Energy Transitions Commission

Better, Faster, Cleaner: Securing clean energy technology supply chains

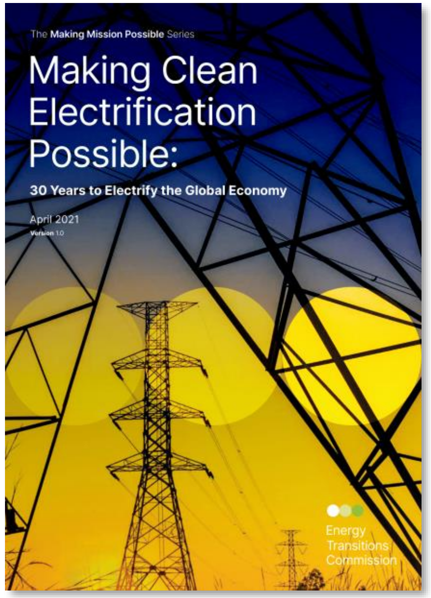
11th September 2023

Better, Faster, Cleaner: Securing clean energy technology supply chains

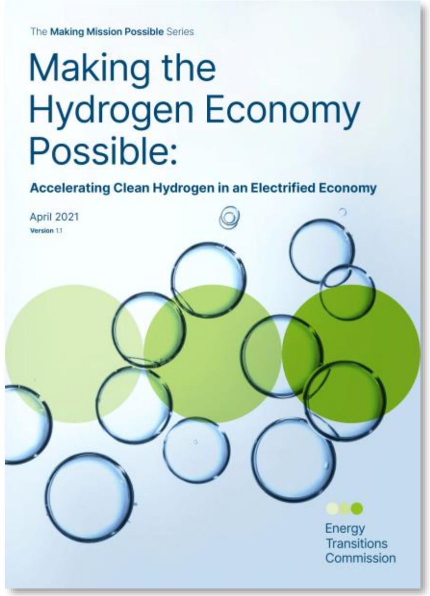
Agenda

- Introduction
- Context
- ETC Analysis of Clean Energy Supply Chains
- EU Deep-Dive
- Intervention: Sandrine Dixson-Declève
- Q+A

The ETC has already set out what is required for deep decarbonisation



April 2021



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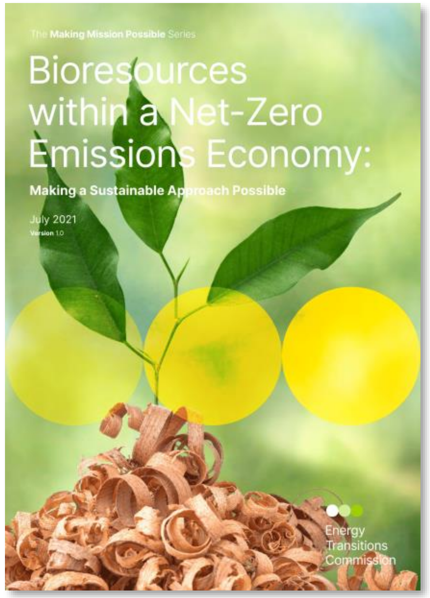

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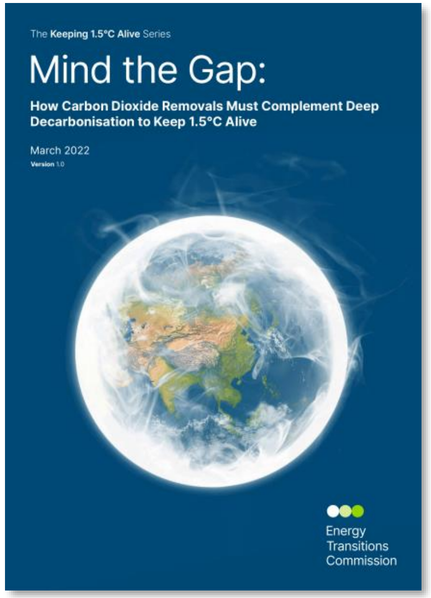
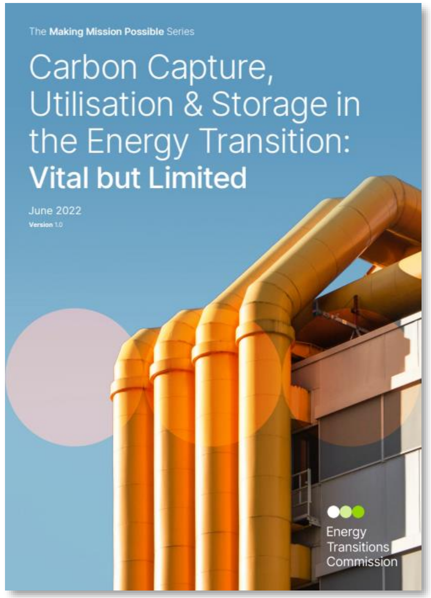


March 2022



June 2022

Source: Systemiq analysis from ETC work

The ETC's *Barriers to Clean Electrification* series has focused on key challenges to implementation

Focus of today

Published in 2022	Published so far in 2023	Due to publish early 2024

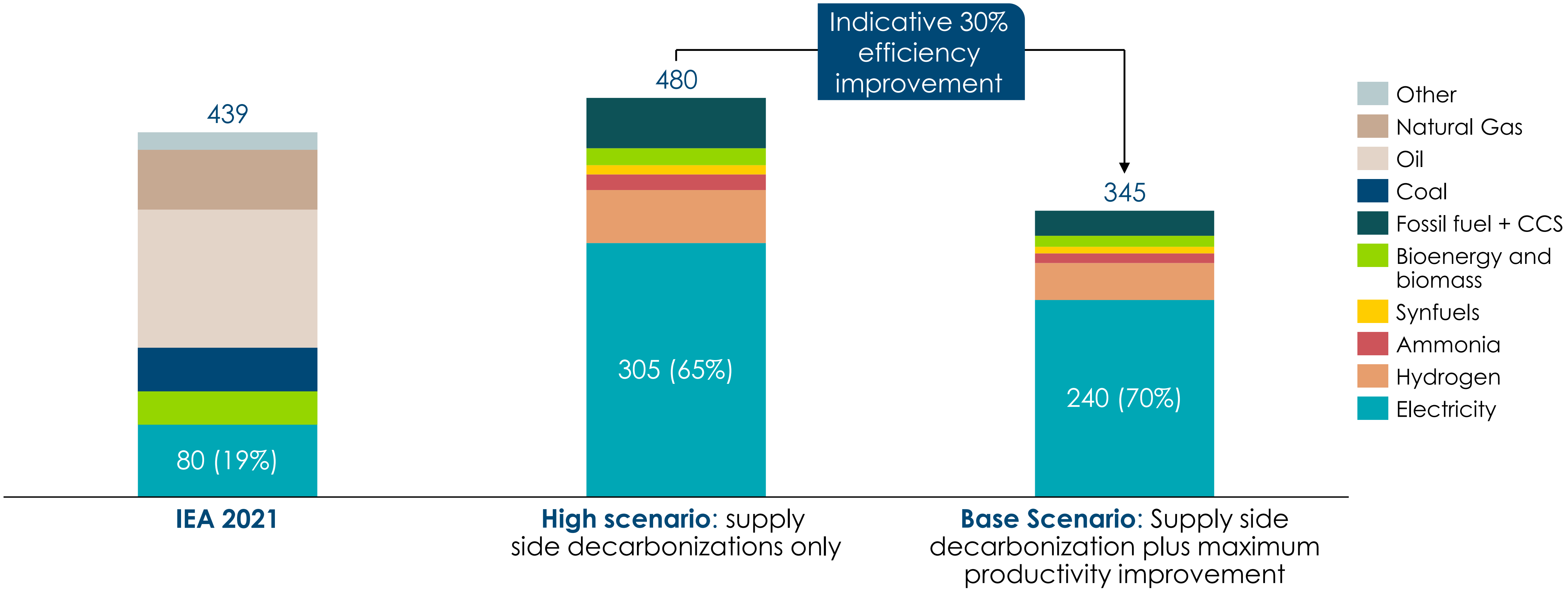
1. Context

Rising concerns about the ability of clean energy technology supply chains to scale up quickly

The future trends towards a highly electrified economy, complemented by hydrogen and sustainable bioresources, and a very limited role for fossil fuels

Final energy mix in a net-zero economy – Illustrative scenarios

EJ/year



Source: Systemiq analysis for the ETC; ETC (2020), *Making mission possible*; IEA (2022), *World energy outlook*;

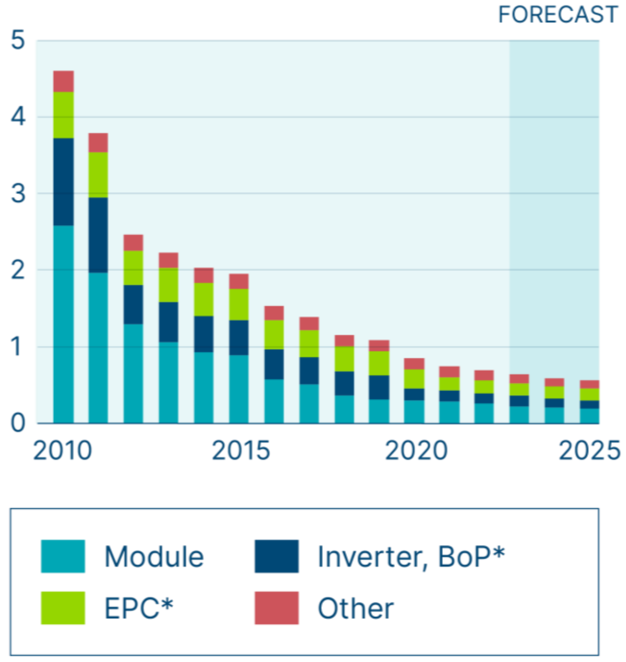
The energy transition will require massive capacity additions of new technologies, by 2030 wind and solar grow ~2.5-4x and EV sales >6x from current levels

	Wind	Solar	Storage and EVs	T&D Grids	Electrolysers	Heat Pumps
Capacity in 2022	940 GW	1240 GW	10m EV sales, 90 GWh of stationary storage	70 million km	~0.2 MtH_2	~200m units
	x 2.5	x 4	x 6	x 1.5	x 100	x 3
Required size in 2030	2400–2600 GW	4900–5100 GW	60–80m EV sales, 1500 GWh of stationary storage	>100 million km	>20 MtH_2	~600m units

Source: BNEF (2023), *Interactive data tool – Power capacity*; ETC (2021) *Making clean electrification possible*; ETC (2021) *Making the hydrogen economy possible*

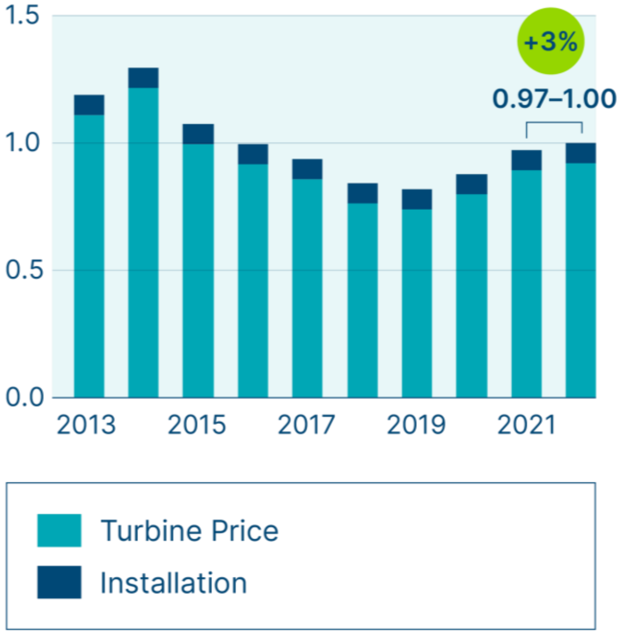
In recent years disruption in global supply chains has led to price rises for wind and batteries

Solar PV capex benchmark
2022 $/W(DC)



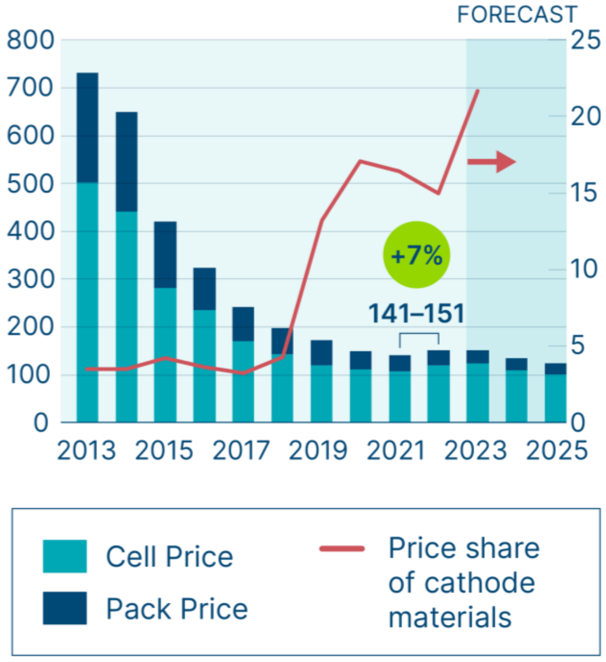
Solar: slowing of price reductions in 2022 due to tight supply for polysilicon and increased freight costs, alongside higher commodity prices, but expected to keep falling from 2023.

