
From gigawatts to critical mineral demands for EU solar and wind

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Supplementary information

From gigawatts to critical mineral demands for EU solar and wind

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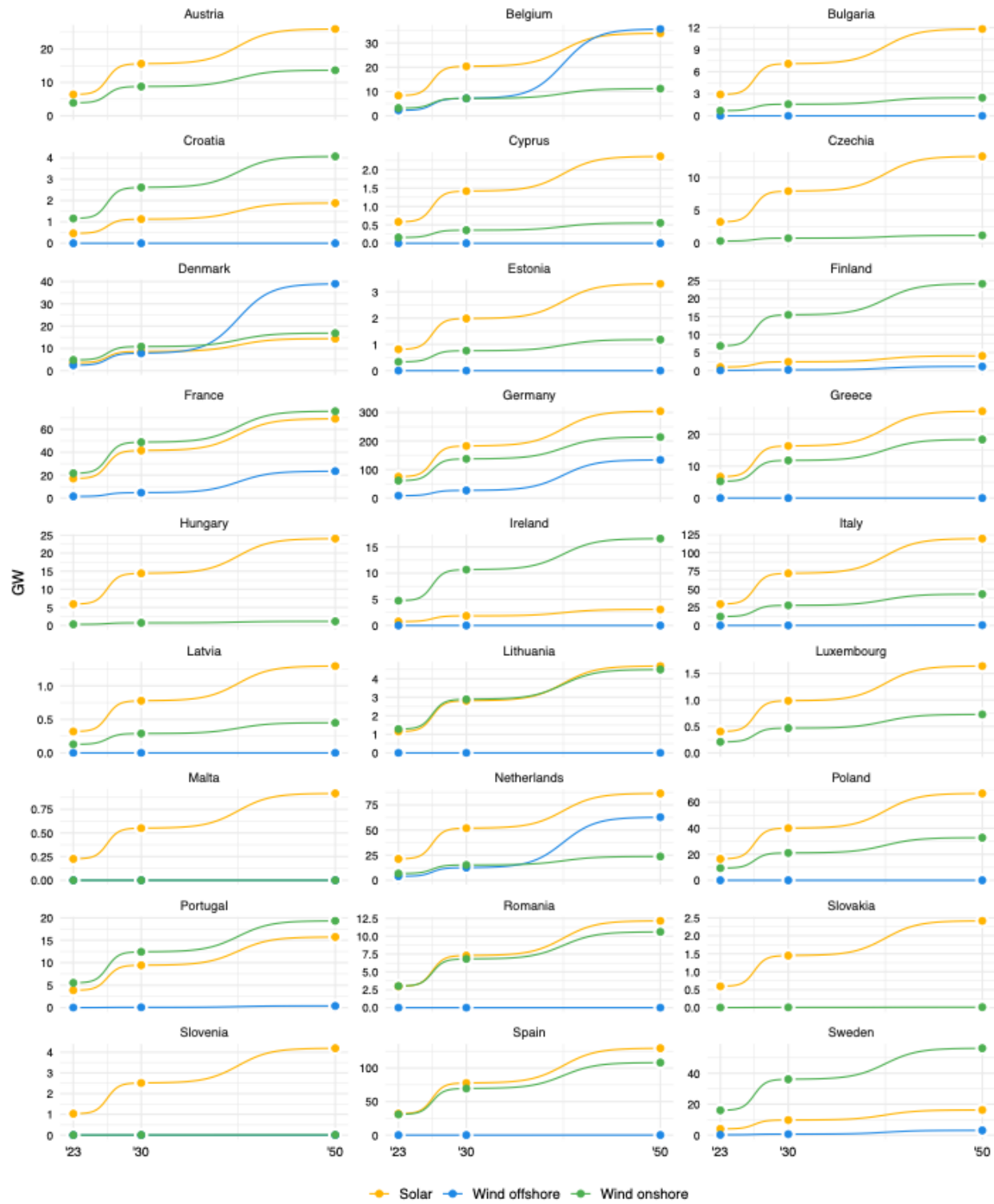
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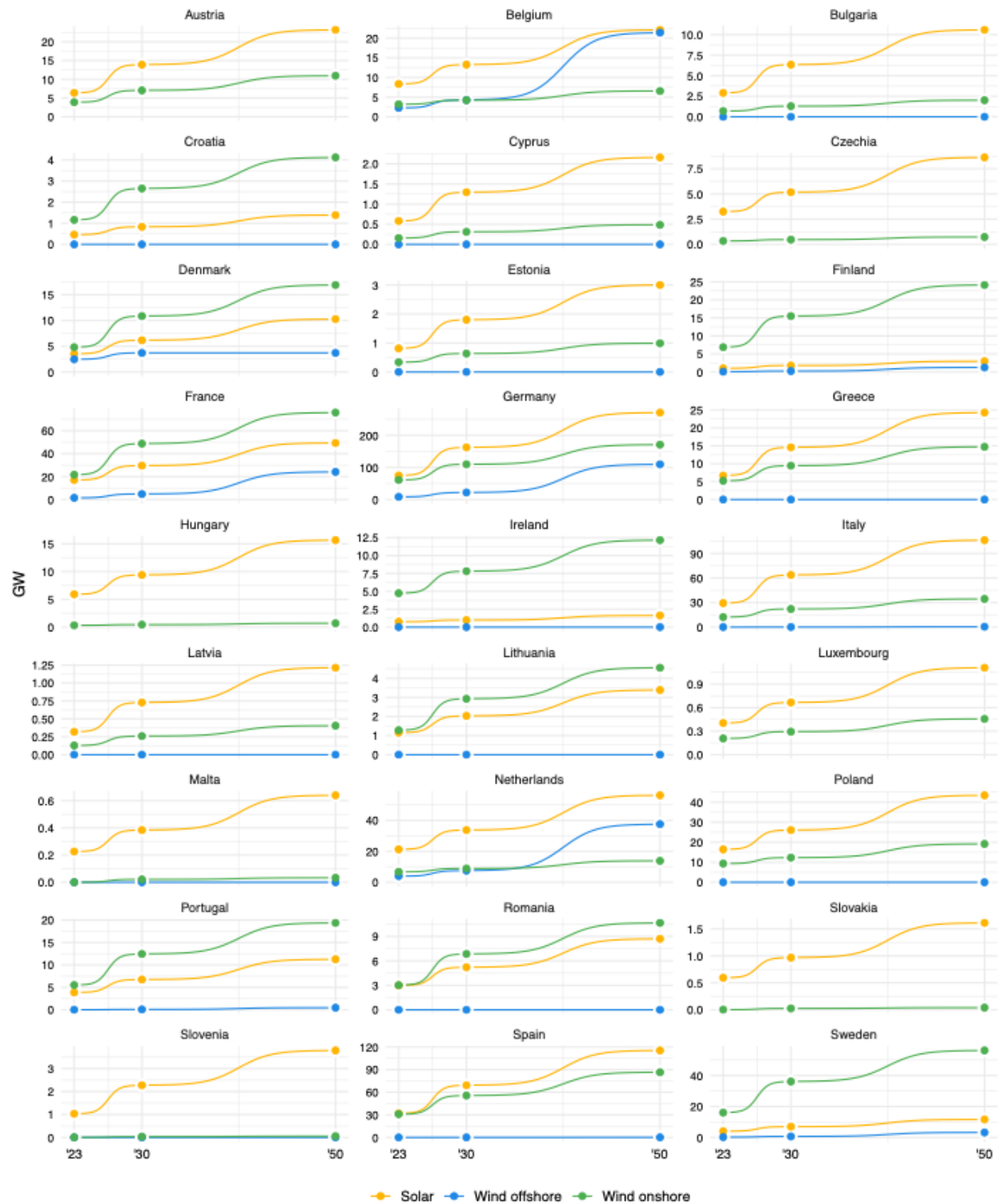
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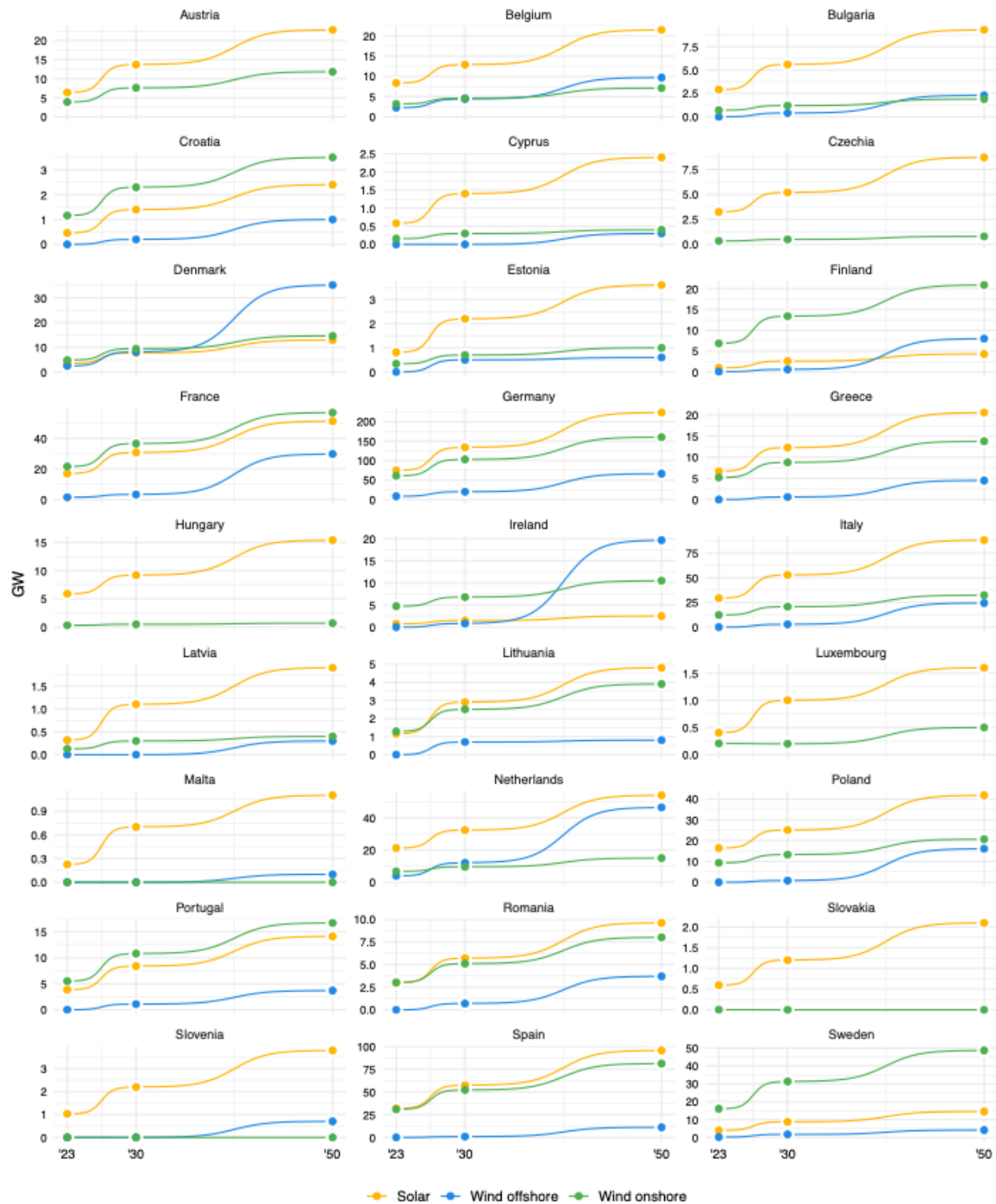
