TradeRES

New Markets Design & Models for 100% Renewable Power Systems

Evaluating different types of CfDs in a fully decarbonized European wholesale electricity market

IEEE‘s European Energy Markets Conference 2023

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Silke Johanndeiter [1], [2]

[1] EnBW Baden-Württemberg AG, [2] Ruhr-Universität Bochum

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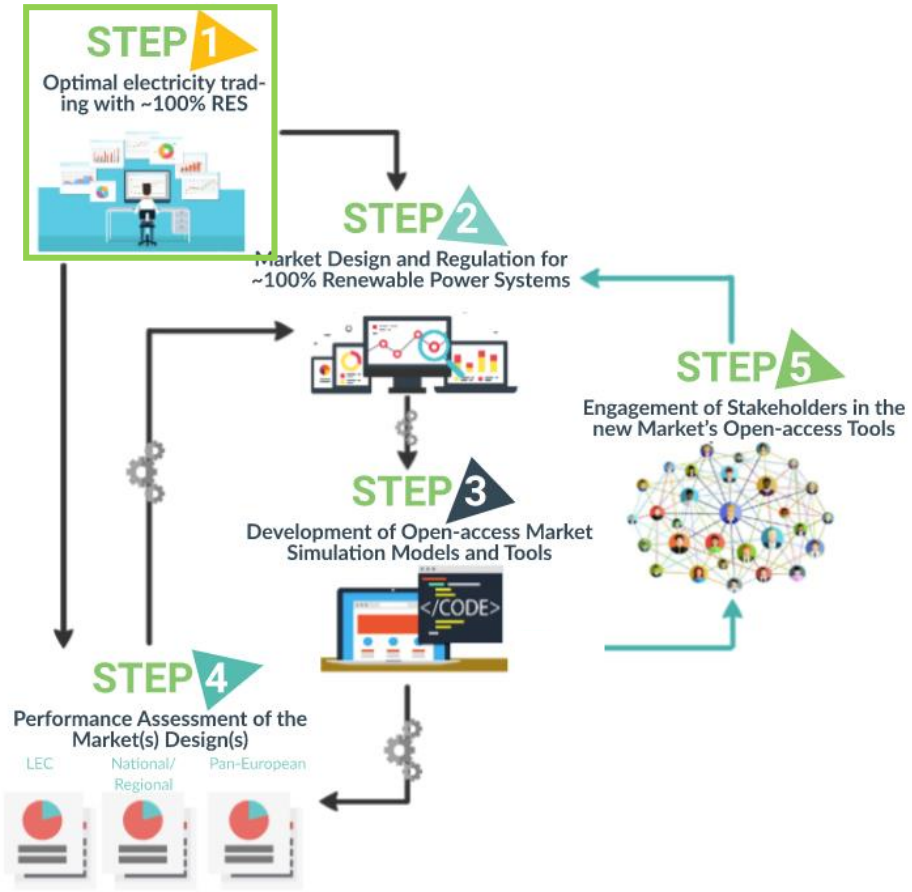
Pan-European Case Study

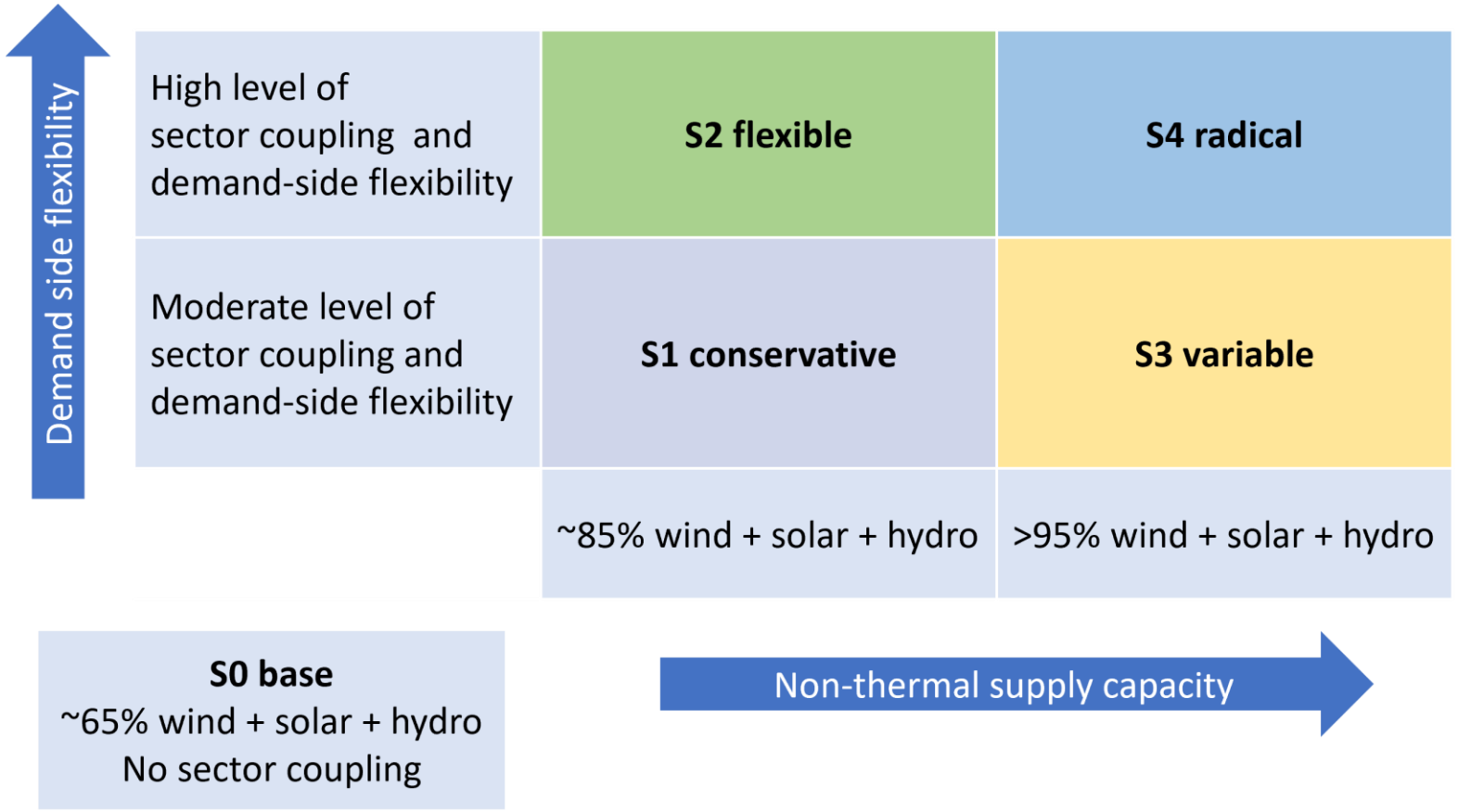
1) Does the energy-only-market yield **sufficient returns** to incentivize investments in different fully renewable European energy system scenarios?

2) If **other instruments complementing the energy-only-market** are needed, how should they be designed?