Wind turbine price by signing date
2022 $m/MW



Wind: cost increases driven by increasing prices of copper, aluminium and steel from 2020 onwards, alongside higher freight and shipping costs; however, **prices have been falling in China.**

Li-ion battery survey price
2022 $/kWh (LHS); % of total price (RHS)



Batteries: first-ever price rises in 2022 as prices of cathode materials (Li, Ni, Co) have risen sharply in past year; will take several years to recover to previous trend.

Source: BNEF (2022), *4Q Global PV Market Outlook*; BNEF (2022) *Lithium-Ion Battery Price Survey*, BNEF, *1H Global Wind Market Outlook*, 2022; BNEF, *1H Wind Turbine Price Index*, 2022

The Big Read Renewable energy + Add to myFT

Will there be enough cables for the clean energy transition?

The trade of renewable electricity will help countries phase out fossil fuels. But demand for the infrastructure is outstripping supply

Business | Awaiting a second wind

The wind-turbine industry should be booming. Why isn't it?

Stiff competition has combined with rising costs and other burdens

Vattenfall halts project, warns UK offshore wind targets in doubt

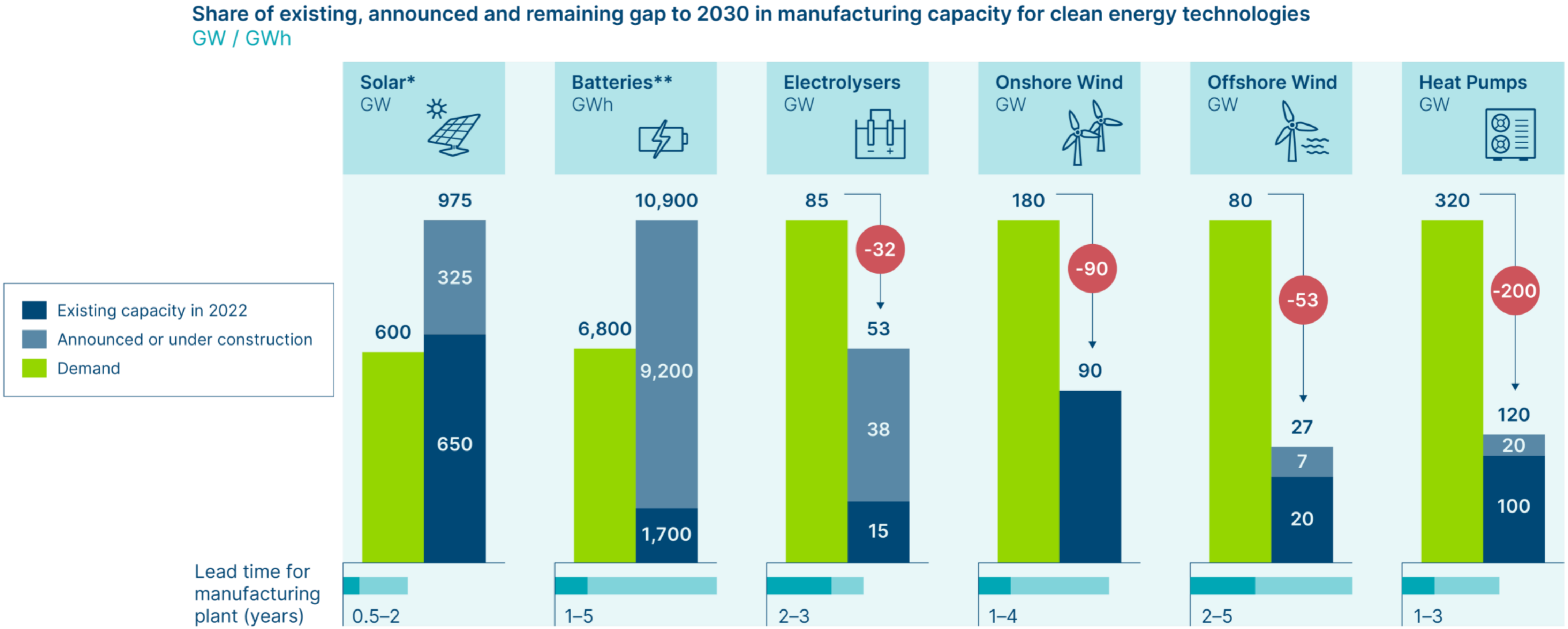
'Polysilicon shortage will continue through 2021'

The latest global PV industry outlook published by trade group SolarPower Europe, has indicated tight supply of the solar panel raw material is expected to persist this year but the trade body said it would be unlikely to drive further price rises.

2. ETC Analysis of Clean Energy Supply Chains

There are no inherent barriers to the long-term scale-up of clean energy supply chains globally, but three key challenges must be addressed

Short manufacturing lead times mean that, at a global scale, manufacturing and assembly of clean energy technologies should be able to scale quickly to meet deployment



*Solar PV installations could significantly exceed 600 GW p.a. in 2030, and therefore the total manufacturing capacity of ~975 GW p.a. should not necessarily be seen as drastic overcapacity

**Not all announced battery capacity is likely to be constructed

Source: ETC (2021), *Making clean electrification* possible; ETC (2021), *Making the hydrogen economy possible*; BNEF (2023) – *Interactive data tool*; BNEF (2022), *Global electrolyzer outlook 2030*; IEA (2023), *Energy technology perspectives*; IEA (2022), *The future of heat pumps*

Three cross-cutting risks pose challenges over the short-to-mid term

1. **While sufficient mineral and metal resources are available globally, issues around scaling supply at a fast enough pace to meet demand could be a problem for some raw materials**, in particular lithium and copper, and for **complex components** within supply chains.

2. **Supply chains for solar PV and battery manufacturing are highly concentrated geographically at several stages**. Future growth expectations for these markets means that clean energy manufacturing is not a 'zero-sum game'.

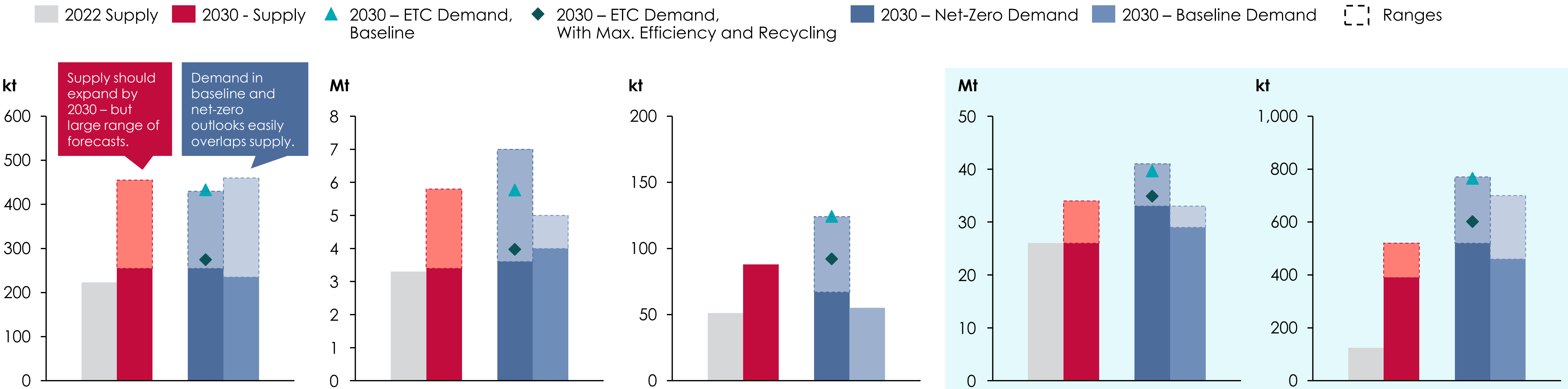
3. **There are some wider environmental and social concerns around materials and mining**, such as around labour and human rights, carbon, and other local resources, that need to be addressed appropriately.

1

Supply forecasts for copper and lithium show tightness through to 2030, raising risk of high input prices for clean energy technologies

Demand and supply forecasts for key energy transition materials in 2030

Nickel, Copper = Million metric tonnes; Cobalt, Lithium, Neodymium = Thousand metric tonnes;



Cobalt

- Demand forecasts falling sharply after shift to low-cobalt NMC.
- Some uncertainty over stability of DRC supply.

Nickel

- Rapid supply expansion in Indonesia.
- Can shift to LFP batteries to reduce demand

Neodymium

- Rising but uncertain demand growth from wind + BEVs.
- Supply can respond to high prices quickly.

Copper

- Used in all clean energy technologies, demand difficult to substitute.
- Supply expansion tricky due to ore grades, low investment.

Lithium

- No viable substitution across battery chemistries at the moment.
- Supply expanding but not quickly enough - gaps likely through to 2030.

Even with supply expansions, future demand growth for copper and lithium would exceed supply in 2030

Source: Systemiq analysis for the ETC; IEA (2023), *Energy technology perspectives* and IEA (2022), *World Energy Investments*; BNEF (2023), *Transition Metals Outlook*; ICF/RMI (2023), *Net zero roadmap to 2050 for copper & nickel mining value chains*; S&P Global (2022), *The future of copper*; &P Global Market Intelligence (2022), *Lithium project pipeline insufficient to meet looming major deficit*; Benchmark Mineral Intelligence (2023), *Albemarle's turbo-charged demand data showcases lithium's growing supply problem*; Albemarle (2023), *Strategic update*; McKinsey & Co. (2023), *Bridging the copper supply gap*; McKinsey & Co. (2022), *Lithium mining: How new production technologies could fuel the global EV revolution*

Three areas of action can help resolve mineral supply-demand imbalances

Accelerating technology and materials efficiency

1. Incentivise increased **R&D spending**
2. Public 'moonshot' targets, **innovation competitions**
3. Public investment in **large-scale demonstration projects**
4. **Advanced market commitments** to provide certainty for new technologies

__Example:__ US DoE is spending $5bn on transmission, storage and distribution infrastructure to enhance grid efficiency

Scaling recycling, re-use and secondary supply

1. **Regulation** on level of recycled content in product and **recycling rates** for materials at end of life
2. **Environmental standards for recycled supply**, including for import – to avoid 'leakage' to other geographies
3. **Subsidies for recycling** of key technologies in early phases (e.g., for solar PV or LFP batteries)
4. **Investment in logistics and infrastructure** for recycling

__Example:__ EU Critical Raw Materials Act, Battery Regulation include targets for recycling rates and recycled supply

Expanding supply at mine site

1. Create **clarity on future demand**
2. **Accelerate mine development** timescales
3. Increase **investment** in exploration and production
4. **Increase output** at existing mines
5. Improve international **data sharing**

__Example:__ Government of Ontario, Canada have put forward legislation to accelerate permitting for mines

Supply chains for complex equipment or components could face short-term delays

Offshore Wind Installation Vessels

- Offshore wind projects can require multiple **vessels to carry out transport and installation**.
- Wind **turbines keep increasing in size**, with spans over 250 metres – vessel builders unsure about future vessel requirements.
- Potential **shortages of installation vessels beyond 2025 could hold back ~35 GW** of offshore wind.

