POMMES-EU

Dataset description

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Contents

			2030	2035	2040	2050
Demand	Electricity		[1] (WS14-25-28)	[1] (WS14-25-28)	[2] DE (WS1995-2008-2009)	[2] DE (WS1995-2008-2009)
	Hydrogen		[1] (WS14-25-28)	[1] (WS14-25-28)[a]	[2] DE (WS1995-2008-2009)	[2] DE (WS1995-2008-2009)
Flexible demand	EVs		[1]	[1]	[2] DE (WS1995-2008-2009)[b]	[2] DE (WS1995-2008-2009)[b]
	HPs		[1]	[1]	[2] DE (WS1995-2008-2009) + [1]	[2] DE (WS1995-2008-2009) + [1]
Electricity production	Solar PV	Capacity bounds	[3]DB2.5 **FIXED**	[3] **Maximum**	[2]	[2]
		Availability	[1] (WS14-25-28)	[1] (WS14-25-28)	[4] 4.2 (WS1995-2008-2009)	[4] (WS1995-2008-2009)
	Wind onshore	Capacity bounds	[3] **FIXED**	[3] **Maximum**	[2]	[2]
		Availability	[1] (WS14-25-28)	[1] (WS14-25-28)	[4] (WS1995-2008-2009)	[4] (WS1995-2008-2009)
	Wind offshore	Capacity bounds	[3] **FIXED**	[3] **Maximum**	[2]	[2]
		Availability	[1] (WS14-25-28)	[1] (WS14-25-28)	[4] (WS1995-2008-2009)	[4] (WS1995-2008-2009)
	Hydro	Capacity bounds	[3] **FIXED**	[1] **FIXED**	[2] **FIXED**	[2] **FIXED**
		Availability	[1] (WS14-25-28)	[1] (WS14-25-28)	[4] (WS1995-2008-2009)	[4] (WS1995-2008-2009)
	Nuclear	Capacity bounds	[3] **FIXED**	[1] **FIXED**	[2]	[2]
		Availability	[1]	[1]	same as 2035	same as 2035
	OCGT	Capacity bounds	[3] Minimum	**FREE**[c]	**FREE**	**FREE**
		Availability	100% assumed	100% assumed	100% assumed	100% assumed
	CCGT	Capacity bounds	[3] **FIXED**	**FREE**[c]	**FREE**	**FREE**
		Availability	[1]	[1]	same as 2035	same as 2035
	OCHT	Capacity bounds	No capacity installed	**FREE**[c]	**FREE**	**FREE**
		Availability		100% assumed	100% assumed	100% assumed
	CCHT	Capacity bounds	No capacity installed	**FREE**[c]	**FREE**	**FREE**
		Availability		100% assumed	100% assumed	100% assumed
	Coal	Capacity bounds	[3] **FIXED**	[3] **Maximum**	[3] **Maximum**	[3] **Maximum**
		Availability	[1]	[1]	same as 2035	same as 2035
	Lignite	Capacity bounds	[3] **FIXED**	[3] **Maximum**	[3] **Maximum**	[3] **Maximum**
		Availability	[1]	[1]	same as 2035	same as 2035
	Oil	Capacity bounds	[3] **FIXED**	[3] **Maximum**	[3] **Maximum**	[3] **Maximum**
		Availability	[1]	[1]	same as 2035	same as 2035
	Other RES	Capacity bounds	[3] **FIXED**	[3] **FIXED**	[3] **FIXED**	[3] **FIXED**
		Availability	[3]	[3]	[3]	[3]
Electricity storage	Batteries		[3] **FIXED**	**FREE**	**FREE**	**FREE**
	PHS		[3] **FIXED**	[1] **FIXED**	[2] **FIXED**	[2] **FIXED**
Electricity eDSR			[1] **FIXED**	[1] **FIXED**	[2] **FIXED**	[2] **FIXED**
Hydrogen production	Electrolysis		[3] **FIXED**	[3] **Maximum**	**FREE**	**FREE**
	SMR		[5] **Maximum**	[5] **Maximum**	[5] **Maximum**	[5] **Maximum**
	eSMR		**FREE**	**FREE**	**FREE**	**FREE**
	SMR+CCS		**FREE**	**FREE**	**FREE**	**FREE**
Hydrogen storage	Tank		**NONE**	**FREE**	**FREE**	**FREE**
	Salt cavern		**NONE**	**NONE**	[2]	[2]
VOLL	Electricity		[1] (6000€/MWh)	[1] (6500€/MWh)	Linear interpolation	Linear interpolation
	Hydrogen		**Not allowed**	**Not allowed**	**Not allowed**	**Not allowed**
Transport	HVAC		[1] **FIXED**	[1] **FIXED**	**2x 2030 capacities max bound in 2050**[d]	
	HVDC		[1] **FIXED**	[1] **FIXED**		
	H_2 Pipeline		**NONE**	**NONE**	[2] (with a 10yrs shift)	[2] (with a 10yrs shift)
	H_2 Imports		**NONE**	**only ammonia ships [2]**	[2] (with revised assumptions)	[2] (with revised assumptions)

