ETH zürich

RRE
Reliability & Risk Engineering

Policy-relevance of a Model Inter-comparison: Switzerland in the European Energy Transition

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sweet swiss energy research for the energy transition

EDGE

Motivation and Research Questions

- What will the Swiss electricity system in 2050 look like?

- How can we guide the energy transition towards the desired future?

Policies:

1. Renewable generation target
2. Market integration reduction
3. Winter net import limitation

Research question

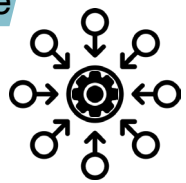
What is the impact of energy policies on the Swiss power system and international interactions?

Methodology

The Models for the Model Inter-comparison

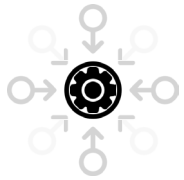
Nexus-e

- Min system costs
- Centralized + decentralized perspective
- Full transmission grid
- CH + neighbors



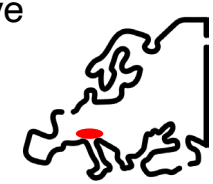
EXPANSE

- Min system costs
- Centralized perspective
- Aggregated transmission grid
- CH + neighbors



FEM

- Min system costs
- Centralized perspective
- NTC values
- CH + EU



OREES

- Max profits for PV and wind
- Centralized perspective
- Full transmission grid
- CH

The Scenarios

European development

Global Ambition

Distributed Energy

The Scenarios - selection

European development	RES target	Market integration	Net winter import limit
Global Ambition	No target	Full market integration	Net winter import not constrained
Distributed Energy	Target at 45 TWh/y	Reduced market Integration	Net winter import constrained at 5 TWh

5 scenarios

Ref	Global Ambition	No target	Full market integration	Net winter import not constrained

Data Harmonization?

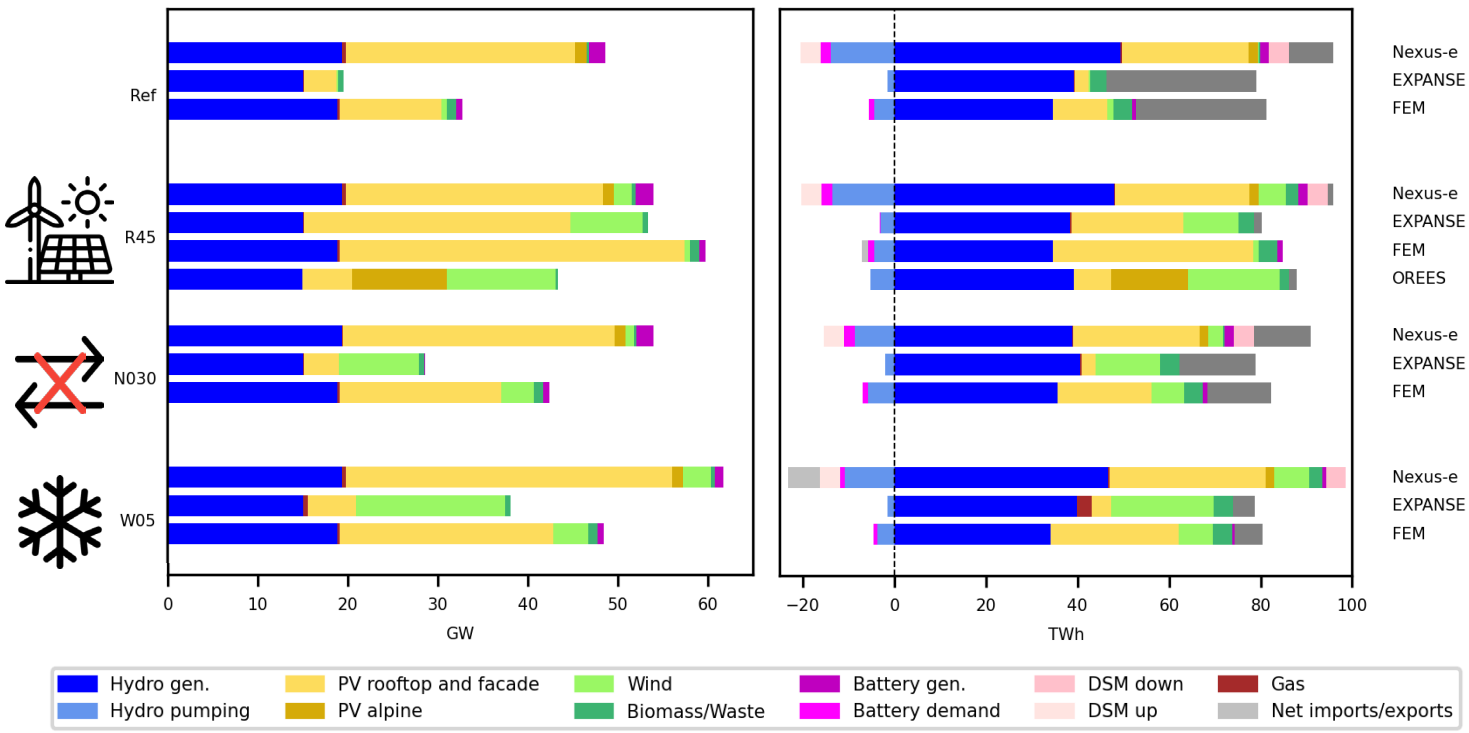
2 main philosophies on data harmonization in model inter-comparisons

