TradeRES

New Markets Design & Models for
100% Renewable Power Systems

Assessments of Market Designs and Market Values in TradeRES Considering Actor Decisions

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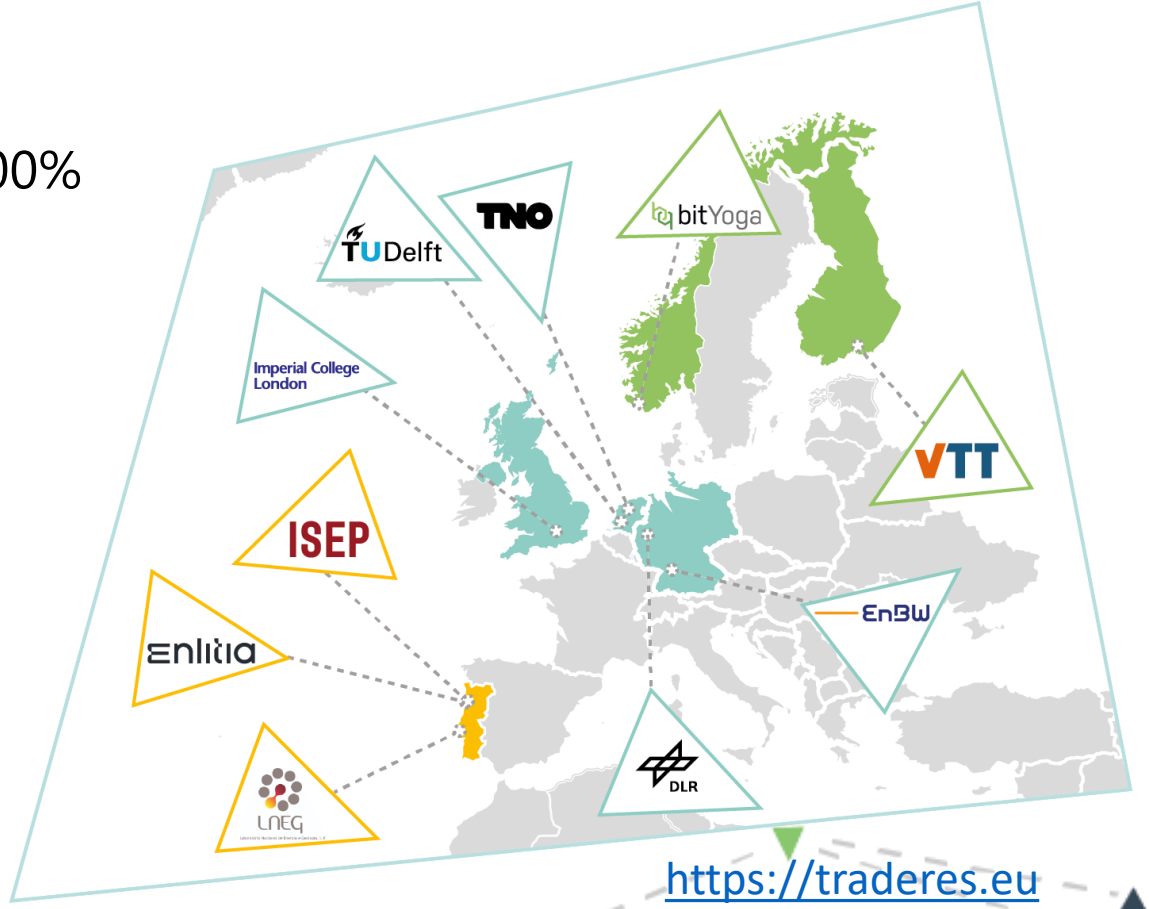
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864276

TradeRES
Overview

Market Designs & Models for a ~100% Renewable European Power System

Goals

1. Develop new electricity market designs for ~100% renewable power systems
2. Model and simulate new market agents, procedures, and mechanisms
3. Develop open-access tools for market analysis
4. Engage key stakeholders



https://traderes.eu

Case Study C: Germany
Research question

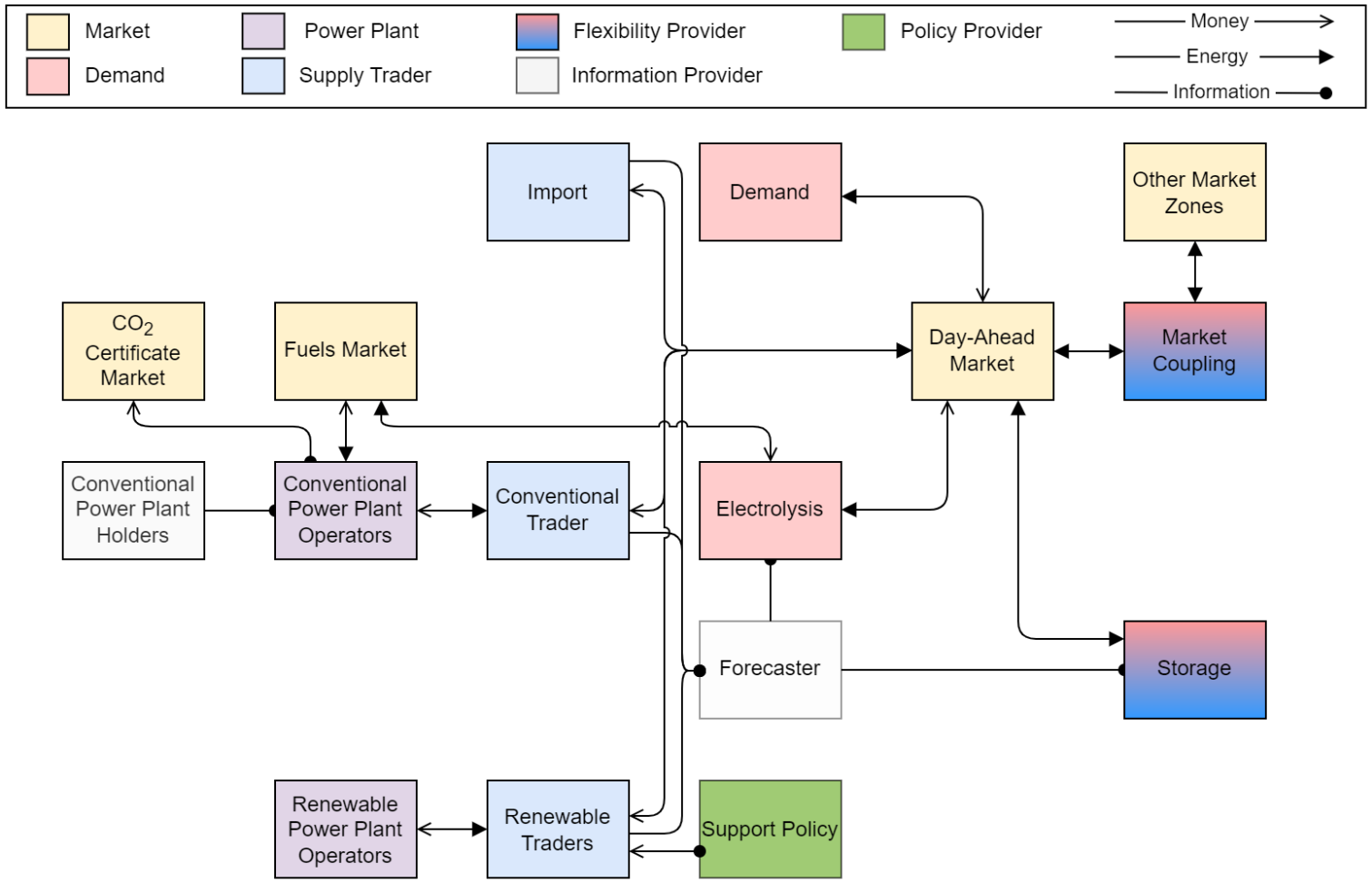
*Are **RES remuneration schemes** needed and if so, how should they be designed?*