TradeRES Approach

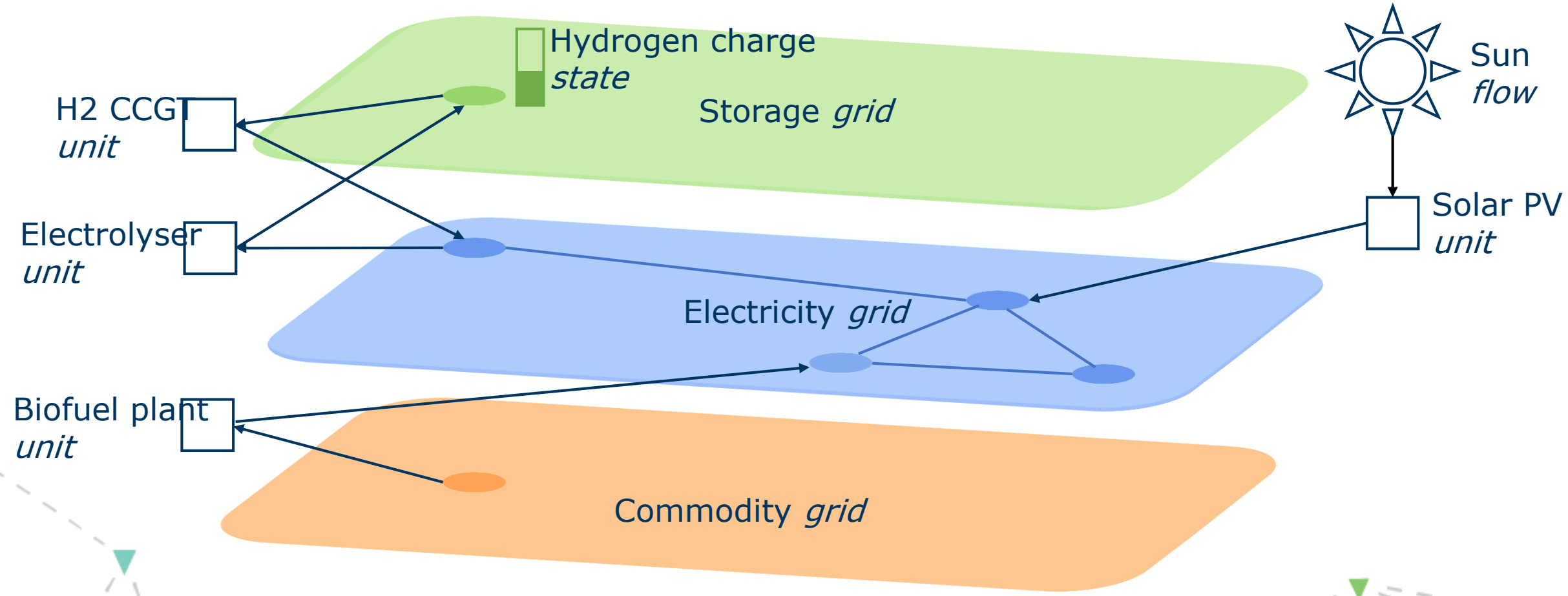


Reference System Calculation



Data: TradeRES Public Deliverable D2.1, Entso-E ERAA 2022, Entso-E TYNDP 2022, Renewables Ninja, RUB EE's Pypsa-to-BB, Denish Energy Agency, Gils et al. (2014)
Literature: Helistö et al. (2019), Böttger et al. (2022), Finke et al. (2023)

