NET ZERO: 2024 Perspective

Trends and challenges in the global energy transition

eden mccallum

Agenda

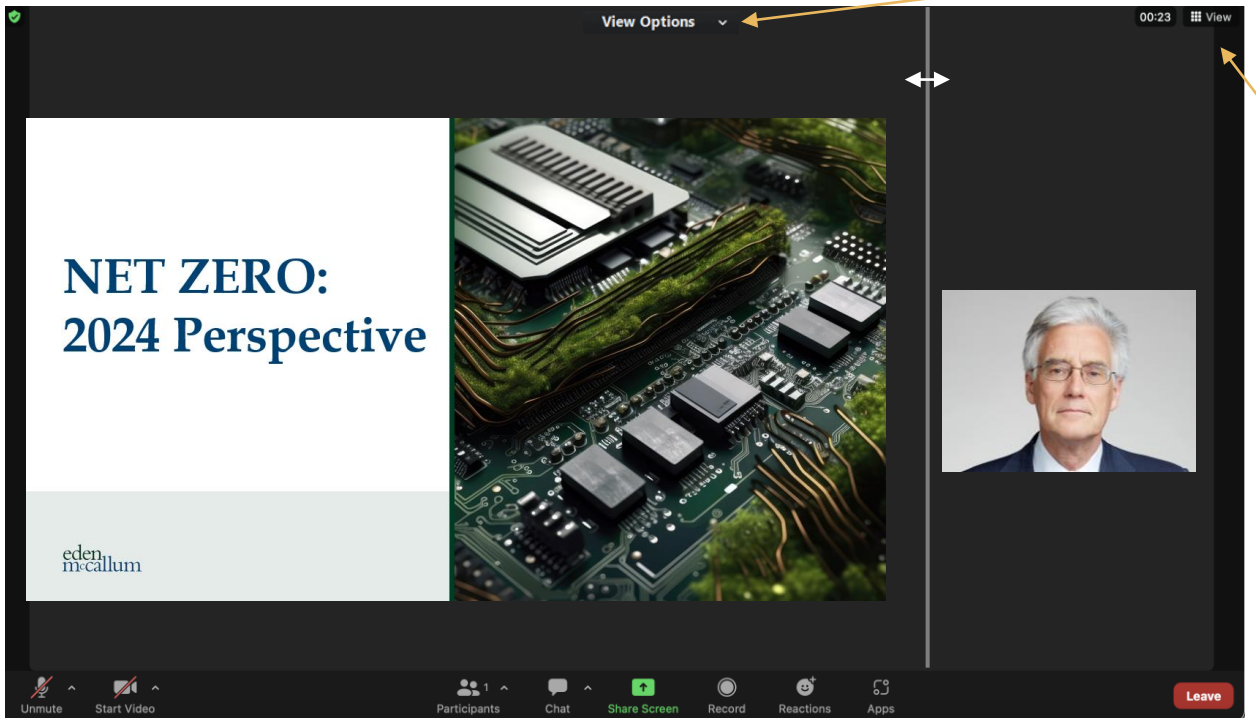
Introduction

Net Zero: 2024 Perspective

Q&A

To get the most out of this session…

ZOOM **TIPS!**



Side-by-side view

SBS Speaker view

Microphone on MUTE

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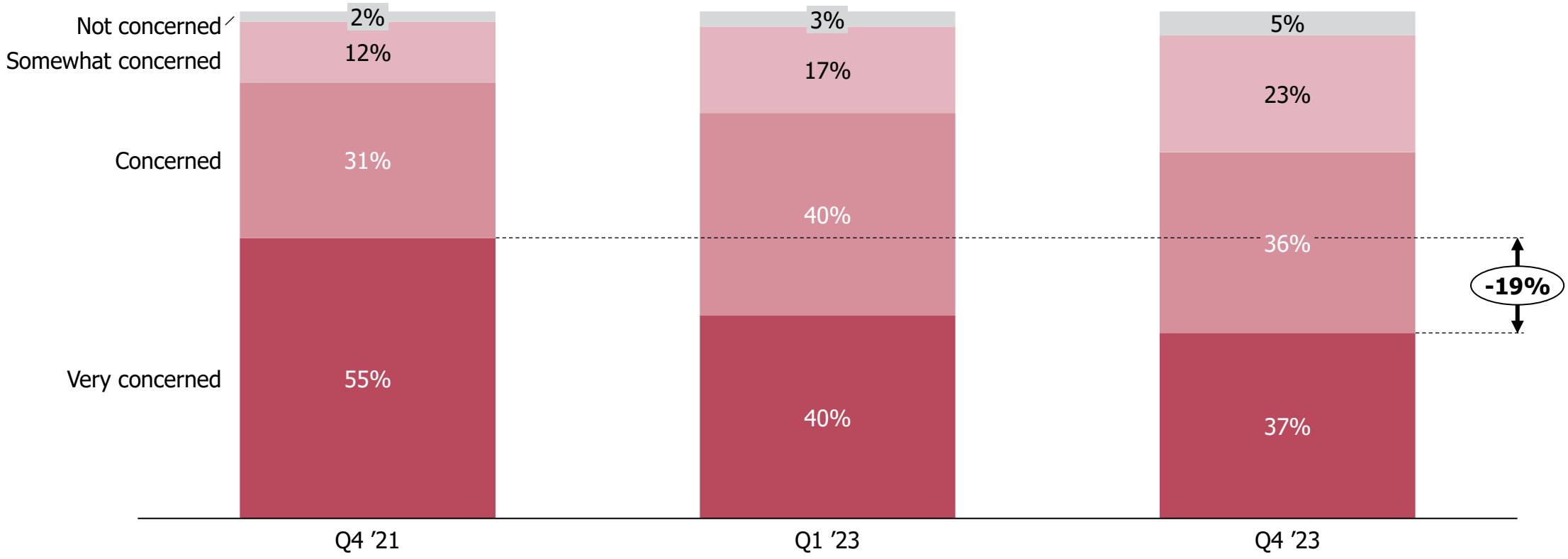
Questions in chat

eden mccallum

High, but reduced intensity of concern about environmental sustainability amongst business leaders

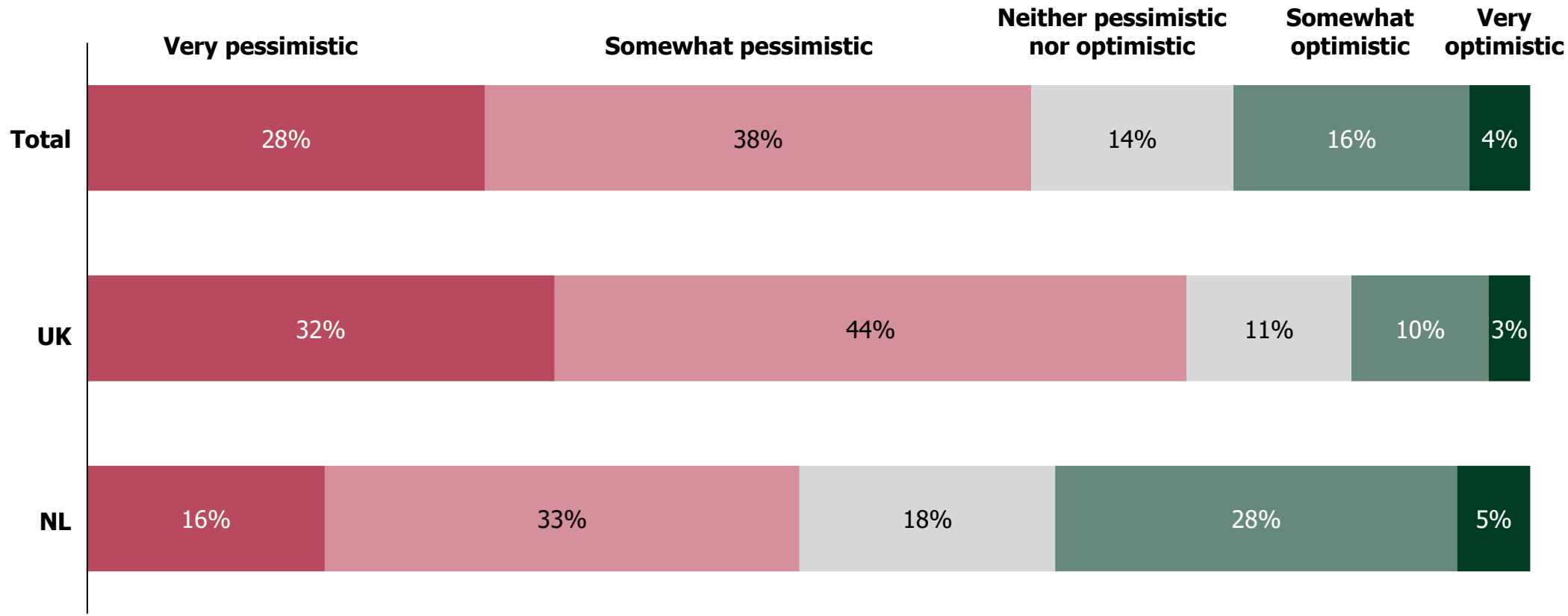
CONCERN ABOUT ENVIRONMENTAL SUSTAINABILITY



Q4 '21 n: 150 ; Q1 '23 n: 235; Q4 '23 n: 216
Source: Eden McCallum Business Outlook Survey Q4 2021, Q1 2023, Q4 2023: Q14 - How concerned are you personally about environmental sustainability?

High levels of pessimism about countries achieving net zero targets by 2050 amongst business leaders

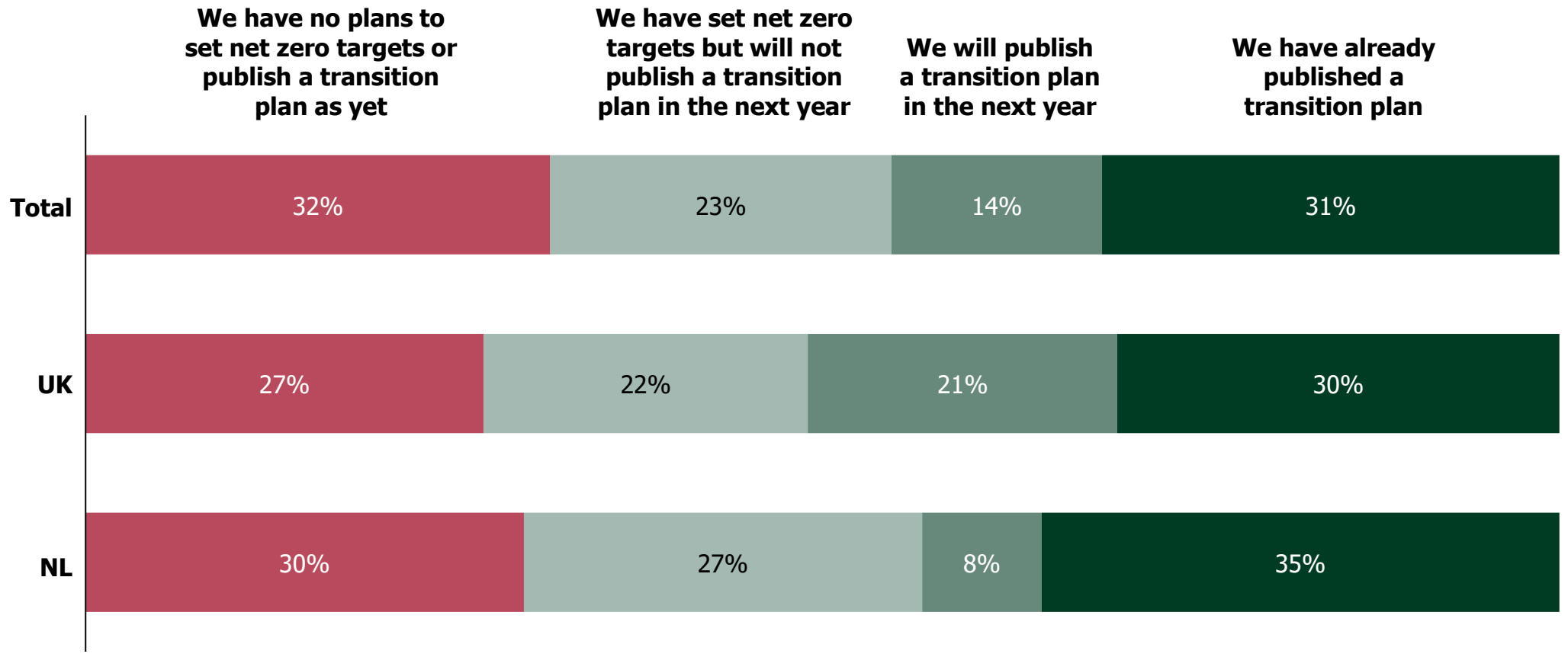
NET ZERO OUTLOOK[1] (Q4 '23)



Total n: 214
Source: Eden McCallum Business Outlook Survey Q4 2023: Q15 - How pessimistic or optimistic are you about your country achieving the target of net zero greenhouse gas emissions by 2050?

Most companies have set net zero targets and/or published a transition plan

CORPORATE NET ZERO TRANSITION PLANNING[1] (Q4 '23)



Total n: 203
Source: Eden McCallum Business Outlook Survey Q4 2023: Q18 - Which of the following best describes the status of net zero transition planning in your organisation?

