TU Delft

TradeRES
New Markets Design & Models for 100% Renewable Power Systems

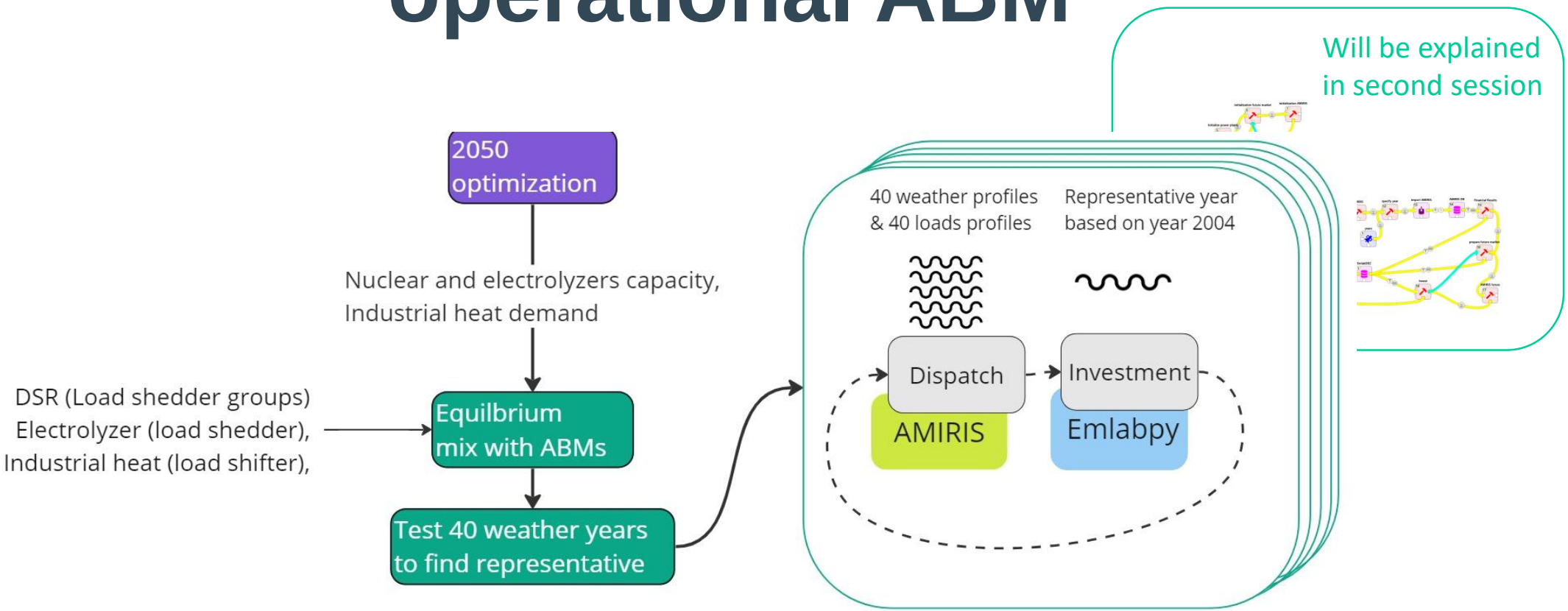
Can an Energy Only Market (EOM) enable Resource Adequacy in a nearly 100% Renewable Power System?

Ingrid Sanchez Jimenez, David Ribo Perez, Laurens de Vries (TU Delft)

Christoph Schimeczek, Johannes Kochems (DLR)

