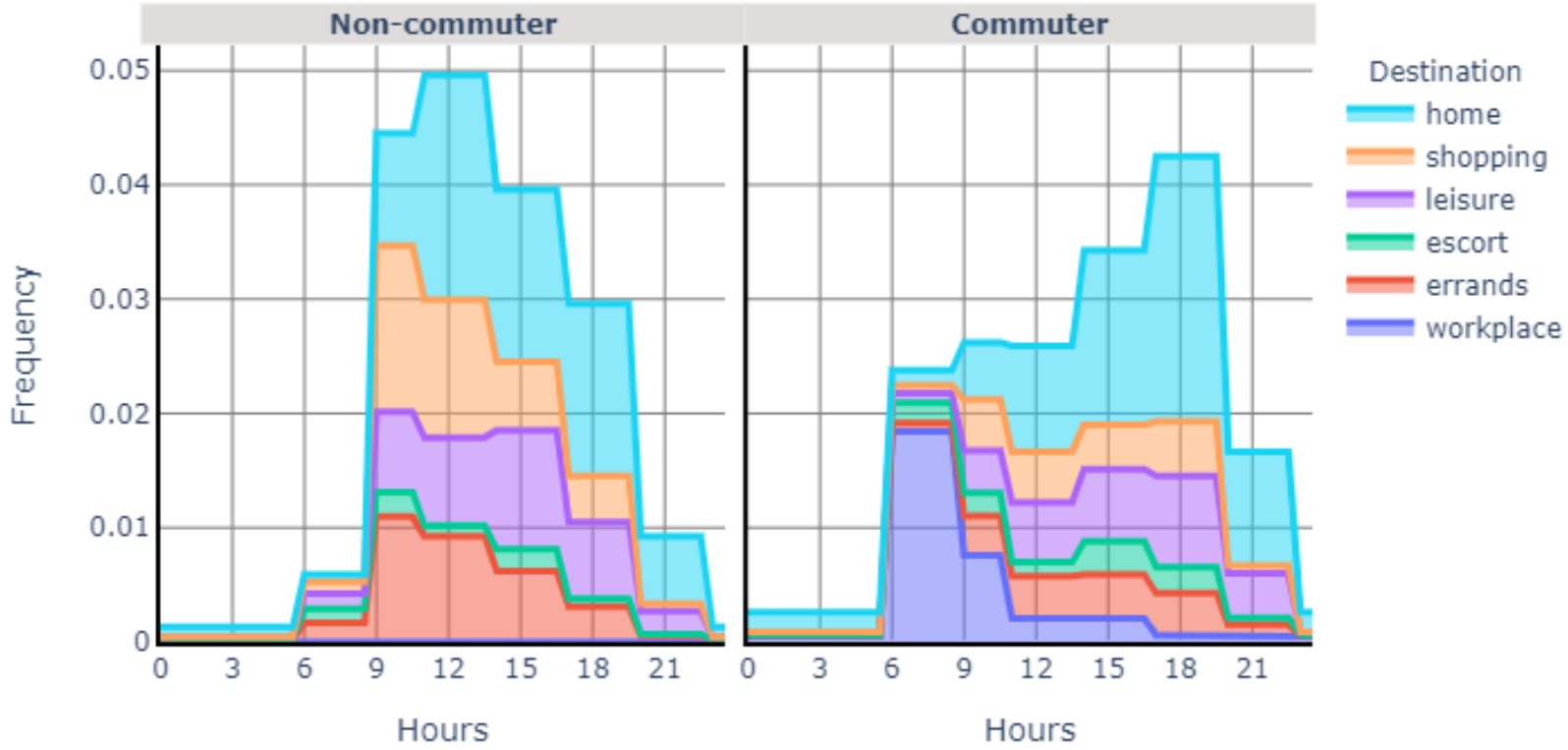
Feature: **Smart G2V**



Feature: **V2G**

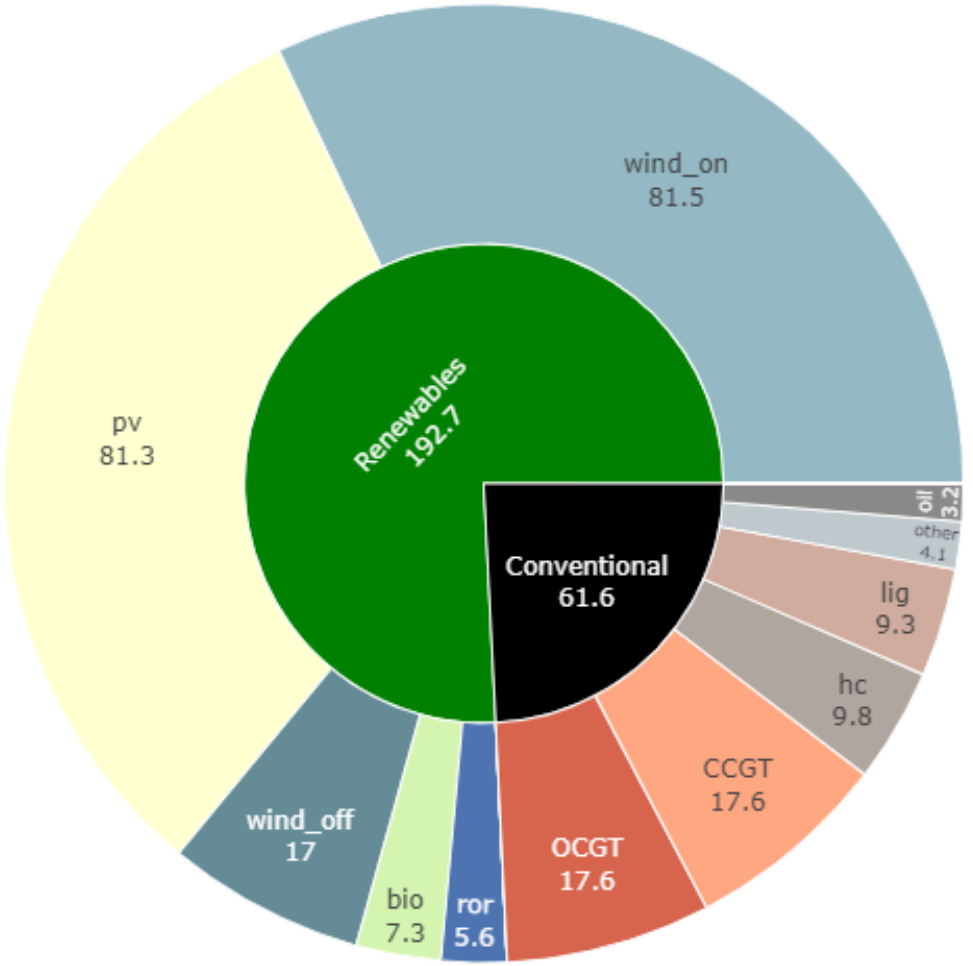


Features	Qty	Detail
Type of drivers	2	Non-commuter (38%), Commuter (Full time 50%, Part time 12%)
Destinations	6	Home, shopping, leisure, escort, errands, workplace (MiD2017)
BEV models	4	Model 3 (Tesla), ID.3 (VW), Kona (Hyundai), Zoe (Renault)
Charging stations	4	Garage (3.7 kW), Street (22 kW), Workplace (11 kW), Fast (75-150 kW)
Number of profiles	40	Type of driver share and 10 profiles with every BEV model



Features
- Open-source power sector model minimizes overall system costs