- Full harmonization ⟶ study and describe the model features
- Partial harmonization ⟶ study the impact of variations in the scenarios

Results

Installed Capacity and Annual Generation

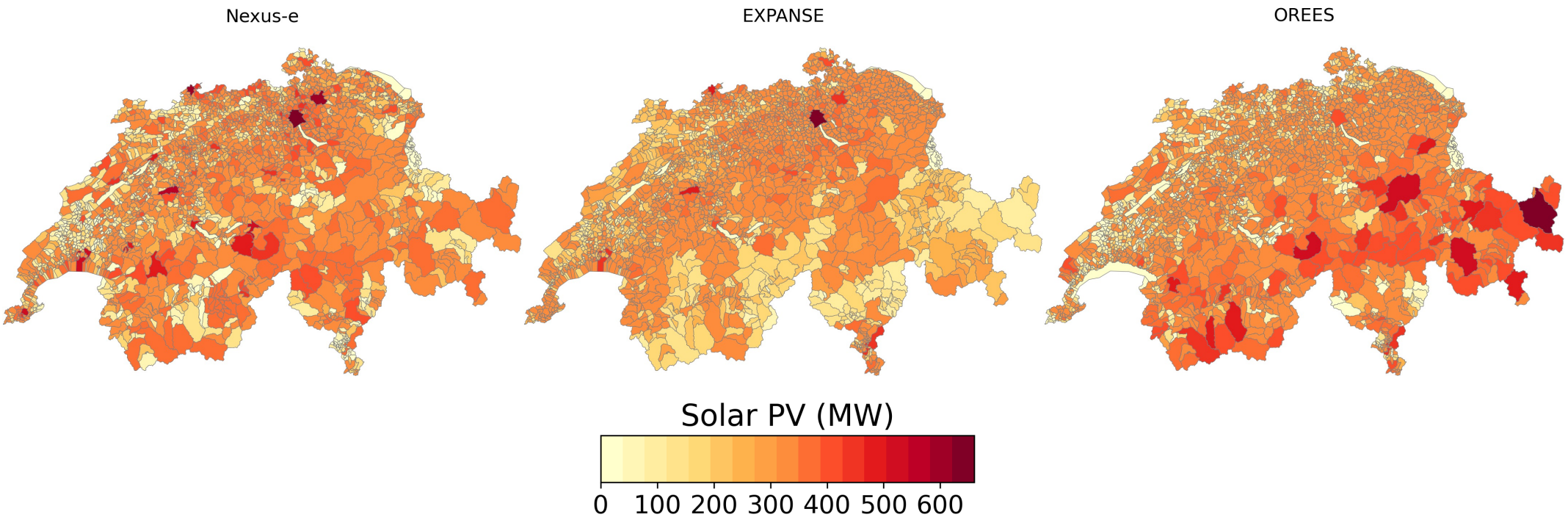
Example scenarios



- The different model perspective leads to large differences in Ref
- Renewable generation plays a significant role in the future generation mix. The alternative is increasing imports
- The renewable target (R45) can be achieved in different ways
- Reducing the market integration with Europe (N030) or the net winter import (W05) leads to higher installed capacities

Installed Capacity – Municipal Level (R45)

