Mitigating future variable renewable energy sources curtailment in Poland through demand-side management strategies

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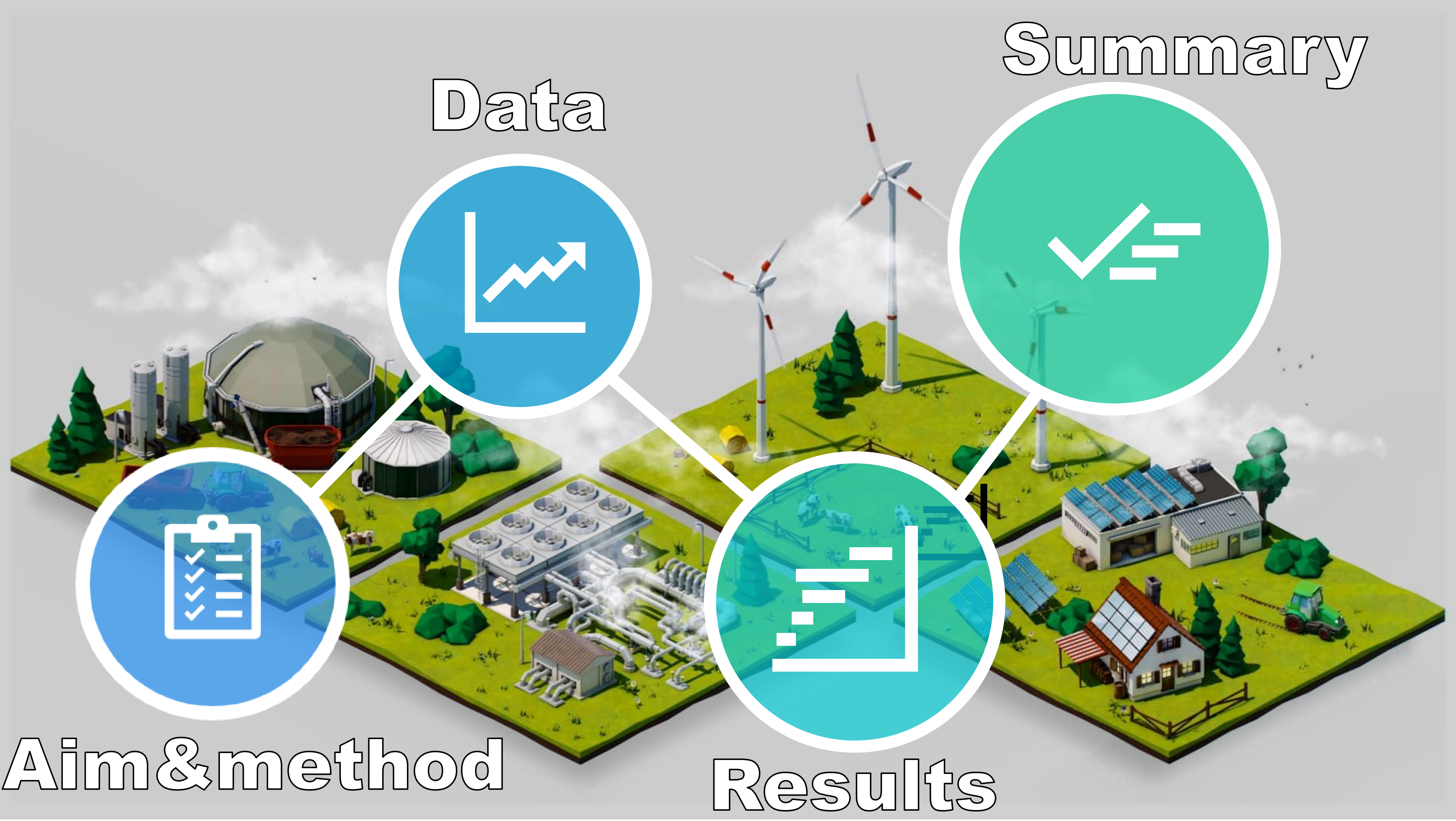
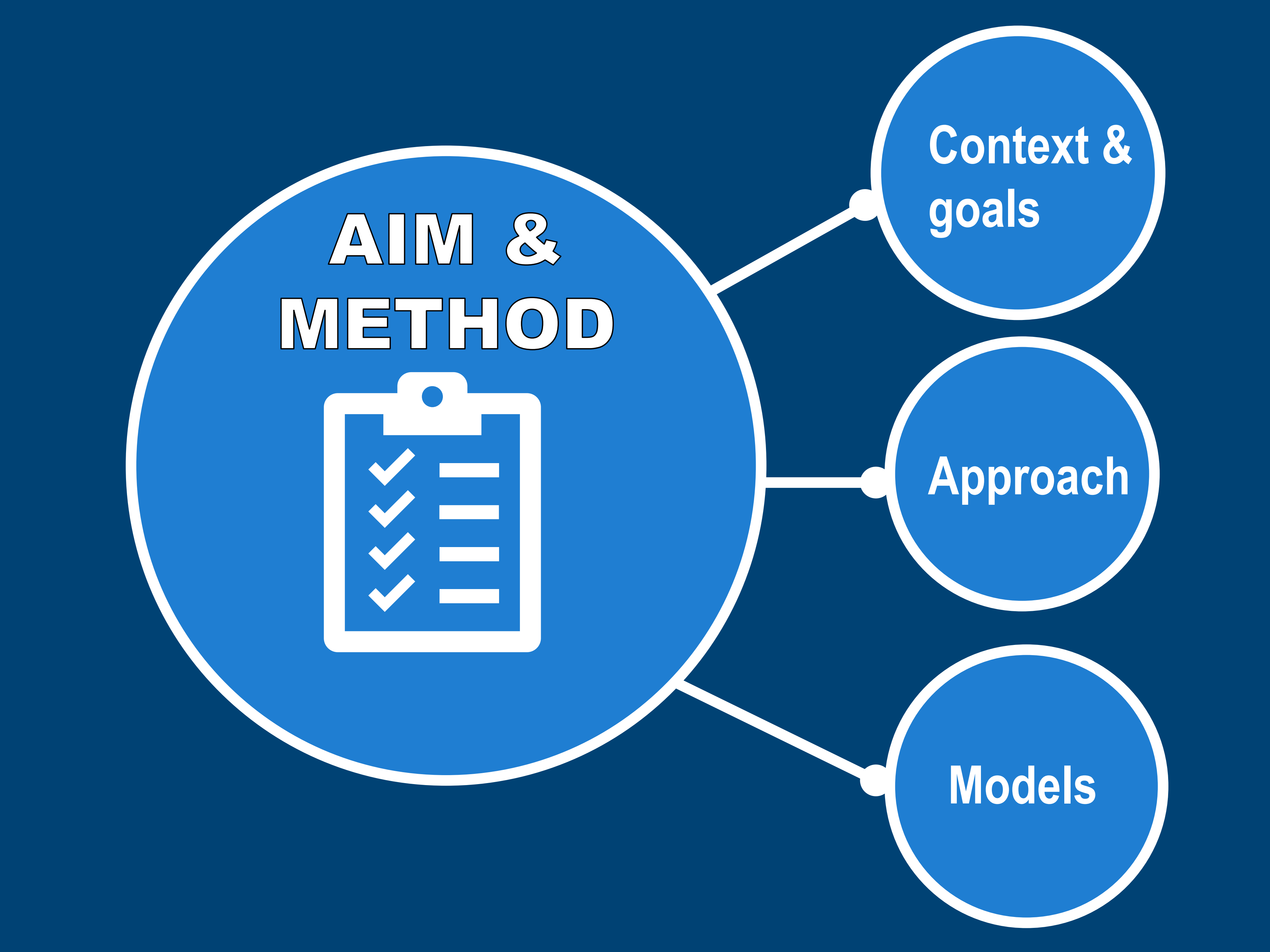
EsMlab


