FlexBuild
Year 3 2022

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Teams

The value and effects on end-use flexibility in the low carbon transition of the Norwegian energy system

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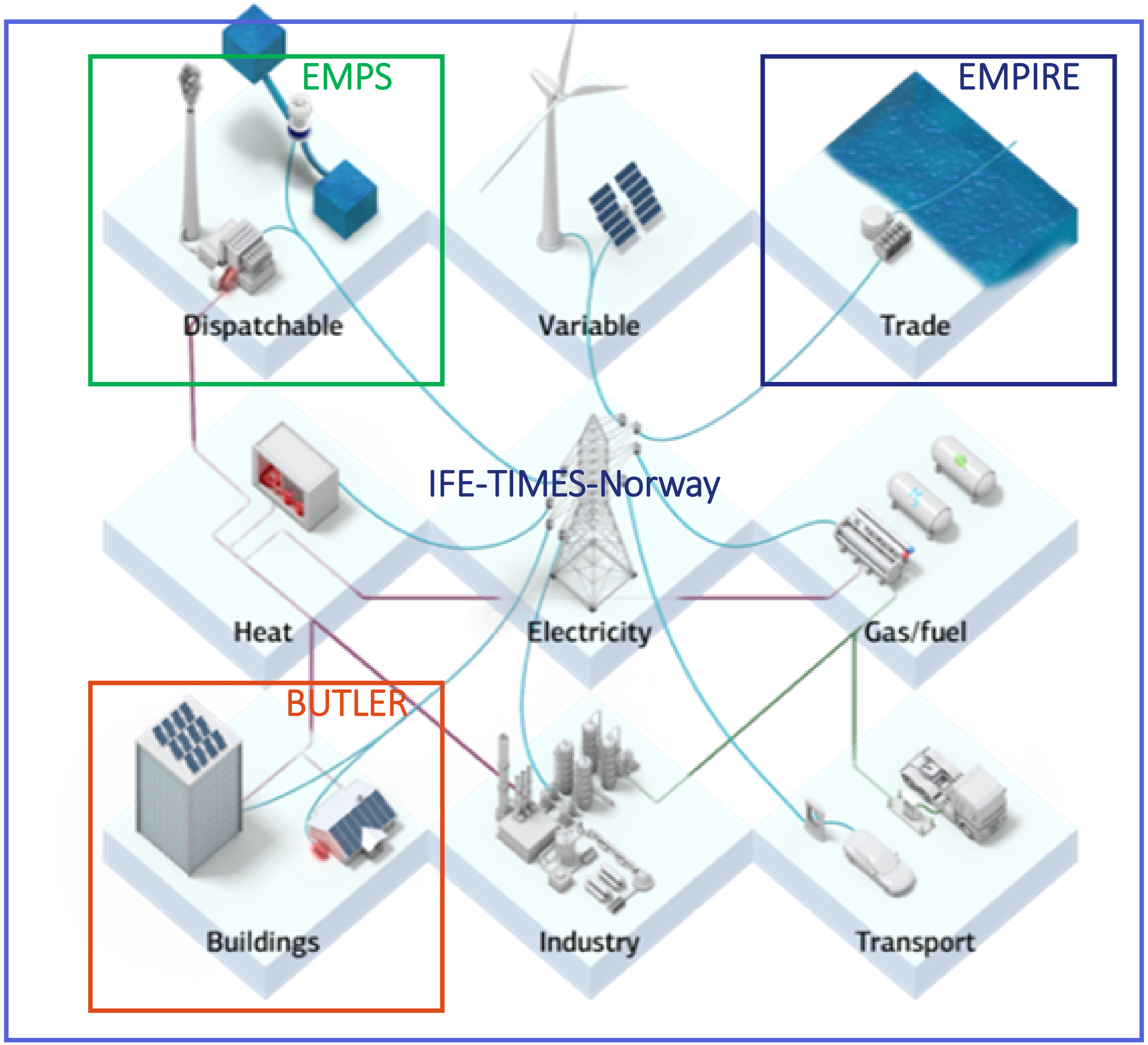
KPN FlexBuild

IFEs research activity Year 3

- Harmonization & linking of IFE-TIMES-Norway with other models
  - EMPS
    - Hydropower
    - Model results Energy nation with and without flexibility
  - EMPIRE
    - Harmonized e.g., generation and transmission capacities, costs
    - From TIMES: el. demand
    - From EMPIRE: European prices
  - BUTLER
    - Harmonized e.g., PV and grid tariffs
    - From TIMES: energy prices
    - From EMPIRE: energy profiles



Figur: IEA, NETP 2016

IFEs research activity Year 3

- Model improvements
  - Thermal storage in local and district heating
  - Stationary batteries in buildings and on a grid level
  - Flexibility options
    - Flexible hot water tanks
    - Flexible EV charging, When and where
    - Stationary batteries
  - Building applied PV
  - Offshore wind power
- Customize TIMES model for model linkage
- TIMES model of building sector (for comparison with BUTLER)
- Update scenario files for all 4 storylines
- stochastic scenarios - weekly temporal resolution
- Reserve market analysis
- Contribution to common paper
- Initial work with paper on linking with BUTLER

IFEs plans and wishes for Year 4

Further work involves close cooperation with research and user-partners.

- **Continue linking** with EMPS, EMPIRE & BUTLER
  - Ambition = two common scientific paper with research partners on linking with EMPIRE and BUTLER
- **Analyze more storylines** - Start with Nature nation
- Stochastic modelling of **weather-dependent parameters**
- Analyze the effect of **various grid tariff structures**
  - In dialogue with Elvia & Energi Norge together with Sintef
- Improve modelling and analysis of **district heat and local heat**
  - In dialogue with Fjernvarmeforeningen together with Sintef
- Improve modelling of **transmission grid modelling**
  - In dialogue with Statnett together with NTNU

IFEs plans and wishes for Year 4

- Write a scientific paper on: “The role of end-use flexibility in the low-carbon transition”
  - With sensitivities on deployment of end-use flexibility
  - Based on first presentation below.