Lord Adair Turner

Currently

- **Chair, The Energy Transitions Commission**
- Chair, Chubb Europe
- Advisory Board, Envision Energy
- Member of the board, AESC
- Advisor to Watershed Technologies Inc.
- Advisor to ReNew Power India
- Chairman, Oaknorth Bank plc

Previous public policy roles

- Chair, Financial Services Authority
- Chair, Climate Change Committee
- Chair, Pensions Commission
- Chair, UK Low Pay Commission

Previous business roles

- Vice-Chair, Merrill Lynch Europe
- NED, Standard Chartered plc
- Director-General, CBI
- Director, McKinsey

Energy Transitions Commission

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Energy Transitions Commission

Trends and challenges in the global energy transition

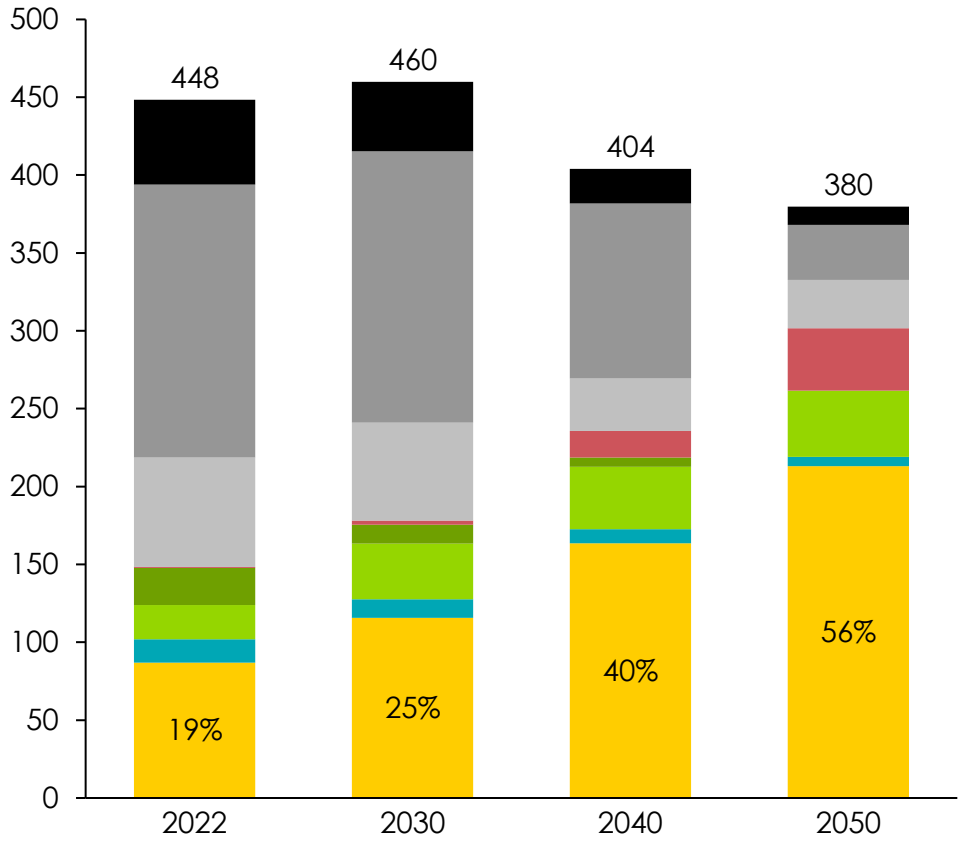
Eden McCallum

15th March 2024

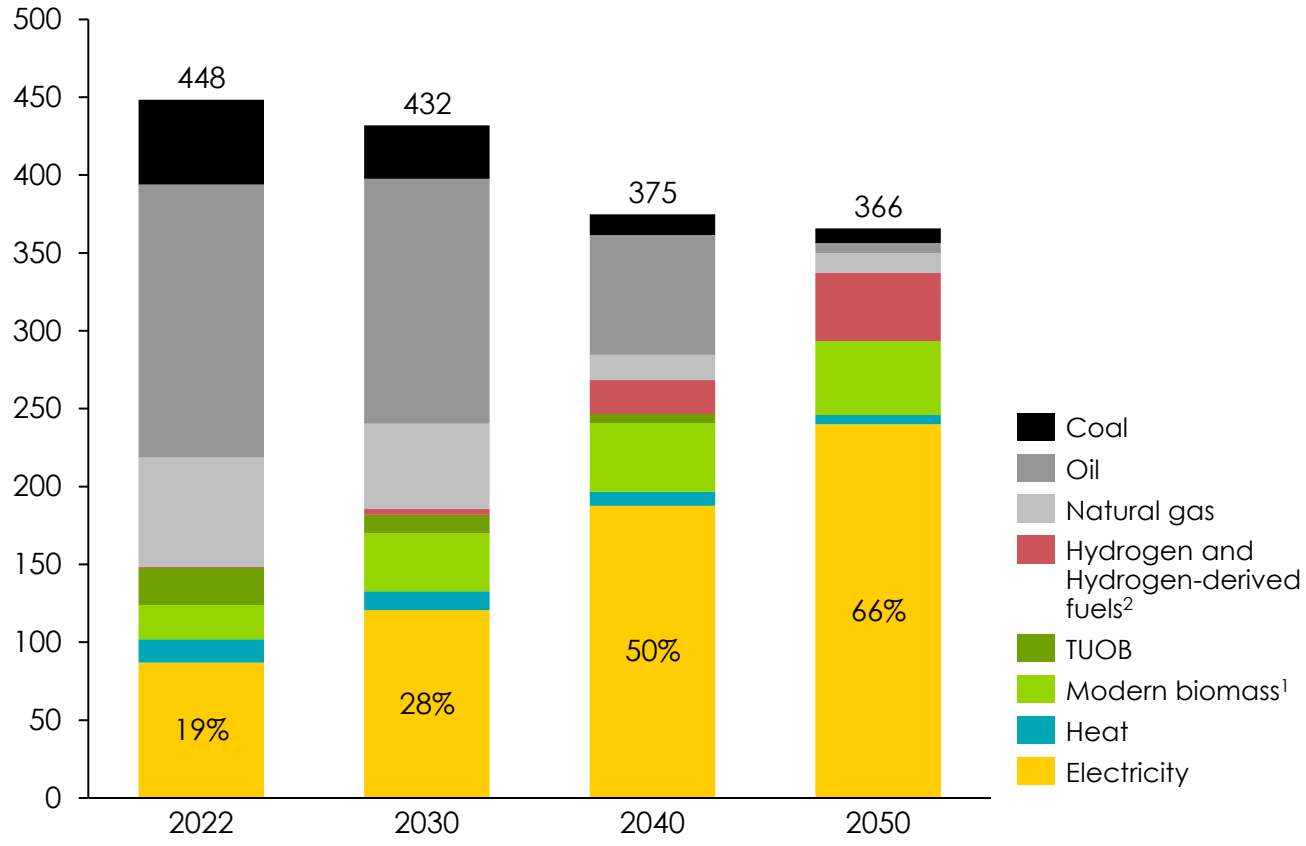
Final Energy Consumption in ETC scenarios

EJ per annum

ACCELERATED BUT CLEARLY FEASIBLE



POSSIBLE BUT STRETCHING

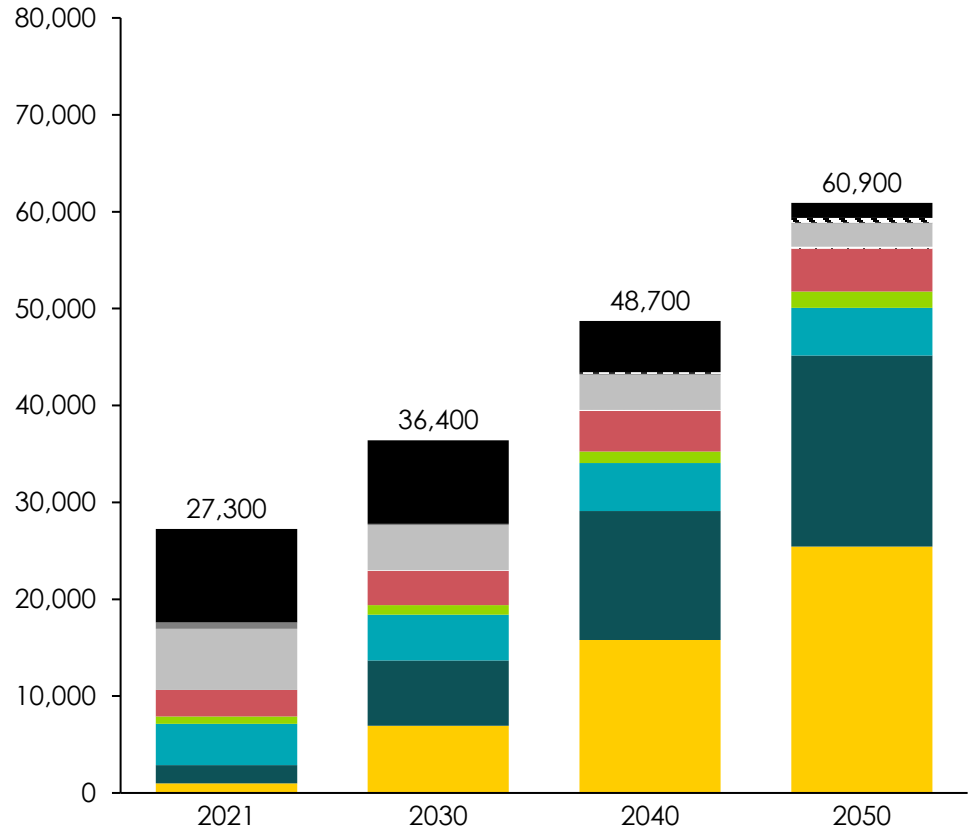


Note: [1]Final energy demand from Modern biomass to be finalized. [2]Mainly from green sources.
Source: Systemiq analysis for the ETC (2023).

Global power generation by source

TWh

ACCELERATED BUT CLEARLY FEASIBLE



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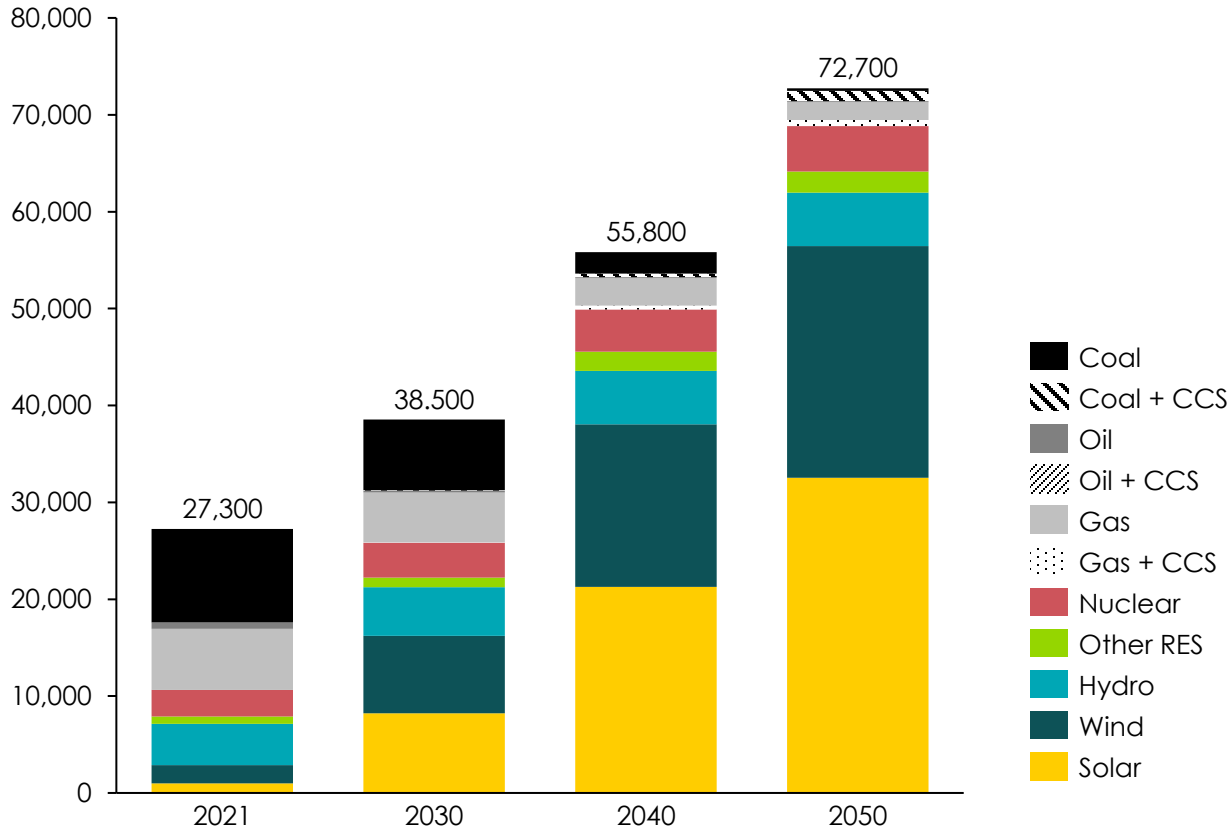
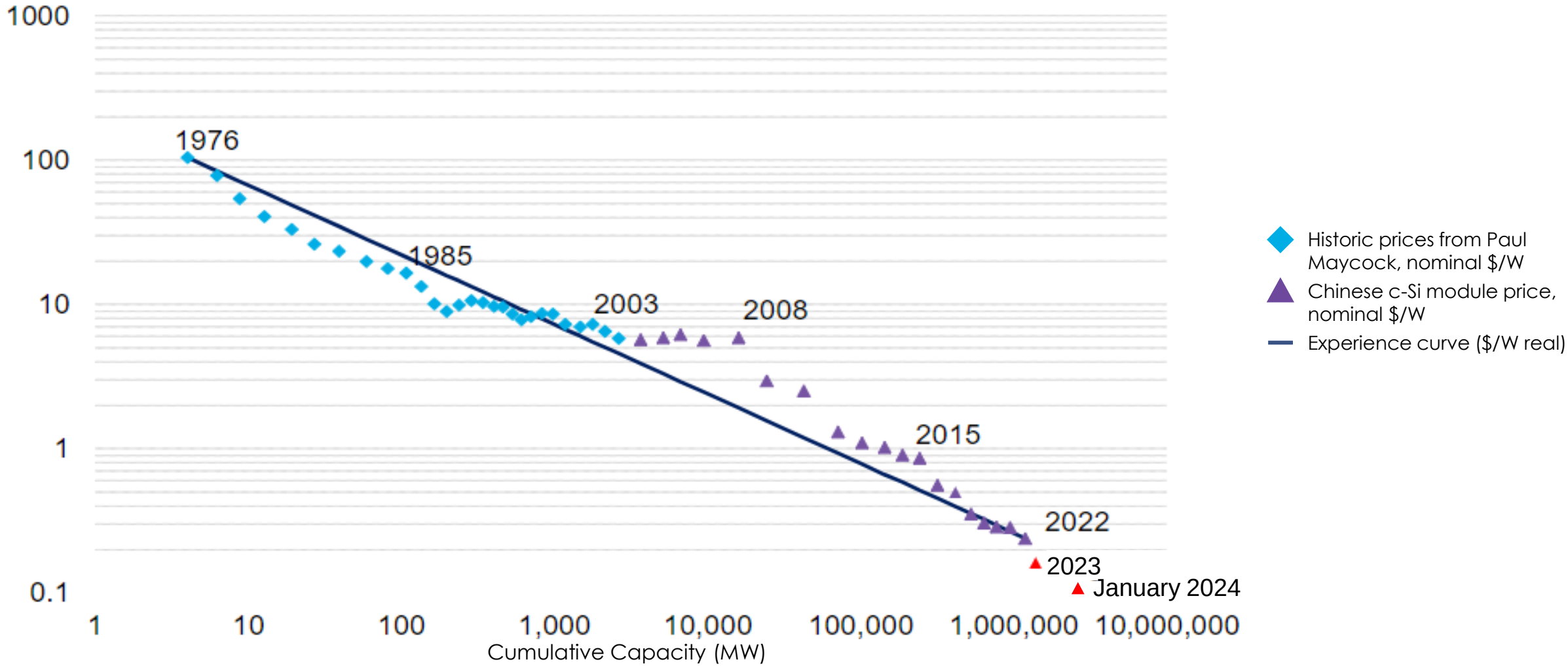


Note: figures include power demand from DACCS from 2030 onwards.
Source: Systemiq analysis for the ETC (2023).

