Linking TIMES-EMPIRE: Norwegian and European response to residential flexibility

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Research questions

1. How does the European power market influence the cost-optimal development of the Norwegian energy system?

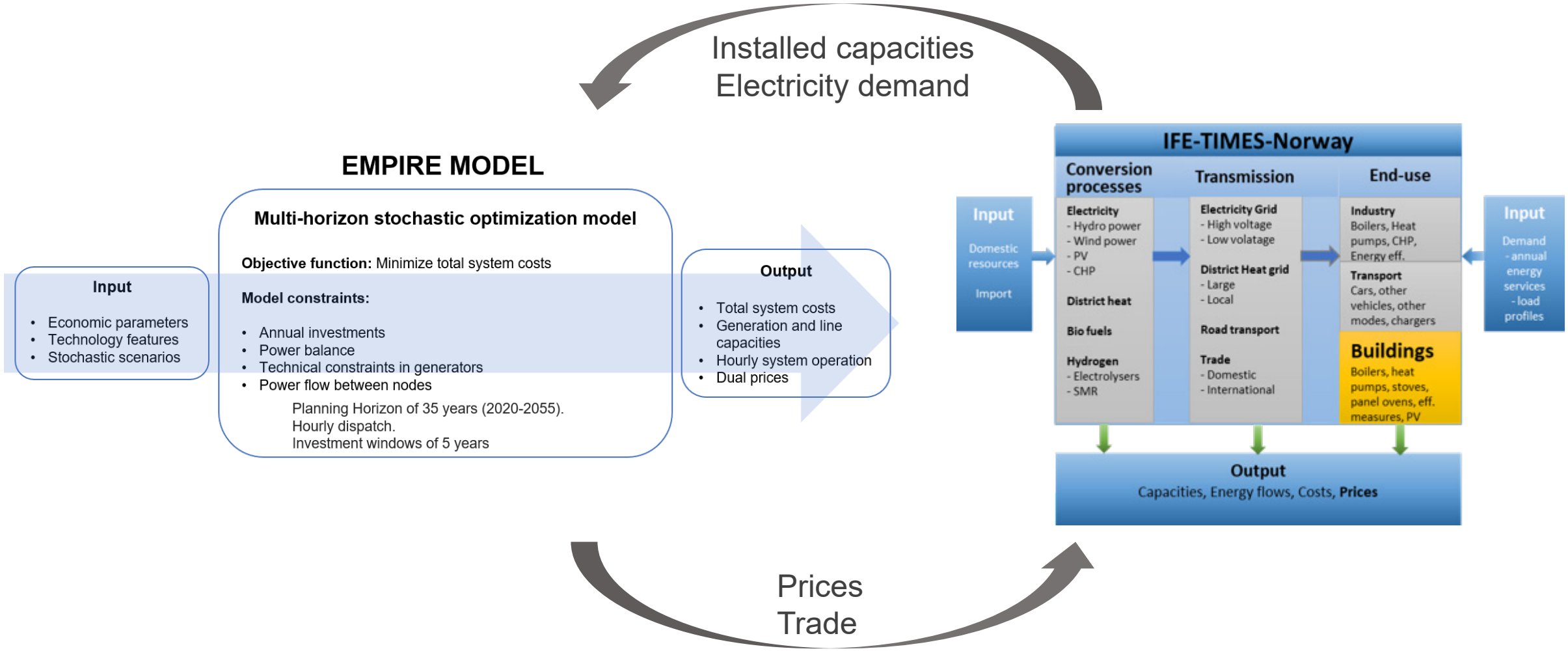
2. How does the development of the Norwegian energy system influence the European market?

3. What are the effects of residential flexibility at the European level on the electricity market?

Motivation for linkage

- Each model has its strengths and limitations
- Linkage enables better decision-making and reduces the limitations
- Challenge to TIMES-Norway
  - The Norwegian energy system is largely affected by the European power marked
- Challenge to EMPIRE
  - Detailed representation of Norway
  - Competition and interaction with other energy carriers other than power