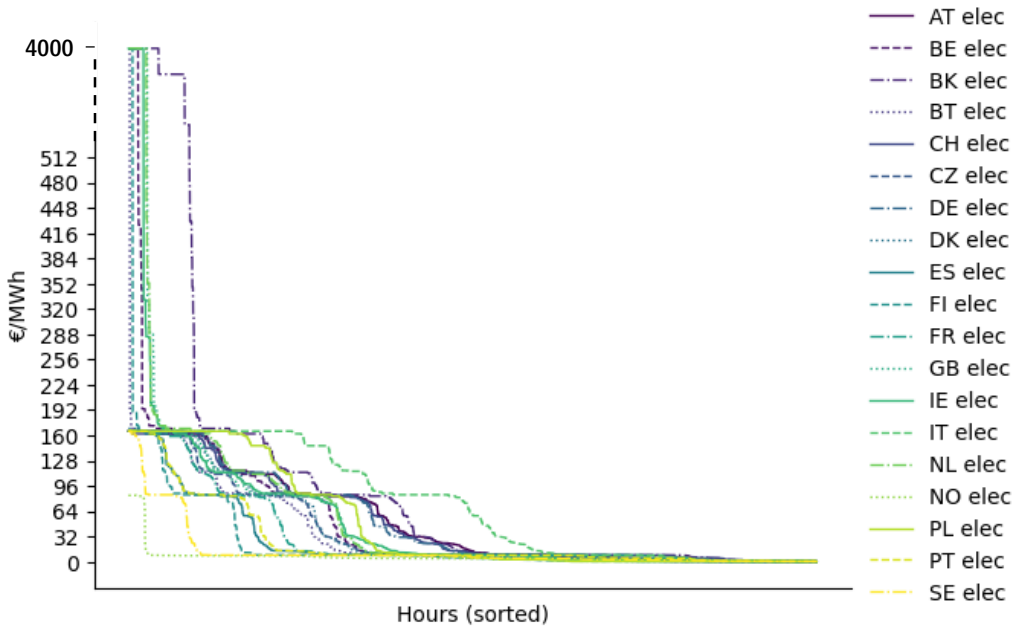
Backbone



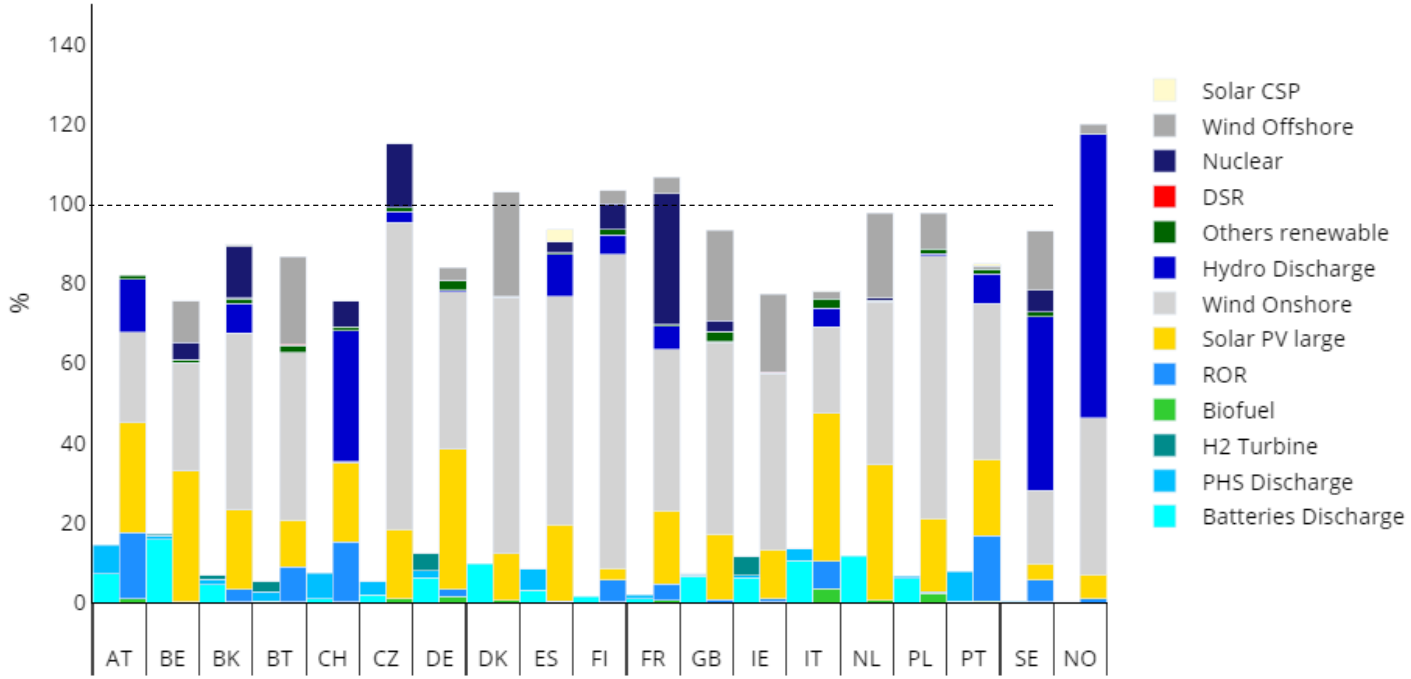
https://gitlab.vtt.fi/backbone/backbone

Reference System with ≥ 95% non-thermal renewables by constraint

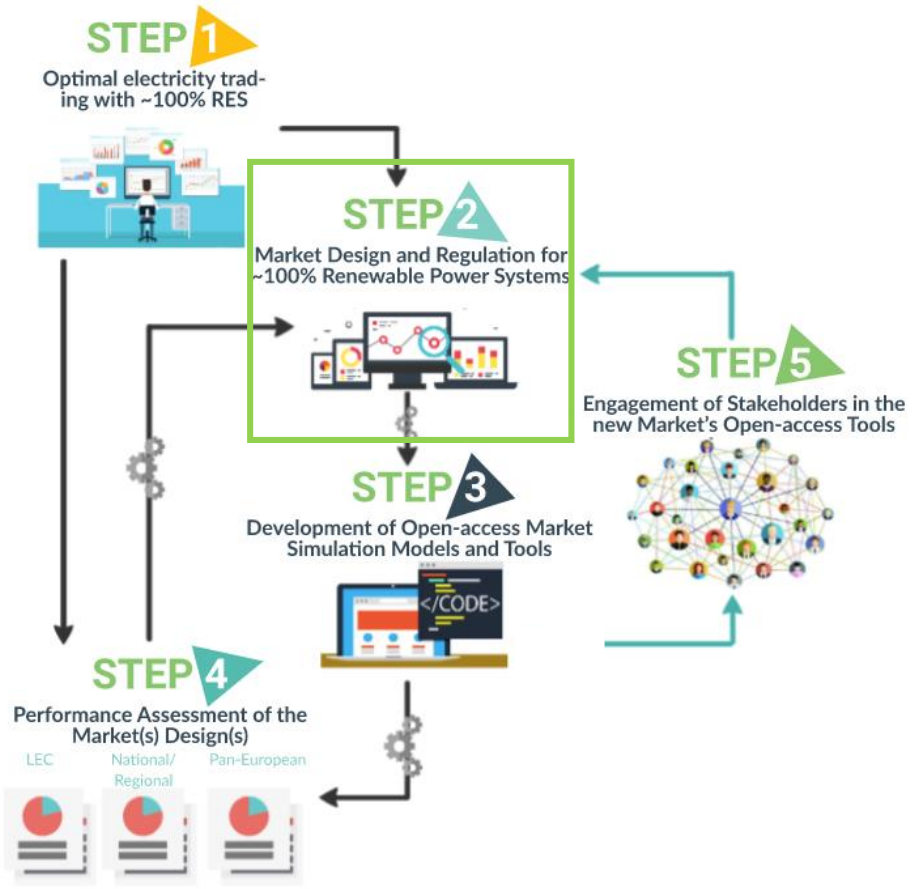
Price Duration Curves



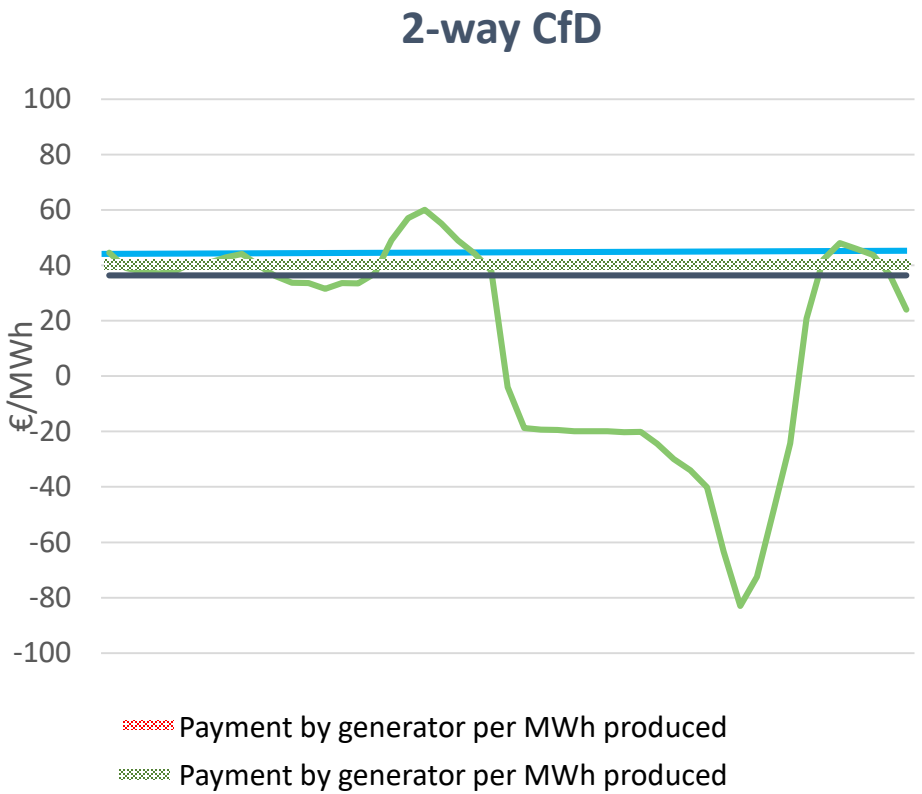
Electricity Generation Share by Type



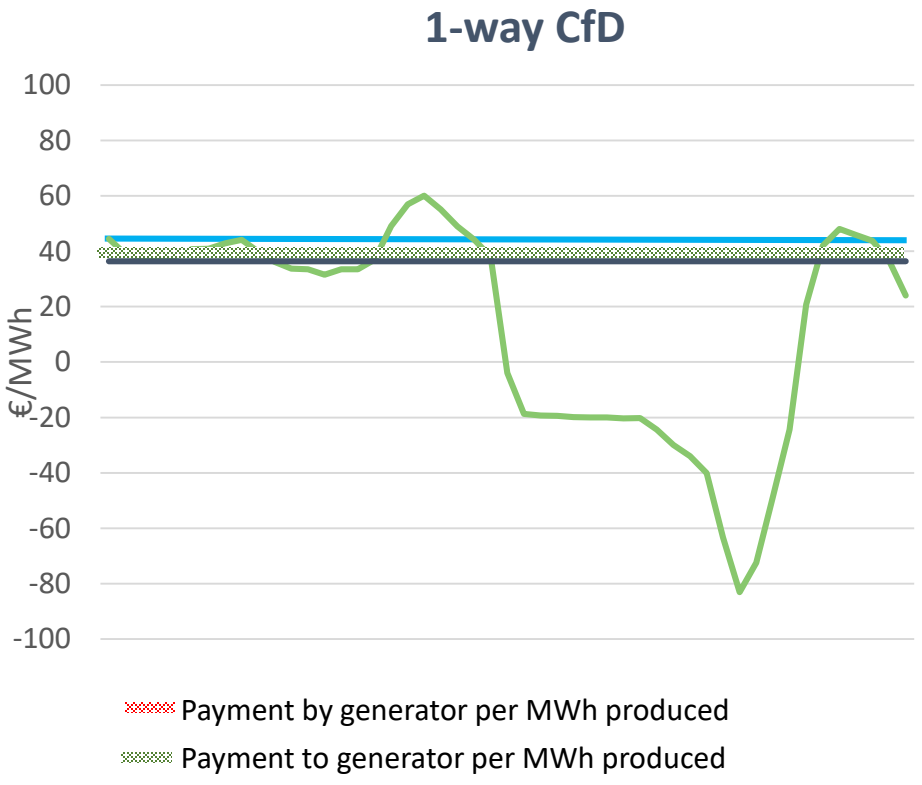
TradeRES Approach



Sophisticated Contract for Difference – Case 1