The crystalline silicon PV experience curve

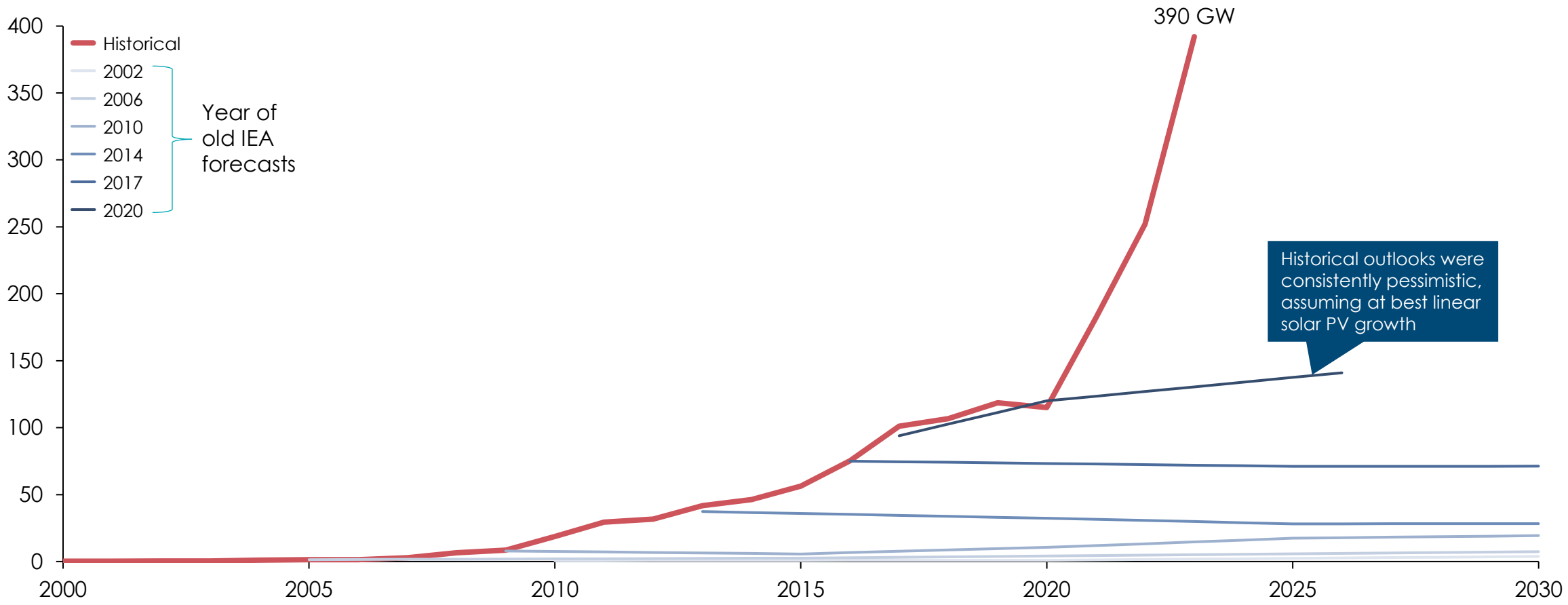
$/W (real 2023)



Past forecasts consistently underestimated solar PV deployment

Annual solar PV installations compared to IEA forecasts

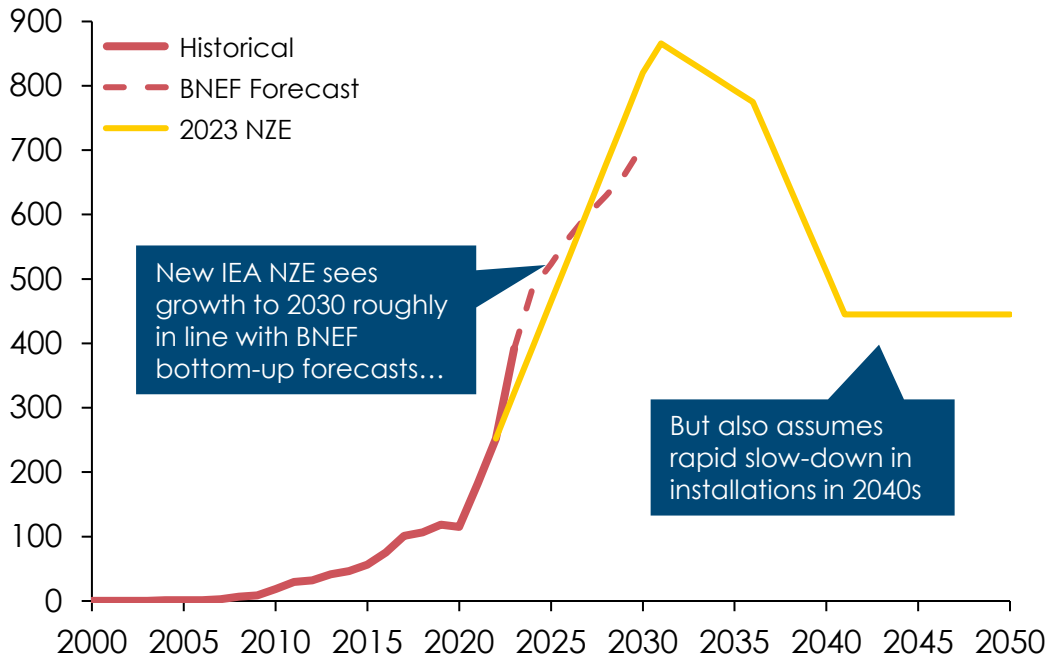
GW



Source: Auke Hoekstra/IEA World Energy Outlooks; Hoekstra et al. (2017), *Creating agent-based energy transition management models…*; BNEF (2023), *Interactive data tool – Global installed capacity*; IEA (2023), *Net zero roadmap – update*.

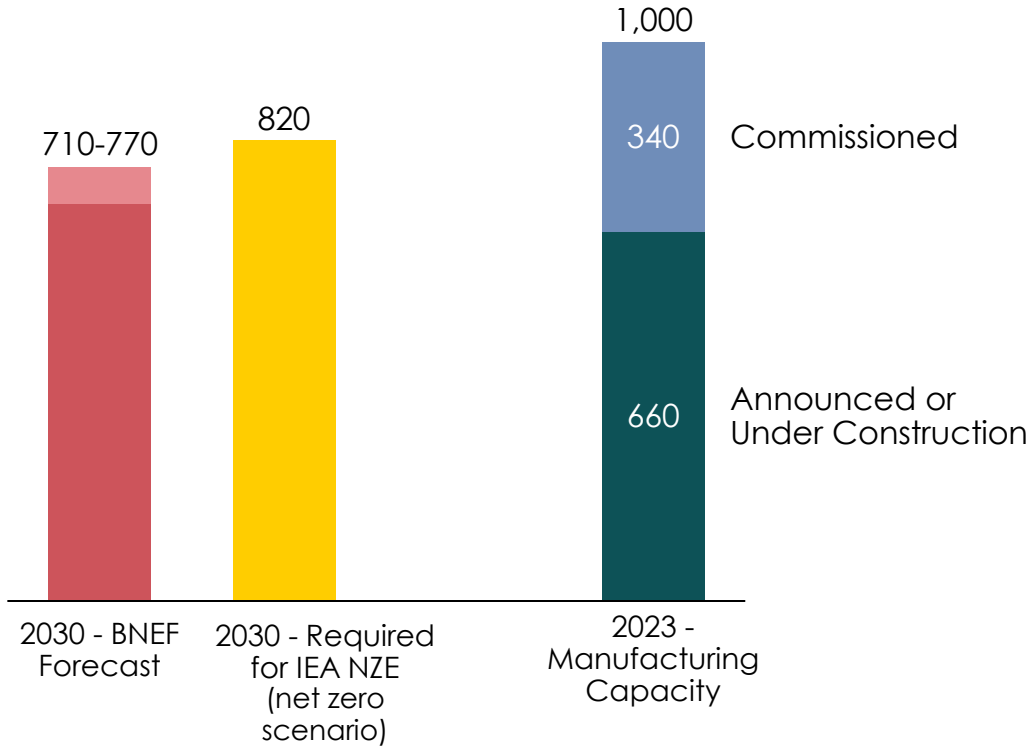
Even the IEA's newest Net Zero scenario assumes a slowdown in solar over the long term

Annual solar PV installations projected BY IEA, GW



Whilst the newest Net Zero scenario anticipates strong acceleration of solar through to 2035, installations then slow down markedly after 2040…

2030 solar PV installations and manufacturing capacity, GW

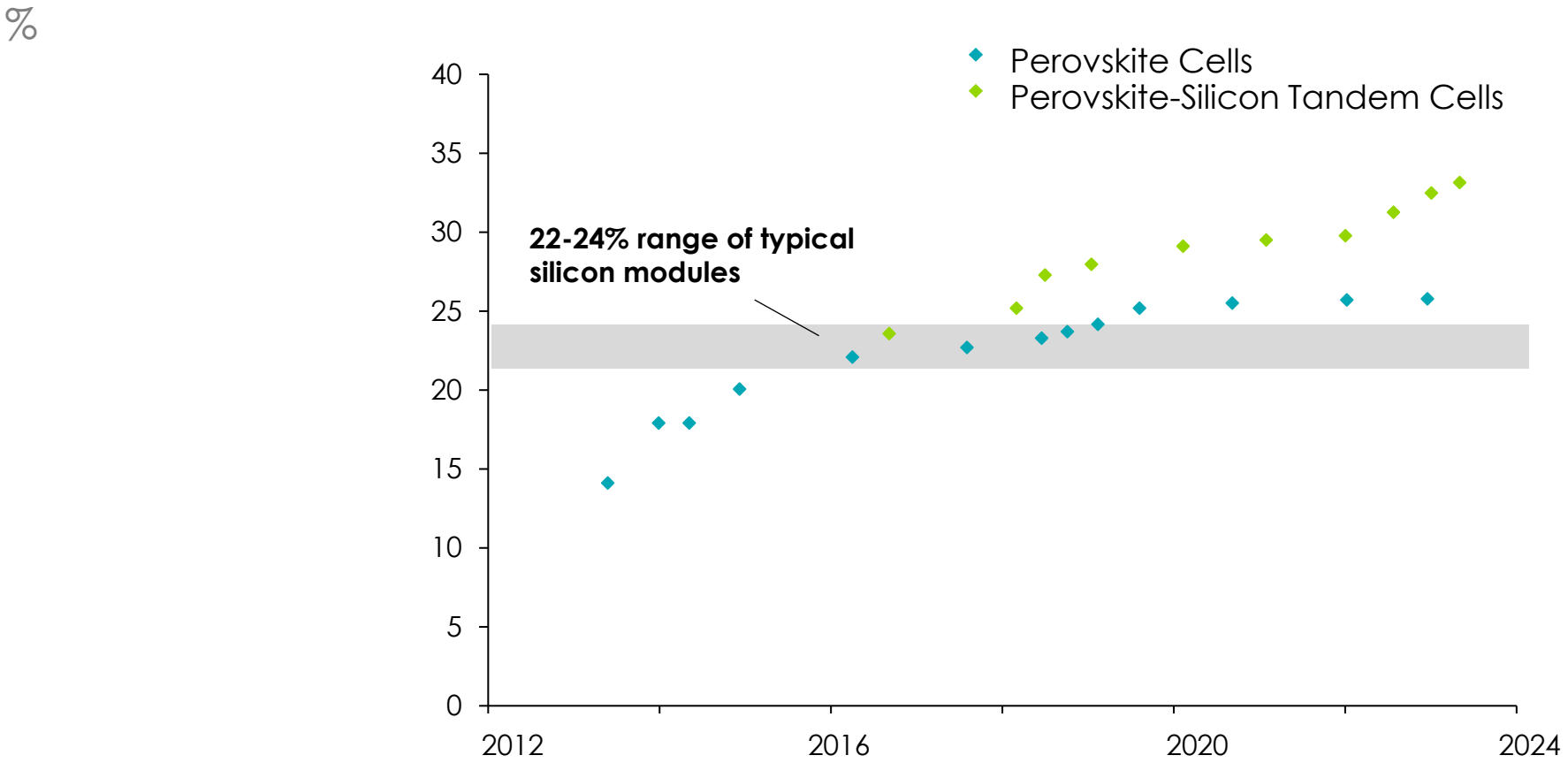


…Even though announced solar manufacturing capacity is on track for 1 TW

Source:Auke Hoekstra/IEA World Energy Outlooks; Hoekstra et al. (2017), *Creating agent-based energy transition management models…*; BNEF (2023), *Interactive data tool – Global installed capacity*; IEA (2023), *Net zero roadmap – update.*

Solar panel 540 Watt on sale in Spain - €99

Solar power conversion efficiency[1]



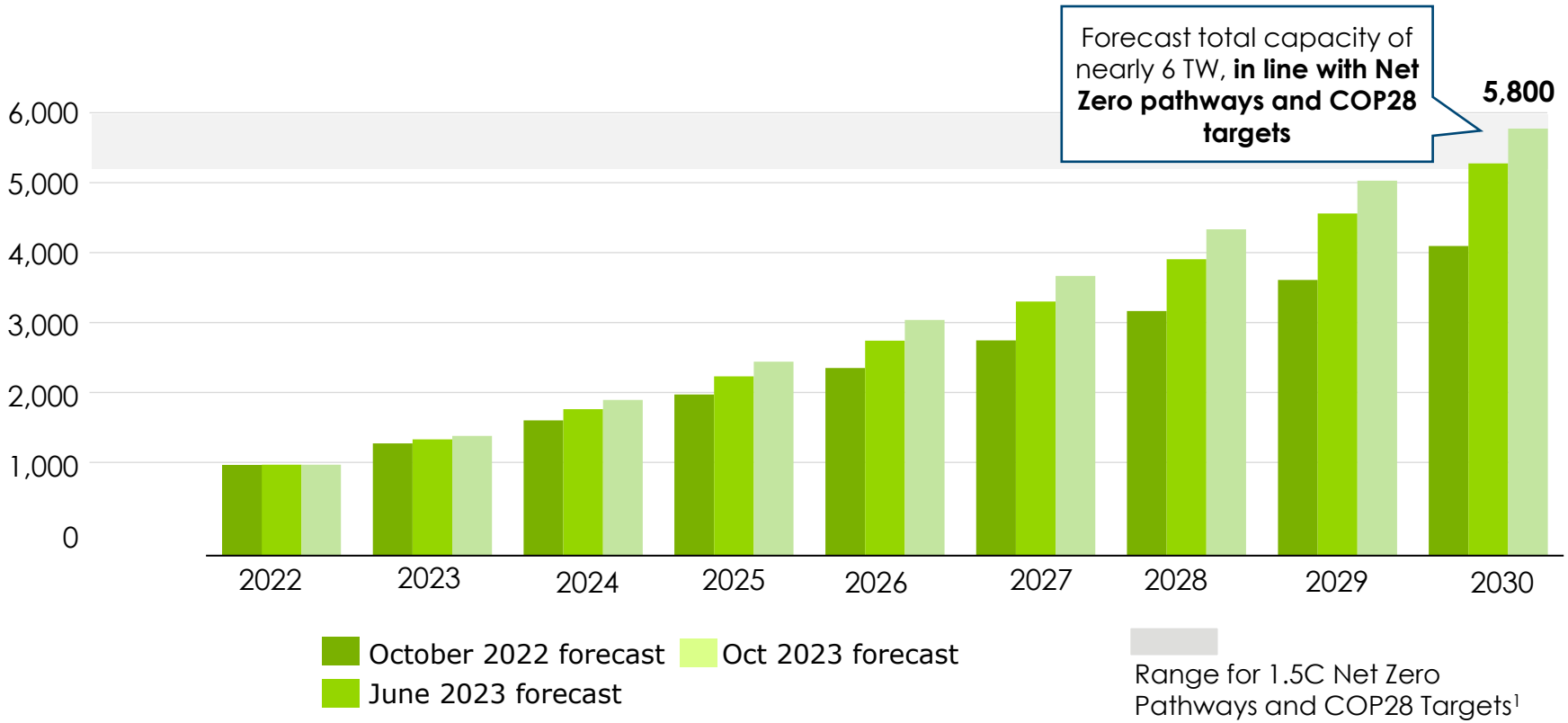
Solar efficiencies keep creeping up; perovskite tandems can help drive progress in late 2020s-30s

Note: [1] Efficiencies for perovskite and perovskite-silicon tandem cells are under research/laboratory conditions. Efficiencies for
Source: BNEF (2023), *3Q Solar PV Global Market Outlook*; Financial Times (2023), *Solar/perovskites: British start-up powers up*; NREL (2023), *Best research-cell efficiency chart*; BNEF (2023), *Long-term electric vehicle outlook*.