- A perfect foresight is assumed by considering all consecutive hours of an entire year
- It captures the variability of renewable energy sources
- Brownfield setting based on **2030** scenario for Germany
- Relevant decision variables: Technology dispatch, investment and BEV (dis)charging

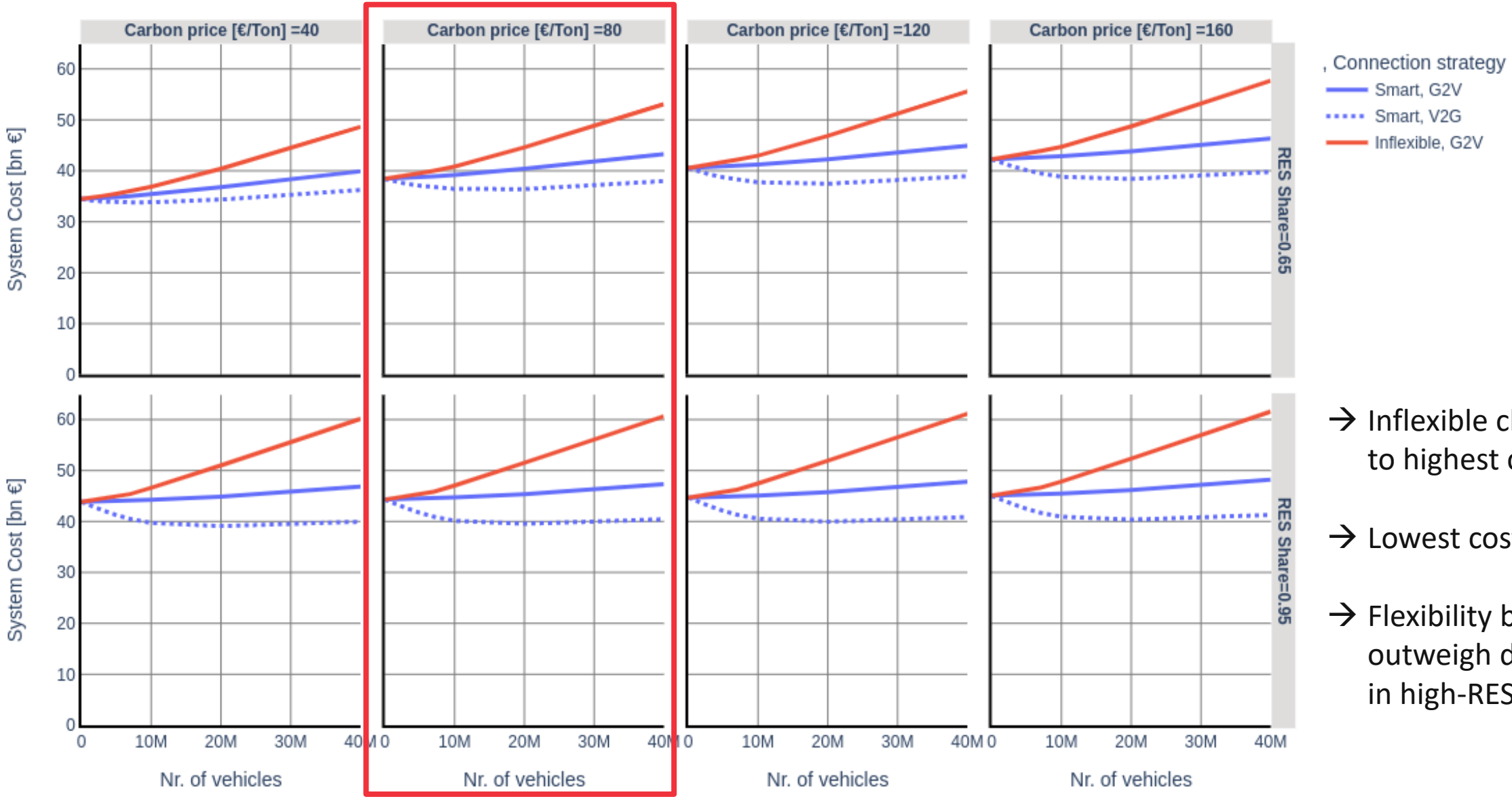
Renewables: Lower bounds



Fossil-based: Upper bounds

Scenarios:

Parameter	Qty	Detail
BEV quantity	8	0, 1M, 3M, 5M, 7M, 10M, 20M, 40M
Carbon price	4	40, 80, 120, 160 €/Ton
Connection strategy	3	Inflexible (Immediate), Smart G2V, Smart V2G
Minimum RES share	2	65%, 95%
Total scenarios	**192**	

