



TradeRES

New Markets Design & Models for
100% Renewable Power Systems

Market design issues for very high shares of wind and solar

KAKENHI Workshop: Challenges and Solutions for Power Systems with Large Shares of Renewables

10 May 2023

Niina Helistö, Senior Scientist, VTT Technical Research Centre of Finland

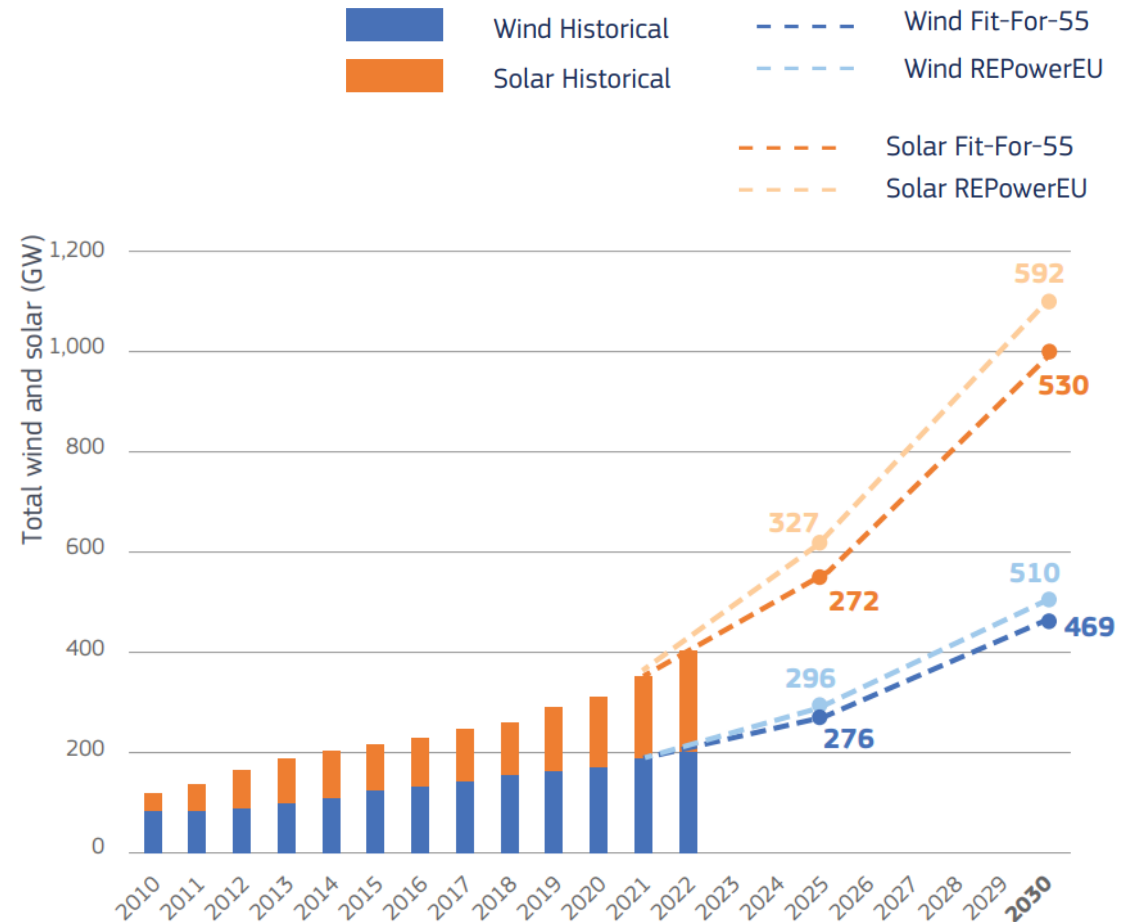


This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864276



Towards renewable integrated energy systems in Europe

- REPowerEU
 - end the dependency on Russian fossil fuel imports
 - plan for saving energy, producing clean energy, and diversifying our energy supplies
- Renewables are the cheapest and cleanest energy available, and can be produced domestically
- Enable industry and transport to substitute fossil fuels faster to bring down emissions and dependencies
- Additional investments of €210 billion needed between now and 2027
- Russian fossil fuel imports currently costing European taxpayers nearly €100 billion per year