EMPIRE-TIMES linkage



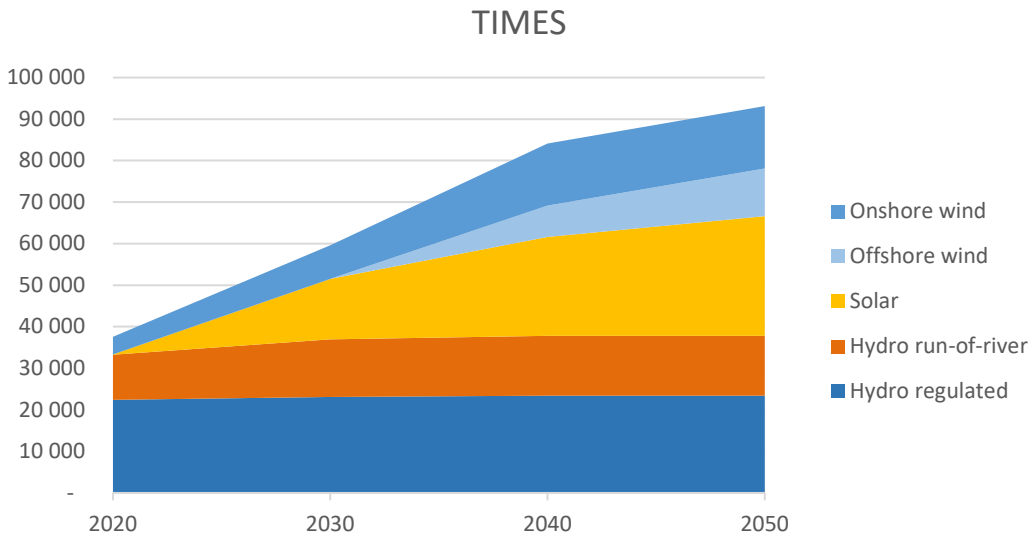
Harmonization & linking

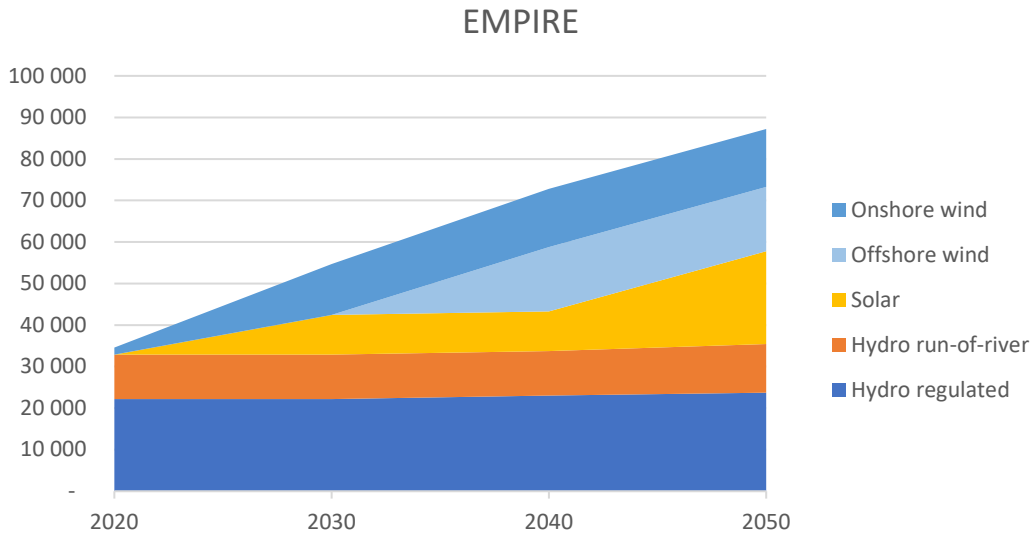
- Harmonized data input
  - Transmission capacity expansion on national & international trade
  - Existing capacities (generation and trade)
  - Capacity factors for wind and solar
  - Cost, technology learning and maximum capacities of offshore wind
- Linking
  - Demand profiles per region from TIMES
  - Generation capacities from TIMES
  - European prices from EMPIRE
  - Availability of trade cables from EMPIRE

EMPIRE-TIMES: Baseline capacity

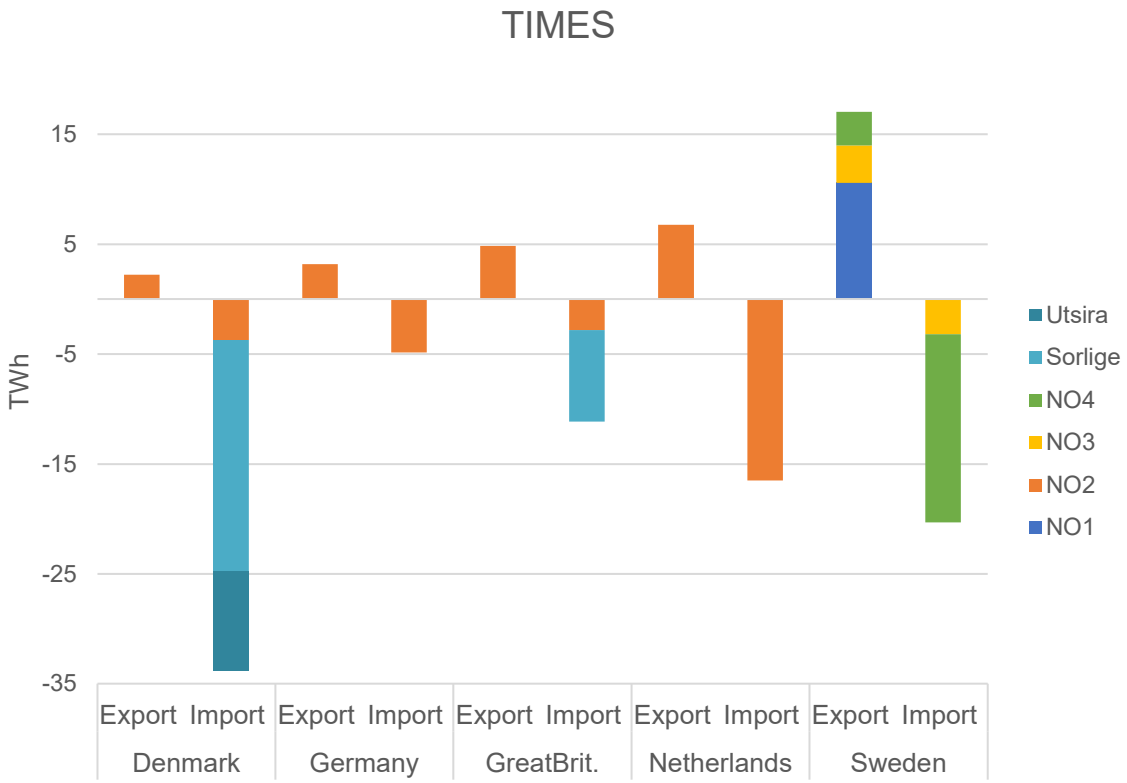
	Hydro regulated	Hydro run-of-river	Solar	Offshore wind	Onshore wind
2020	22 398	10 828	123		4 244
2030	23 066	13 916	14 560		8 040
2040	23 355	14 441	23 839	7 500	14 987
2050	23 355	14 441	28 813	11 517	14 987