Data
Summary
Aim&method
Results


AIM & METHOD
Context & goals
Approach
Models

Context and goal

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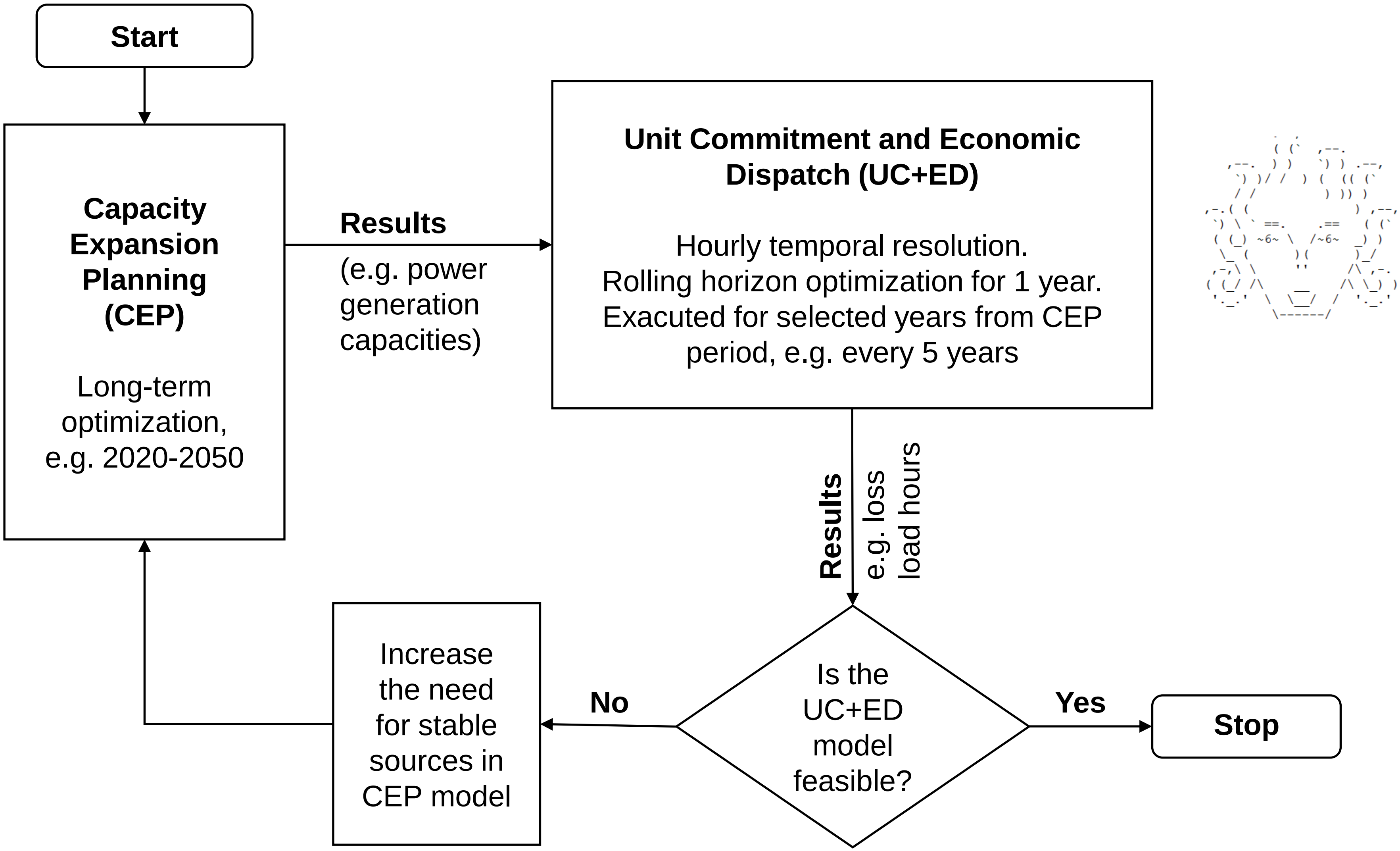
Regulative context

