

# *pommesdata* and *pommesinvest*

Data processing and multi-period investment  
optimization modelling using oemof-solph

# Overview

*What is POMMES?*

*POMMES* is an open source suite for bottom-up linear fundamental power market modeling, consisting of ...



- |                              |   |
|------------------------------|---|
| • <b><i>pommesdata</i></b>   | <b>data preparation routine</b>                   |
| • <b><i>pommesinvest</i></b> | <b>multi-period investment and dispatch model</b> |
| • <i>pommesdispatch</i>      | dispatch model                                    |
| • <i>pommesevaluation</i>    | collection of visualization and analyses scripts  |

- *POMMES* is short for **P**ower **M**arket **M**odel of **E**nergy and re**S**ources
- Originally developed at the Chair of Energy and Resources Management at TU Berlin
- Code hosted at: <https://github.com/pommes-public>

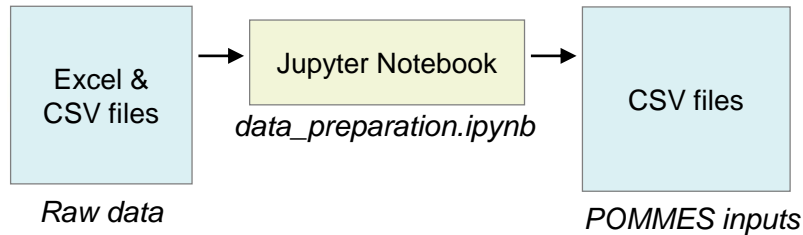


# pommesdata – Overview

*A full-featured transparent data preparation routine from raw data to POMMES model inputs*

- Prepare data for ...
  - *pommesdispatch* and
  - *pommesinvest*
- *Provide transparency*
  - *Start with (mostly) raw data*
  - *end with POMMES inputs*

## Aim



## Scope



- Time frame: 2020-2045
- Resolution: Hourly (infeed) or annually (costs)



- Bidding zone / country-level for DE + neighbours + IT (DE, AT, CH, FR, BE, NL, CZ, PL, DK, NO, SE, IT)
- no georeference in prepared data; but in some raw data



- Existing
  - RES: wind onshore / offshore, solar PV, biomass, run of river, others
  - conventionals: nuclear, lignite, hard coal, biomass, oil, other / mixed
  - Storages: pumped hydro, reservoir



- Expansion
  - Backup: natural gas, hydrogen, biomass, oil
  - Storages: pumped hydro, (lithium-ion) batteries, electrolyzers
  - Demand response: households, commercial and industrial

