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DECARBONIZATION, GREEN ENERGY TRANSITION AND IMPACTS ON INFRASTRUCTURE INVESTMENTS

Team Leader
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17 OCTOBER 2024

Agenda

1.0

SETTING THE SCENE

A new phase of the energy transition

Introduction

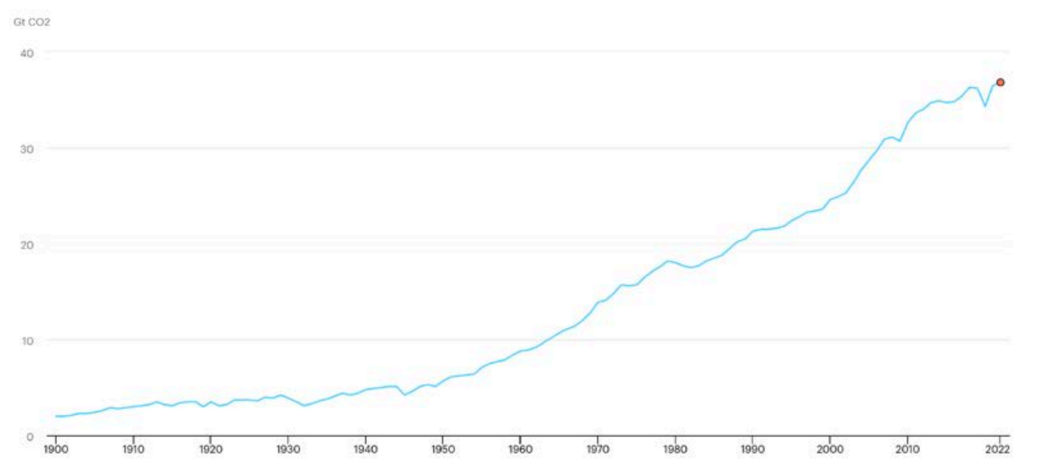
The Climate Challenge

Demand for the three main fossil fuels expected to peak this decade

In 2021-22 the assessment report (AR6) by the Intergovernmental Panel on Climate Change (IPCC) indicated that global greenhouse gas (GHG) emissions need to peak before 2025 at the latest and be reduced by 43% by 2030. Since, initiatives have been introduced to reduce emissions and achieve climate-neutrality

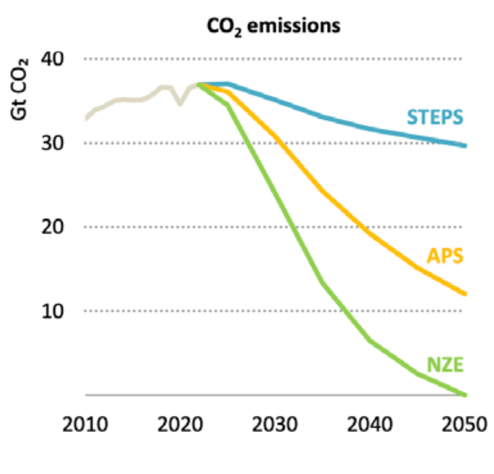
The latest International Energy Agency (IEA) Net Zero roadmap indicates that based on today's policies, demand for the three main fossil fuels is expected to peak this decade; however, they are still not sufficient to reach 1.5 ° C goal

Global CO2 emissions from energy combustion and industrial processes, 1900-2022



Source: IEA (2023)

Global energy-related and industrial process CO2 emissions by scenario



Source: IEA (2023)

Introduction

The Energy Crisis

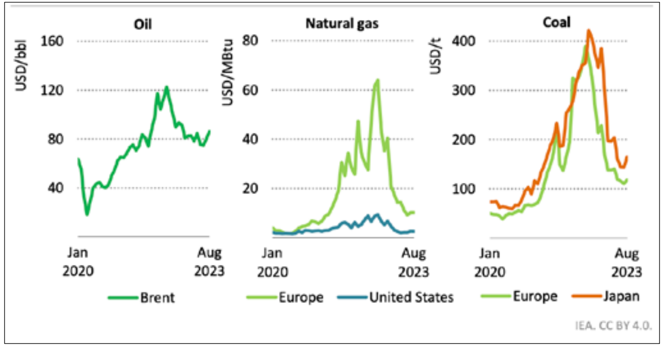
A global energy crisis contributing to high inflation and high interest environments

High energy prices during the energy crisis contributed towards inflationary pressures and increased costs for consumers and businesses

Critical mineral prices surged in 2021 and 2022, and remain above historical averages in 2023