- European Green Deal: *EU climate neutrality in 2050*
- Real challenge, especially in power systems that are still dominated by coal power plants

Aim

- Study the future power system operation with high VRES shares considering storage and DSM to evaluate the curtailment and eventual surplus of electricity that could be used for hydrogen production
- Compare PEP2040(AGH) and ENTSO-E energy scenarios for 2050

TIMES-PL



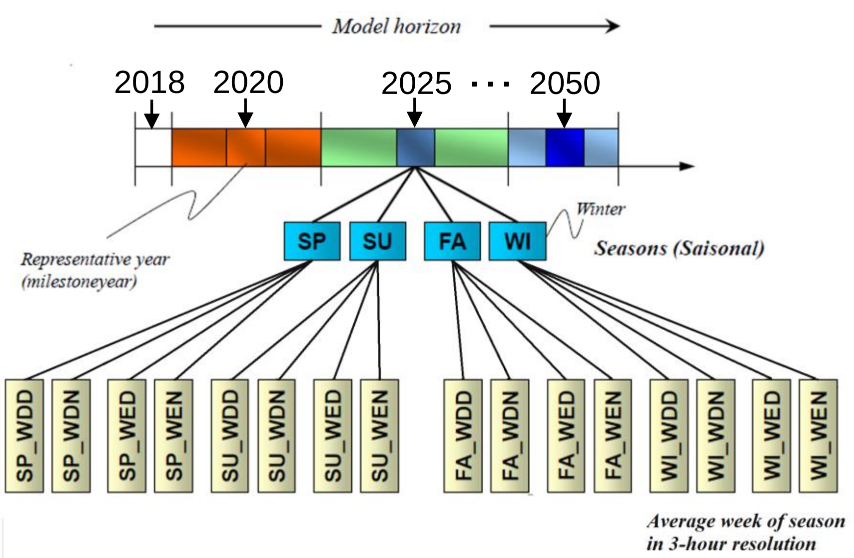
Start
Capacity Expansion Planning (CEP)
Long-term optimization, e.g. 2020-2050
Results
(e.g. power generation capacities)
Unit Commitment and Economic Dispatch (UC+ED)
Hourly temporal resolution.
Rolling horizon optimization for 1 year.
Exacuted for selected years from CEP period, e.g. every 5 years
Results
e.g. loss load hours
Is the UC+ED model feasible?
No
Yes
Stop
Increase the need for stable sources in CEP model

Capturing time in the models

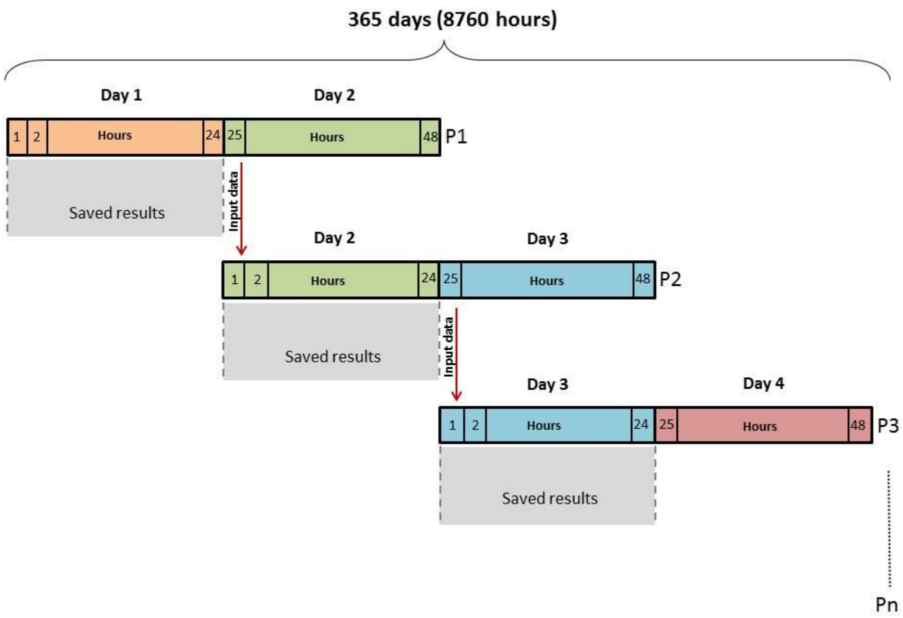
AGH

TIMES-PL

Perfect foresight optimization



Rolling horizon optimization



Models specifications

TIMES-PL

$$eObj = \sum_{i,t} \frac{1}{(1+r)^t} \cdot \left(C_{i,t}^{cap} \cdot N_{i,t}^{cap}\right) \quad \textbf{Capacity expansion}$$
$$+ \sum_{i,t} \frac{1}{(1+r)^t} \cdot \left(C_{i,t}^{elc} \cdot P_{i,t}^{elc}\right) \quad \textbf{Operation}$$

Obj: Minimize *<u>long-run</u> marginal costs*

Main Variables:

- Continues & discrete: new capacity additions
- Continues: Power output, emissions, etc.