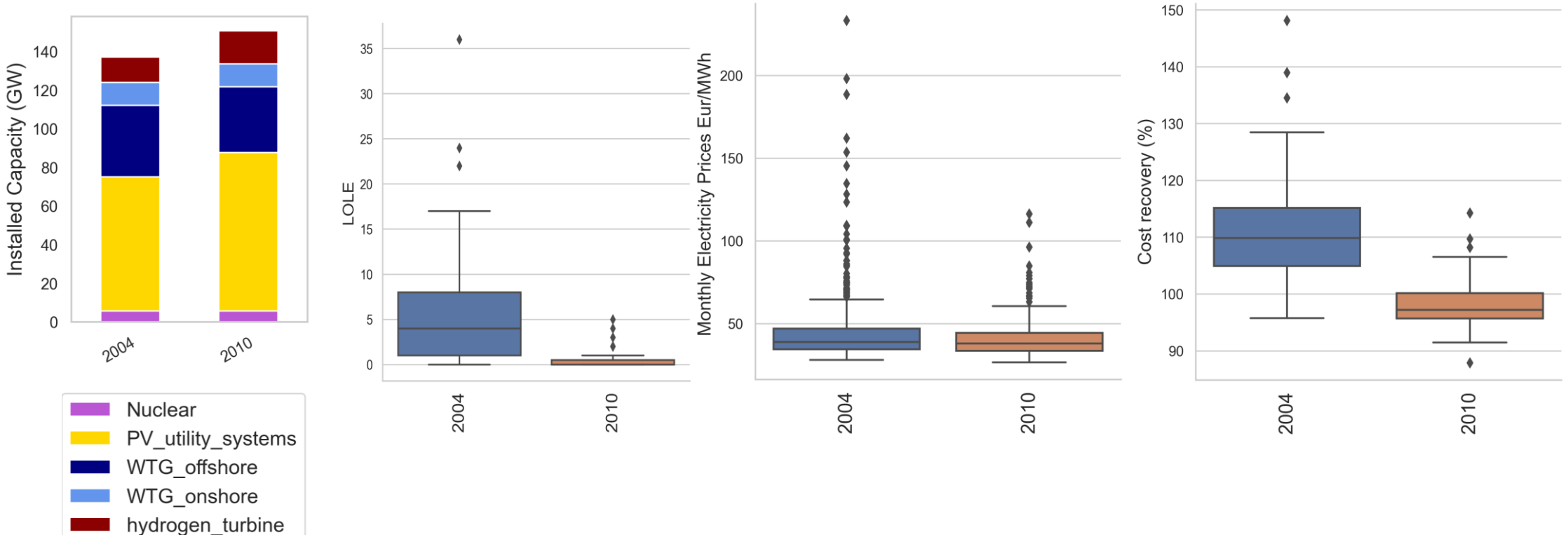
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864276

Modelling with investment and operational ABM



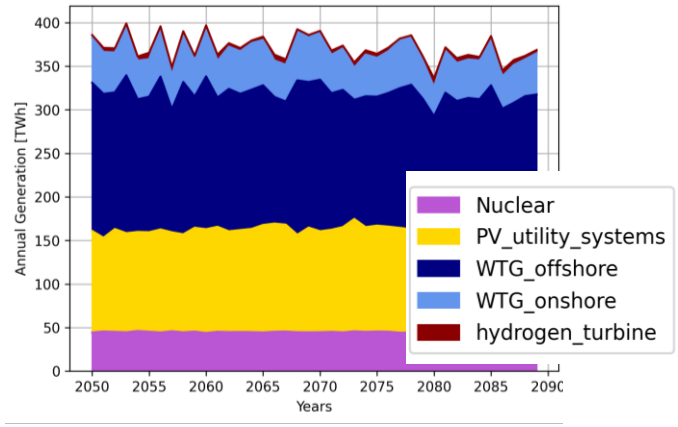
Would investors base their decisions to ensure reliability?

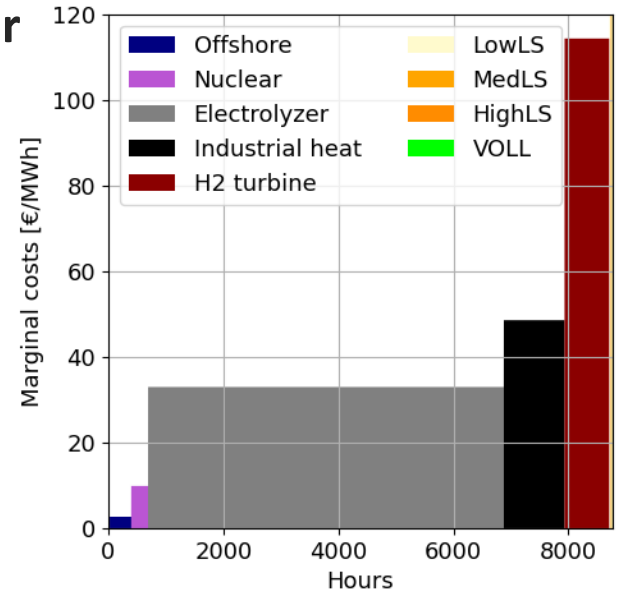
Investment decisions based on year 2004 (median) and 2010 (reduced RE)