High-Power Grid Transformers

- High-power, large-scale transformers are **highly specialised, complex components** – often very labour-intensive.
- Seeing **rising costs and longer lead** times, especially in the US.
- Further potential constraints from **regulation of use of F-gases** in transformers, exacerbating shortages.

Battery Cathode Materials

- Capacity could be constrained by lack of refined materials – **highest risk is for class 1 nickel**.
- Building new manufacturing capacity requires **high-specification equipment** (e.g. kilns), can risk delays.
- Building up manufacturing capacity in Europe or N. America from very low base: **lack of experience of building and operating complex** plants.

Delays or high prices could materialise – but these would likely be resolved over short term (1-3 years), so do not pose a fundamental risk to energy transition

Source: BNEF (2023), *Offshore wind expansion under threat from vessel shortage*; US DoE (2022), *Electric grid supply chain review*; BNEF (2022), *2H Battery metals outlook*;

Strategic assessments and investments can help unblock supply for complex components

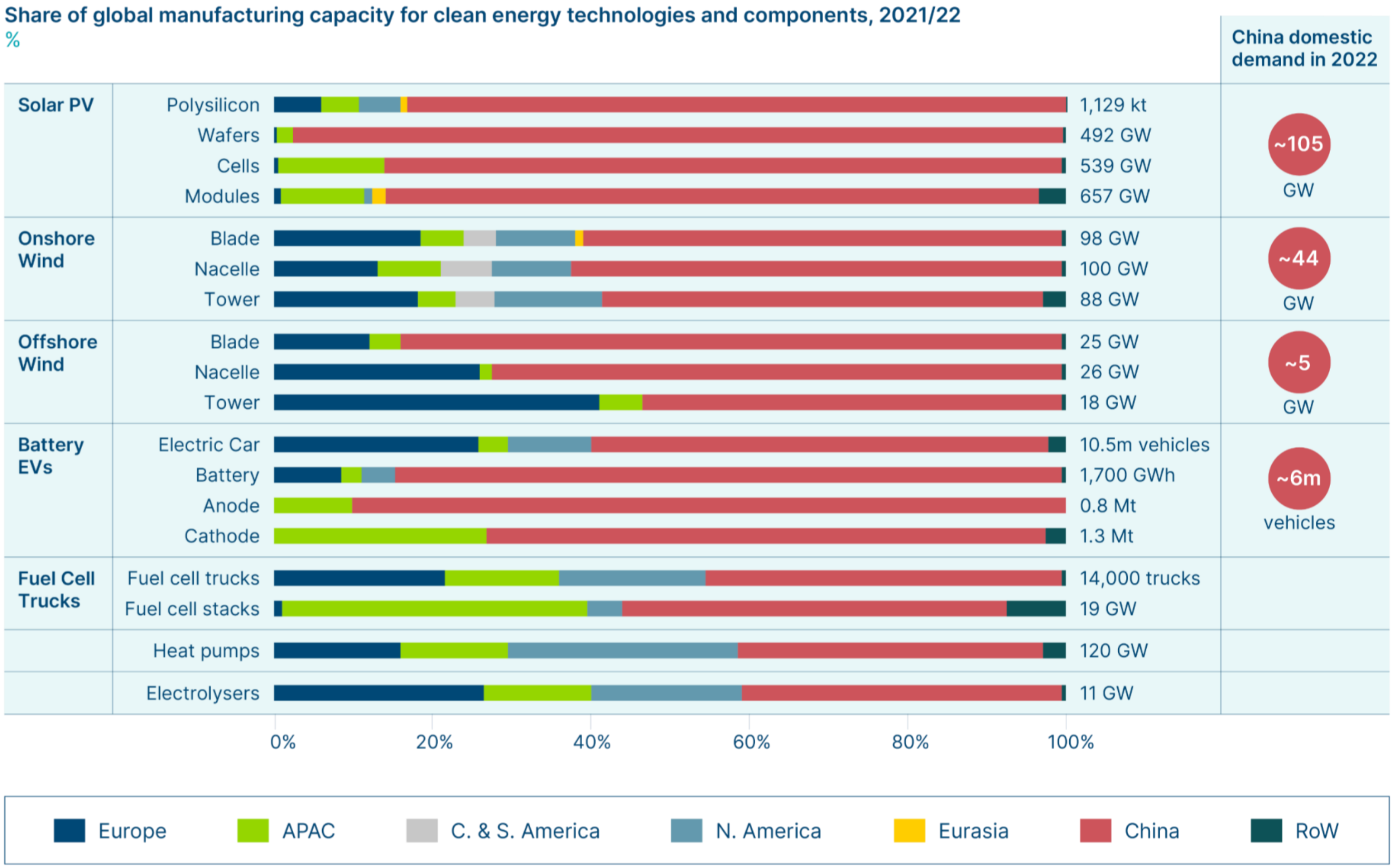
1. **Clear domestic deployment targets, auctions etc. to provide demand certainty**
2. **National/Business strategic assessments of supply chain risks**
3. **Targeted investments to secure/expand supply of complex components**

US Department of Energy Supply Chain Assessments

- Thirteen deep-dive studies of key components and supply chains for the energy industry.
- Include assessments of bottlenecks, concentration of supply, and domestic manufacturing capacity.
- Helped feed into e.g., Inflation Reduction Act, CHIPS & Science Act.
- Biden administration has authorised use of Defence Production Act to boost domestic manufacturing of e.g., high power grid transformers, electrolysers etc.

Source: US Department of Energy (2022), *Securing America's clean energy supply chain.*

Clean energy supply chains are heavily concentrated – especially for batteries and solar PV

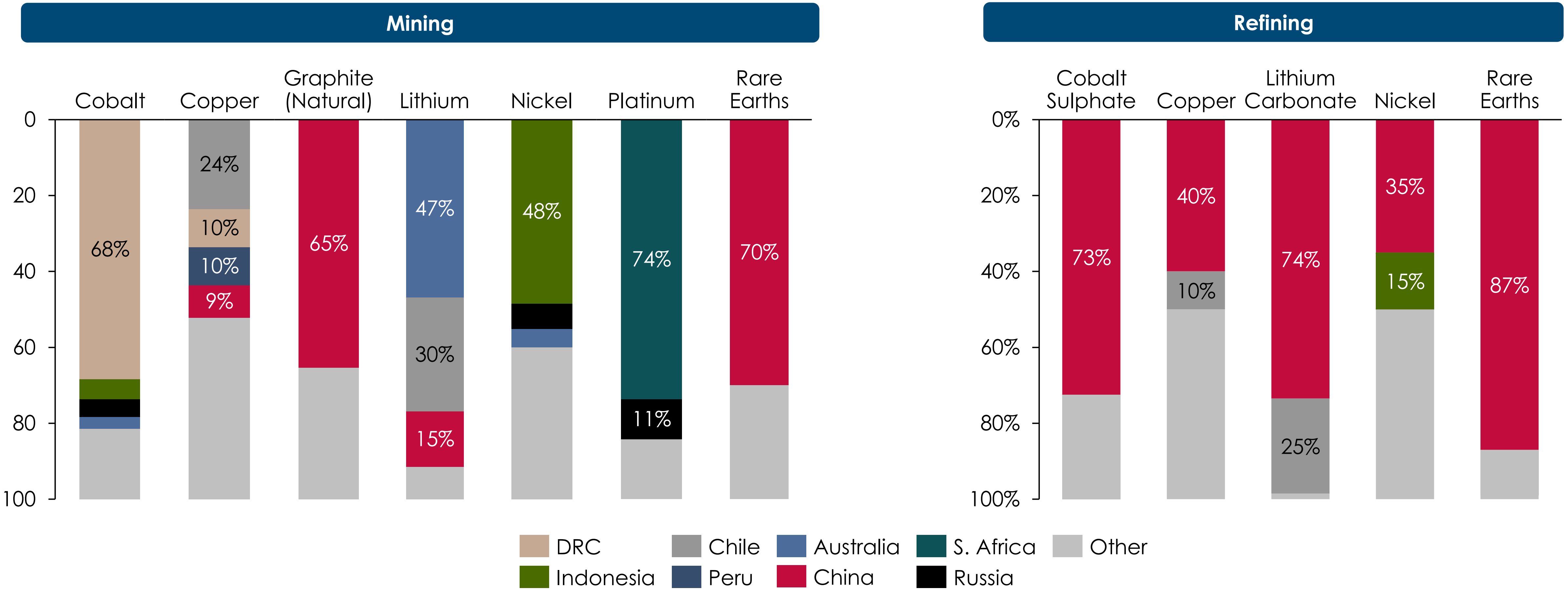


Source: IEA (2023), *Energy technology perspectives*; BNEF (2023), *Interactive data tool – Equipment manufacturers*; BNEF (2022), *Localizing clean energy supply chains comes at a cost.*

Mining and especially refining of key raw materials is also highly concentrated

Share of global mining and refining production by country, 2022

%



Source: US Geological Survey (2023), *Mineral Commodity Summaries*; IEA (2021), *The role of critical minerals in clean energy transitions*; BNEF (2022), *Localising clean energy supply chains comes at a cost*.

Countries should not aim to fully decouple; focus on de-risking and diversification

De-risking not Decoupling

Inflation Reduction Act is designed to develop domestic mining, manufacturing and supply chains – includes domestic content incentives and requirements, e.g. for batteries/EVs, iron and steel content.
No explicit % targets for domestic share of production.

Net-Zero Industry Act includes target for 40% of demand for clean energy technologies to be met by domestic manufacturing.
Critical Raw Materials Act includes targets for domestic production to meet 10% of demand for mined materials, 40% for refined materials, 15% for recycled supply.

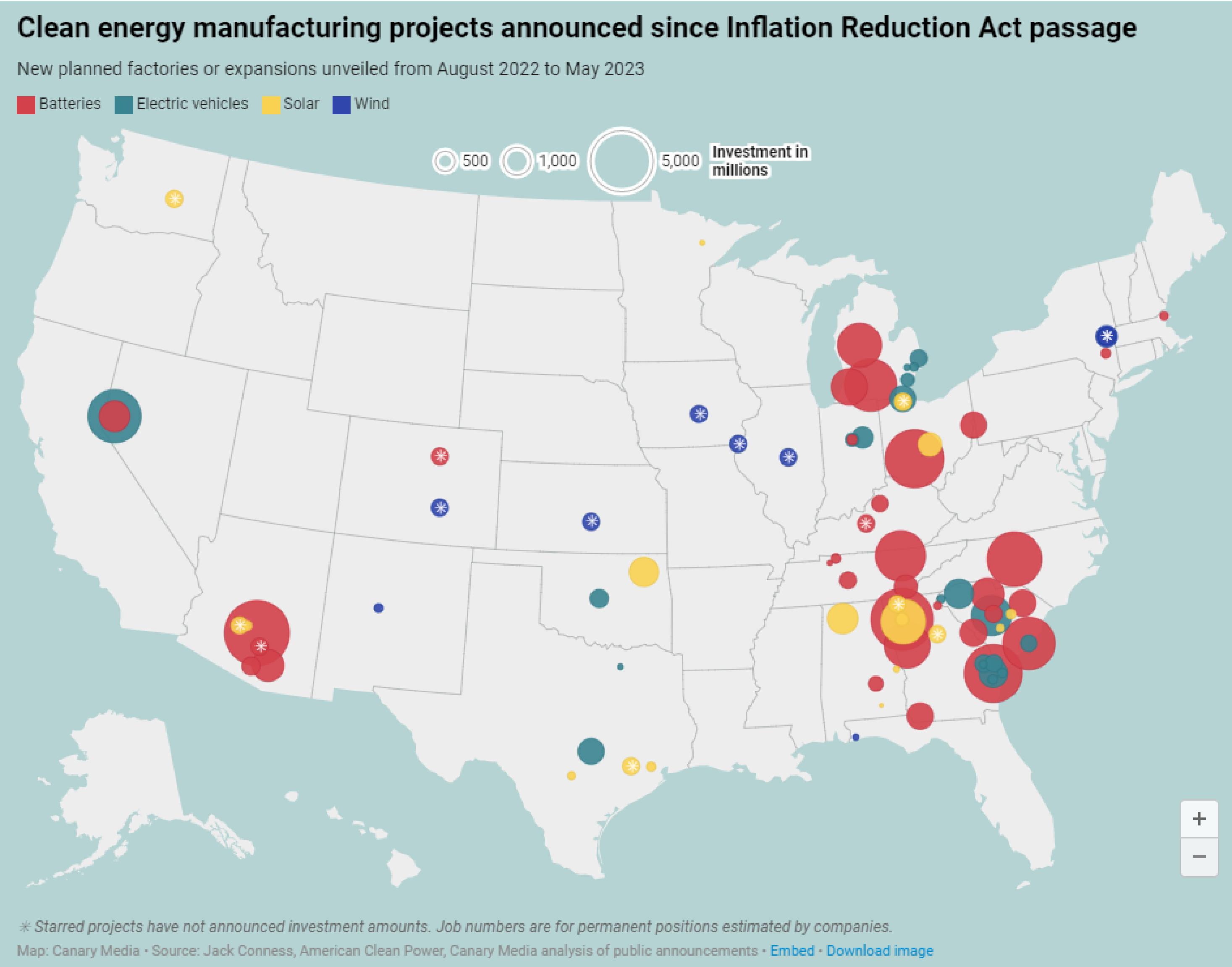
Production Linked Incentive scheme to promote domestic manufacturing, e.g. on EVs and solar PV.
Also imposed **tariffs on imports of solar PV** modules from China.
No explicit % targets for domestic share of production.