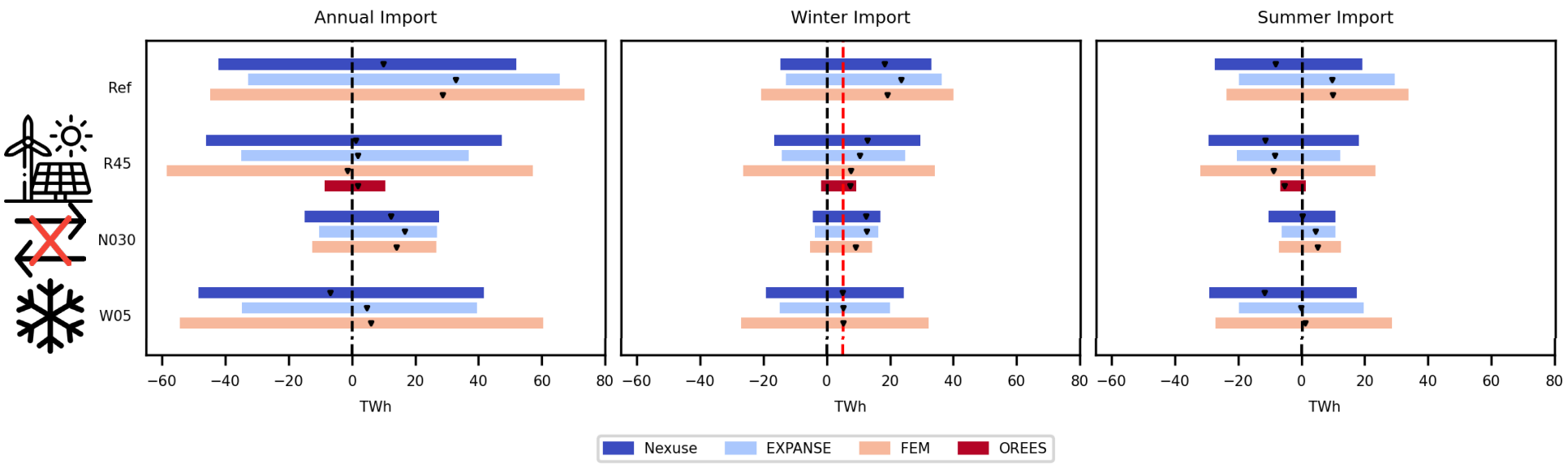
Example scenario R45



We see important differences in the spatial distribution of installed PV

Exchanges with the neighboring countries

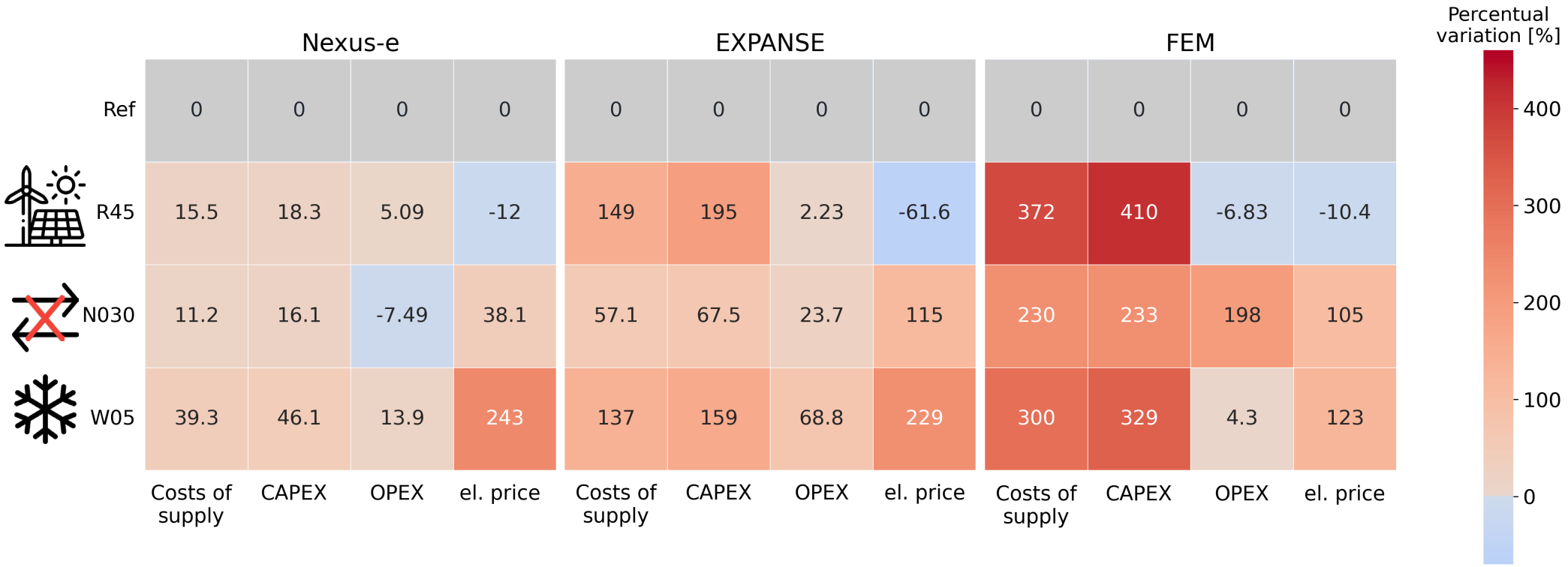
Example scenarios



- The renewable target (R45) reduces the need for imports
- Reduced market integration (N030) reduces both imports and exports but has no clear impact on the net
- Limiting winter net imports (W05) affects imports and exports, and induces unfavorable trade