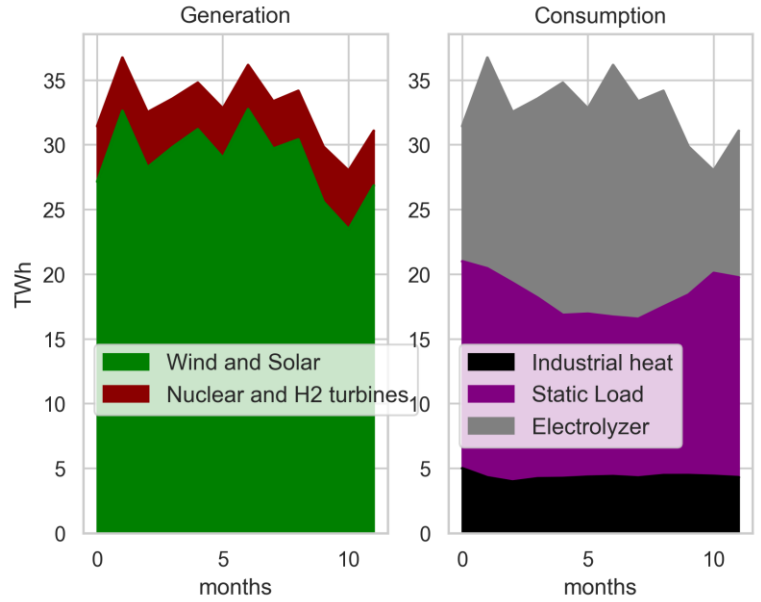


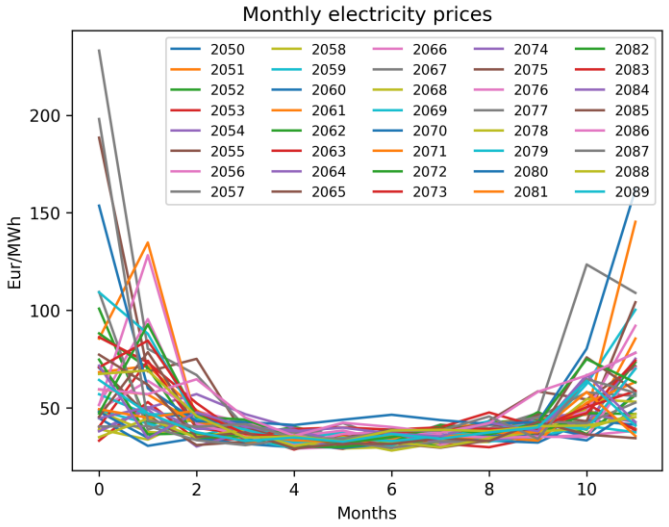
Investments based on representative year