Feasibility of Local Implementation

- Higher environmental and social standards
- Rules/quotas on local content requirements
- Slower permitting for new projects
- Lower risk appetite, driving financing challenges
- (Re-)Starting manufacturing or mining from a low base

These **challenges must be addressed** to implement and scale up local supply chains, especially across **Europe and N. America**

Clean energy manufacturing announcements have exploded since the passage of the US IRA

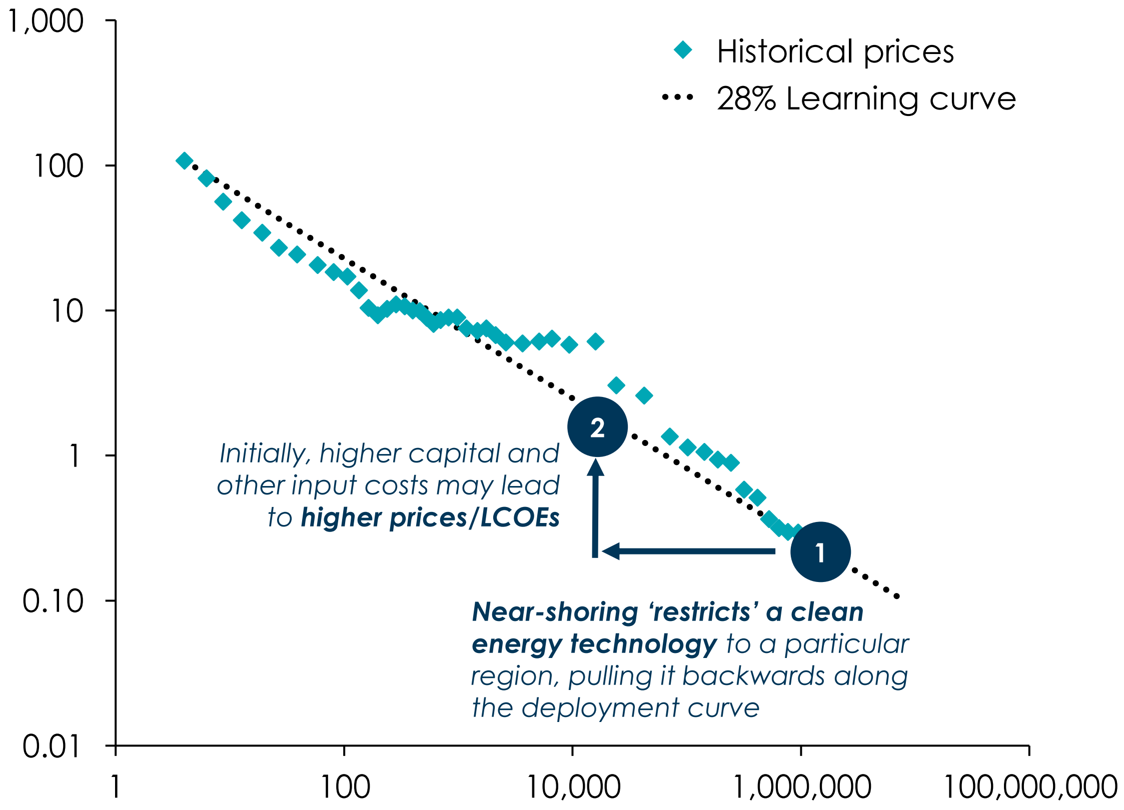


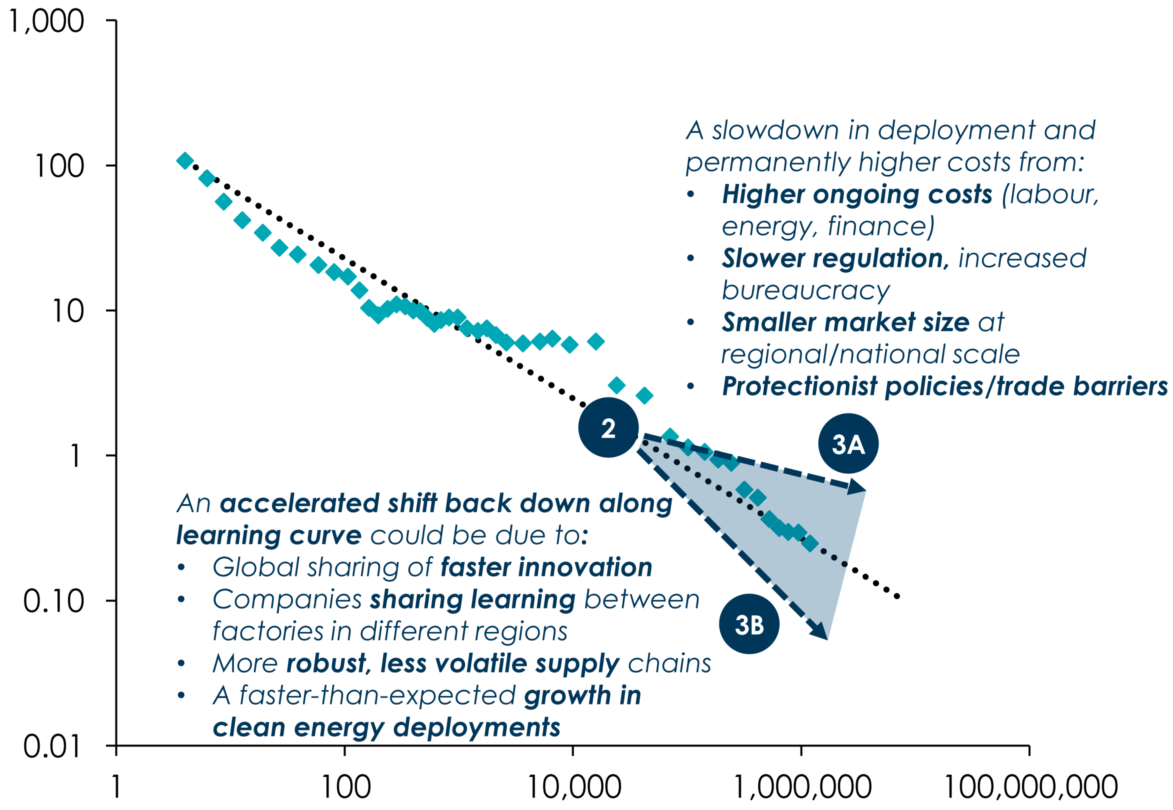
Source: Canary Media (2023), *The remarkable upsurge in US clean energy manufacturing, in charts*

Near-shoring would lead to higher costs, moving back and up the learning curve; but a mix of policy and market dynamics could bring rapid cost declines after a few years

Solar Example: Initially, near-shoring dynamics can be seen as moving back and up a clean energy technology 'learning curve', and a range of factors will influence how costs come down in future years

Solar learning curve: US$/W (Y-axis); MW (X-axis)

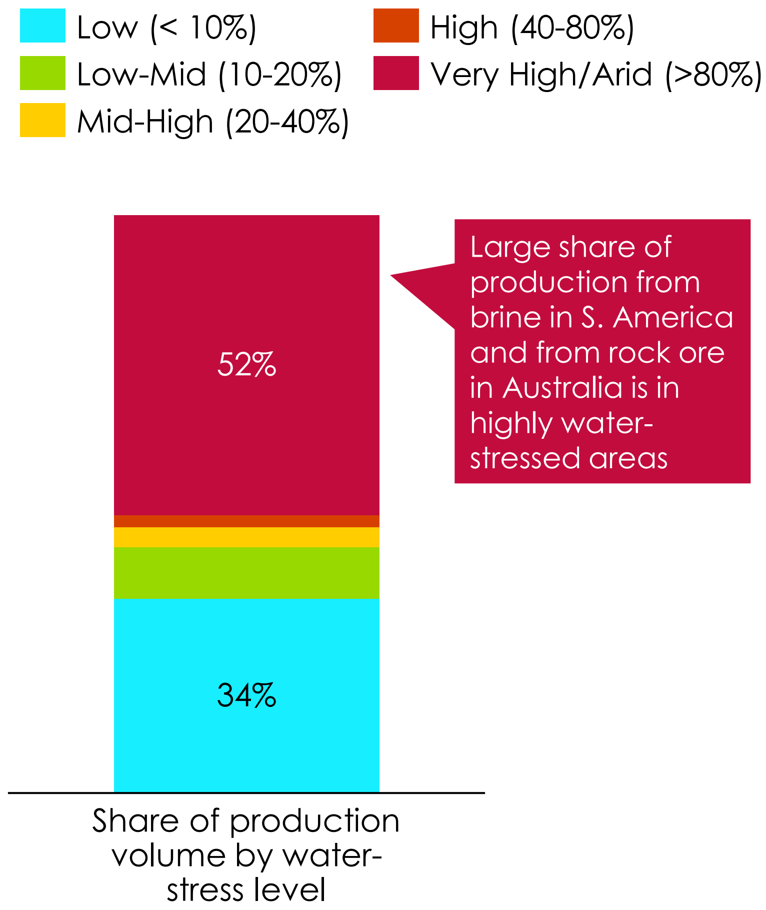




Source: BNEF (2022), *4Q Global PV market outlook*; Helveston et al. (2021) *Quantifying the cost savings of global solar photovoltaic supply chains*; Way et al. (2022) *Empiricallygrounded technology forecasts and the energy transition*

Battery materials have varying ESG concerns: water use, energy and emissions, and human rights challenges all need to be mitigated

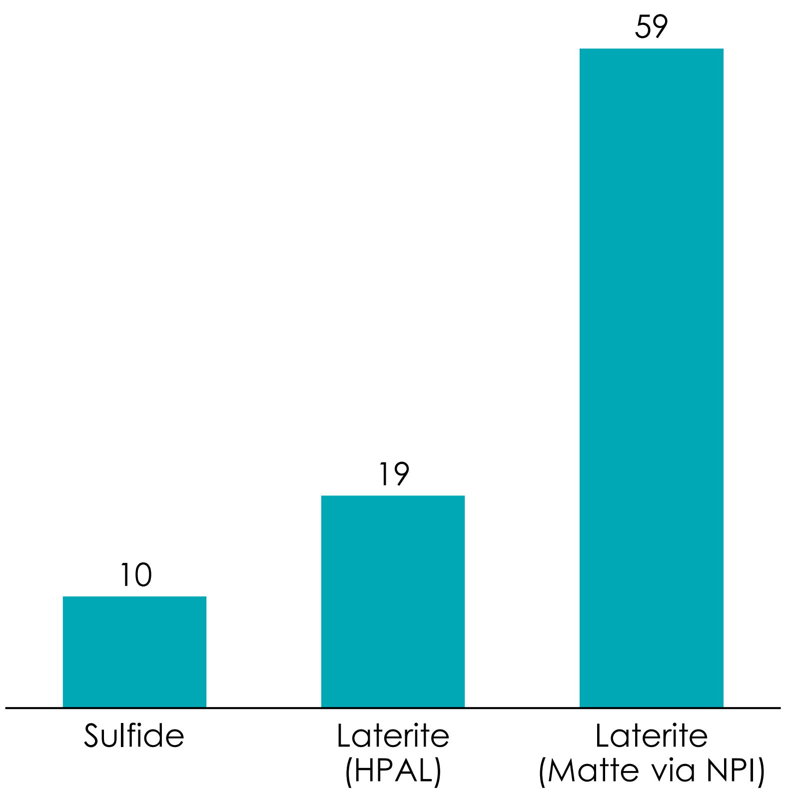
Lithium: High water use for all production routes