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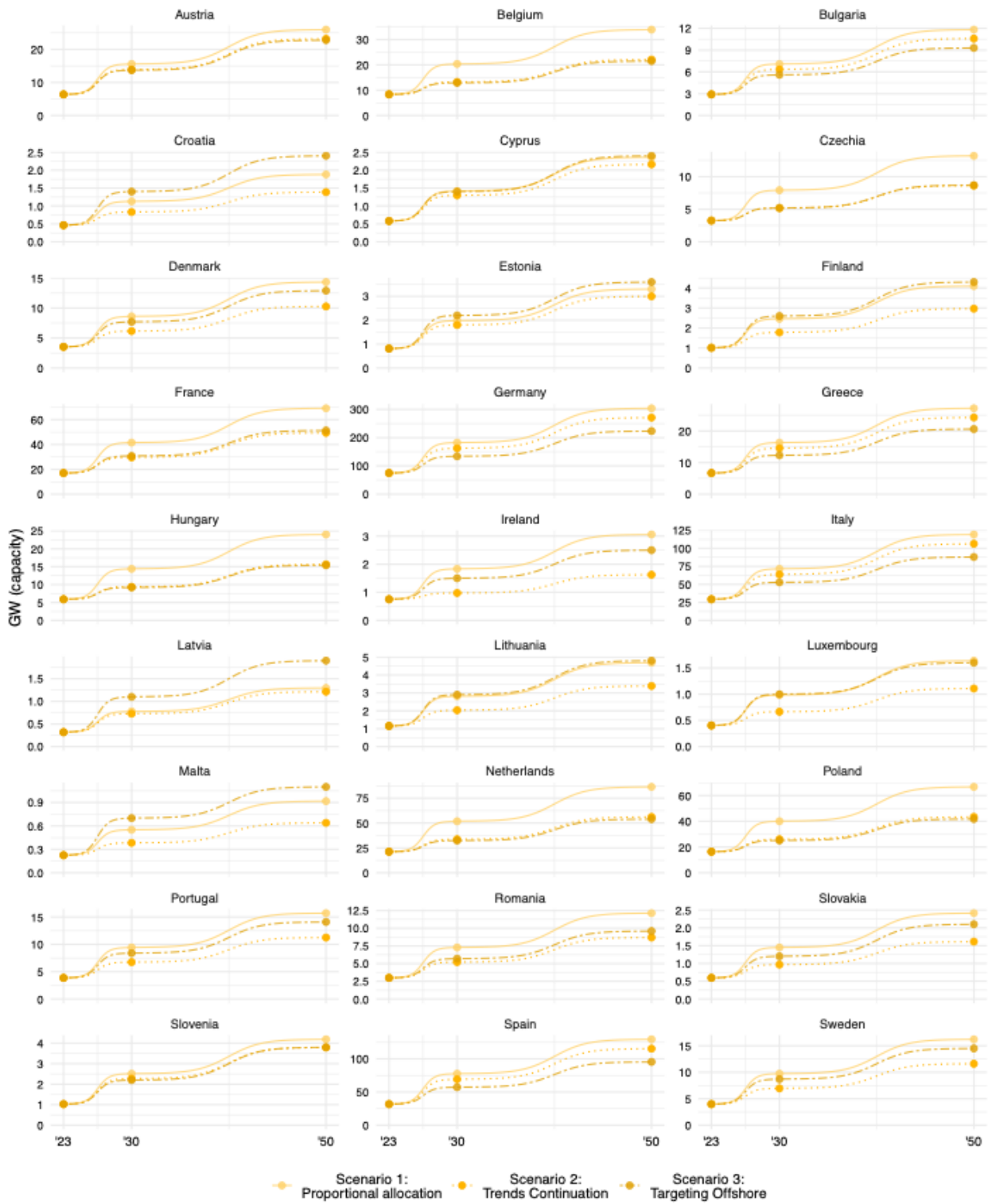
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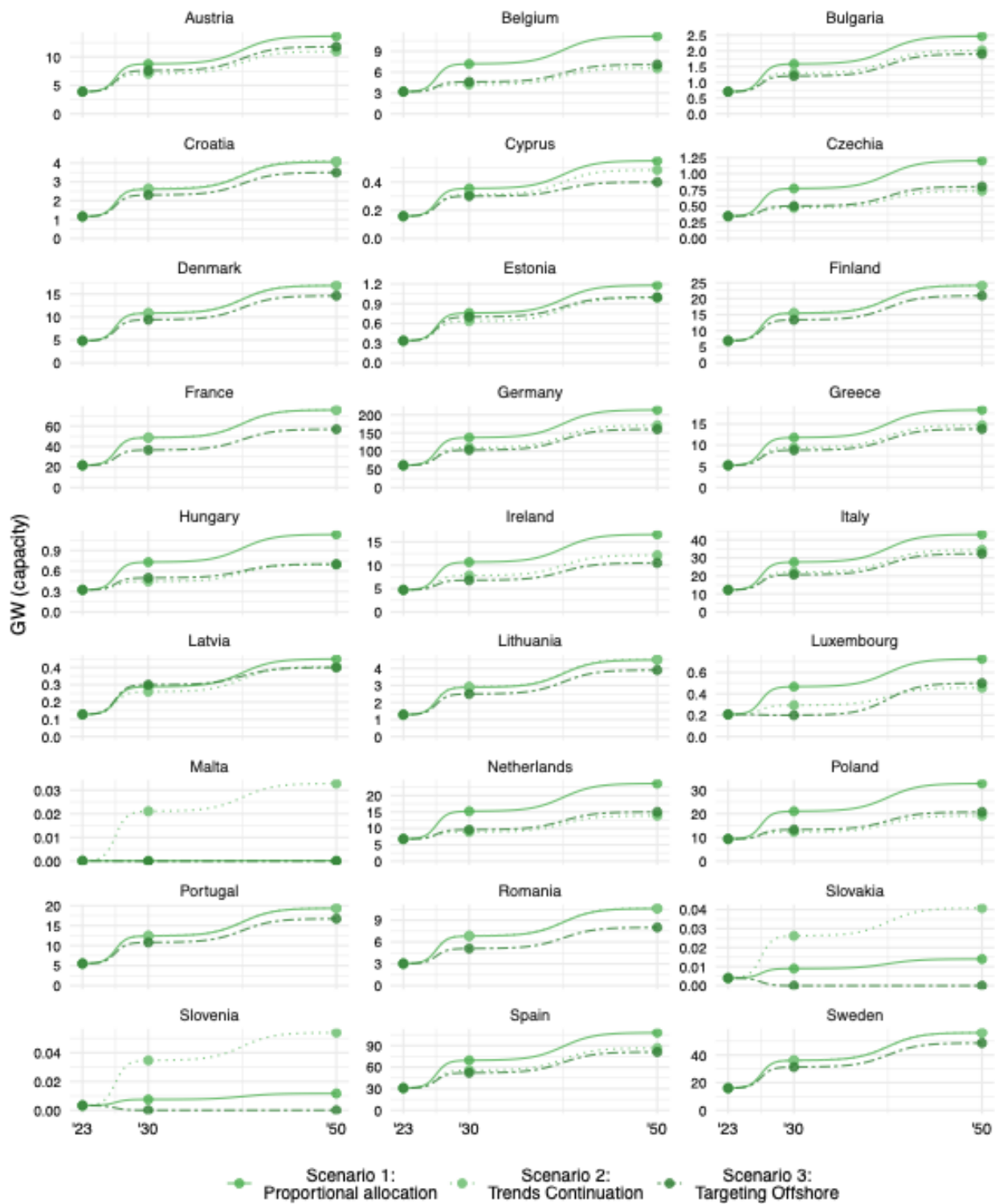