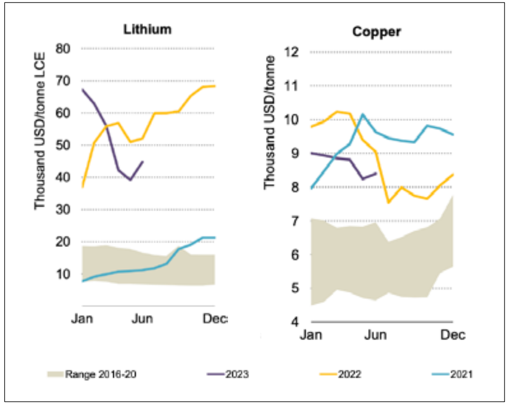
Renewable energy businesses underperformed fossil fuel companies in a high inflation and high interest rate environment

Benchmark International fossil fuel prices



Source: IEA (2023)

Price development for selected energy transition minerals and metals



Source: IEA (2023)

S&P Energy Index 2023

Climate change+energy crisis =?

Challenges and Opportunities

Critical Materials Supply

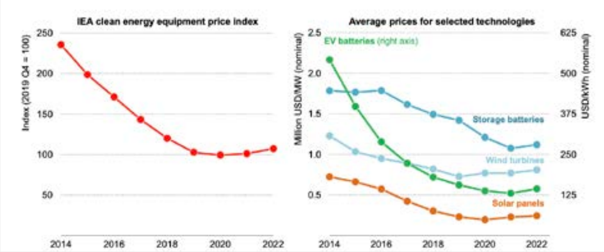
Critical minerals demand is expected to grow by up to 3.5x to 2030 (IEA, 2023), yet the high geographic concentration results in a supply security risk

Indicative supply chains for selected clean energy technologies

Source: IEA (2022)

Clean Technology Prices

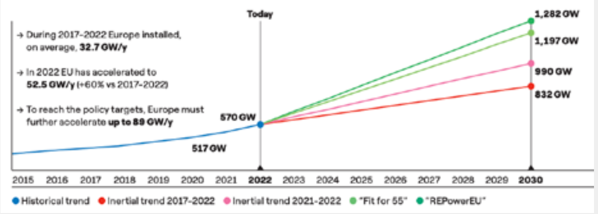
Prices for the selected technologies and critical materials increased in 2021-22



Source: IEA (2023)

Manufacturing Capacity

To reach policy targets, Europe needs to increase renewable installation capacity from 32.7 GW/y (2021-22 average) to 89 GW/y

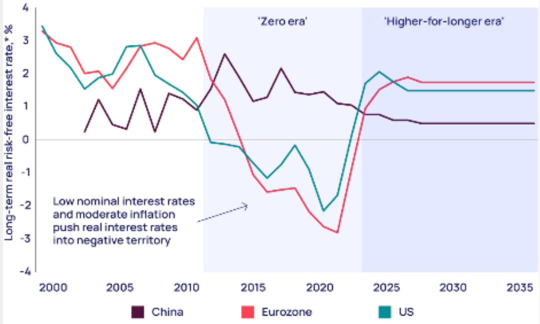


Source: Enel and Ambrosetti (2023)

Interest rates

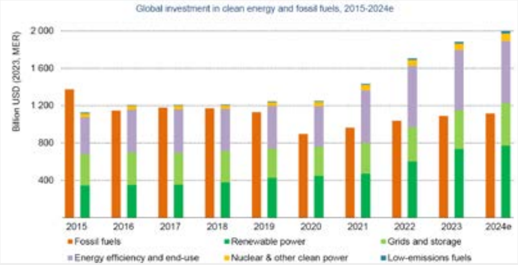
Investments for a global net zero economy will have to happen against a less favourable monetary scenario than the world has been used to since 2009

Source: Wood Mackenzie (2024)



Historical investments

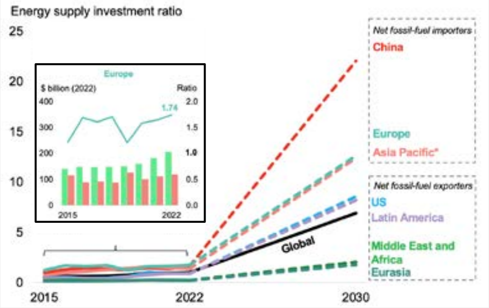
In 2024 global investment in clean energy is set to reach almost double the amount going to fossil fuels



Source: IEA (2024)

Future Investment

To keep on track for 1.5C of global warming and net-zero emissions by 2050, the energy supply investment ratio for Europe increases largely from 1.74 in 2022