Nickel: Indonesian production relies on a lot of coal power

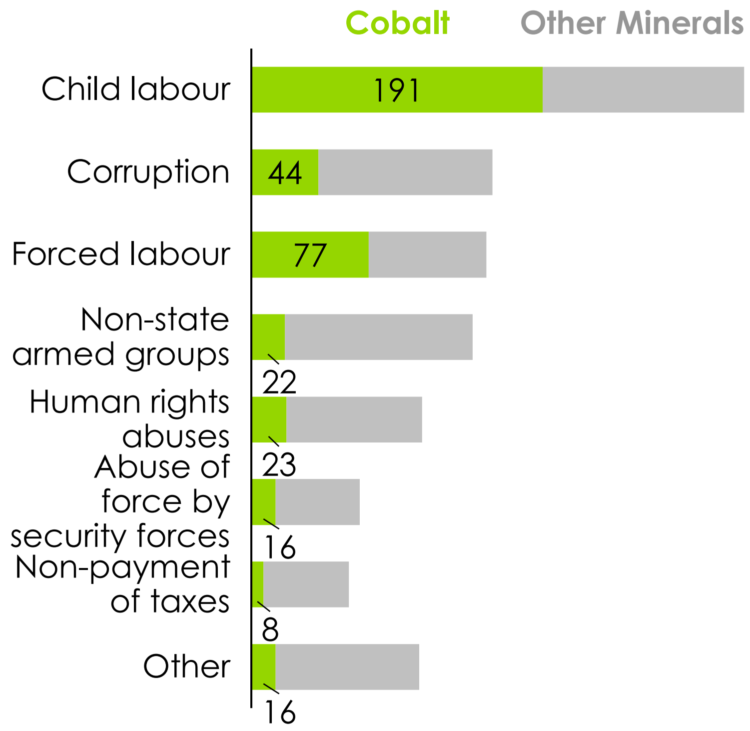
GHG emissions intensity for Class 1 nickel

tCO_2e/tonne of Ni



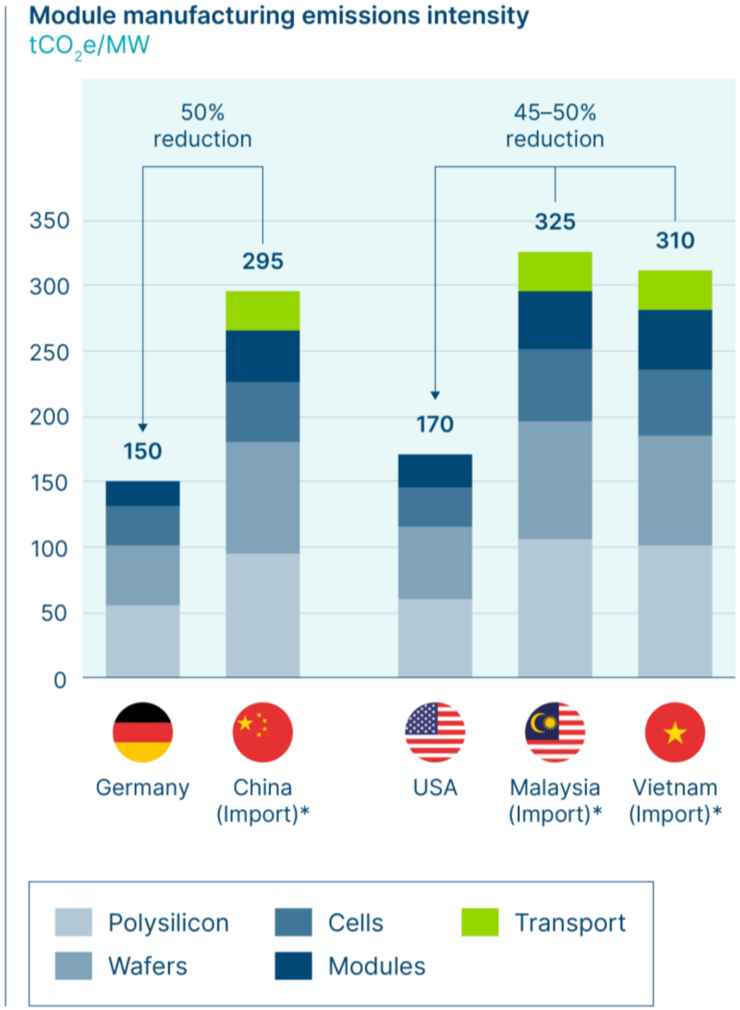
Cobalt: Human rights and corruption concerns for DRC supply

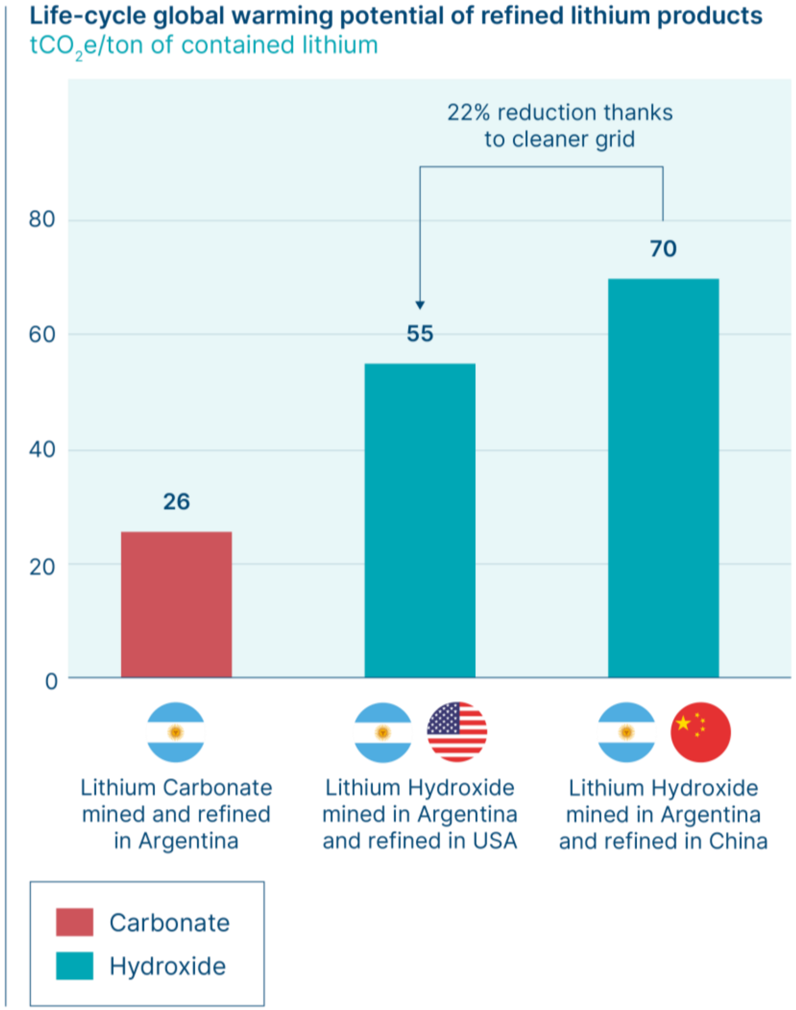
Public reports of governance-related risks



Source: IEA (2021), *The role of critical minerals in clean energy transitions*; IEA (2022), *Why is ESG so important to critical mineral supplies, and what can we do about it?*

Production of clean energy technologies could be decarbonised by using low-carbon electricity in China, or by shifting production to countries with less carbon-intensive grids





Note: *Assuming final product (solar PV module) is transported from producing country to Germany/USA.

Source: Minviro/Livent (2022), *2021 Sustainability Report*; Ricardo Energy (2020), *Determining the environmental impacts of conventional and alternatively fuelled vehicles through LCA*; IEA (2022), *Special report on solar PV global supply chains.*

3. Deep-dive on Europe's challenges and solutions

The European Green Deal is constructed to address all the key challenges facing supply chains – the focus must now shift to implementation and continuous ambition

Europe's Green Deal plays a key role in addressing many challenges across clean energy supply chains

EU Green Deal: Long-term target for net-zero emissions by 2050

Action linked to clean energy supply chains

Fit for 55	*REPowerEU*	*Green Deal Industrial Plan:*	*Batteries, Circularity and Waste*
55% emissions reduction by 2030[1]	• Reduce dependence on Russian gas • Accelerate wind + solar deployment	• Net-Zero Industry Act • Critical Raw Materials Act	• Battery Regulation • End-of-Life Vehicles Directive • Update to Ecodesign

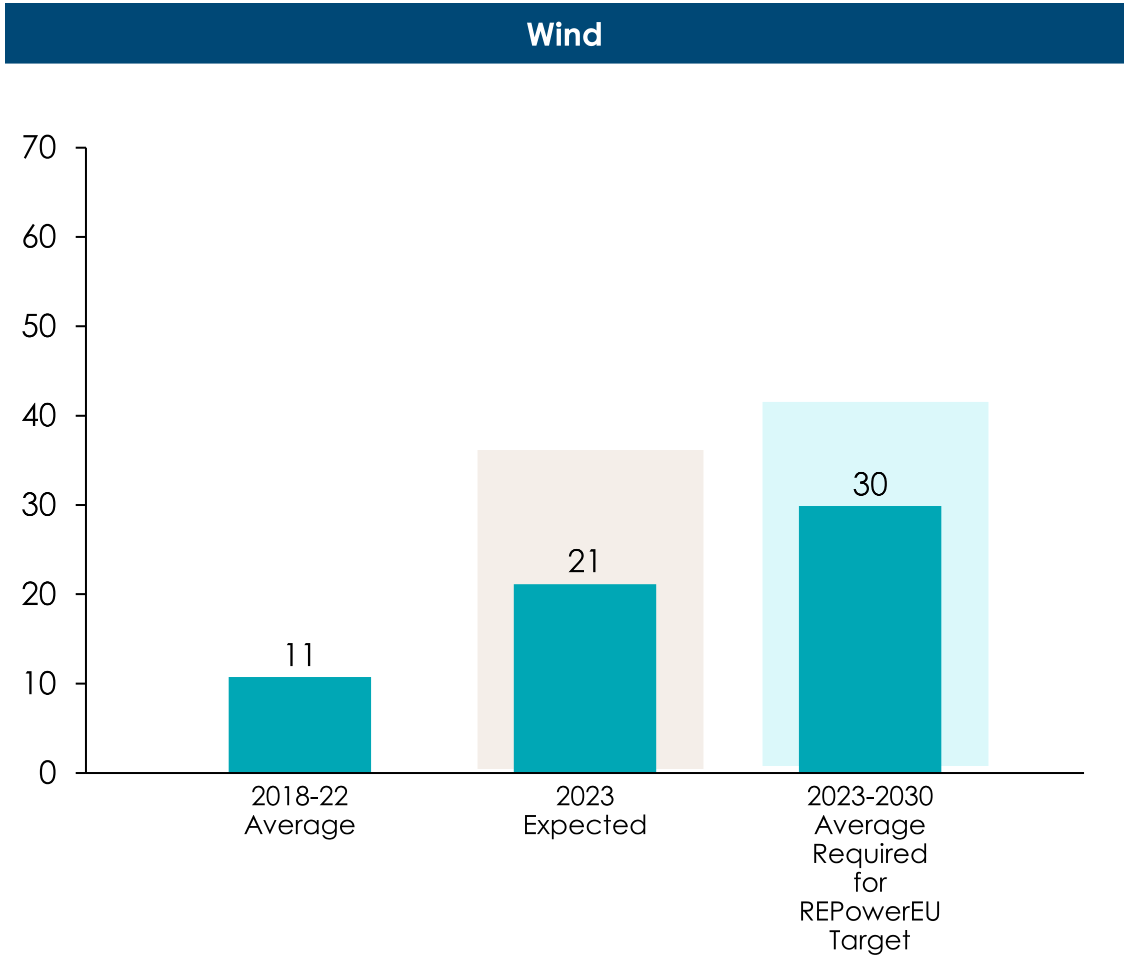
Wider action on: biodiversity, agriculture, chmicals, just transition, adaptation and more