Main constraints:

- CO_2 emission caps
- annual RES shares
- Upper/lower limit bounds on new capacities
- **Peak capacity (with reserve)**
- Availability (DN, seasonal, annual)

$$eObj = \sum_{i,t} \left(vOn_{i,t} \cdot pC_{i,t}^{Pmin} + \sum_{b} vPk_{i,t,b} \cdot pC_{i,b}^{Bid} \right) \quad \textbf{Operation}$$
$$+ \sum_{i,t,s} vSt_{i,t,s} \cdot pC_{i,s}^{St} + \sum_{i,t} vSd_{i,t} \cdot pC_{i}^{Sd} \quad \textbf{Start-up \& shut-down}$$
$$+ \sum_{t,b} vDsm_{t,b} \cdot pC_{t,b}^{Dsm} \quad \textbf{Demand-side response}$$
$$+ \sum_{t} vLS_t \cdot pVOLL \quad \textbf{Load shedding}$$

Obj: Minimize *<u>short-run</u> marginal costs*

Main Variables:

- Discrete: status, start-up, shut-down
- Continues*: Power output, DH output

Main Constraints:

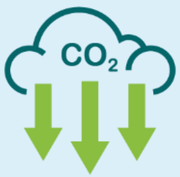
- Ramping
- Start-up, shut-down times
- Min uptime
- Min downtime
- Min Spining reserve
- DSR – daily load shifitng


Data
Scenario composition
Selected data

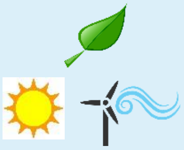
Scenario composition – 2050 targets

AGH

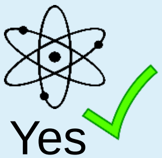
NUC Scenario



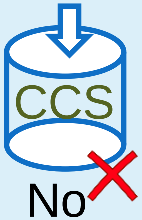
ca. 95%*
(100%)



min. 40%



Yes



No

Total electric capacity in RES in [GW]

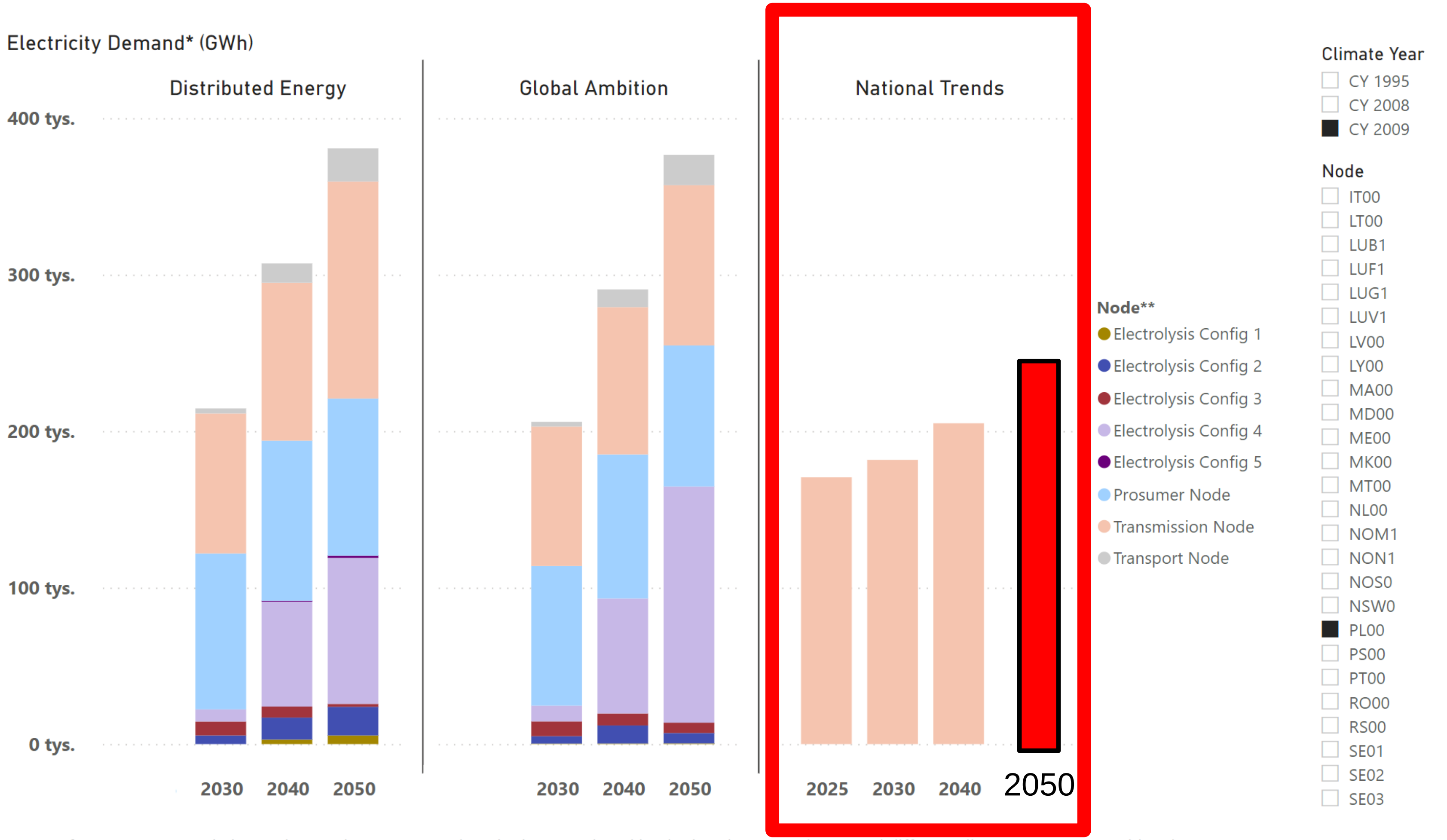
	2023	2040*	2050
PV	13	16	**40**
Wind onshore	9.5	10	**20**
Wind offshore	0	11	**20**

