EVS35
OSL2022

ampcontrol

Synergy of Unidirectional and Bidirectional Smart Charging of Electric Vehicles for Frequency Containment Reserve Power Provision

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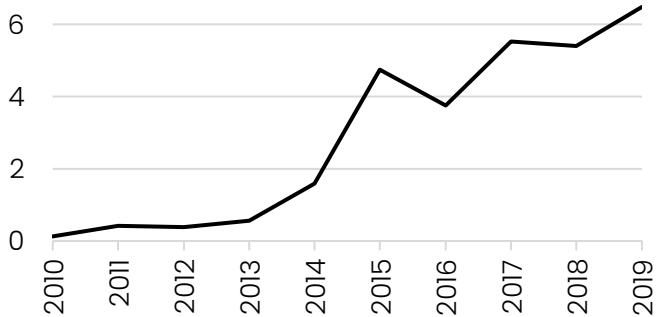
Flexibility

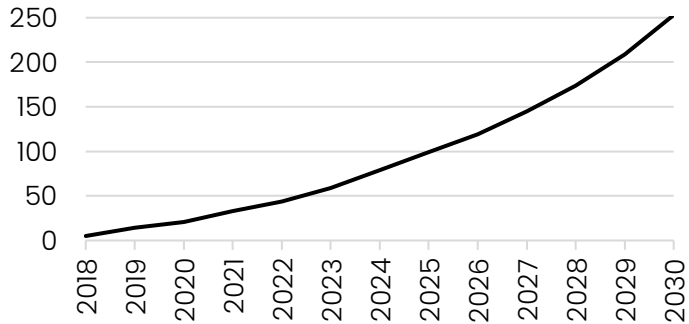
Curtailed electricity in TWh (Germany)



BNetzA, *Monitoring Report 2020*

Flexibility Need

EV stock in million units (World)

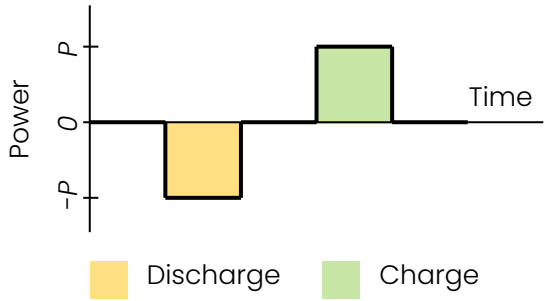


IEA, *Electric vehicle stock in the EV30@30 scenario*

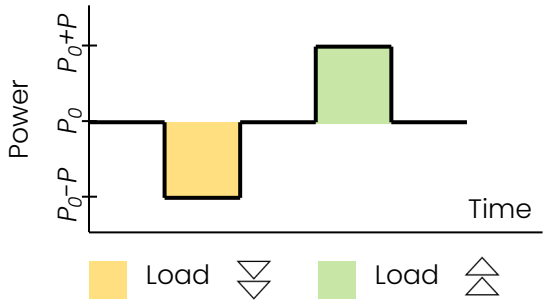
Flexibility Potential

Bi- vs. Unidirectional Smart Charging

Bidirectional Charging

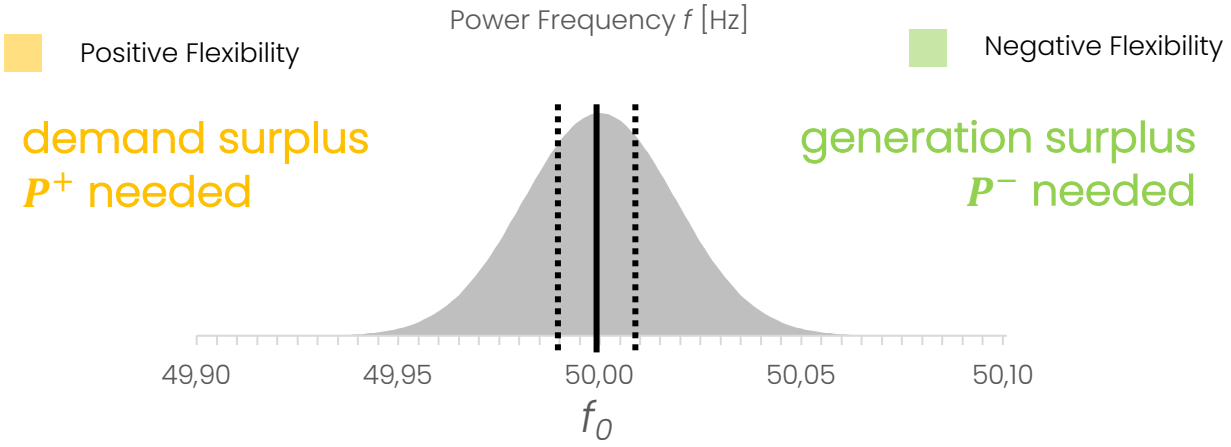


Unidirectional Charging



✓	Bidirectional Flexibility	✓
✓	More Flexibility Per Asset	
	Cheaper Hardware	✓
	More Assets	✓
	No Additional Aging	✓
	Less Losses	✓