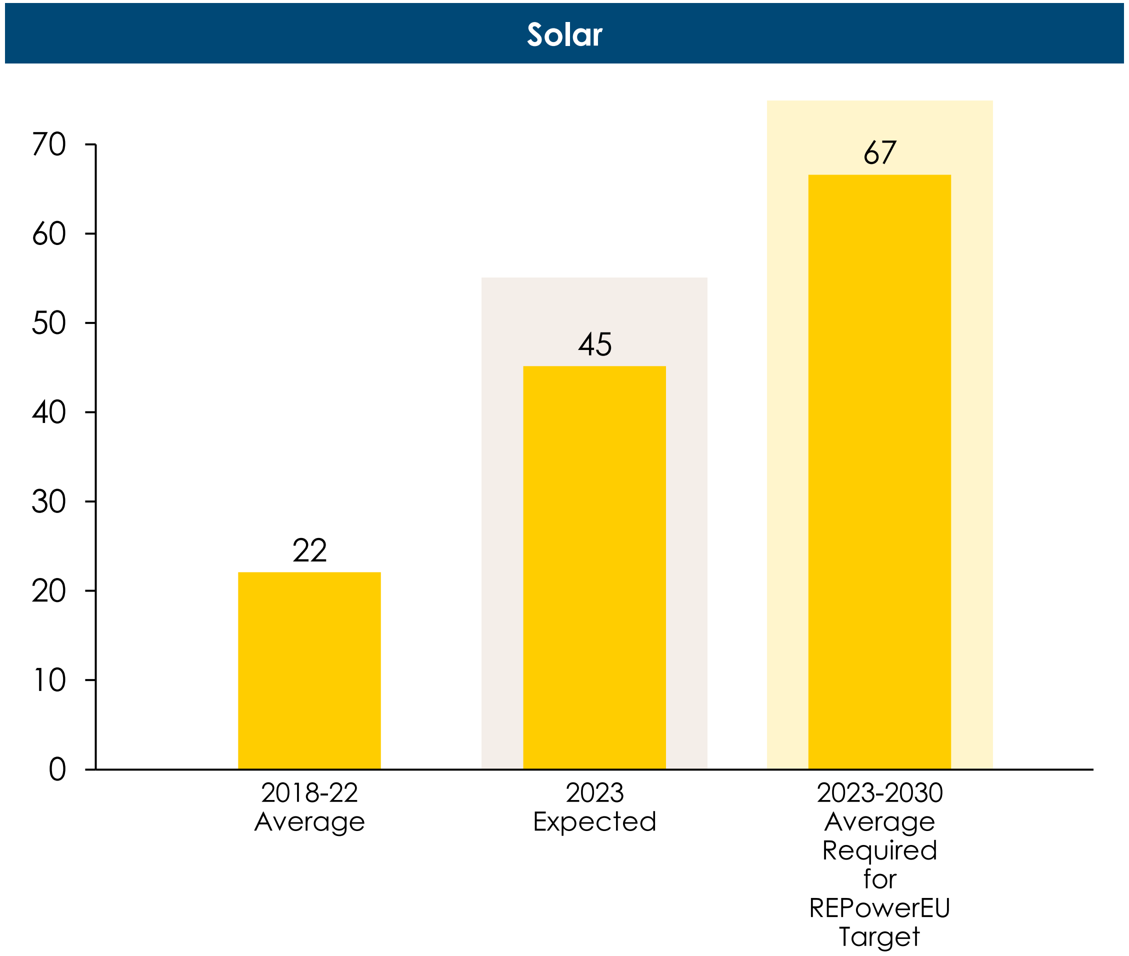
[1]Relative to 1990 baseline.

Annual installations of wind and solar need to keep growing rapidly to meet EU targets

EU annual installed capacity for wind and solar

GW

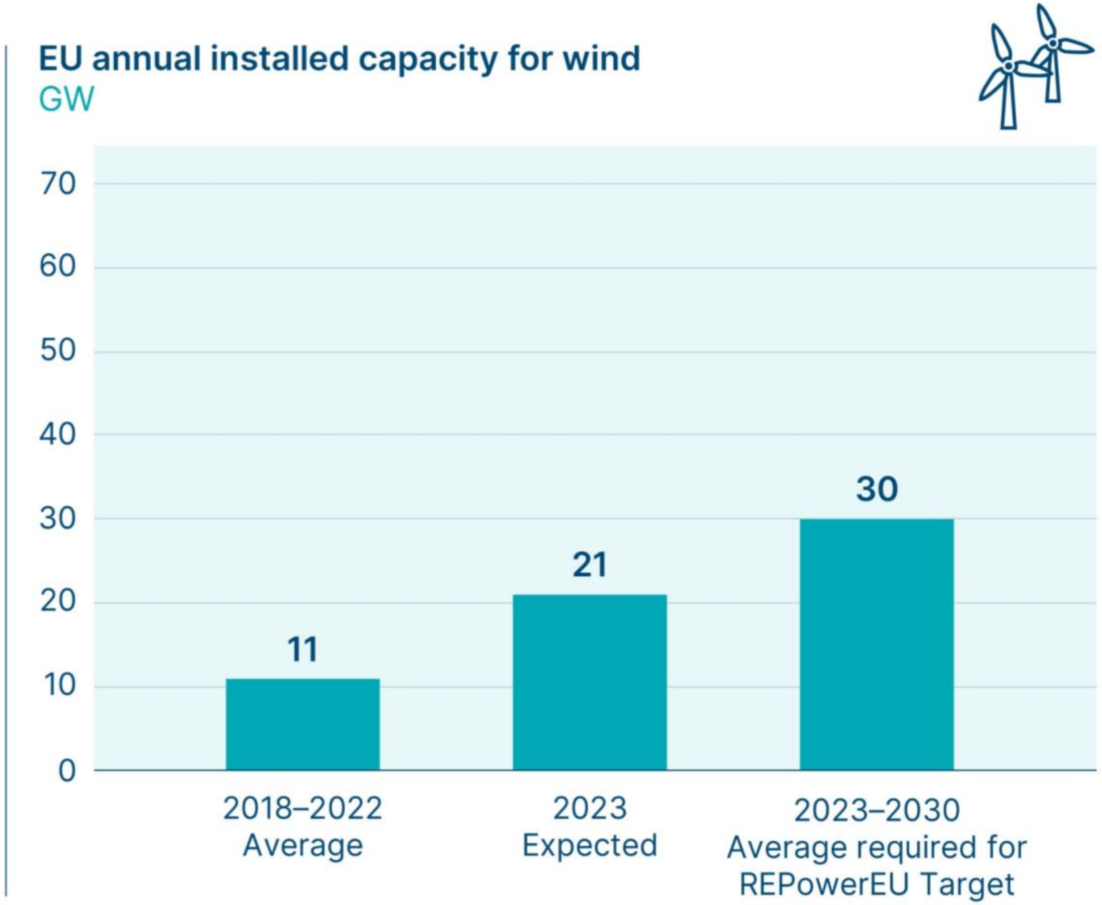


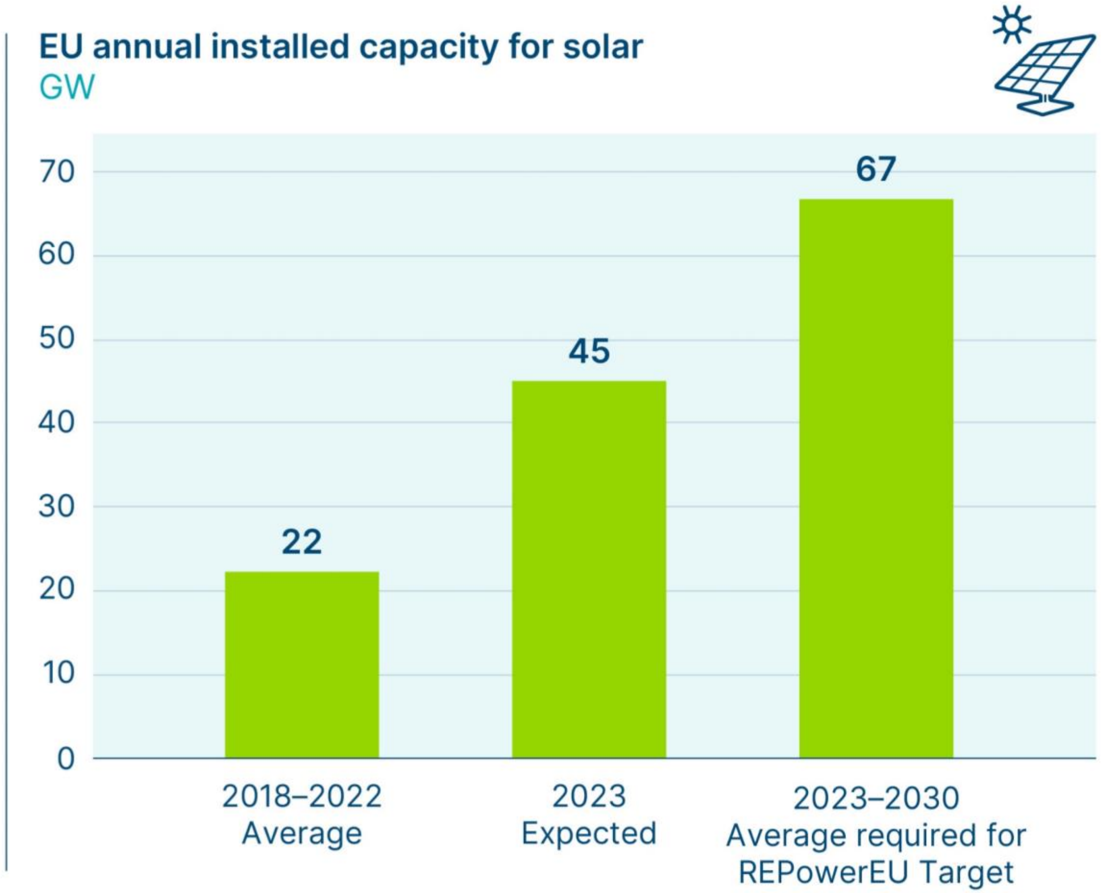


*Estimated for 2023

Source: BNEF (2023), *Interactive data tool – global installed capacity*; Ember (2023), *Wind and solar deployment in the EU*