Approach

- Dispatch simulation of electricity market
- Vary support instruments
- RES traders consider support instruments in their bid
- Check market performance indicators

AMIRIS

Agent-based **M**arket model for the **I**nvestigation of **R**enewable and **I**ntegrated energy **S**ystems

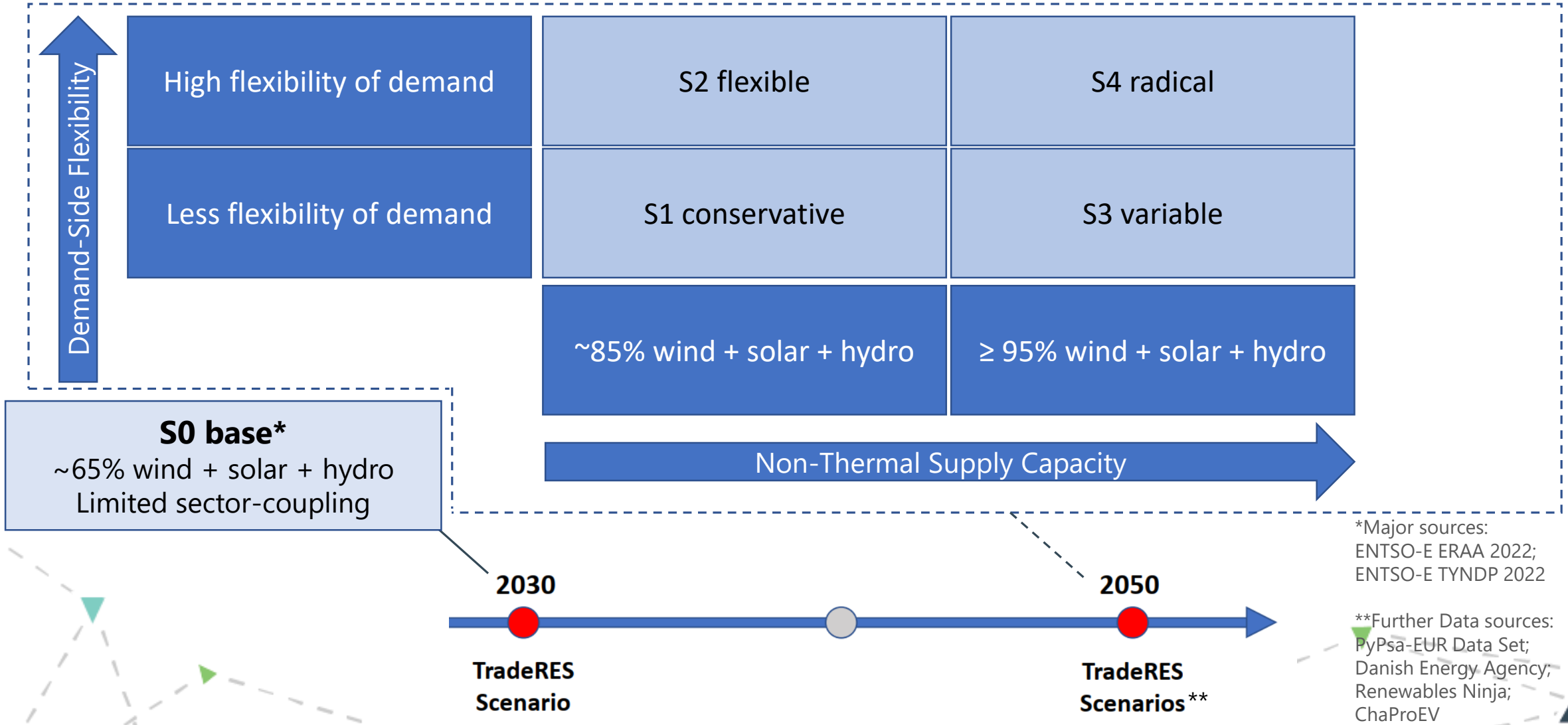


- is an **agent-based** model for the power market
- models **business-oriented,** strategic dispatch decisions
- considers **different regulatory framework conditions**
- is available **open source**

