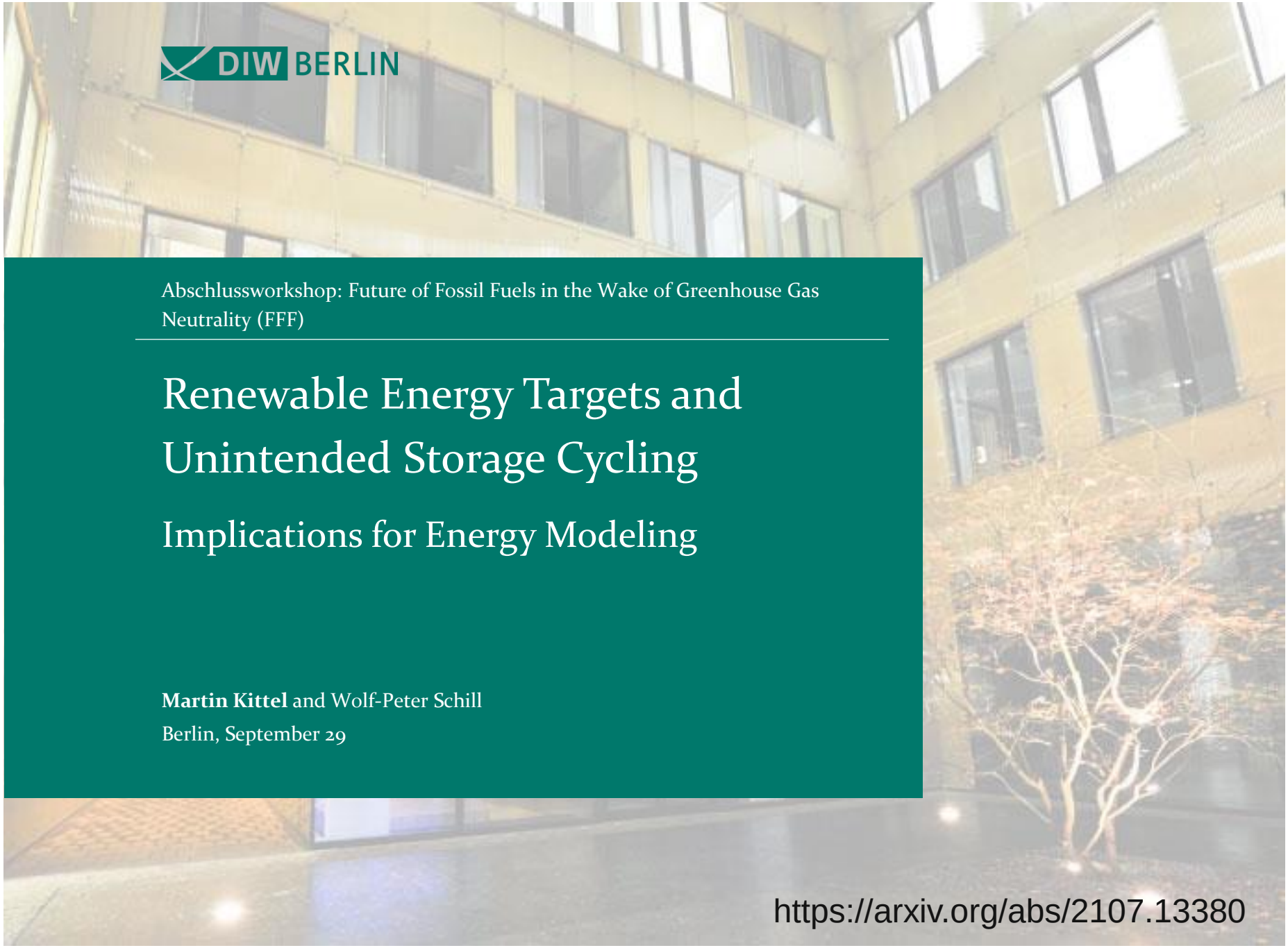

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Abschlussworkshop: Future of Fossil Fuels in the Wake of Greenhouse Gas Neutrality (FFF)

