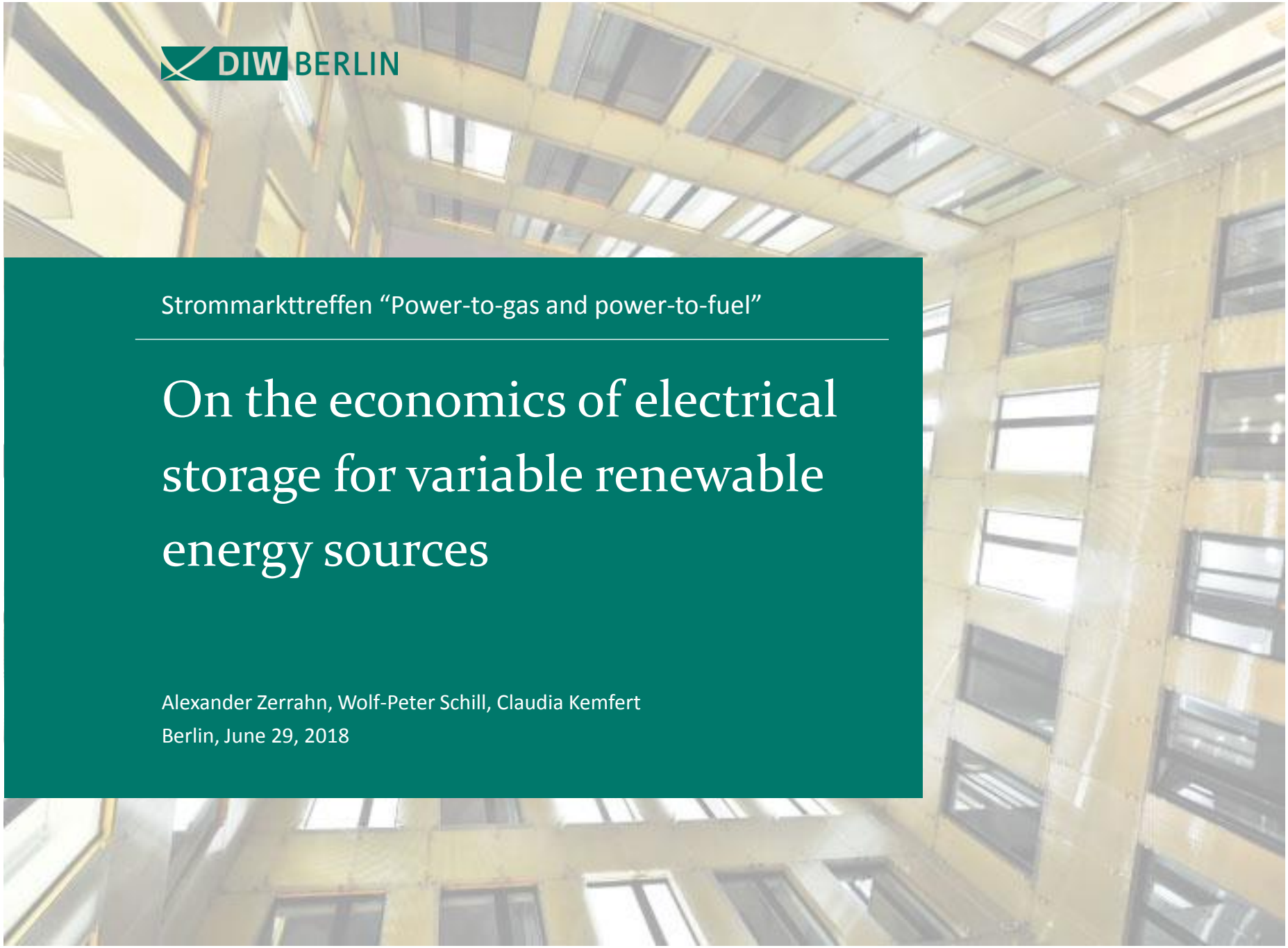


DIW BERLIN

Strommarkttreffen “Power-to-gas and power-to-fuel”

On the economics of electrical storage for variable renewable energy sources

Alexander Zerrahn, Wolf-Peter Schill, Claudia Kemfert

Berlin, June 29, 2018

An outlier topic in this session:

How much electrical storage does the integration of variable renewable energy sources require?

1 Our answer to Sinn (2017)

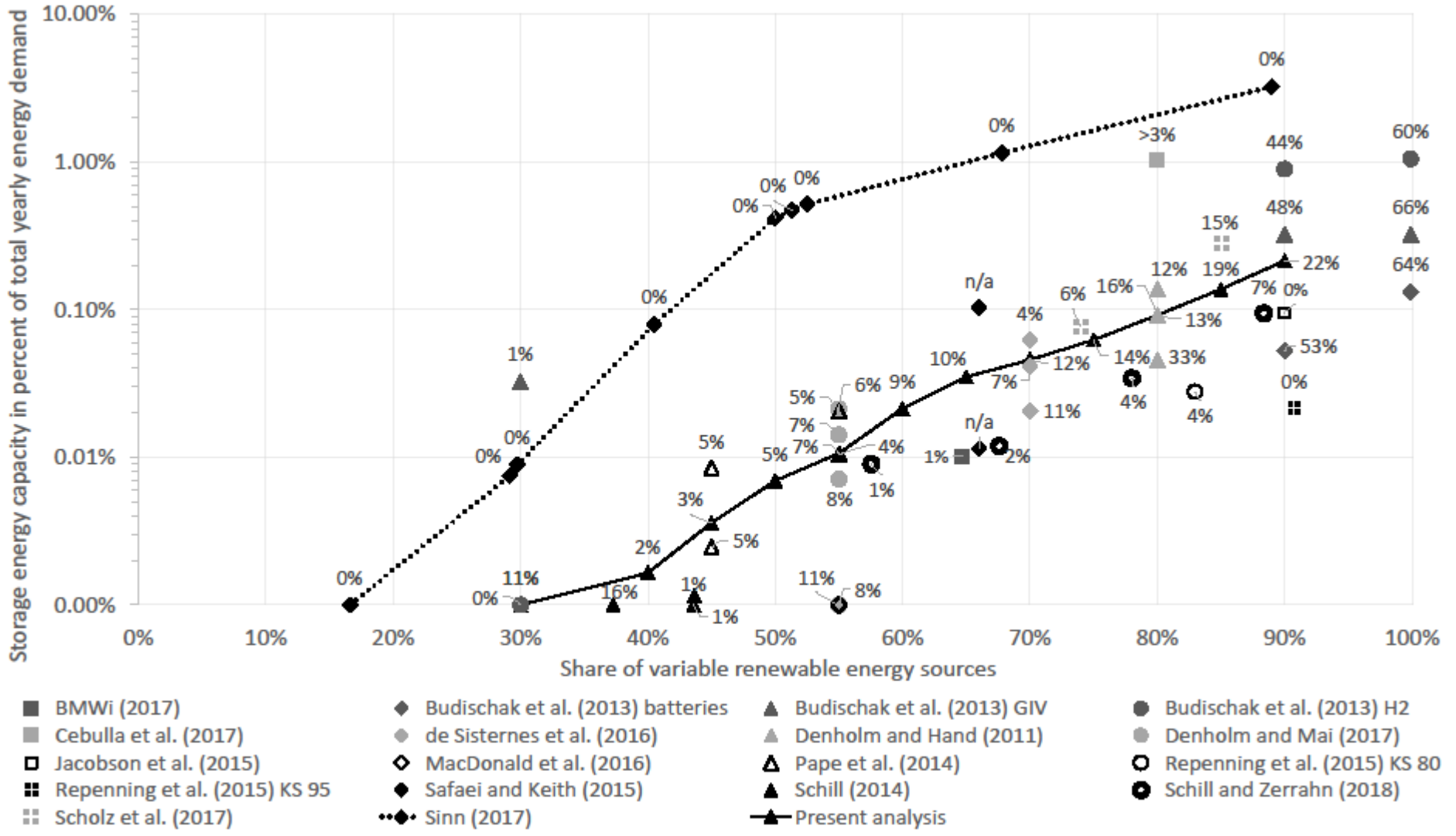
Paper by Hans-Werner Sinn (*European Economic Review* 2017)