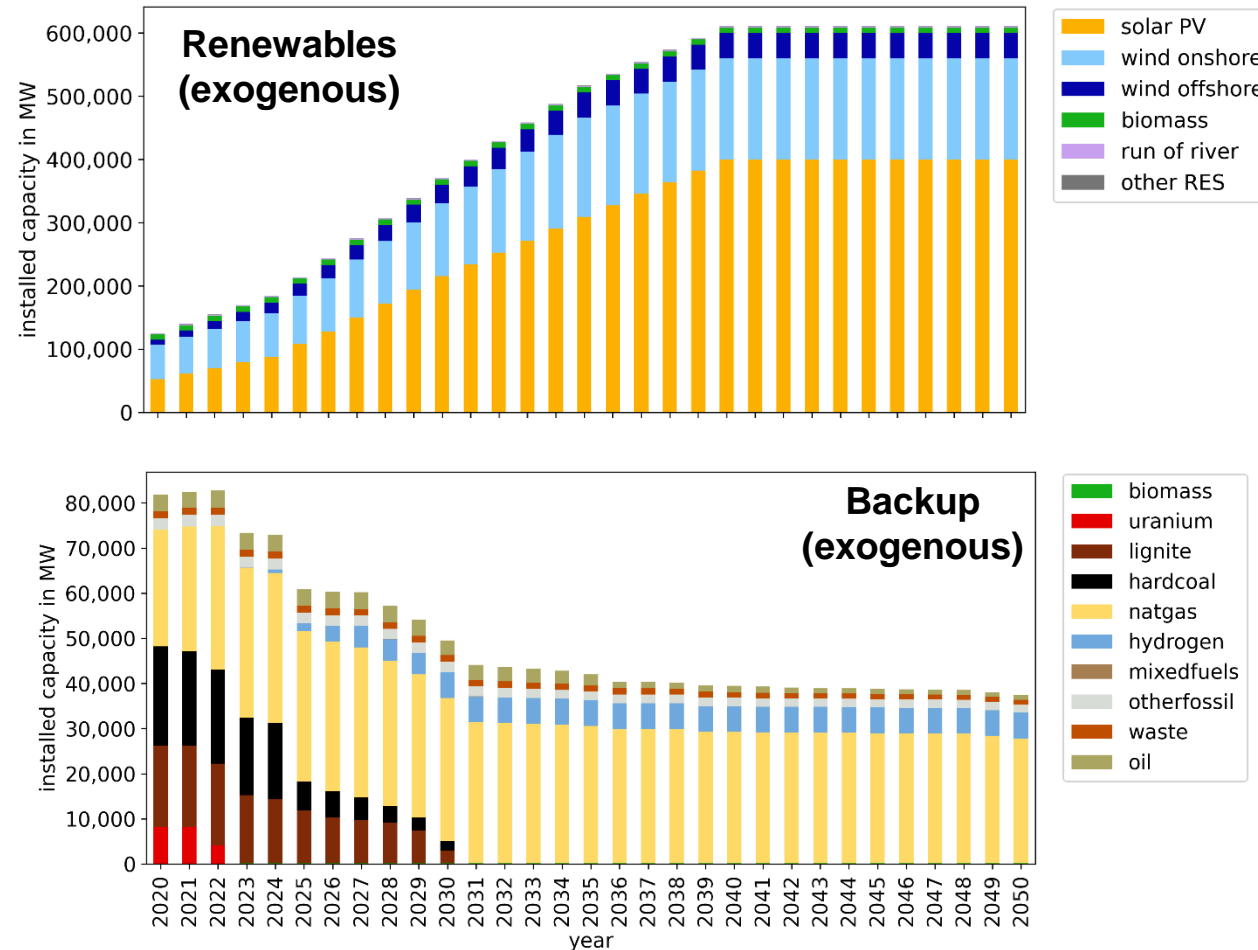
# *pommesdata* – Selected main data sets used

*Combining various open data sources for the power sector*

Element	Sources
Conventional <b>power plants</b>	<ul style="list-style-type: none"><li>• National: OPSD [1], BNetzA [3], BDEW [4], NEP [5], KVBG [6]</li><li>• European: FRESNA Power plant matching [2], ENTSO-E TYNDP 2022 [7]</li></ul>
<b>Renewable energy sources</b>	<ul style="list-style-type: none"><li>• National: EEG 2023 [32]</li><li>• European: ENTSO-E TYNDP 2022 [7]</li></ul>
<b>Interconnectors</b>	<ul style="list-style-type: none"><li>• (time-dependent) NTC values from ENTSO-E [11]</li></ul>
<b>Storages</b>	<ul style="list-style-type: none"><li>• Reservoir: Approximizing maximum inflow from historical filling rate &amp; generation [8, 13]</li><li>• Hydrogen storage (assumed unlimited)</li><li>• Batteries, i.e. Lithium-Ion (can be invested into)</li></ul>
<b>Demand &amp; Demand Response</b>	<ul style="list-style-type: none"><li>• Demand: OPSD time series [20], scaling according to Prognos [14] / ENTSOE- TYNDP 2022 [7]</li><li>• Demand Response: data compiled from 30 primary sources [21]</li></ul>
<b>Investment expenses, variable &amp; fixed costs</b>	<p>Data from different sources combined:</p> <ul style="list-style-type: none"><li>• PIK [26], PyPSA-EUR data set [27], FlexMex data [28], DieterPy data [29], UNSEEN data [30], Fraunhofer ISE 2020 [31]</li><li>• Deriving 5%, median and 95% quantile estimates</li></ul>