- Analyse how reserve markets influences in the value and role of end-use flexibility
  - (Hopefully) in dialogue with SINTEF ER and Statnett

Analysis:

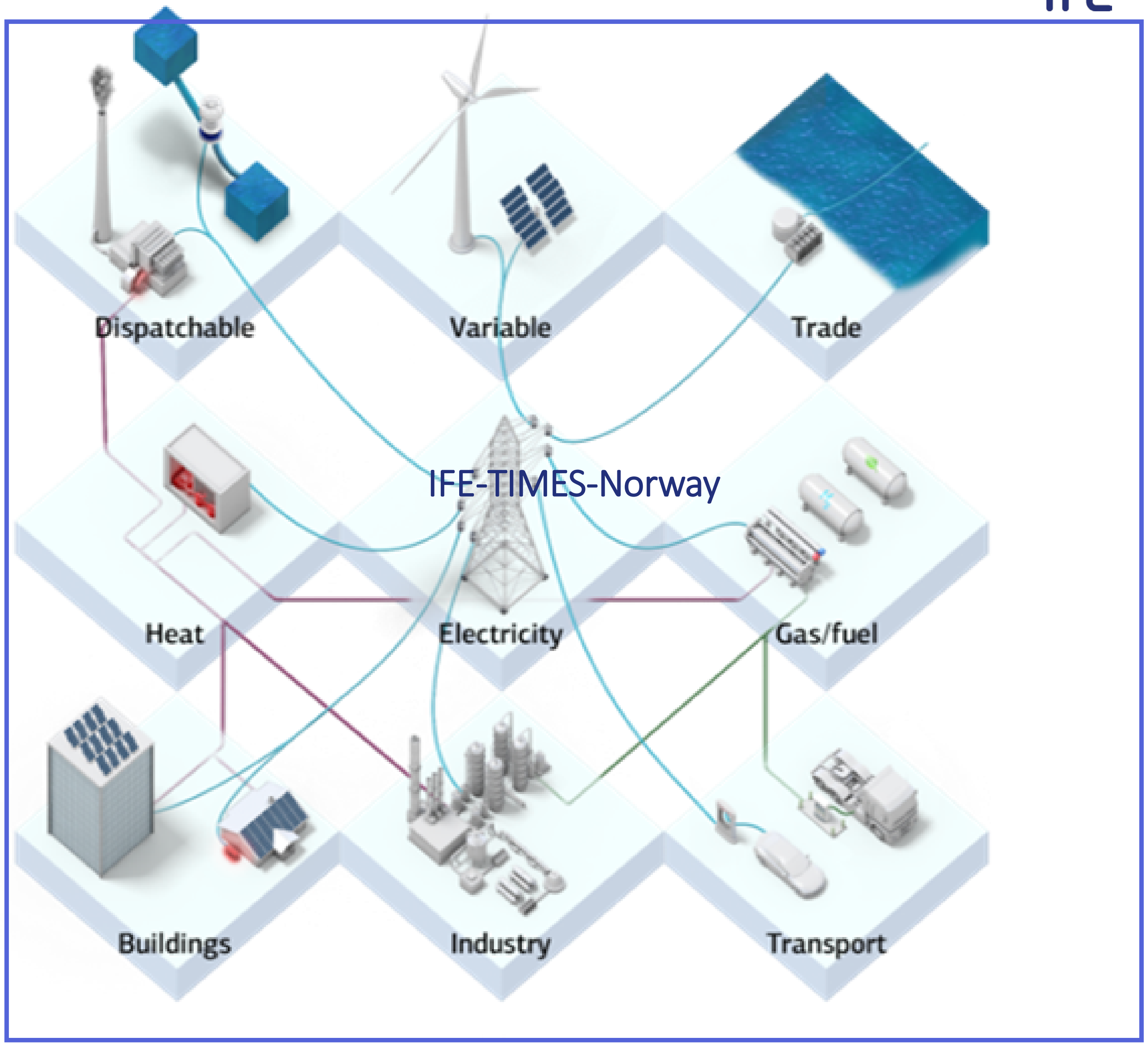
The value and effects on end-use flexibility in the low carbon transition of the Norwegian energy system

Research questions of analysis

- How can end-use flexibility facilitate the Norwegian energy transition?
- Who are the winners and losers of flexible demand?
- How will end-use flexibility effect the energy system?

Methodology

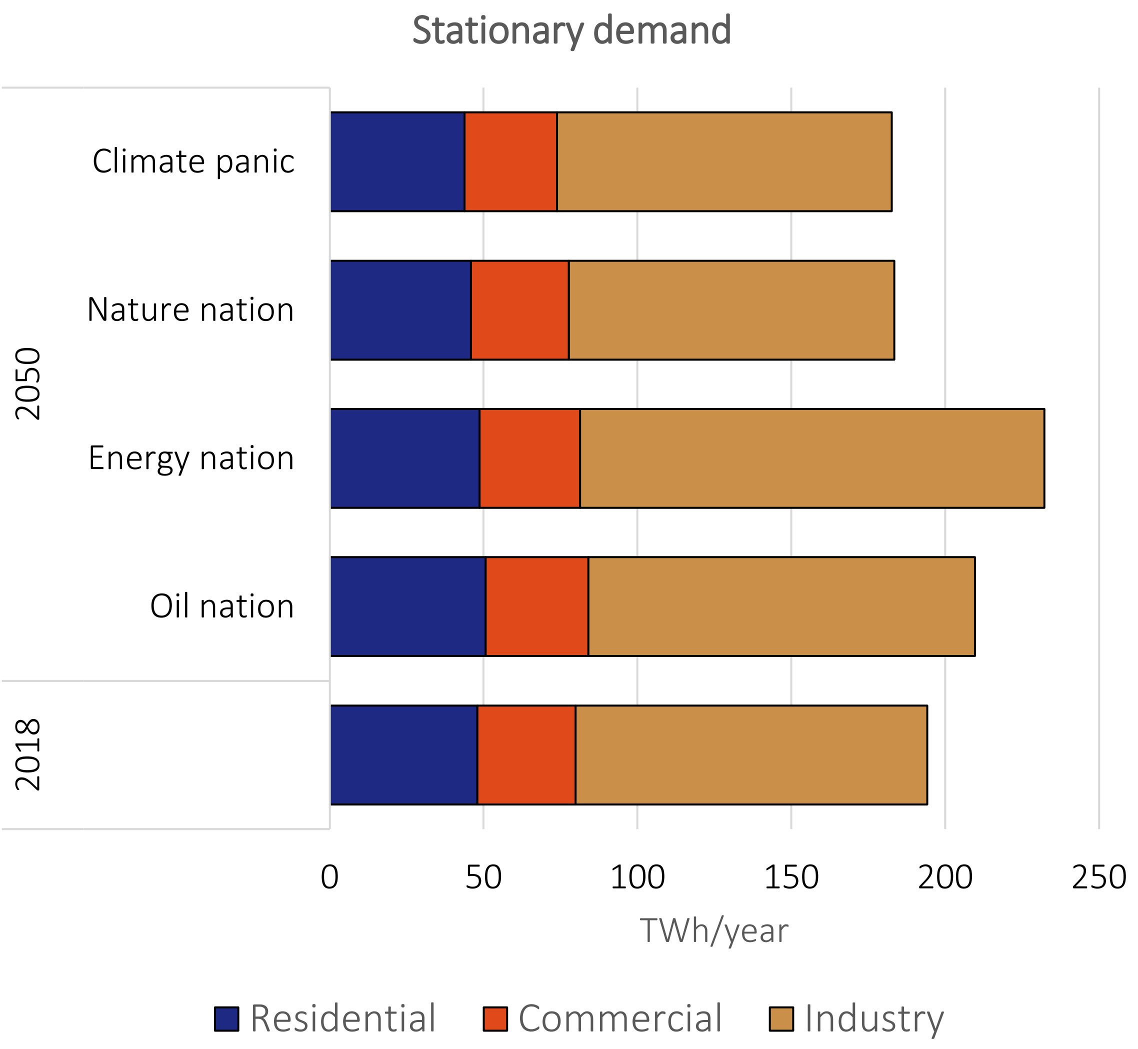
- **IFE-TIMES-Norway (2018-2060)**
- Long-term optimization model of the Norwegian energy system
- Covers entire energy system, including end-use; buildings, industry & transport
  - Sector coupling
  - Competition and interplay between energy carriers and technologies
- Assumptions of this study:
  - Carbon neutrality in 2050
  - Norway as an energy nation
  - Harmonised with EMPIRE on European power market
  - Harmonised input to BUTLER