- Increasing vRES shares would require excessive storage
- Reason: volatility of (onshore) wind power and PV
- Stylized analysis for Germany:
  - 17% variable RES share → No storage required
  - 30% variable RES share → 40 GWh storage required (roughly as PHS today)
  - 50% variable RES share → 2,100 GWh
  - 68% variable RES share → 5,800 GWh (more than European PHS potential)
  - 89% variable RES share → 16,300 GWh
- Somewhat lower in (stylized) European interconnection
- Sinn‘s conclusion: storage needs limit the transition to RES

Our answer

- Open-source rebuttal, addressing questionable implicit assumptions
- We illustrate the effects of flexible sector coupling (power-to-x)

1 Sinn vs. literature



1 How does Sinn derive such large figures?

Stylized general approach

- Hourly time series on demand and a combined (onshore) wind and PV capacity factor (2014 German data)
- Scale up RES capacity until desired annual RES share is reached
- Minimum storage capacity (GWh) to integrate all variable renewables

Storage heuristic

- Store hourly renewable surplus generation
- Release energy as soon as residual demand is positive again

What is missing

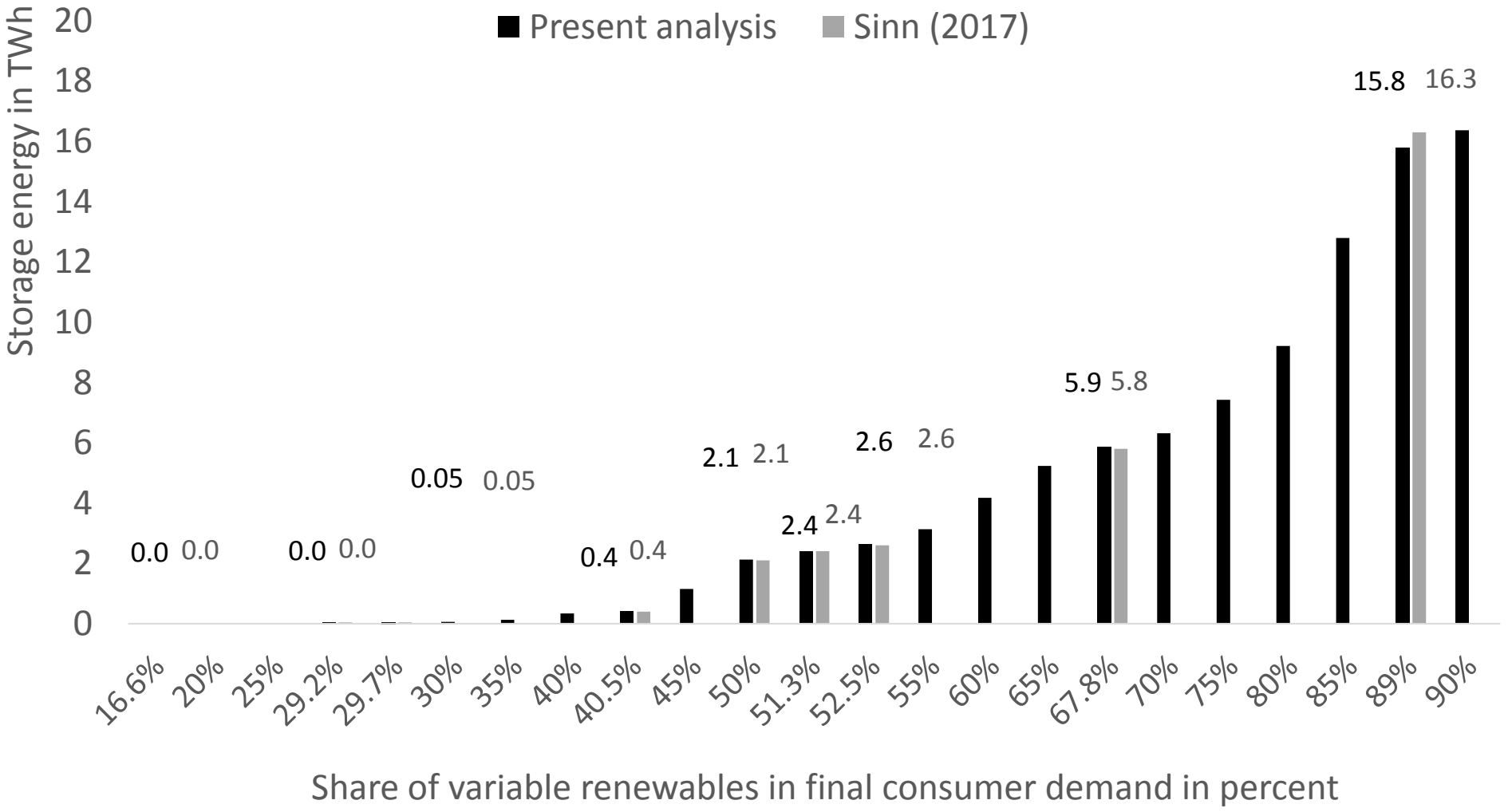
Questionable implicit assumptions

- Full RES integration by electrical storage, no curtailment
- No economic objective function
- Heuristic storage strategy (w.r.t. both dispatch and investment)
- No flexible power-to-x
- Others:
  - No dispatch of other plants
  - No other flexibility options
  - No endogenous combinations of renewables
  - No offshore wind
  - …

2 Replication

We can replicate it!