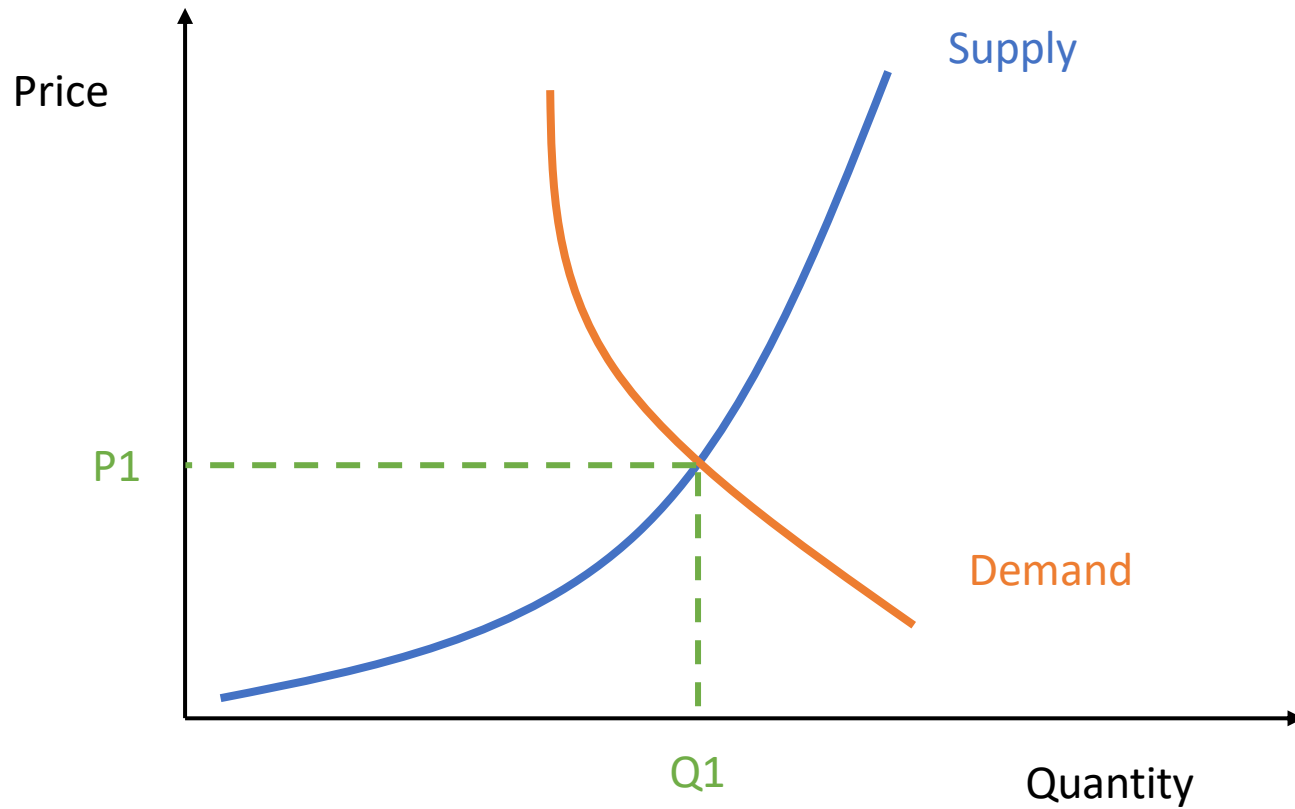


Market design goals and TradeRES approach

- European Commission: Revision of the electricity markets to
 - Boost renewable energy investments
 - Better protect and empower EU consumers
 - Enhance competitiveness of EU industry
- TradeRES: How can market designs ensure system adequacy, incentives for investments and effective management of the power balance?
- TradeRES approach
 - Energy system modelling is the key to successful analysis
 - Scenarios with varying levels of wind and solar energy and sector coupling
 - Optimisation tools that provide reference systems for testing new market designs
 - Further analysis using agent-based models