https://dlr-ve.gitlab.io/esy/amiris/home/

TradeRES Scenarios

Differing in Flexibility of Demand and Supply

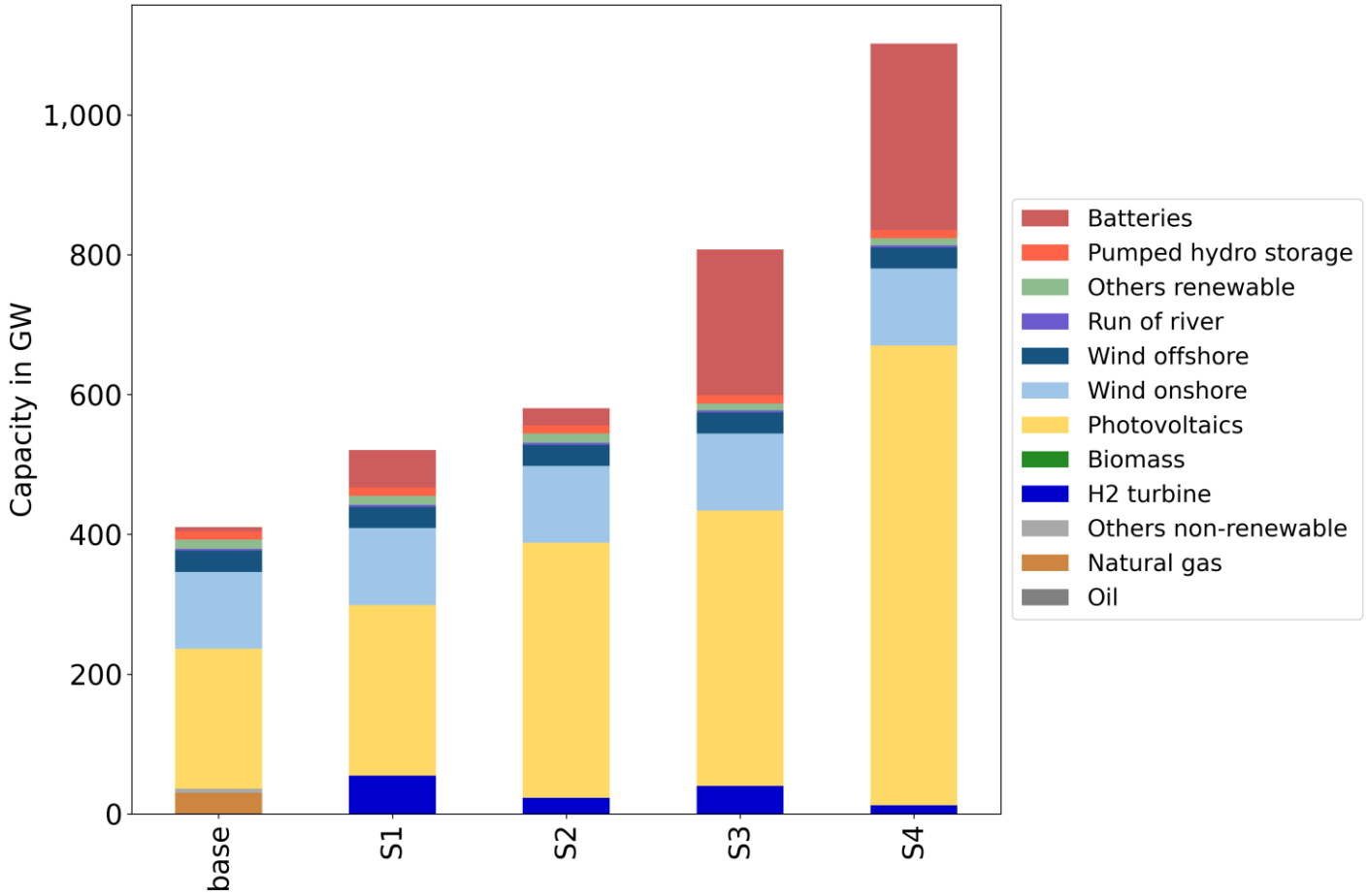


*Major sources:
ENTSO-E ERAA 2022;
ENTSO-E TYNDP 2022

**Further Data sources:
PyPsa-EUR Data Set;
Danish Energy Agency;
Renewables Ninja;
ChaProEV
Rasku (2022)

TradeRES Scenarios

Installed capacities from Backbone[1]



	vRES:	*~85%*	*≥ 95%*
High flexibility		*S2*	*S4*
Less flexibility		*S1*	*S3*

S0: base, ~65% vRES

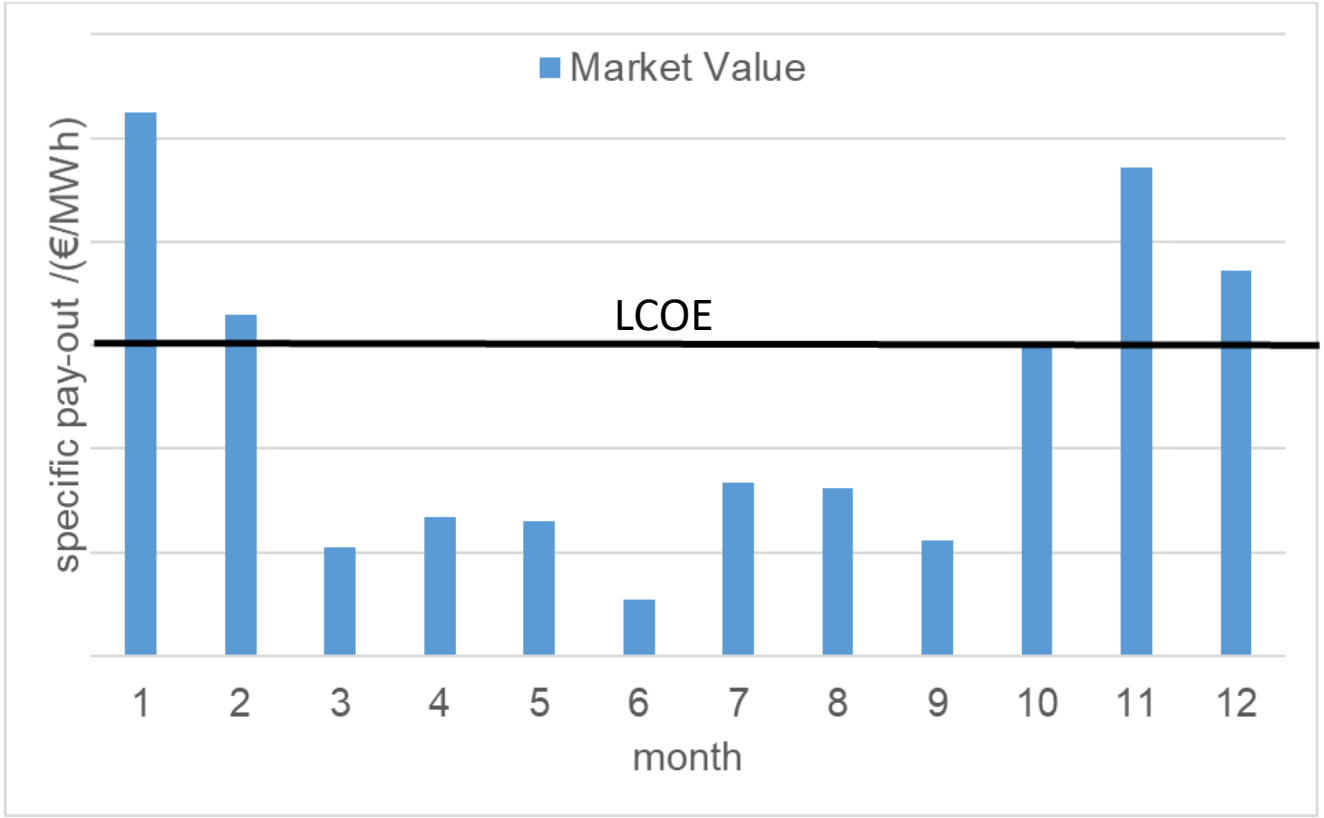
- S1-S4: ~100% renewable energy system
- Scenarios are dominated by **PV** and **batteries**, especially for scenarios S3 and S4
- Backup capacity: **H2 turbines**, particularly in S1 and S3
- Little investment in wind