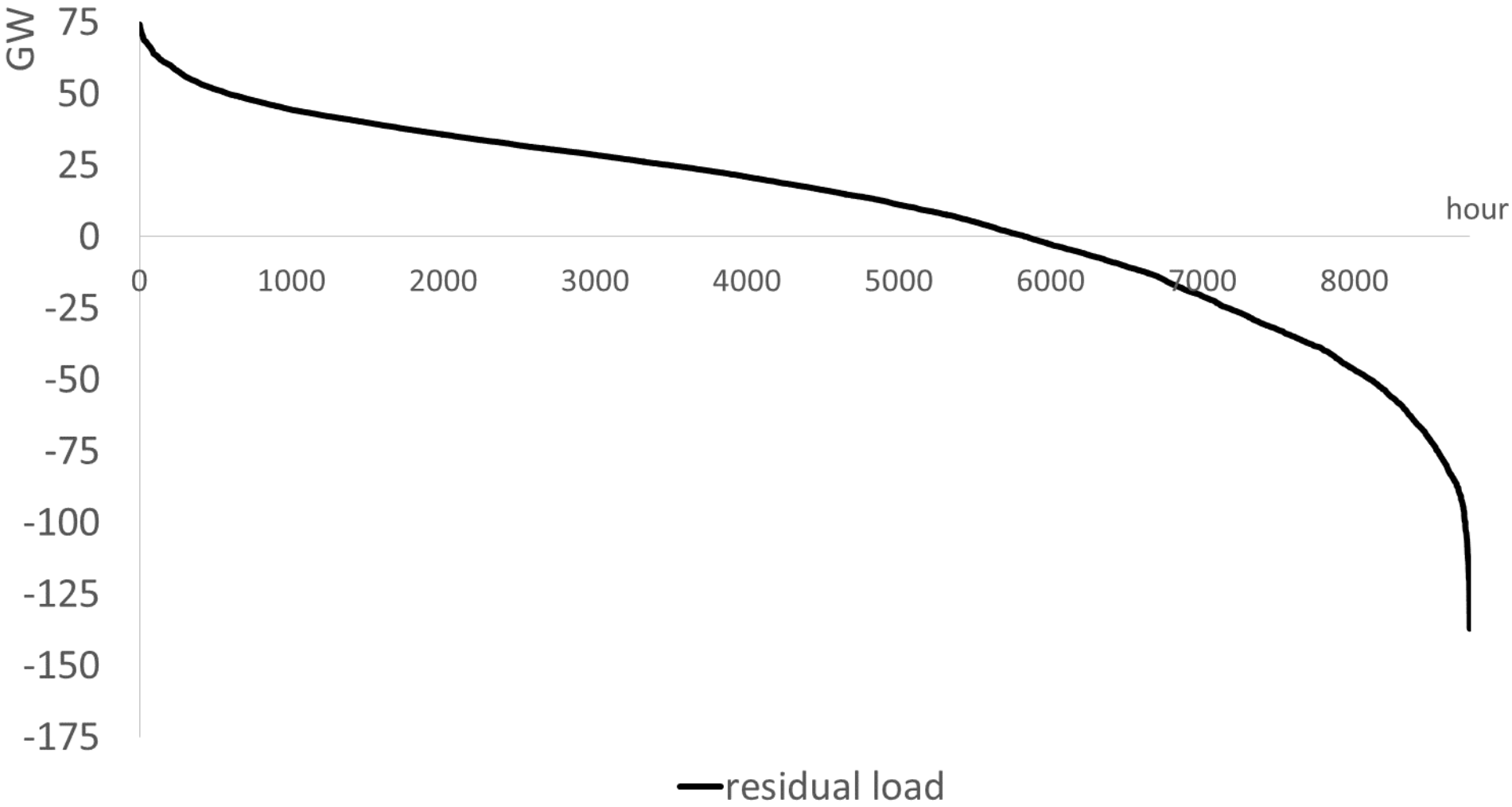
- Open input data (OPSD), open Excel tool (https://doi.org/10.5281/zenodo.1170554)



3 Intuition: What drives Sinn's results?

Full integration of all vRES drives storage requirements

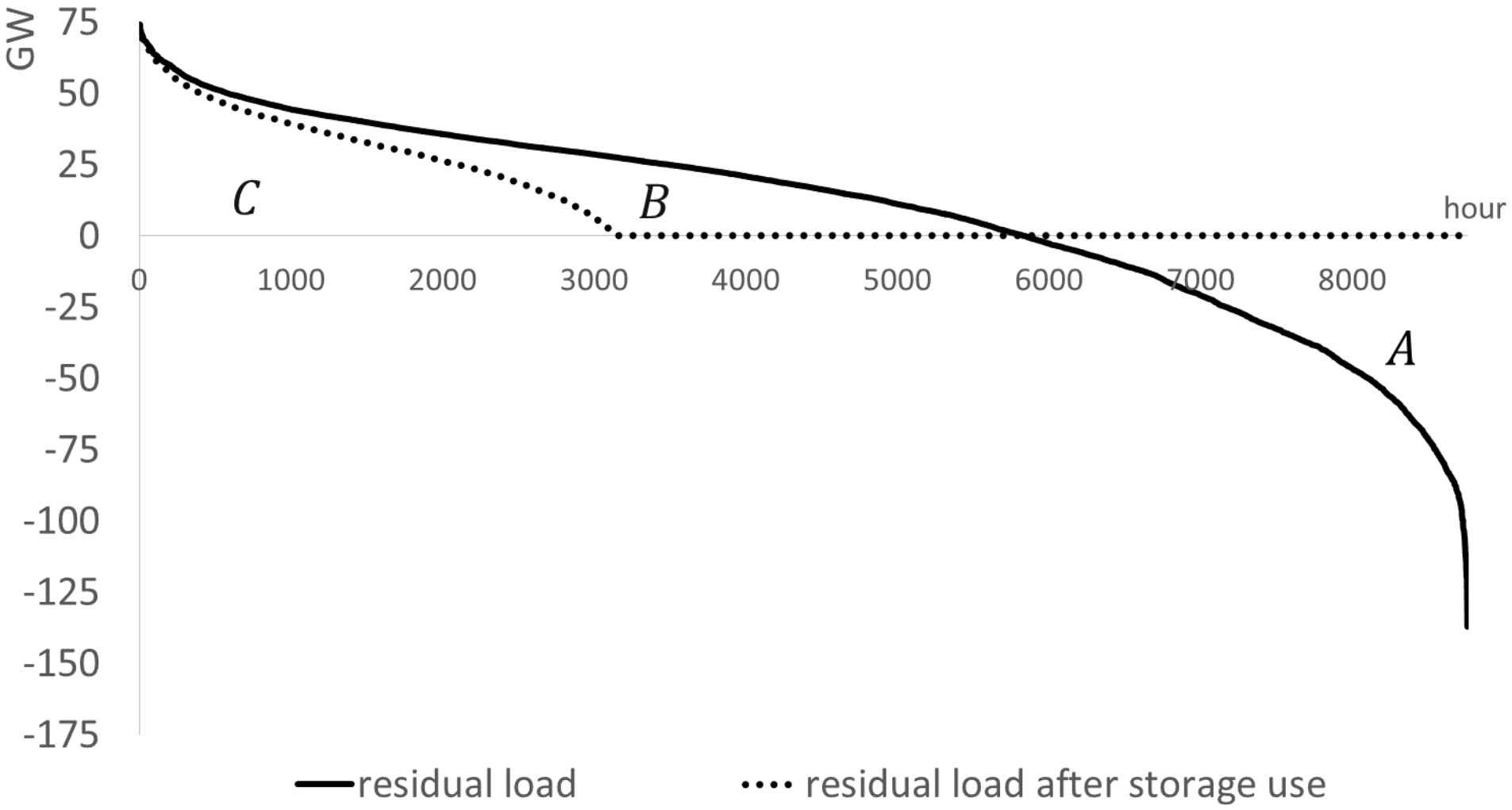
- Residual load duration curve (here 80% vRES)