Reference Price = Reference Market Value



Revenues with generation q_t: $\sum_t^T (p_t q_t - (\bar{p} - S) q_t)$



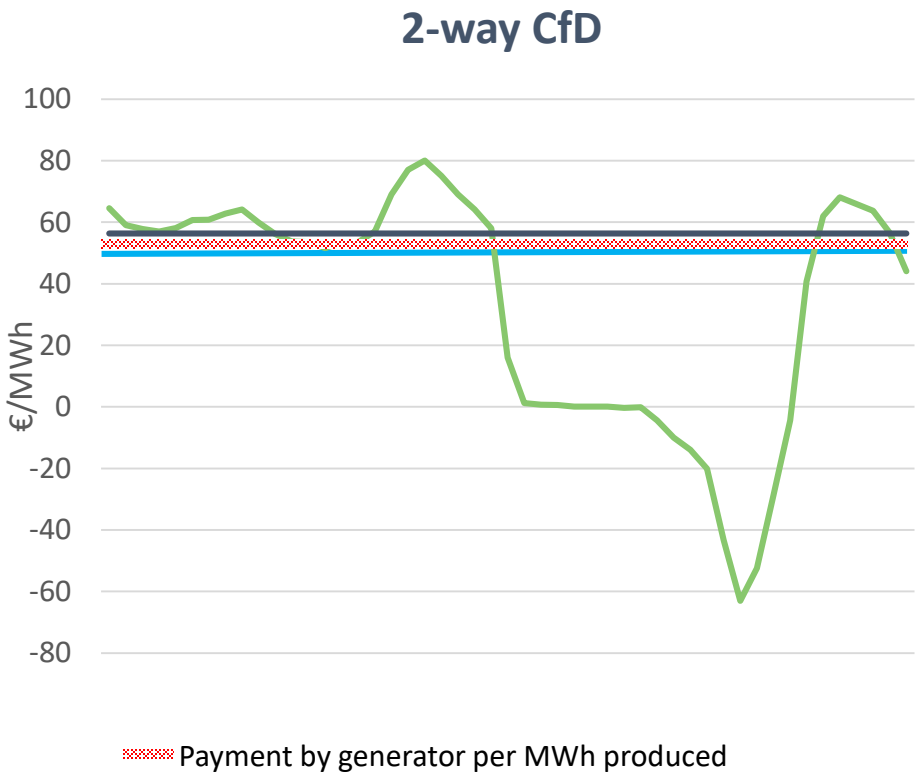
Revenues with generation q_t: $\sum_t^T (p_t q_t - (\min\{0, \bar{p} - S\}) q_t)$

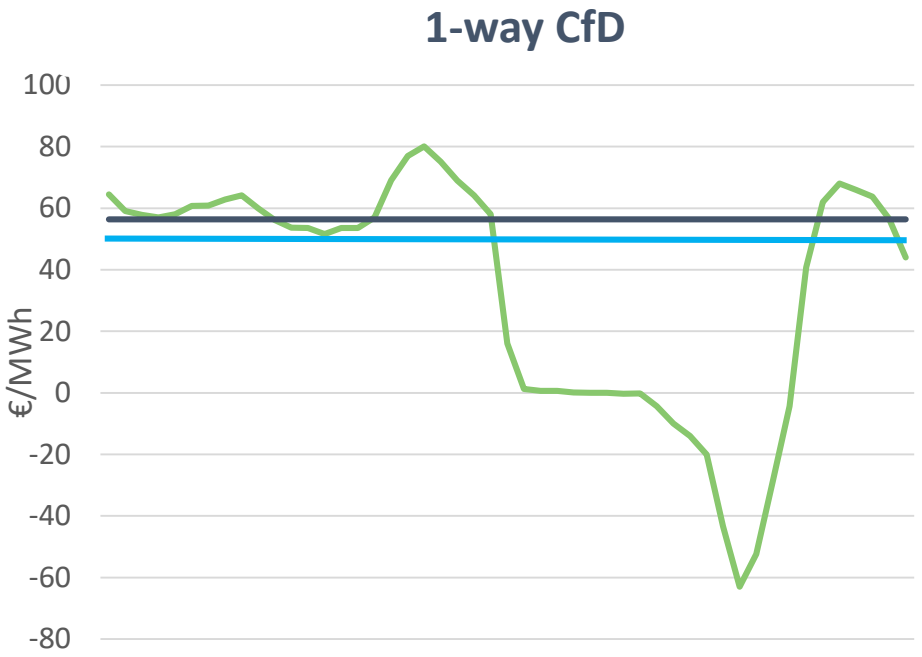
Strike Price (S)

Reference Price ($\bar{p}$)

Market Price (p_t)

Sophisticated Contract for Difference – Case 2
Reference Price = Reference Market Value





Reference Price ($\bar{p}$)