[a] readjustment required for consistency with 2040

[b] readjusted if more than 15% lower than 2035

[c] unless capped by TSO declarations in [1]

[d] as proposed in the [2] 2026 draft

Table 1: Capacity bounds and demand & availability time series origins summary

1 Data & assumptions

1.1 Capacity Expansion Constraints

1.1.1 Hydrogen system

For 2040-2050, the model imposes no capacity constraints on the expansion of electrolysers or ATR+CCS. Similarly, eSMRs and hydrogen tank storage are not subject to capacity limitations.

Legacy SMR units are restricted to existing capacities, which the model may decommission if unnecessary. Underground hydrogen storage capacities are capped based on TYNDP 2024 assumptions [2] to reflect infrastructure and geological constraints.

1.1.2 Electricity system

The initial setpoint for installed capacities in 2030 is based on the PEMMDB2.5 dataset [3]. Wind and solar capacities are capped according to the potential outlined in TYNDP 2024 [2]. Hydro technologies—including run-of-river (RoR), pondage, reservoir, and pumped hydro storage (PHS)—as well as "Other-RES" (small biomass, wave, and geothermal) are fixed based on PEMMDB2.5 data [3]. Coal and lignite power plant capacities are upper-bound capped according to PEMMDB2.5 [3], while gas and hydrogen turbines remain unconstrained. For nuclear power plants, the maximum remaining capacity of historical reactors and the installable capacities for new reactors are both capped based on the maximum values derived from a comparison between TYNDP 2024 assumptions [2] and PEMMDB2.5 [3] (see Table 2). The model may decommission historical reactors if optimal. Consequently, Belgium is modelled as having no nuclear power plants by 2050, despite recent PATHS2050[6] scenario updates—most of which include the deployment of new reactors (4–8 GW).

Country Code	BG	CZ	FI	FR	HU	NL	PL	RO	SE	SI	SK	UK
Long Term Operation (GW)		3.1	1.9	30.1		0.5		0.6	7.0	0.7	1.9	2.9
New (GW)	2.4	7.0	10.0	20.0	2.6	6.4	15.0	2.4	11.6	1.1	1.2	19.3

Table 2: Maximum nuclear capacity potential per country in 2050

1.2 Technology availability & climate

1.2.1 Renewable Energy

As illustrated in Figure 1, POMMES-EU incorporates distinct investment and operation horizons, with three operation horizons between each investment horizon. Each operation horizon corresponds to a specific weather scenario. For the 2030–2035 period, weather scenarios 14, 25, and 28 from ERAA 2024 [1] were selected, as these were used for the ERAA economic viability assessment. Similarly, climate years 1995, 2008, and 2009 from TYNDP 2024 [2] were chosen for the 2040–2050 period for consistency. However, the renewable energy availability time series from the PECD 4.1 dataset provided in TYNDP

2024 [2] were incomplete, particularly for 2050. To address this, these time series were manually reconstructed using the PECD 4.2 platform[1].

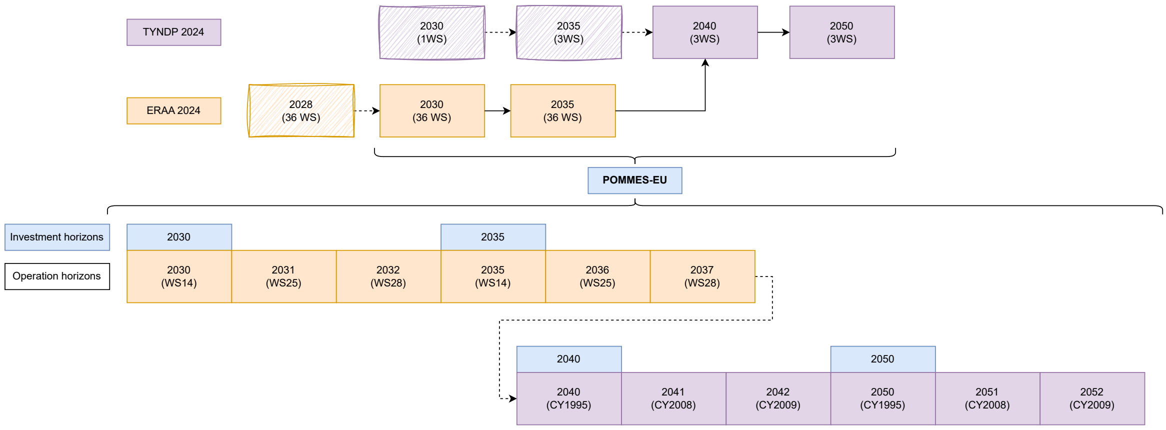

Fig. 1: POMMES-EU data horizons | we only use one climate year from the database | CY = Climate Year, WS = Weather Scenario