3 Intuition: What drives Sinn's results?

Full integration of all vRES drives storage requirements

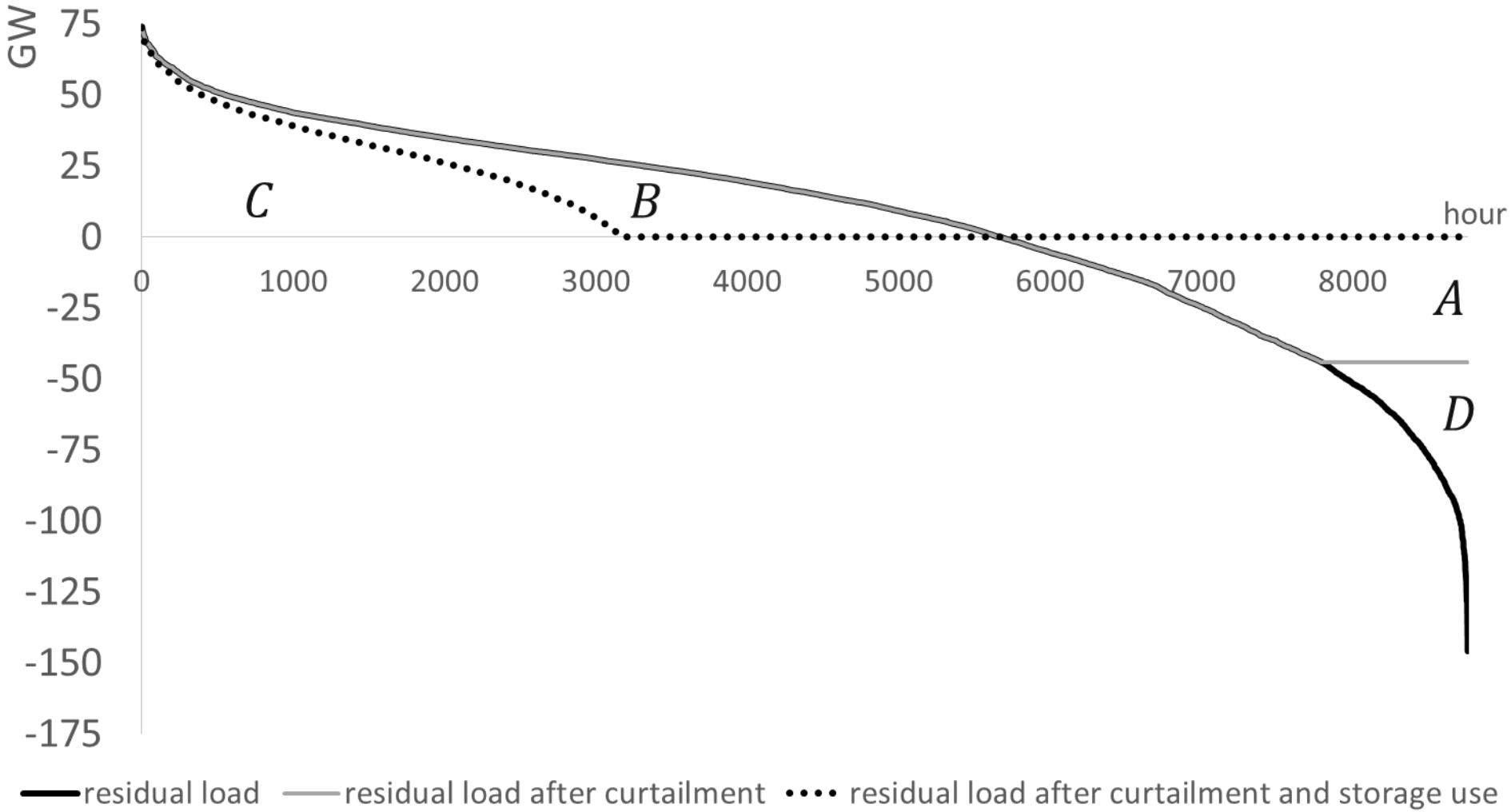
- Residual load duration curve: storage shifts surplus from A to B



3 Renewable curtailment strategy 1: power-oriented

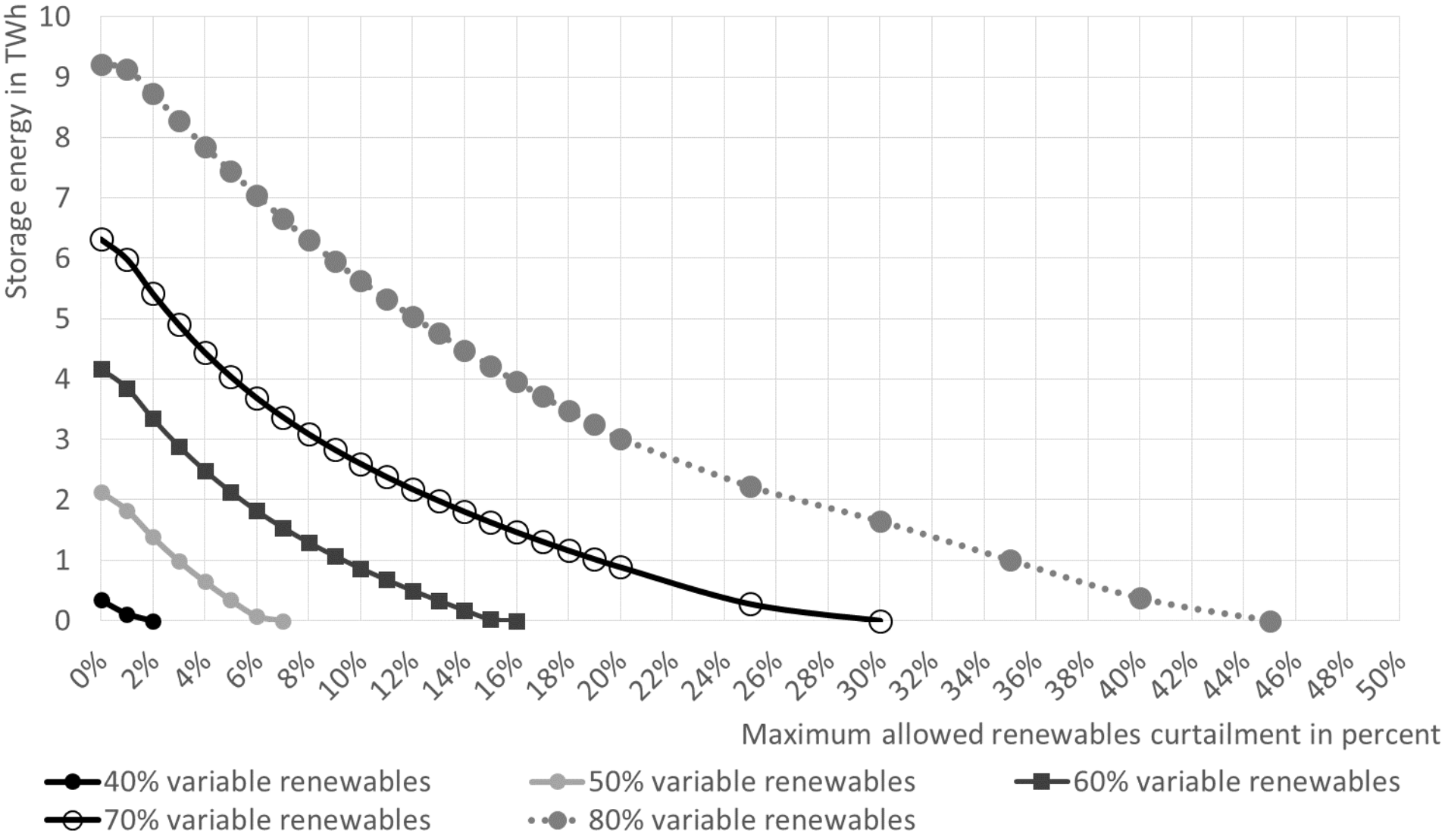
We introduce *power-oriented* curtailment (storage loading restriction)