# pommesdata – Exogenous plant status

*RES expansion, coal phase out, shutdown estimates*

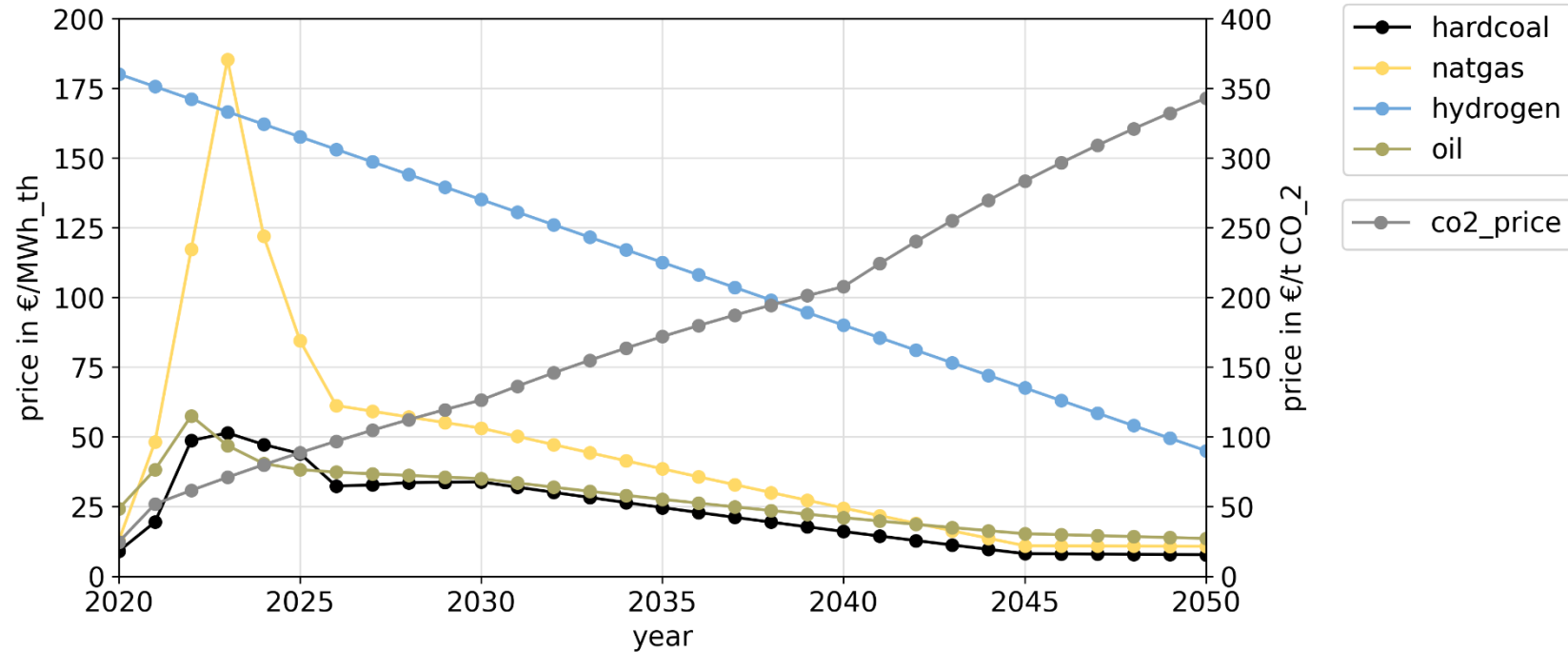


## Important premise

brownfield approach  
considering  
current planning and  
state of legislation!