Renewable Energy Targets and Unintended Storage Cycling

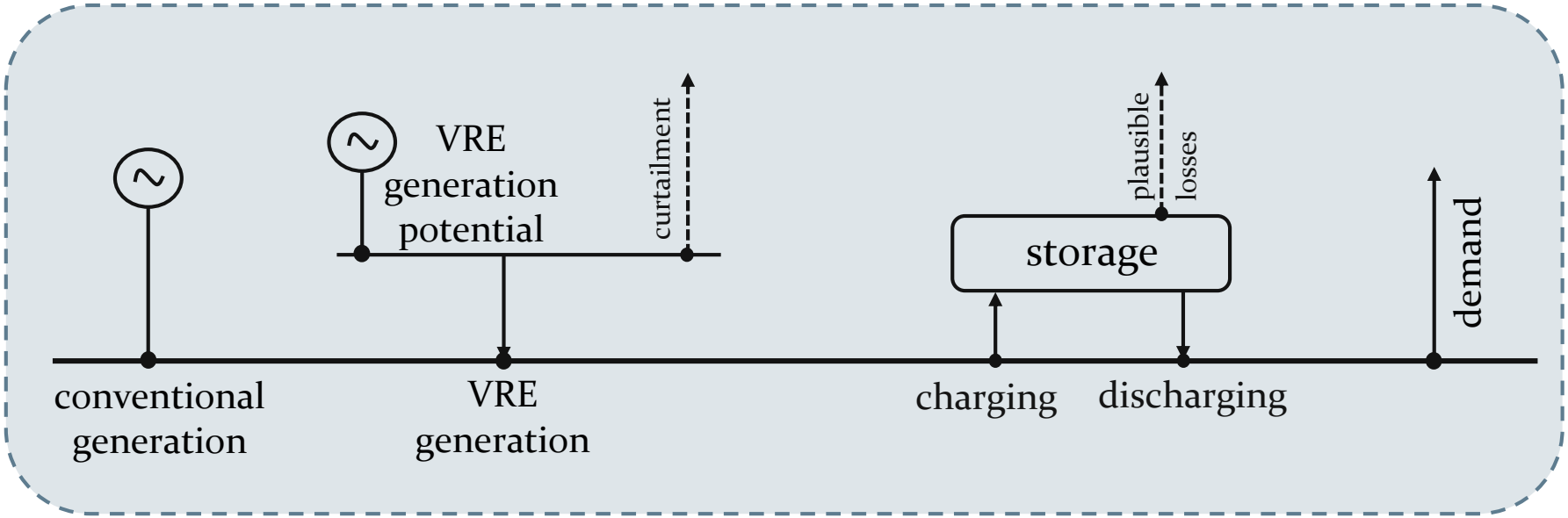
Implications for Energy Modeling

Martin Kittel and Wolf-Peter Schill

Berlin, September 29

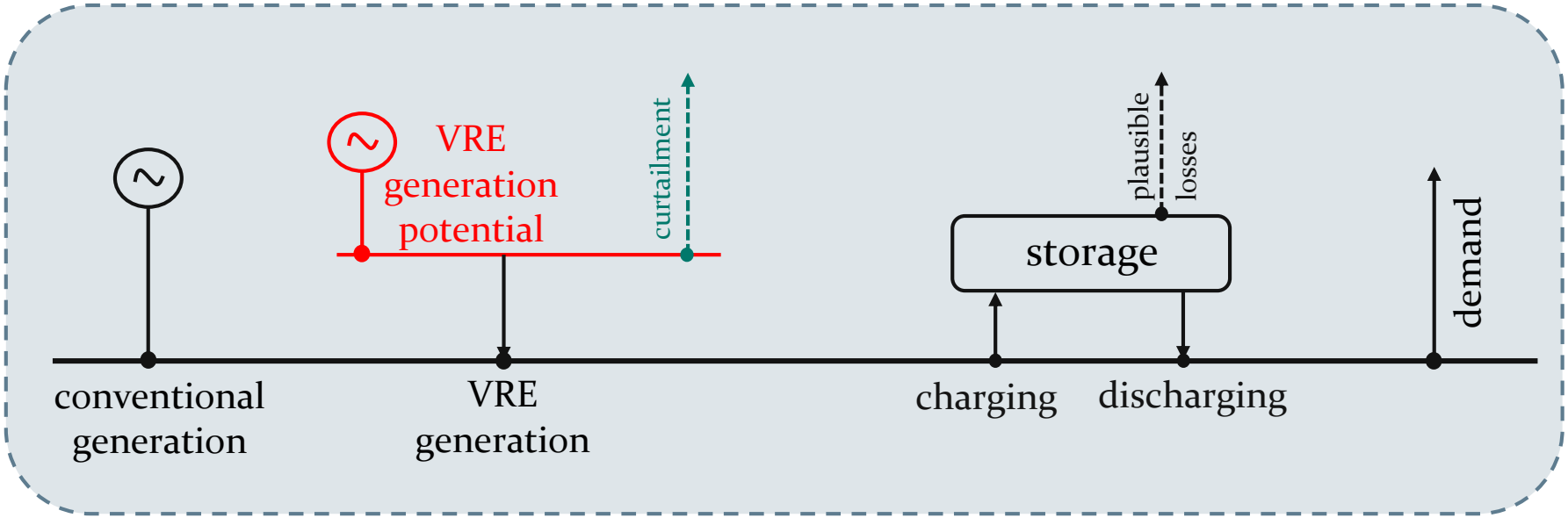
https://arxiv.org/abs/2107.13380

Simplified power sector



Source: own illustration

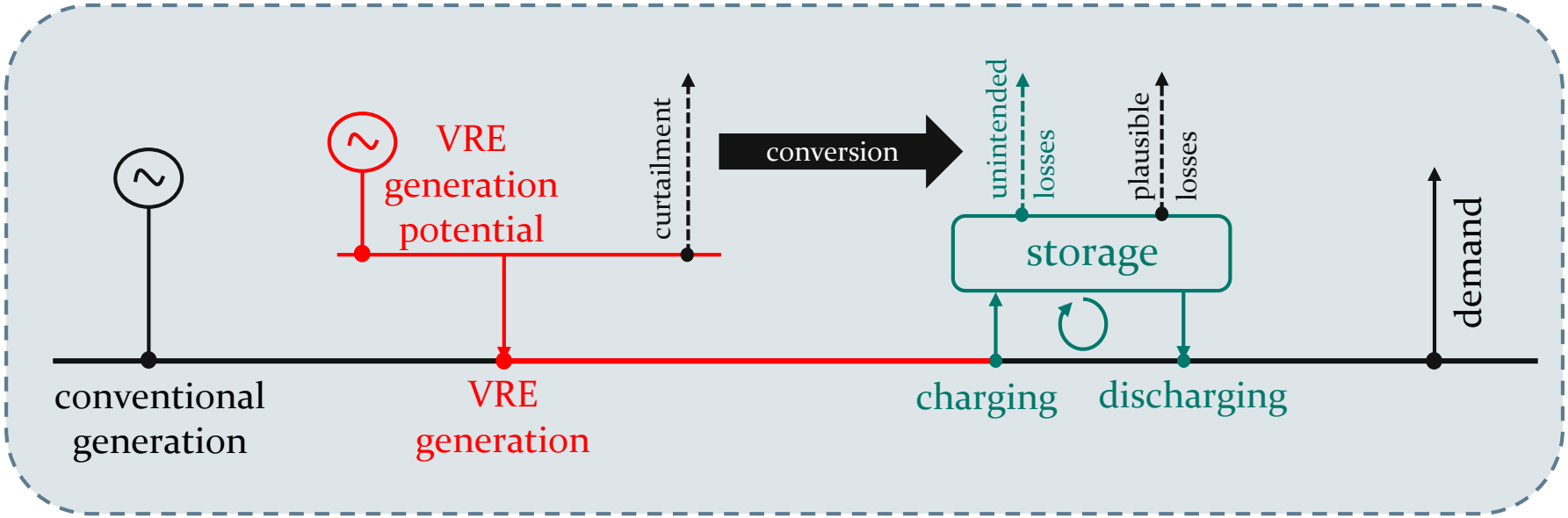
Expected outcome: some curtailment of renewable excess (or surplus) electricity (cp. Zerrahn et al. (2018))



Source: own illustration

Imposition of minimum RES share ϕ causes unintended effects

$$\sum Generation^{RES} \geq \phi \sum Demand$$



Source: own illustration

- Unintended storage cycling ≡ simultaneous, thus excessive, charging and discharging of the same storage capacity