- Same Excel tool, but renewable surplus curtailed if larger than threshold (D)



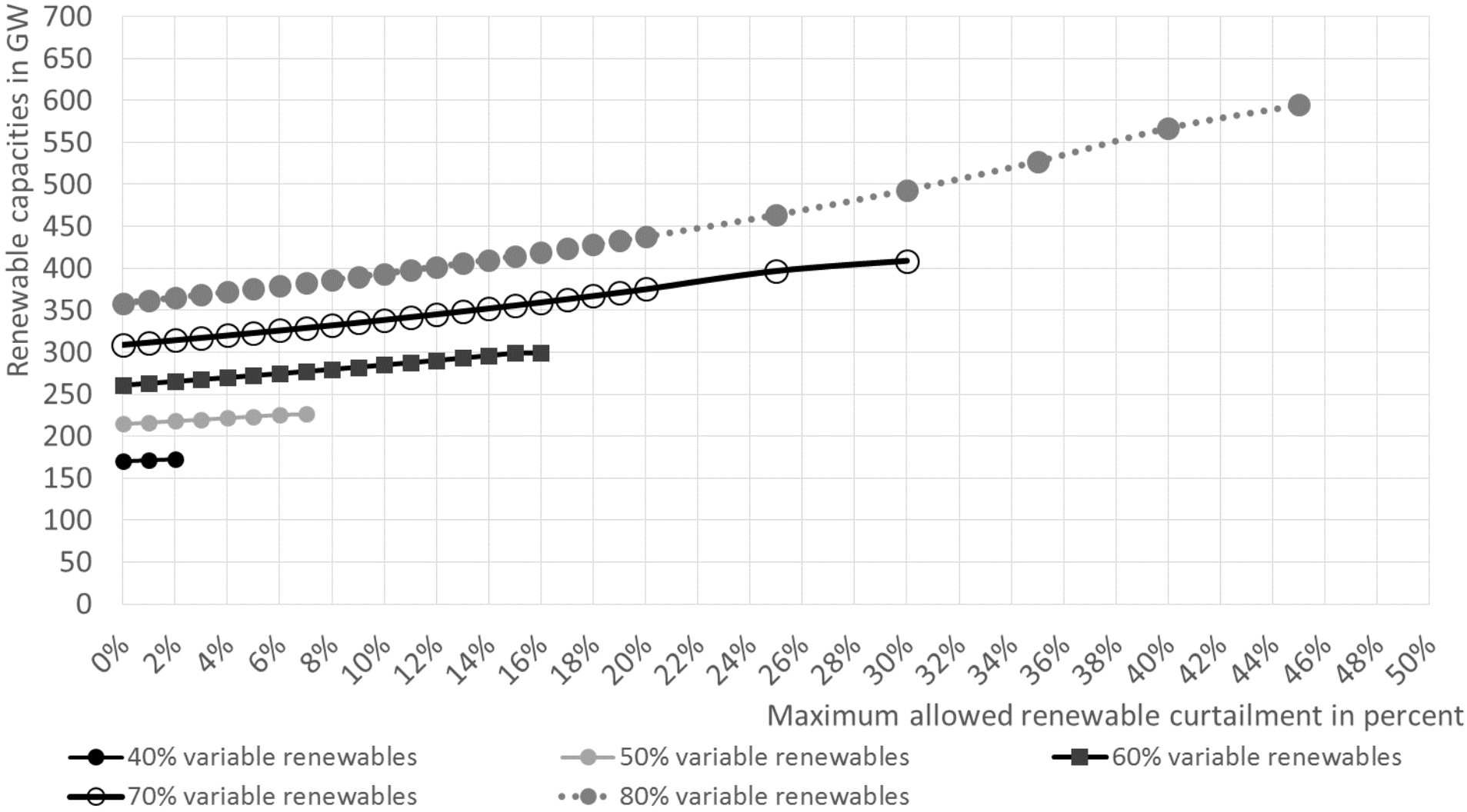
3 Renewable curtailment strategy 1: power-oriented

Result: storage needs substantially lower



3 Slightly increased renewable capacities

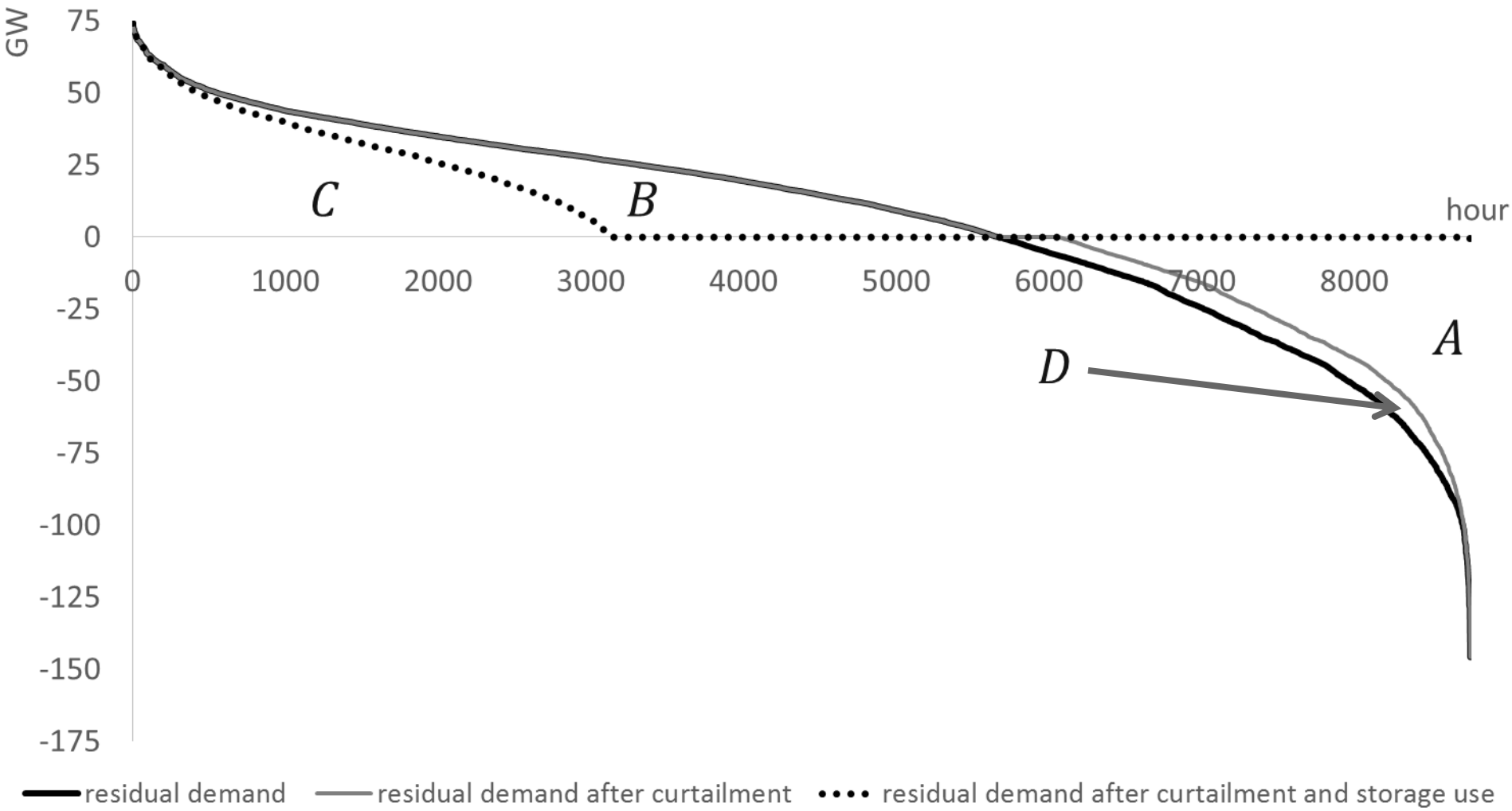
If some renewable energy is curtailed, necessarily higher renewable capacities