Source: Bloomberg NEF (2023)

European Union

Evolution of Climate Policies

Dec 2015 — **Paris Agreement** is adopted

Nov 2019 — European Parliament declared climate emergency

Dec 2019 — **Green Deal** is presented by European Commission

Jul 2021 — **Fit for 55** package and **European Climate law** enters into force

May 2022 — **REPowerEU** is launched

Feb 2023 — **Green Deal Industrial Plan** presented

Mar 2023 — **Net Zero Industry Act, Critical Raw Material Act** and **Electricity Reform Acts** are proposed

Jun 2024 — Member States to submit final updated **National energy and climate plans (NECPs)**

Green Deal

Climate-neutral by 2050

55% reduction of greenhouse gas emissions by 2030 (compared to 1990)

Fit for 55

Initiatives to align EU policies with climate goals:

EU Emissions Trading System reform
New EU ETS for building & road transport fuels
Social Climate Fund
Effort Sharing Regulation
Land Use, Forestry and Agriculture
CO2 emissions standards for cars and vans
Carbon Border Adjustment Mechanism
Energy Efficiency Directive
Alternative Fuels Infrastructure Regulation
FuelEU Maritime Regulation
Renewable Energy Directive
ReFuel EU Aviation Regulation

REPowerEU

Save energy
Securing affordable energy supplies
Diversify its energy supplies
Invest in renewables

Green Deal Industrial Plan

Faster access to funding

Enhancing skills

Open trade for resilient supply chains

Predictable and simplified regulatory environment

Net Zero Industry Act

Manufacturing capacity of **net-zero strategic technologies** approaches or reaches at least 40% of annual deployment needs by 2030

Critical Raw Material Act

Setting clear priorities for action
Improving resilience
Investing in research, innovation and skills
Promoting a more sustainable & circular critical raw materials economy

Electricity Reform Act

Deliver energy security and affordability through an integrated EU energy market

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Setting the scene

Key messages

- **A new phase of the energy transition**, driven by the acceleration of climate challenge and by the aftermath of the energy crisis
- Greater emphasis on security of supply of energy commodities and clean technologies.
- Multiple technologies needed for net zero with electricity as the low hanging fruit
- More investments in clean energy needed than current ones (e.g. triple renewables by 2030)
- Certain critical materials as crucial for the energy transition
- A less positive macroeconomic scenario
- China as dominant player in the clean tech supply chain (mining, processing, manufacturing)
- Greater focus to establish a domestic clean tech supply chain
- New ambitious policy packages (e.g. EU Green Industrial Plan)

2.0

THE CLEAN TECHNOLOGY SUPPLY CHAIN

From mining critical materials to manufacturing strategic technologies

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Critical materials

EU – Today

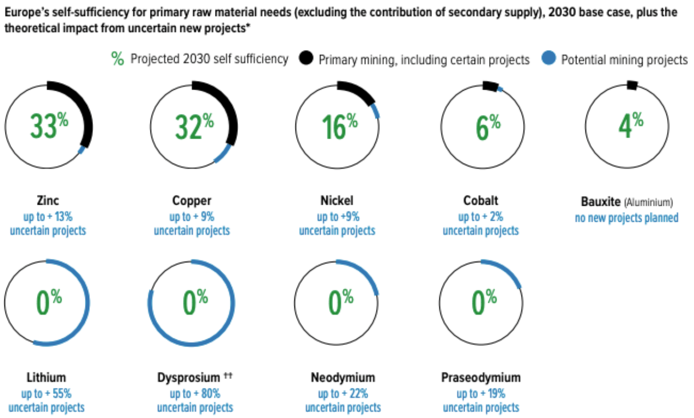
To address its dependence on imports the EU has introduced policies and targets towards domestic production and manufacturing in its clean energy technologies value chains

European demand for metals is either sourced from imports or domestic production, through two channels: primary supply (mining and processing) and secondary supply (recycling).

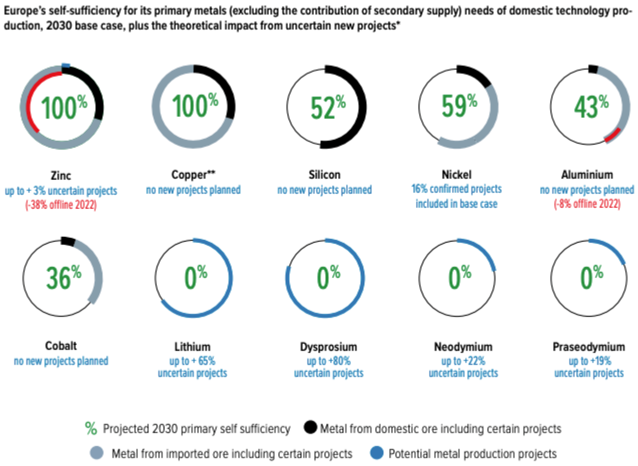
Critical Raw Materials Act (CRMA)