Solar projections are in line with ETC required pathways

Recent solar forecasts are now aligned to ETC 2030 milestones

GW total capacity installed



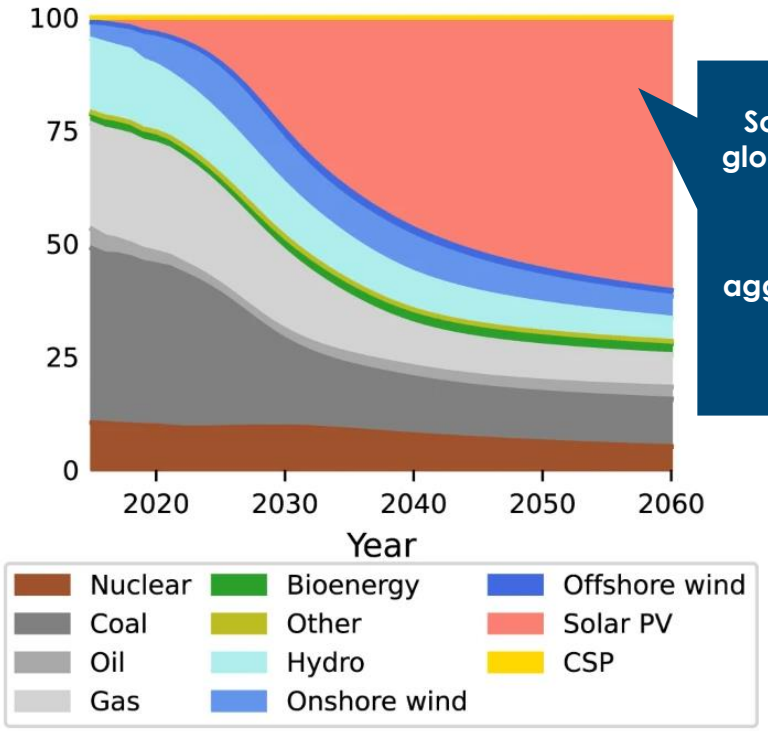
Solar forecasts keep accelerating due to manufacturing capacity buildup and the modularity of panels

Note: [1] The COP28 presidency has a target to treble renewables (incl. solar, wind, hydropower, bioenergy, geothermal) by 2030. This would involve a roughly 5x increase in solar PV and 3x increase in wind from 2022.
Source: Systemiq analysis for the ETC; BNEF (2022/23) *Global Installed Capacity*

New research[1] argues that solar will dominate global power generation

Global share of electricity generation

%

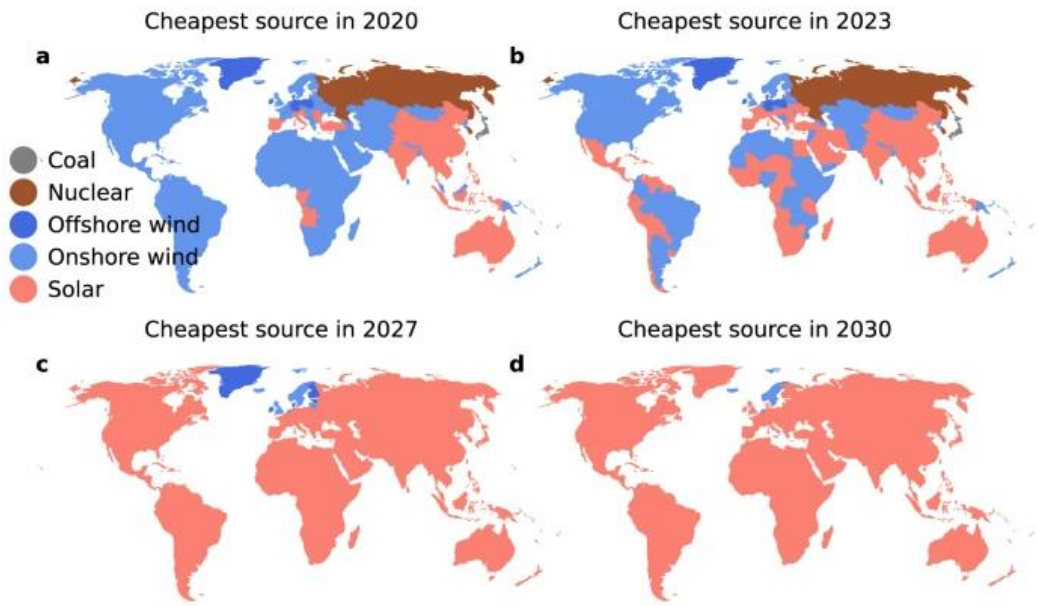


Solar PV ~56% of global generation in 2050[1]

vs 44% in ETC aggressive scenario

Lowest-cost LCOE by region

LCOE includes system and storage costs



Note: [1] Modelling is for a BAU/Baseline-type scenario where technology adoption is driven purely by costs – i.e. this is not for a net-zero or climate-aligned scenario.
Source: Nijsse et al. (2023), *The momentum of the solar energy transition*

Wind power ‘in crisis’?

The offshore wind fiasco takes government self-harm to new heights — The Telegraph

Why EU offshore wind is in trouble — euobserver

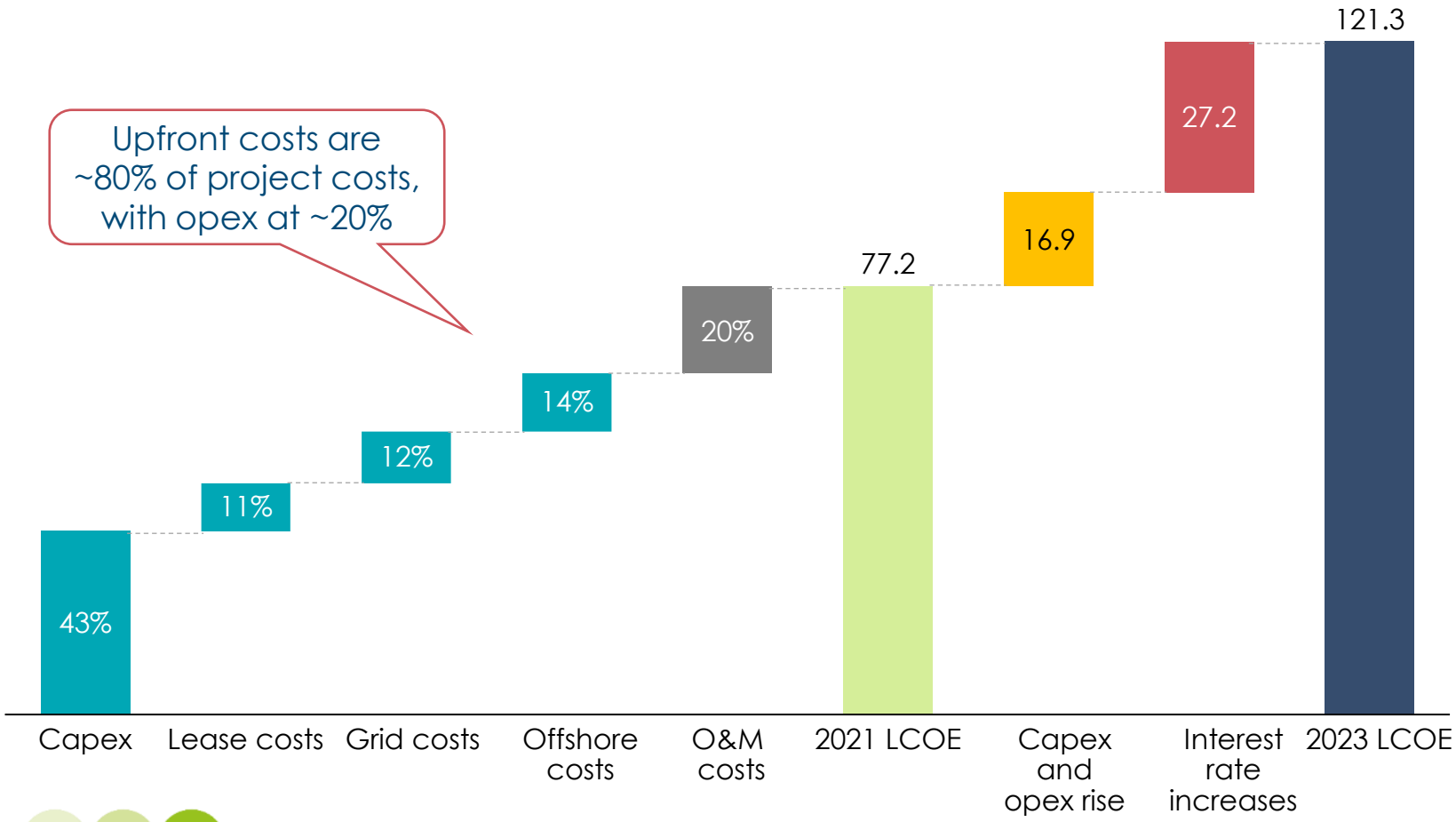
UK offshore wind at ‘tipping point’ as funding crisis threatens industry — The Guardian

World’s Biggest Wind Power Projects Are in Crisis Just When World Needs Them Most — Bloomberg

Offshore Wind Runs Into Rising Costs and Delays — The New York Times

Significant increases in offshore wind costs in US and Europe

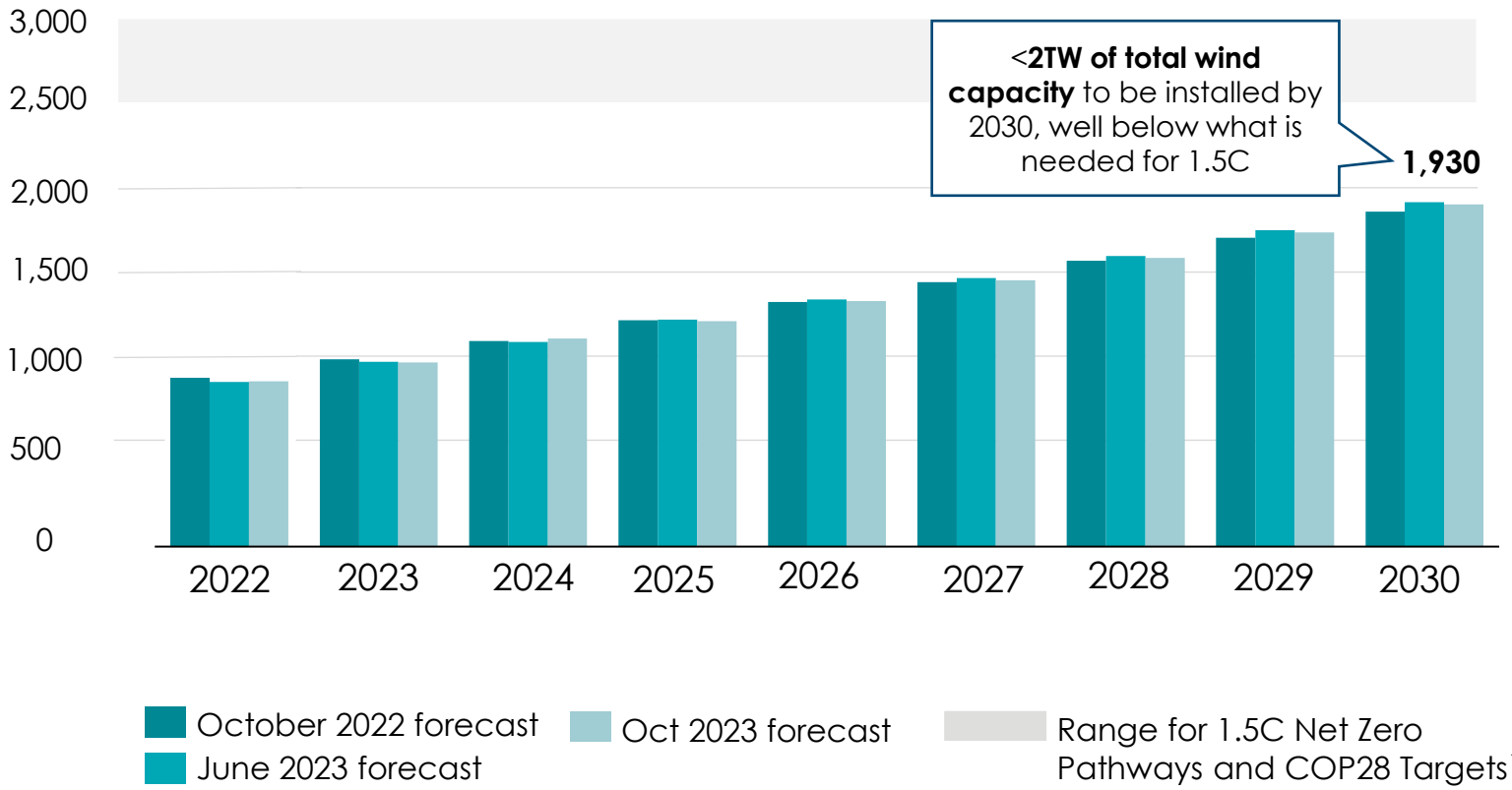
US offshore wind LCOE progression from 2021-2023
$/MWh, 2021 nominal prices



- Rising capex and opex, and interest rate hikes have added **$44/MWh** to US offshore wind LCOE – a **57% increase between 2021 and 2023.**
- **In the UK** ECIU find some developers **costs have increased 40%** since 2022.