3 Renewable curtailment strategy 2: energy-oriented

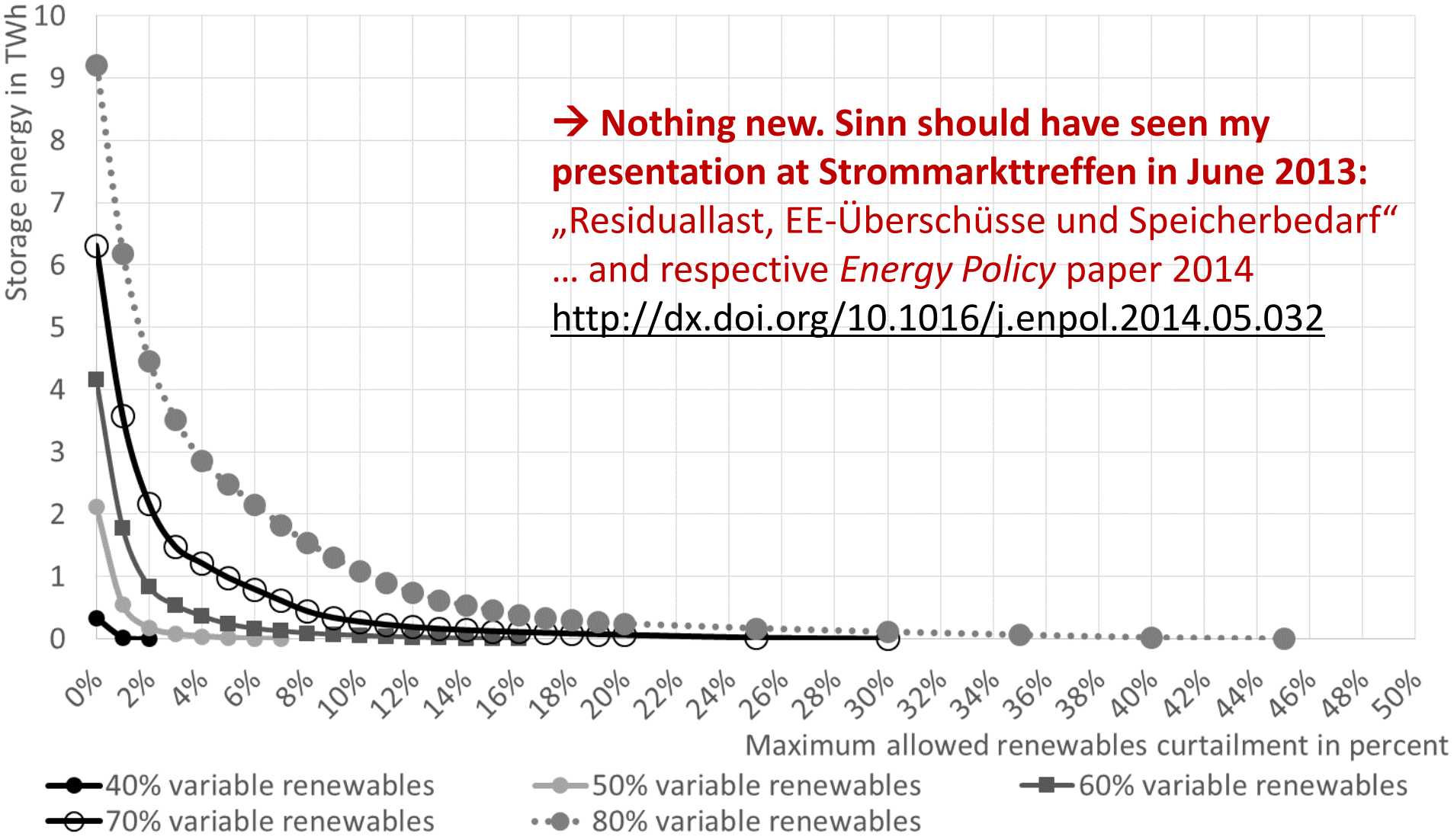
We introduce *energy-oriented* curtailment (storage energy restriction)

- Same Excel tool, but renewable surplus curtailed if storage full



3 Renewable curtailment strategy 2: energy-oriented

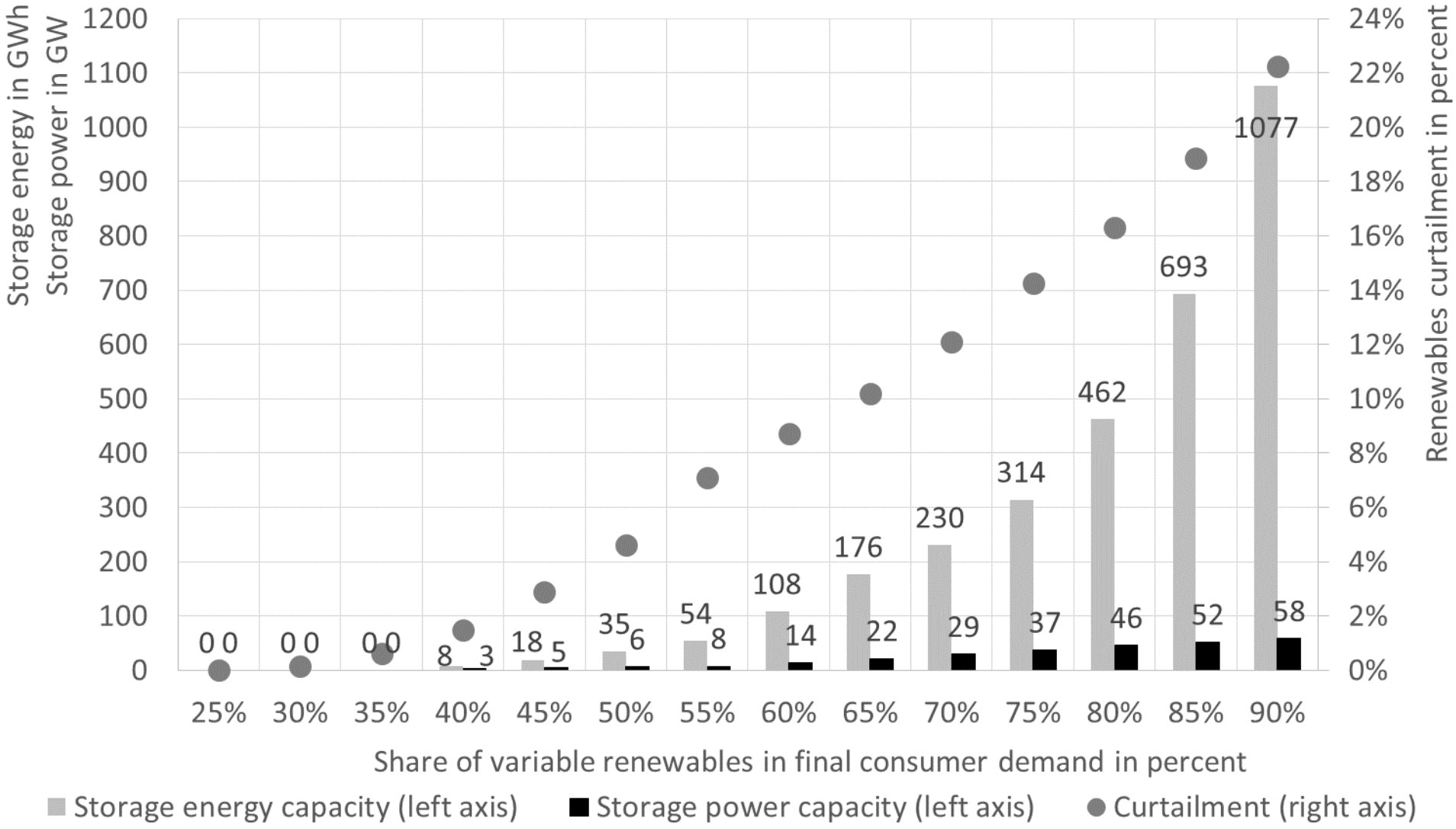
Result: storage needs even lower than under strategy 1