# *pommesdata* – Fuel & emissions price estimates

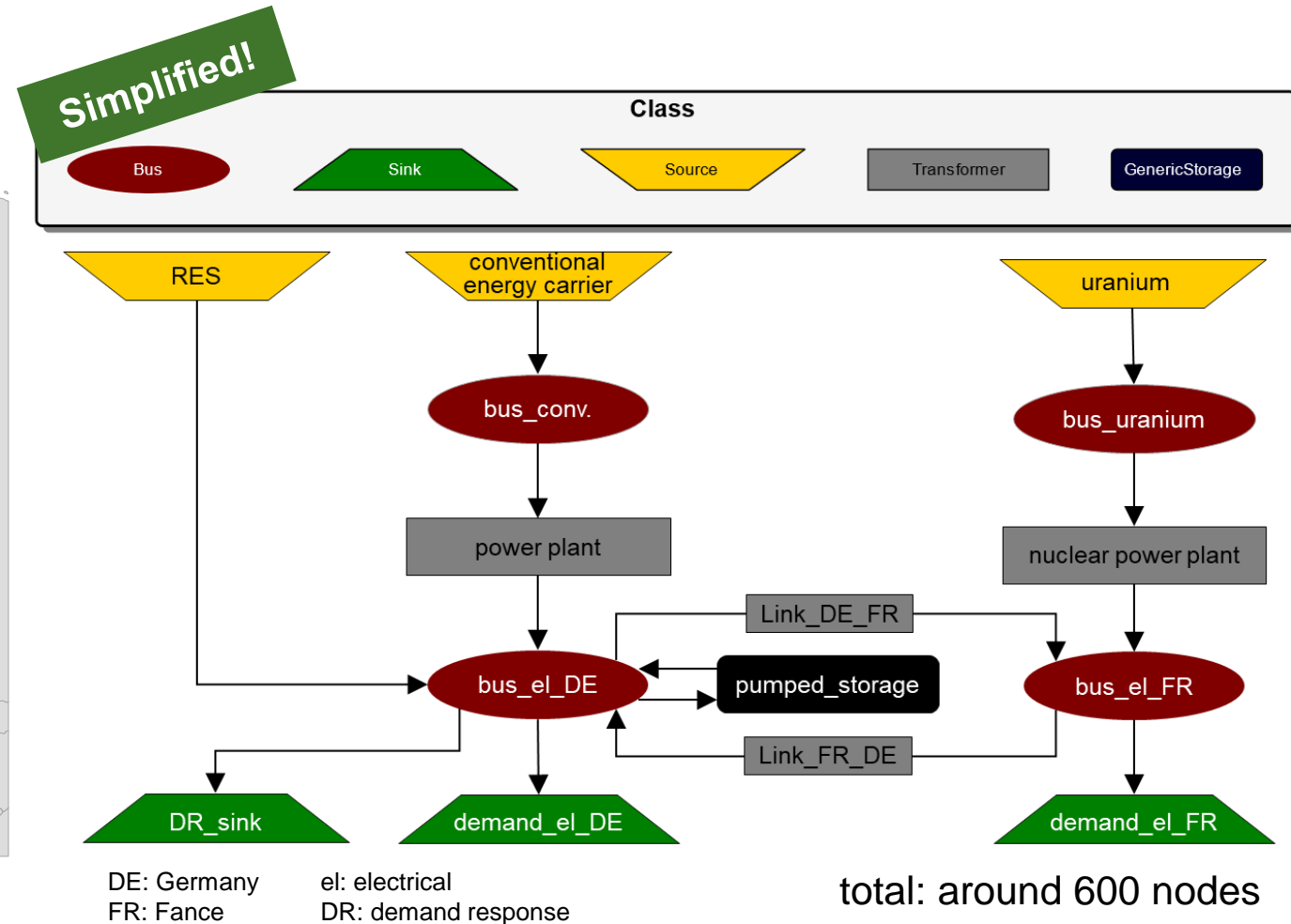
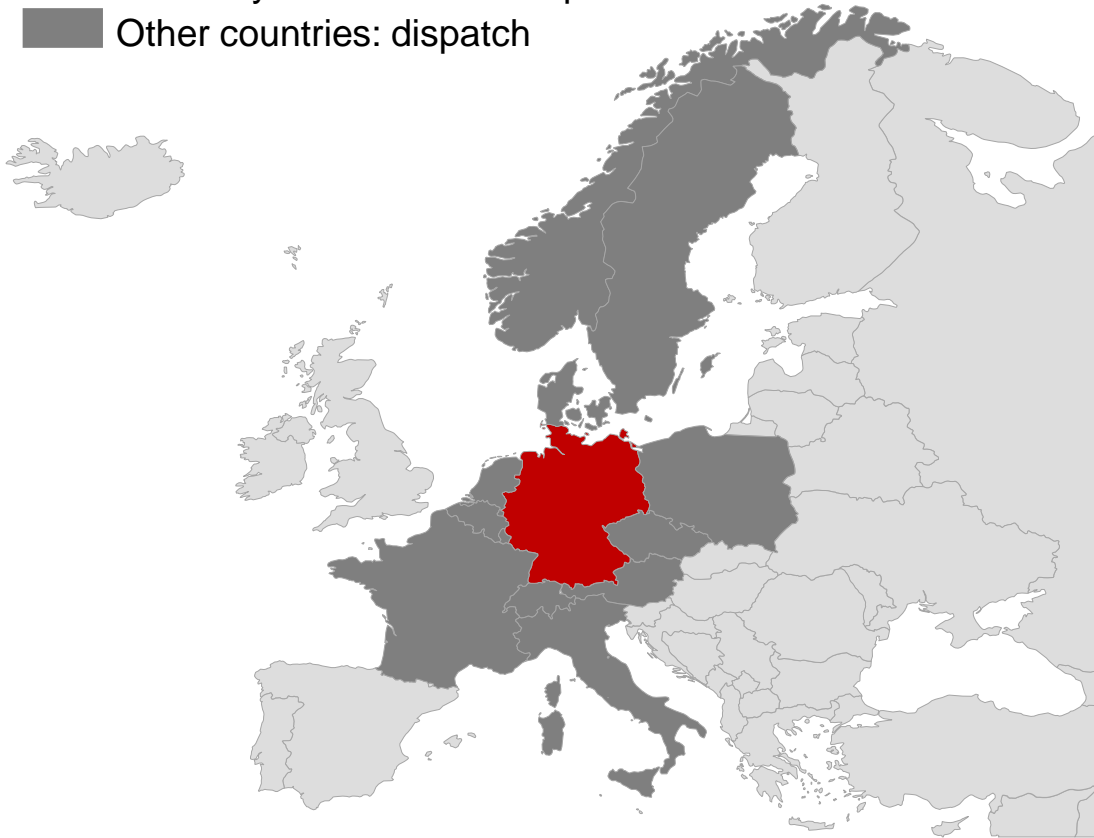
*Exemplary pathways, based on world energy outlook*