[1] https://gitlab.vtt.fi/backbone/backbone

German Case Study
Research design

Analysed support instruments

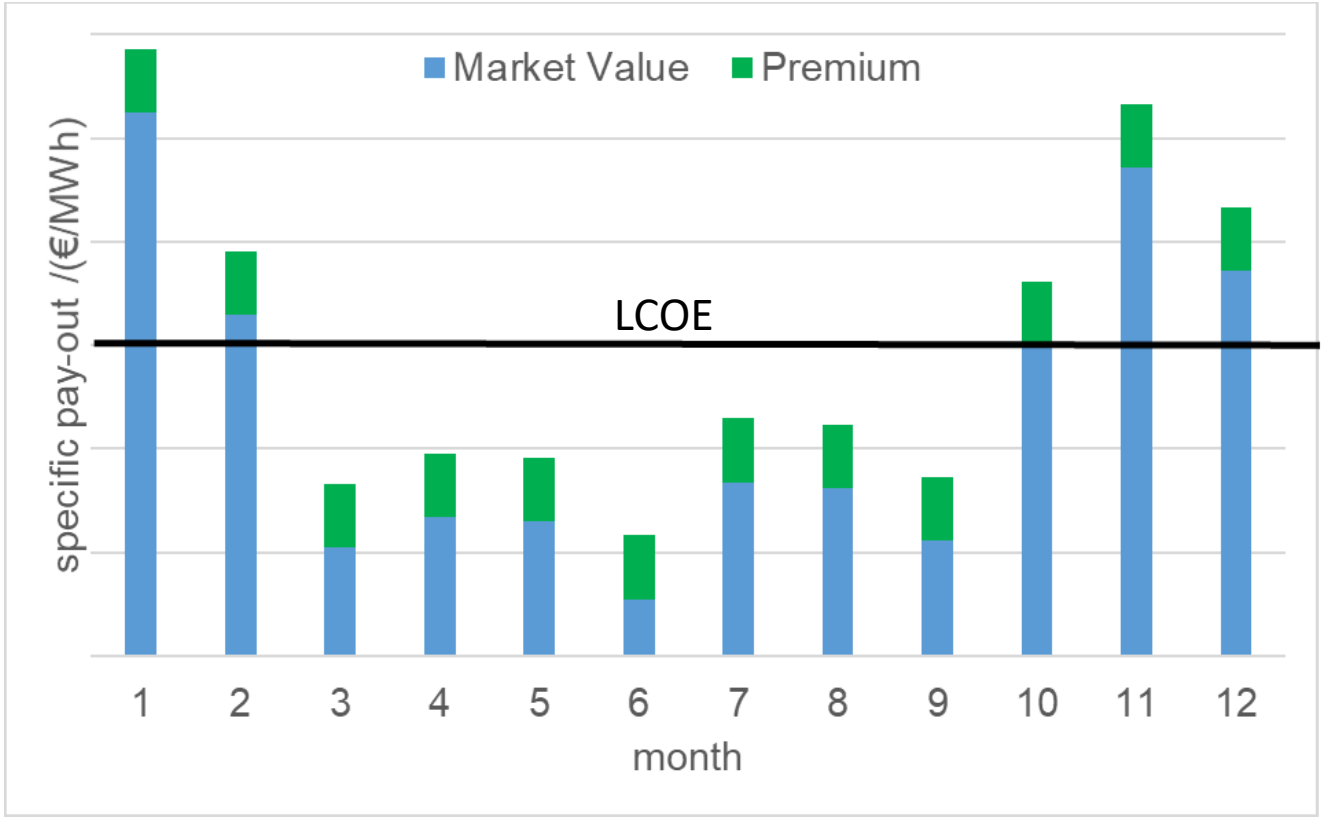
- "**NONE**": no support



German Case Study
Research design

Analysed support instruments

- "**NONE**": no support
- "**MPFIX**": fixed market premium (ex ante)



German Case Study
Research design

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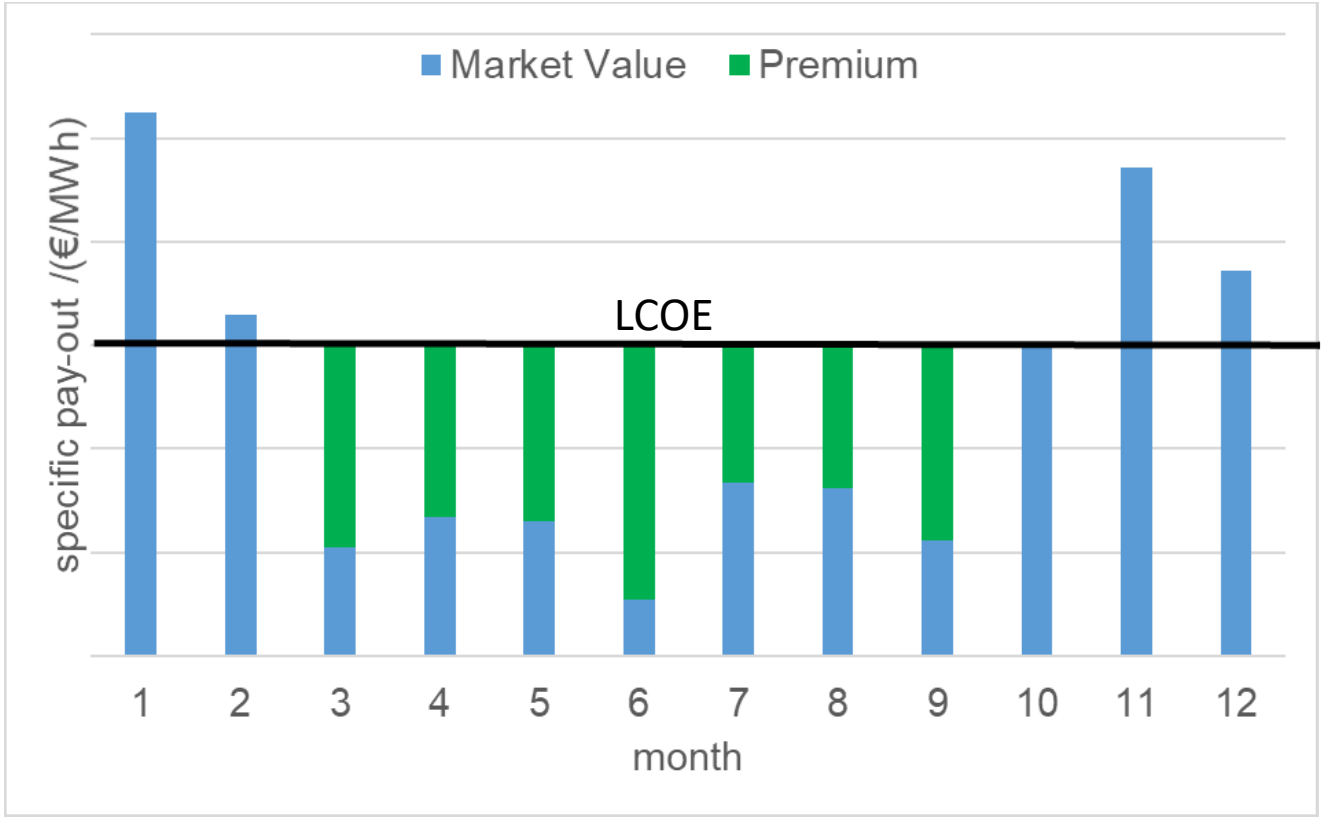
- "**1-WAY-CFD**": variable market premium (ex post) with a *monthly* reference period