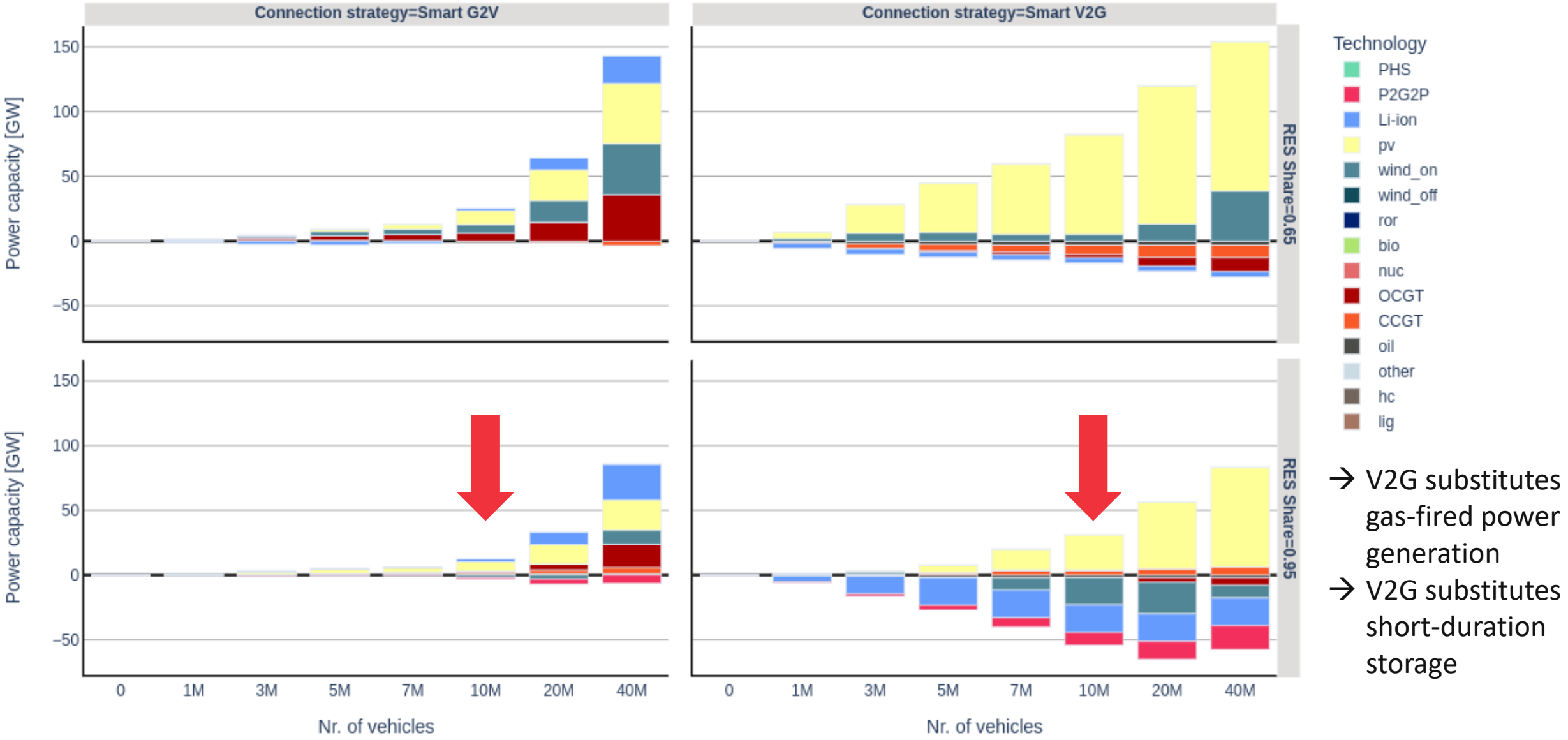


→ Inflexible charging leads to highest costs

→ Lowest costs with V2G

→ Flexibility benefits outweigh demand effect in high-RES settings

RESULTS | Investment difference zero BEV | Carbon price: 80 Euros/Ton | Smart G2V vs V2G