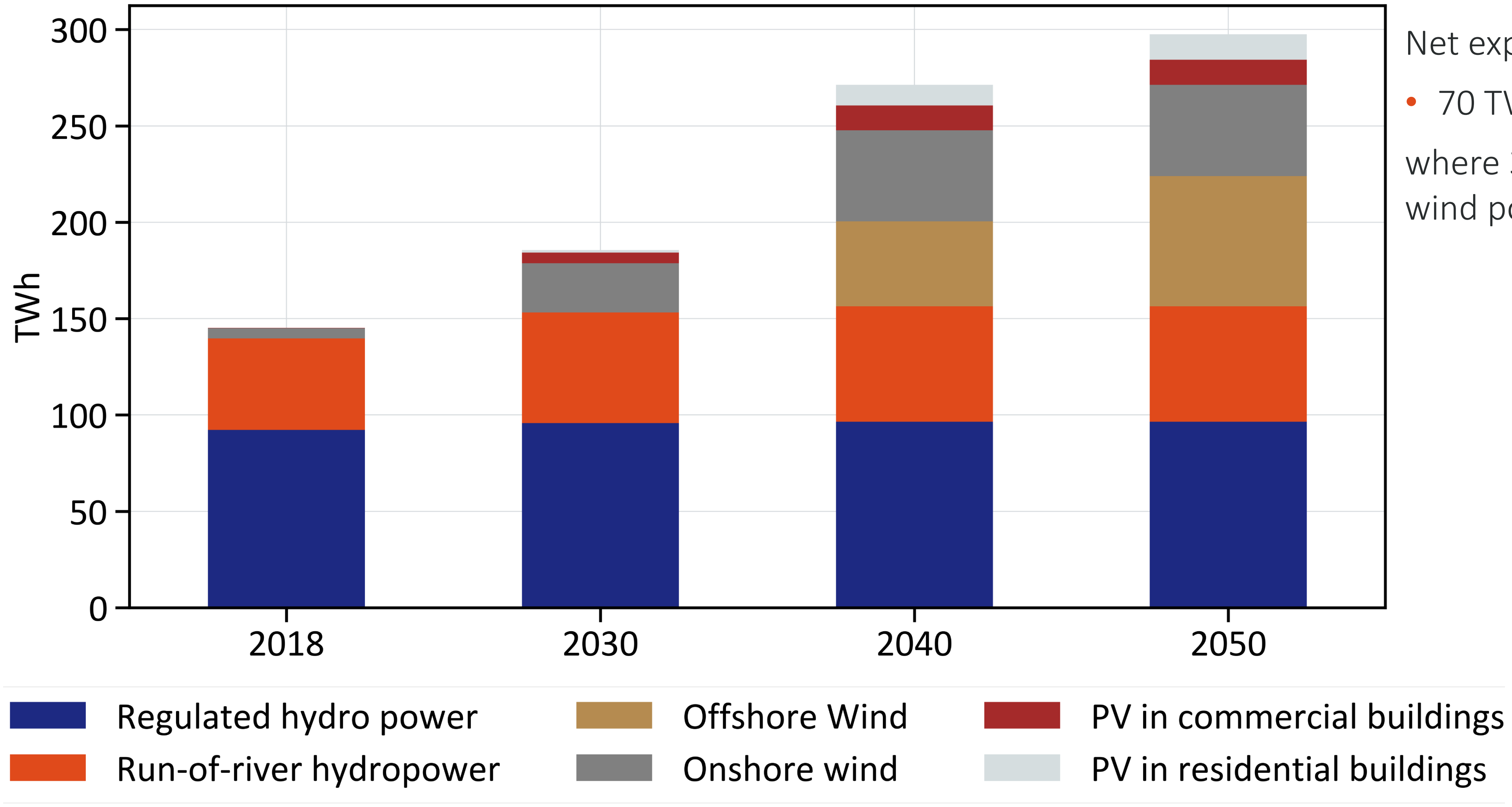
Figur: IEA, NETP 2016

Energy nation Norway

- No Carbon Capture and Storage and blue hydrogen
- High technology learning
  - Green hydrogen
  - PV and stationary batteries
  - Wind power (onshore and offshore)
- High wind power expansion potential
- Expansion of domestic and international grid if cost-efficient
- Energy efficiency in buildings



Energy nation doubles of electricity generation to 2050



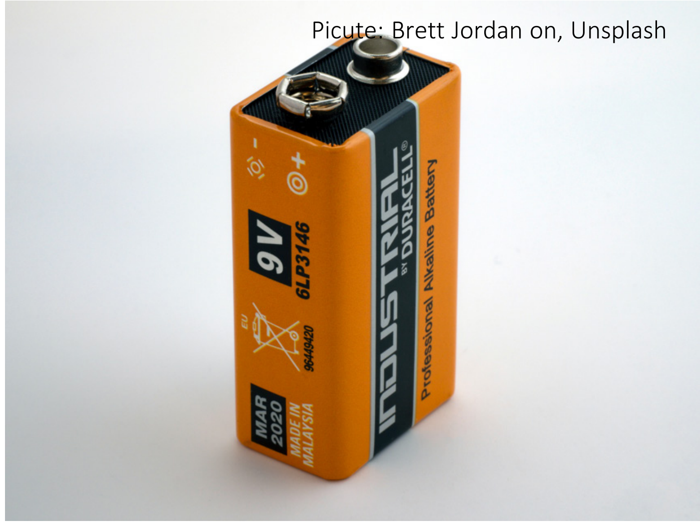
Net export 2050:

- 70 TWh

where 39 TWh is offshore wind power

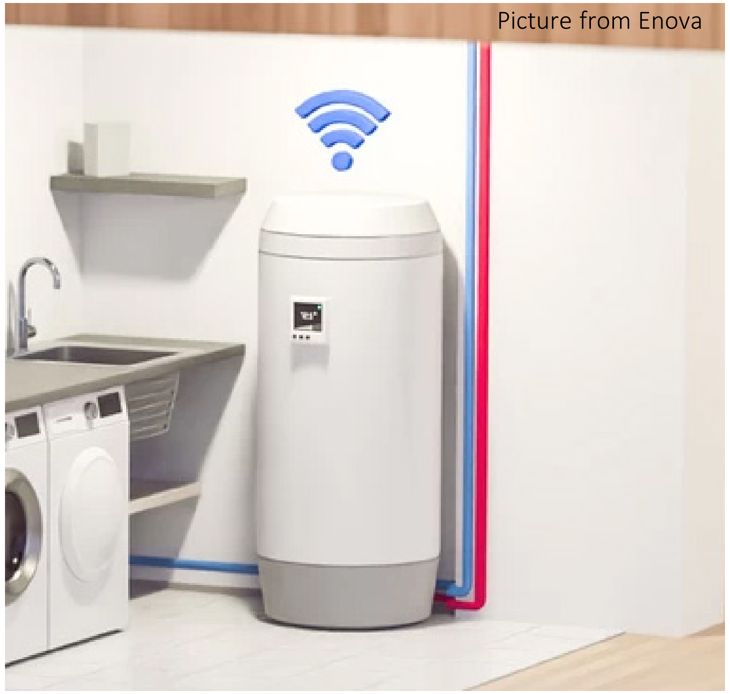
Results

No “winner takes is all” among end-use flexibility options



Picute: Brett Jordan on, Unsplash

Picute: Michael Fouset, Unsplash

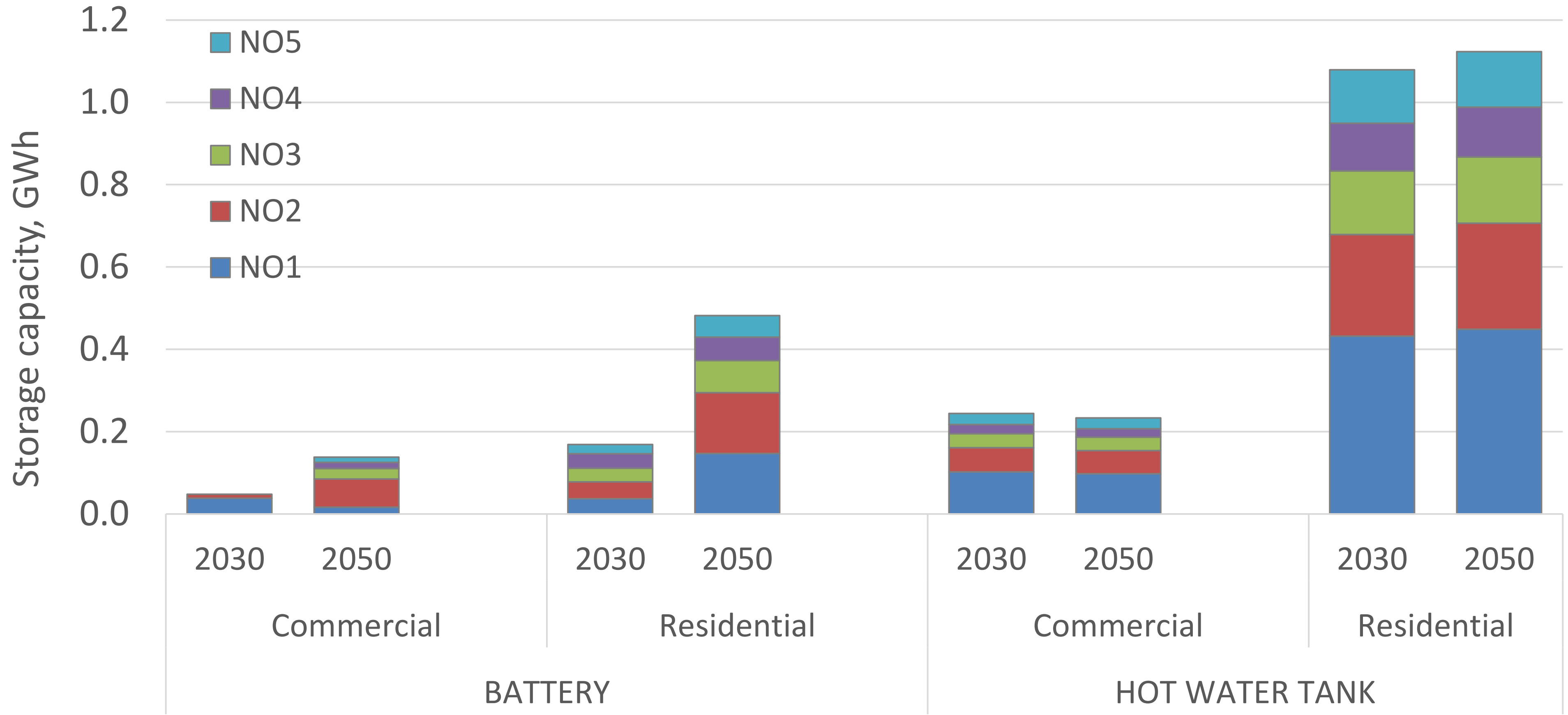

Picture from Enova

1. Stationary batteries

2. Flexible EV charging
- Where
- When

3. Flexible hot water tanks

Investments in flexible hot water tanks and batteries are cost-efficient solutions



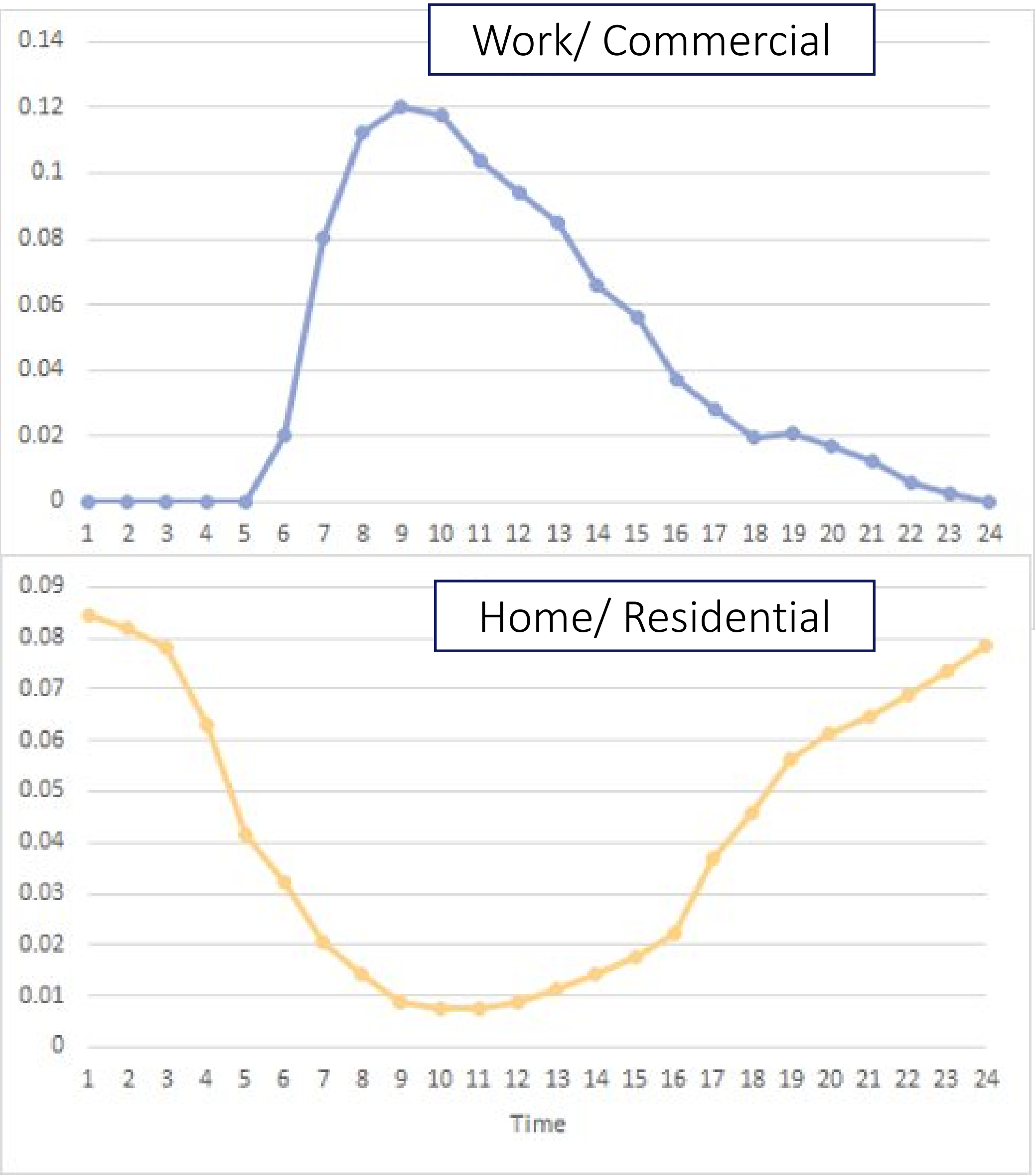
- 0.48 GWh batteries = 7742 Nissan leaf batteries @ 62 kWh
- 9% of hot water tanks are flexible