Identifying a list of critical and strategic raw materials and setting benchmark for domestic capabilities for 2030 (EC, n.d)
-**10%** of the EU's annual needs for extraction,
- 40% for processing
- **15%** for recycling,
- no more than 65% of EU's annual needs of each strategic raw material at any relevant stage of processing should come from a single third country

Mining



Refining



Source: KU Leuven (2022)

Manufacturing

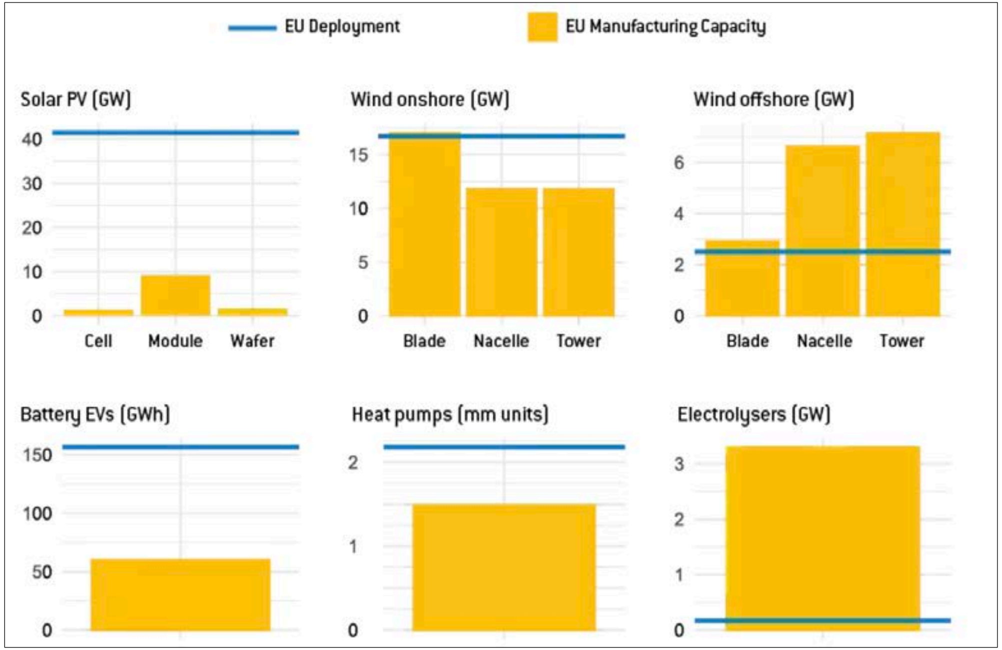
EU - Today

Varying situations for different clean technologies despite the same 40% manufacturing target (Bruegel, 2023)

Net Zero Industry Act (NZIA)

Aims to reach at least **40%** of annual deployment needs by 2030 ensuring the manufacturing capacity of 8 net-zero strategic technologies* approaches or (EC, n.d):
- Solar photovoltaic and solar thermal;
- Electrolysers and fuel cells;
- Onshore wind and offshore renewables;
- Sustainable biogas/biomethane;
- Batteries and storage;
- Carbon capture and storage;
- Heat pumps and geothermal energy;
- Grids

Europe cleantech manufacturing capacities and domestic deployment levels in selected technologies, 2021-22



Source: Bruegel (2023)

Notes:
Import/Export capacities are not included or illustrated

Manufacturing

EU – Investment needs

€89bn of manufacturing capacity investments required to meet NZIA policy scenario in 2030 (EC, 2023)

In a *'status quo scenario'* where it assumes current market shares for EU manufacturing remains until 2030, total investment needs for the manufacturing of five key technologies is EUR 48bn. 75% is required for batteries where solar PV makes up a small share given the deployment needs are only slightly higher than 2022 capital deployed (EC, 2023)

Technology	Annual technology deployment in 2030	Current installed EU manufacturing capacity*	Share of EU production in EU demand	EU manufacturing capacity in 2030	New manufacturing capacity needed	Factory CAPEX (M€/unit/year)	Manufacturing capacity investment needs (Bn EUR)
Wind	42	13	85%	36	23	260	6.073
Solar PV	53	1	3%	2	0,4	340	0.129
Heat Pump	51	14	60%	31	17	333	5.624
Battery cell	610	75	54%	327	252	144	36.249
Electrolysers	25	2,3	10%	2.5	0	60	0.007
Total							**48.082**

Table 1: Manufacturing capacity needed and investment needs per technology in a status quo scenario. Capacity is expressed in GWh/year for batteries and GW/y for the other technologies (GW of electricity for electrolysers, GWAC for solar PV).