FCR with Unidirectional Charging



Characteristics

- ❖ (Mostly) symmetrical, full provision at ±0.2 Hz
- ❖ Fast activation proportional to Δf
- ❖ Not energy intensive
- ❖ Tendered in 4 hour slices
- ❖ **Reservation of contracted power over 15 min**

Approach

- ➢ Simulation of large EV fleets on country level
- ➢ Analysis of the 0.25-hour energy flexibility over a full year

Methodology: Simulation Model

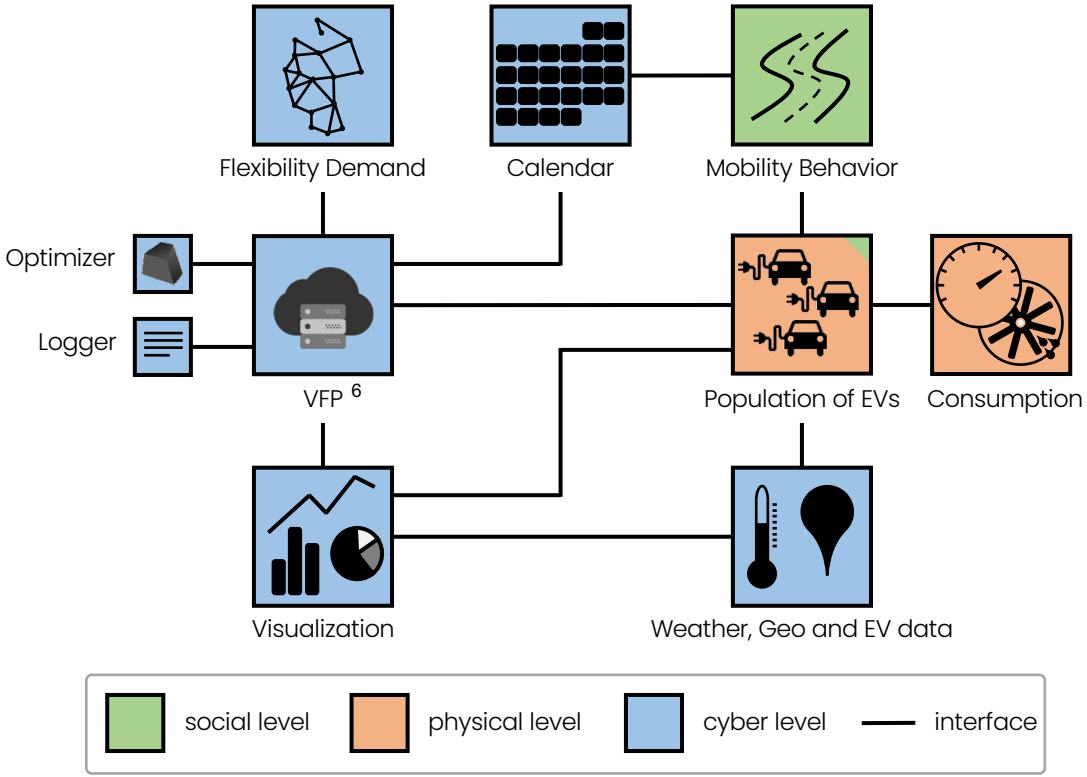
General
- 48 high level model parameters
- Up to several years in 1 minute timesteps
- Up to 50,000 EV instances
- Representation of any number of vehicles
- Interactive online simulation
- Empowered by **i7-AnyEnergy**

Geographic resolution[1]
- county, state, grid group, TSO[2] Group, country
- GIS data integration (OpenStreetMap)

Weather data[3]
- 90 weather stations over three years

Vehicle data
- registration figures per county[4]
- registration figures per model type and state[4]
- technical data of 43 most common EV models[5]

Demand data[5]
- full year data of feed-in management, redispatch per grid group



[1]from Federal Statistical Office & Ministry of Transport and Digital Infrastructure, [2]Transmission System Operator, [3]from German Meteorological Service, [4]from German Federal Motor Transport Authority [5]from different sources collected by [Posner, FAU], [6]Virtual Flexibility Plant

Methodology: Stochastic Behavior Model

Scenario Definition

Type of EV,...