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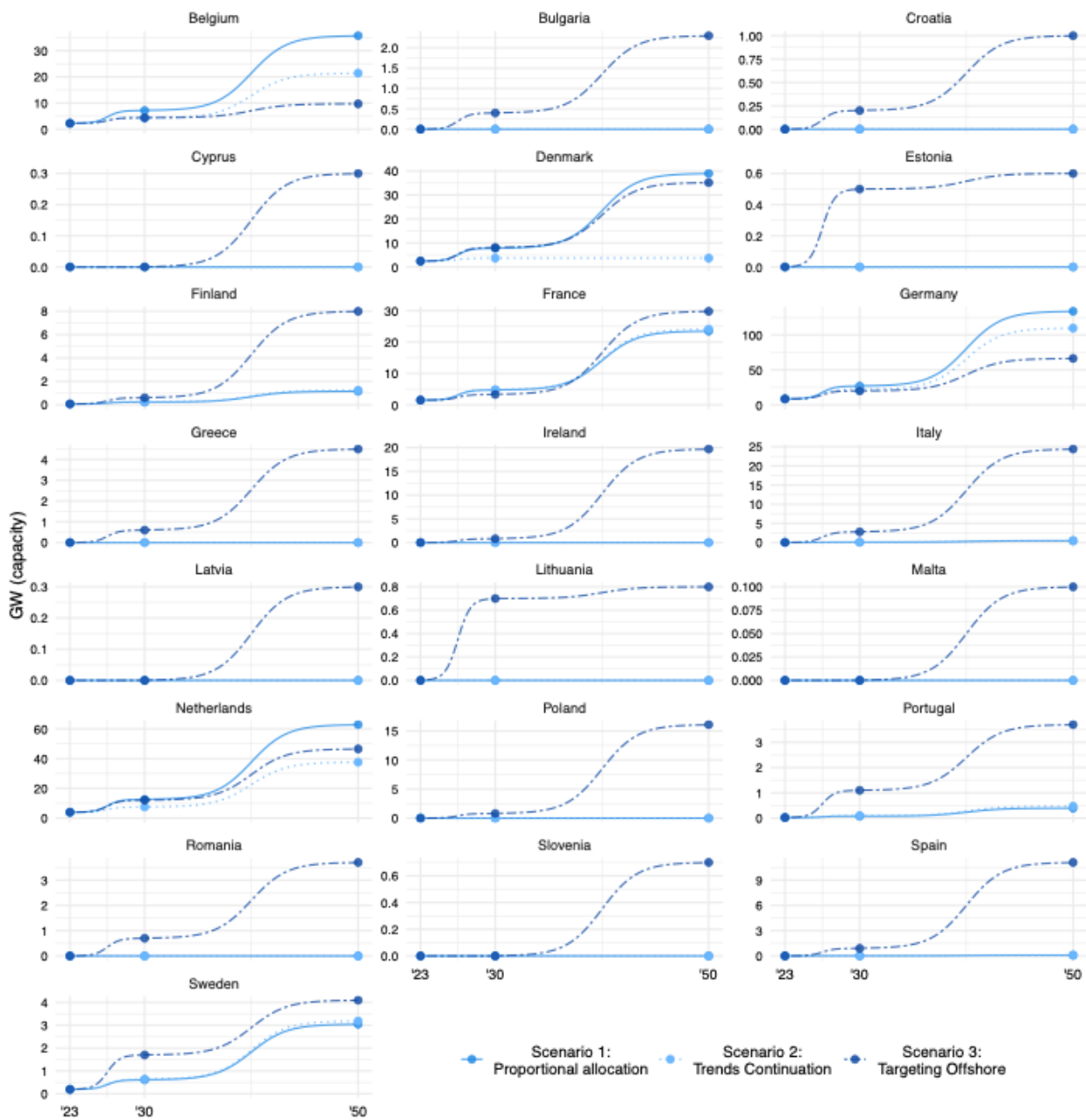
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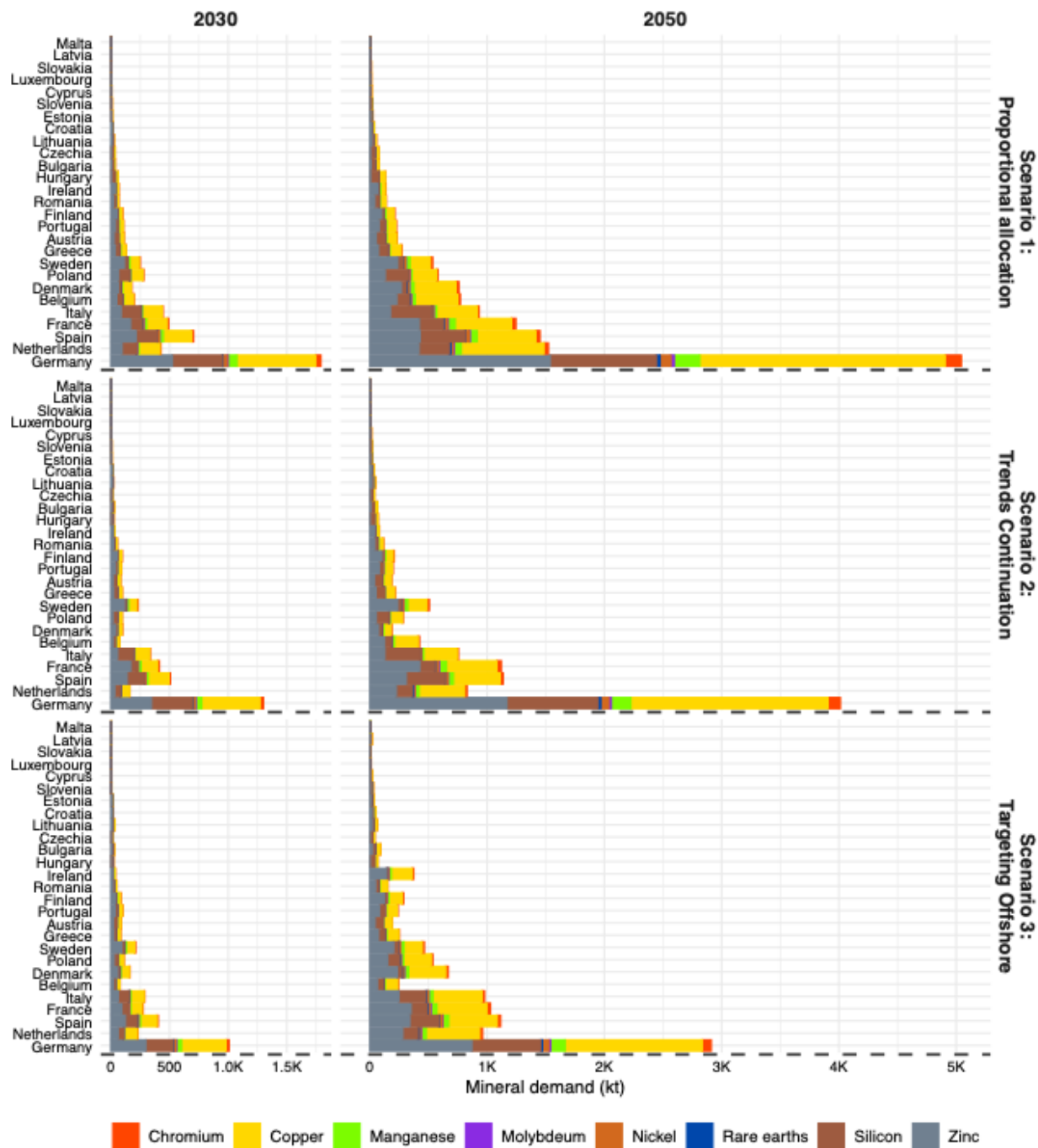
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Supplementary Tables