Costs

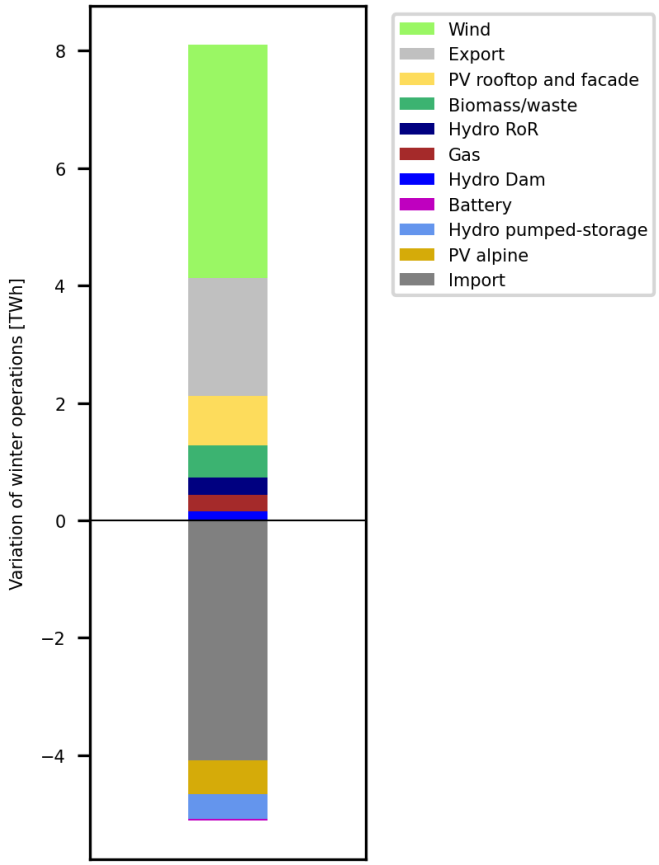
Example scenarios



- Increasing the investments in renewables (R45) leads to higher system costs but lowers the electricity price
- Limiting the winter net imports (W05) and the integration with the European market (N030) leads to higher system costs and electricity prices

Operation Under Limited Winter Net Imports

All scenarios

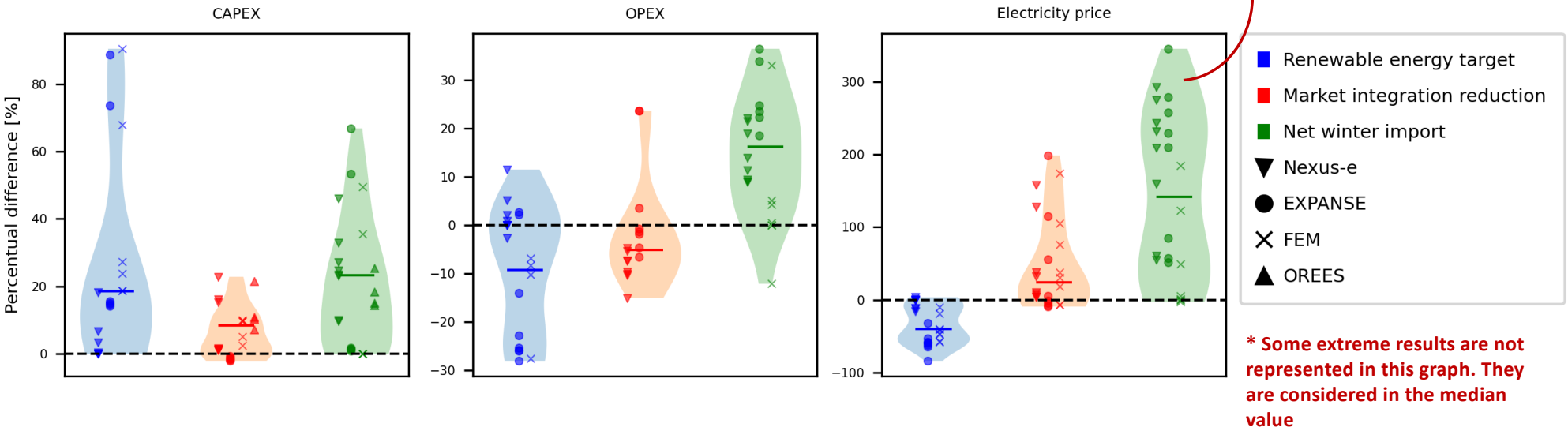


* Average impact of the winter net import limit on the operations of different generation technologies in the winter months

- W05 leads to increased investments and operations of PV, wind, biomass
- Hydro pumped storage operation is reduced because arbitrage on other European markets is reduced