Source: European Commission (2023)

In a *'NZIA policy scenario**'* manufacturing capacity investment needs increases by 84% to c€89bn for batteries (77%), solar PV (9%), wind (7%), heat pumps (6%) and electrolysers (1%). Electrolysers take up the smallest share at EUR 1.3 bn given its limited deployment in 2030 (EC, 2023)

Technology	Annual technology deployment in 2030	Current installed EU manufacturing capacity*	Share of EU production in EU demand	EU manufacturing capacity in 2030	New manufacturing capacity needed	Factory CAPEX (M€/unit/year)	Manufacturing capacity investment needs (Bn EUR)
Wind	42	13	85%	36	23	260	6.073
Solar PV	53	1	45%	24	22	340	7.579
Heat Pump	51	14	60%	31	17	333	5.624
Battery cell	610	75	90%	549	474	144	68.244
Electrolysers	25	2.3	100%	25	22	60	1.332
Total							**88.852**

Table 2: Manufacturing capacity needed and investment needs per technology in a NZIA policy scenario. Capacity is expressed in GWh/year for batteries and GW/y for the other technologies (GW of electricity for electrolysers, GWAC for solar PV).

Source: European Commission (2023)

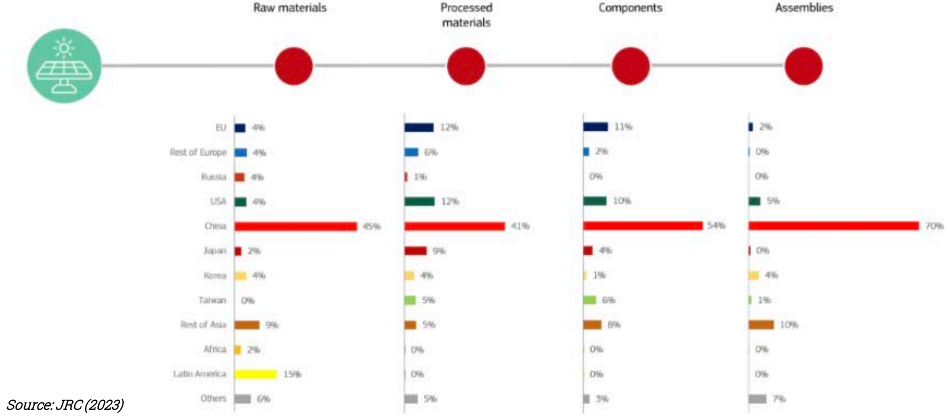
Notes
Column 1 - Physical deployment needs in 2030 as determined in the Fit-for-55 and REPowerEU energy modelling scenario
Column 3 - Market share of EU production or manufacturing that meets the level of the demand required to fulfil the decarbonisation deployment needs aimed at in the EU.
Column 5 - [Market share of EU production]*[Annual technology deployment in 2030]}-[Current installed EU manufacturing capacity].
Column 6 - Investment needed in manufacturing (measured in Factory CAPEX–operational costs are not relevant for determining manufacturing investments needs) to increase the manufacturing capacity by one GW(h) per year.
Column 7 - [New manufacturing capacity needed] * [Factory CAPEX].

*Capacity is expressed in GWh/year for batteries and GW/y for the other technologies (GW of electricity for electrolysers, GWAC for solar PV)
**NZIA scenario includes the EU manufacturing market shares of these technologies needed to reach the indicative technology-specific objectives outlined in the recitals to the Net-Zero Industry Act Proposal: 30GW solar manufacturing capacity by 2030, maintaining wind and heat pump capacity, 90% battery target (European Battery Alliance), 10mt of domestic renewable hydrogen production (REPowerEU) translating into 100% share for electrolysers

Strategic technologies
Solar PV

Highly strategic due to high contribution to targets, manufacturing gap to target and concentrated market (EnTEC, 2023)

Current supply chain



Source: JRC (2023)