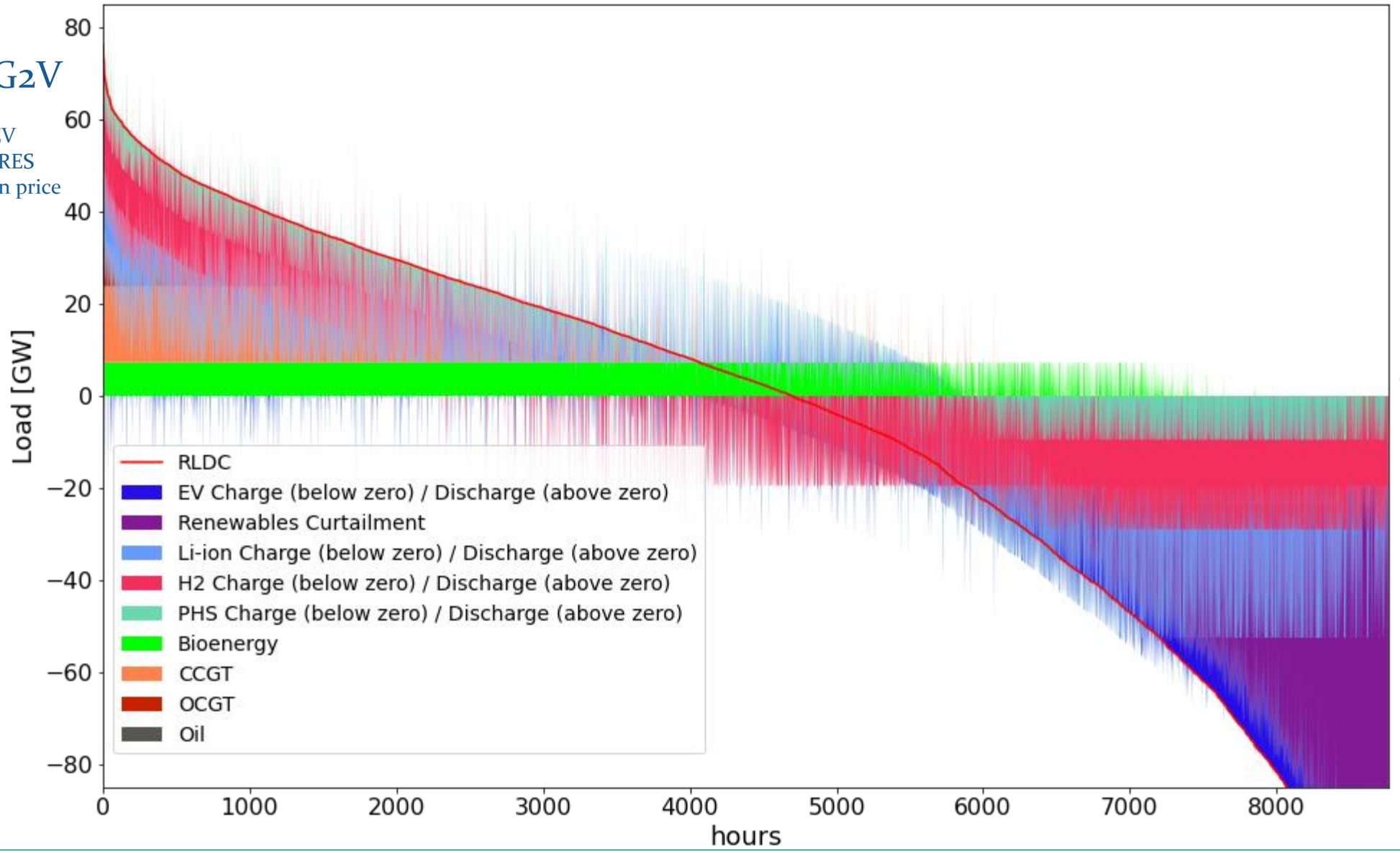


→ V2G substitutes gas-fired power generation

→ V2G substitutes short-duration storage

Smart G2V

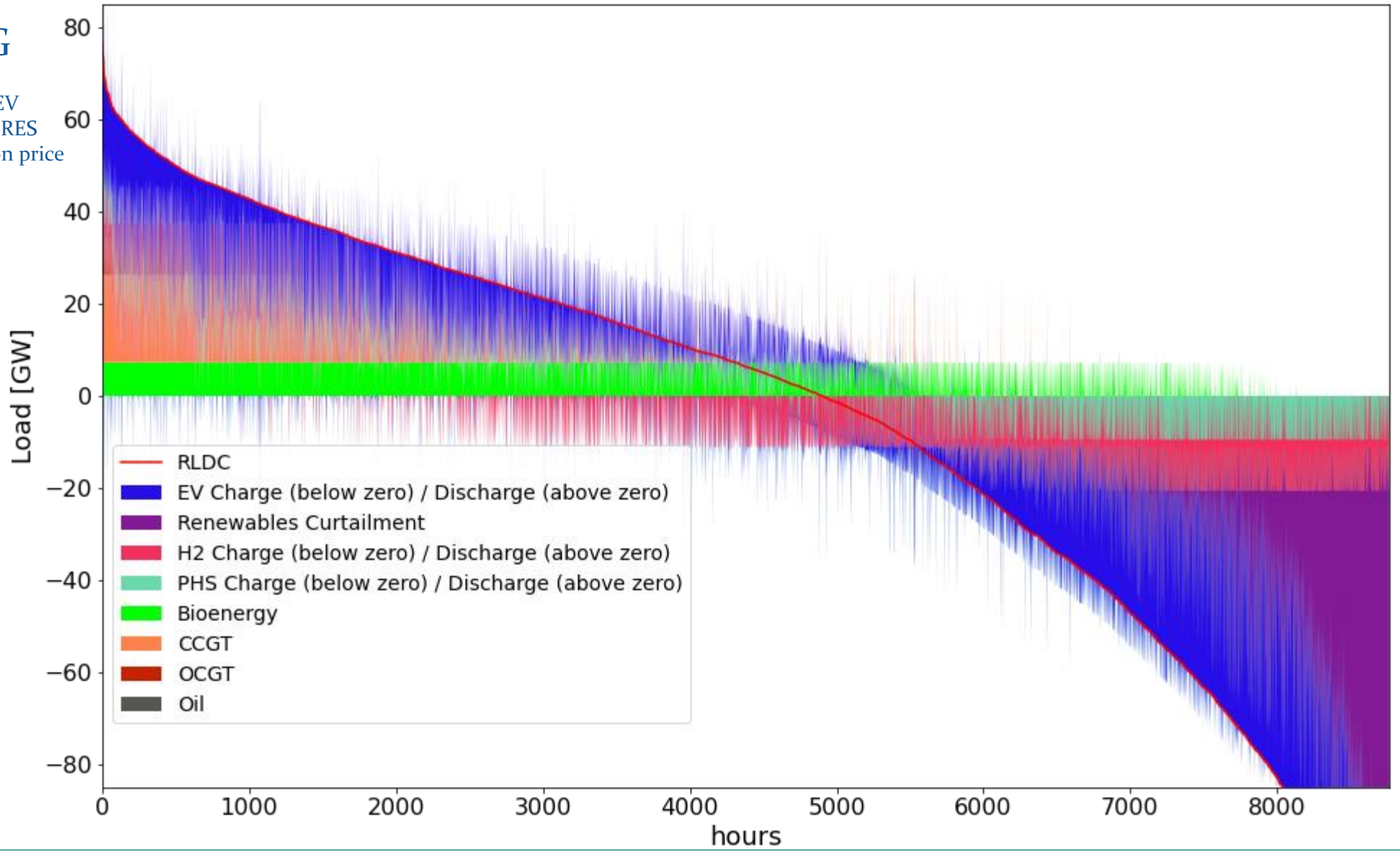
10 M BEV
95% Min RES
80 €/t Carbon price