Annual generation for 40 weather years



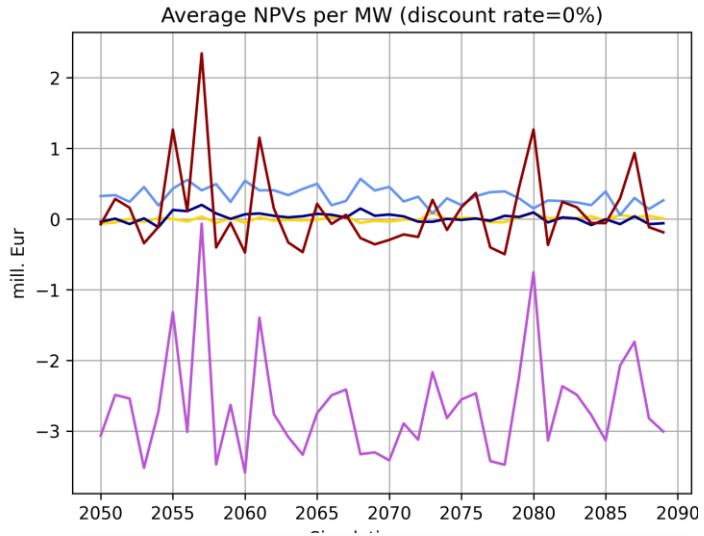


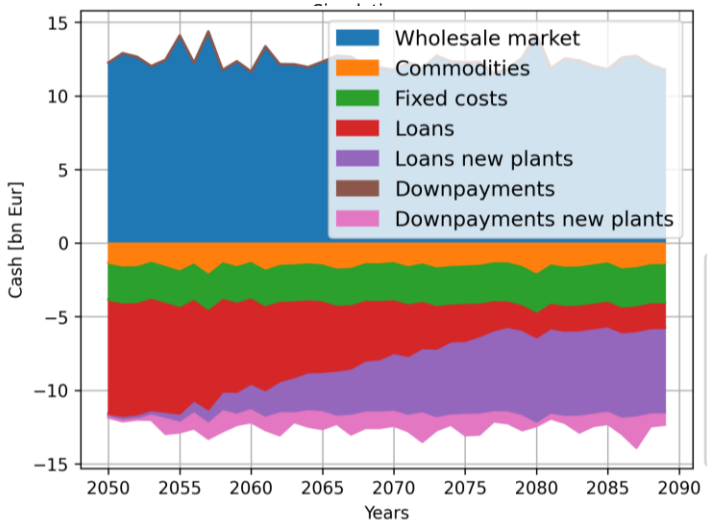




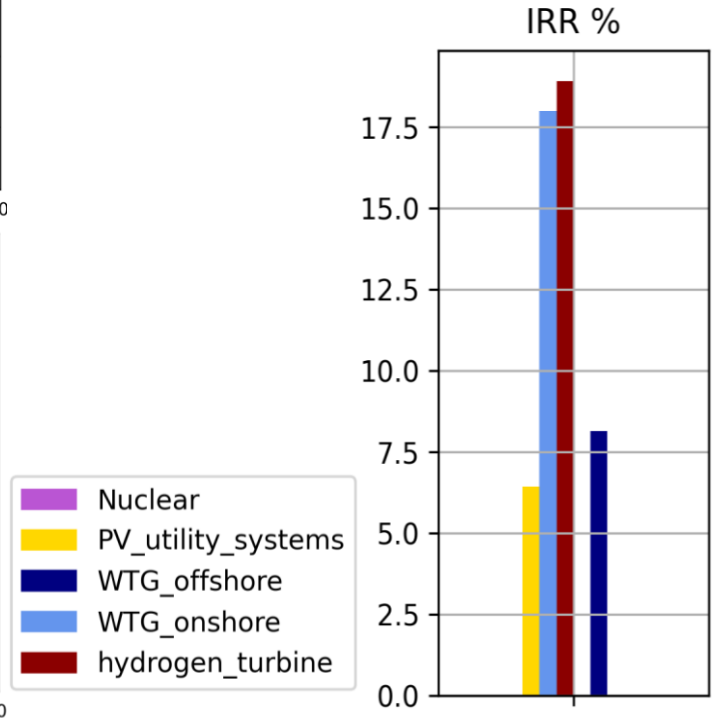
- Most energy was renewable, but the **price was mostly set by the flexible demand** (electrolyzer and the industrial heat)
- Load was higher in winter months. Electrolyzer consumption decreased. But still electricity prices were highest in those months.