Supply and demand





Clearing in electricity spot markets

Current electricity market

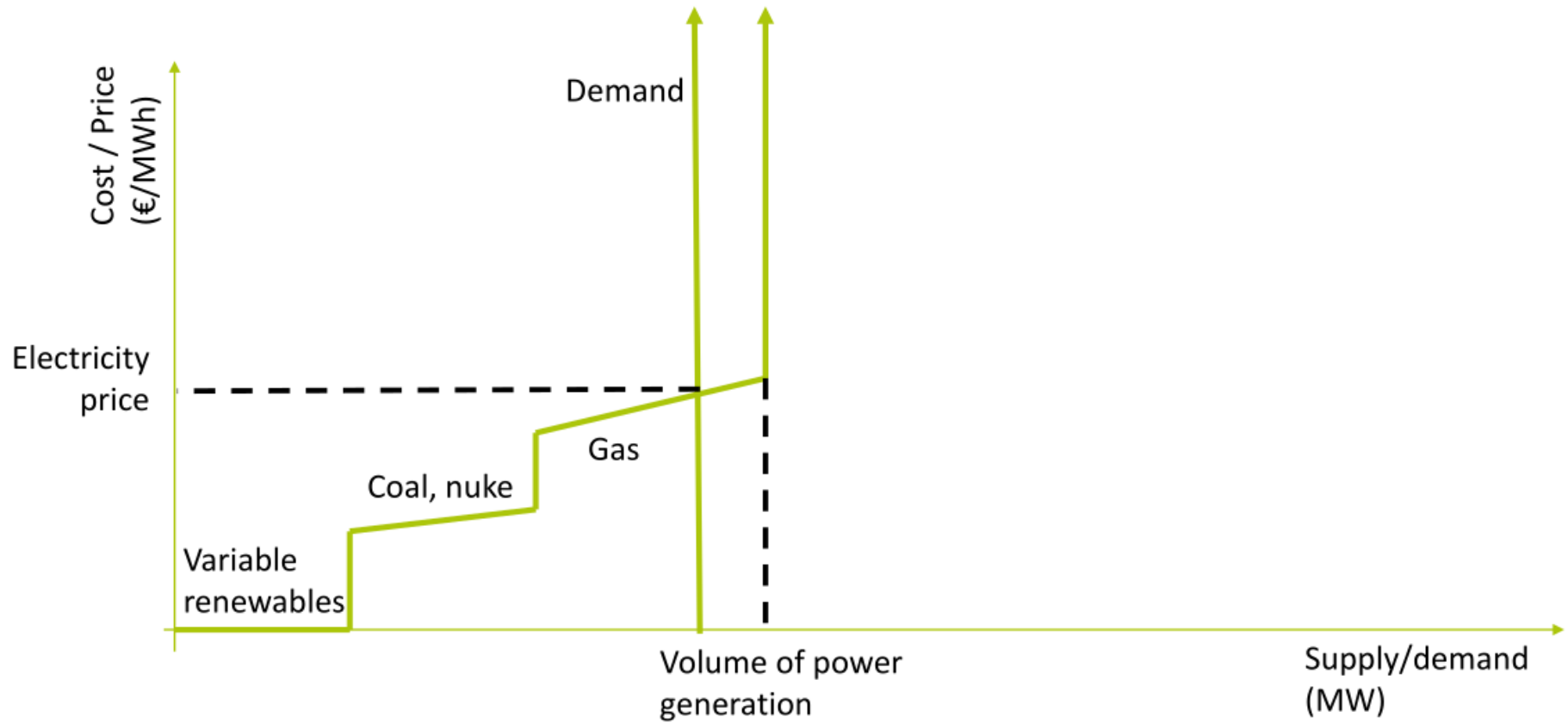


Figure: Laurens de Vries, TU Delft



Clearing in electricity spot markets

Current electricity market, high renewable generation

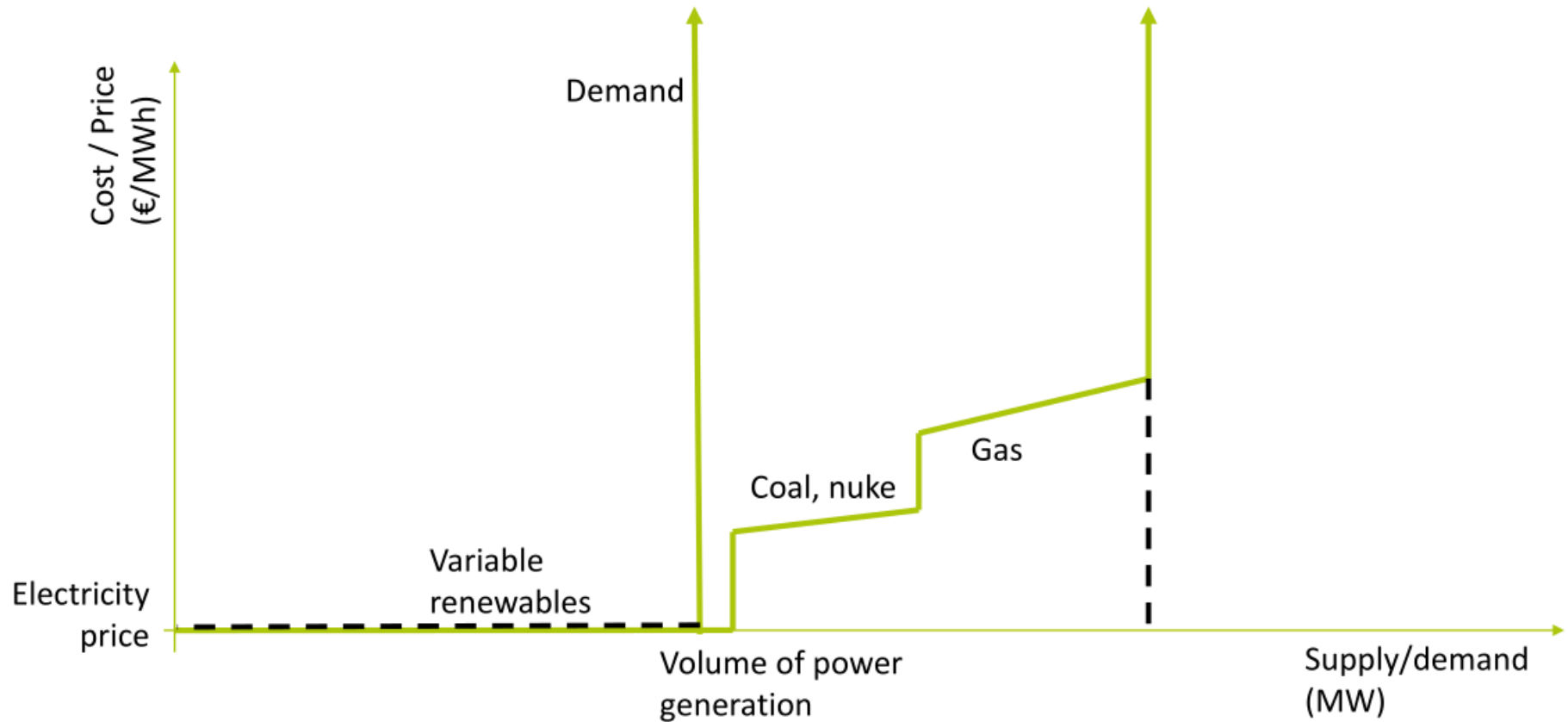


Figure: Laurens de Vries, TU Delft