→ Nothing new. Sinn should have seen my presentation at Strommarkttreffen in June 2013:
„Residuallast, EE-Überschüsse und Speicherbedarf“
… and respective *Energy Policy* paper 2014
http://dx.doi.org/10.1016/j.enpol.2014.05.032

4 Alternative approach: optimization with stylized cost minimization model and same input data

Endogenous storage and curtailment: still moderate storage capacities



Effects of (generic) power-to-x

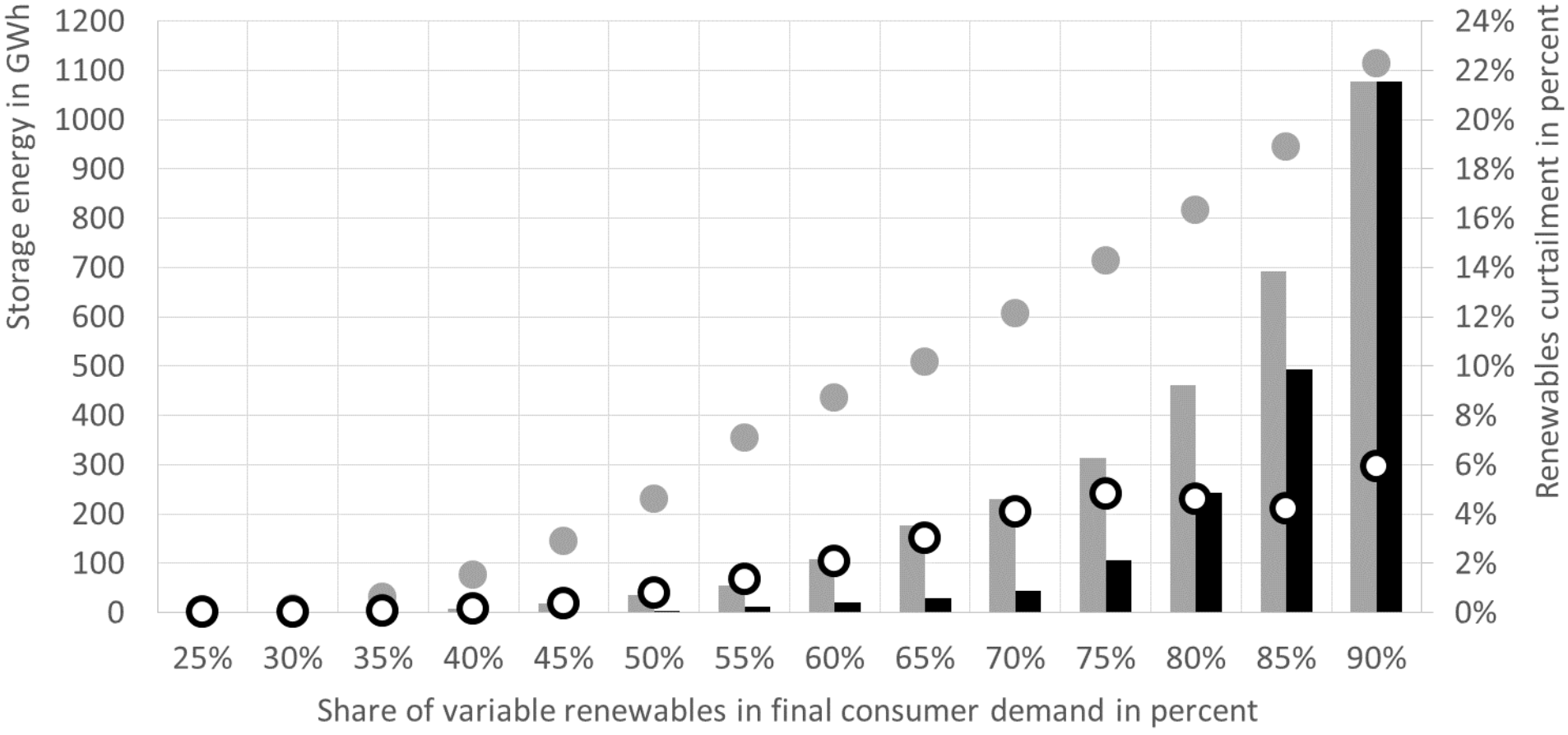
Flexible use of (additional) vRES for „X“

- Heat, mobility, hydrogen, …
- This triggers both
  - additional renewable capacity expansion
  - and additional demand flexibility
- Stylized parameterization:
  - 50 GW
  - 2,000 full-load hours (i.e. 100 TWh)
  - perfectly flexible