→ Substantial electricity storage needs

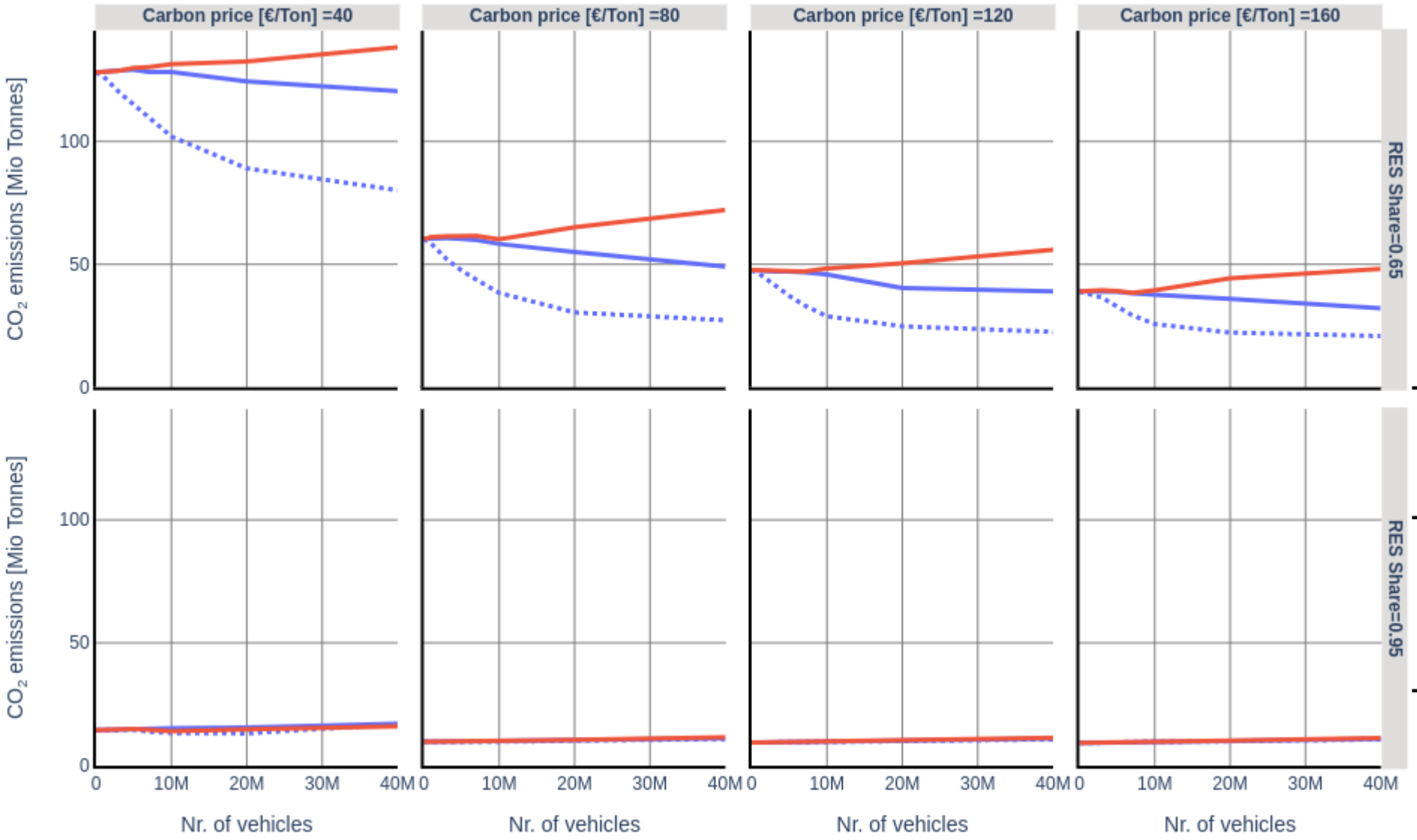
V2G

10 M BEV
95% Min RES
80 €/t Carbon price



→ V2G largely mitigates storage needs

RESULTS | Power system perspective | Total carbon emissions

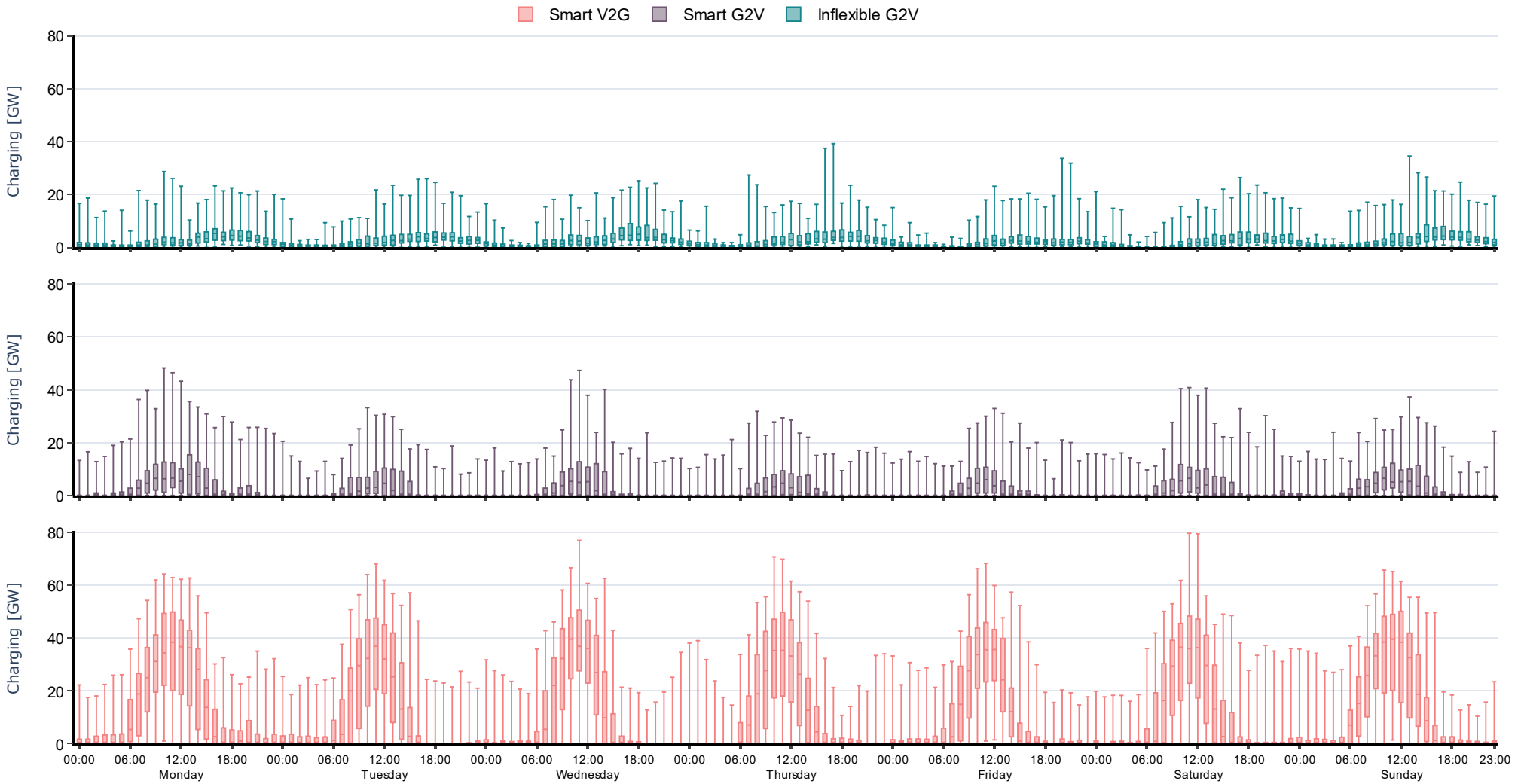


→ Inflexible charging leads to highest emissions

→ Lowest emission with V2G because of additional VRE integration

→ Flexibility benefits again outweigh demand effects

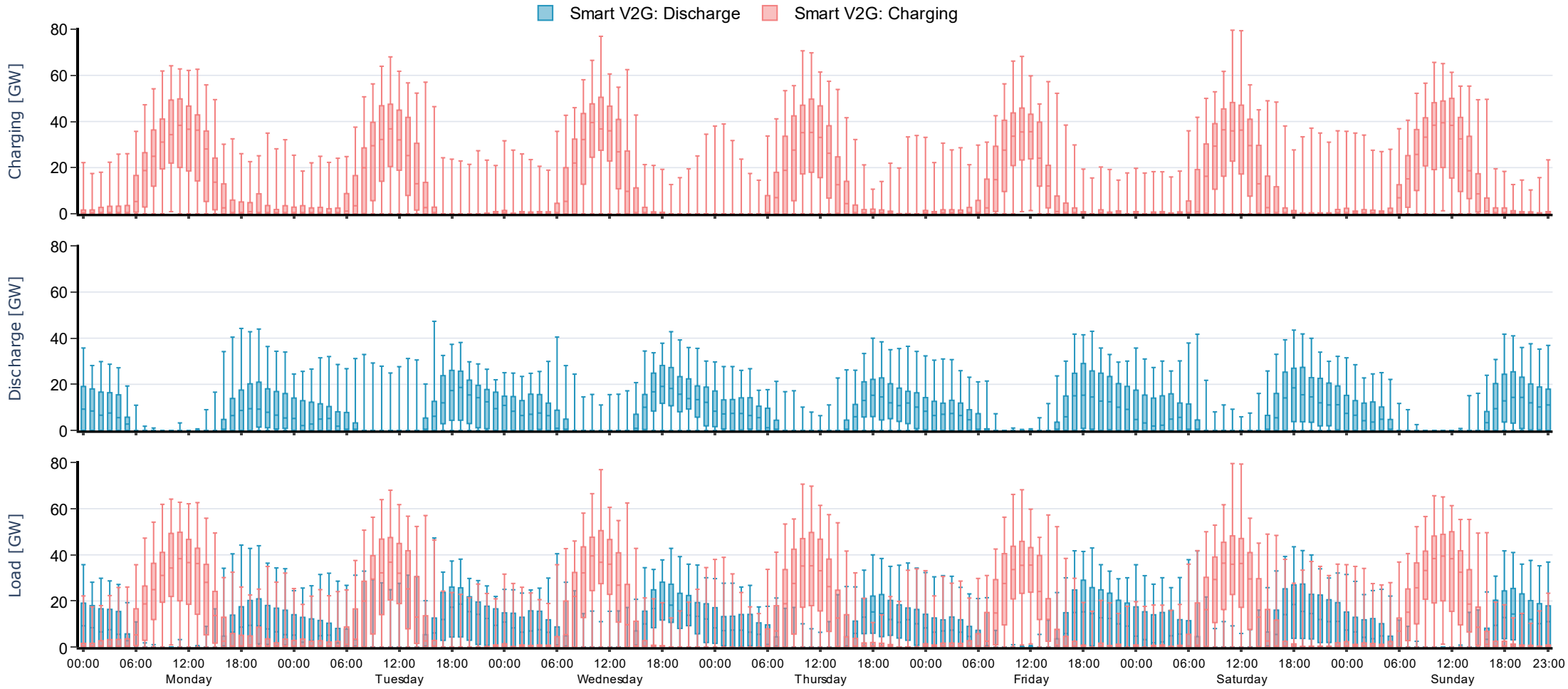
RESULTS | Electric vehicle perspective | Charging patterns for 10M BEV, 95% RES



→ Optimized charging follows PV generation

→ High hourly variations, also at night-time, related to wind energy integration

RESULTS | Electric vehicle perspective | Charging patterns for 10M BEV, 95% RES



→ Optimized discharge is more significant at peak-load hours

→ Discharge remains almost constant through the night

CONCLUSIONS

- Main findings
  - Flexible charging and V2G substantially reduce system costs and fosters VRE integration
  - Flexibility benefits of BEV can outweigh their demand effects in high-RES settings
  - V2G can substantially mitigate electricity storage needs
- Conclusions
  - Policy makers should work on enabling flexible BEV charging and V2G
  - Complementary carbon pricing remains important
- Limitations and future research
  - Real-world barriers to V2G: user acceptance and distribution grid issues
  - Include other countries in the European interconnection
  - …and other sector coupling options

https://gitlab.com/diw-evu/emobpy/emobpy

Vielen Dank für Ihre Aufmerksamkeit.