Clearing in electricity spot markets

Future electricity market, low renewable generation

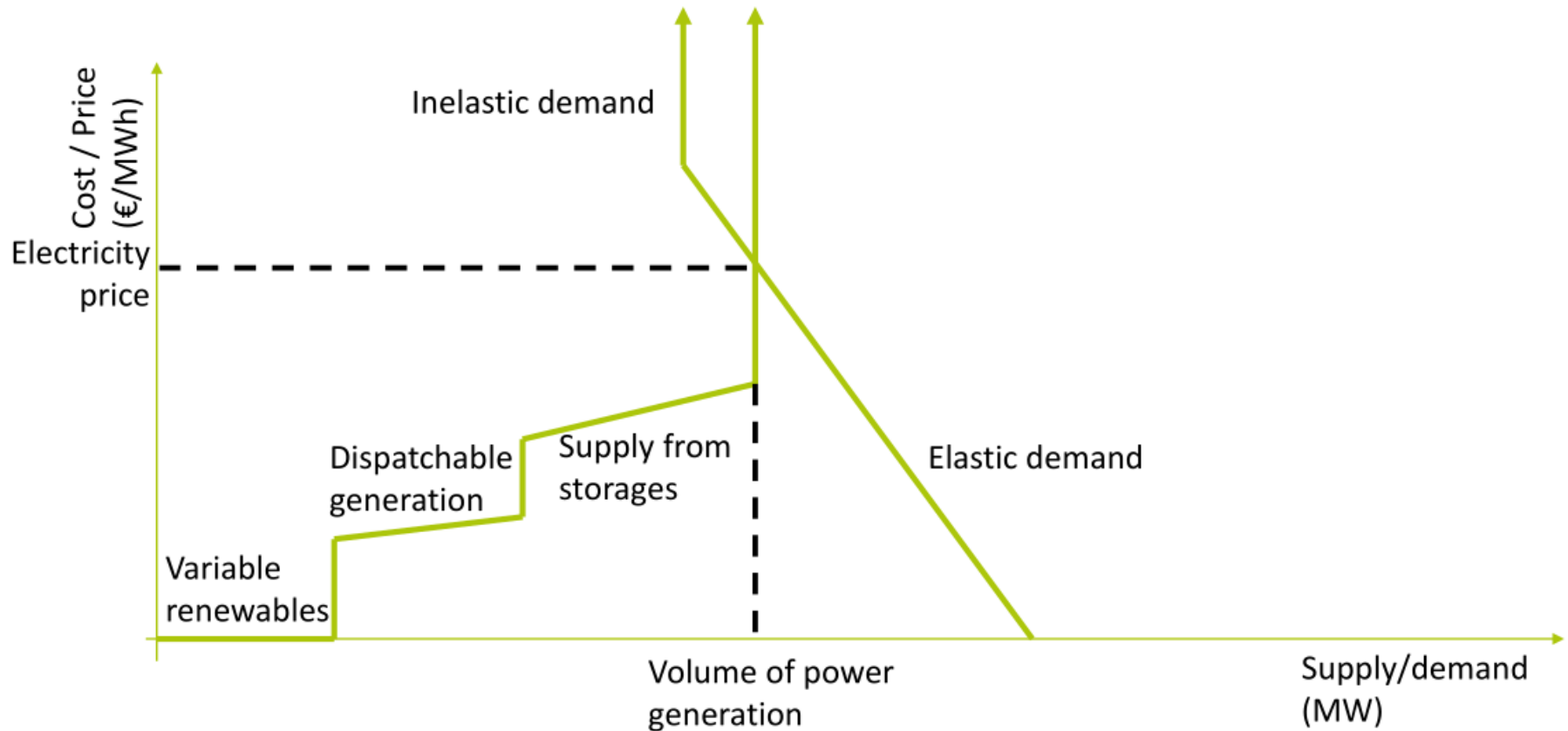


Figure: Laurens de Vries, TU Delft



Clearing in electricity spot markets

Future electricity market, high renewable generation

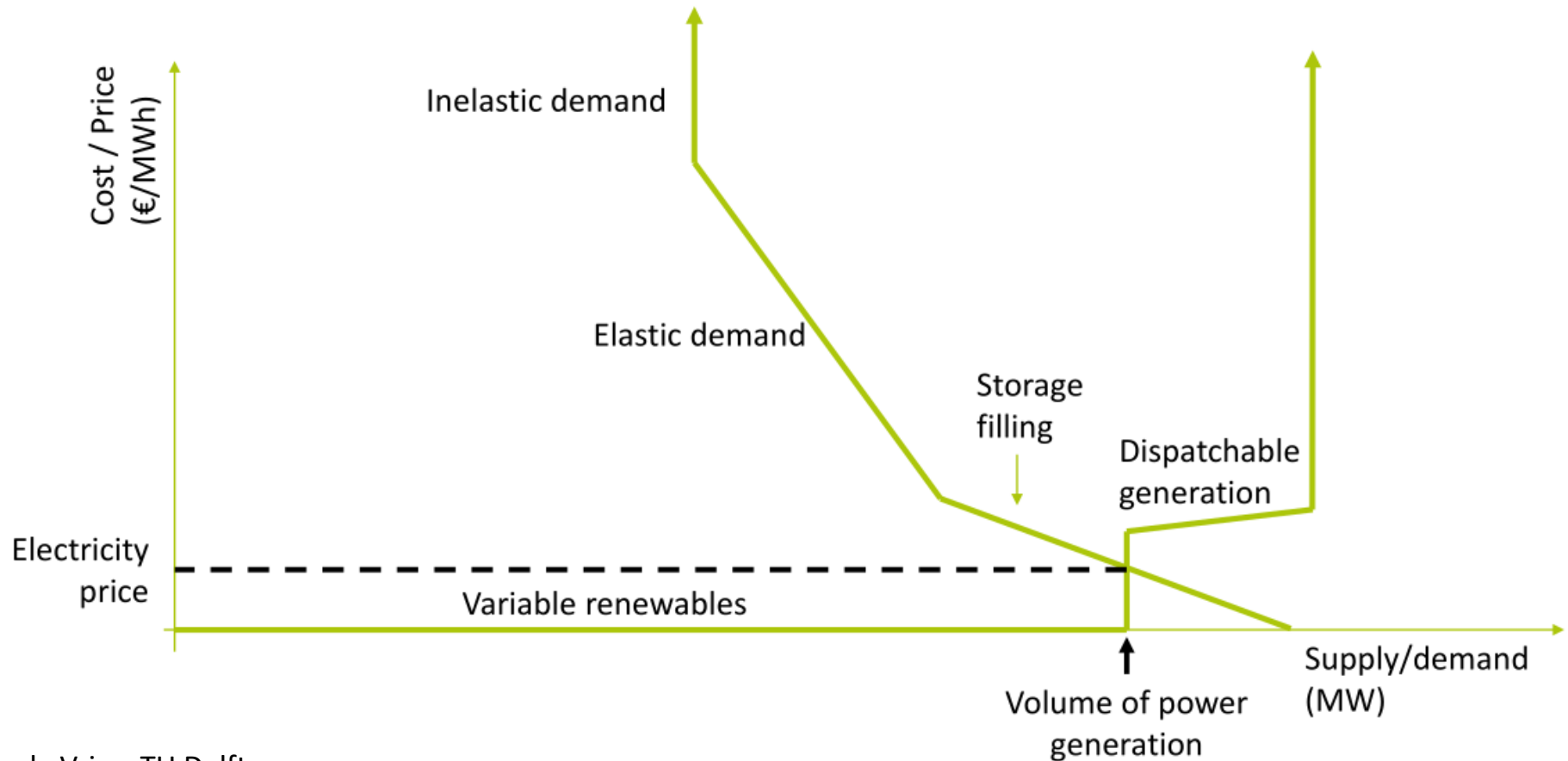
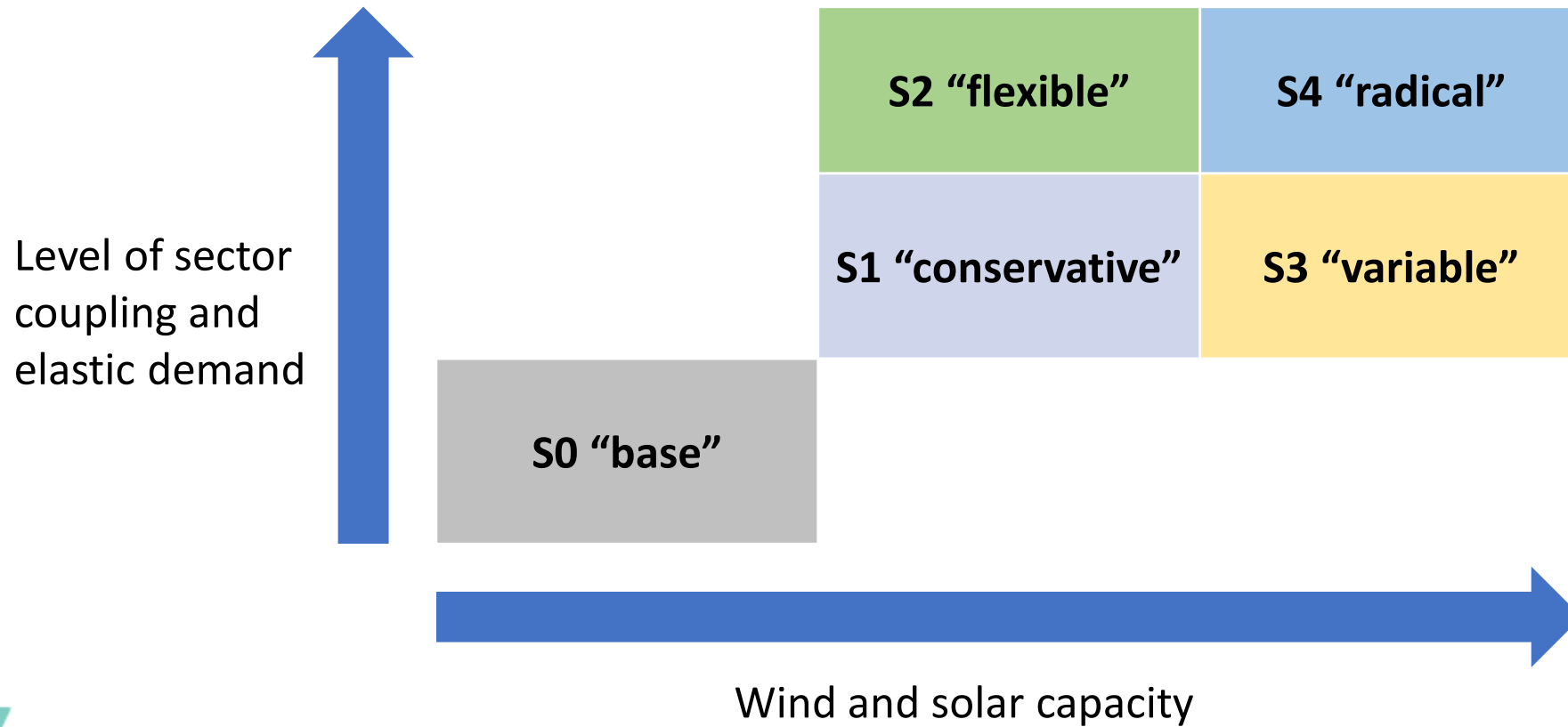