# pommestinvest – Overview

Linearly optimizing investment & dispatch from 2020 to 2045 ...

 Germany: investment & dispatch  
 Other countries: dispatch

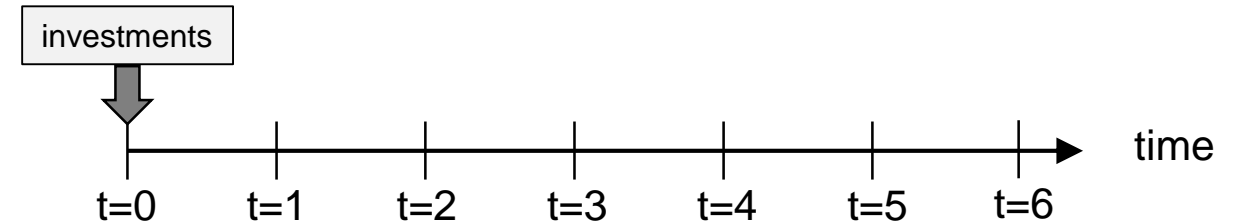


# *pommesinvest* – Overview

*... taking a multi-period investment approach*

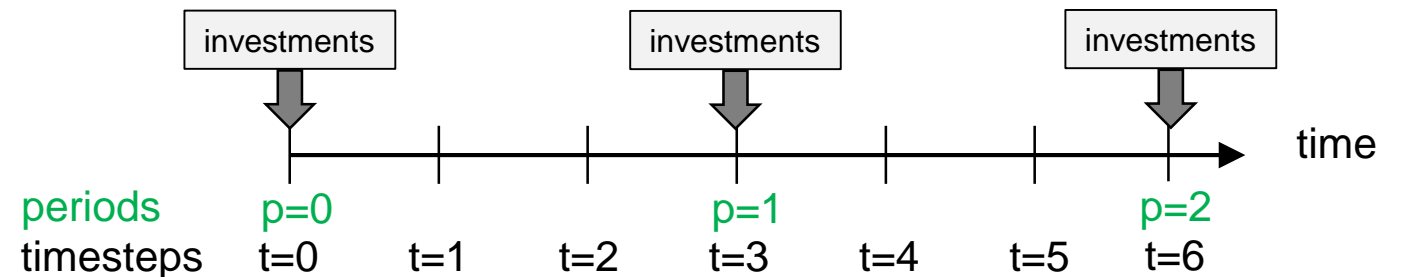
- **Single-period** optimization

- Only one timestep where investments may occur →  $t=0$ , i.e. the begin of the optimization
- Investments are accounted for by their annuity



- **Multi-period** optimization

- Depict different periods in addition to different timesteps → there are two time-related indices
- Investments may occur in every **period**, i.e. every **year** for *pommesinvest*
- Lifetime tracking & discounting