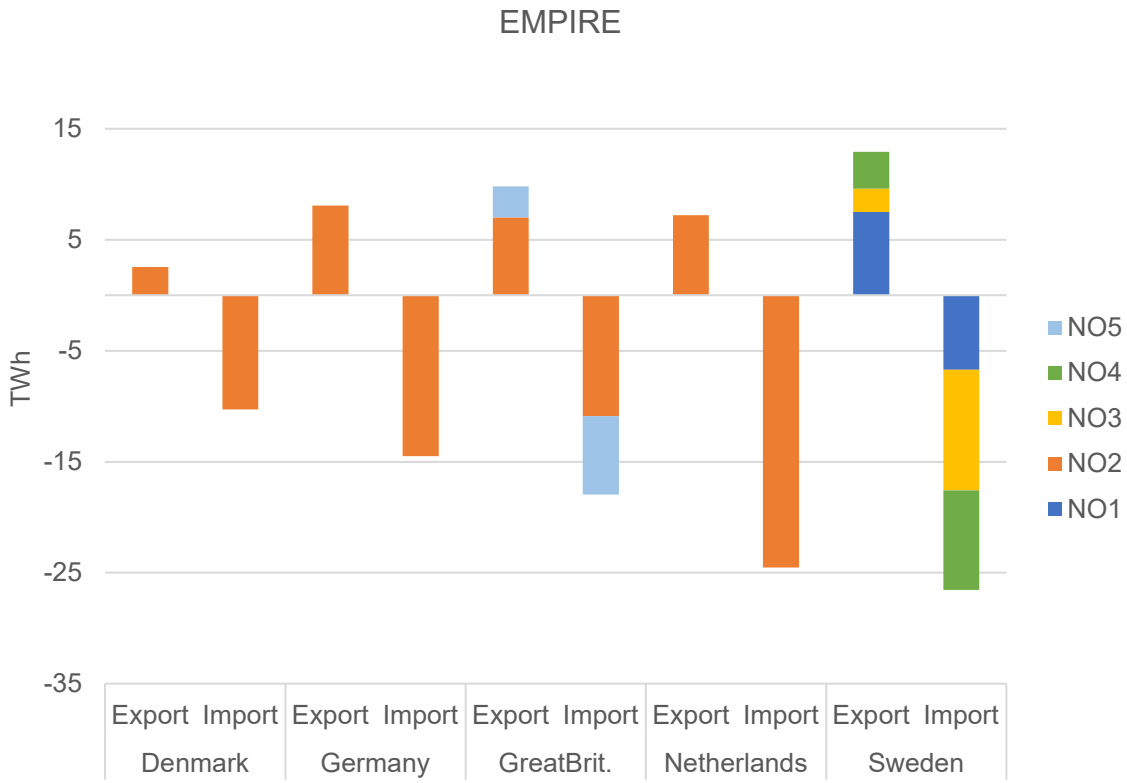
	Hydro regulated	Hydro run-of-river	Solar	Offshore wind	Onshore wind
2020	22 132	10 728	52		1 687
2030	22 143	10 728	9 540		12 292
2040	23 038	10 728	9 540	15 468	14 000
2050	23 709	11 700	22 367	15 468	13 944