Recent wind forecasts fall behind ETC 2030 milestones

GW total capacity installed



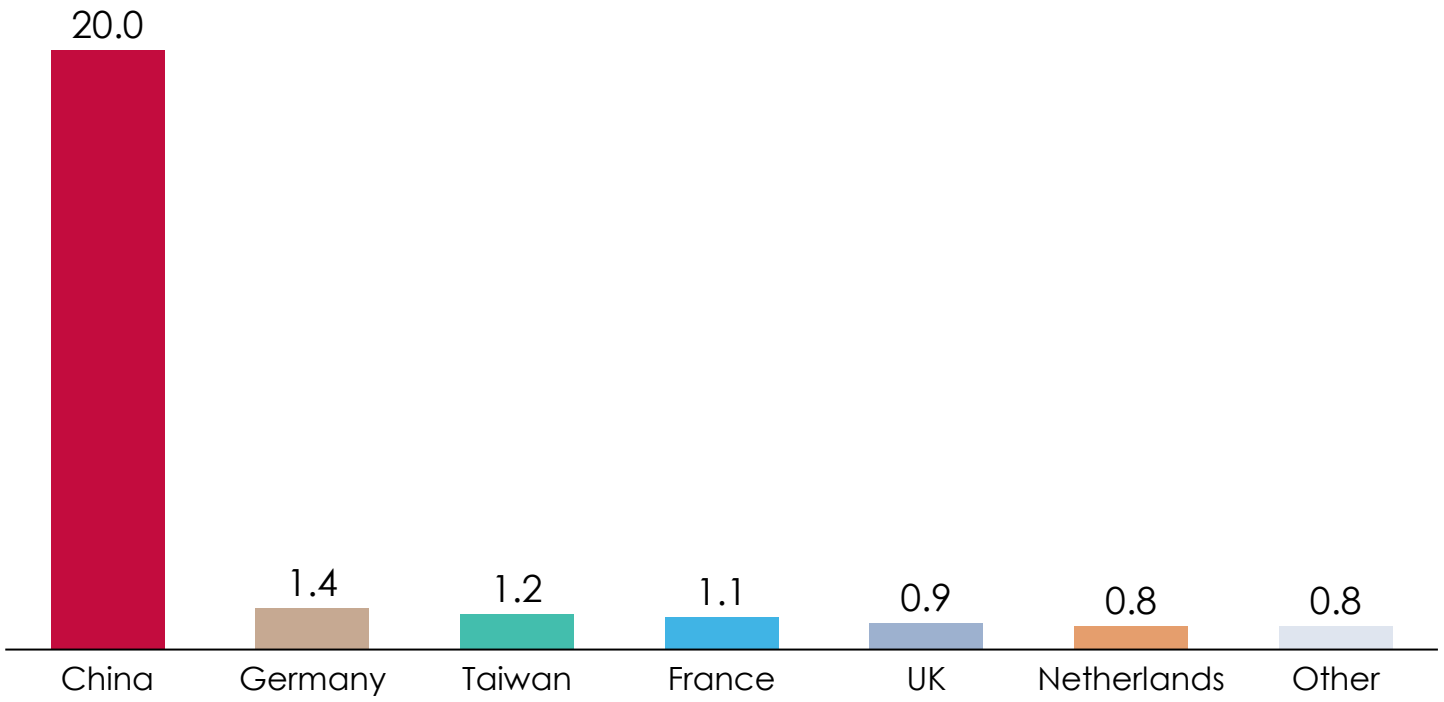
Continued slow growth for wind ex-China, where barriers are higher (e.g. supply chain, land allocation, permitting)

Note: [1] The COP28 presidency has a target to treble renewables (incl. solar, wind, hydropower, bioenergy, geothermal) by 2030. This would involve a roughly 5x increase in solar PV and 3x increase in wind from 2022.
Source: Systemiq analysis for the ETC; BNEF (2022/23) *Global Installed Capacity*

China has pulled ahead of other countries on offshore wind

Offshore wind capacity secured financing 2022-23

GW



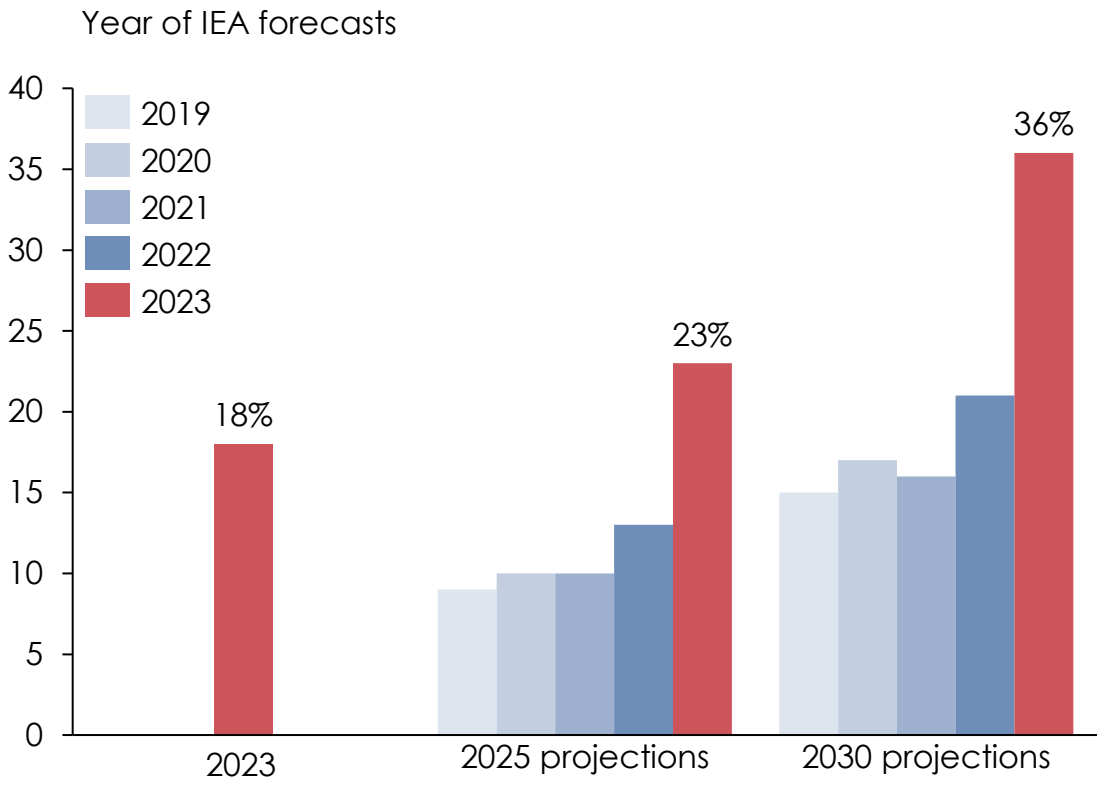
From 2020 to 2023, prices for offshore wind turbines sold in mainland China **dropped more than 40%**, driven by fierce supplier competition

Notes: Other includes Japan, South Korea, US and Vietnam. Charts refers to projects reaching FID
Source: BNEF (2023) Localizing Offshore Wind Supply Chains Threatens Growth

Projected and actual EV sales

EV share of passenger vehicle sales

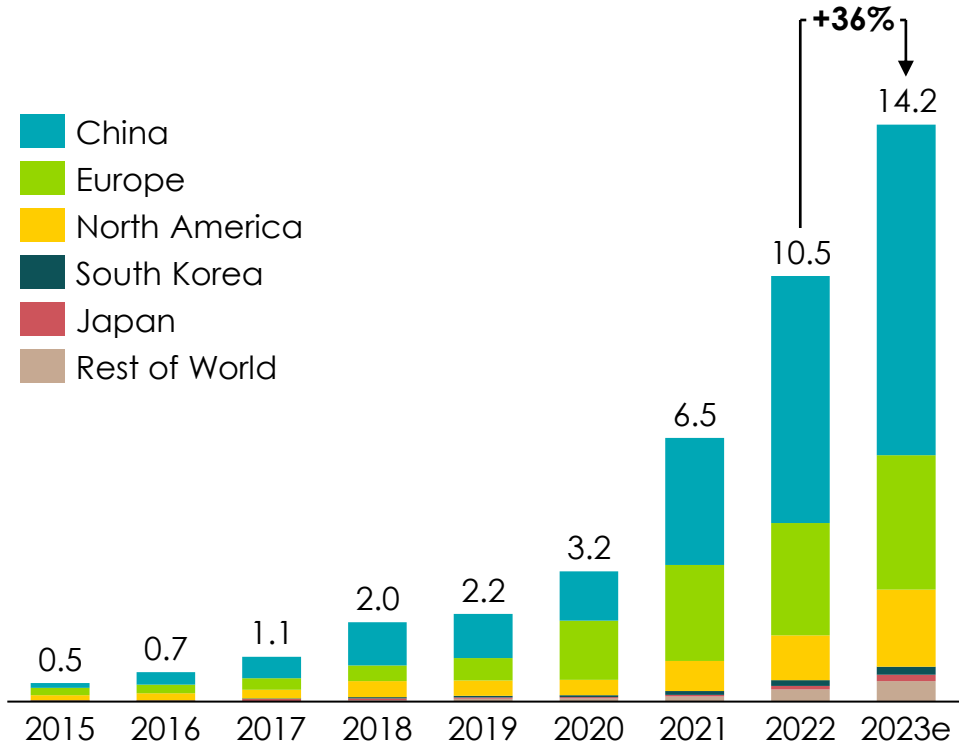
% of total sales



Expectations of EV sales this year are higher than BNEF's projections for 2030 made only two years ago.

Total passenger EV sales

Millions



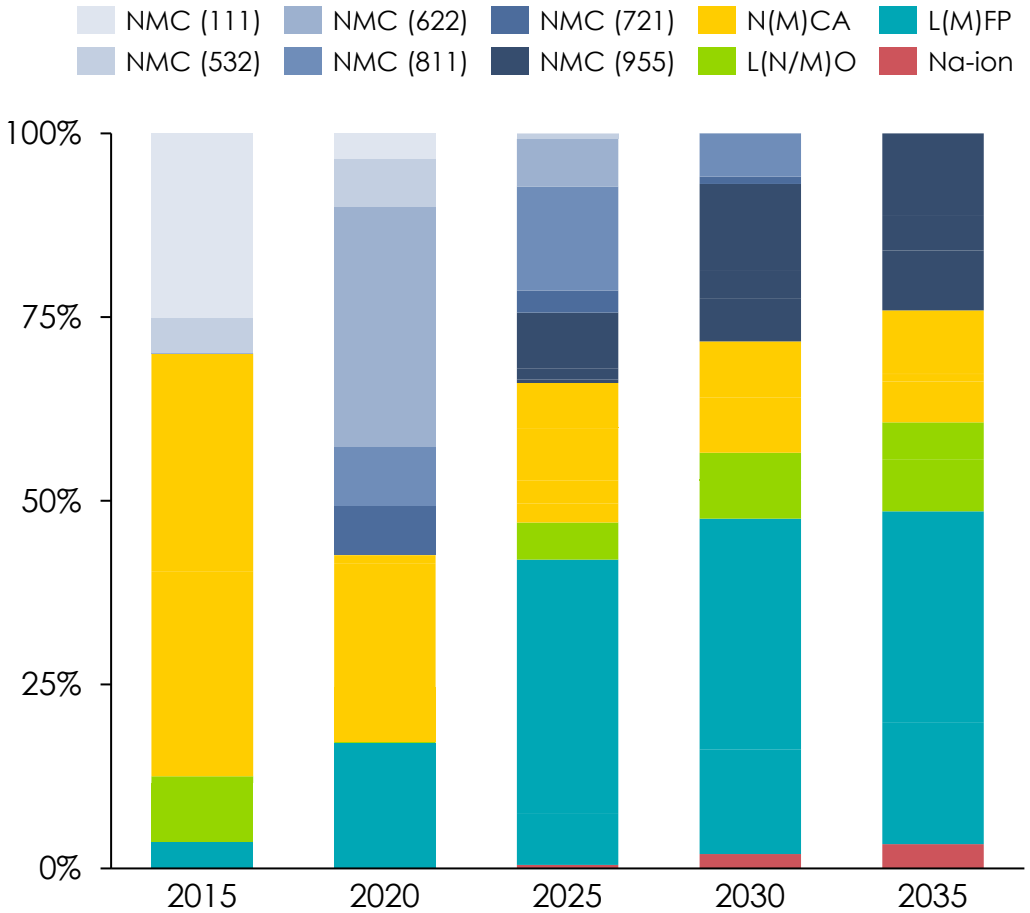
EV sales in China rose 42% YoY in 2Q 2023, driven by strong uptake in cities.

Source:Auke Hoekstra/IEA World Energy Outlooks; Hoekstra et al. (2017), *Creating agent-based energy transition management models…*; BNEF (2023), *Interactive data tool – Global installed capacity*; Hannah Ritchie/IEA Electric Vehicle Outlooks; BNEF (2022), *Long-term electric vehicle outlook*. Bloomberg (2022), *Chinese Oil Giant Brings Forward Its Key Carbon Deadlines*