Supplementary Table 1. Existing offshore targets (in GW) in EU27 member states

Country ¹	2030	2050
Belgium ^{2,3}	5.8	10.2
Denmark ⁴	14.0	52.0
Estonia ²	1.0	-
Finland ²	1.0	12.0
France ²	4.0	45.0
Germany ²	30.0	70.0
Ireland ²	7.0	37.0
Lithuania ²	2.0	-
Netherlands ²	21.0	70.0
Poland ⁵	5.9	28.0
Portugal ²	2.0	-
Romania ²	3.0	-
Spain ²	3.0	17.0
Sweden ²	3.0	-

Notes:

1) While offshore wind targets are explicitly compiled at the Member State level in EU framework agreements, solar PV and onshore wind targets are established in official EU policy exclusively as continental aggregates.

Consequently, member-state capacity trajectories for solar and onshore wind across scenarios are derived through our scenario modelling framework.

2) <https://ember-energy.org/latest-insights/offshore-wind-targets-underpin-acceleration-to-2030-and-beyond/>

3) For Belgium, the 2040 target is 8.0 GW, so we approximated the 2050 target by a linear increase in time.

4) https://offshore-coalition.eu/wp-content/uploads/2025/03/Denmark_Factsheet_FINAL_country-profile.pdf

5) <https://seawind.eu/expertise/polish-offshore-wind-market-overview/>

Supplementary Table 2. Mineral demand associated with solar and wind expansion in the EU27. Data expressed in thousand metric tons (kt), by scenario

Mineral	Scenario 1: Proportional allocation		Scenario 2: Trends Continuation		Scenario 3: Targeting Offshore	
	2030	2050	2030	2050	2030	2050
Chromium	139.1	382.6	96.2	278.0	88.0	297.6
Copper	2,052.3	5,826.1	1,387.9	4,181.3	1,283.7	4,498.0
Manganese	227.5	612.1	157.6	446.6	142.7	471.9
Molybdenum	29.2	80.1	20.2	58.3	18.5	62.3
Nickel	110.8	269.2	77.4	200.1	67.0	198.6
Rare earths	13.3	74.2	8.3	49.2	11.7	69.2
Silicon	1,397.4	2,976.7	949.4	2,231.0	766.1	1,926.5
Zinc	1,611.9	4,318.9	1,116.9	3,152.9	1,009.3	3,323.1

Supplementary Table 3. Mineral demand associated with solar and wind expansion in the EU27. Data expressed in thousand metric tons (kt), by technology and scenario

Mineral	Technology	Scenario 1: Proportional allocation		Scenario 2: Trends Continuation		Scenario 3: Targeting Offshore	
		2030	2050	2030	2050	2030	2050
Copper	Solar	998.8	2,127.7	678.6	1,594.6	547.6	1,377.0
Silicon		1,397.4	2,976.7	949.4	2,231.0	766.1	1,926.5
Zinc		10.6	22.6	7.2	17.0	5.8	14.6
Chromium	Wind offshore	21.5	147.5	12.8	96.1	21.3	141.7
Copper		328.0	2,248.0	194.8	1,463.8	324.8	2,159.2
Manganese		32.4	222.0	19.2	144.6	32.1	213.2
Molybdenum		4.5	30.6	2.7	19.9	4.4	29.4
Nickel		9.8	67.4	5.8	43.9	9.7	64.8
Rare earths		9.8	67.2	5.8	43.7	9.7	64.6
Zinc		225.5	1,545.5	133.9	1,006.4	223.3	1,484.5
Chromium	Wind onshore	117.6	235.1	83.4	182.0	66.7	155.9
Copper		725.4	1,450.4	514.5	1,122.9	411.3	961.8
Manganese		195.1	390.1	138.4	302.0	110.6	258.7
Molybdenum		24.8	49.5	17.6	38.3	14.0	32.8
Nickel		100.9	201.8	71.6	156.2	57.2	133.8
Rare earths		3.5	7.0	2.5	5.4	2.0	4.6
Zinc		1,375.8	2,750.8	975.7	2,129.6	780.1	1,824.0

Note: Technology-specific values may not sum exactly to the aggregate values for each scenario because results were rounded independently to one decimal place.

Supplementary Table 4. Benchmarking scenarios for EU mineral demand against current global production and reserves (2030 and 2050)

Mineral	EU demand 2030 (kt)	EU demand 2050 (kt)	World production 2024 ¹	2050 as % of 2024 world production	World reserves ¹	2050 as % of world reserves
Chromium						
- scenario 1	139.1 kt	382.6 kt	47.0 Mt	0.81%	>1,200 Mt	<0.1%
- scenario 2	96.2 kt	278.0 kt		0.59%		<0.1%
- scenario 3	88.0 kt	297.6 kt		0.63%		<0.1%
Copper						
- scenario 1	2,052.3 kt	5,826.1 kt	23.0 Mt	25.3%	980 Mt	0.59%
- scenario 2	1,387.9 kt	4,181.3 kt		18.2%		0.43%
- scenario 3	1,283.7 kt	4,498.0 kt		19.6%		0.46%
Manganese						
- scenario 1	227.5 kt	612.1 kt	20.0 Mt	3.1%	1,700 Mt	<0.1%
- scenario 2	157.6 kt	446.6 kt		2.2%		<0.1%
- scenario 3	142.7 kt	471.9 kt		2.4%		<0.1%
Molybdenum						
- scenario 1	29.2 kt	80.1 kt	260 kt	30.8%	15.0 Mt	0.53%
- scenario 2	20.2 kt	58.3 kt		22.4%		0.39%
- scenario 3	18.5 kt	62.3 kt		24.0%		0.42%
Nickel						
- scenario 1	110.8 kt	269.2 kt	3.7 Mt	7.3%	>130 Mt	<0.21%
- scenario 2	77.4 kt	200.1 kt		5.4%		<0.16%
- scenario 3	67.0 kt	198.6 kt		5.4%		<0.16%
Rare Earths						
- scenario 1	13.3 kt	74.2 kt	390 kt	19.0%	>90,000 kt	<0.1%
- scenario 2	8.3 kt	49.2 kt		12.6%		<0.1%
- scenario 3	11.7 kt	69.2 kt		17.7%		<0.1%
Silicon						
- scenario 1	1,397.4 kt	2,976.7 kt	4.6 Mt ²	64.7%	No estimates ³	—
- scenario 2	949.4 kt	2,231.0 kt		48.5%		—
- scenario 3	766.1 kt	1,926.5 kt		41.9%		—
Zinc						
- scenario 1	1,611.9 kt	4,318.9 kt	12.0 Mt	36.0%	230 Mt	1.88%
- scenario 2	1,116.9 kt	3,152.9 kt		26.3%		1.37%
- scenario 3	1,009.3 kt	3,323.1 kt		27.7%		1.44%