  → relaxes renewable energy constraint

2.1 Research questions

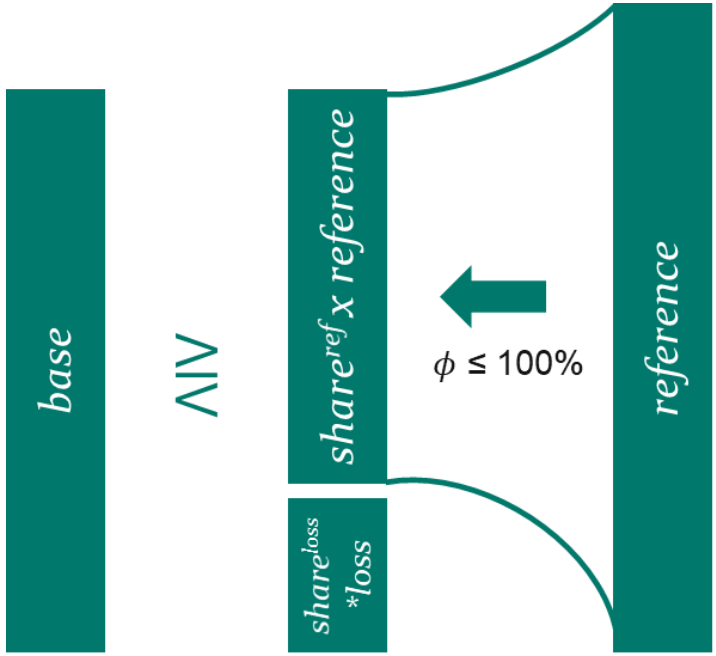
1. What is the effect of unintended storage cycling on model outcomes?
2. What are solution strategies?

Further questions (not discussed here):

1. What are possible RES share constraint formulations?
2. Impact of different formulations on optimality conditions of storage operators in long-term equilibrium?
3. What are drivers of unintended storage cycling?
4. What are alternative solution strategies?

Storage Losses Coverered by Renewables (SLCR)

a) Zero SLCR: Storage losses covered by conventionals
b) Proportionate SLCR: Storage losses partially covered by VRE and conventionals
c) Complete SLCR: Storage losses completely covered by VRE