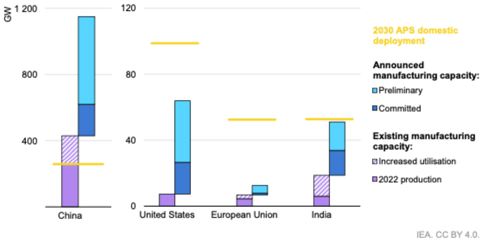
Initiatives and targets

EU Solar Energy Strategy

European Solar PV Industry Alliance

30 GW manufacturing capacity by 2025

Outlook



Source: IEA (2023)

DEMAND
Growing market with doubling capacities between 2020 and 2022 (EC, 2023)

SUPPLY
Manufacturing active in silicon, ingot/wafer/cell/module and inverter manufacturing and offering commercial products (EC, 2023):

- Germany (Wacker, Silicon Products, MeyerBurger)
- Norway (REC Solar Norway ,Norwegian Crystals, NorSun),
- France (EDF PW)
- Hungary (Ecosolifer),
- Lithuania (Solitek/Valoe),
- Italy (ENEL)

OUTLOOK (2030)
Gap between the current pipeline and additional target for solar PV (IEA, 2023), implying continued reliance on imports (EC, 2023):

- Germany (Meyer Burger) – Cells/Module
- Netherlands (Solarge B.V) – Module
- Austria (Kioto Energy) – Module
- Poland (Saule technologies) – Module
- Germany (Oxford PV) - Cells/Module
- Italy (Enel Green Power) - Cells/Module
- Spain (Greenland Gigafactory)- Module
- France (REC Solar) – Module

KEY FACTORS

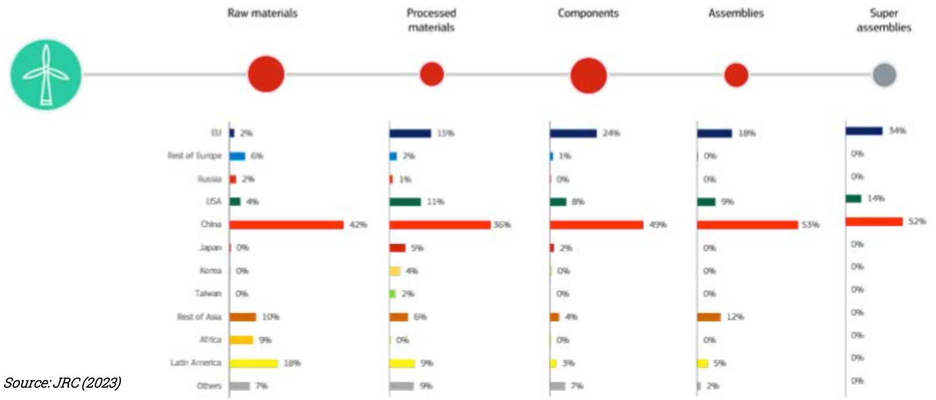
- OPPORTUNITITES: R&D**,** recycling and polysilicon technology, EU support
- RISKS: Imports, cost gaps to competitors
- DEPENDENCIES: Increasing manufacturing, technological progress, grid, permitting

Strategic technologies

Wind

Highly strategic due to deteriorating trade balance, rising costs, and increasing LCRs in export markets (EnTEC)

Current supply chain



Source: JRC (2023)

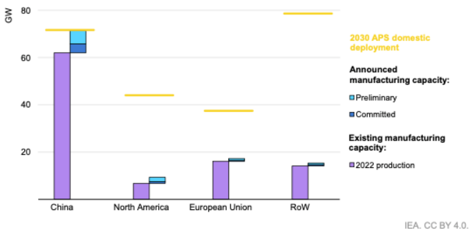
Initiatives and targets

ETIP Wind Roadmap

Wind Action Plan

(proposed in October 2023)

Outlook



Source: IEA (2023)

DEMAND
2022 annual demand was 28% higher year-on-year ((EnTEC), 2023).

SUPPLY
- EU which ranks second globally accounting for 31% of global wind turbines value chain ((EnTEC), 2023) and 85% of EU market (EC, 2023).
- Current capacity is well suited for current demand with high manufacturing capabilities in components, however dependent on raw material imports
- 2022 new wind installations in Europe (WindEurope, 2023)
  - Germany (14%)
  - Sweden (13%)
  - Finland (13%)
  - France (11%)
  - UK (9%)
  - Spain (8%)
  - Other (32%)