Battery chemistries have evolved rapidly and will continue to do so

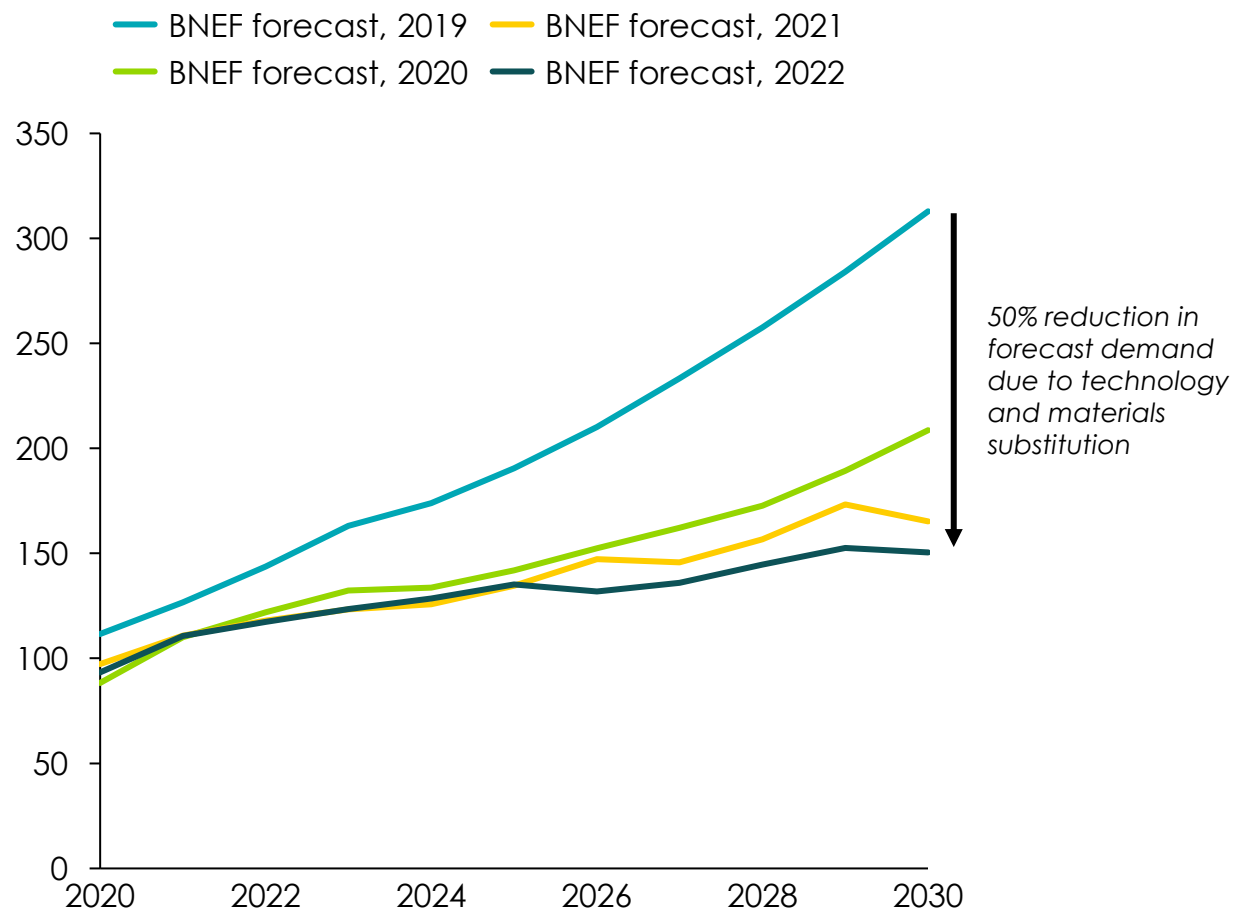
Passenger vehicle battery market share

%



Projected future cobalt demand

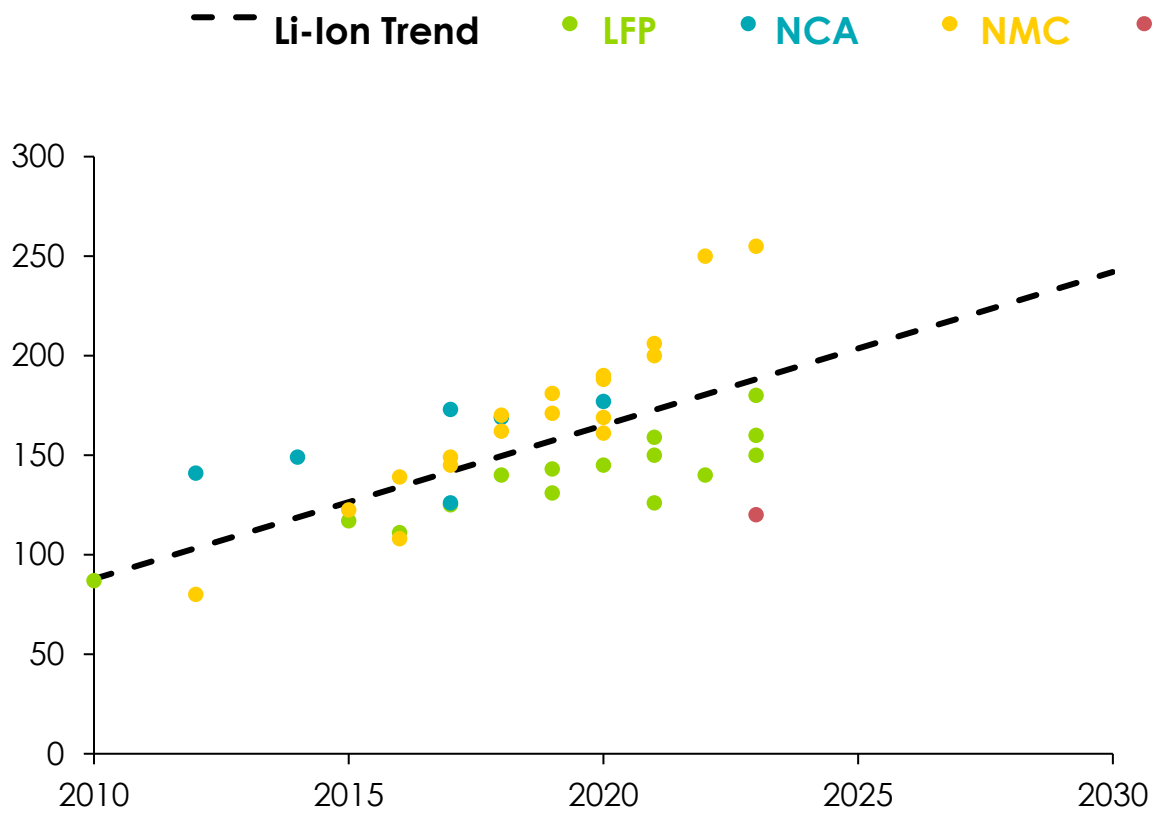
Thousand metric tonnes



Source: BNEF (2023), *Long-term electric vehicle* outlook; BNEF (2022), *Long-term electric vehicle outlook*

Battery energy density

Wh/kg



Battery energy density keeps going up; low-cost LFP/Na-ion options for storage

Note: [1] Efficiencies for perovskite and perovskite-silicon tandem cells are under research/laboratory conditions. Efficiencies for
Source: BNEF (2023), *3Q Solar PV Global Market Outlook*; Financial Times (2023), *Solar/perovskites: British start-up powers up*; NREL (2023), *Best research-cell efficiency chart*; BNEF (2023), *Long-term electric vehicle outlook*.

this cutting-edge technology breaks the limits that have long restricted the development of the battery sector and will open up a new scenario of electrification

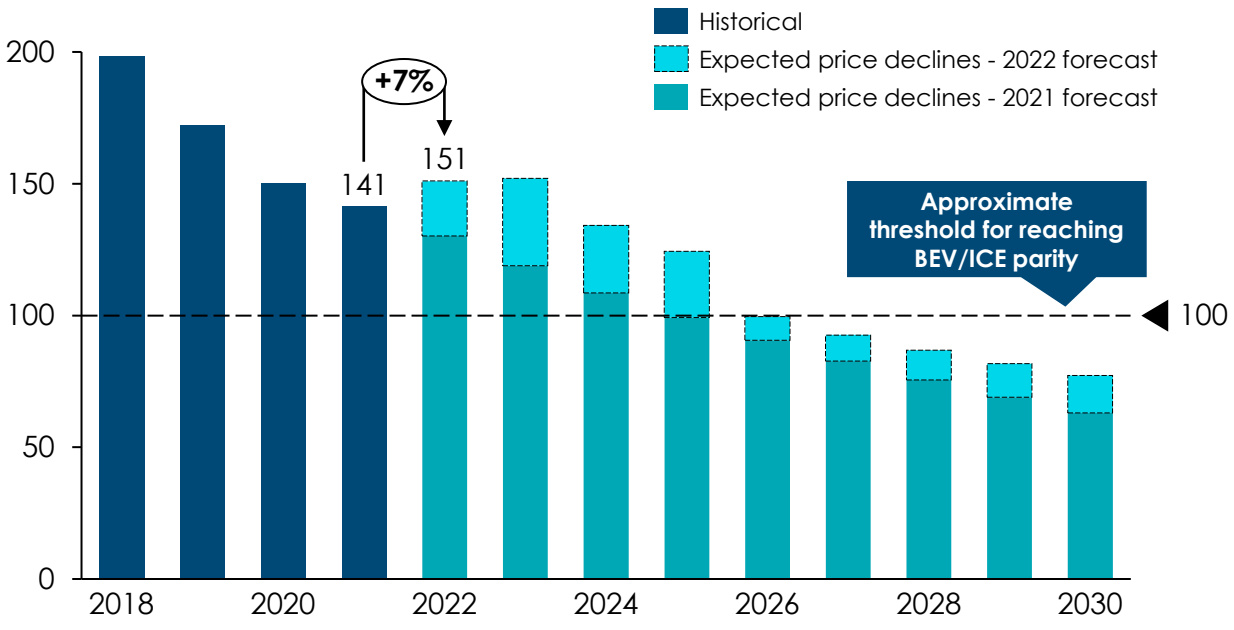
… CATL is cooperating with partners in the development of electric passenger aircrafts

… we will also launch the automotive-grade version of condensed batteries, into mass production within this year.

Temporary rise in battery costs, but long-term trend still down

Global weighted-average Li-ion battery pack price

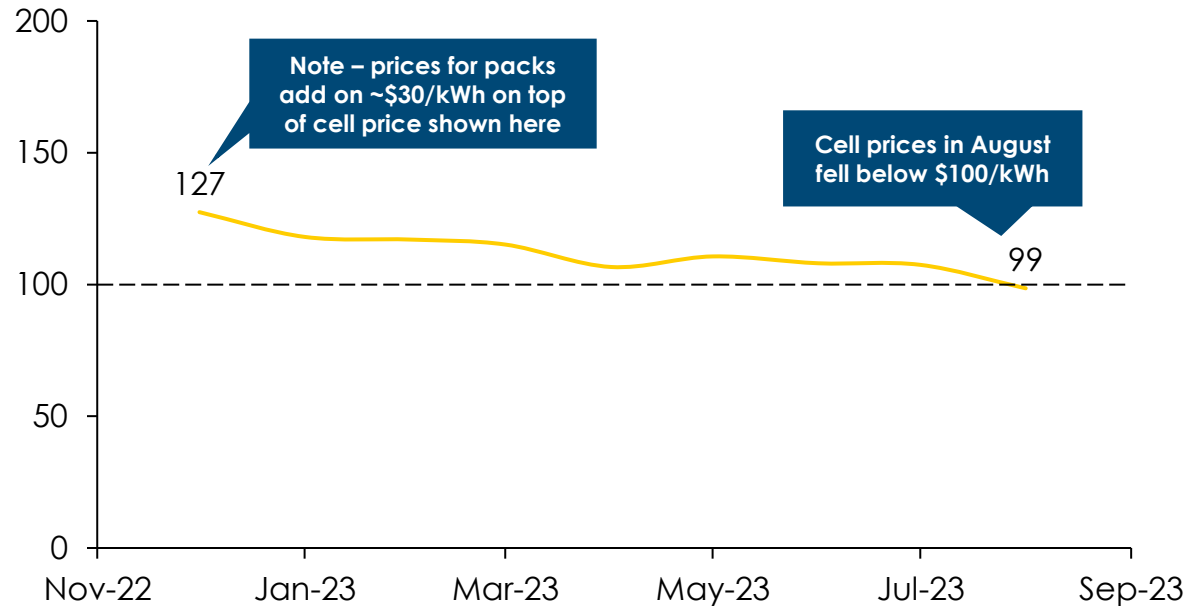
USD/kWh; 2022 nominal



Battery prices rose in 2021-22, raising concerns around long-term cost declines for batteries and Evs…

Global weighted-average Li-ion battery cell price

USD/kWh; 2022 nominal

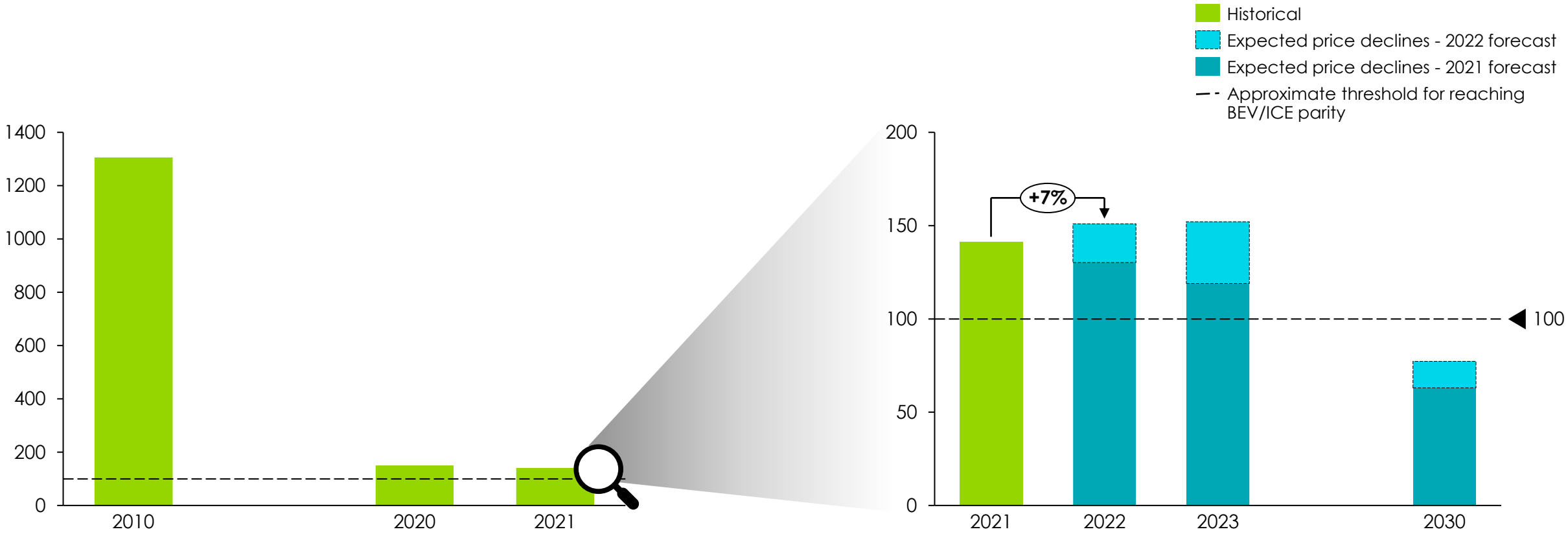


But short-term analysts reckon prices have fallen consistently through 2023, highlighting short-term nature of disruptions

BNEF (2023), *Long-term electric vehicle outlook*; BNEF (2022), *Lithium-ion battery price survey*; Benchmark Mineral Intelligence (2023), *Lithium ion battery cell price assessment*.