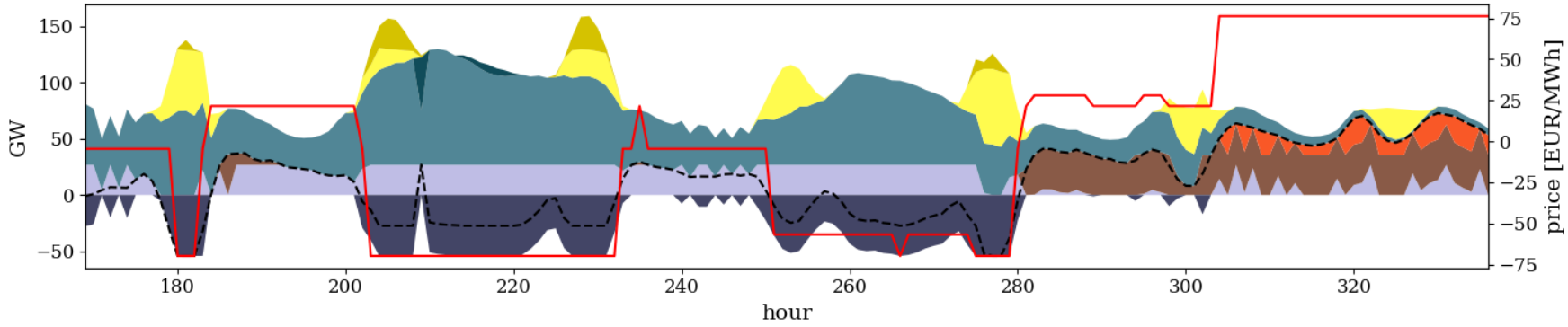
Source: own illustration

Stylized numerical power sector model

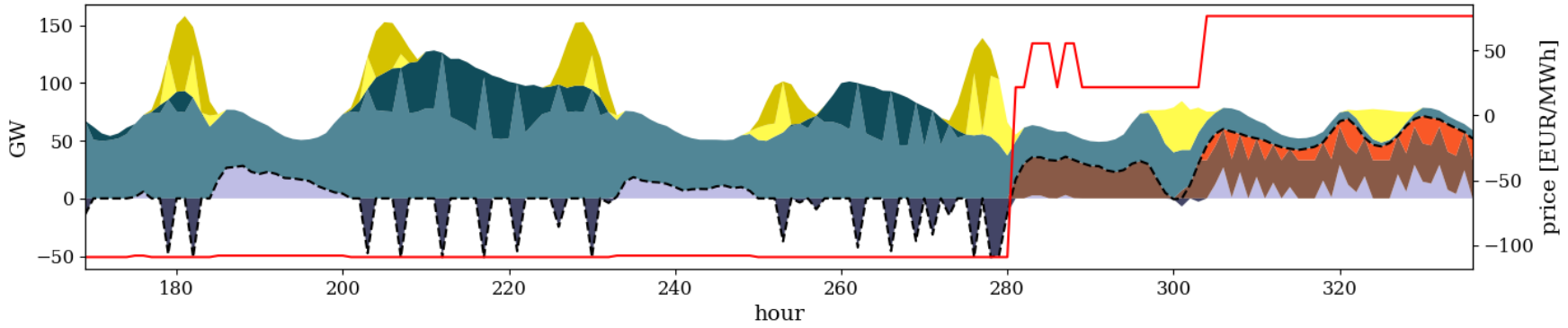
- Linear capacity expansion model
- Power sector of one region (loosly parameterized to German case)
- Wind power, solar PV, mid-term storage, conventional generators
- Renewable share 80%

3.1 Results: hourly generation and price profiles

Unintended storage cycling



No unintended storage cycling



storage charge
storage discharge
coal
ocgt
wind
wind curtailment
pv
pv curtailment
residual load
electricity price

Source: own illustration

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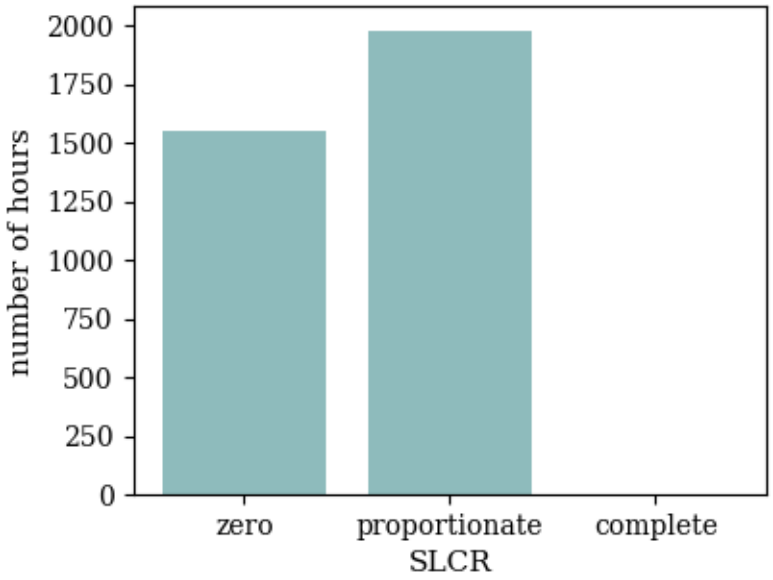
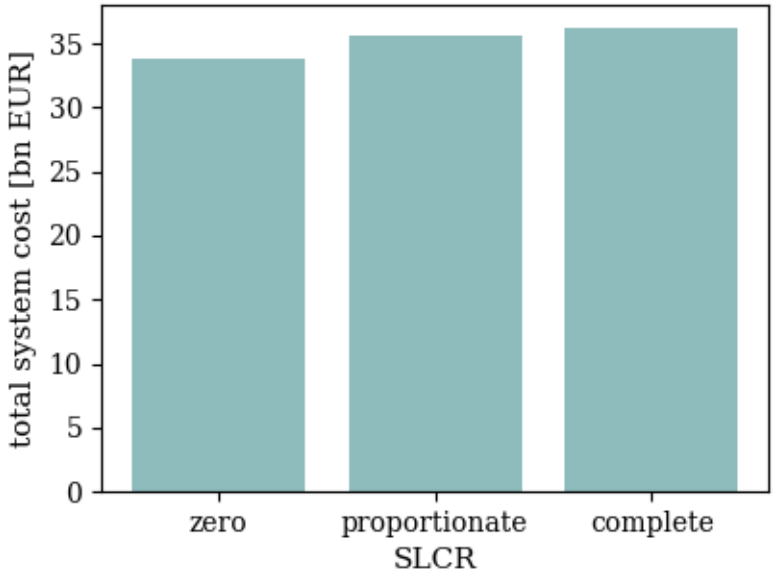
3.2 Unintended storage cycling – „medical report“