Results Robustness

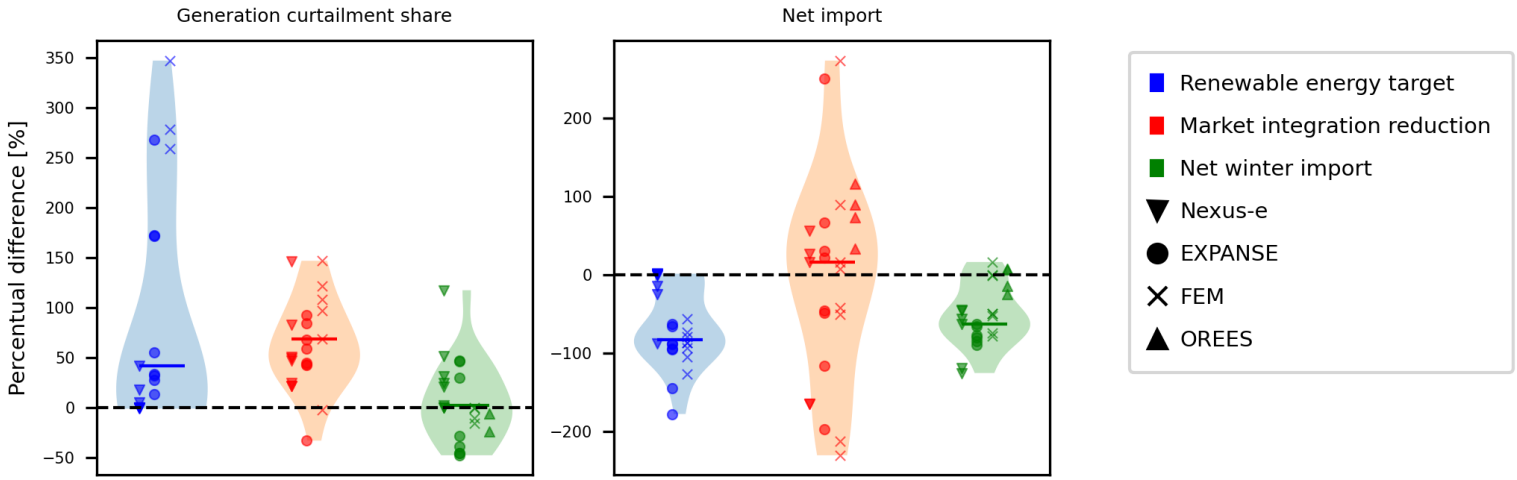
All scenarios



- The winter import limit and the renewable target have the strongest influence on costs of electricity supply and electricity price

Results Robustness

All scenarios



- The renewable target leads to less efficient use of the VRES generation but reduces net imports
- The market integration reduction does not reduce net imports, but it does increase costs of electricity supply, electricity prices and curtailment
- The winter net import limitation does not lead to an increase of curtailment share

Conclusions and Future Work

Conclusion

- **The renewable generation target** requires important investments (+19% CAPEX) but reduces operational costs (-9%), electricity prices (-40%), and net imports (-83%). Subsidies are needed to achieve a large buildup of renewable generation.
- **Reduced market integration** negatively affects the Swiss and the European energy transition by reducing the potential benefits of trading and hence reducing the utilization of VRES while increasing the cost of electricity supply (24%).
- **Limited net winter imports** are feasible. However, it harms electricity trading leading to increased costs of electricity supply (increasing CAPEX by 23% and OPEX by 16%) and electricity prices (141%).

Future Work

- A third EDGE model inter-comparison will start soon! Same models but different focus.
- Investigate import dependency and security of supply under different scenarios

That’s all, thanks! Questions?

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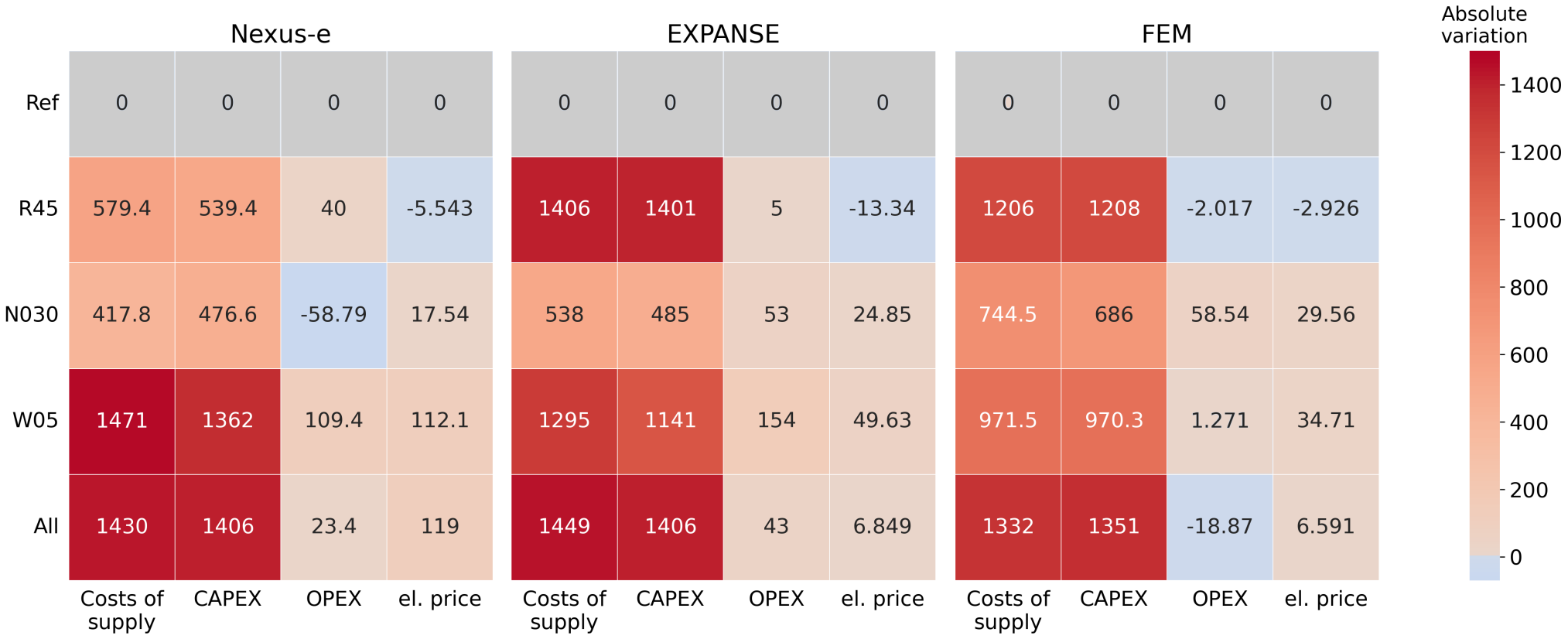
Backup slides