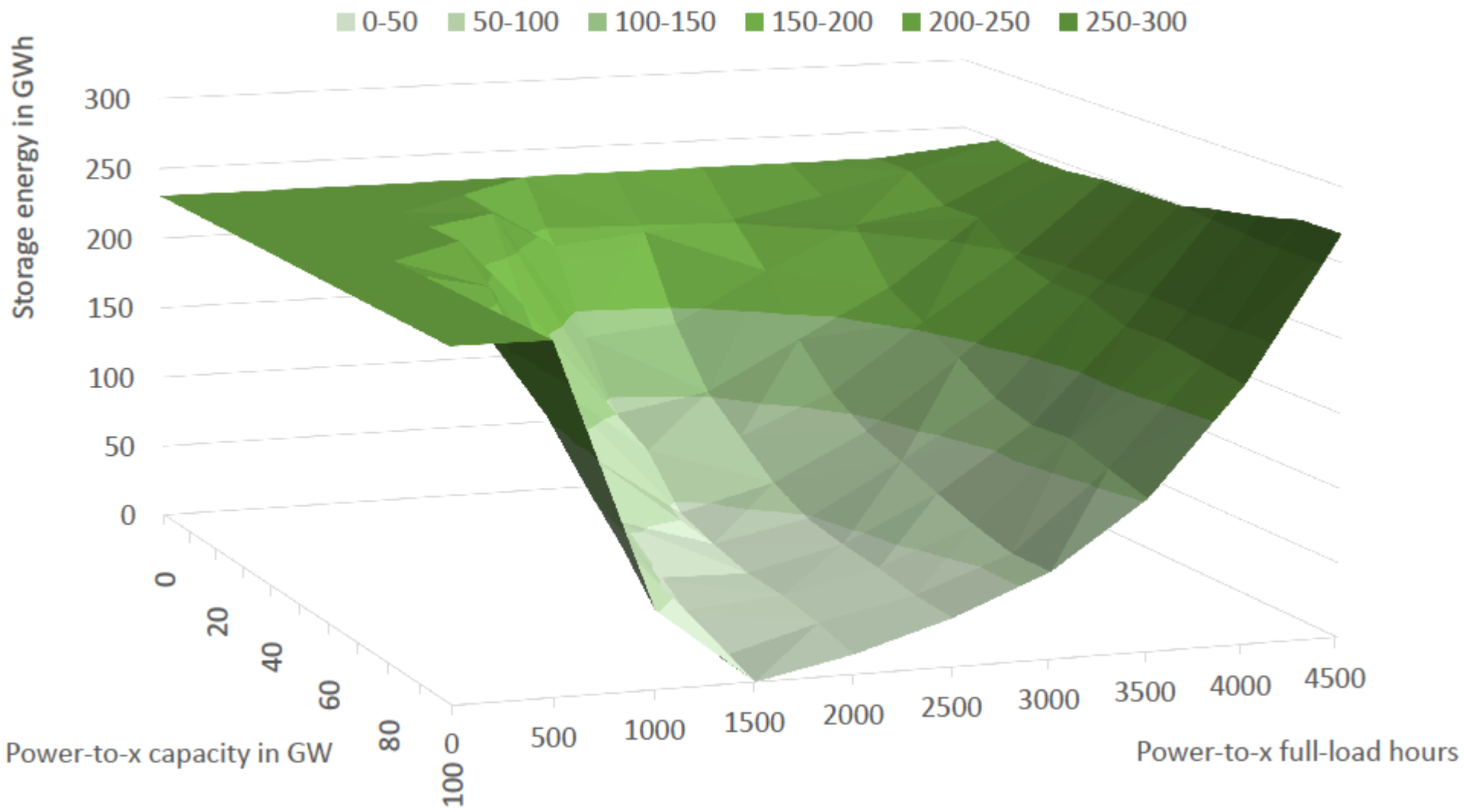
5 Effects of (generic) power-to-x

Result: substantially lower storage and curtailment

- Renewable surplus as a valuable resource



5 Electrical storage needs for different P2X settings for 70% vRES



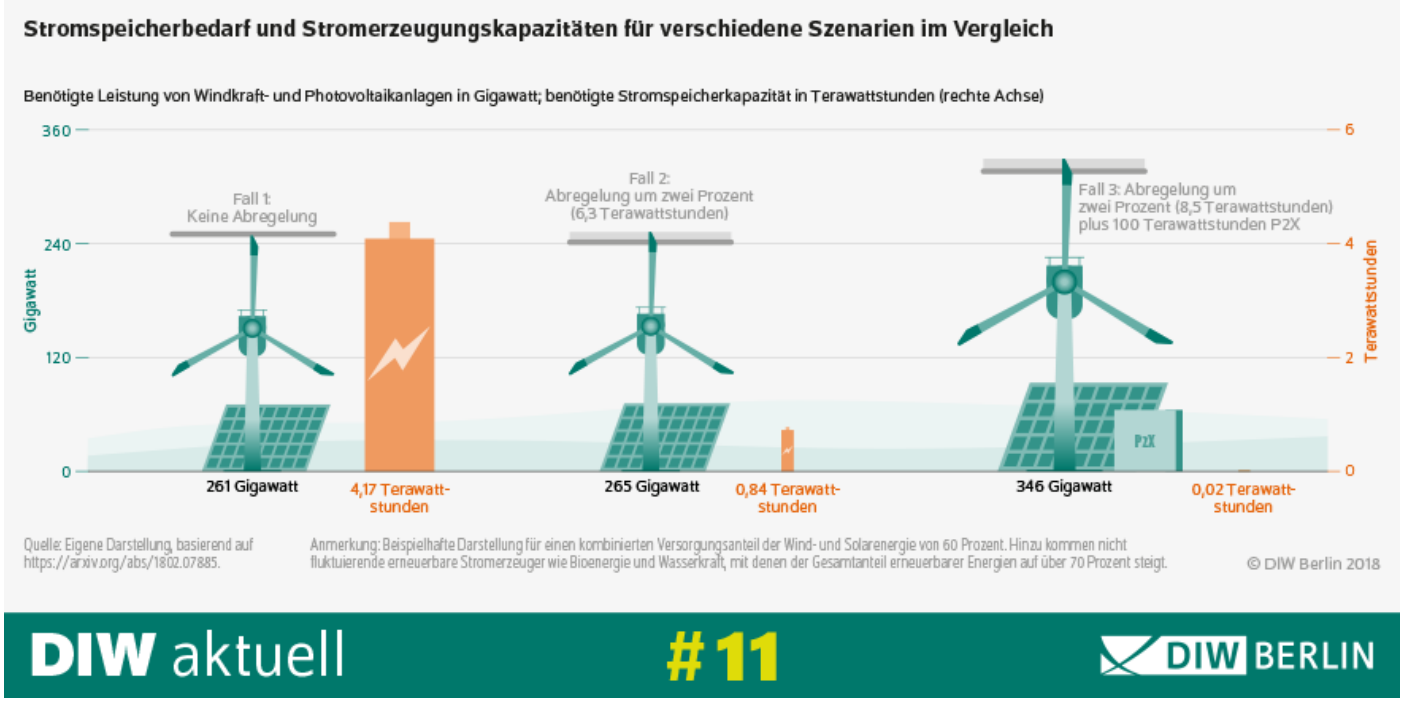
6 Conclusions

- Sinn‘s findings on storage needs deviate strongly from the literature
- We replicate and extend the analysis with open data and open-source tools
  - https://doi.org/10.5281/zenodo.1170554
  - http://arxiv.org/abs/1802.07885 (just accepted for publication in *EER*)
- Main point: assumption of full vRES integration (no curtailment)
- More suitable: cost minimization approach
  - More detailed analysis desirable
- Flexible sector coupling further decrease storage needs
  - Especially those triggered by right-hand side of residual load curve

Additional material

- Shorter German version: DIW Aktuell 11

  http://www.diw.de/documents/publikationen/73/diw_01.c.591369.de/diw_aktuell_11.pdf



- News coverage: Tagesspiegel Background, EUWID, PV magazine…
- Reply by Hans-Werner Sinn and re-reply by us

Thank you for listening

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