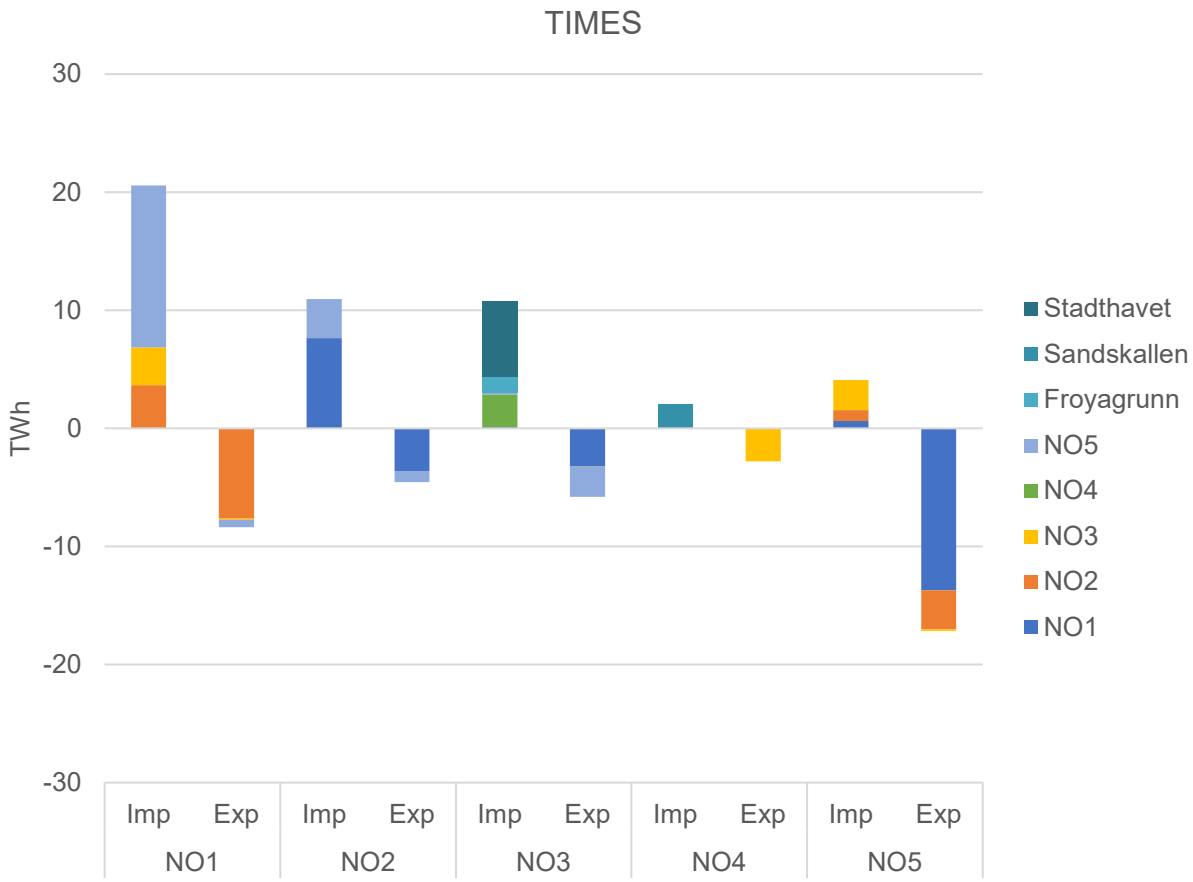


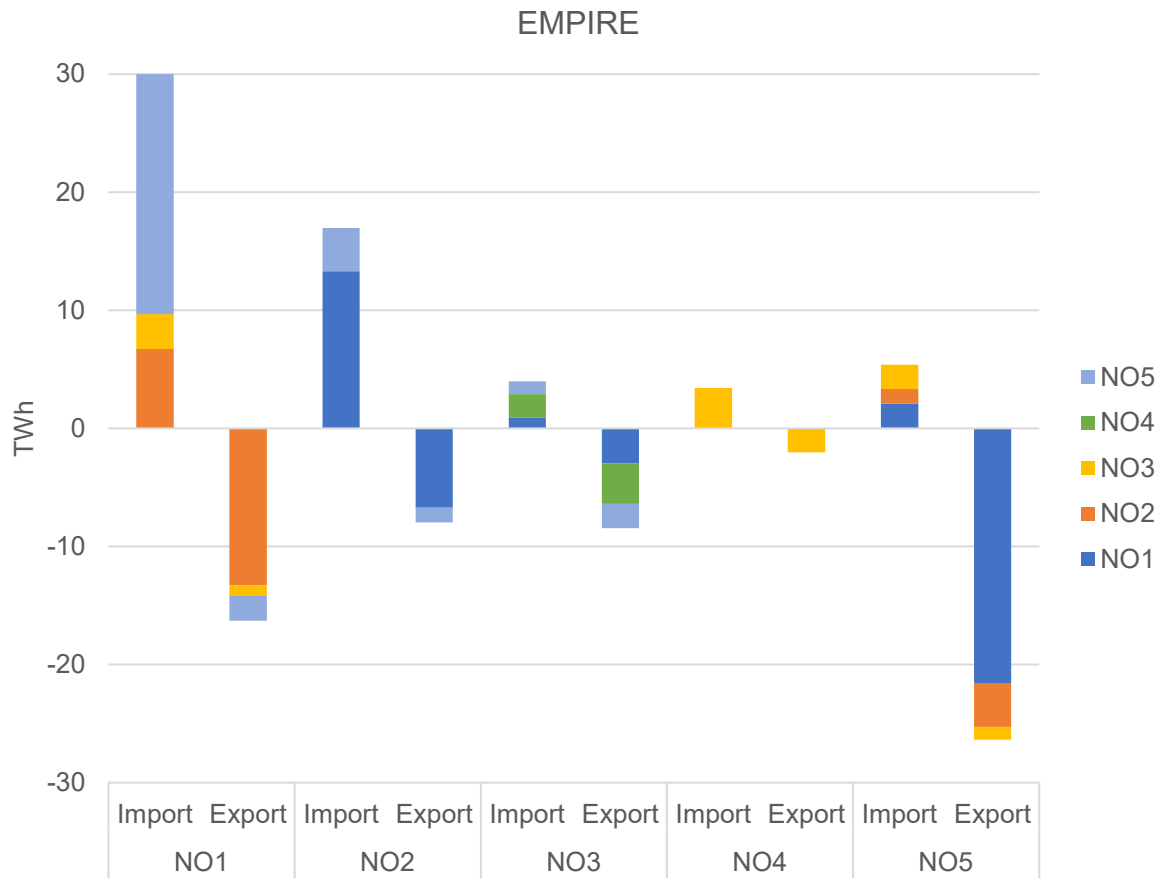
EMPIRE-TIMES: International trade



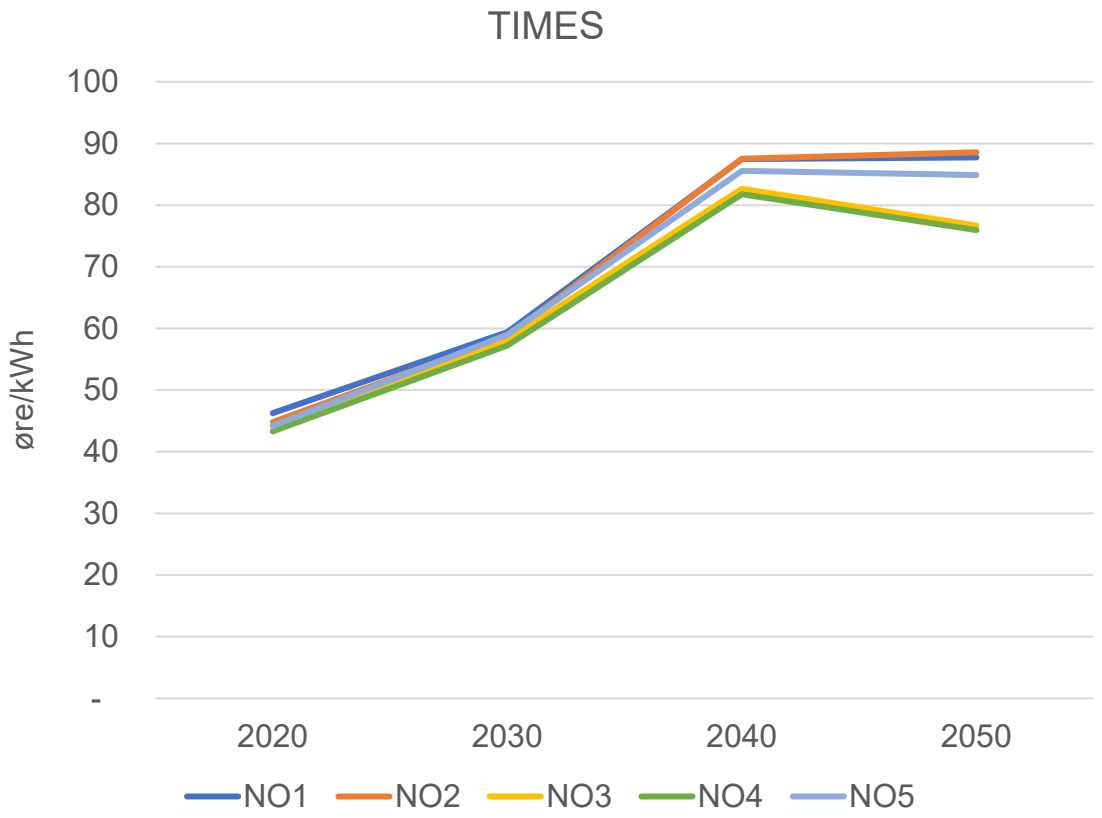


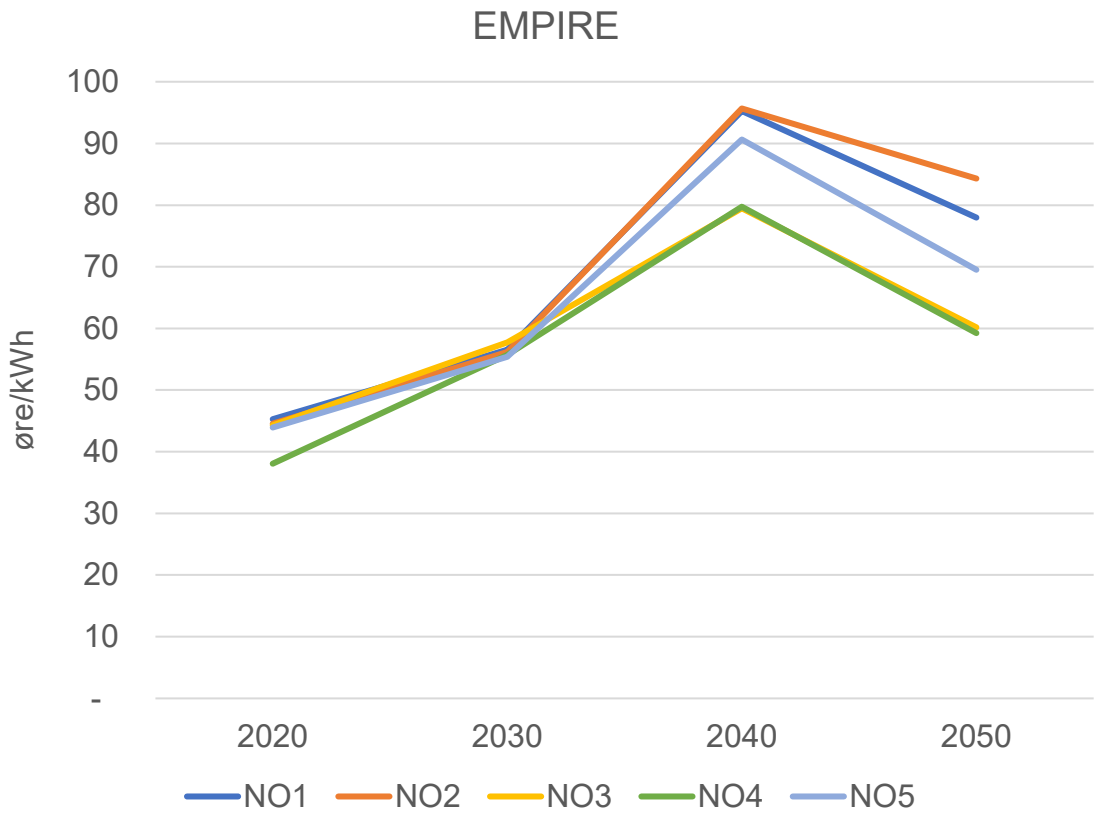
EMPIRE-TIMES: National trade





EMPIRE-TIMES: Average electricity price





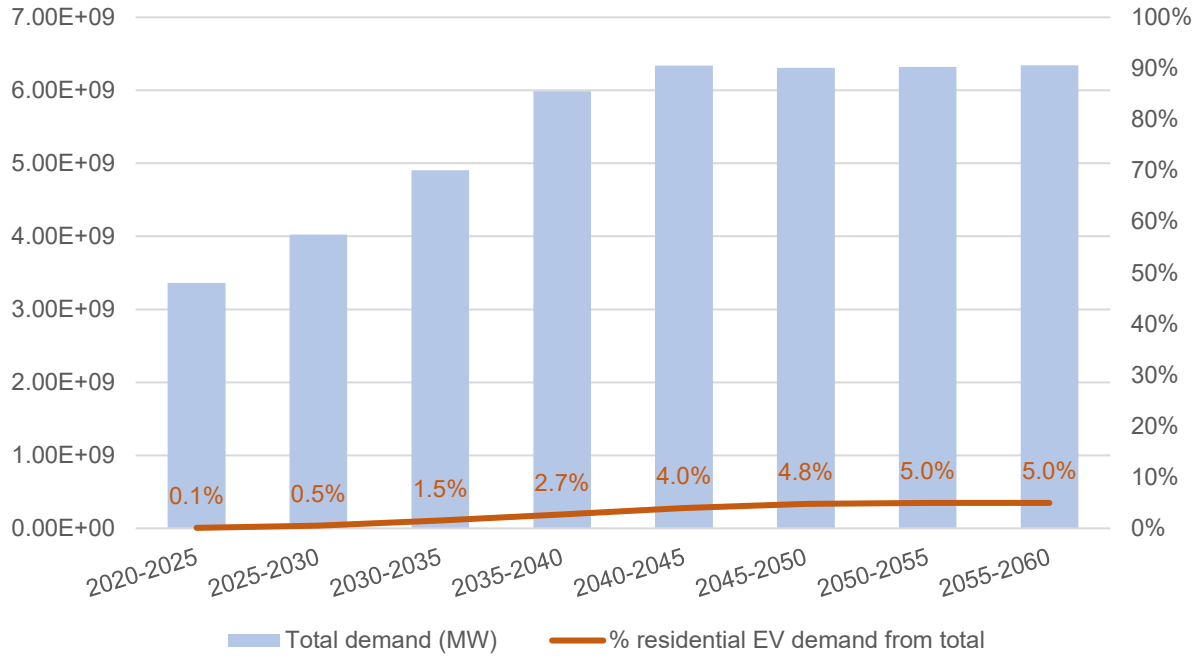
EMPIRE- Residential Module

What are the effects of residential flexibility at the European level on the electricity market?

- Understand the role and value of residential flexibility at a large-scale.
- Residential Module → load-shifting of residential appliances
- Flexibility potential defined by:
  - Load: Aggregated load for a particular asset type in a node
  - Participation rates: % of load that is willing to provide flexibility services
  - Time windows: Period in within which the load can be shifted.

EMPIRE- Residential Module

Appliance	EMPIRE Appliance group	Participation Rates	Time windows
Electric Vehicle	EV	0.249	4
Dryer	Wash	0.315	6
Washing Machine		0.315	6
Dish Washer		0.315	6
Space Heat	Heat	0.171	12
Water Heat		0.302	12
Refrigeration	Ref	0.34	2
Air Conditioning	AC	0.218	2