* based on PEP2040

*According to Eurostat CO_2 emissions from fuel combustion in public electricity and heat production in 1990 equalled to ca. $227{\cdot}10^6$ [t]

Demand: ENTSO-E, TYNDP2022

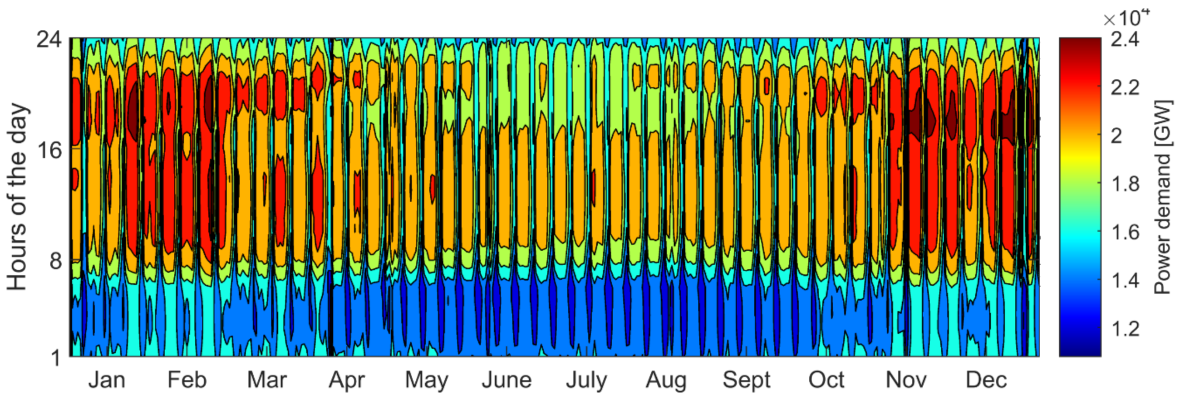
https://2022.entsos-tyndp-scenarios.eu/visualisation-platform

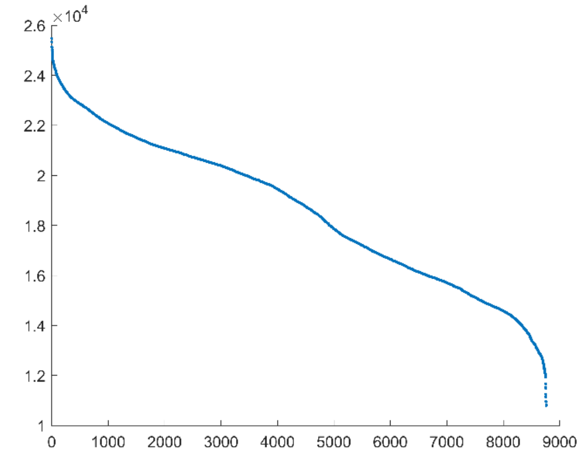


** Sum of prosumer, transmission and EV node are not equal to Final Demand workbook, since here T&D losses and different climate years are considered.*
*** Please see TYNDP 2022 Scenario Building Guideline for hydrogen configurations (Electrolysis Configurations 1/2/3/4/5)*