Battery costs – past and projected

USD/kWh; 2022 nominal

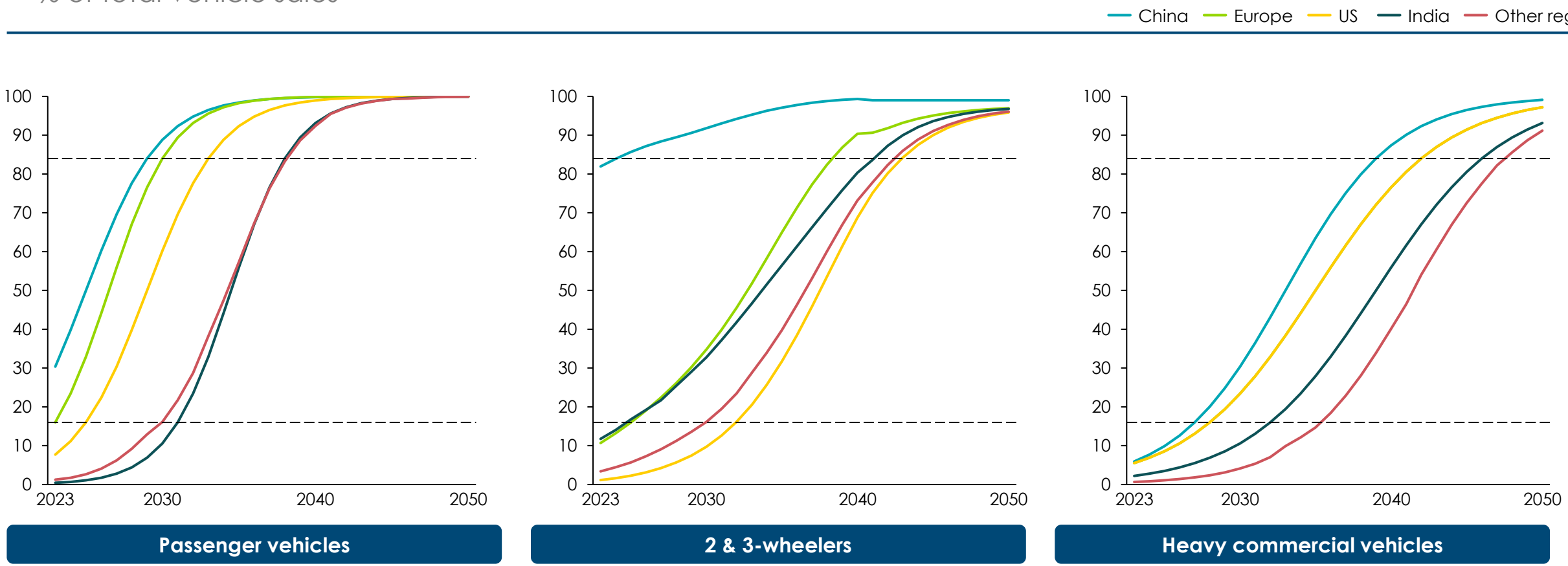


Source: Systemiq analysis for the ETC; BNEF (2023), Long-term electric vehicle outlook; BNEF (2022), Long-term electric vehicle outlook; ETC (2023); Better, faster, cleaner: Securing clean energy technology supply chains; BNEF (2023), Interactive data tool – battery manufacturing


ELECTRIC
ECW 27G

Share of electric vehicles as a function of total sales in ETC's accelerated scenario

% of total vehicle sales

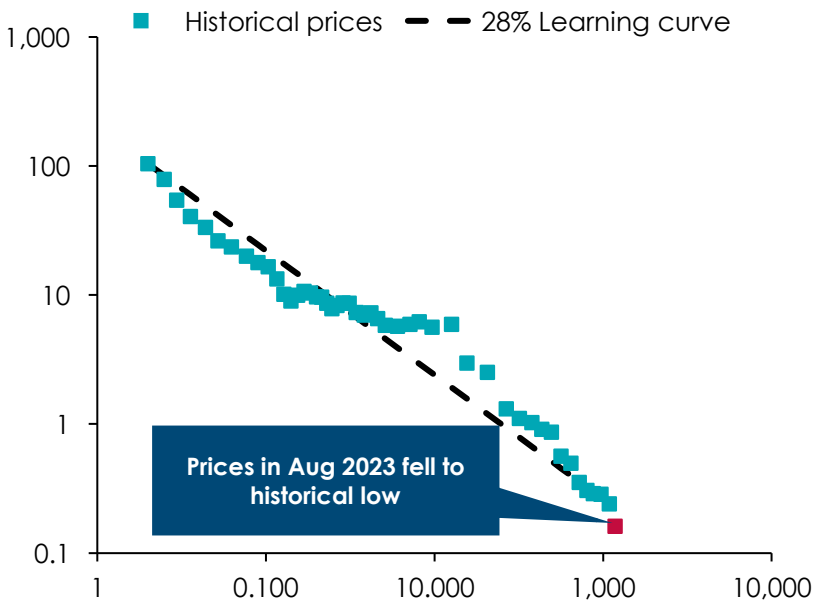


Note: Electric vehicle include both battery electric and fuel-cell vehicles for heavy commercial vehicles. S-curve methodology is based on Rogers' innovation diffusion theory (1962). Dotted lines represent the maximum growth and inflection points, respectively equivalent to 16 and 84% of sales. These points are defined as points on the curve in which the concavity changes. Growth and inflection point are calculated based on BNEF 2023 Electric Vehicle Outlook.
Source: Systemiq analysis for the ETC (2023); BNEF (2023), *Electric Vehicle Outlook,* MPP (2022), *Making Zero-Emissions Trucking Possible.*

Are we still underestimating technology growth for solar and batteries, and therefore role of solar + batteries?

Solar PV cost curve

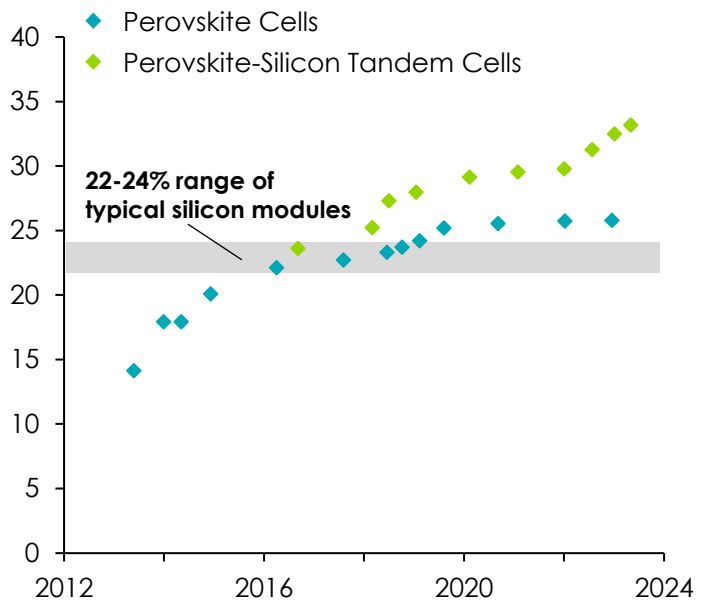
US$/W, 2023 real (Y-axis); GW (X-axis)



Solar module prices are back on long-term trend and keep falling

Solar power conversion efficiency[1]

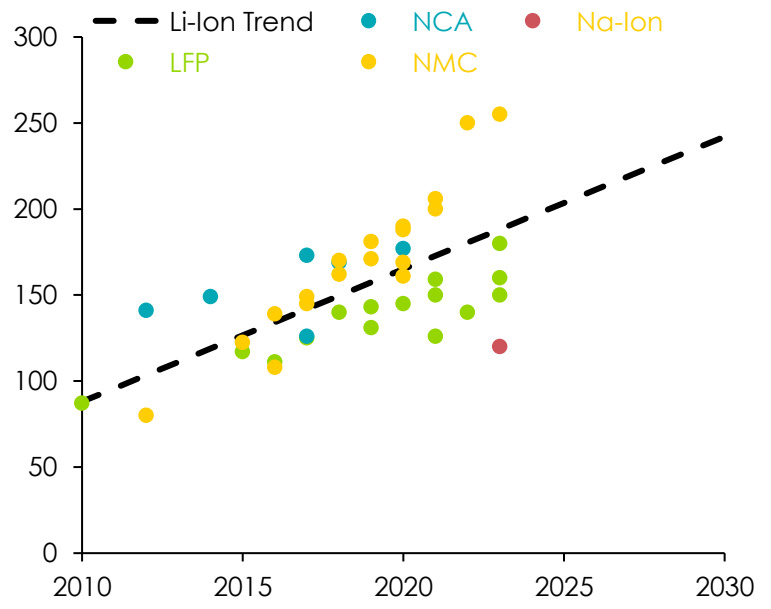
%



Solar efficiencies keep creeping up; perovskite tandems can help drive progress in late 2020s-30s

Battery energy density

Wh/kg



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Note: [1] Efficiencies for perovskite and perovskite-silicon tandem cells are under research/laboratory conditions. Efficiencies for

Source: BNEF (2023), *3Q Solar PV Global Market Outlook*; Financial Times (2023), *Solar/perovskites: British start-up powers up*; NREL (2023), *Best research-cell efficiency chart*; BNEF (2023), *Long-term electric vehicle outlook*.

The vehicle battery capacity and vehicle to grid opportunity

Global 2050 EV fleet battery capacity

1.5bn vehicles x 60kwh = 90 twh capacity

Global 2050 electricity consumption

~70000twh per annum
~ 190 twh per day

11 hours of storage capacity available per day as free by product

Huge long-term opportunity for digitally enabled demand management and VtoG

Key questions:

- How soon and where?
- With what business model?
- Who has competitive advantage?

The balance / storage challenge and opportunity

Undoubted trend

Solar (in particular) and wind becomes lowest LCOE in almost all locations

Key challenge- balancing variable demand and intermittent supply

Lithium/sodium-ion batteries - diurnal balance

Flow batteries
Compressed air
Liquid air
Pumped storage
Other gravity based
Heat storage at end use

Multi hour to several day balance

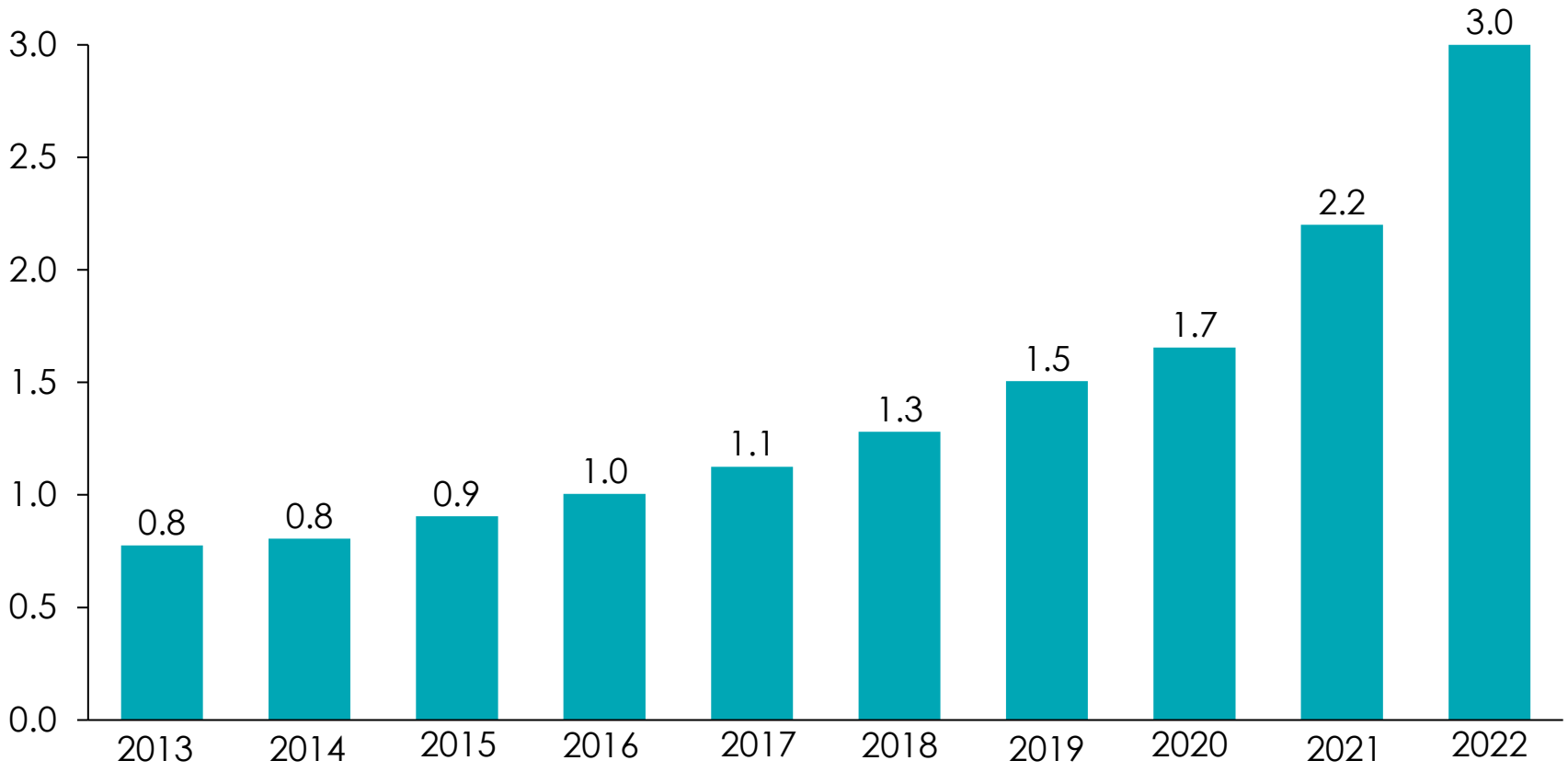
H2 or gas+CCS in CCGTs - seasonal balance

Digitally enabled integration and demand management

Heat pump sales are soaring and will continue

Annual heat pump sales in Europe

Million units



Total number of gas and oil boilers in EU + UK
↓ ~ 120m

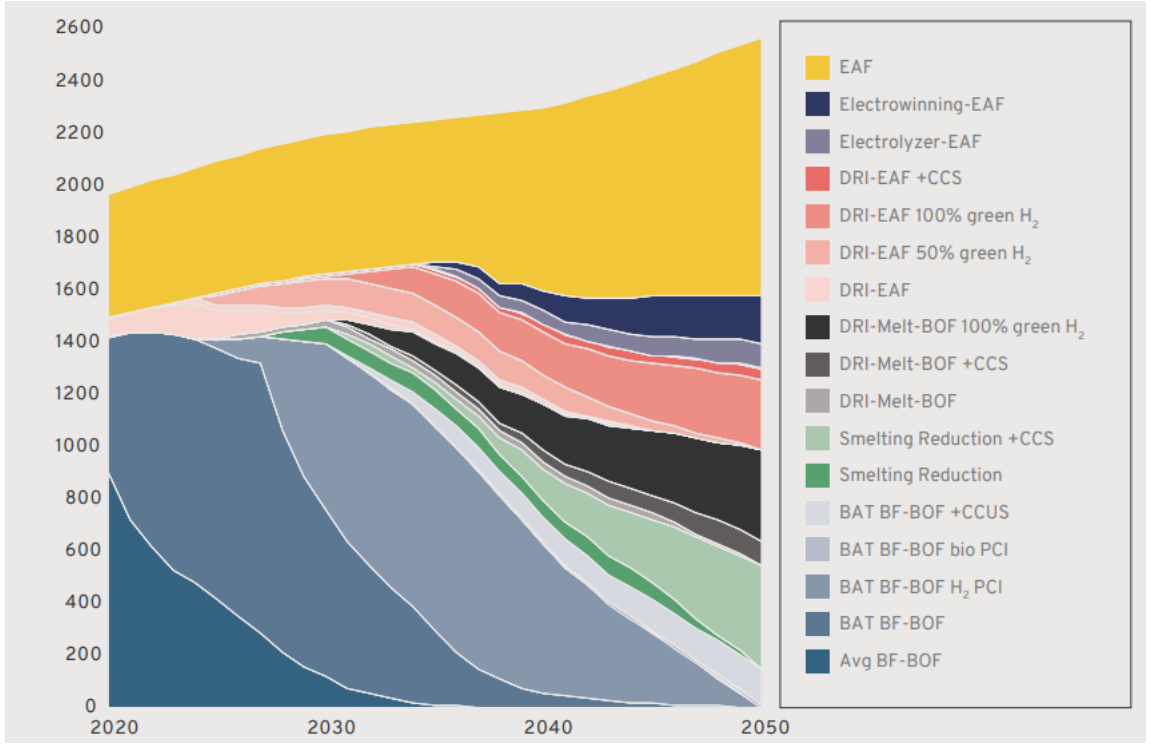
Bidirectional aircon/heat-pumps to become dominant heating source in locations that have large cooling needs