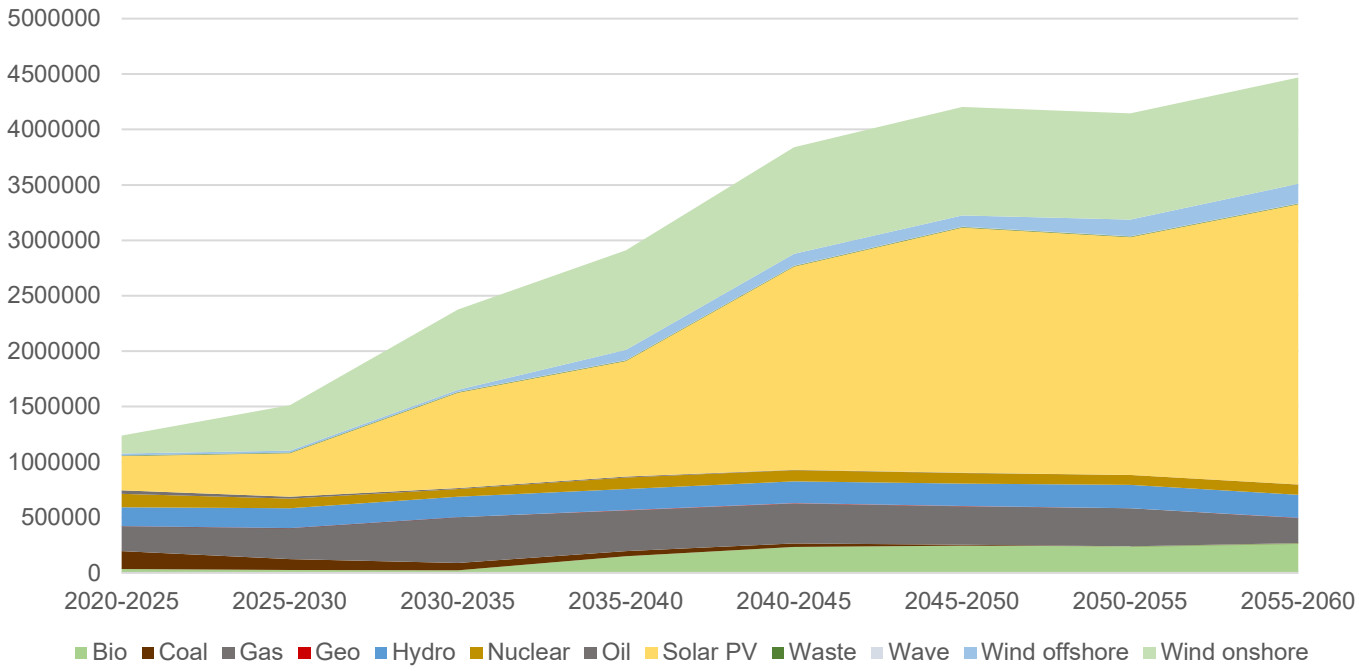
Norwegian EV Fleet

2020	2030	2040	2050
320 000	1 400 000	1 700 000	1 800 000

Baseline Europe – Energy Nation

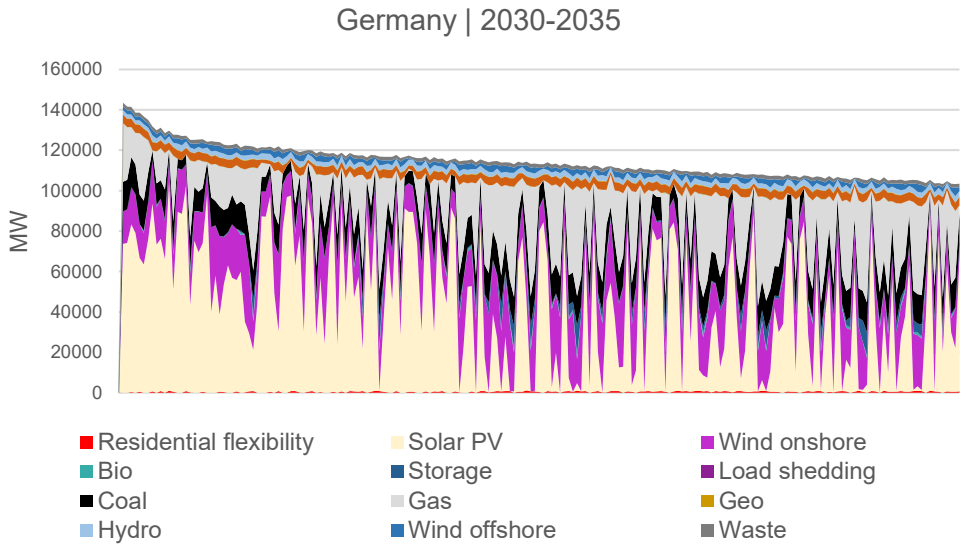
Total cost: 1% reduction using residential flexibility