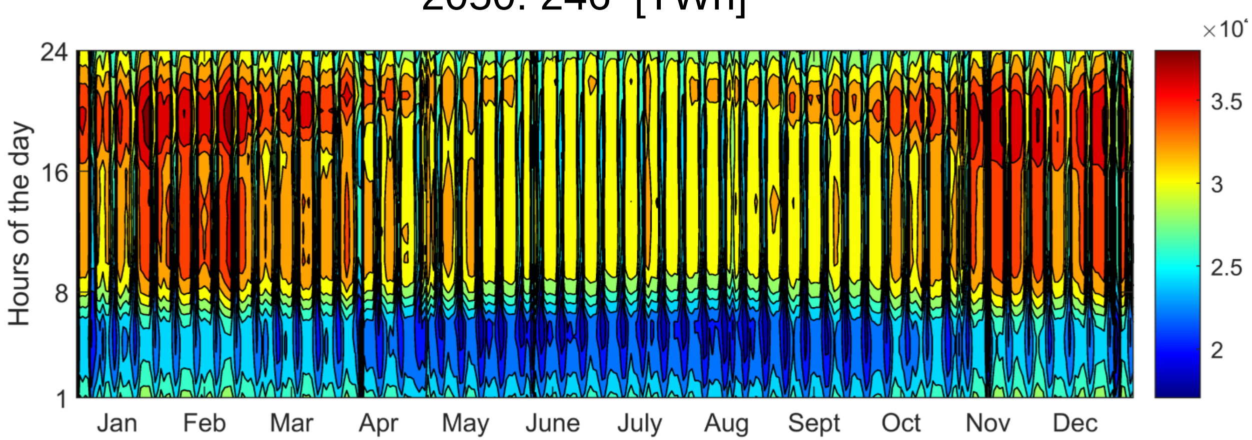
Electricity demand patterns

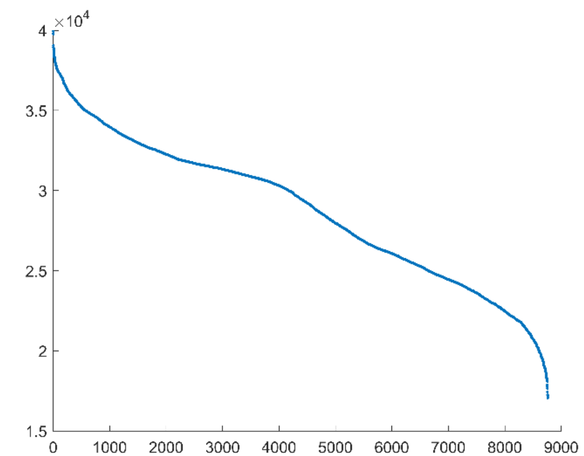
2023: 166 [TWh]





2050: 246* [TWh]