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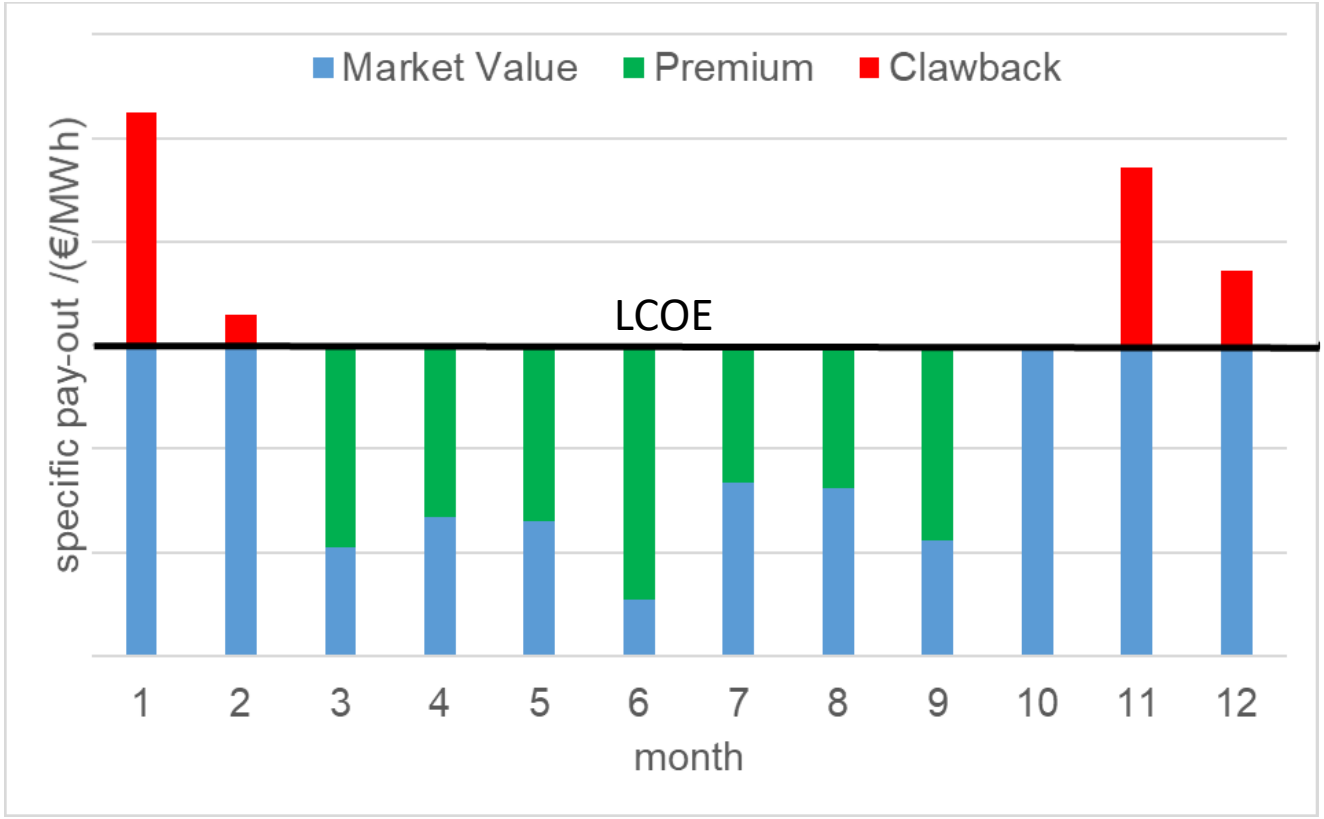
- "**1-WAY-CFD**": variable market premium (ex post) with a *monthly* reference period
- "**2-WAY-CFD**": two-way Contracts for Differences (CfD) as extension to the market premium (ex post) with a *monthly* reference period



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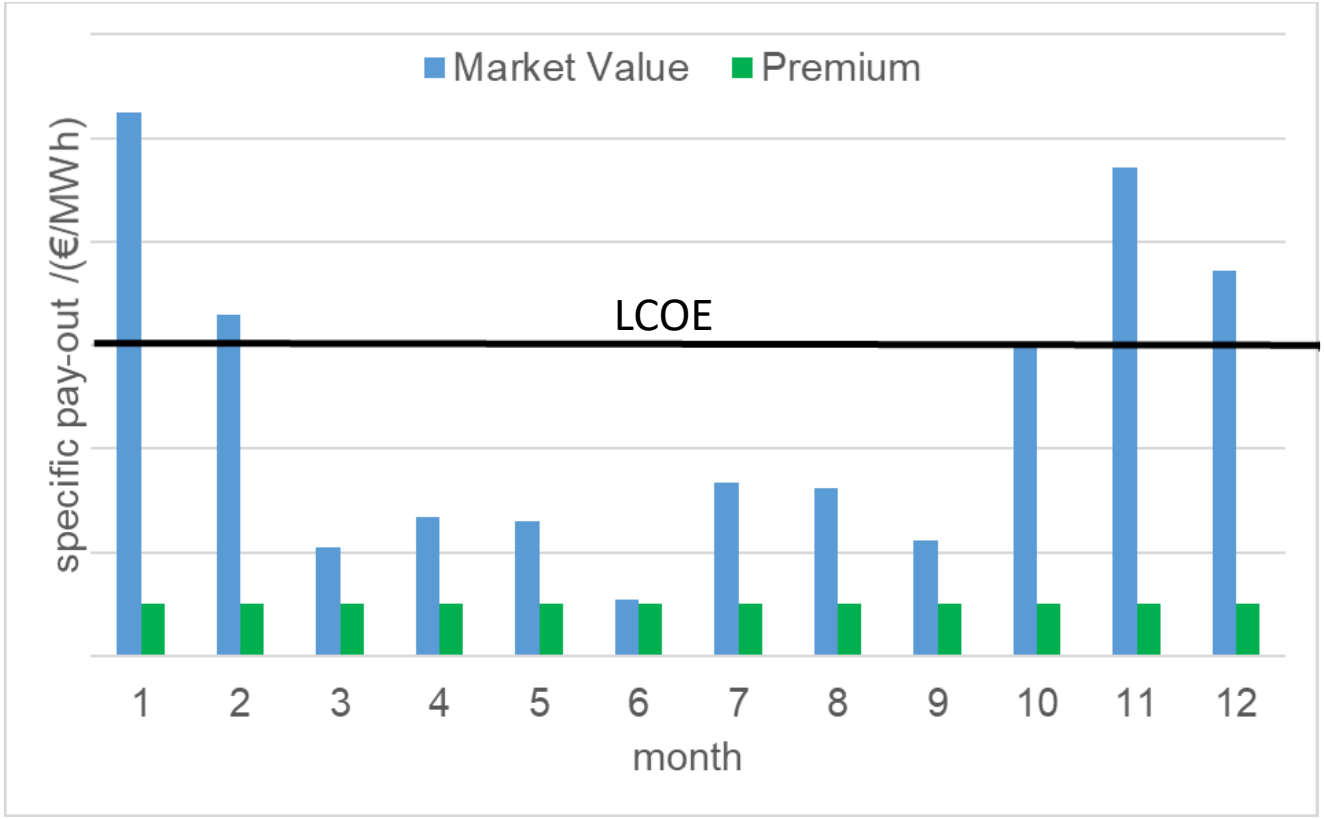
- "**CP**": fixed capacity premium