Static Geo Data

States, RegionTypes

Time Data

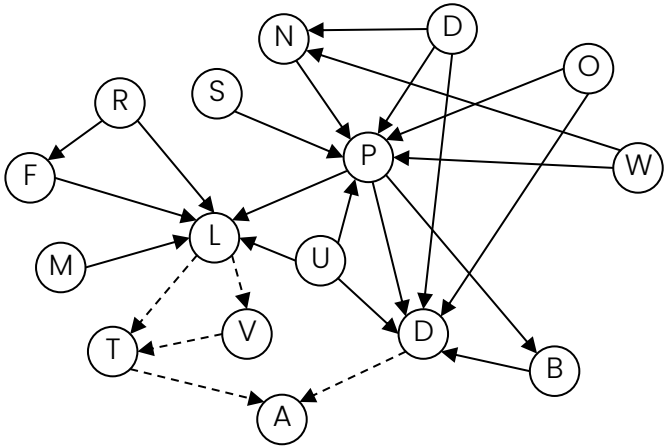
Weekday, holidays, weather

User Behavior

User group, defined user

Mobility Model

Bayes networks of MiD2017
(1 million paths, 316k persons, 217k cars)



TripChain

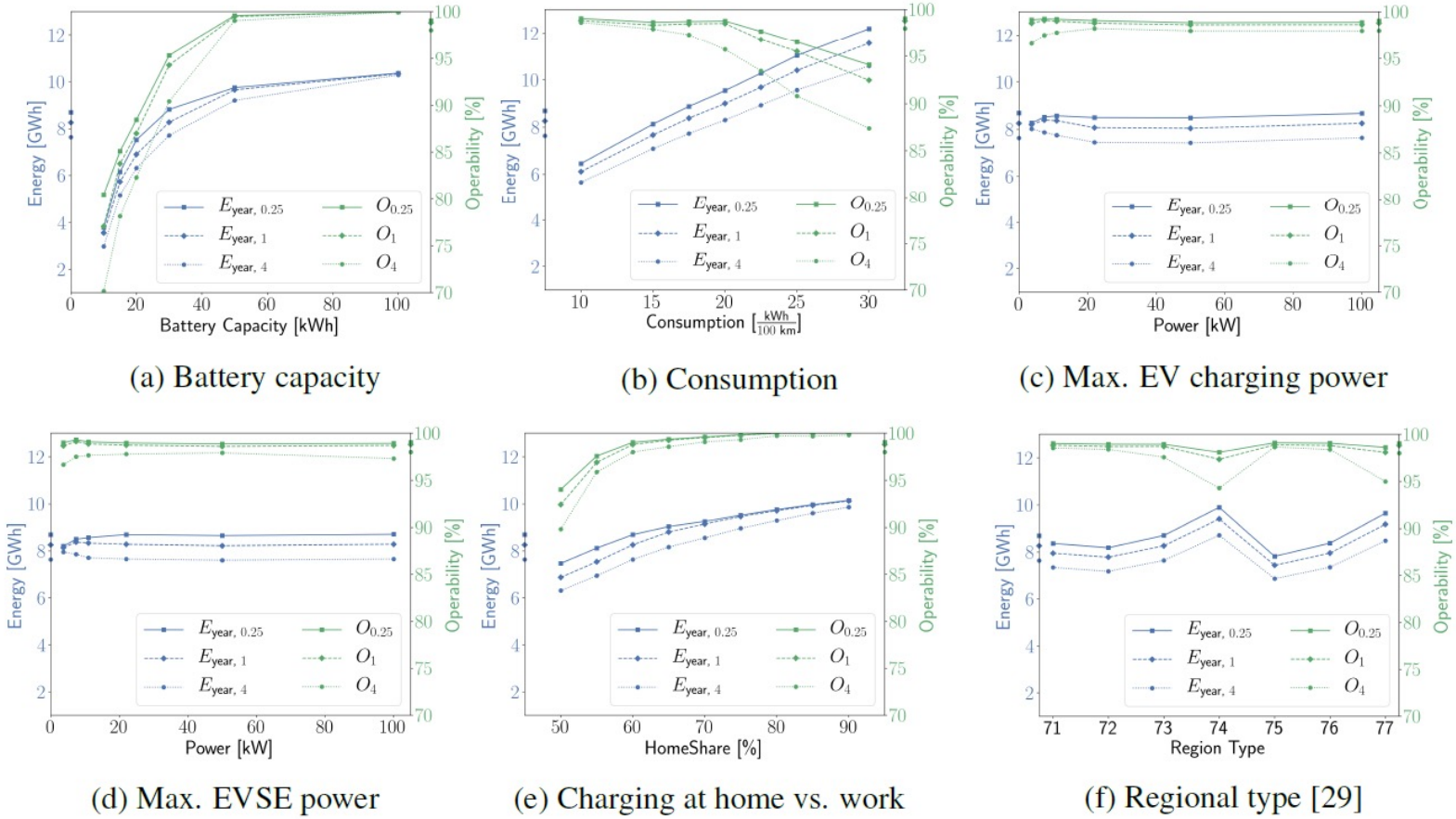
- Length

SingleTrip

- DepartureTime
- TravelDuration
- ArrivalTime
- Distance
- Purpose
- MeanSpeed

GitHub

Results: Sensitivity Analysis (5k EVs)