1.2.2 The case of nuclear energy

The ERAA 2024 [1] dataset provides availability and must-run ratios for nuclear power plants, which remain constant across weather scenarios. This allows the application of the same time series to all scenarios. However, the TYNDP 2024 dataset does not include consistent nuclear power plant operation data. To address this inconsistency, the ERAA 2024 [1] assumptions for nuclear power plant availability (originally derived for 2035) were extended and applied to the 2040–2050 period.

1.3 Demand assumptions

1.3.1 Electricity

As for renewable energy availability time series, electricity demand data were derived from the ERAA 2024 [1] and TYNDP 2024 [2] datasets (see Figure 1). To ensure consistency in long-term projections, the data for the 2035–2040 period were adjusted accordingly.

In the ERAA 2024 dataset [1], electricity consumption from heat pumps and electric vehicles is treated as flexible, allowing for demand shifts within a 6-hour window. The degree of flexibility varies by country. For the 2040–2050 period, the POMMES-EU model extends this methodology by integrating heat demand time series from TYNDP 2024 [2] to adapt the flexibility assumptions for heat pumps.

To achieve this, the TYNDP 2024 [2] heat demand time series are converted into

[1] https://cds.climate.copernicus.eu/datasets/sis-energy-pecd?tab=overview

electricity demand for heat pumps using the following relationship:

$$HP_{a,t}^{demand} = \frac{Heat_{a,t}^{demand}}{COP_{a,t}} \tag{1}$$

where $HP_{a,t}^{demand}$ is the electricity demand of heat pumps in country a at time t, $Heat_{a,t}^{demand}$ is the heat demand in country a at time t, and $COP_{a,t}$ is the coefficient of performance of heat pumps in country a at time t.

		2030	2035	2040	2050
Electricity (inelastic)	Demand time series	[1]	[1]	DE [2]	DE[a] [2]
Electric vehicles	Demand time series	[1]	[1][b]	DE [2]	DE[a] [2]
	Flexible ratio	[1]	[1]	same as 2035	same as 2035
Heat Pumps	Demand time series	[1]	[1][b]	Eq. 1	Eq. 1
	Flexible ratio	[1]	[1]	same as 2035	same as 2035
Hydrogen	Demand time series	[1]	[1][b]	DE[a] [2]	DE[a] [2]

[a]Distributed Energy Scenario
[b]Demand for 2035 was readjusted if >15% to 2040 demand

Table 3: Demand data origin

1.3.2 Hydrogen

As for electricity demand, hydrogen demand data were derived from the ERAA 2024 [1] and TYNDP 2024 [2] datasets (see Table 3). To ensure consistency in long-term projections, the data for the 2035–2040 period were adjusted accordingly.

1.4 Hydrogen Backbone

The assumptions regarding the European Hydrogen Backbone in this study are derived from the TYNDP 2024 dataset [2]. However, the TYNDP 2024 projections assume the deployment of an almost fully structured EHB by 2030, a timeline that is quite unrealistic. While this inconsistency does not affect the scope of our study—given its focus on the 2050 horizon—the POMMES-EU dataset adopts a more conservative assumption, delaying the initial deployment of the EHB to 2040.

2 Commodity prices and potential

2.1 Price assumptions

Commodity price assumptions (Table 4) were taken from TYNDP 2026 assumptions [3].