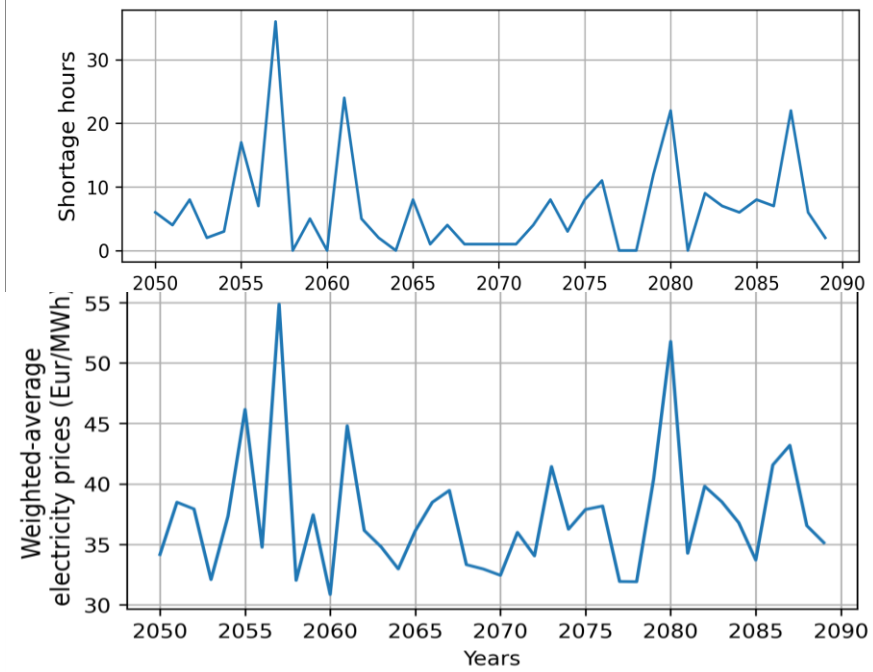
Investments based on representative year





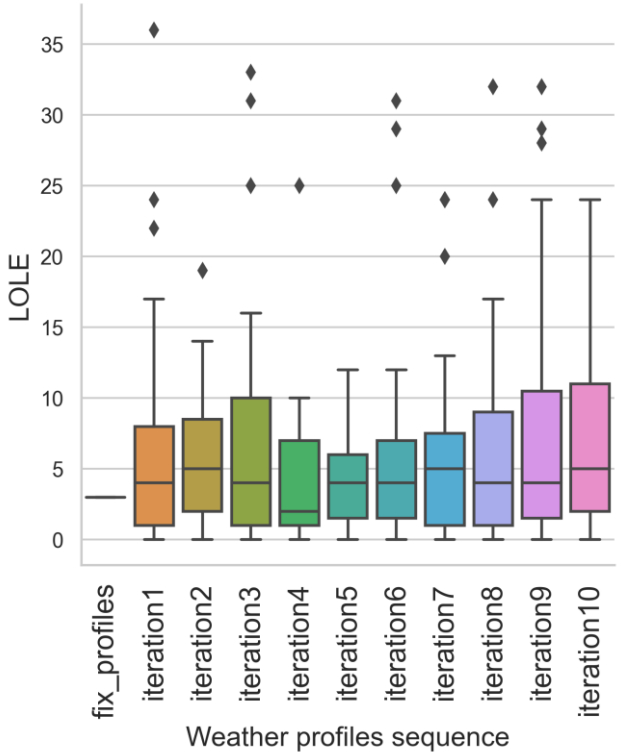
- Base-load technology (i.e. Nuclear) was unprofitable.
- Hydrogen turbine IRR were the most volatile but also the most profitable
- Years with the highest shortages caused the highest costs and highest electricity prices