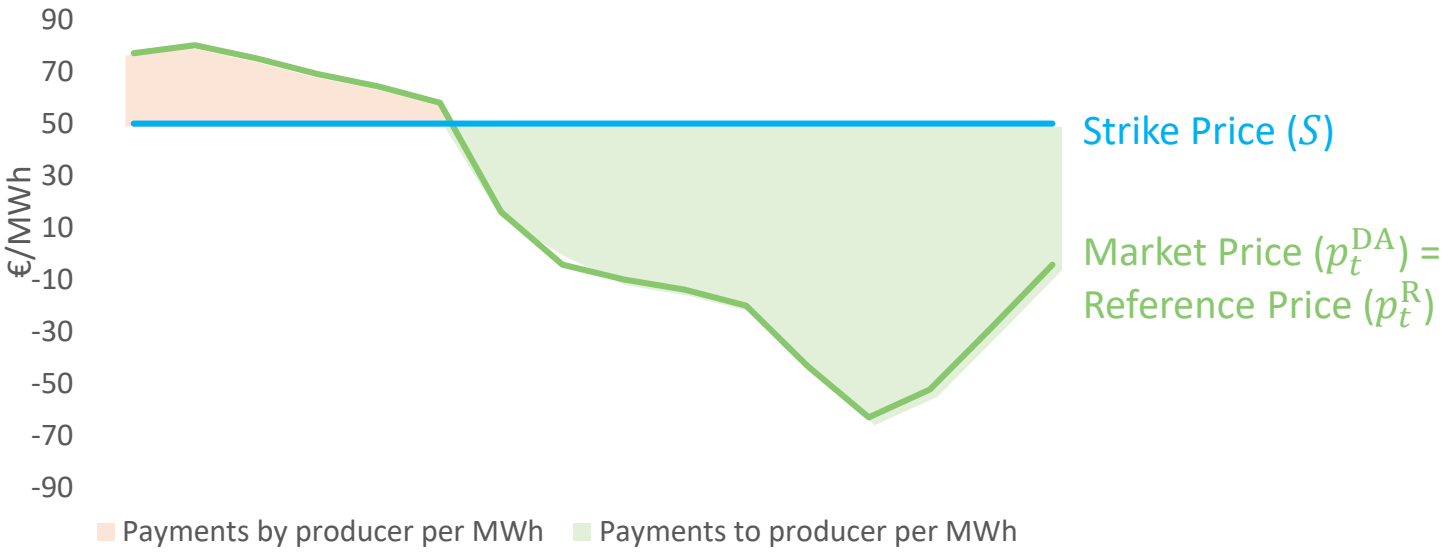
Strike Price (S)

Market Price (p_t)

Revenues with generation q_t: $\sum_t^T (p_t q_t - (\bar{p} - S) q_t)$

Revenues with generation q_t: $\sum_t^T (p_t q_t - (\min\{0, \bar{p} - S\}) q_t)$

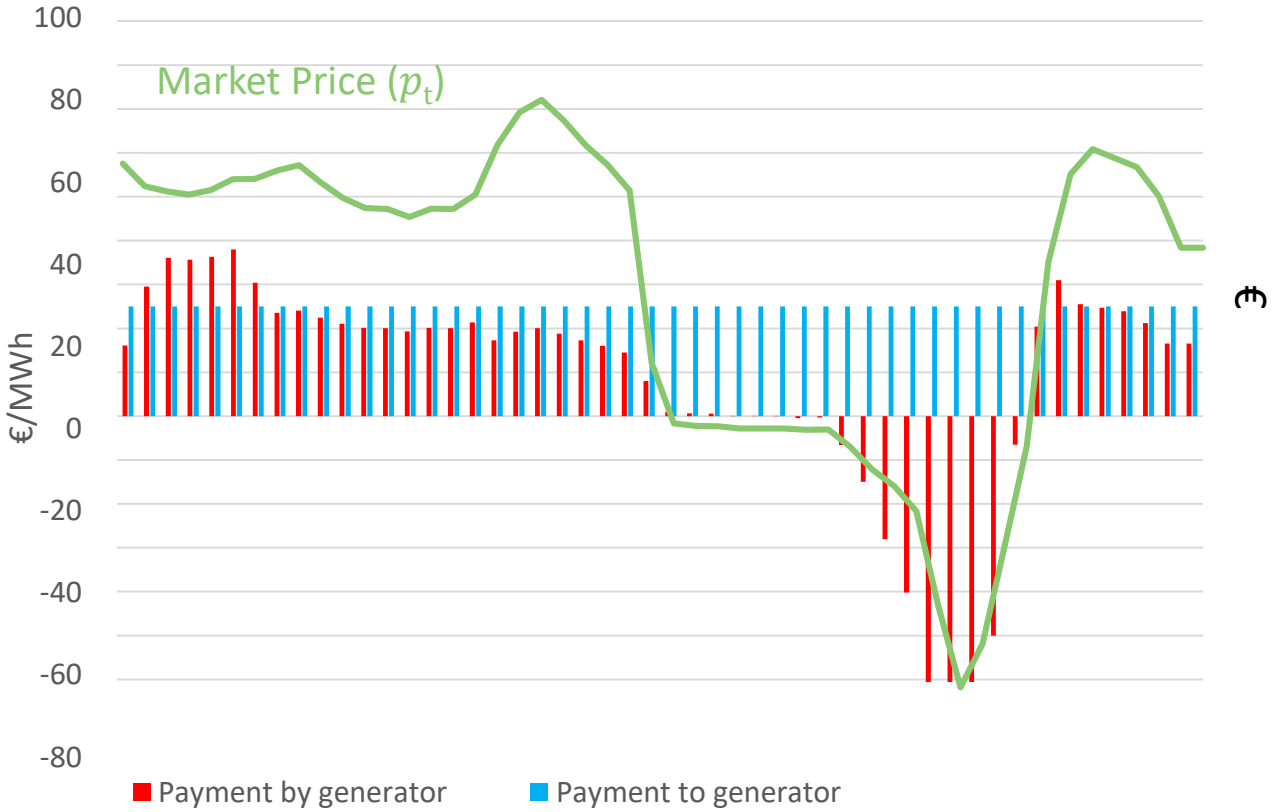
Simple 2-way Contract for Difference
Reference Price = Hourly day-ahead price



Revenues with generation q_t:

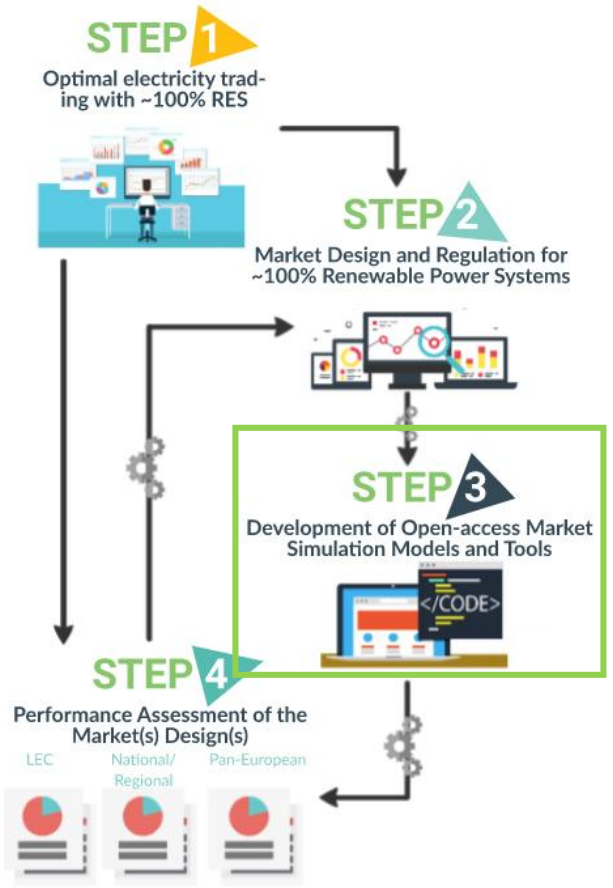
$$\sum_{t}^{T}(p_t^{DA} + S - p_t^{R})q_t$$