	Commodity Prices [€/MWh_{th}]			
Fuel	2030	2035	2040	2050
Uranium	2.2	2.2	2.2	2.2
Lignite G1 (BG - MK - CZ)	6.69	6.69	6.69	6.69
Lignite G2 (SK - DE - RS - PL - ME - UKNI - BA - IE)	8.6	8.6	8.6	8.6
Lignite G3 (SL - RO - HU)	11.33	11.33	11.33	11.33
Lignite G4 (GR - TR)	14.82	14.82	14.82	14.82
Hard coal	14.8	14.8	14.8	14.8
Natural Gas	33.2	35.25	37.3	35.5
Biomethane	49.9	50.4	50.8	50.0
Light oil	65.7	70.2	74.7	93.1
CO_2 price [€/tCO_2]	97.5	197.5	297.5	502.7

Table 4: Commodity price assumptions for POMMES-EU

2.2 Biogas potential

The TYNDP 2024 [2] relies on the ENSPRESO database [7] to estimate the biomass potential, although the methodology for allocating this potential across sectors remains unspecified. For both the TYNDP 2024 and TYNDP 2026, biogas production is assumed to mainly come from manure. Consequently, the *MINBIOGAS1* commodity from the ENSPRESO database is used as the reference. Given the relatively low price assumptions for bio-methane in the TYNDP 2026, it is further assumed that biogas is also intended for industrial applications. To reflect this, a volume equivalent to the *ENS_Med* scenario is allocated (see Fig. 2).

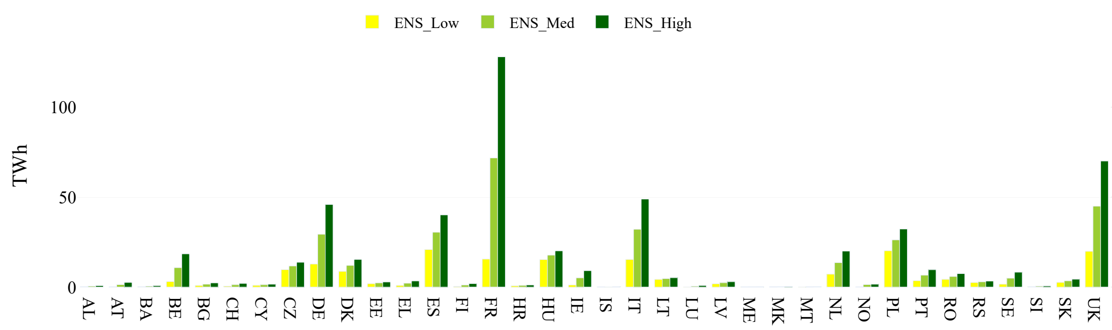

Fig. 2: Biogas from manure potential (ENSPRESO database [7])

2.3 Carbon constraints

While POMMES allows for the imposition of limits on emission volumes, no such constraints were applied in this study. Instead, decarbonisation incentives arise solely from the availability of technologies, their associated costs, commodity prices, and the CO_2 price, as detailed in Table 4.

3 Techno-economic assumptions

3.1 Electricity production

3.1.1 General assumptions

	Direct emissions [tCO_2/MWh]	Efficiency	Investment Costs [€/kW]				Fixed Costs [€/kW/yr]		Variable Costs[a] [€/MWh]	Lifetime [yr]	WACC	Sources
			2030	2035	2040	2050	2030	After				
Wind Onshore			1150	1130	1110	1090	1.4% CAPEX	1.4% CAPEX	1.98 to 1.85	30	5%	[8, 9]
Wind Offshore			2390	2250	2140	1990	1.4% CAPEX	1.4% CAPEX	3.45 to 2.78	30	5%	[8, 9]
Solar PV			380	350	320	290	2.5% CAPEX	2.5% CAPEX		40	5%	[8, 9]
LTO Nuclear		33%					319	319	8	20	[b]	[10, 1]
New Nuclear		37%	9500	9500	5500	4946	100	100	8	60	7%	[10, 1]
Hydro[c]							130	130		50	[b]	[10]
Coal	0.825	41%					33.9	33.9	3.45	10	[b]	[11]
Lignite	0.983	37%					38.8	38.8	4.1	10	[b]	[11]
Oil	0.702	42%					26.5	26.5	3.2	10	[b]	[1]
OCGT	0.513	40%		522	522	522	20[d]	20.8	2.4	25	6.17%	[1]
CCGT	0.342	60%		889	889	889	11.9[d]	33.8	2.4	25	7.54%	[1]
OCGT-H_2		40%		600	600	600		23.9	2.5	25	6.17%	[1]
CCGT-H_2		60%		978	978	978		37.2	2.5	25	7.54%	[1]

[a]does not include fuel consumption
[b]all in opex
[c]pumped-hydro not included
[d]includes capex

Table 5: Economic characteristics in POMMES-EU for electricity production technologies

3.1.2 The case of explicit demand side response

Explicit Demand Side Response (eDSR) was modelled as an electricity generation technology, featuring fixed capacities (derived from ERAA 2024 [1] for 2030–2035 operations and PEMMDB2 [2] for 2040–2050), a variable cost equivalent to the activation price, and a maximum daily energy shed limit[2]. Table 6 presents the assumptions taken for the different eDSR bands for Belgium.