Flexibility enables charging of EVs when sun is shining & prices are low

- Without flexibility EVs charge:
  - 10 % Fast
  - 15 % at commercial buildings
  - 75 % at residential buildings

- Assume with flexibility EVs charge up to:
  - 50 % at commercial buildings
  - 90 % at residential buildings

- **Optimal charging strategi is to charge as much as possible at commercial buildings.**
  - 50 % commercial
  - 10 % fast
  - 40 % residential

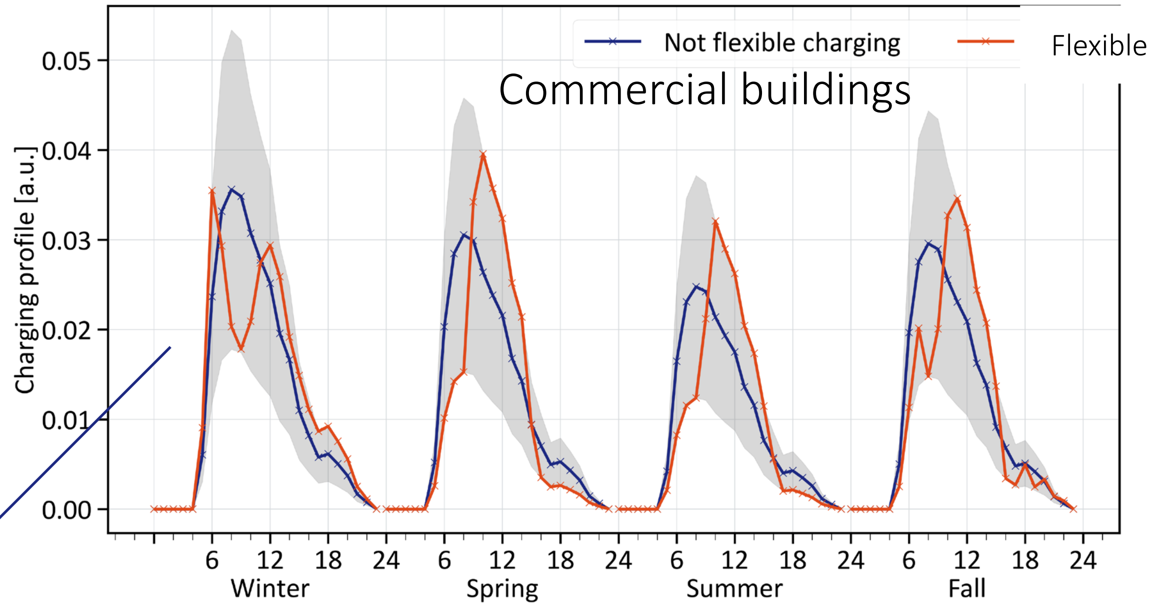


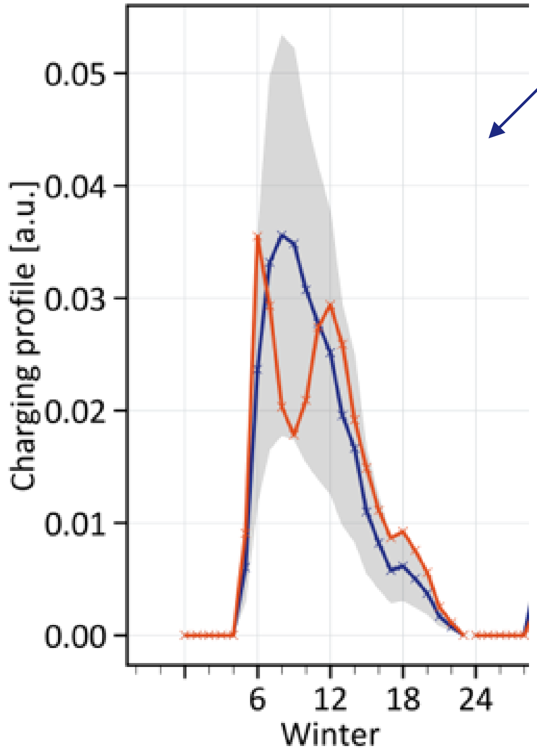
The electricity price is the driver for **When** and **Where** EVs charge