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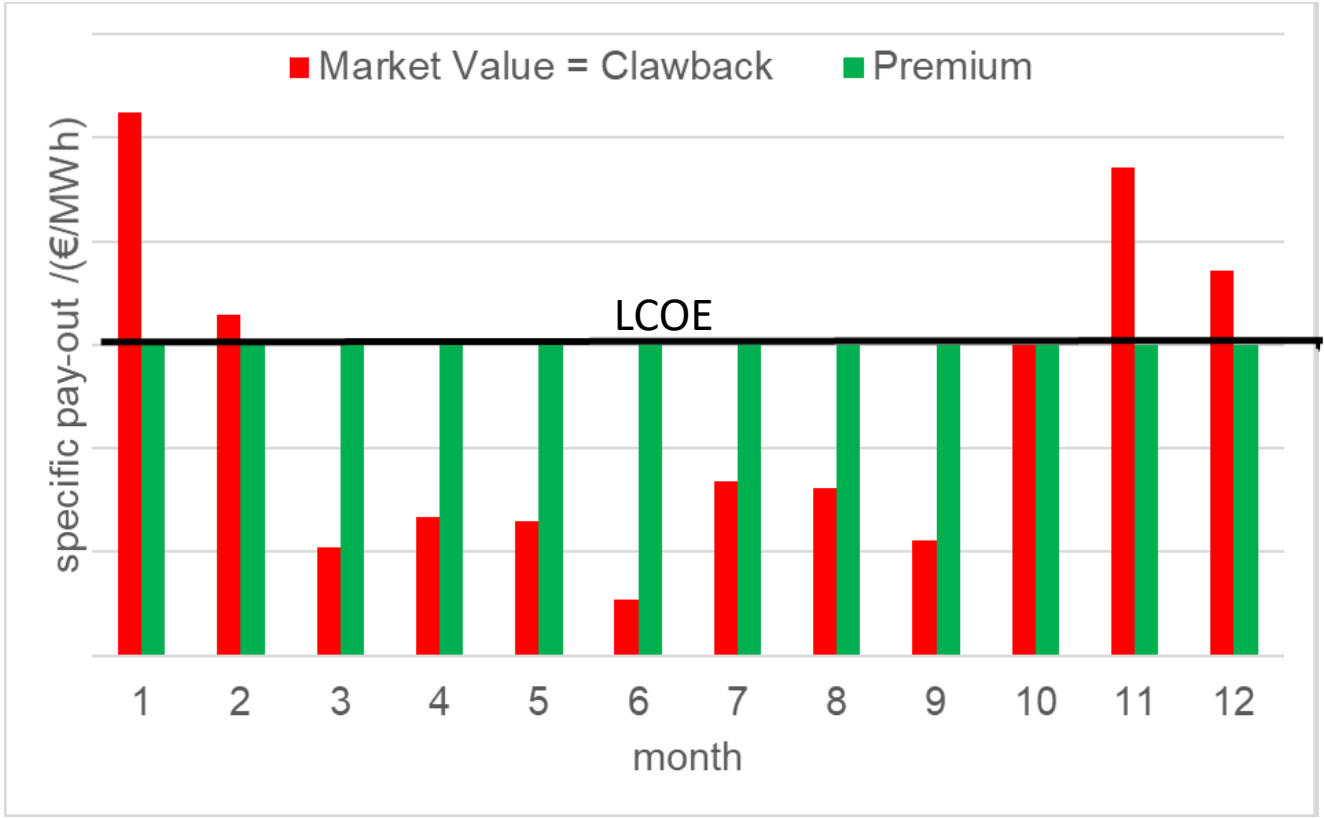
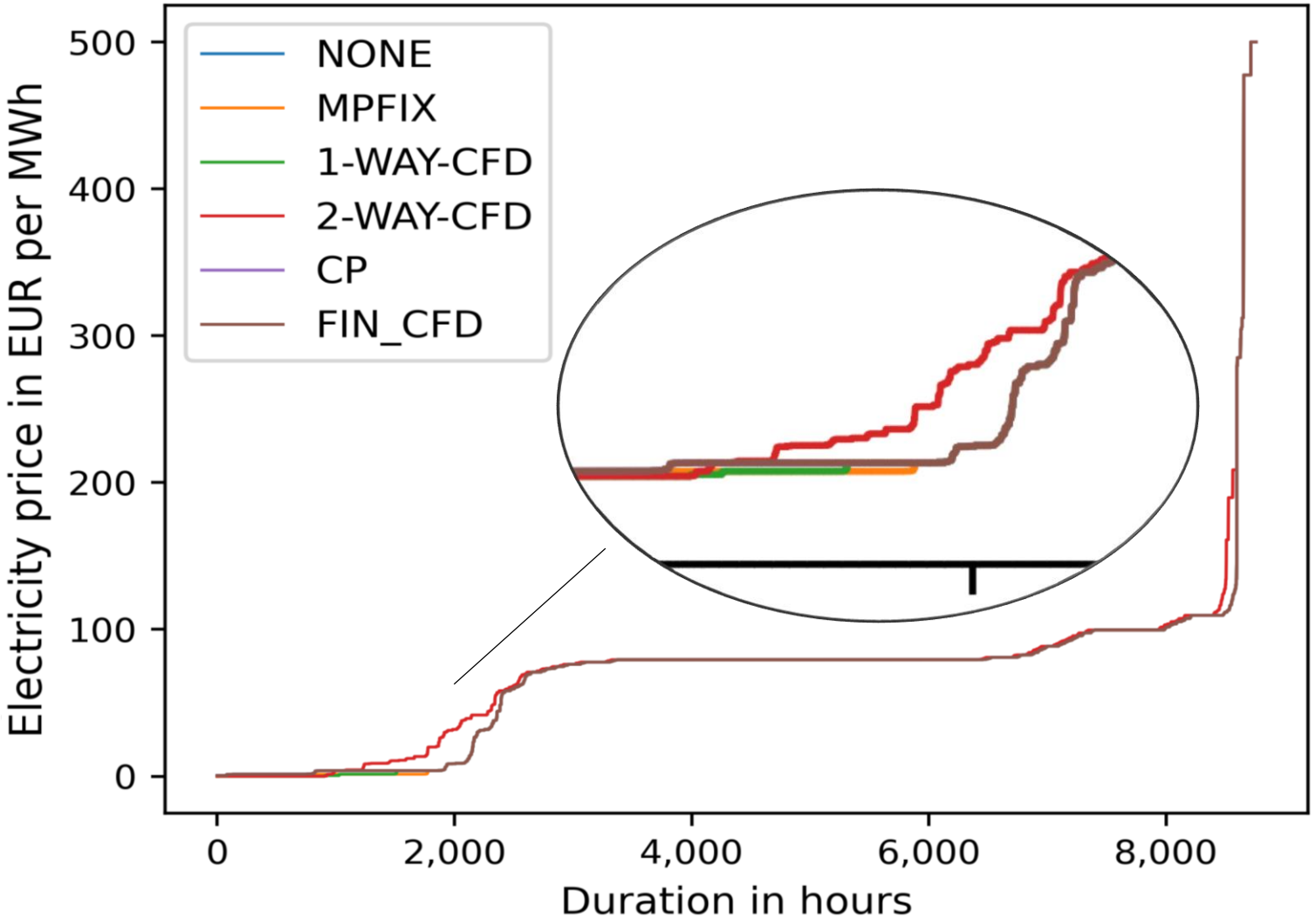
- **CP**": fixed capacity premium
- "**FIN_CFD**": Financial CfD, as suggested by Schlecht et al. (2023) with country average as reference plant