Unintended storage cycling occurrences



Total system costs

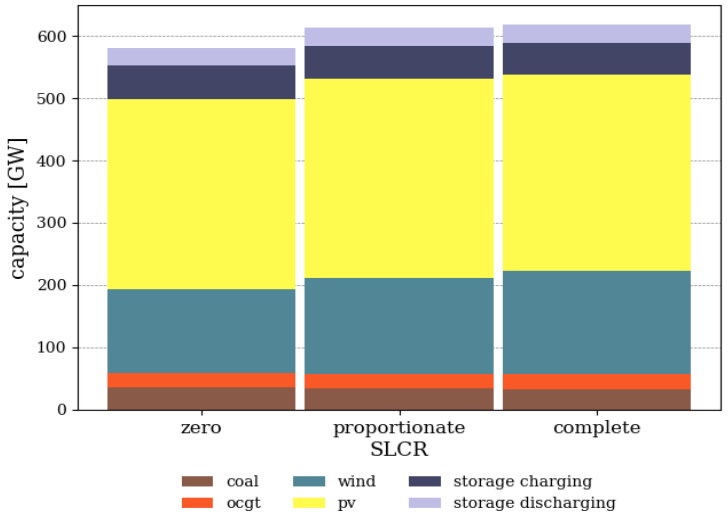


- SLCR: Storage Losses Coverered by Renewables
- Models with complete SLCR by RES avoid unintended storage cycling