Figure: Laurens de Vries, TU Delft



Scenarios with varying levels of wind and solar energy and sector coupling





Energy system modelling

- Endogenous investments:
 - Solar photovoltaics (PV), concentrating solar power (CSP), wind, nuclear, batteries, electrolysers, hydrogen (H2) turbines, H2 storage
- Samples of the time series

- Exogenous capacities based on 2030 plans
 - Solar PV, CSP, wind, hydro, biofuel, waste, nuclear, batteries
 - Fossil in SO
 - Cross-border transmission
- Energy demand: electric vehicles, building heating, other electric loads, hydrogen, industrial load shedding units
- Full year hourly time series based on weather year 2019
- Fuel and emission data

Backbone modelling tool

Investment optimisation

Operational optimisation

Geographical Scope

- New capacities

- Production and consumption
- Transfers
- Price time series
- Total costs

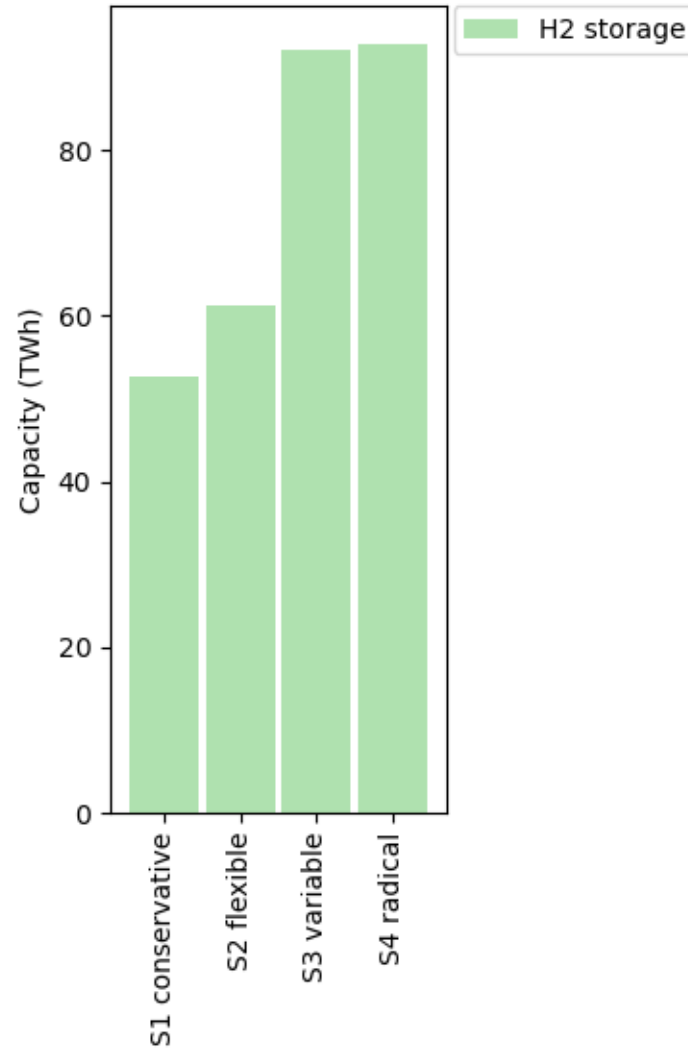
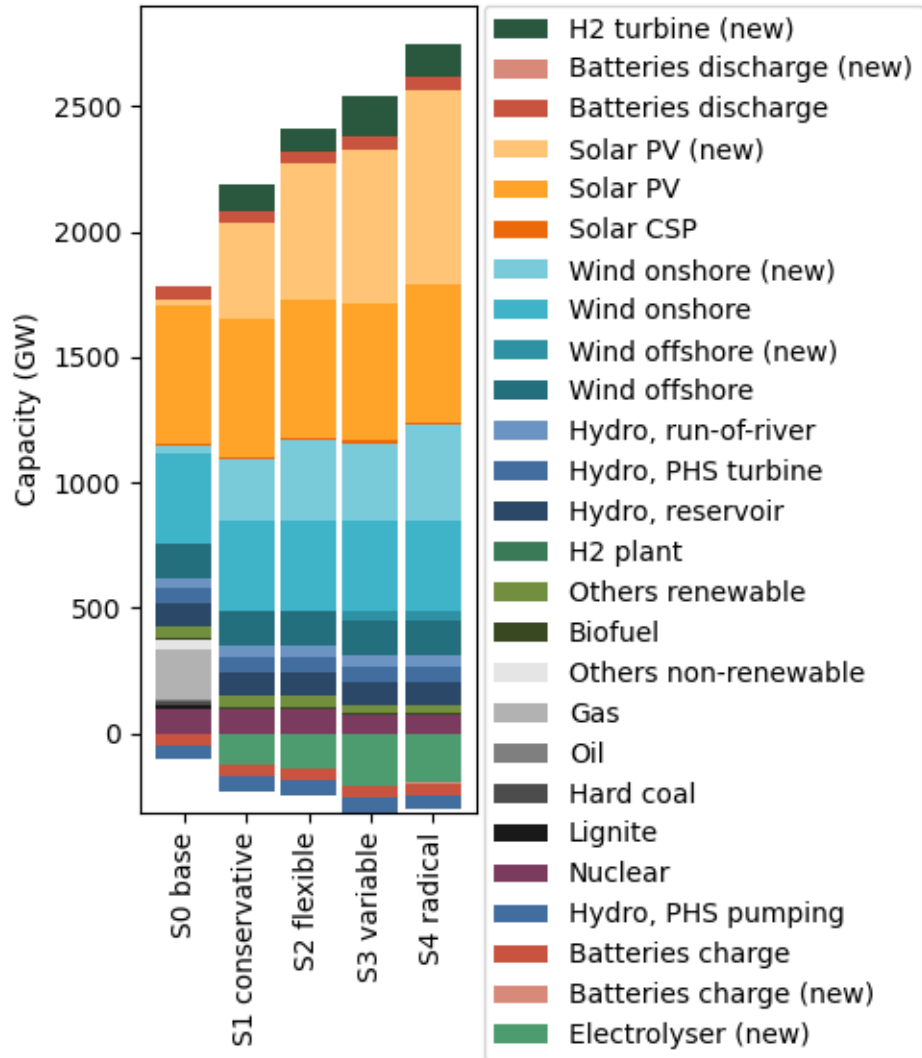
- Focus on energy markets
- No PPAs, CfDs, forwards, futures, reserve products