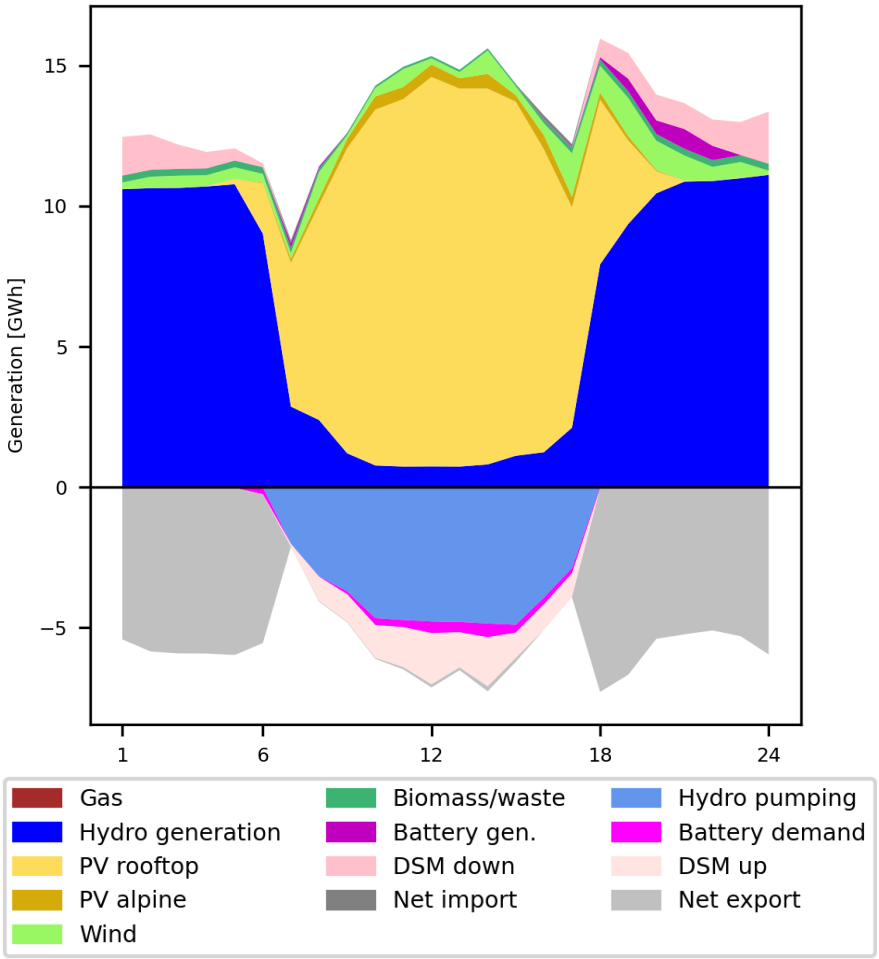
Costs – Absolute Variation



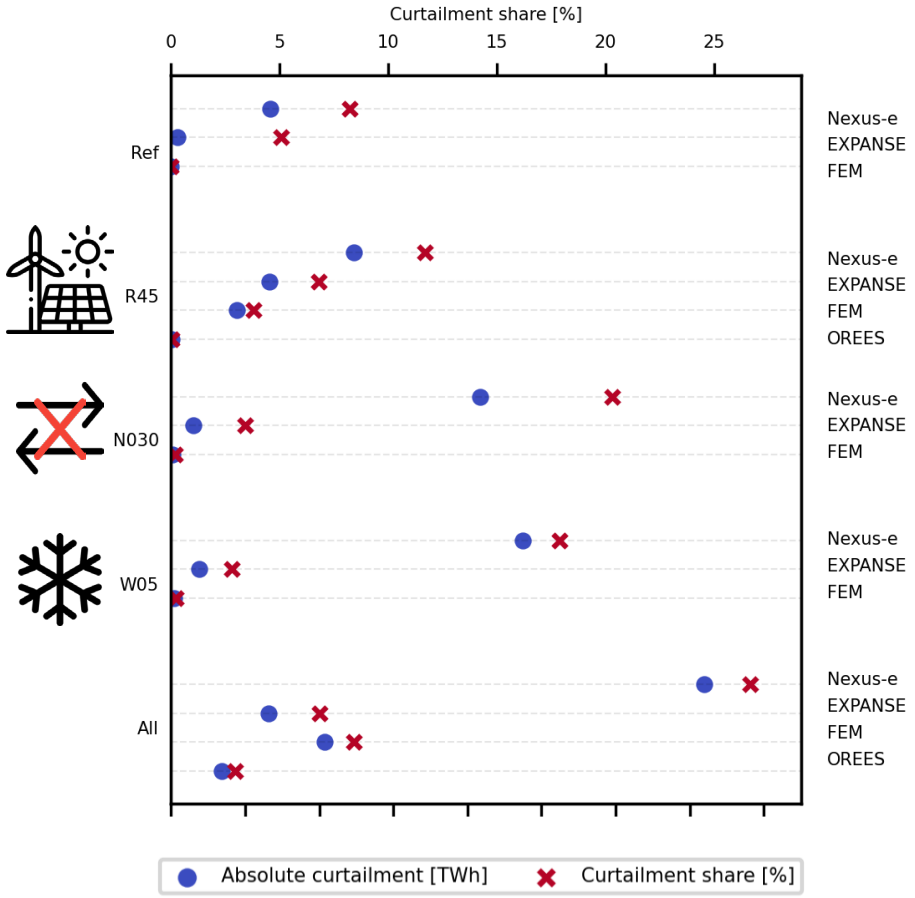
Costs: Mio Eur

Electricity price: Eur/MWh

Operations of a typical day

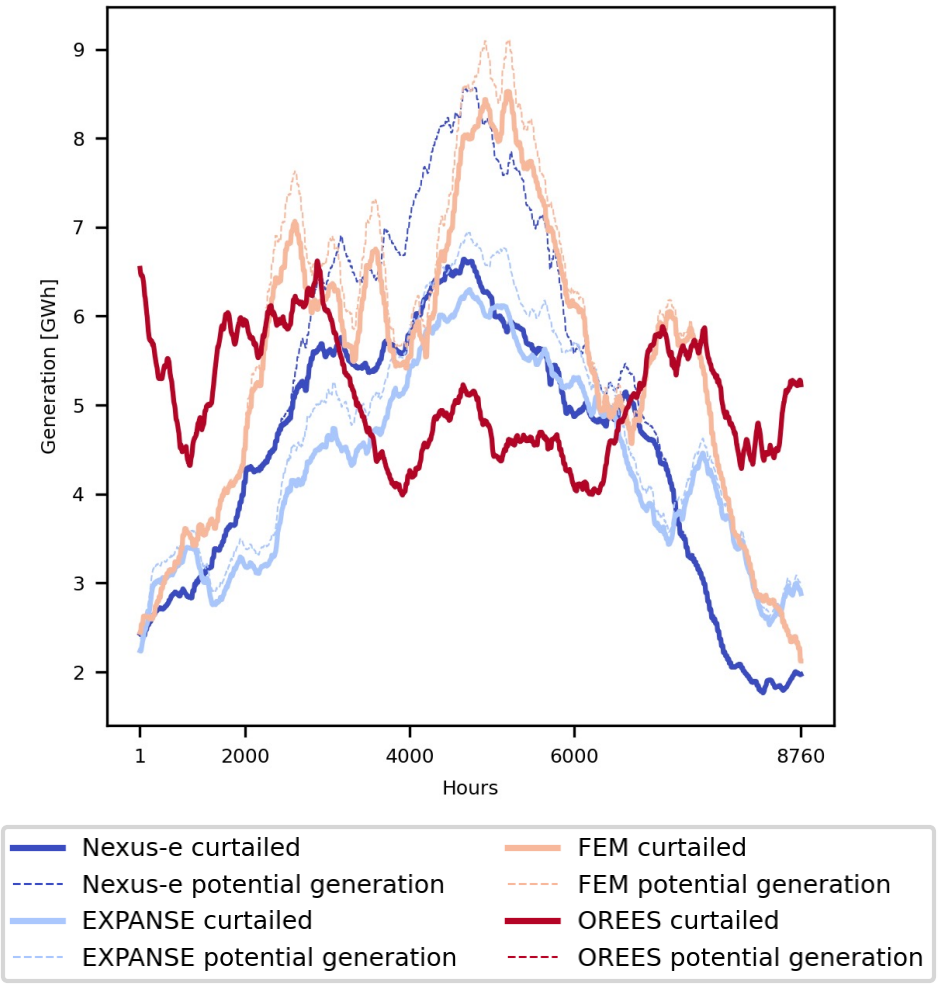


Curtailment

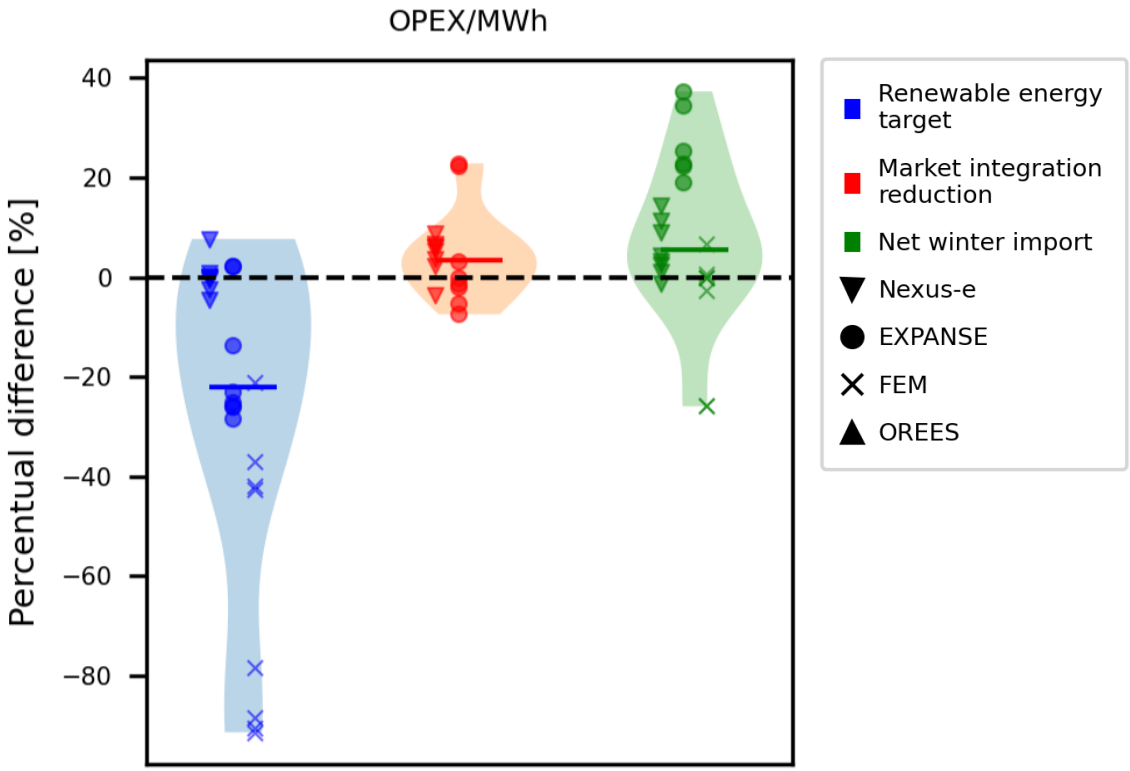


- Curtailment can be either grid-based or economical
- The renewable target (R45) leads to in increase of the absolute curtailment and the curtailment share
- Several factors contribute to the high curtailments in Nexus-e

VRES generation



OPEX relative to the generated electricity



Renewable target subsidy

Table 2: Levels of renewable subsidy for the different scenarios and models [Eur/MWh].

EU development	Renewable target [TWh]	Market integration [%]	Winter net import [TWh]	Nexus-e [Eur/MWh]	FEM [Eur/MWh]	EXPANSE [Eur/MWh]
GA	45	100	NC	18	29	37
GA	45	030	NC	14	28	38
GA	45	100	05	0	28	25
GA	45	030	05	0	28	27
DE	45	100	NC	28	38	36
DE	45	030	NC	0	33	34
DE	45	100	05	0	33	24
DE	45	030	05	0	33	27

5 TWh winter net import limit – certificate price