*Based on: Entso-e TYNDP 2022: National Trends

Results

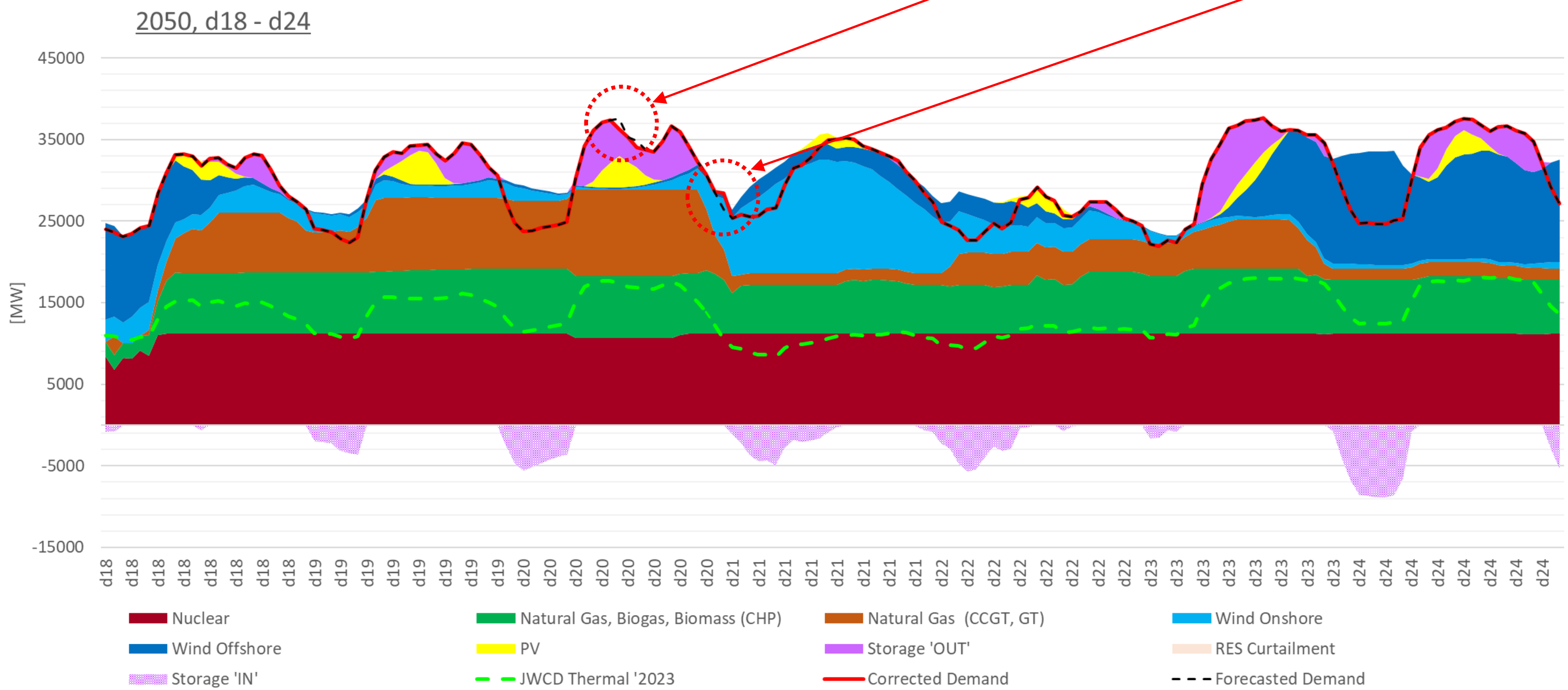
MEDUSA

2050

Daily operation profiles – DSM in use

Electricity Curtailment - NO

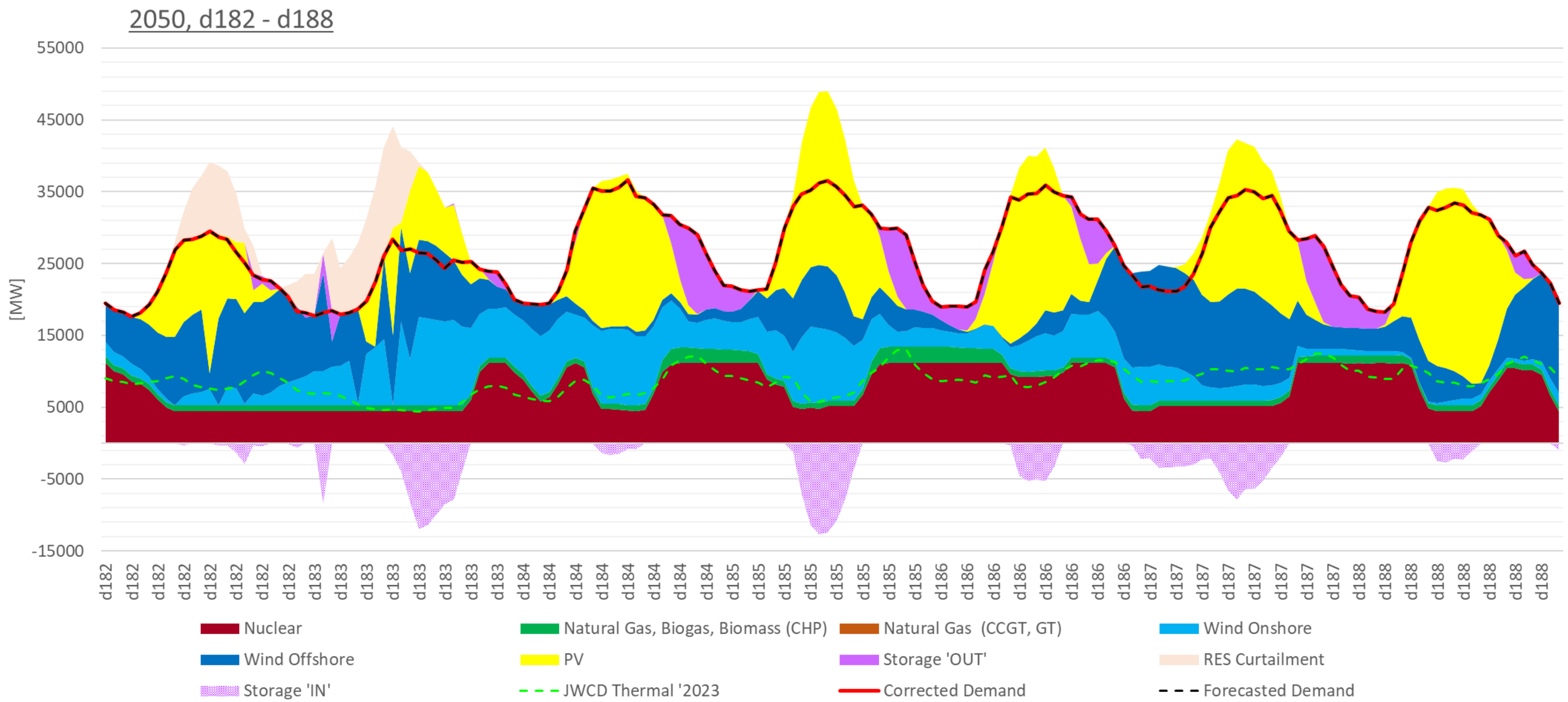
No of day	Hour	DsmDecr	DsmIncr
d20	t12	1273	
	t14	808	
	t23		82
	t24		2000



Daily operation profiles – summer time

Electricity Curtailment - YES

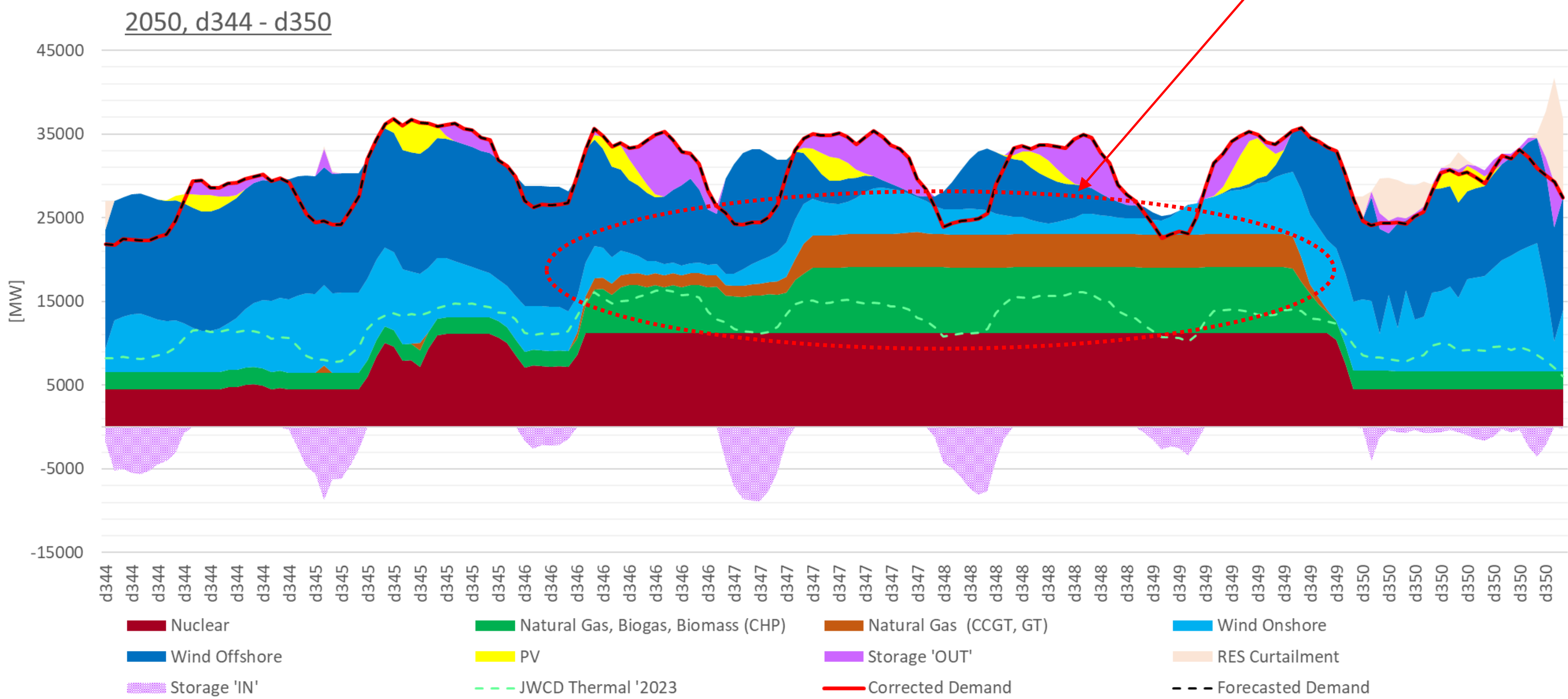
Renewables – **high**
Thermal units – **low, no gas**