Financial Contract for Difference
Payments = Reference Revenues
Strike Price = fixed hourly payment

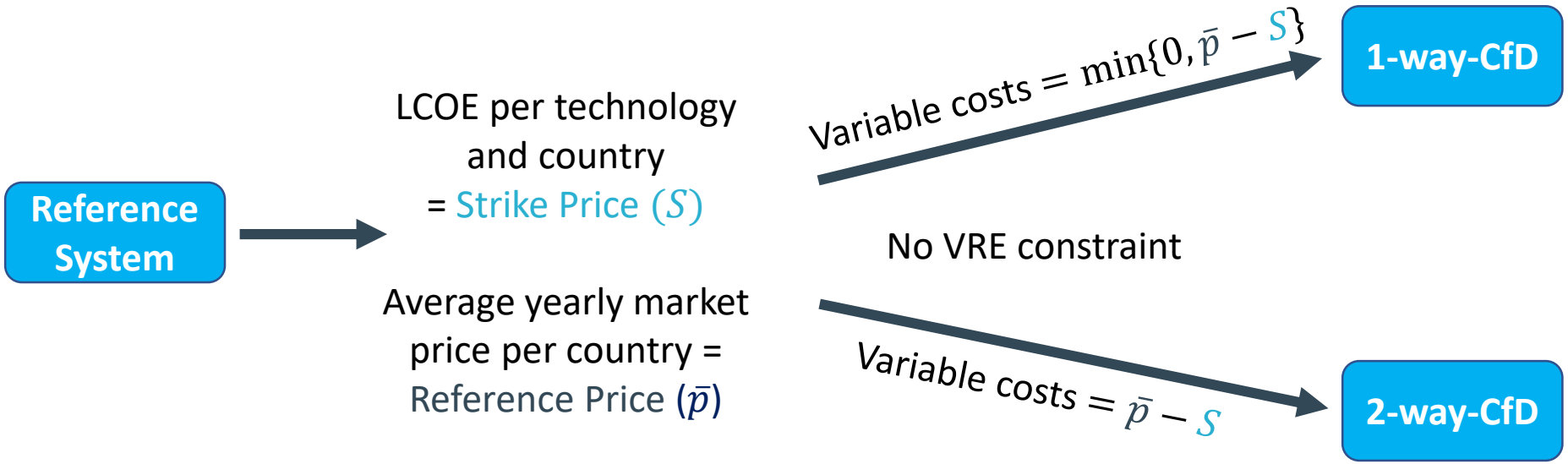


Revenues with generation q_t: $\sum_t^T (p_t q_t) + S - R$

TradeRES Approach

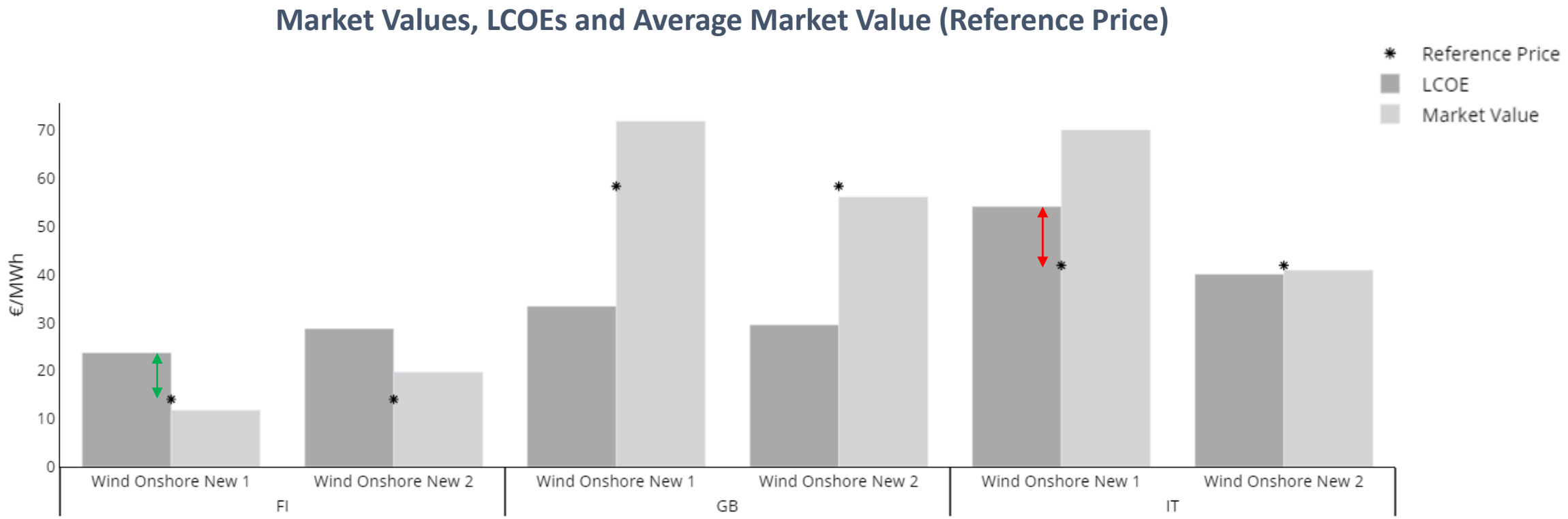


Implementation of sophisticated CfDs in our model

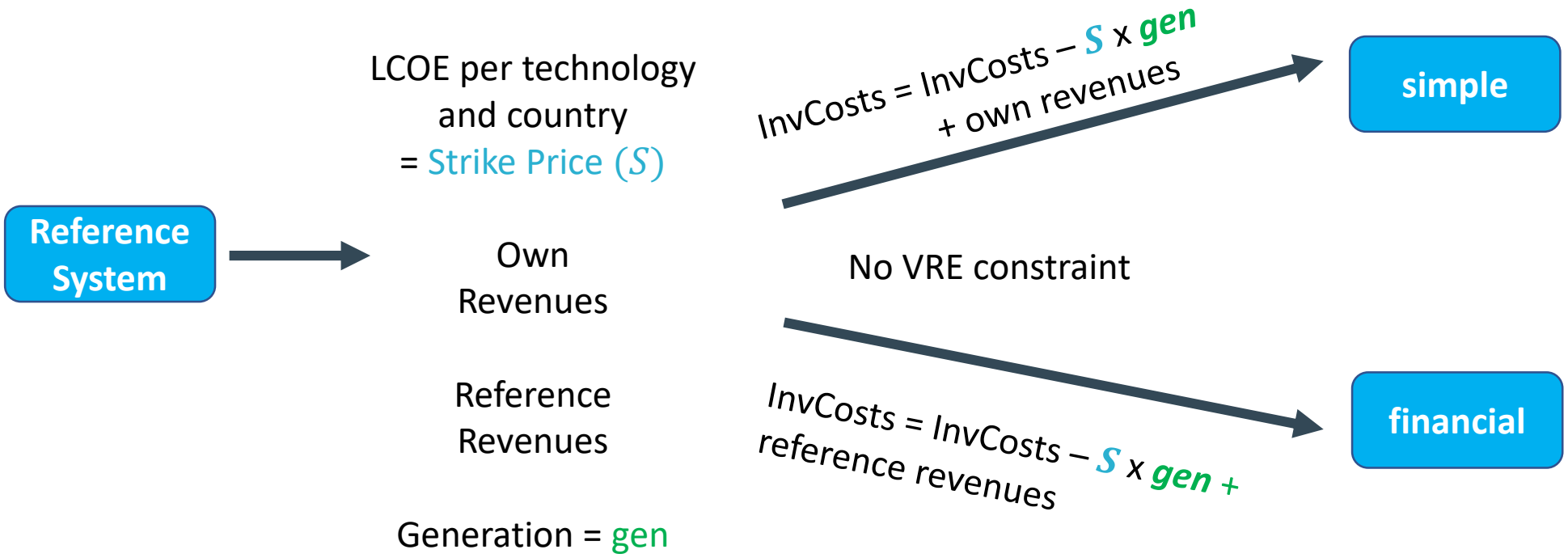


Literature: Frey et al. (2020), Gillich & Hufendiek (2022)

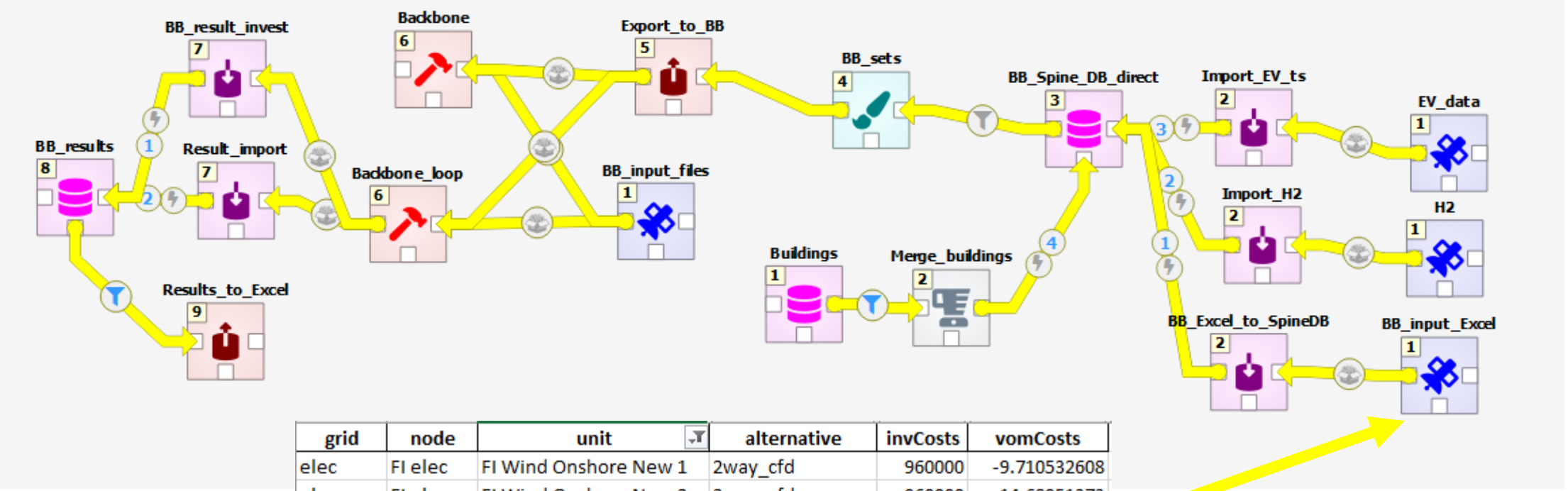
Reference System with ≥ 95% non-thermal renewables by constraint



Implementation of simple 2-sided CfD and financial CfD



Workflow in Spine Toolbox