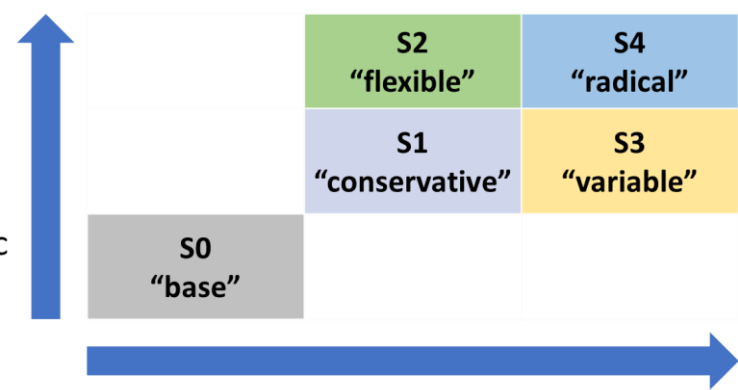


Results

Capacities



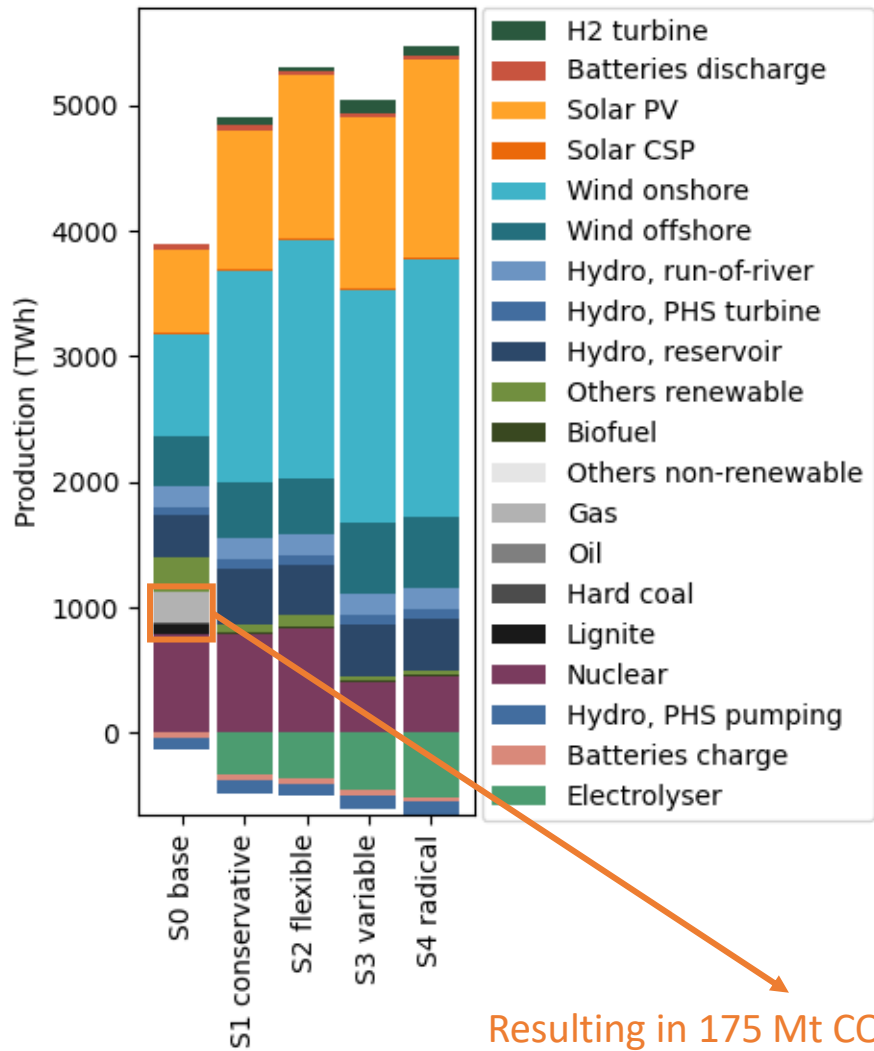
Level of sector coupling and elastic demand