→ **Support instruments influence bidding behaviour**

Day-ahead electricity prices
Scenario S1



MPFIX, 1-WAY-CFD

vRES traders factor opportunity cost of premium in supply bids
→ lower prices

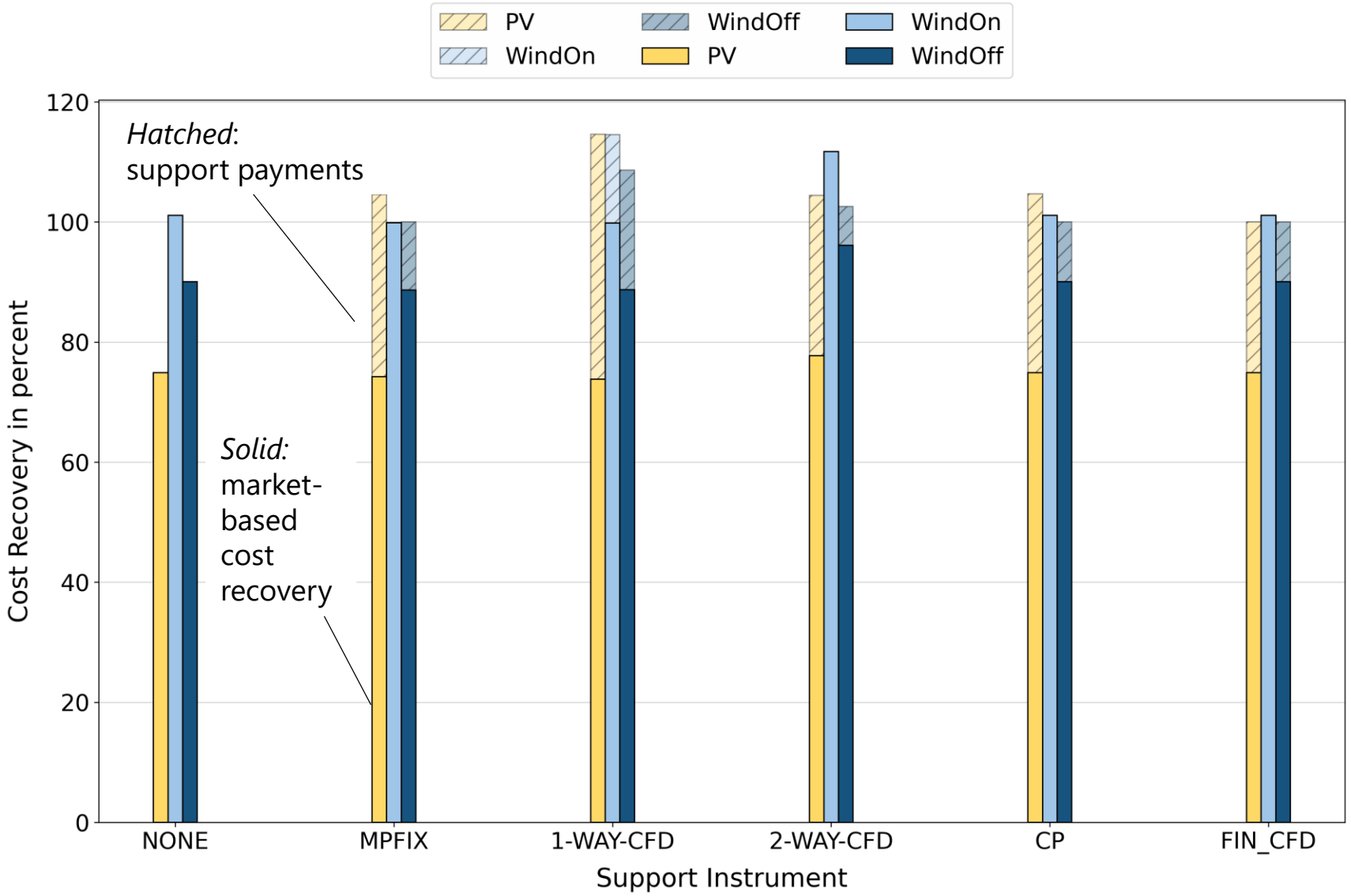
2-WAY-CFD

vRES traders bid at higher prices due to payback obligation in clawback periods
→ higher prices

CP, FIN-CFD

support not based on production
→ no price impact

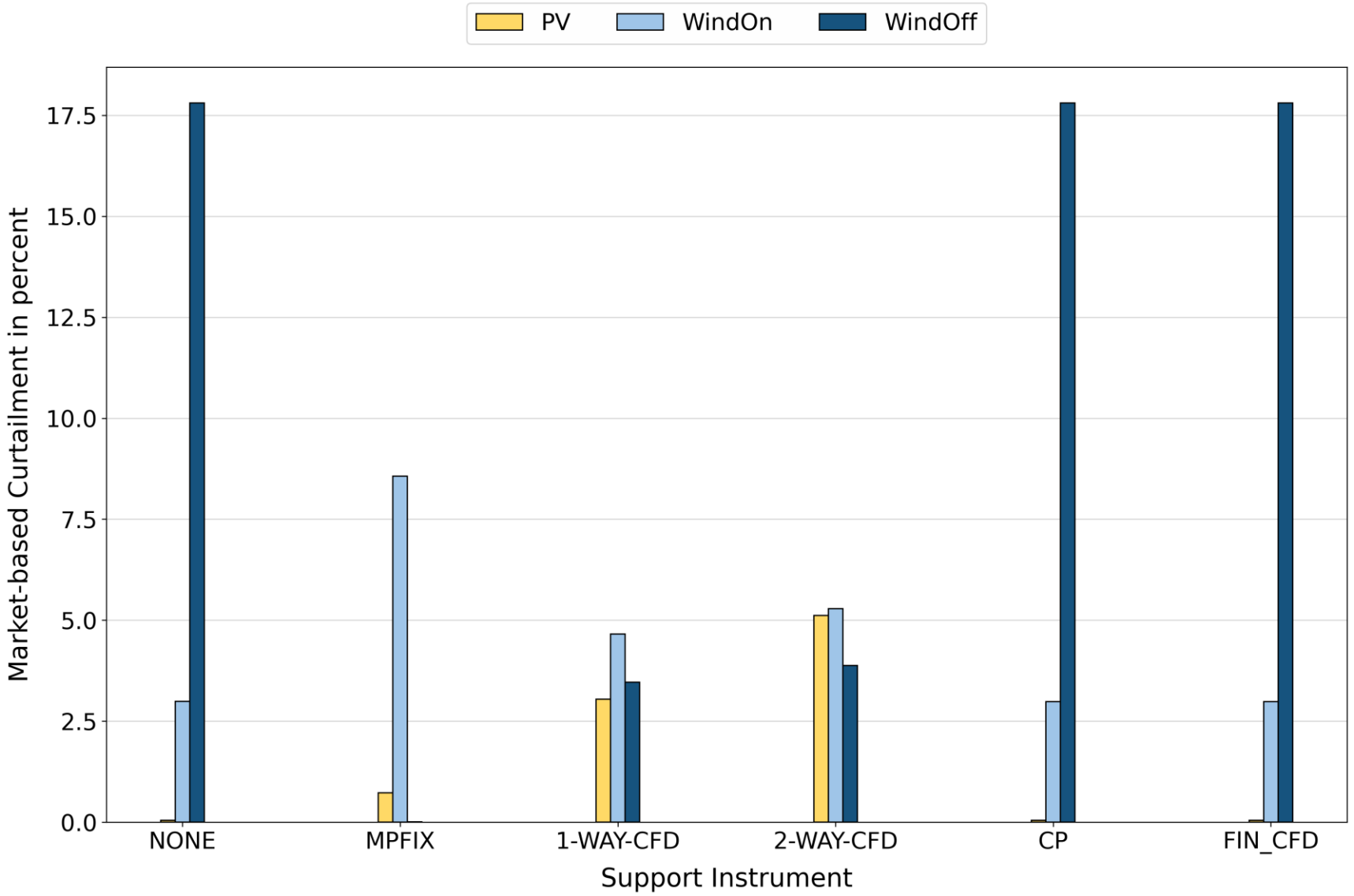
Cost recovery rates for vRES
Scenario S1