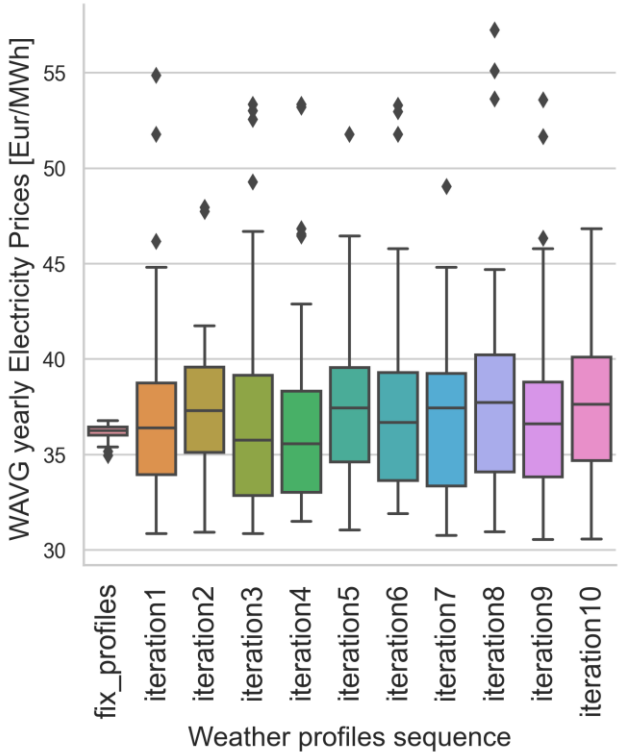


Weather impact on electricity prices

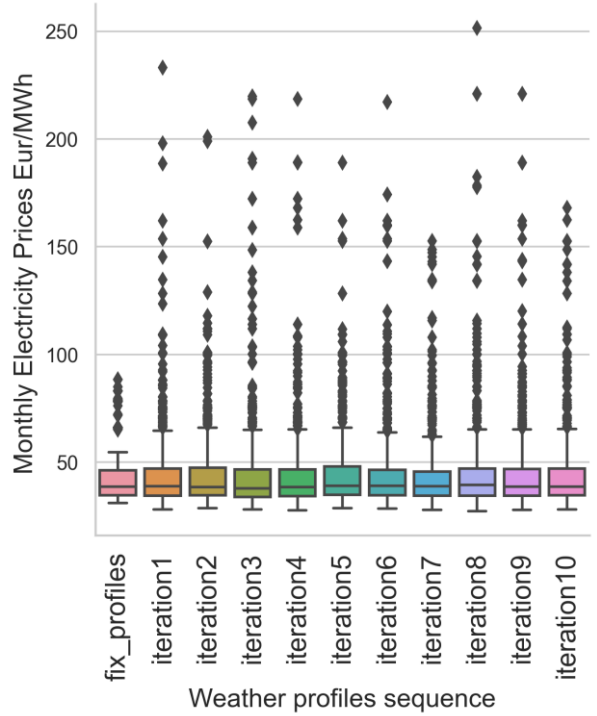
Shortage hours



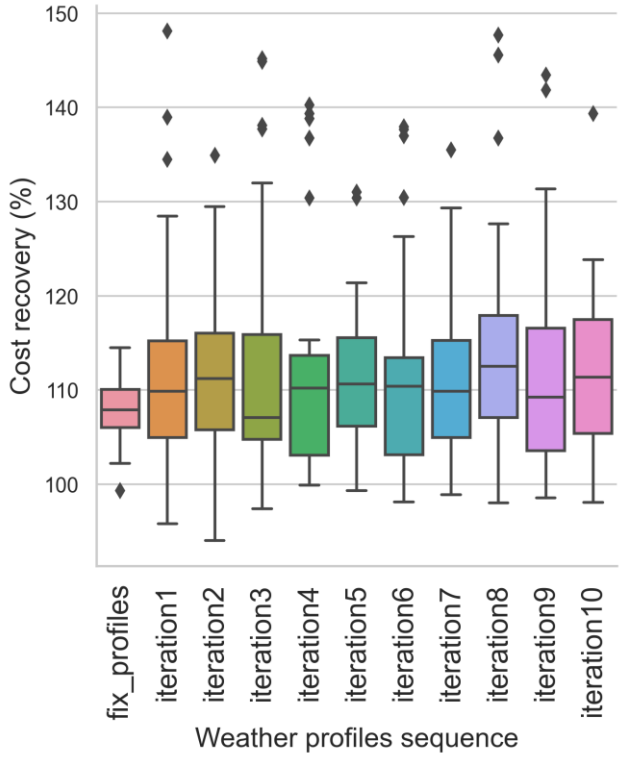
Yearly electricity prices



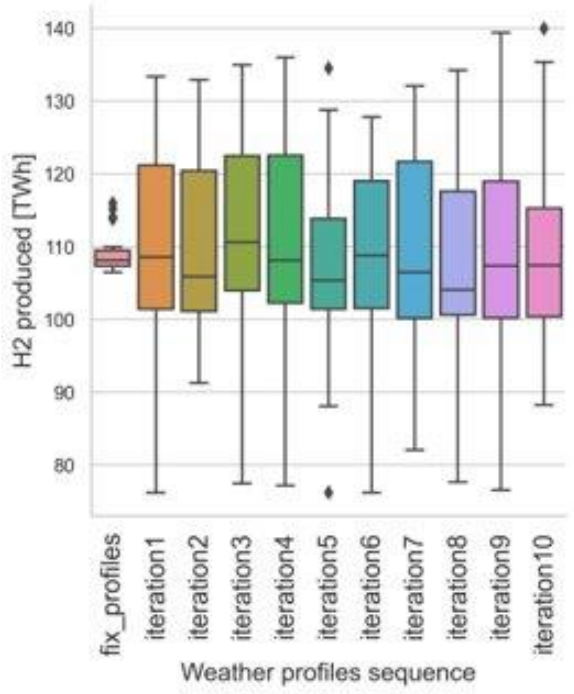
Monthly electricity prices



Cost recovery %



H2 production TWh



Conclusions

- Flexible consumers set the price most of the time.
- If investors would base their decisions on a median weather year