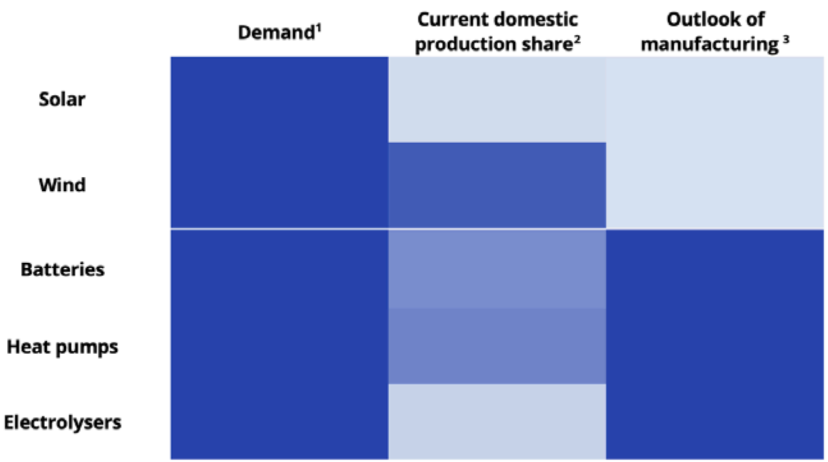
OUTLOOK (2030)
- 129 GW of new wind farm installations until 2027, of which 98 GW will be EU-27 and ¾ onshore (WindEurope, 2023)
- Outlook of 20GW/yr for next 5 years is below targets (EC, 2023).

KEY FACTORS
- OPPORTUNITITES: Competitive advantage, high share of domestic manufacturing of demand, revised RED directive and Wind Power Action
- RISKS: Trade balance, uncertain demand, permitting, inflation and commodity prices, international competitors, skilled workforce
- DEPENDENCIES: Imports, circular economy, manufacturing capacity, installation volumes, permitting and simplified procedures, workforce

Heatmap

Key indicators

Key clean technologies

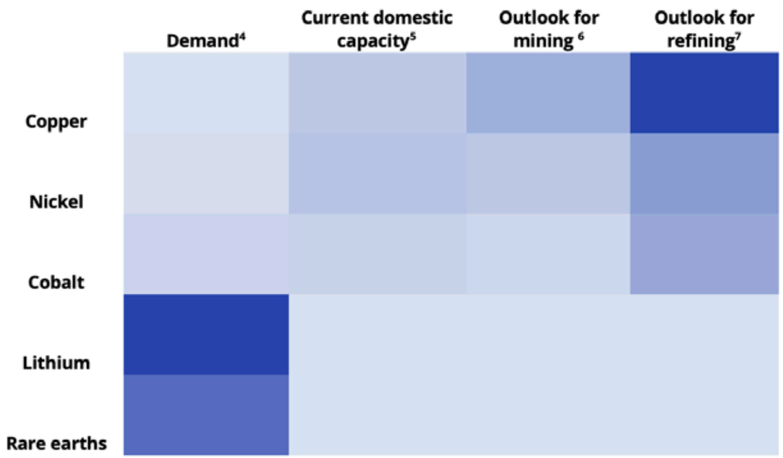


[1] Indicator for the assessment for EU demand (Dark blue = highly strategic). Sourced from *'EnTEC – Supply chain risks in the EU's clean energy technologies' (EnTEC, 2023)*

[2] The market share of EU production or manufacturing of the respective technology that meets the level of the demand required to fulfil the decarbonisation deployment needs that we aim at in the EU (Dark blue = high % share of domestic needs). Sourced from *'Investment needs assessment and funding availabilities to strengthen EU's Net-Zero technology manufacturing capacity' (European Commission, 2023)*

[3] Comparison of current and projected manufacturing output for key clean technologies and domestic deployment in the Announced Pledges Scenario in the European Union (Dark blue = domestic demand in the APS met). Sourced from *'The State of Clean Technology Manufacturing: An ETP Special Briefing' (IEA, 2023)*

Key critical materials



4 Forecasted demand increase from 2020 to 2050 (Dark blue = high % change). Sourced from *'Metals for Clean Energy – Report for Policymakers' (KU Leuven, 2022)*

5 Based on 2019 metal from domestic ore (Dark blue = high % share of supply). Sourced from *'Metals for Clean Energy – Report for Policymakers' (KU Leuven, 2022)*

6 Based on Europe's self-sufficiency for primary raw material needs (excluding the contribution of secondary supply) - 2030 base case excluding uncertain new projects (Dark blue = high % share of supply). Sourced from *'Metals for Clean Energy – Report for Policymakers' (KU Leuven, 2022)*

7 Based on Europe's self-sufficiency for its primary metals (excluding the contribution of secondary supply) needs of domestic technology production - 2030 base case included metal from domestic and imported ore and excluding uncertain new projects (Dark blue = high % share of supply). Sourced from *'Metals for Clean Energy – Report for Policymakers' (KU Leuven, 2022)*