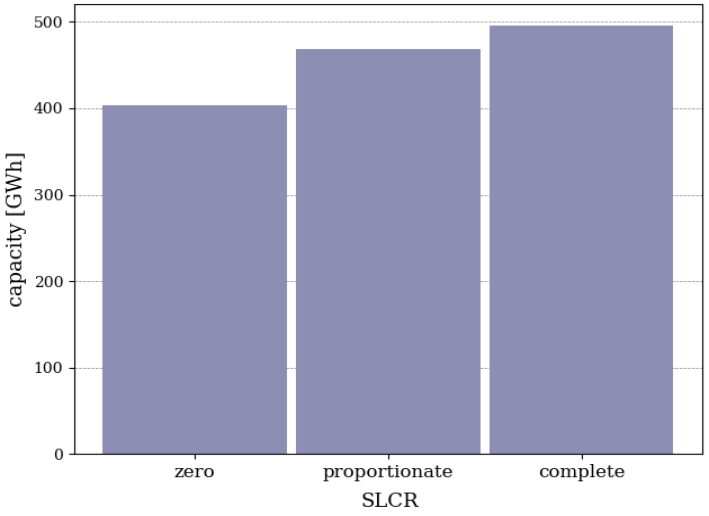
Source: own illustration

3.3 Impact on optimal dispatch and investment decisions

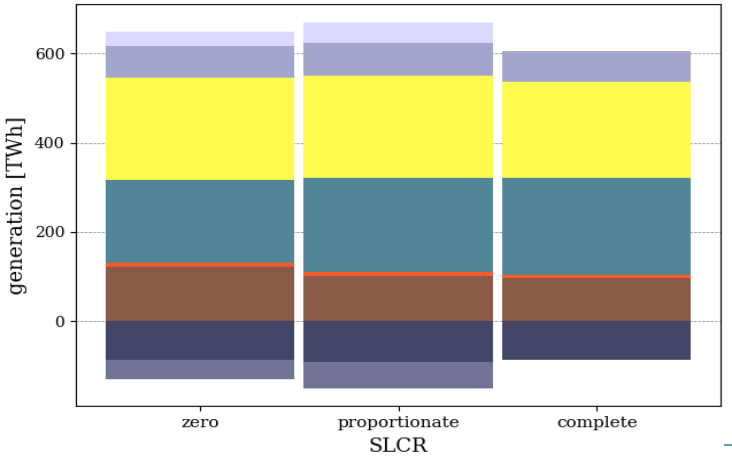
Generation capacity



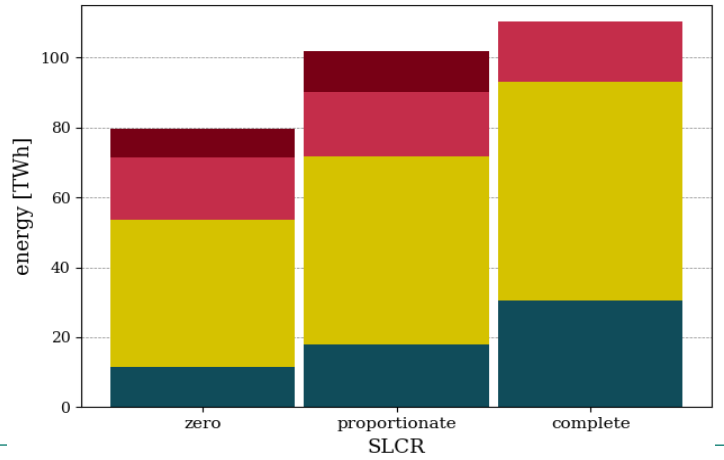
Storage energy capacity



Generation

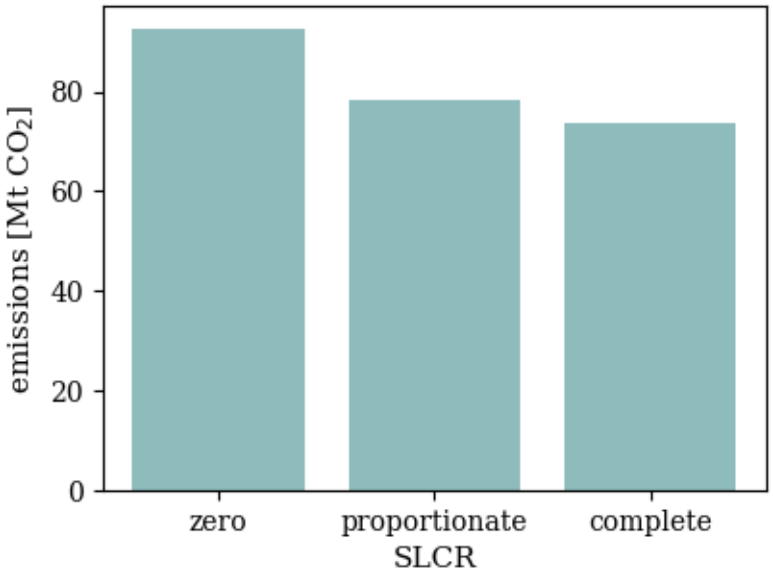


Curtailment and storage losses



3.4 Emissions

Increased generation from coal → rise in emissions

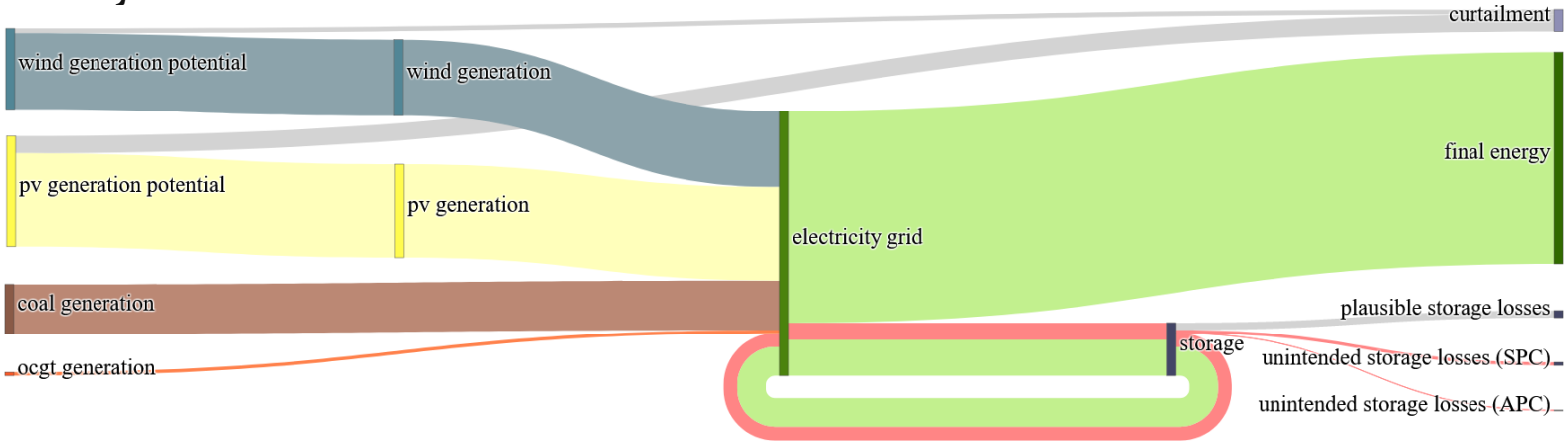


SLCR: Storage Losses Covered by Renewables

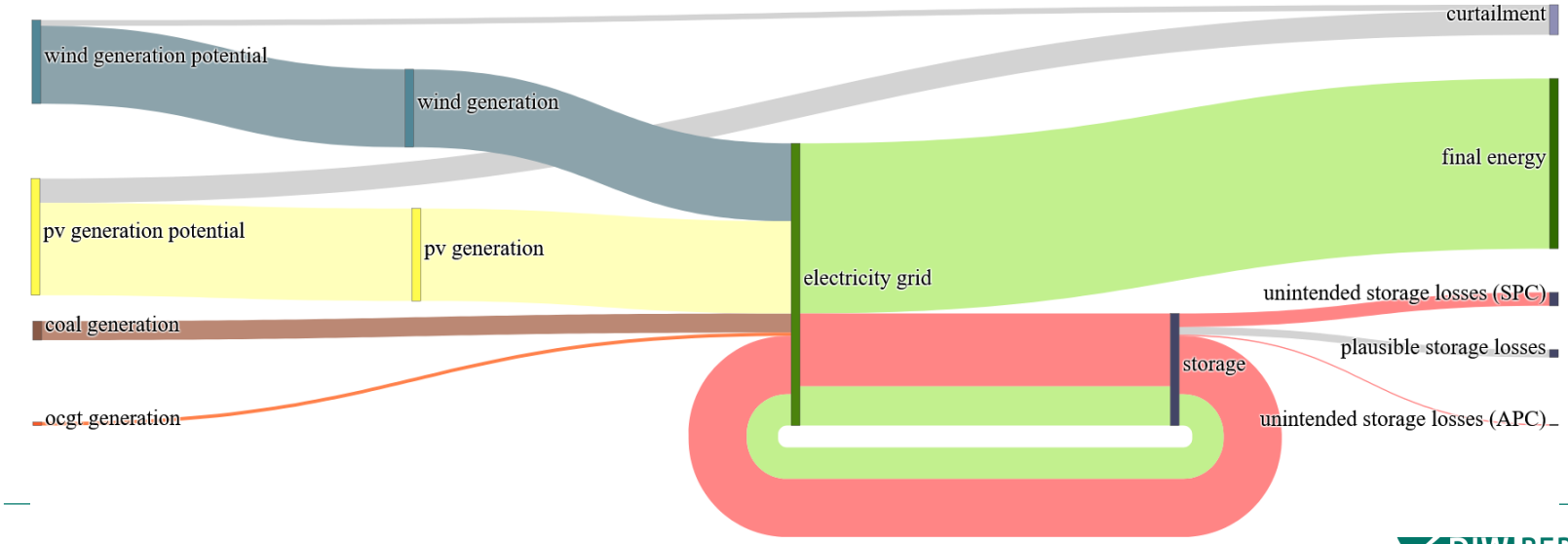
Source: own illustration

3.5 Energy flows in a for different renewable penetration levels

System with 80% RES



System with 100% RES



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4.1 Summary

- Unintended storage cycling has significant effect on model outcomes
- Solution: Complete coverage of storage losses by RES prevents unintended storage cycling
- Alternatives: exist but cannot be used for modeling binding renewable targets
  - Theoretical RES generation potential
  - RES capacity expansion pathways
  - CO_2 budget
  - CO_2 price
- Unintended storage cycling is special case of unintended energy losses
  - conversion losses (BEV)
  - standing losses (LH_2)
  - transmission losses in multi-regional settings

Want to read more? Here is the preprint:

Renewable Energy Targets and Unintended Storage Cycling:
Implications for Energy Modeling
https://arxiv.org/abs/2107.13380

Thank you for your attention!

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