Table 3: Certificate price corresponding to the 5 TWh winter net import limit [Eur/MWh].

EU development	Renewable target [TWh]	Market integration [%]	Winter net import [TWh]	Nexus-e [Eur/MWh]	FEM [Eur/MWh]	EXPANSE [Eur/MWh]
GA	NT	100	05	59	73	124
GA	45	100	05	59	3	42
GA	NT	030	05	63	44	123
GA	45	030	05	63	0	42
DE	NT	100	05	60	86	109
DE	45	100	05	60	17	42
DE	NT	030	05	64	76	110
DE	45	030	05	67	0	31

Conclusion

- The renewable generation target has a major influence on the electricity system, leading to increased VRES installed capacity and, therefore, increased CAPEX costs of about 19%. However, it also leads to reduced operational costs (-9%), electricity prices (-40%), and net imports (-83%). In general, we find that in three out of four models, the target must be enforced to achieve the expected VRES shares. This suggests that direct or indirect subsidies are needed to achieve a large buildup of renewable generation.
- We find that VRES curtailments are part of an efficient system with high VRES shares. We also observe that the renewable generation target and the limited trading lead to higher generation curtailments, while the limited net imports in winter have a less decisive impact on curtailments.
- The study shows that limiting international trading capacities has a less clear effect on the cost of electricity supply and the electricity price, showing divergent outcomes across models and scenarios. However, reduced trading capacity negatively affects the Swiss and the European energy transition by reducing the potential benefits of trading and hence reducing the utilization of VRES while increasing the cost of electricity supply.
- Finally, limiting the net winter imports leads to both a reduction of imports as well as an increase in exports to meet the target. Additional capacities are added to support exports to neighboring countries and thus maintain the 5TWh net import target. Overall, limiting the net winter imports harms electricity trading leading to increased costs of electricity supply (increasing CAPEX by 23 and OPEX by 16%) and electricity prices (141%).