[2]This corresponds to the fixed capacity multiplied by the number of hours per day the eDSR can be activated. This approach was used to maintain the model's full linearity, as tracking activation hours would require binary or integer variables.

Year	eDSR Band	1	2	3	4	5	6	7	8
2030	Capacity [MW]	620.4	324	193	610	309	634	454	
	Activation price [€/MWh]	67	178	300	500	1000	1500	2000	
	Hours per day	24	24	24	8	11	4	2	
2035	Capacity [MW]	832.6	606	193	610	423	634	454	
	Activation price [€/MWh]	70	186	300	500	1000	1500	2000	
	Hours per day	24	24	24	8	14	4	2	
2040	Capacity [MW]	832.6	378.6	193	545.2	131	99.8	634	454
	Activation price [€/MWh]	70	186	300	500	1000	1000	1500	2000
	Hours per day	24	24	24	8	1	24	4	2
2050	Capacity [MW]	832.6	378.6	193	545.2	131	99.8	634	454
	Activation price [€/MWh]	70	186	300	500	1000	1000	1500	2000
	Hours per day	24	24	24	8	1	24	4	2

Table 6: Explicit Demand Side Response Assumptions for Belgium

3.2 Hydrogen production

	Year	Unit	Investment Costs [€/unit]	Fixed Costs [€/unit/yr]	Variable Costs [€/MWh$_{H_2}$]	Lifetime [yr]	WACC	Sources
Electrolyser	2030	kW$_e$	1330	53.2		20	10%	[3] ([12] for WACC)
	2035	kW$_e$	1190	47.6		20	10%	[3] ([12] for WACC)
	2040	kW$_e$	1050	42.0		20	8%	[3] ([12] for WACC)
	2050	kW$_e$	910	36.4		20	6%	[3] ([12] for WACC)
SMR (legacy)		kW$_{H_2}$		198		25	(all in opex)	[12]
eSMR		kW$_{H_2}$	850	144		25	5%	[12]
ATR+CCS		kW$_{H_2}$	1600	108	3.1[a]	25	7%	[12]

[a]for CO_2 transport & storage

Table 7: Economic characteristics in POMMES-EU for hydrogen production technologies

		Direct emissions [tCO_2/MWh]	Consumption [kWh/kWh$_{H_2}$]		Ramp up/down [hr]
	Year		Electricity	Methane	
Electrolyser	2030		1.449		<1
	2035		1.428		<1
	2040		1.408		<1
	2050		1.351		<1
SMR (legacy)		0.28	0.017	1.31	25
eSMR		0.176	0.327	0.79	2/<1
ATR+CCS		0.023	0.108	1.25	3.5

Table 8: Technical characteristics in POMMES-EU for hydrogen production technologies

3.3 Hydrogen imports

	Investment Costs [€/kW$_{H_2}$]				Fixed Costs [€/kW$_{H_2}$/yr]	Import price [€/MWh$_{H_2}$]				Lifetime [yr]	Ramping	LTC[a] Band	Sources
	2030	2035	2040	2050		2030	2035	2040	2050				
Ammonia ships	446	406	379	343	3% CAPEX	137.9	123.15	108.4	86.8	25	30% weekly	70%	[2, 3, 13]
Ukraine imports	50	50	50	50	2% CAPEX	97.5	80.62	63.75	63.75	50	3.5hrs	70%	[2, 3]
Norway imports	50	50	50	50	2% CAPEX	60	60	60	60	50	3.5hrs	70%	[2, 3]
MENA imports	50	50	50	50	2% CAPEX	78.75	65.62	52.5	52.5	50	<1	50%	[2, 3]

[a]Long Term Contract

Table 9: Technical characteristics in POMMES-EU for hydrogen imports

3.4 Storage

		PHS[a]	Battery				Salt Cavern				Tank			
			2030	2035	2040	2050	2030	2035	2040	2050	2030	2035	2040	2050
Invesment Costs	Power [€/kW]	4250	80	70	70	70								
	Volume [€/kWh]		200	190	170	170	2.13	1.865	1.6	1.28	480	385	290	220
Fixed Costs	Power [€/kW/yr]	8.5	8.1	8.1	8.7	9.2	≈0	≈0	≈0	≈0	0.532	0.532	0.532	0.425
Lifetime [yr]		50	20	25	30	30	100	100	100	100	30	30	30	30

[a]Pumped Hydro Storage

Table 10: Economic characteristics in POMMES-EU for storage technologies | from [8]

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url: https://www.ewi.uni-koeln.de/en/publications/ewi-global-ptx-cost-tool-v2-1/