https://gitlab.com/diw-evu/dieter_public/dieterpy

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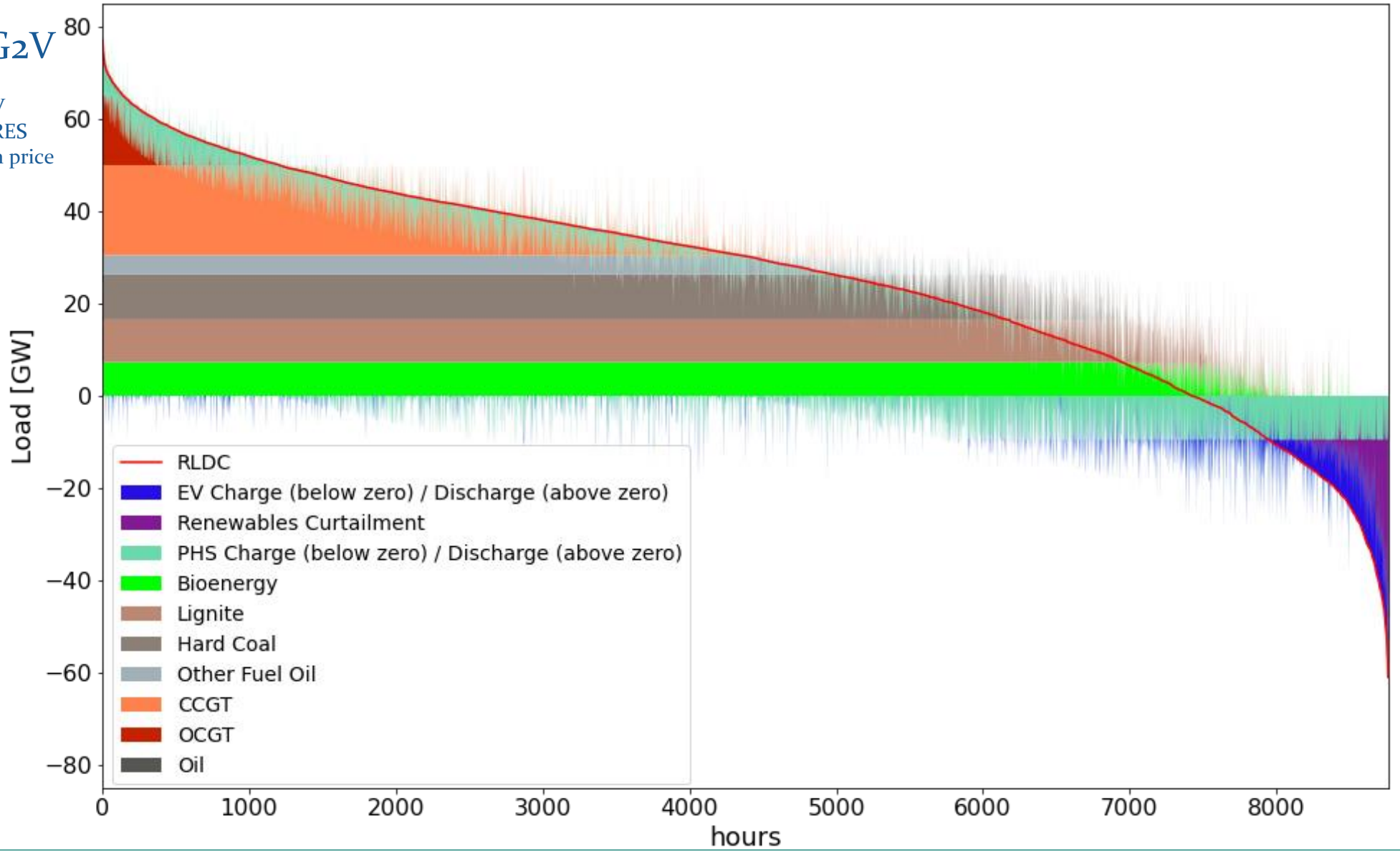
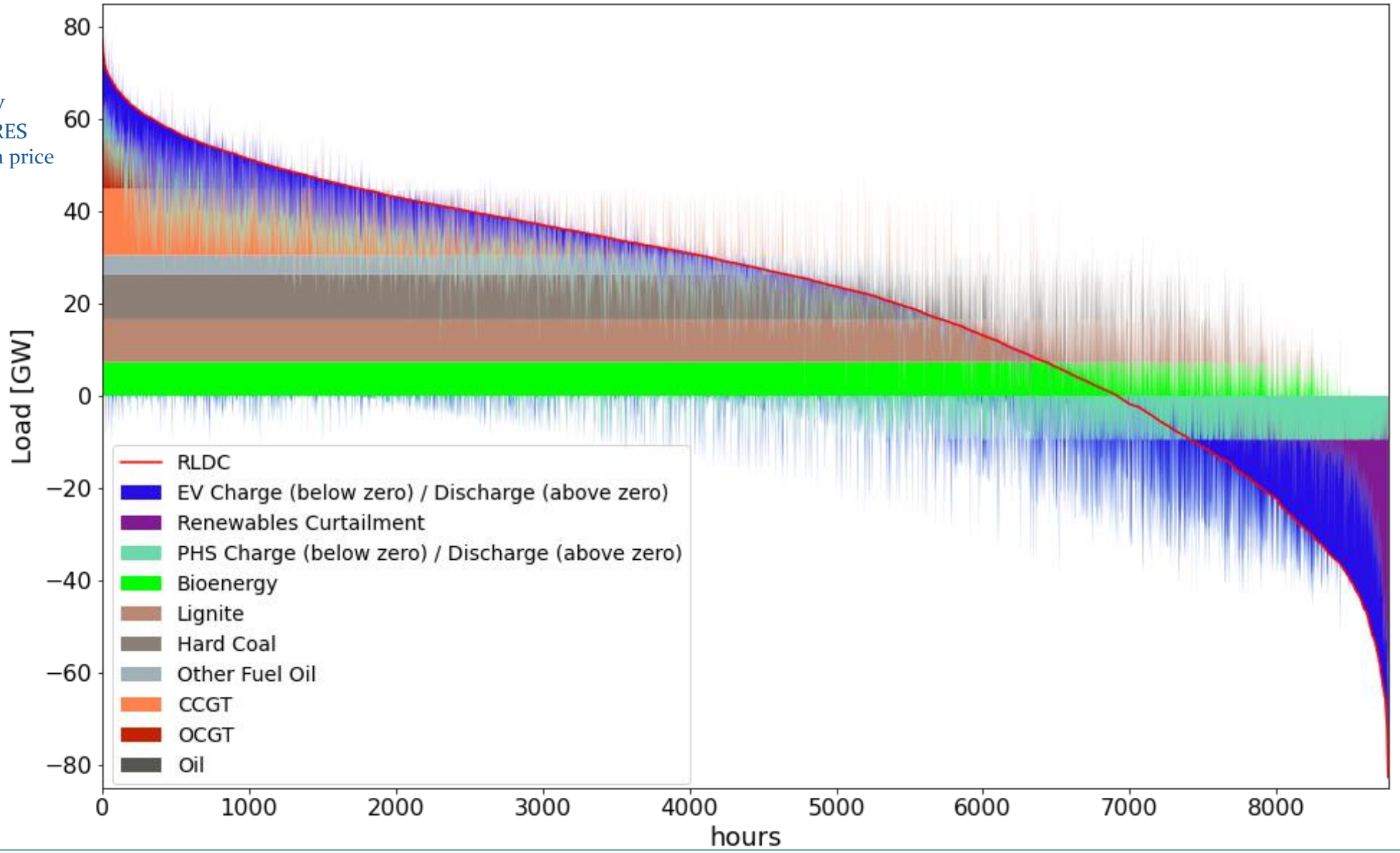
Smart G2V