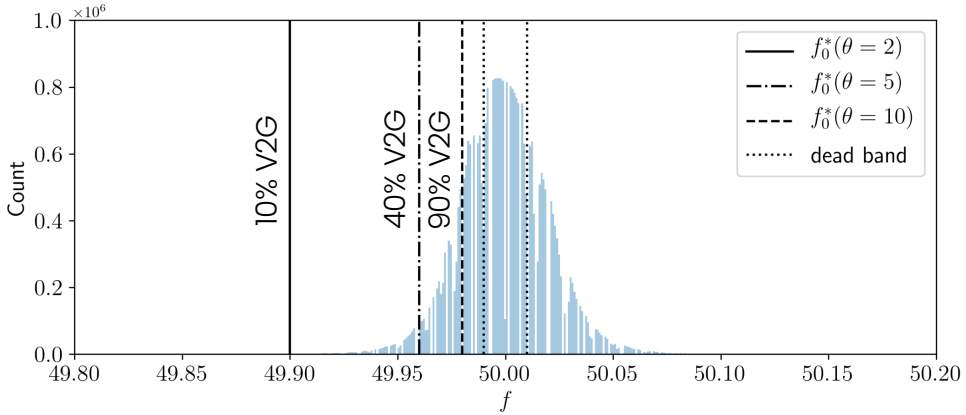
(a) Battery capacity (b) Consumption (c) Max. EV charging power

(d) Max. EVSE power (e) Charging at home vs. work (f) Regional type [29]

Results: Synergy with Bidirectional Charging

Combining bi- and unidirectional chargers the idle frequency f_0 is shifted towards higher frequencies. With certain shares of V2G capable chargers we can contract θ-times more power.

- More Flexibility Per Asset ✓
- Cheaper Hardware ✓
- More Assets ✓
- No Additional Aging ✓
- Less Losses ✓

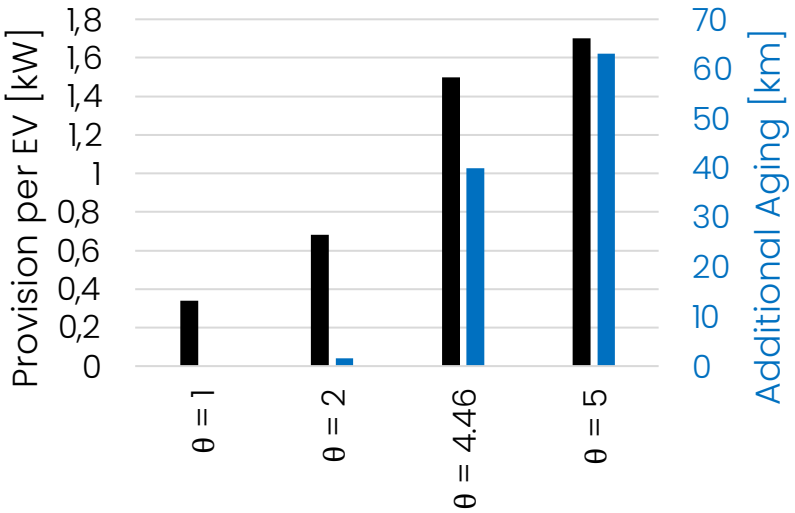


Results: Economical Evaluation

With unidirectional charging, the best suitable user groups can reach annual charging savings of 7.5-18.7%.

In synergy with 35% V2G capable chargers the average savings amount to 33%-83%, without significant additional battery degradation.

Economical results are subject to a high price volatility on the FCR power market.



Conclusion

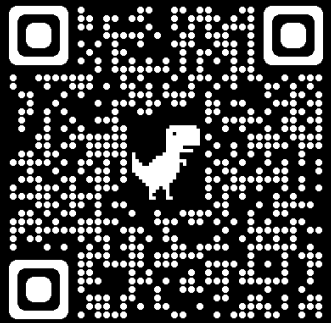
The technical potential is high and can eventually satisfy the whole German market in 2030 scenarios

Smart combination of bi-and unidirectional chargers in operation can enable the advantages of both.

Commercial vehicles with a high usage are most promising.

Thanks for your attention!

Dr.-Ing. Jonas Schlund



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