The clean technology supply chain

Key messages

- Clean technologies are mineral intensive and will drive a large share of critical material demand over the coming years.
- The EU is heavily dependent on imports of most critical materials used to manufacture clean technologies.
- The EU does not have any processing capability and very little recycling capability at present.
- Likewise the EU relies heavily on imports for clean technologies such as EVs, batteries, fuels cells and solar PVs, importing almost all of its solar panels.
- Instead the outlook is much more positive for wind turbines, electrolizers and heat pumps.
- The EU has introduced the Green Deal Industrial Plan to enhance the continent’s competitiveness in net-zero industry, in particular with reference to the domestic production of critical materials and clean technologies.
- To meet relevant targets, the EU will require substantial investments to build up domestic capacity for mining, processing, recycling and manufacturing.

3.0

CONNECTING THE DOTS

Implications for infrastructure investments

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Implications (1/2)

The clean energy transition present a wide scope of opportunities as well as challenges

POLICY

Due to the long-term nature of investments in renewable energy technologies, they face risk of changes in policies prior to pay-out (LTIAA, 2023). In COP 28 Parties were called to take actions towards achieving, at a global scale, a tripling of renewable energy capacity and doubling energy efficiency improvements by 2030 (UNCC, 2023)

LOCAL ADMINISTRATION

Long lead times and lack of flexibility tend to exacerbate the complexity, uncertainty, and delay in project implementation (LTIAA, 2023).

ENABLING INFRASTRUTURE

Required integration of renewable energy sources and the efficient distribution of electricity (LTIAA, 2023). With an increase in electrification and decarbonisation will come an additional need for expansion and upgrading of grids. Traditional grid infrastructure will represent 135 bn EUR of investments for 42,800km of transitional grid expansion within next years (EnTEC, 2023).

TECHNOLOGY

Innovation remains essential for clean technology progression, however with increasing cost technology development could be impacted without sufficient support.

MARKET

The macroeconomic environment is a challenge due to higher short-term returns for fossil fuel assets, rising borrowing costs and debt burdens (IEA, 2023). Long dated infrastructure investments are also more sensitive to changes in discount rates (Imperial College London and IEA, 2022). However historical negative effects of higher rates were offset by strong investment in infrastructure assets and climate policies (Imperial College London and IEA, 2022).

COST

Despite clean energy investments usually having lower operating costs over time, they require high upfront spending (IEA, 2023).

Higher expenses relating to critical minerals and other materials resulted in increases in clean energy costs between 2021 and 2022. Yet these cost pressure have eased in 2023, and clean technologies remain competitive in today's fuel price environment (IEA, 2023).

Implications (2/2)

The clean energy transition presents a wide scope of opportunities as well as challenges

SUPPLY CHAIN

Targets from action plan and policies are driving up investments requirements in clean technologies, with new demand and opportunities. Investment is flowing to critical minerals and clean energy manufacturing, however a challenge will be to ensure the growth of supporting new supply chains where robust and diversified supply chain of clean energy technology is fundamental.

GEOPOLITICAL

Recent geopolitical disruptions have significantly impacted global supply chains essential for the energy transition such as critical minerals and batteries (LTIAA, 2023).

Additionally foreign policies such as US's IRA and Made in China 2025 can shift the focus towards other markets.

DATA AND TRANSPARENCY

Insufficient access to accurate and comprehensive information poses a significant risk of greenwashing, and it reduces the ability of policymakers, investors, and stakeholders to make well-informed decisions, monitor progress, and evaluate the effectiveness (LTIAA, 2023). The upcoming submission of the NECPs will provide greater clarity and predictability (EC, 2023)

ENVIRONMENT

The transition will come with own adverse environmental impacts, such as mining impacts and increased material use (LTIAA, 2023)

Final remarks

- **Manufacturing and supply chain** are the two most important industrial challenges of the energy transition.
- These two issues significantly **differ** from conventional concerns of EU energy policy with deploying energy technologies and infrastructures for emissions reduction.
- In fact, they involve flows of goods and materials that stretch far beyond EU borders, have objectives and timeframes which are not “just” limited to net zero, and raise **different questions** for investments and policy.
- **The EU’s Green Deal** has set a bar for governmental engagement with the manufacturing and material aspects of low-carbon transition, by setting out a long-term strategic approach to decarbonization, which relies on **radical manufacturing transformation**.
- Such an **industrial strategy** should balance the need for rapid emissions reduction, which sometimes can be more efficiently achieved with imported technologies and materials (e.g. from China), while nurturing innovation and growing a **domestic green industry**.