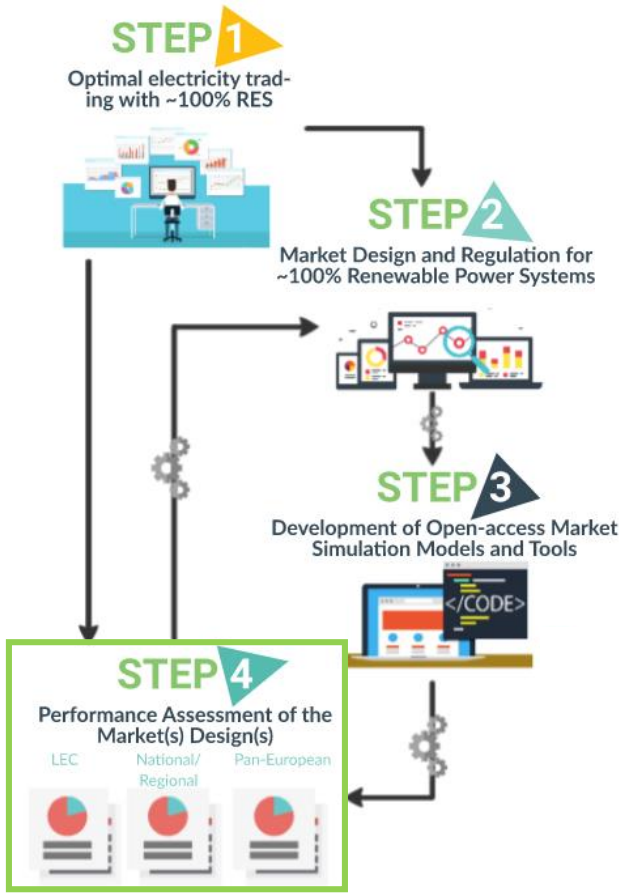


grid	node	unit	alternative	invCosts	vomCosts
elec	FI elec	FI Wind Onshore New 1	2way_cfd	960000	-9.710532608
elec	FI elec	FI Wind Onshore New 2	2way_cfd	960000	-14.68951373
elec	FI elec	FI Wind Onshore New 1	1way_cfd	960000	-9.710532608
elec	FI elec	FI Wind Onshore New 2	1way_cfd	960000	-14.68951373
elec	FI elec	FI Wind Onshore New 1	2way_CfD_simple	391966.8	0.5
elec	FI elec	FI Wind Onshore New 2	2way_CfD_simple	606768	0.5
elec	FI elec	FI Wind Onshore New 1	Financial_CfD	461165.1	0.5
elec	FI elec	FI Wind Onshore New 2	Financial_CfD	465349.9	0.5