Notes:

1) World production and reserves based on U.S. Geological Survey, 2025, Mineral commodity summaries 2025 (ver. 1.2, March 2025): U.S. Geological Survey, 212 p., <https://doi.org/10.3133/mcs2025>

2) Word production of silicon metal. The U.S. Geological Survey provides information about the additional 5.1 Mt of world production of ferrosilicon in 2024;

3) The U.S. Geological Survey provides information indicating that world and domestic resources for producing silicon metal and alloys are abundant and adequate to supply global demand for many decades in most producing countries.

Supplementary Table 5. Mineral used (in kg per MW) in clean energy technologies

Mineral	Technology	Kg/MW
Copper	Solar	2,822.1
Silicon		3,948.3
Zinc		30.0
Chromium	Wind offshore	525.0
Copper		8,000.0
Manganese		790.0
Molybdenum		109.0
Nickel		240.0
Rare earths		239.0
Zinc		5,500.0
Chromium	Wind onshore	470.0
Copper		2,900.0
Manganese		780.0
Molybdenum		99.0
Nickel		403.5
Rare earths		14.0
Zinc		5,500.0

Source: IEA (2021), Minerals used in clean energy technologies compared to other power generation sources, IEA, Paris <https://www.iea.org/data-and-statistics/charts/minerals-used-in-clean-energy-technologies-compared-to-other-power-generation-sources>, Licence: CC BY 4.0

Supplementary Note: Boundary conditions and excluded technology justifications

To maintain analytical clarity and model data consistency across the EU27, our quantitative simulation focuses explicitly on solar PV, onshore wind, and offshore wind generation assets. Other power technologies and infrastructure segments are treated as follows:

(1) Hydropower saturation: Conventional hydropower capacity is held fixed at 2023 national Eurostat levels. European Commission Joint Research Centre (JRC) studies confirm that technoeconomically feasible conventional hydropower sites in Europe are over 85–90% harnessed ([https://setis.ec.europa.eu/system/files/2021-](https://setis.ec.europa.eu/system/files/2021-01/Assessment_European_PHS_potential_pumped_hydropower_energy_storage.pdf)

[01/Assessment_European_PHS_potential_pumped_hydropower_energy_storage.pdf](https://setis.ec.europa.eu/system/files/2021-01/Assessment_European_PHS_potential_pumped_hydropower_energy_storage.pdf)).

Furthermore, new greenfield run-of-river or reservoir hydro projects face stringent environmental protection constraints under the EU Water Framework Directive (Directive 2000/60/EC) and Habitats Directive, limiting net expansion of primary conventional capacity to minor modernisations and retrofits.

(2) Biomass and geothermal constraints: Biomass expansion is heavily constrained by sustainability and land-use criteria under the revised Renewable Energy Directive (RED III) and the EU Biodiversity Strategy 2030, preventing major net capacity additions in power generation. Geothermal energy serves localised thermal-heating niches rather than acting as a macro-scale electricity driver for EU targets.

(3) Nuclear baselines: Divergent national nuclear energy policies across Member States (e.g., phase-outs versus new build programs) result in a near-stable net EU-wide nuclear capacity footprint out to 2050 under Commission long-term strategic pathways (A Clean Planet for All).

(4) Storage and grid Infrastructure: Electric battery storage and high-voltage transmission grid expansion represent substantial mineral sinks (primarily for copper, aluminium, lithium, and cobalt). Excluded from our primary generation scope, their omission means our reported mineral volumes serve as a strict conservative lower bound for the total material requirements of the European energy transition.

Supplementary Methods: Sensitivity analysis for mineral intensity

In our main analysis presented in the paper, we estimated mineral demand using the mineral-intensity coefficients published by the International Energy Agency.¹ Since the conducted mineral intensity analysis relies heavily on a single source, we compared the IEA data with the technology- and scenario-specific estimates reported by Carrara et al.² in the European Union Joint Research Centre (JRC) report, “Raw materials demand for wind and solar PV technologies in the transition towards a decarbonised energy system.”

In the analysis presented below, we retained the IEA coefficients as the reference specification and used the JRC estimates to identify candidate lower and upper bounds for a sensitivity analysis (see Supplementary Table 6).

The IEA (2021) dataset reports the mass of selected minerals intensity used per unit of installed solar photovoltaic (PV), onshore wind, and offshore wind capacity. In our original model, these values were expressed in kilograms per megawatt (kg/MW). The JRC (2020) report provides corresponding estimates for solar PV and several wind-generator configurations in tons per gigawatt (t/GW), which are numerically equivalent to kg/MW.

The IEA specifies that its onshore wind material intensity coefficients are based on a doubly fed induction generator system. However, its offshore wind coefficients are based on a direct drive permanent magnet synchronous generator system and include array cables. To make the most technology-specific comparison possible within the JRC classification, we matched the IEA’s onshore coefficients to the JRC’s Gearbox-Based Double-Fed Induction Generator (GB-DFIG), and we matched the IEA’s offshore coefficients to the JRC’s Direct-Drive Permanent-Magnet Synchronous Generator (DD-PMSG). This matching reflects our harmonization procedure rather than a direct recommendation from either source.

For each mineral m and technology t , the lower bound is defined as the lowest comparable coefficient reported in the IEA reference specification and JRC specifications:

$$I_{m,t}^L = \min(I_{m,t}^{IEA}, I_{m,t}^{JRC}).$$

The upper candidate was defined as the highest comparable coefficient:

$$I_{m,t}^U = \max(I_{m,t}^{IEA}, I_{m,t}^{JRC}).$$

Here, $I_{m,t}^L$, $I_{m,t}^{IEA}$, and $I_{m,t}^U$ denote the lower, reference, and upper mineral-intensity coefficients, respectively, for mineral m and technology t . Where the technology-matched IEA and JRC

estimates were identical, the lower, reference, and upper values were the same. These cases indicate cross-source agreement under the selected technological assumption. Note, however, that several lower coefficients were not the minimum of the two source values; they were obtained by applying JRC low-demand-scenario reductions, as described below.