Daily operation profiles – winter time

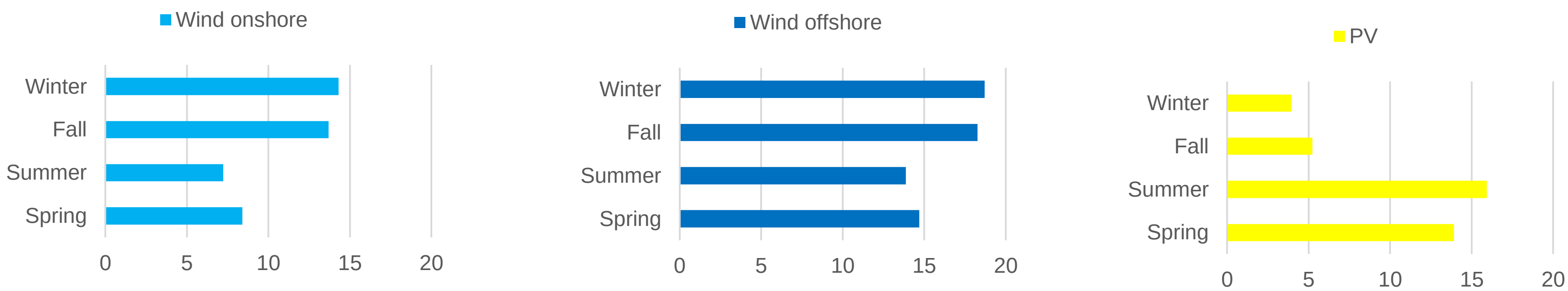
Electricity Curtailment - YES

Renewables – **high/low**
Thermal units – **low/high**

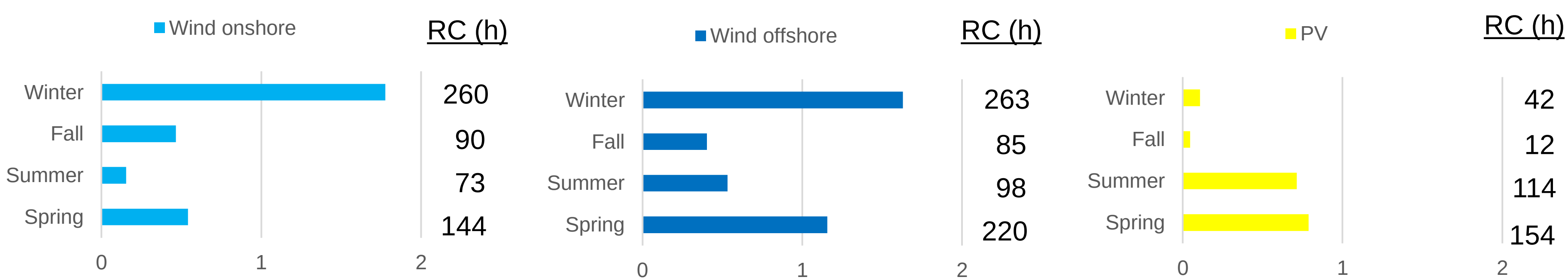


Sesonal Results for 2050

Electricity generation [TWh]



Electricity curtailment [TWh]



RC - sum of hours per year in which RES-based generation was reduced to avoid negative residual load

In each seson ca. 3 TWh of electricty goes into(from) the storage

Summary

Conclusions

- In our study VRES triple installed capacities by 2050 as compared to present situation
- This grow is necessary to balance the future power demand and to decarbonized the power system
- To secure system operation in 2050 there should be at least 20 GW installed in dispatchable power generation technologies, excluding CHP (~8 GW) and storage (~17 GW)
- Daily load variations managed by: storage + DSM
- Seasonal variation and RES Curtailment: a chance for hydrogen production?
  - ✓ In fact, in our study only 8 TWh of RES electricity is curtailed (with ca. 80 GW in VRES) – this can be used for hydrogen production in electrolyzers
  - ✓ ENTSO-E scenarios show that even 150 TWh will be consumed by electrolyzers in 2050
  - ✓ Therefore, the scenarios constituting a base of the current Polish energy policy, which are even more modest in future development of RES than our study must be significantly changed if we want to produce hydrogen according to the assumptions of ENTSO-E scenarios

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