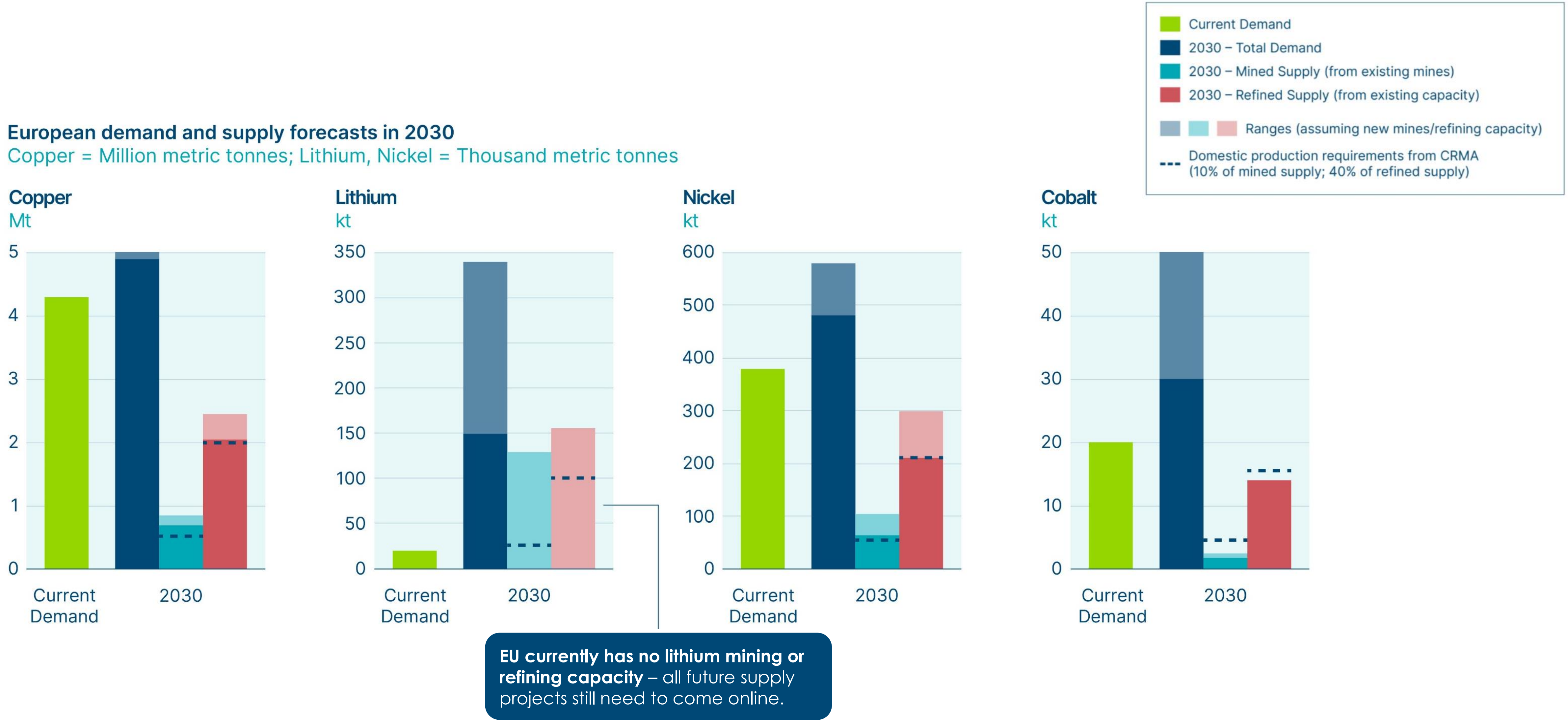
Annual installations of wind and solar needs to grow rapidly to meet EU targets





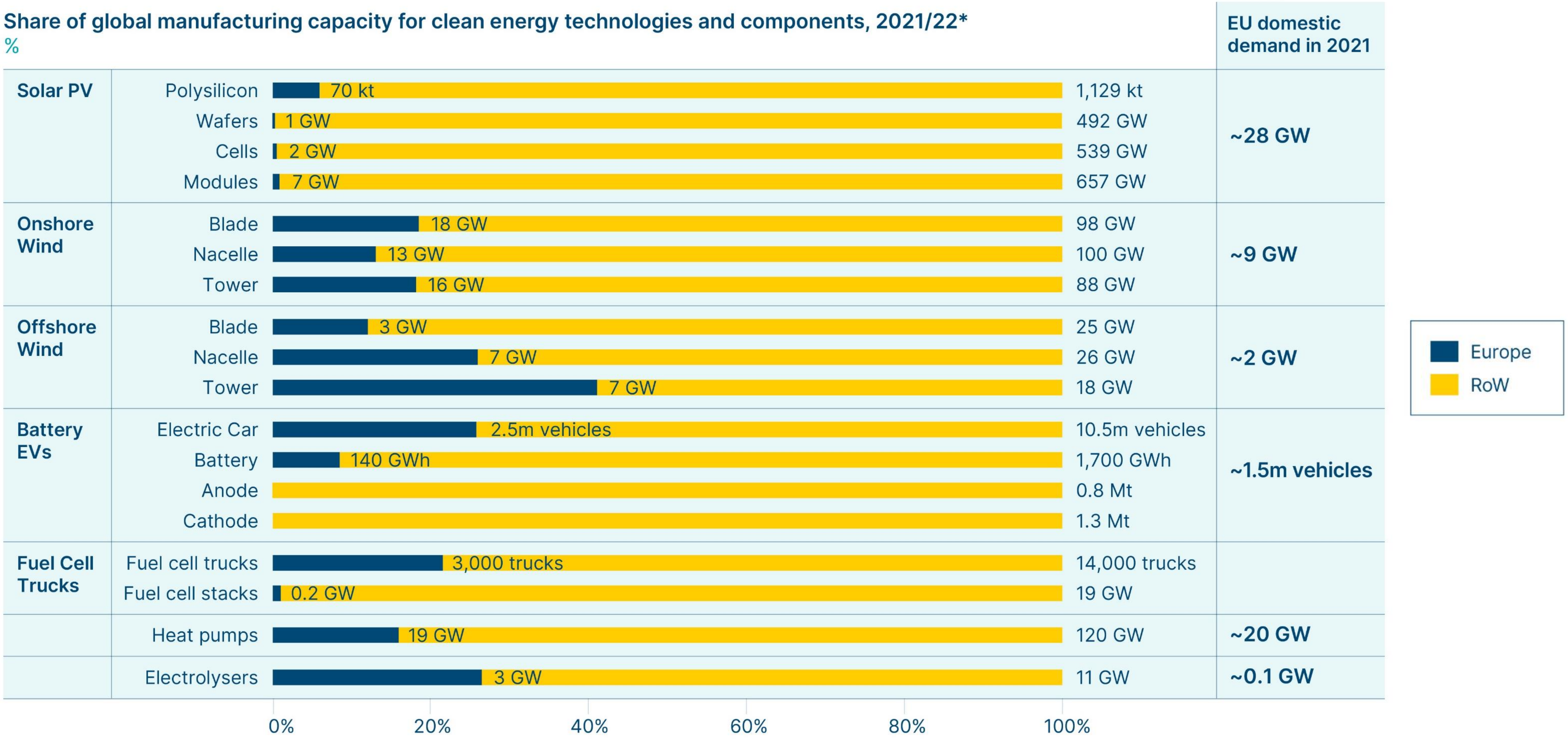
Source: BNEF (2023), *Interactive data tool – global installed capacity*; Ember (2023), *Wind and solar deployment in the EU*

Expanding lithium mining and refining will be biggest challenge to meet Europe's Critical Raw Materials Act domestic supply targets



Note: Demand is from all sectors, including both energy transition and non-energy transition sectors. Ranges indicate medium/high demand scenarios and base/optimistic supply scenarios from KU Leuven (2022) report. High demand scenarios assume aggressive policy action is taken to accelerate the energy transition, i.e. including and beyond REPowerEU and similar programmes.
Source: KU Leuven (2022), *Metals for clean energy: Pathways to solving Europe's raw materials challenge*

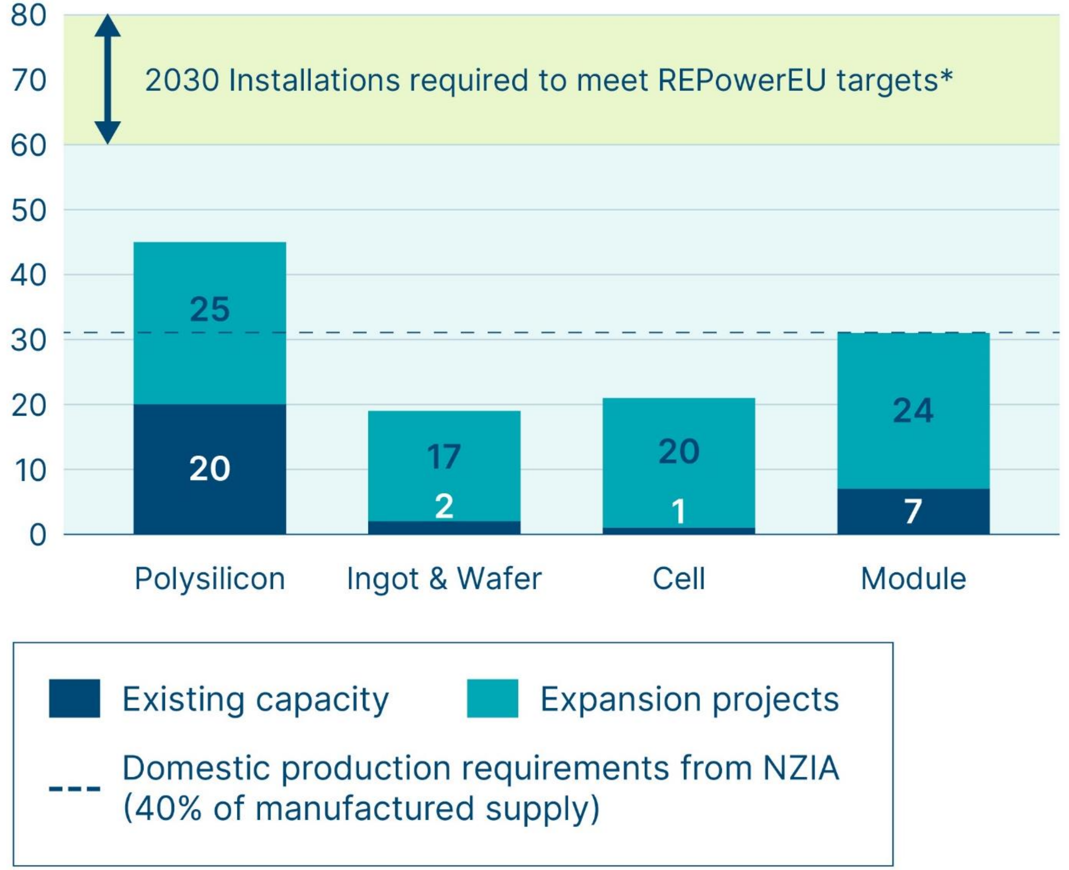
European domestic capacity is currently sufficient for domestic demand for wind, heat pumps and electrolysers



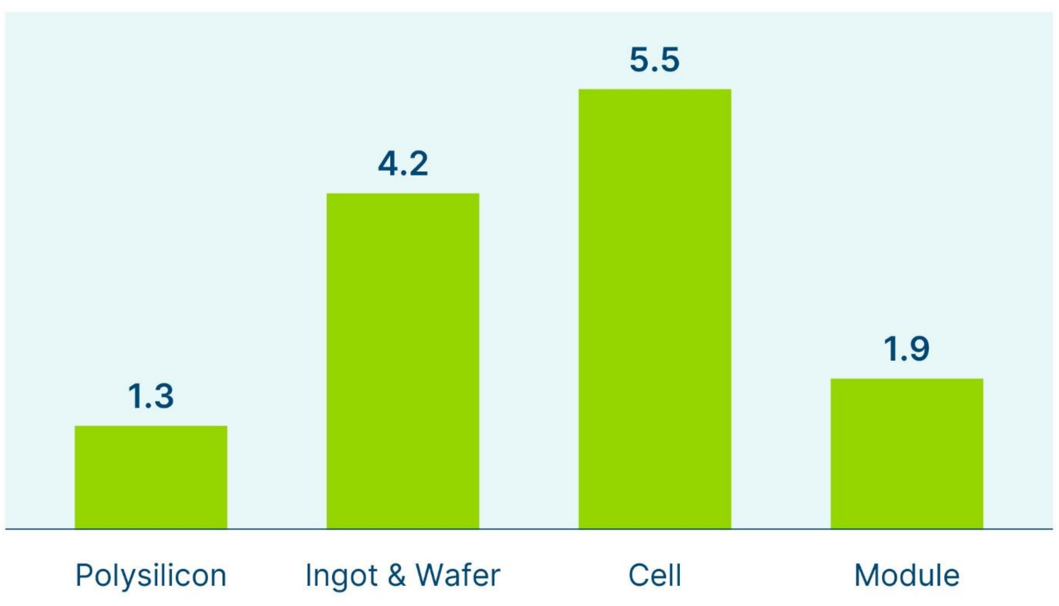
Source: IEA (2023), *Energy technology perspectives*; BNEF (2023), *Interactive data tool – Equipment manufacturers*; BNEF (2022), *Localizing clean energy supply chains comes at a cost*

For the EU to meet 40% of domestic supply by 2030, ~€13 bn would need to be invested across the solar supply chain, with a focus on midstream manufacturing