Results

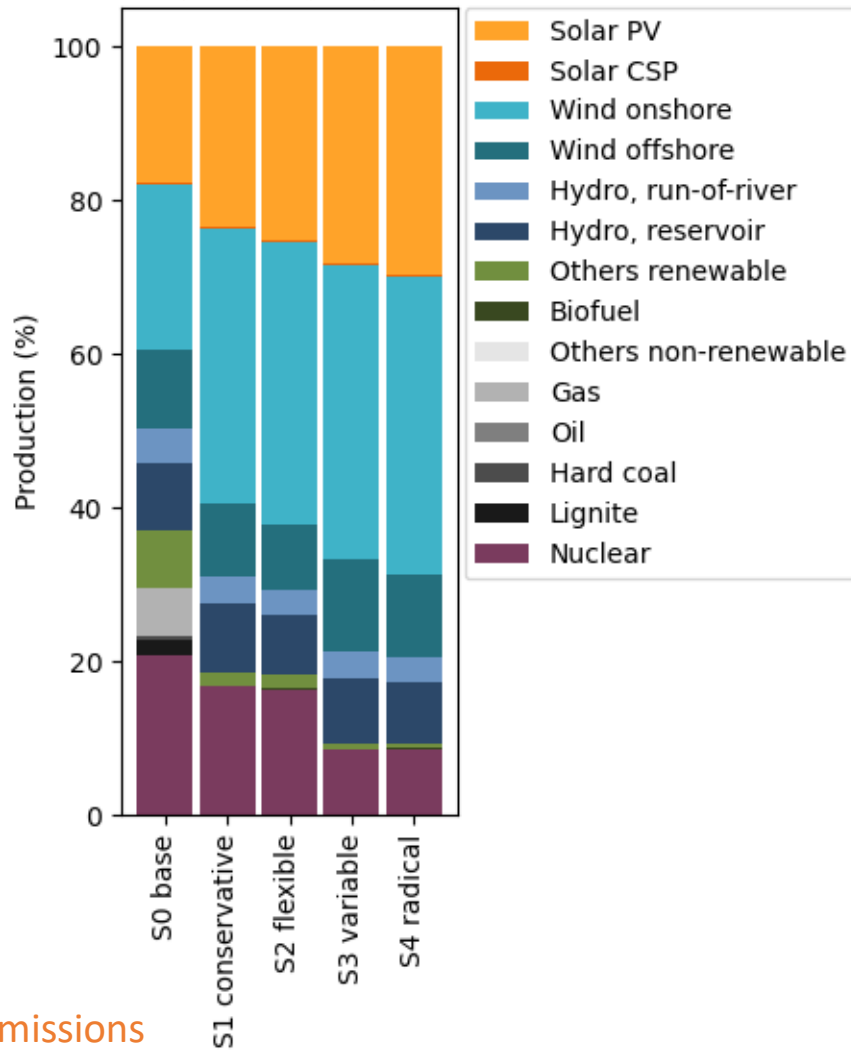
Production



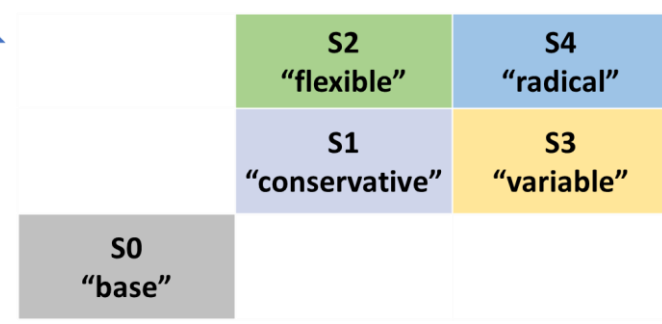
Resulting in 175 Mt CO₂ emissions

Share of wind + solar (%):