  - Generation costs were recovered (except base technologies)
  - Reliability standards were compromised
  - Monthly electricity prices and hydrogen production would be very volatile.
- Next steps: transition scenario and capacity mechanisms (Capacity subscription)

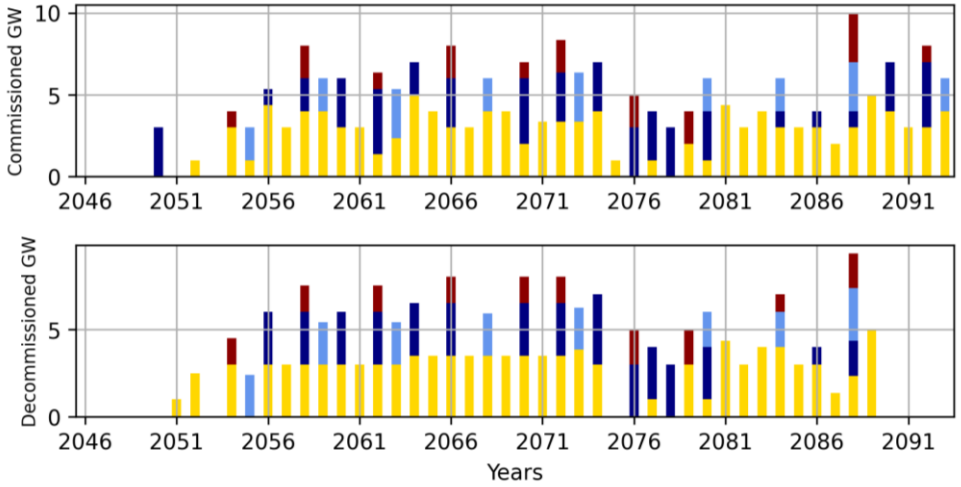
TradeRES

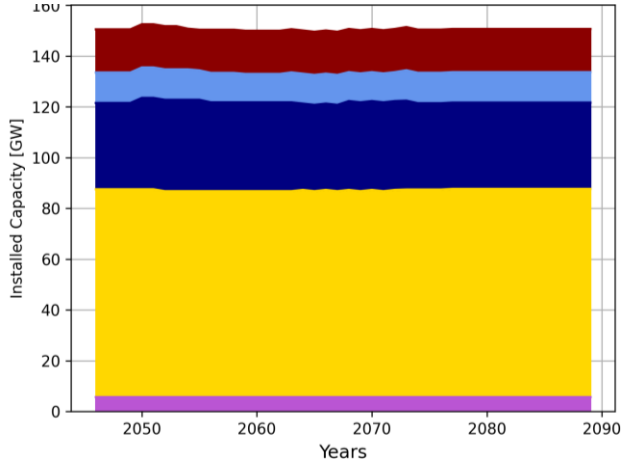
New Markets Design & Models for
100% Renewable Power Systems