# *pommesinvest* – Analysis: scenario design

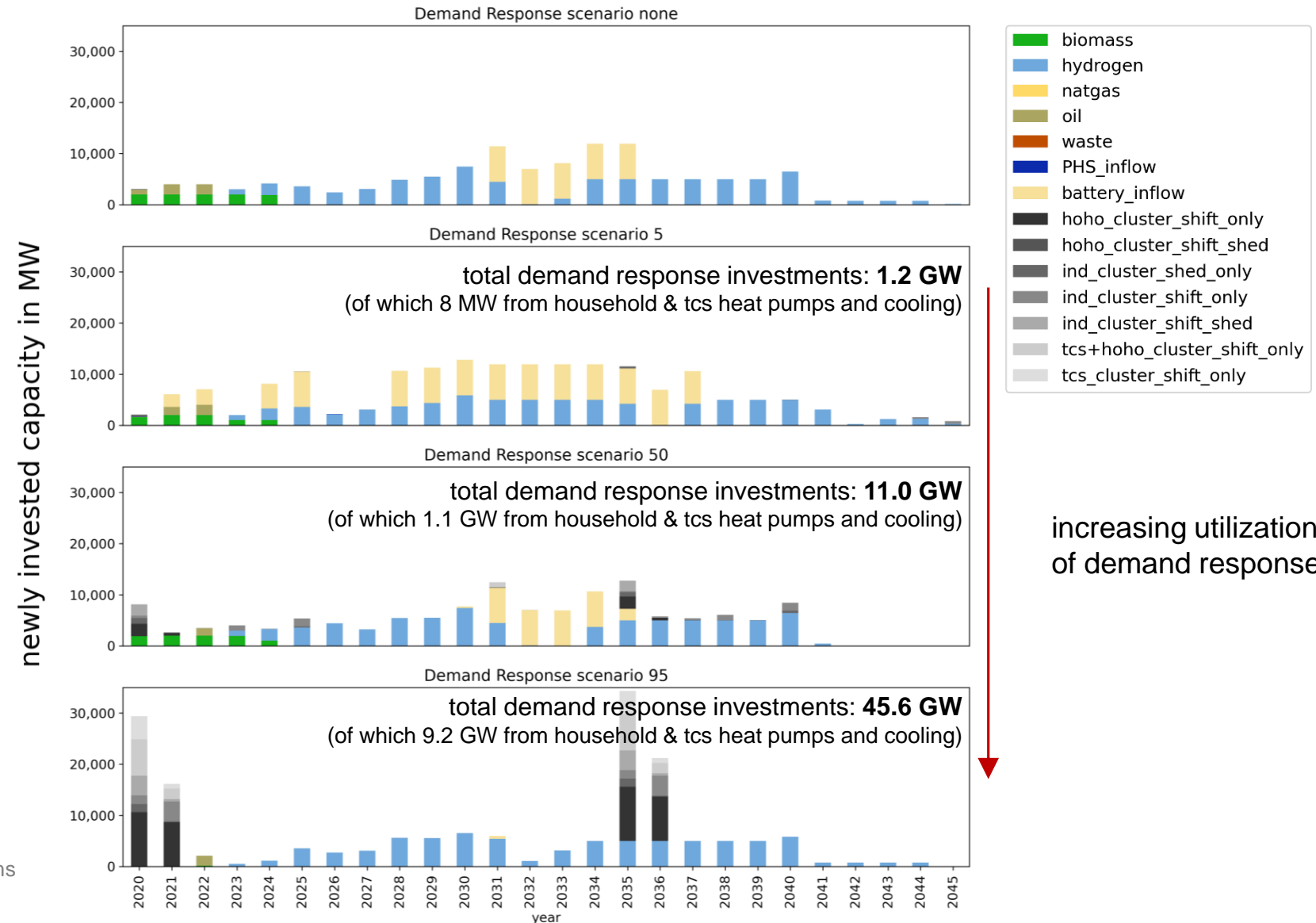
*Considering one scenario without and three scenarios with demand response*

	no DR (DR none)	DR pessimistic (DR 5)	DR neutral (DR 50)	DR optimistic (DR 95)
Demand response (DR) prevalent?	✗	✓	✓	✓
Costs of DR	✗	↑	○	↓
technical potential of DR	✗	↓	○	↑
Costs of other flexibility options	○	↓	○	↑