For aggregate rare-earth elements, the JRC values for dysprosium, neodymium, praseodymium, and terbium were summed to obtain a category comparable with the aggregate IEA coefficient.

Supplementary Table 6. Mineral-intensity coefficients (in kg per MW) used in the sensitivity analysis

Technology/Mineral	Candidate lower value	Reference IEA value	Candidate upper value	Main sources
Solar PV / Copper	2,822.1	2,822.1	4,600.0	IEA (2021); JRC (2020)
Solar PV / Silicon	1,000.0	3,948.3	4,000.0	IEA (2021); JRC (2020)
Solar PV / Zinc	30.0	30.0	30.0	IEA (2021)
Offshore wind / Chromium	420.0	525.0	525.0	IEA (2021); JRC (2020)
Offshore wind / Copper	3,000.0	8,000.0	8,000.0	IEA (2021); JRC (2020)
Offshore wind / Manganese	632.0	790.0	790.0	IEA (2021); JRC (2020)
Offshore wind / Molybdenum	87.2	109.0	109.0	IEA (2021); JRC (2020)
Offshore wind / Nickel	192.0	240.0	240.0	IEA (2021); JRC (2020)
Offshore wind / Rare earths	119.5	239.0	239.0	IEA (2021); JRC (2020)
Offshore wind / Zinc	4,400.0	5,500.0	5,500.0	IEA (2021); JRC (2020)
Onshore wind / Chromium	376.0	470.0	470.0	IEA (2021); JRC (2020)
Onshore wind / Copper	1,400.0	2,900.0	2,900.0	IEA (2021); JRC (2020)
Onshore wind / Manganese	624.0	780.0	780.0	IEA (2021); JRC (2020)
Onshore wind / Molybdenum	79.2	99.0	99.0	IEA (2021); JRC (2020)
Onshore wind / Nickel	322.8	403.5	430.0	IEA (2021); JRC (2020)
Onshore wind / Rare earths	7.0	14.0	14.0	IEA (2021); JRC (2020)
Onshore wind / Zinc	4,400.0	5,500.0	5,500.0	IEA (2021); JRC (2020)

Rationale for the solar PV coefficients

Copper

The IEA reference value of 2,822.1 kg/MW was chosen as the lower candidate because it falls below the copper intensity levels reported in the JRC solar pathways. The JRC (2020) reports solar PV copper intensities ranging from approximately 3,700 to 4,600 kg/MW depending on the reference year and mineral demand pathway. The upper candidate, 4,600 kg/MW, corresponds to the JRC's highest estimate and represents a comparatively mineral-intensive PV pathway in which reductions in copper use per MW are limited.

Silicon

The lower estimate of 1,000 kg/MW corresponds to the JRC's low-mineral-demand scenario for 2050. The upper bound of 4,000 kg/MW corresponds to the JRC baseline value, which is nearly identical to the IEA coefficient of 3,948.3 kg/MW.

The JRC trajectories are year-specific. Reported silicon intensities are 2,000, 2,750, and 3,500 kg/MW for the low-, medium-, and high-demand pathways in 2030 and 1,000, 2,000, and 3,000 kg/MW in 2050. Consequently, the 1,000–4,000 kg/MW range provides an overall, cross-source sensitivity range, while the JRC's year-specific trajectories provide a more detailed temporal sensitivity specification.

Zinc

There was no directly comparable solar PV zinc coefficient available in the JRC table used for triangulation. Therefore, the lower, reference, and upper values were all retained at the IEA coefficient of 30 kg/MW. Continued dependence on a single source for this coefficient is reported as a limitation.

Rationale for the offshore-wind coefficients

Chromium

The IEA offshore coefficient and the technology-matched JRC DD-PMSG coefficient are both 525 kg/MW. However, for chromium, manganese, molybdenum, nickel, and zinc, the JRC (2020, p. 23) report assumes a 20% reduction in mineral intensity in offshore and onshore wind in the Low Demand Scenario (LDS); thus, we set the lower bound at 420 kg/MW and kept the upper bound at 525 kg/MW.

Copper

The lower bound candidate is 3,000 kg/MW, which is the JRC value for a DD-PMSG configuration. The upper bound candidate is the IEA reference value of 8,000 kg/MW. This is the largest discrepancy among the offshore wind coefficients. Note, however, the IEA offshore specification explicitly includes array cables, which are highly copper-intensive. In contrast, the JRC estimate is based on the turbine and foundation configuration. Thus, for copper, we used the lower, directly reported, technology-matched source coefficient without applying an additional

LDS reduction, because the IEA and JRC estimates differ substantially in their system boundaries.

Manganese and molybdenum

The JRC values matched to the technology are identical to the IEA coefficients: 790 kg/MW for manganese and 109 kg/MW for molybdenum. Therefore, the upper bounds equal the reference values, and the lower bounds constitute 80% of the reference, as suggested by the JRC estimated under the LDS.

Nickel

Both the IEA and the JRC report a value of 240 kg/MW for the offshore DD-PMSG configuration. Therefore, no cross-source sensitivity range was applied to the upper bound, but a 20% reduction to the lower bound.

Rare-earth elements

The JRC reports separate coefficients for dysprosium, neodymium, praseodymium, and terbium. For the DD-PMSG configuration, the aggregate intensity is as follows:

$$17 + 180 + 35 + 7 = 239 \text{ kg/MW.}$$

The aggregate value is exactly equal to the IEA reference coefficient of 239 kg/MW. Therefore, the reference and upper candidates were all set to 239 kg/MW. However, as the JRC (2020, p. 23) report assumes a 50% reduction in mineral intensity under the LDS, we introduced a lower bound equal to 119.5 kg/MW.

Zinc

The JRC DD-PMSG coefficient is 5,500 kg/MW, which matches the IEA report. A 20% reduction in the LDS scenario set a lower bound of 4,400 kg/MW.

Rationale for the onshore-wind coefficients

Chromium

The IEA and JRC GB-DFIG coefficients are both 470 kg/MW. Therefore, the upper candidates equal the reference value, whereas the lower candidate is reduced by 20% in the LDS, as argued in the JRC (2020, p.23) report.

Copper

The JRC GB-DFIG coefficient of 1,400 kg/MW was chosen as the lower candidate, and the IEA reference of 2,900 kg/MW was chosen as the upper candidate. This substantial difference indicates that the demand for copper in onshore wind is sensitive to the source's mineral intensity.

Technology matching is particularly important for this coefficient. The JRC report contains a lower copper value for a geared permanent-magnet configuration; however, that value was not used because it describes a generator architecture different from the DFIG assumed in the original IEA-based model.