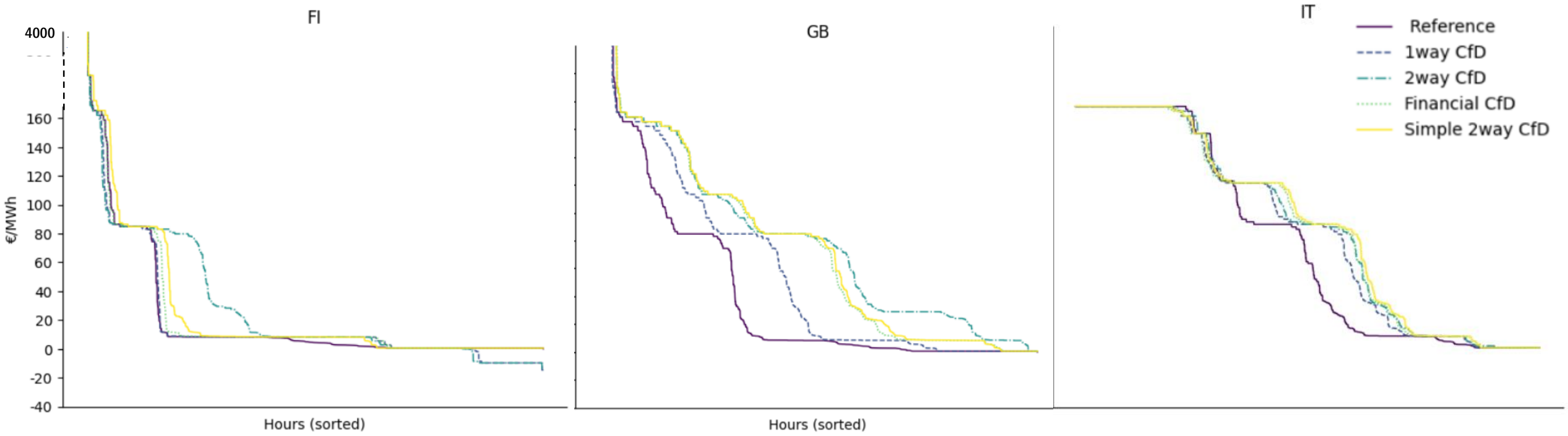
Workflow in Spine Toolbox

alternative	mples-roe	1sample	5samples	H2grid	profiles	2way_CfD_simple	2way_cfd	1way_cfd	Financial_CfD
scenario									
base-iberia	☐	☐	☐	☐	☐	☐	☐	☐	☐
buildings-low-iberia	☐	☐	☐	☐	☐	☐	☐	☐	☐
H2-low-iberia	☐	☐	☐	☐	☐	☐	☐	☐	☐
base-europe	☐	☐	☐	☐	☐	☐	☐	☐	☐
VRE+flex+europe	☐	☐	☐	☐	☐	☐	☐	☐	☐
VRE+flex-europe	☐	☐	☐	☐	☐	☐	☐	☐	☐
VRE-flex+europe	☐	☐	☐	☐	☐	☐	☐	☐	☐
VRE-flex-europe	☐	☐	☐	☐	☐	☐	☐	☐	☐
VRE+europe	16	☐	17	☐	☐	☐	☐	☐	☐
VRE-europe	15	☐	14	☐	☐	☐	☐	☐	☐
VRE+europe+	11	☐	10	☐	18	☐	☐	☐	☐
VRE+europe+_finCfD	10	☐	9	☐	17	☐	☐	☐	18
VRE+europe+_simpleCfD	10	☐	9	☐	17	18	☐	☐	☐
VRE+europe+_1wayCfD	10	☐	9	☐	17	☐	☐	18	☐
VRE+europe+_2wayCfD	10	☐	9	☐	17	☐	18	☐	☐

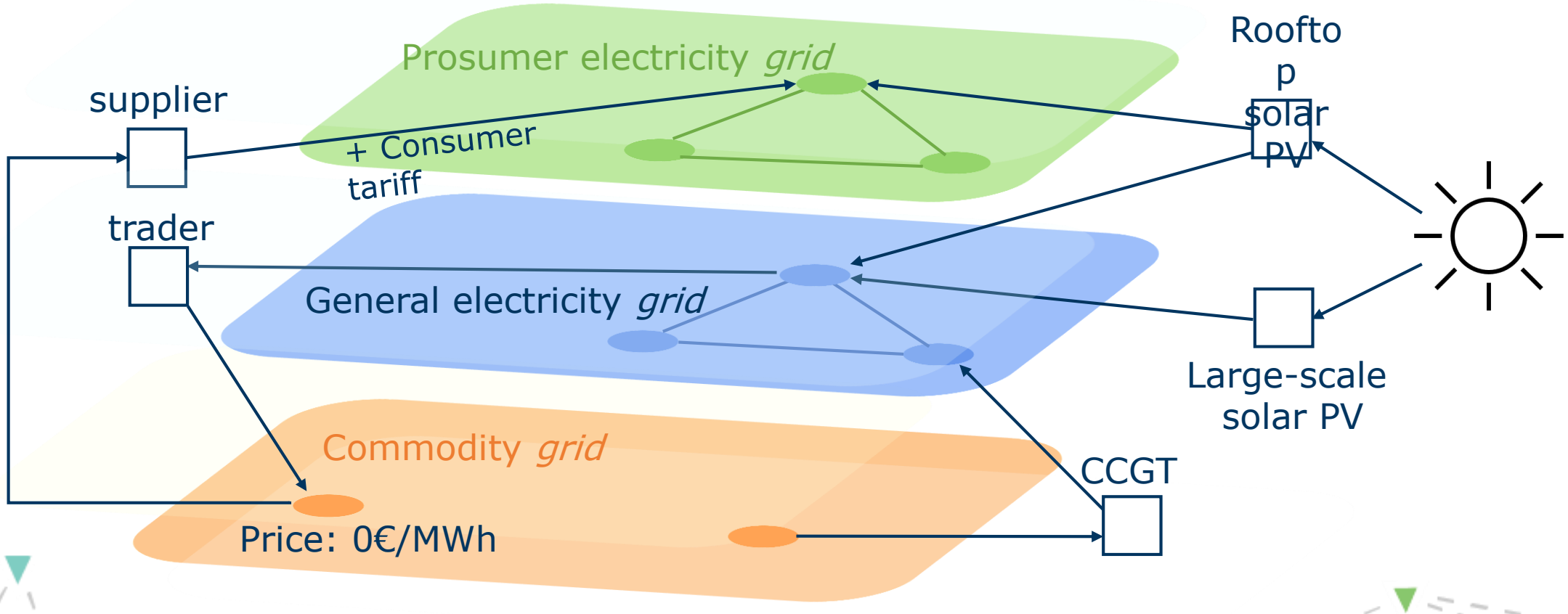
TradeRES Approach



Preliminary Results: Price Duration Curves



Outlook: integrating prosumers into the European wholesale electricity market



EnBW

RUB Chair of Energy Systems & Energy Economics

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Thanks ☺

Silke Johanndeiter

silke.johanndeiter@rub.de

www.traderes.eu

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3. Method
Energy System Model

Model

- Flexible open-source energy system modelling framework **Backbone**
- Cost-minimizing **capacity expansion planning** and subsequent **unit commitment**
- Minimum share of variable renewables as **constraint**
- Interpretation of **marginal system costs as electricity prices**

Power Plants

- **VRE:** Solar PV, Solar CSP, Wind onshore and offshore, Run of river hydro (weather year 2019)
- **Thermal:** Biofuel, waste, nuclear and hydrogen CCGT
- **Storage:** Pumped hydro and reservoir hydro, batteries and hydrogen storage with electrolysers
- Industrial load shedding units
- Maximum price = 3000€
- Exogeneous and unlimited endogeneous capacities for all technologies except hydro power

Geographical Scope

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