*DR: Demand Response*

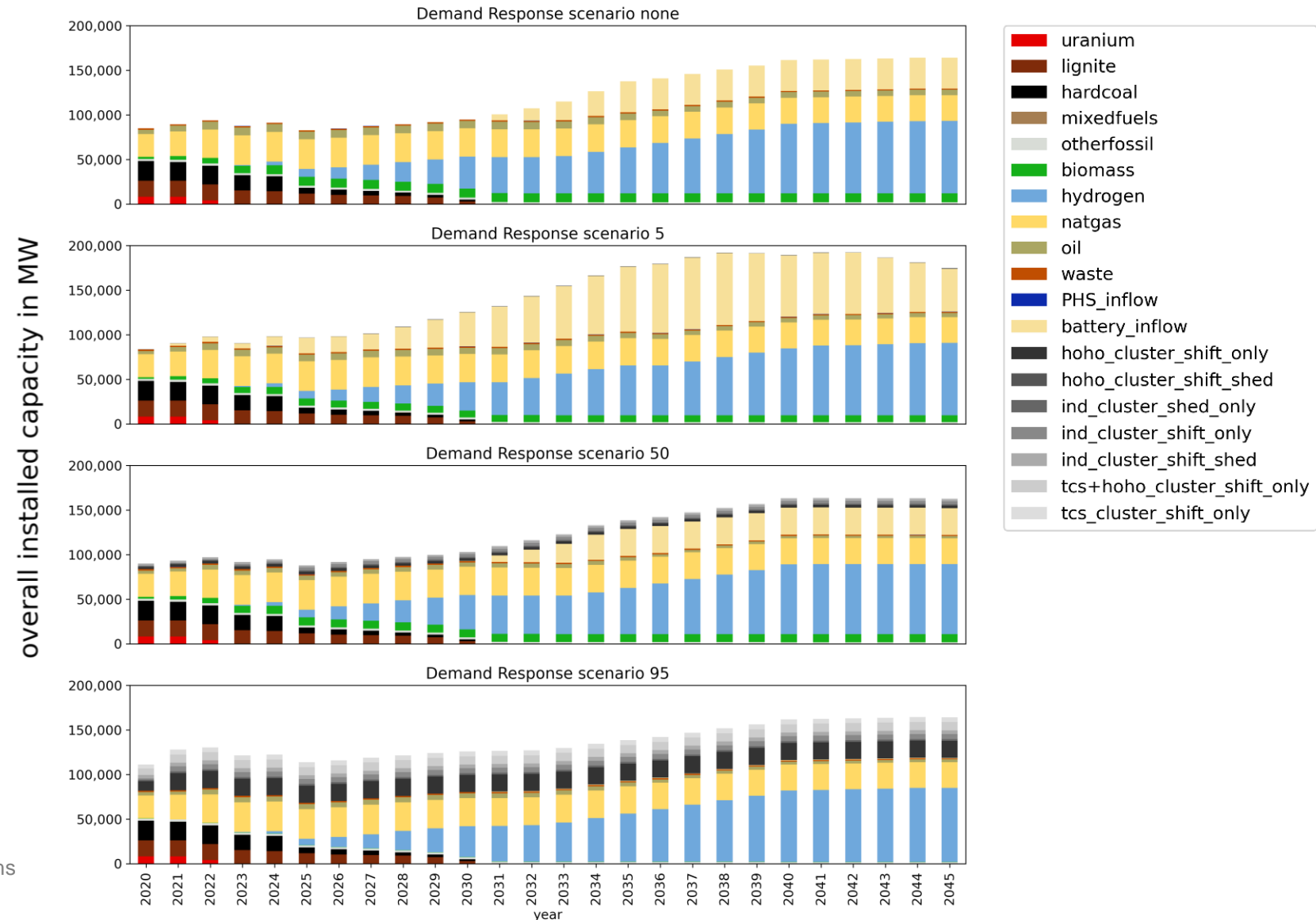
# *pommesinvest* – Analysis: investments in backup capacities

*Cost assumptions for flexibility options drive decisions; re-investments are visible*



# *pommestinvest* – Analysis: total installed backup capacities

*Overall capacity level is comparable; share of batteries and demand response differs*



# Summary & critical thoughts

*pommesdata & pommesinvest offer some cool features, but like all models have their flaws*

## Summary

### *pommesdata*

- offers extensive **data preparation** routines for POMMES or other models of the power market
- combines a lot of different **open** data sets

### *pommesinvest*

- is an application for **multi-period investment** modelling using oemof.solph
- has been applied to study **demand response** investments

## Critical thoughts

### *pommesdata*

- is hard to **maintain** in its current form  
→ should be transferred to a different format
- can be “**exploited**” by taking out parts of interest

### *pommesinvest*

- has been soft-**coupled** to model **AMIRIS**
- offers room for improvement in terms of computational performance and **complexity**

# Thank you very much!

## Contact

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[kochems@campus.tu-berlin.de](mailto:kochems@campus.tu-berlin.de)