Manganese and molybdenum

The IEA and JRC GB-DFIG estimates are the same: 780 kg/MW for manganese and 99 kg/MW for molybdenum. Therefore, no cross-source range was introduced to the upper bounds. Again, the lower bounds are reduced by 20% for both minerals as assumed by the LDS.

Nickel

The IEA reference is 403.5 kg/MW. However, the JRC reports a value of 430 kg/MW for the GB-DFIG configuration. Therefore, following the LDS scenario, the lower candidate was set to 80% of 403.5 kg/MW and the upper candidate to 430 kg/MW. This relatively narrow interval is unlikely to produce significant differences in aggregate estimates of nickel demand.

Rare-earth elements

The aggregate rare-earth intensity for the JRC GB-DFIG configuration is as follows:

$$2 + 12 + 0 + 0 = 14 \text{ kg/MW.}$$

This value matches the IEA's onshore wind coefficient. Therefore, the reference and upper candidates were all set to 14 kg/MW. Given the 50% reduction in REE intensity assumed in the LDS scenario, as reported by JRC (2020, p. 23), the lower bound was set to 7 kg/MW.

Zinc

The IEA's reference value and JRC's coefficient are 5,500 kg/MW. After a 20% reduction, this yields a lower bound of 4,400 kg/MW.

Implementation in the revised mineral-demand model

The IEA coefficients are the primary specification for the results. Two additional sets of coefficients are used for sensitivity analysis: one based on lower bounds, and one based on upper bounds.

For each scenario s , reference year y , technology t , country c , mineral m , and intensity specification k , mineral demand is calculated as follows:

$$D_{c,m,s,y}^{kt} = \sum_c \sum_t \frac{\Delta C_{c,t,s,y} \times I_{m,t}^{(k)}}{10^6}.$$

In this expression, $\Delta C_{c,t,s,y}$ is the additional installed capacity relative to 2023, expressed in MW; $I_{m,t}^{(k)}$ is the lower, IEA-reference, or upper coefficient in kg/MW; and division by 10^6 converts kilograms to thousands of metric tons.

The sensitivity assessment focuses on whether the magnitude of the projected demand and the ranking of the three deployment scenarios remain stable.

Supplementary Table 7. Mineral demand associated with solar and wind expansion in the EU27, expressed in thousand metric tons (kt) – sensitivity analysis for Scenario 1

Mineral	Scenario 1 (lower bounds): Proportional allocation		Scenario 1 (IEA data): Proportional allocation		Scenario 1 (upper bounds): Proportional allocation	
	2030	2050	2030	2050	2030	2050
Chromium	111.3	306.1	139.1	382.6	139.1	382.6
Copper	1,472.0	3,670.9	2,052.3	5,826.1	2,681.5	7,166.5
Manganese	182.0	489.7	227.5	612.1	227.5	612.1
Molybdenum	23.4	64.1	29.2	80.1	29.2	80.1
Nickel	88.6	215.4	110.8	269.2	117.4	282.5
Rare earths	6.7	37.1	13.3	74.2	13.3	74.2
Silicon	353.9	753.9	1,397.4	2,976.7	1,415.7	3,015.7
Zinc	1,291.6	3,459.6	1,611.9	4,318.9	1,611.9	4,318.9

Supplementary Table 8. Mineral demand associated with solar and wind expansion in the EU27, expressed in thousand metric tons (kt) – sensitivity analysis for Scenario 2

Mineral	Scenario 2 (lower bounds): Trends continuation		Scenario 2 (IEA data): Trends continuation		Scenario 2 (upper bounds): Trends continuation	
	2030	2050	2030	2050	2030	2050
Chromium	76.9	222.4	96.2	278.0	96.2	278.0
Copper	1,000.0	2,685.6	1,387.9	4,181.3	1,815.4	5,185.9
Manganese	126.1	357.3	157.6	446.6	157.6	446.6
Molybdenum	16.2	46.6	20.2	58.3	20.2	58.3
Nickel	61.9	160.1	77.4	200.1	82.1	210.4
Rare earths	4.2	24.6	8.3	49.2	8.3	49.2
Silicon	240.5	565.0	949.4	2,231.0	961.8	2,260.2
Zinc	895.0	2,525.7	1,116.9	3,152.9	1,116.9	3,152.9

Supplementary Table 9. Mineral demand associated with solar and wind expansion in the EU27, expressed in thousand metric tons (kt) – sensitivity analysis for Scenario 3

Mineral	Scenario 3 (lower bounds):		Scenario 3 (IEA data):		Scenario 3 (upper bounds):	
	Targeting offshore		Targeting offshore		Targeting offshore	
	2030	2050	2030	2050	2030	2050
Chromium	70.4	238.1	88.0	297.6	88.0	297.6
Copper	868.0	2,651.0	1,283.7	4,498.0	1,628.7	5,365.5
Manganese	114.2	377.5	142.7	471.9	142.7	471.9
Molybdenum	14.8	49.8	18.5	62.3	18.5	62.3
Nickel	53.6	158.9	67.0	198.6	70.7	207.4
Rare earths	5.8	34.6	11.7	69.2	11.7	69.2
Silicon	194.0	487.9	766.1	1,926.5	776.1	1,951.7
Zinc	808.6	2,661.4	1,009.3	3,323.1	1,009.3	3,323.1

The sensitivity analysis (see Supplementary Methods Tables 2-4) shows that the projected demand is more strongly affected by alternative assumptions about material intensity than by general differences among the three deployment scenarios. Copper is the most source-sensitive material. Compared to the IEA reference specification, the lower-bound coefficients decrease total copper demand by about 28–32% in 2030 and 36–41% in 2050, depending on the deployment scenario. In turn, the upper-bound specification increases total copper demand by 27–31% in 2030 and 19–24% in 2050. This range is due to differences in copper requirements between the IEA and JRC estimates for solar PV, offshore wind, and onshore wind, as well as differences in the system boundaries applied by the sources, especially for offshore infrastructure. Silicon demand is also highly sensitive, albeit in an asymmetric manner. The lower specification reduces projected silicon demand by about 75% across all scenarios and reference years. In contrast, the upper specification only increases it by about 1%.

The sensitivity ranges for the remaining minerals are more structured. The lower specification reduces the demand for manganese, molybdenum, and zinc by approximately 20% across the scenarios. Meanwhile, the upper estimates generally coincide with the IEA reference results. Nickel demand decreases again by 20% under the lower specification and increases by only 4–6% under the upper specification. REE demand decreases by about 50% under the low-intensity assumption. Still, it remains unchanged under the upper specification because the IEA and JRC technology-matched REE coefficients coincide in the reference configuration. Importantly, the lower REE case changes the scale, but not the pattern of the scenario. Scenario 3 continues to produce REE demand that is considerably higher than in Scenario 2 and close to that in Scenario 1.

References

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