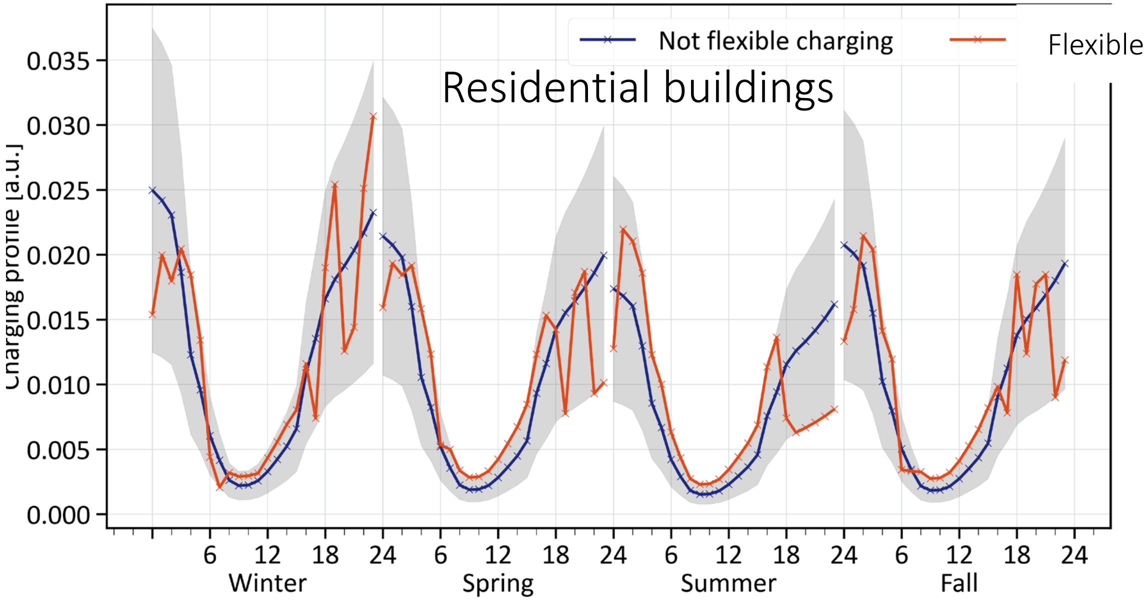
We assume a span of flexibility of 50 % on when EVS are charged.

Commercial and Residential buildings

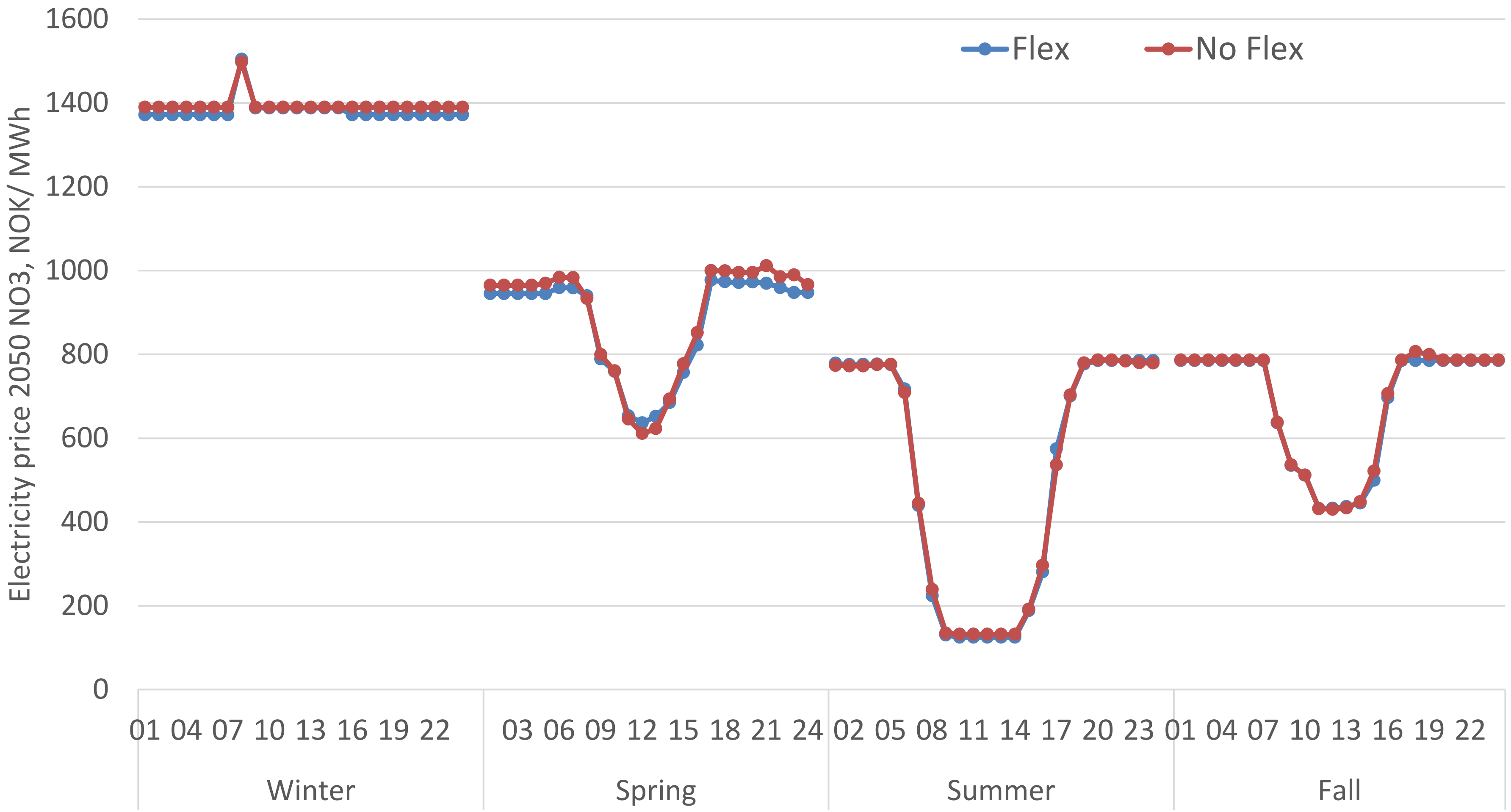
- Choses to charge at middle of day when PV is producing