- No market-based refinancing for **rooftop PV** in any case
- **Wind** can (almost) recover costs on the market
- **1-WAY-CFD** and **2-WAY-CFD**: additional support payments during months with insufficient market incomes
- **2-WAY-CFD**: higher prices due to negative premia in clawback periods and corresponding bidding / curtailment
- **Refinancing with support**: *ideally parameterized* market designs

Market-based curtailment of vRES

Scenario S1



Offshore wind

Highest variable costs among considered vRES technologies

→ Heavy **curtailment** for NONE, CP and FIN_CFD (no dispatch distortions)

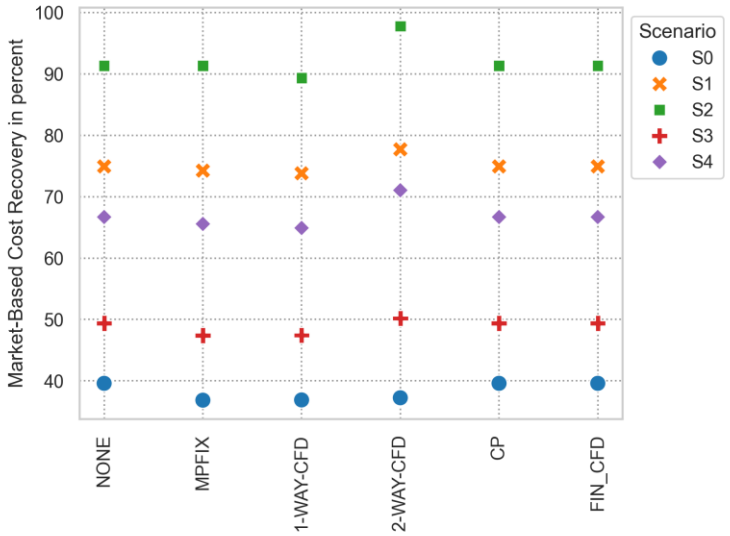
MPFIX & CFD

Bids & merit order impacted by expected premium payments

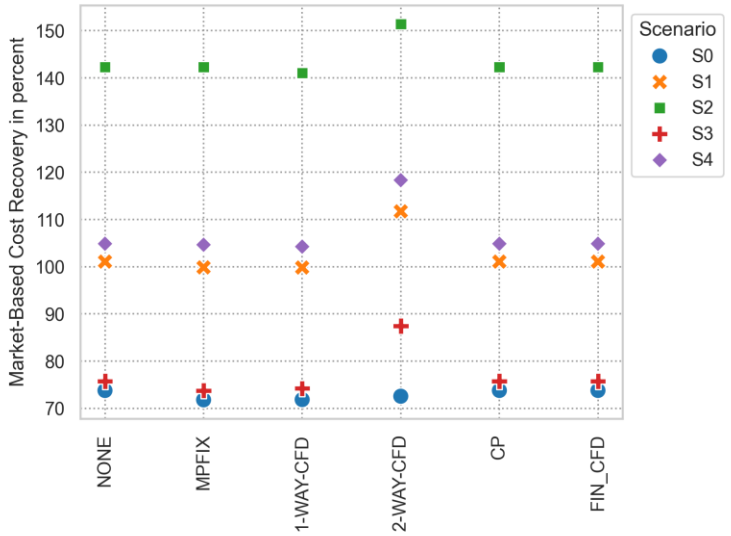
→ **Displacement** of PV & onshore wind by offshore wind

Market-based cost recovery
Scenarios S0-S4

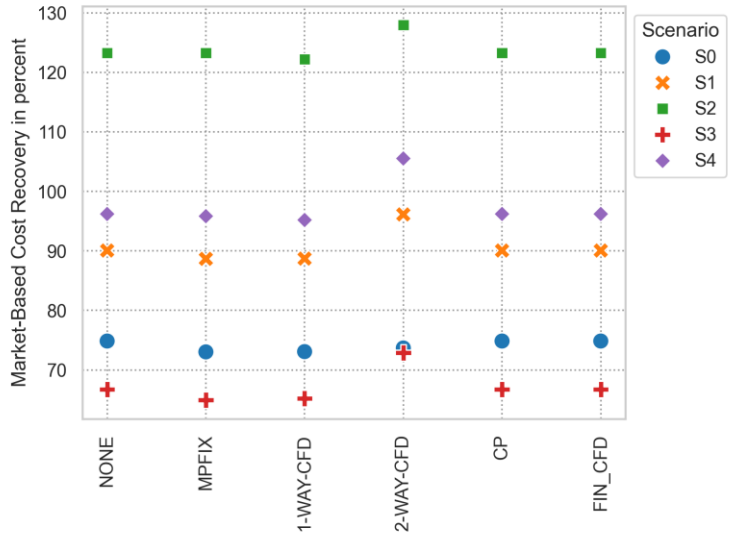
PV



Wind Onshore



Wind Offshore



- Highest cost recovery rates for flexible scenario S2 due to higher hydrogen price (on average 106 €/MWh)
- Lower hydrogen price in S4 (on average 76 €/MWh) → less vRES cost recovery
- S3: lowest prices and market values for PV and wind across scenarios S1 to S4 (more vRES, less electrolysis)
- **2-WAY-CFD significantly changes market behavior**
- **Differences between scenarios** have a greater impact than those between support instruments!

Summary and conclusion

- Support instruments are likely required to *de-risk RES investments*
- 2-WAY-CFD tends to
  - Increase market-based cost recovery
  - Increase market prices
  - Increase curtailment

- Results are *highly sensitive* with regard to scenario assumptions
  - Especially regarding the hydrogen price and electrolysis dispatch

→ Analysis of future electricity markets requires insights on (global) hydrogen market

→ All results from TradeRES project available at http://traderes.eu

→ Upcoming interactive webtool for result comparison