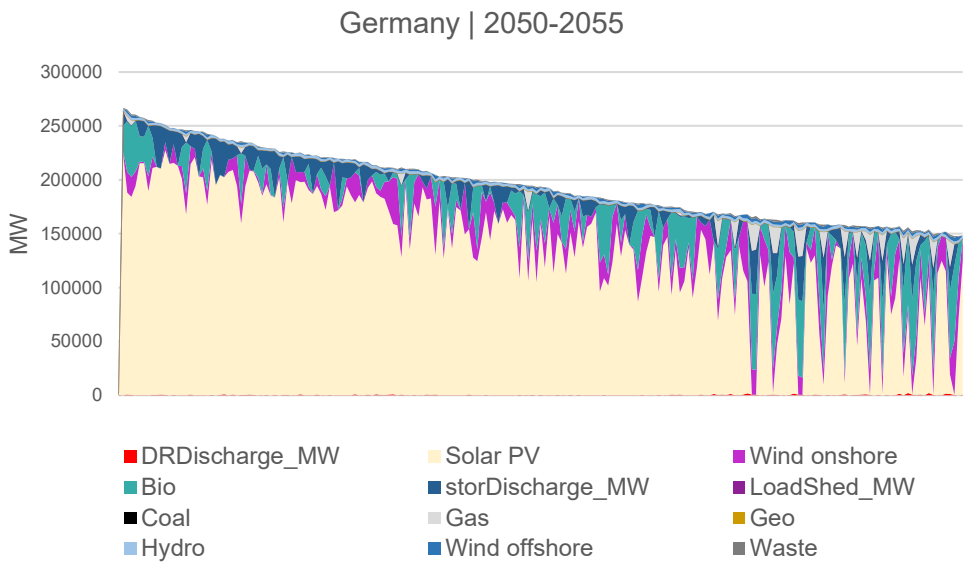
- **Installed capacities** similar despite residential flexibility
  - Slight decrease of gas
  - Coal kept longer
  - Increase of solar PV and bio
  - Lithium batteries investments reduced



Baseline Europe – Energy Nation

- **Total generation** slightly different with residential flexibility
  - Decrease dependency on gas and oil
  - Less curtailment of wind
  - Solar and Bio gain presence in the energy mix



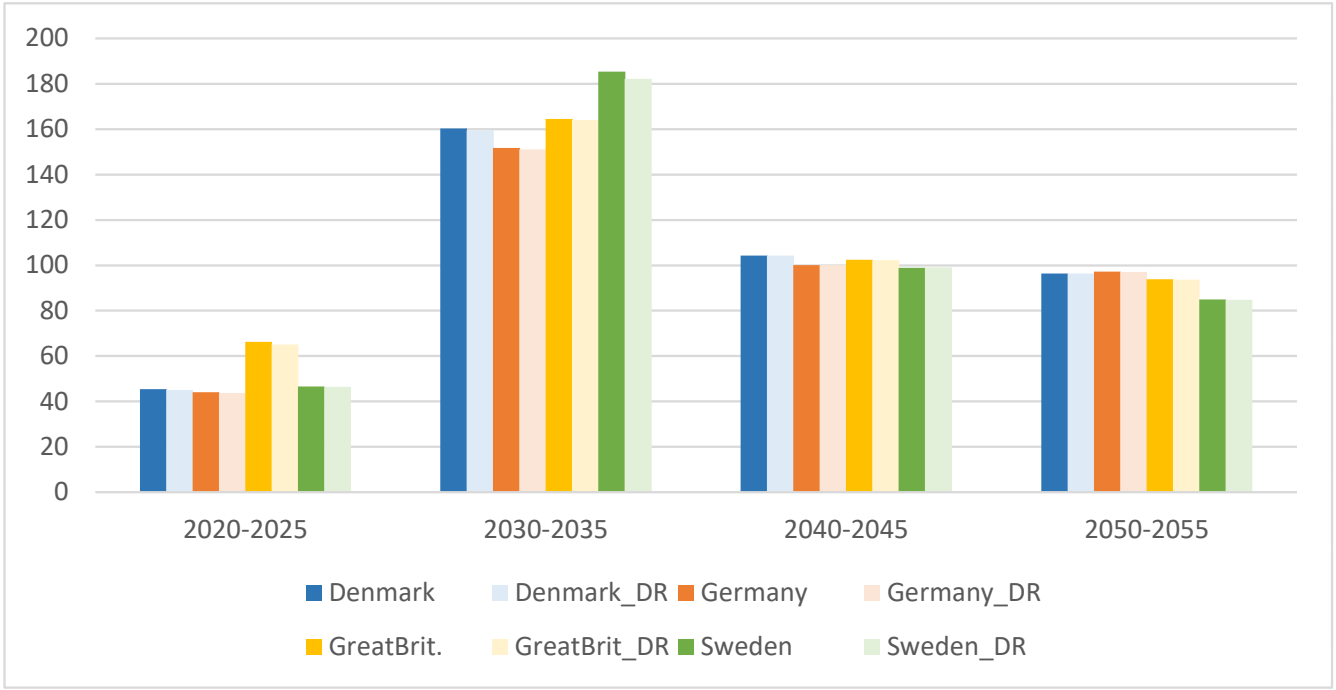


Baseline Europe – Energy Nation

Prices:

- Stabilisation of prices (less variability)
- Effect on prices in “extreme” times

- Average prices almost not affected
- Mid-term expected to have the highest average prices



Future work in linking (short-mid term)

- **Price variations** reflected in TIMES.
- **Stochastic scenarios**
- **Compare with Nature Nation**

Conclusions

- Technical limitations in Norway from TIMES to EMPIRE while economic results from EMPIRE to TIMES
- Baseline already quite aligned → not too many iterations:
  - Pace of deployment solar and wind
- Residential flexibility in Europe:
  - Prices variability affected, not average
  - Solar investments: ↑ and accelerated
  - Battery investments: ↓
  - Reduce curtailment and fossil-fuel production

THANK YOU