End-use flexibility has limited impact on spot prices



Price reduction 2050

NO1: 0.05%

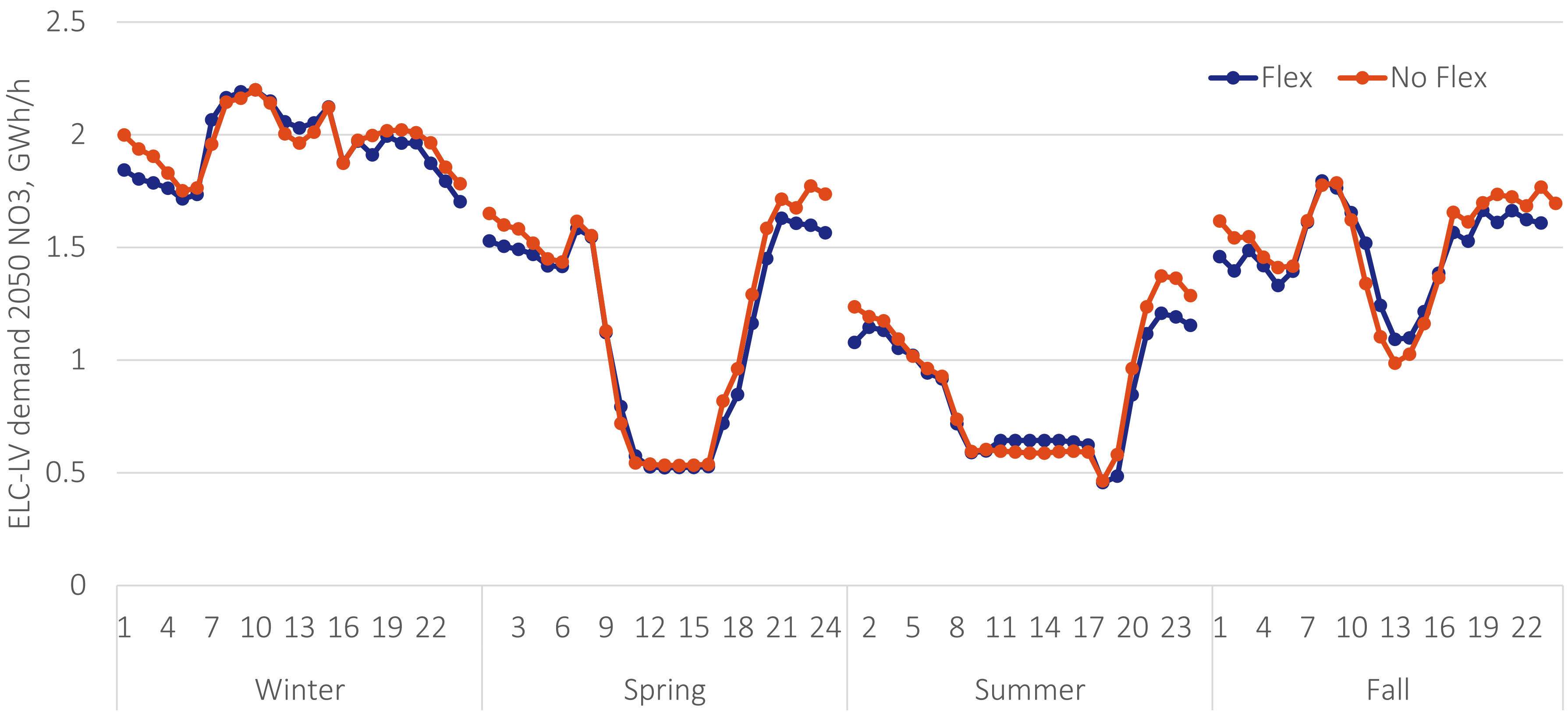
NO2: 0.05%

NO3: 1.2%

NO4: 0.33%

NO5: 0.05%

End-use flexibility does not impact expansion needs for the distribution grid



Peak increase 2050

NO1: + 0.13 GWh/h

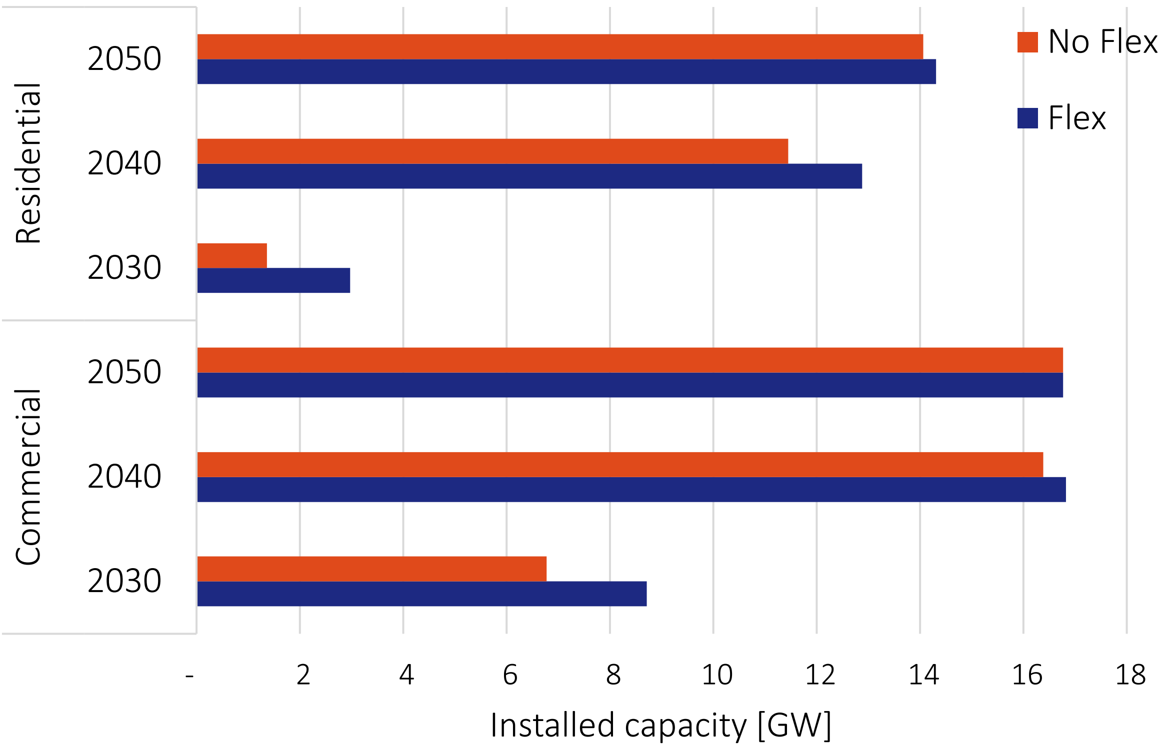
NO2: + 0.02 GWh/h

NO3: 0.00 GWh/h

NO4: + 0.01 GWh/h

NO5: - 0.01 GWh/h

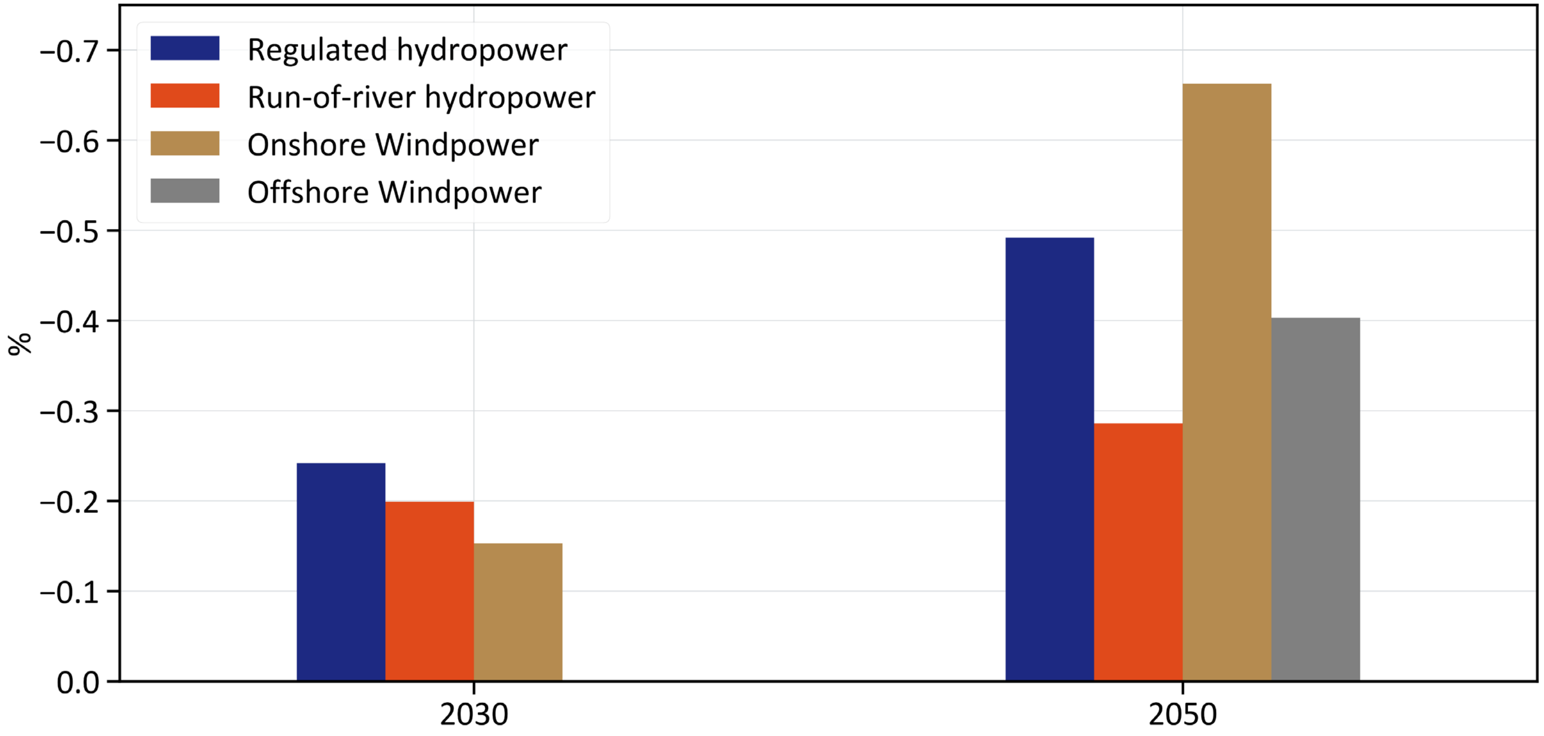
End-use flexibility accelerate investments in PV



- Only a change in PV
- No impact on wind power

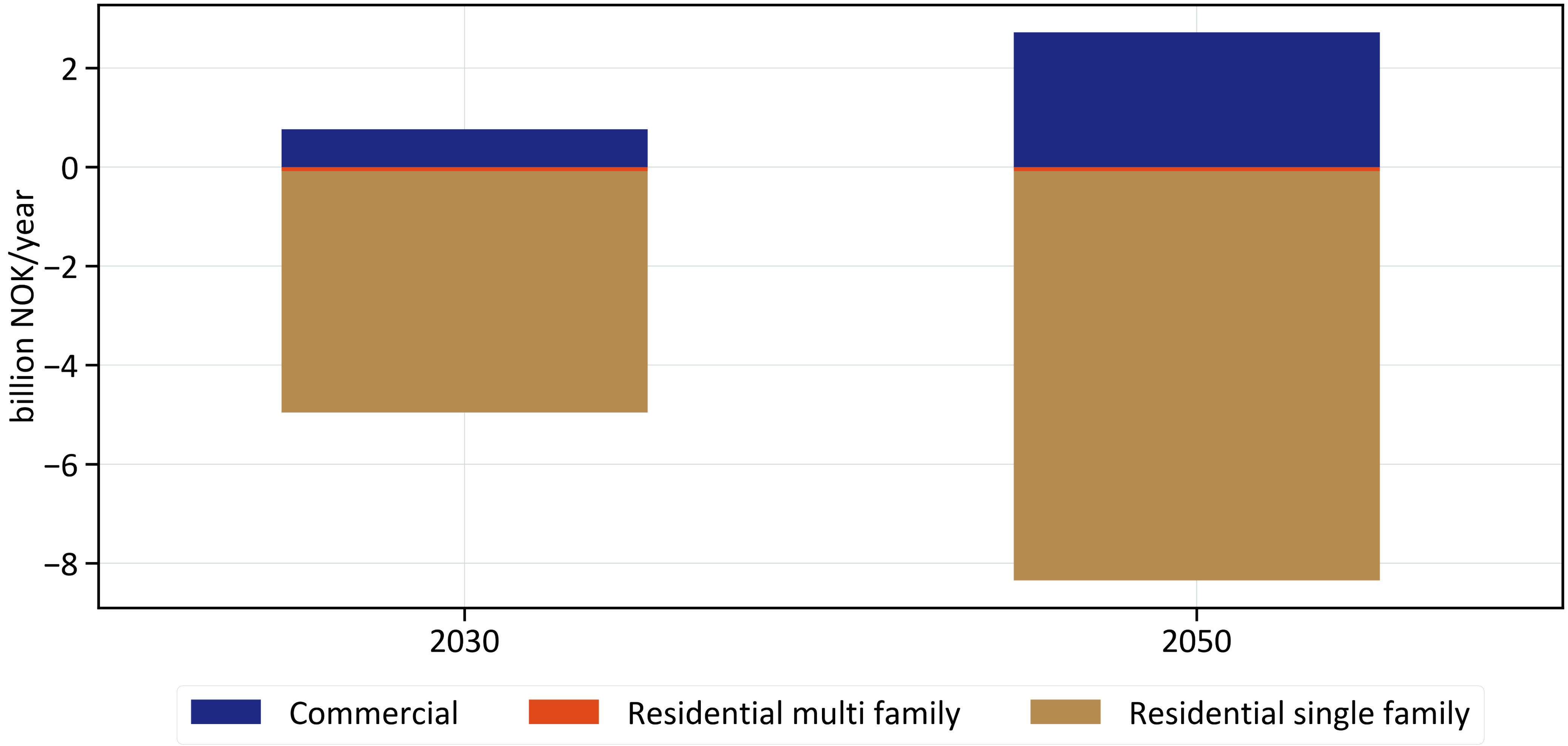
- **PV is profitable earlier**
  - 30 % more in 2030 in commercial buildings and 120 % more in residential buildings
  - The difference evens out and is 0 % and 2 % in 2050

End-use flexibility marginally lowers income of power producers



- Total loss in 2030: 0.23 billion NOK/year
- Total loss in 2050: 1.3 billion NOK/year
- **Less than 0.7 % of their yearly income.**
- Remember: The loss of revenue of supply side is only 1.3 billion NOK/year in 2050

End-use flexibility significantly lowers building electricity bill



- The total savings of end-users is 5.6 billion NOK/year in 2050 = 7% lower electricity bill
  - Remember: The loss of revenue of supply side is only 1.3 billion NOK/year in 2050

Conclusions and further work

End-use flexibility in Norway as a future Energy nation

- lowers energy costs of building owners and lowers profits of power producers
- is used to move demand in hours when the prices are low
- accelerate investments in building applied solar power
- does not necessarily lower peak demand

Further analysis

- end-use flexibility in alternative future scenarios
- sensitivity on grid tariffs
- address differences from an energy system and building owner perspective
- role of end-use flexibility in reserve markets