GitHub: jokochems

# Collection of useful links

- POMMES-public (GitHub): <https://github.com/pommes-public>
- pommesdata
  - GitHub: <https://github.com/pommes-public/pommesdata>
  - Data preparation Jupyter Notebook: [https://github.com/pommes-public/pommesdata/blob/dev/pommesdata/data\\_preparation.ipynb](https://github.com/pommes-public/pommesdata/blob/dev/pommesdata/data_preparation.ipynb)
- pommesdispatch
  - GitHub: <https://github.com/pommes-public/pommesdispatch>
  - Read the Docs: <https://pommesdispatch.readthedocs.io/en/latest/>
  - PyPI: <https://pypi.org/project/pommesdispatch/>
- pommesinvest
  - GitHub: <https://github.com/pommes-public/pommesinvest>
- pommesevaluation
  - GitHub: <https://github.com/pommes-public/pommesevaluation>

# Selected data sources for *pommesdata* 1/4

*For all data sources used, see data preparation script:*

[https://github.com/pommes-public/pommesdata/blob/dev/pommesdata/data\\_preparation.ipynb](https://github.com/pommes-public/pommesdata/blob/dev/pommesdata/data_preparation.ipynb)

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- [7] ENTSO-E (2022): Updated Electricity Modelling Results, Capacity & Dispatch, TYNDP 2022 Scenario Report – additional Downloads, [https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2F2022.entsos-tyndp-scenarios.eu%2Fwp-content%2Fuploads%2F2022%2F04%2F220310\\_Updated\\_Electricity\\_Modelling\\_Results.xlsx&wdOrigin=BROWSELINK](https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2F2022.entsos-tyndp-scenarios.eu%2Fwp-content%2Fuploads%2F2022%2F04%2F220310_Updated_Electricity_Modelling_Results.xlsx&wdOrigin=BROWSELINK), accessed 18.11.2022.
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- [11] ENTSO-E (Forecasted Transfer Capacities - Day Ahead)
- [12] Zusammenstellung technische Profile aus MA Timona Gosh; siehe auch: Ghosh, T., Kochems, J., Grosse, B. und Müller-Kirchenbauer, J. (2019): [Modelling of imports and exports for the German electricity system](#), Conference Paper, Enerday 2019, Dresden, 12.04.2019, TU Dresden.
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  - ÜNB (2018): EEG-Anlagenstammdaten zur Jahresabrechnung 2017, <https://www.netztransparenz.de/EEG/Anlagenstammdaten>.
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- [21] Primärquellen, siehe Anhang in Kochems, Johannes (2020): Lastflexibilisierungspotenziale in Deutschland – Bestandsaufnahme und Entwicklungsprojektionen, Langfassung: In: Tagungsband 16. Symposium Energieinnovation, 12.-14.02.2020, Graz.
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  - Hard coal: OTC Prices for API#2 (Amsterdam, Rotterdam, Antwerpen), provided by Spectron (values in USD/t), trading dates 03.01.2022 - 09.09.2022.
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  - Pietzcker, Robert, Osorio, Sebastian, Rodrigues, Renato (2021): Tightening EU ETS targets in line with the European Green Deal: Impacts on the decarbonization of the EU power sector, in: Applied Energy 293 (2021), <https://doi.org/10.1016/j.apenergy.2021.116914>.

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- [27] PyPSA-EUR assumptions on costs compiled from various (primary) sources: <https://github.com/PyPSA/pypsa-eur/blob/master/data/costs.csv>, accessed 01.07.2022.
- [28] FlexMex, <https://zenodo.org/record/5802178>, including data compiled from various (primary) sources, accessed 01.07.2022.
- [29] dieterpy input data compiled from various (primary) sources: [https://gitlab.com/diw-evu/dieter\\_public/dieterpy\\_reduced/-/blob/main/input/data\\_input.xlsx](https://gitlab.com/diw-evu/dieter_public/dieterpy_reduced/-/blob/main/input/data_input.xlsx), accessed 01.07.2022.
- [30] a collection of data from various (primary) sources from the research project UNSEEN (as of 03/2021).
- [31] Fraunhofer ISE (2020): Appendix to the study "Wege zu einem klimaneutralen Energiesystem. Die deutsche Energiewende im Kontext gesellschaftlicher Verhaltensweisen.", <https://www.ise.fraunhofer.de/de/veroeffentlichungen/studien/wege-zu-einem-klimaneutralen-energiesystem.html>, accessed 08.07.2022.
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