EU production capacity, existing and under development
GW



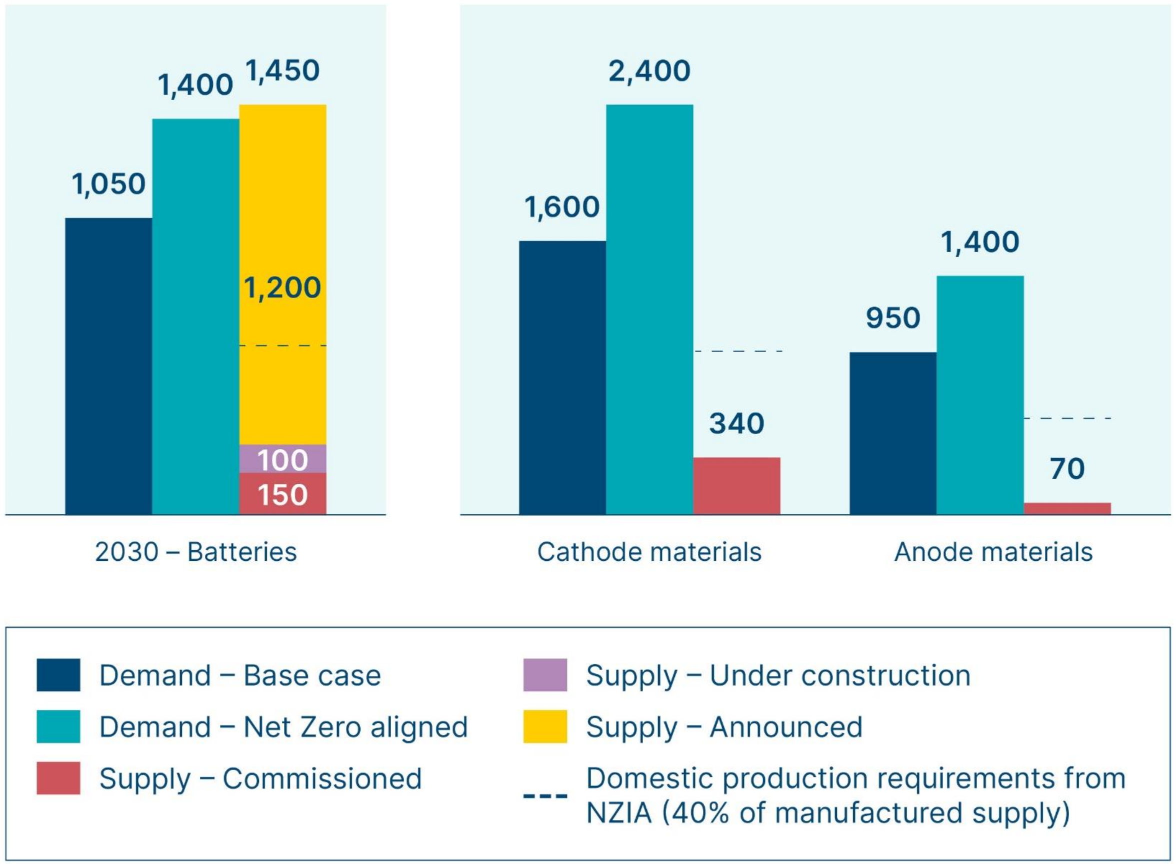
Associated investment requirements to meet 2030 targets**
€ bn



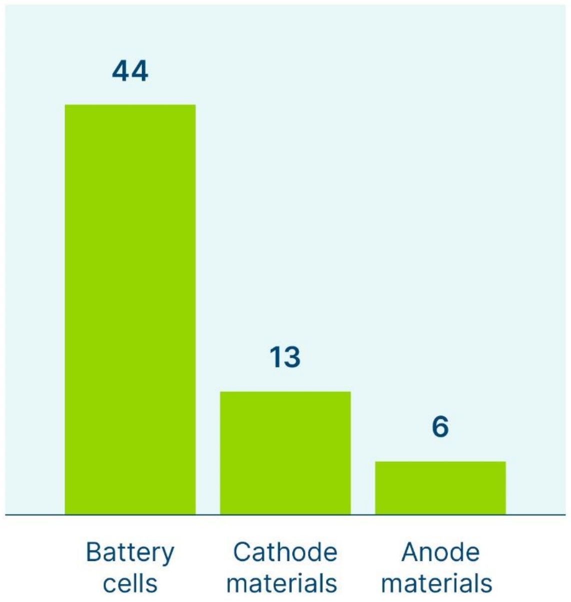
*Assuming REPowerEU 2030 target of ~600 GW-AC corresponds to ~750 GW-DC of total installed capacity in the EU
Note: assuming an average capital investment of €115 M/GW for a polysilicon plant, €145 M/GW for ingot & wafer, €180 M/GW for cells, €80 M/GW for modules.
Source: Systemiq analysis for the ETC; McKinsey (2022), *Building a competitive solar-PV supply chain in Europe*; European Commission; BNEF (2023) *Interactive data tool - Solar*

Current European battery manufacturing pipeline is more than sufficient to meet NZIA targets; ~€63 bn investments would be needed for required batteries and materials

European demand and supply forecasts for 2030*
EV battery cells (GWh); Anode/Cathode materials (kt)



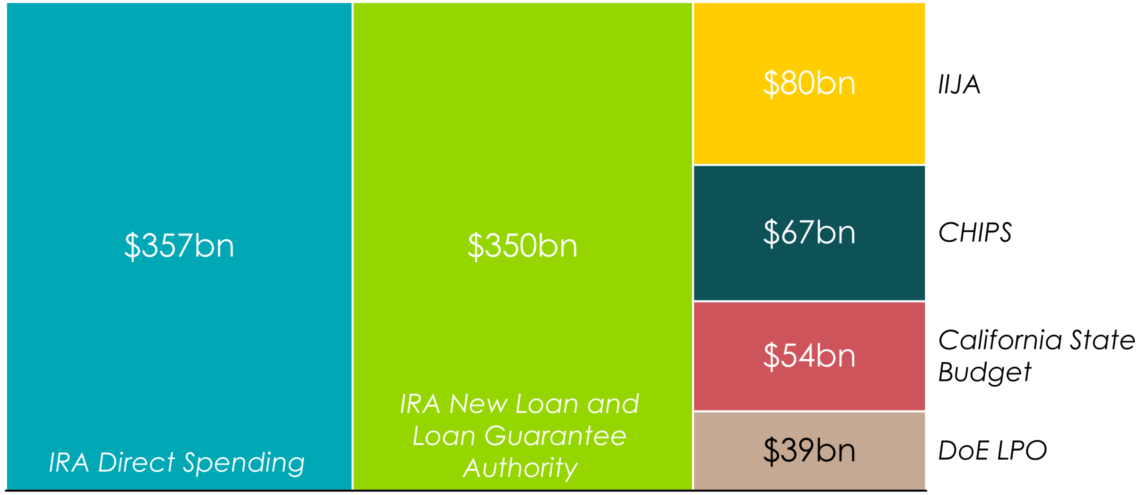
Associated investment requirements to meet 2030 targets**
€ bn



*Demand base case scenario is from T&E, data on supply pipeline from BNEF; EV categories included are passenger cars, vans, trucks, buses and coaches
**Investments calculated assuming no announced projects have yet reached final investment decision, and assuming an average capital investment of €0.14 Bn/GWh for battery assembly, €26 Bn/Mt for cathodes, and €14 Bn/Mt for anodes.
Source: Systemiq analysis for the ETC; Transport & Environment (2023), *A European Response to the US Inflation Reduction Act*; BNEF Equipment Manufacturers Data Hub;

Although available funding is similar across the US and EU, there is a lack of access, coherence and clarity for European spending

US: $1trn of spending across federal and state govs.



- *Overall funding could reach **~$1trn** across various packages*
- *Total of **~$35bn available for clean energy manufacturing***
- *Significant **tax credits for investment and production**, across electricity and hydrogen*
- *Strong consumer credits available (e.g. for EVs, heat pumps, batteries)*
- ***Clear, easy-to-access incentives** and a technology-neutral approach*

EU: Similar spending level, but more complex and fragmented

Green Deal Industrial Plan:

Net-Zero Industry Act
- *40% of 2030 clean tech capacity additions met by domestic manufacturing*
- *Enabling policies to streamline permitting and finance*

Critical Raw Materials Act
- *10% of 2030 materials demand met by domestic mining*
- *40% met by domestic refining*
- *15% met by recycled materials*
- *Max 65% of supply from one country*

Other EU and member-state level policy
- *REPowerEU*
- *InvestEU*
- *Introduction of CBAM*
- *Ongoing debate on use of ETS revenues*
- *Member-state EV tax credits, subsidies etc.*

- *Overall funding available could be up to **~€800bn**, comparable to US*
- *Total of **~€37bn available for clean energy manufacturing***
- ***Sources of funding are more fragmented and disparate***
- ***Lack of coherent vision** and messaging across policy packages*

Source: Kaya Advisory/Inevitable Policy Response (2022), *The US discovers its climate policy: A holistic assessment and implications*; Bipartisan Policy Center (2022), *Inflation Reduction Act Summary: Energy and climate provisions*; Bruegel (2023), *How Europe should answer the US Inflation Reduction Act*

Current European policies cover major supply chain challenges: new regulations are not needed, but increased coherence and funding can magnify impact

		Relevant EU Policies	***Strategic Gaps***
Fundamental driver: **a strategic vision for the energy transition**		***Fit for 55 and REPowerEU packages***	***None*** *(deployment targets + strategies need support at MS level)*
1 Addressing supply-demand imbalances	• *Demand:* Accelerate improvements in **materials and technology efficiency** • *Supply:* **Scaling recycling** and secondary supply • *Supply:* **Expand supply from the mine site to manufacturing.**	**Critical Raw Materials Act** **Net Zero Industry Act**	**Easy access to single, large, coherent pot of financing** **Demand-side/circularity measures to reduce scale of challenge**
2 Developing sustainable and responsible supply chains	• **Strong regulations on environmental and social impacts** of clean energy supply, starting with **carbon intensity.** • **Use purchasing power to drive projects** with high environmental and social standards. • **Define and adopt high-quality voluntary** environment and social standards. • **Improve and require supply chain traceability**.	**Critical Raw Materials Act** **Net Zero Industry Act** **Ecodesign** **Battery Regulation** **End-of-Life Vehicles Directive**	**Coherent vision across all relevant sustainability policies**
3 Ensuring diversified, resilient and secure supply	• **Adopt strategies to diversify supply** for mining, refining and manufacturing. • **Where near-shoring is assessed as strategically beneficial**, develop a suite of actions to **maximise benefits of near-shoring** of value chains, including alignment of near-shored industries with domestic growth areas.	**Critical Raw Materials Act** **Net Zero Industry Act** **ETS and CBAM**	**Funding to incentivise domestic and international production** **Coherence across EU/US/G7/G20 critical mineral initiatives**

4. Intervention:
Sandrine Dixson-Declève

Focus must now shift to implementation to ensure success of EU Green Deal

EU Green Deal: Long-term target for net-zero emissions by 2050

Action linked to clean energy supply chains

Fit for 55	*REPowerEU*	*Green Deal Industrial Plan:*	*Batteries, Circularity and Waste*
55% emissions reduction by 2030[1]	• Reduce dependence on Russian gas • Accelerate wind + solar deployment	• Net-Zero Industry Act • Critical Raw Materials Act	• Battery Regulation • End-of-Life Vehicles Directive • Update to Ecodesign

Wider action on: biodiversity, agriculture, chmicals, just transition, adaptation and more

90% of EU Green Deal has been passed into legislation – focus is now on maintaining political momentum, and on ensuring strong implementation

[1]Relative to 1990 baseline.

Four themes for the coming year ahead

- The need to accelerate **implementation of EU Green Deal** and ensure robust enforcement.
- Continuous need for **increasing ambition**: Could REPowerEU 2030 targets for solar be revised up? What will the EU's GHG emissions targets for 2040 be?
- The **politics of the energy transition**, and its role in next year's European elections.
- Narrative of **energy security and industrial strategy** as an 'umbrella' for action to accelerate the energy transition.