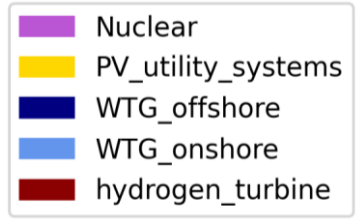
Backup

Historical weather years sequence (1980 to 2019)

Installed capacity







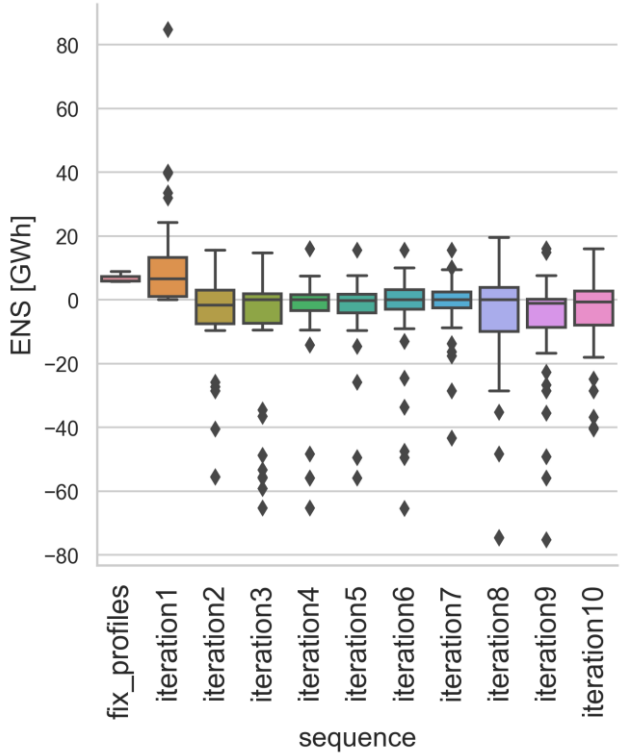
Data

	2020	2030	2050
bioliquids	82.5	82.5	82.5
biomethane	86	74.66	50.29
CO2	163		168
collectable_residues	15	15	15
electricity			1
hard_coal	8.28	7.09	6.73
heavy_oil	21.175	40.68	79.69
light_oil	46.33	36.32	32.83
lignite	6.48	6.48	6.48
LNG	16.717	26.81	46.996
natural_gas	20.05	14.47	14.65
nuclear	1.69	1.69	1.69
oil_shale	4.536	6.696	14.148
processing_residues	7.5	7.5	7.5
wood_pellets	45	45	35

investment costs	millones/MW		
	2020	2030	2050
Biomass_CHP_wood_pellets_DH	€ 2,040,000	€ 2,040,000	
Biomass_CHP_wood_pellets_PH		€ 2,900,000	€ 2,700,000
CCGT		€ 830,000	€ 800,000
CCGT_CHP_backpressure_DH		€ 1,200,000	€ 1,100,000
CCGT_CHP_backpressure_PH		€ 1,200,000	
CCS CCGT		€ 2,670,000	
Coal PSC	€ 3,845,510		
electrolyzer			€ 350,000
Fuel oil PGT	€ 343,000		
fuel_cell			€ 800,000
hydrogen_CHP			€ 730,000
hydrogen_combined_cycle			€ 750,000
hydrogen_turbine			€ 435,000
Hydropower_reservoir_medium		€ 2,690,000	€ 2,685,000
Hydropower_ROR		€ 2,990,000	€ 2,970,000
Lignite PSC	€ 3,845,510		
Lithium_ion_battery	€ 534,000	€ 284,000	€ 270,000
Nuclear	€ 7,940,450	€ 6,000,000	
OCGT		€ 435,000	€ 412,000
Pumped_hydro	€ 2,000,000		
PV_combination 50%50%	€ 878,000	€ 730,500	€ 519,000
PV_residential	€ 1,169,000	€ 1,017,000	€ 688,000
PV_utility_systems	€ 587,000	€ 444,000	€ 350,000
WTG_offshore	€ 2,270,000	€ 1,620,000	€ 1,444,000
WTG_onshore	€ 1,150,000	€ 1,220,000	€ 1,127,000

Other graphs

ENS



Hydrogen produced in Tons