5 M BEV
65% Min RES
40 €/t Carbon price

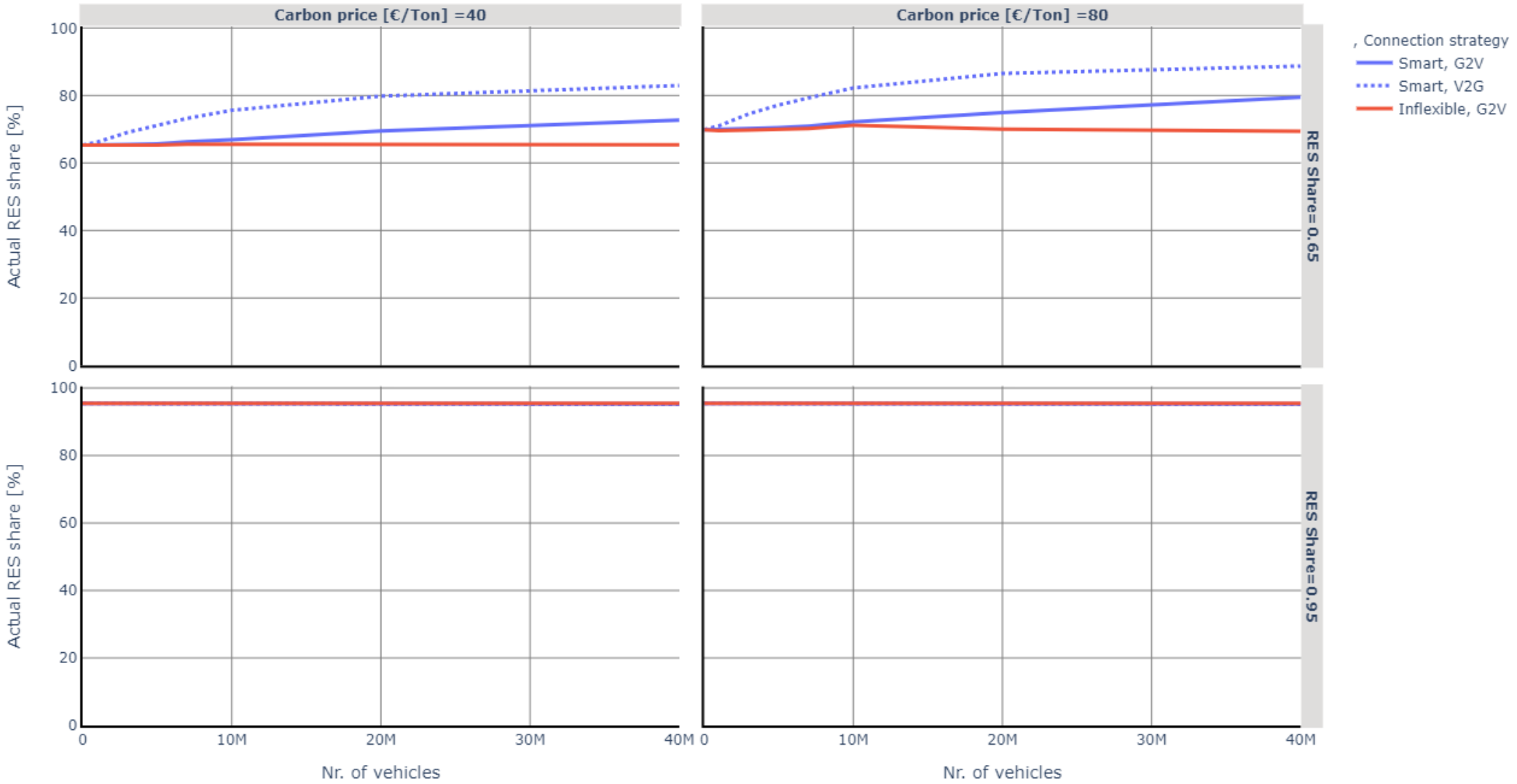


V2G

5 M BEV
65% Min RES
40 €/t Carbon price



RESULTS | Power system perspective | Renewables share



emobpy: time-series types (Example of a single vehicle)

1) + (2) + (3)

+

DIETER

(4)
Grid demand

System Optimized Approach

emobpy: time-series types