50, 70, 70, 80, 80



Level of sector coupling and elastic demand



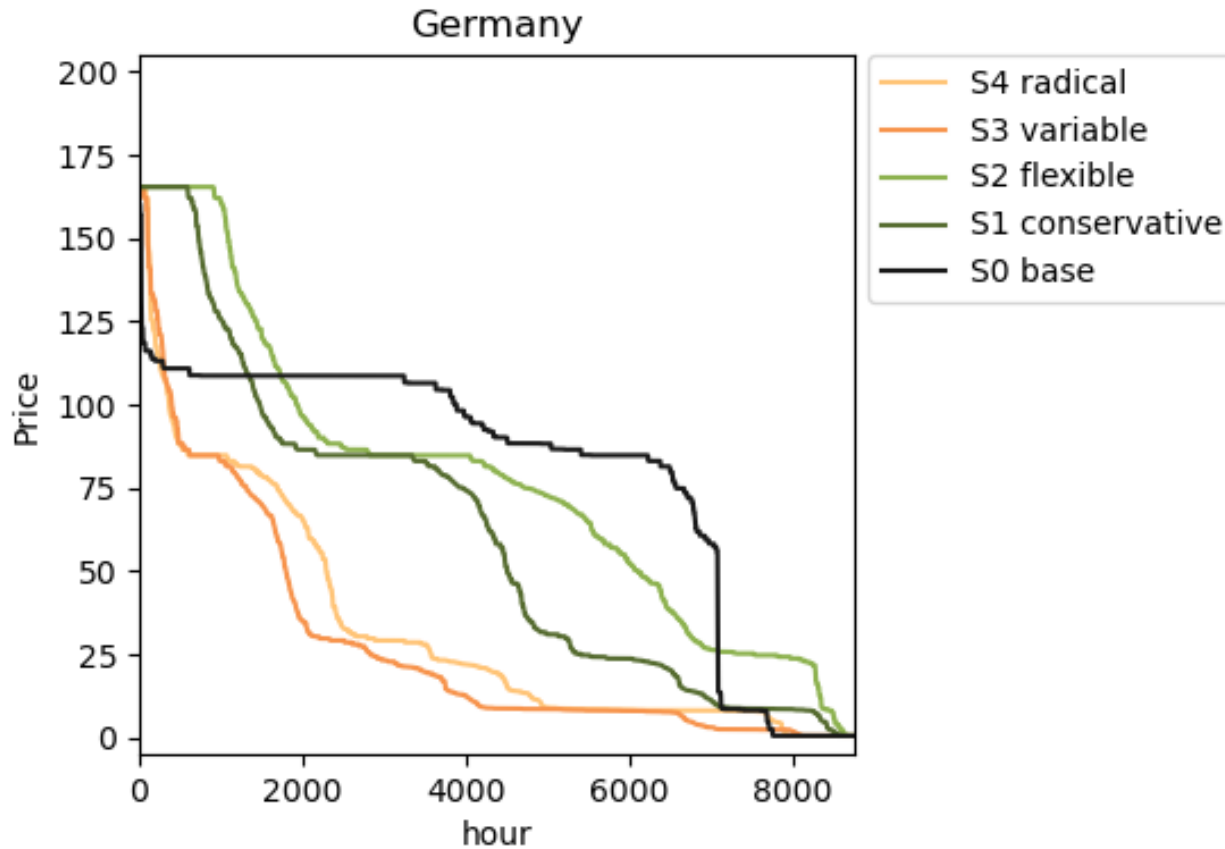
Wind and solar capacity



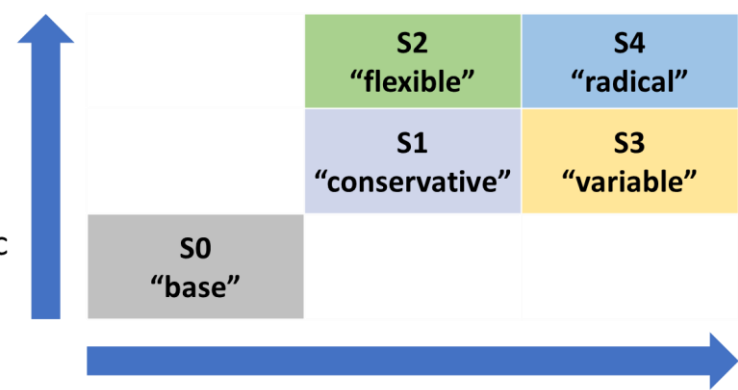


Results

Electricity price duration curves



Level of sector coupling and elastic demand



Wind and solar capacity



Conclusion and remarks

- Energy system modelling to analyse optimal investments and operation
- Scenarios with varying levels of wind and solar energy and demand-side flexibility that provide reference systems for testing new market designs
- Huge investments in both wind power and solar PV
 - to achieve ~70%-80% variable RES and ~85%-95% RES power system
 - to get rid of CO₂ emissions in power production and reduce emissions in industry, transport and heating of buildings
- Huge amounts of wind and solar increase the variability of electricity prices
- Additional demand-side flexibility from sector coupling and electrification can help reduce the variability of the prices and the number of hours with very low prices
- Large scale wind and solar need to participate and need to be allowed to participate in energy and reserve markets to ensure effective balancing of supply and demand
- Support mechanisms such as Contracts for Differences (CfDs) can promote investments but can also cause market distortions



TradeRES

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Thank you!

Niina Helistö

niina.helisto@vtt.fi

www.traderes.eu



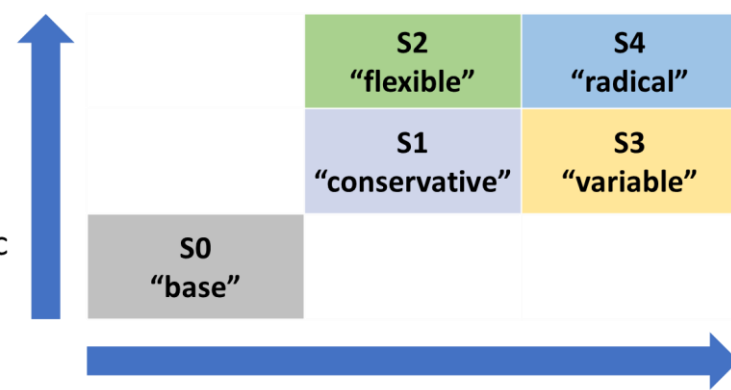
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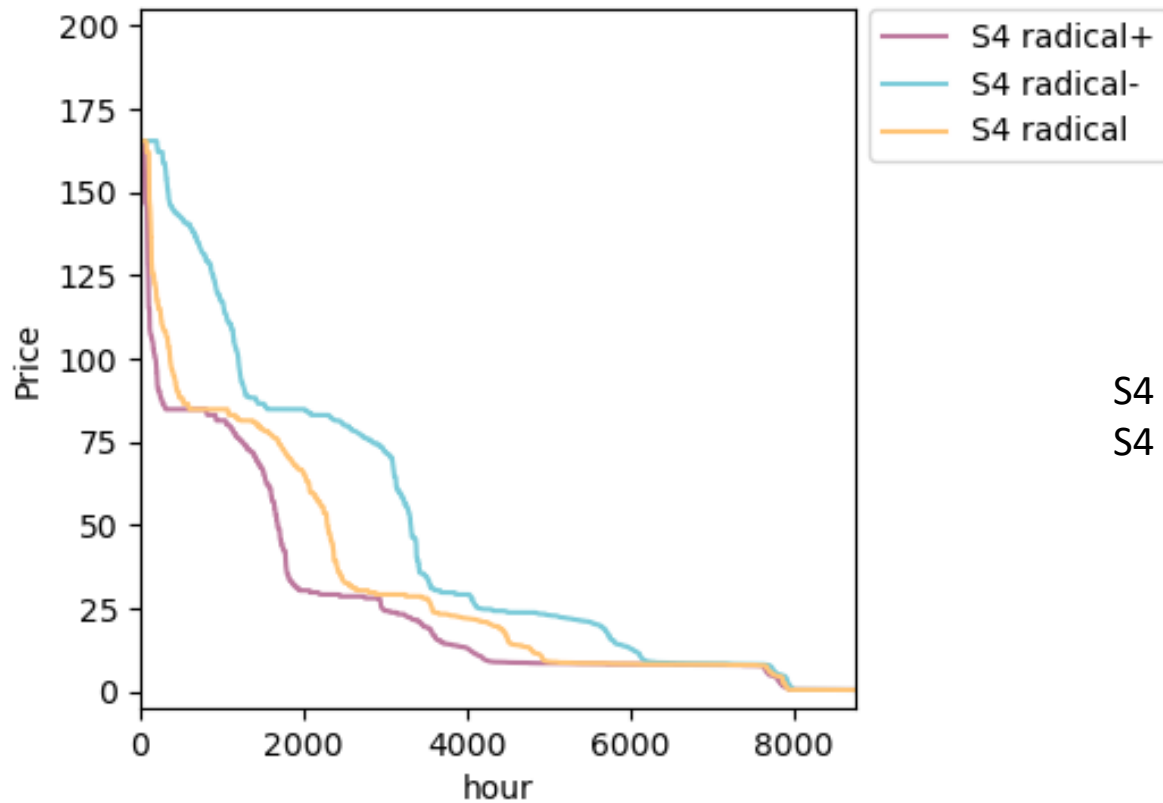
Results

Electricity price duration curves

Level of sector coupling and elastic demand



Germany



S4 radical+ has more thermal capacity
S4 radical- has less thermal capacity