Source: Carbon Brief (2023), *Guest post: How the energy crisis is boosting heat pumps in Europe*

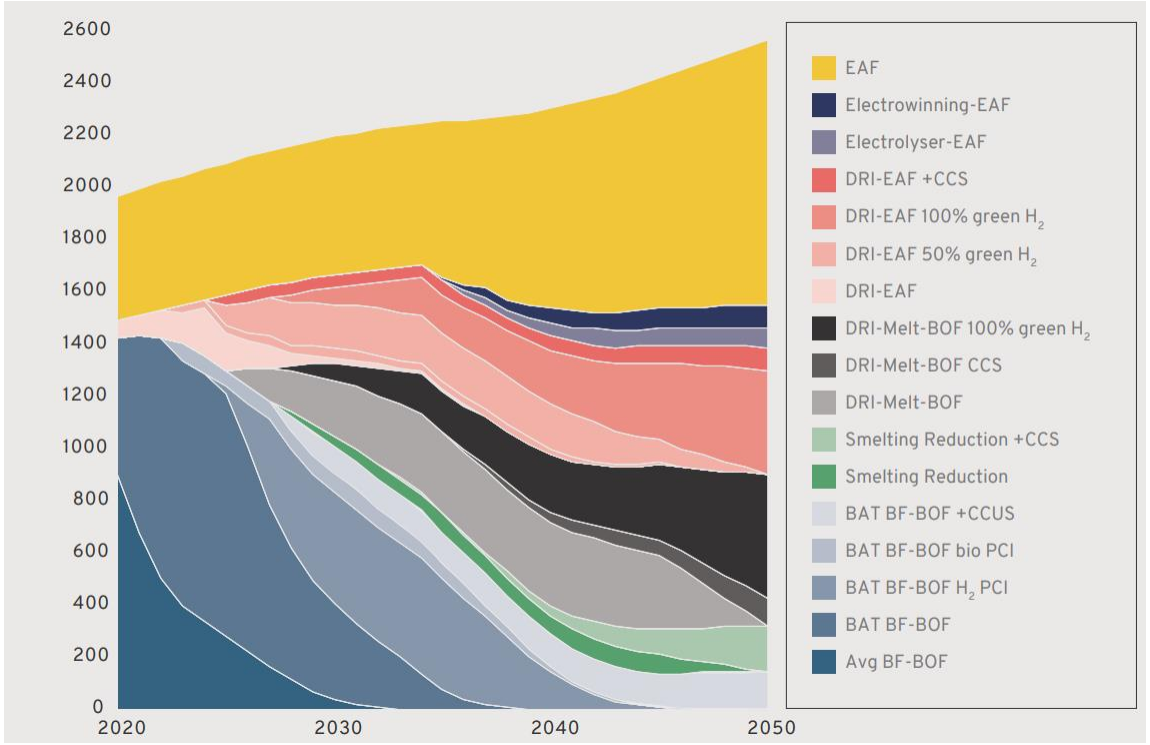
Steel production by technology: decarbonization scenarios

million metric tonnes

Technology Moratorium Scenario



Carbon Cost Scenario

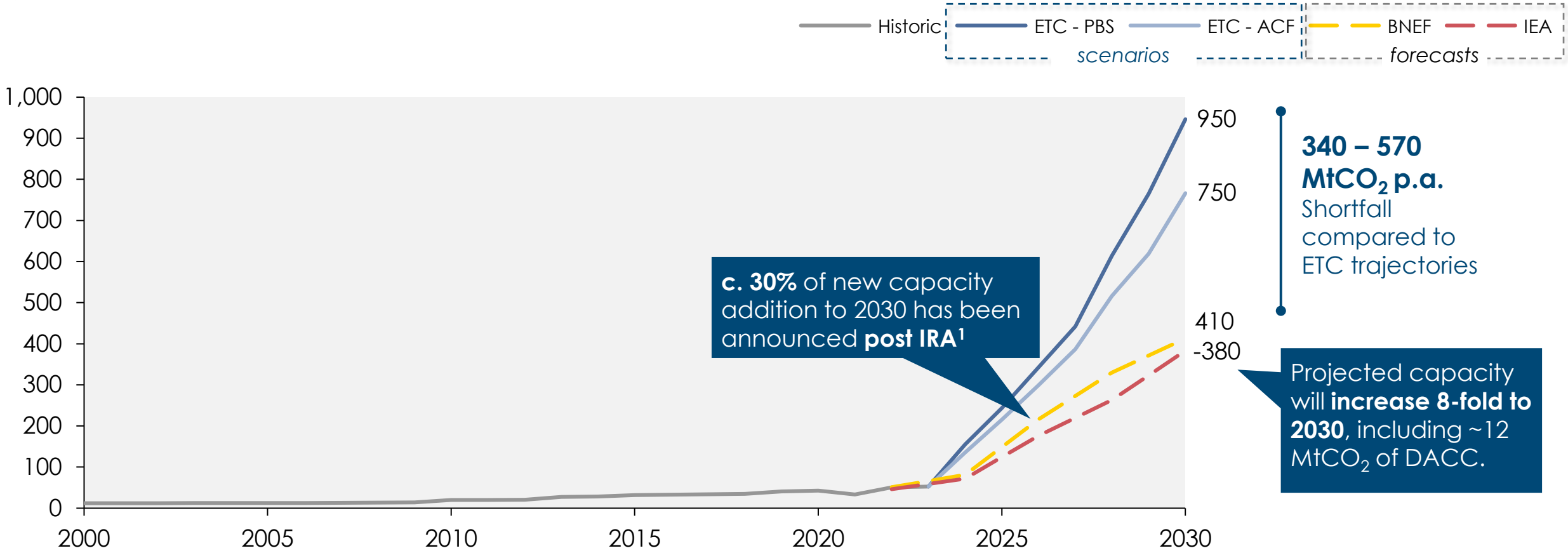


Sources – Mission Possible Partnership (2022), *Making net-zero steel possible.*

Projected CCUS capacity to 2030 includes ~8x growth from current levels, but falls short of what is required for ETC's new pathways

Total Carbon Capture Utilisation and Storage (CCUS) capacity to 2030

$MtCO_2$ p.a.

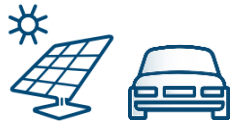


Note: [1] IRA = Inflation Reduction Act. The values presented here based on BNEF/IEA include direct air carbon capture (DACC) projects, but the volumes by 2030 are expected to be very low, 10-15 $MtCO_2$ p.a. of capacity. Values are rounded.
Source: Systemiq analysis for the ETC; BNEF (2023) *CCUS Projects Database;* IEA (2023), *IEA, Capacity of current and planned large-scale CO2 capture projects vs. the Net Zero Scenario, 2020-2030,* BCG (2023), *Impact of IRA, IIJA, CHIPS, and Energy Act of 2020 on Clean Technologies*

The technologies which are deploying fastest are those most susceptible to mass production and easy deployment

Fastest progress

Slower progress

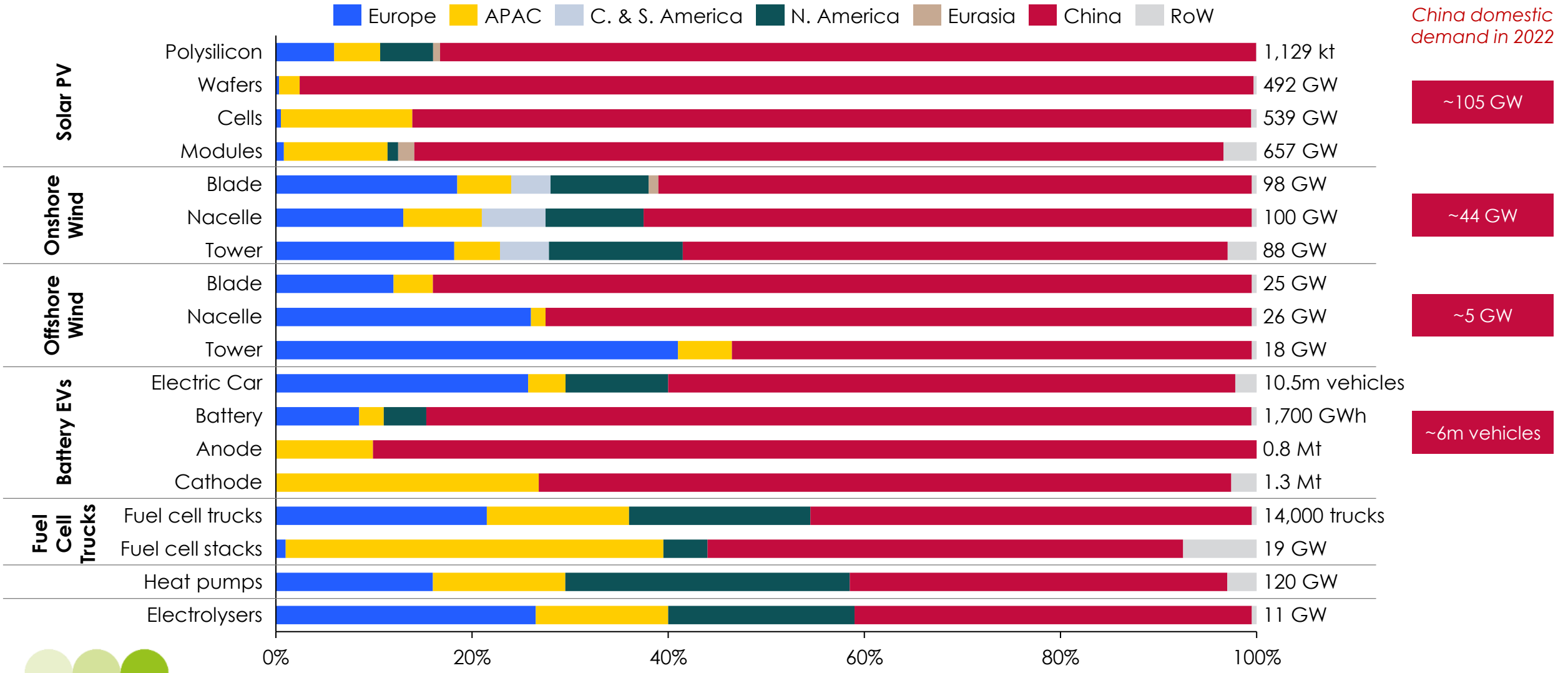
Solar PV, EVs and batteries		▪ Mass produced in large-scale, replicable factories ▪ Easily transported ▪ Easily deployed / installed
Heat pumps		▪ Mass produced in large factories ▪ Easily transported ▪ Complex installation
Wind		▪ Turbines supply chains very complex; scale of production is orders of magnitude smaller than PV/batteries ▪ Higher degree of customisation for projects ▪ Transport and installation more complex
Electrolyser and green H_2		▪ Can be mass produced, but balance of system costs and specific project complexities important
CCUS		▪ Customised engineering design and deployment
Large scale nuclear		▪ Hugely complex large-scale systems

Key issue: opportunity for standardised and/or smaller scale units?

- *Standardised CCUS units?*
- *Small modular nuclear?*

Share of global manufacturing capacity for clean energy technologies, 2021/22

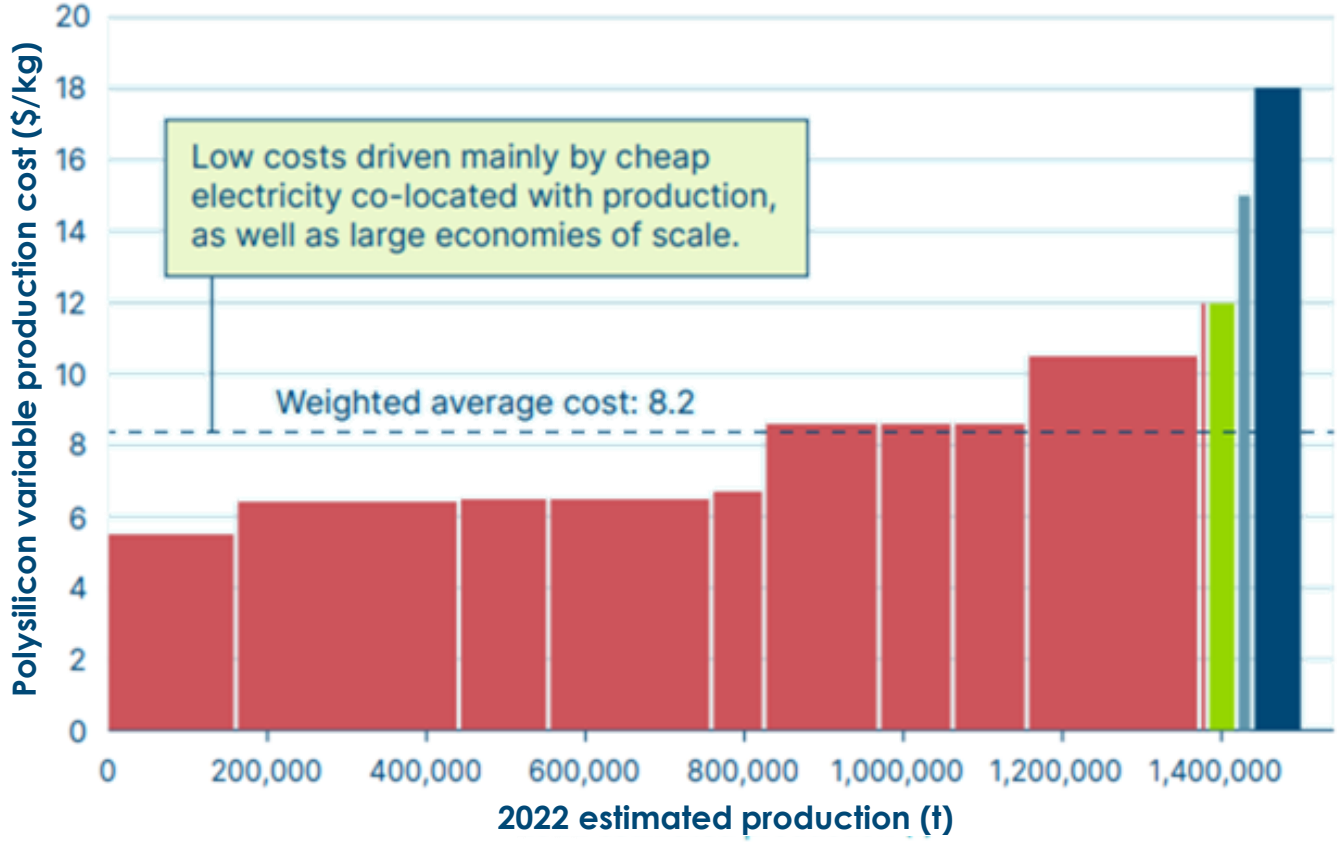
%



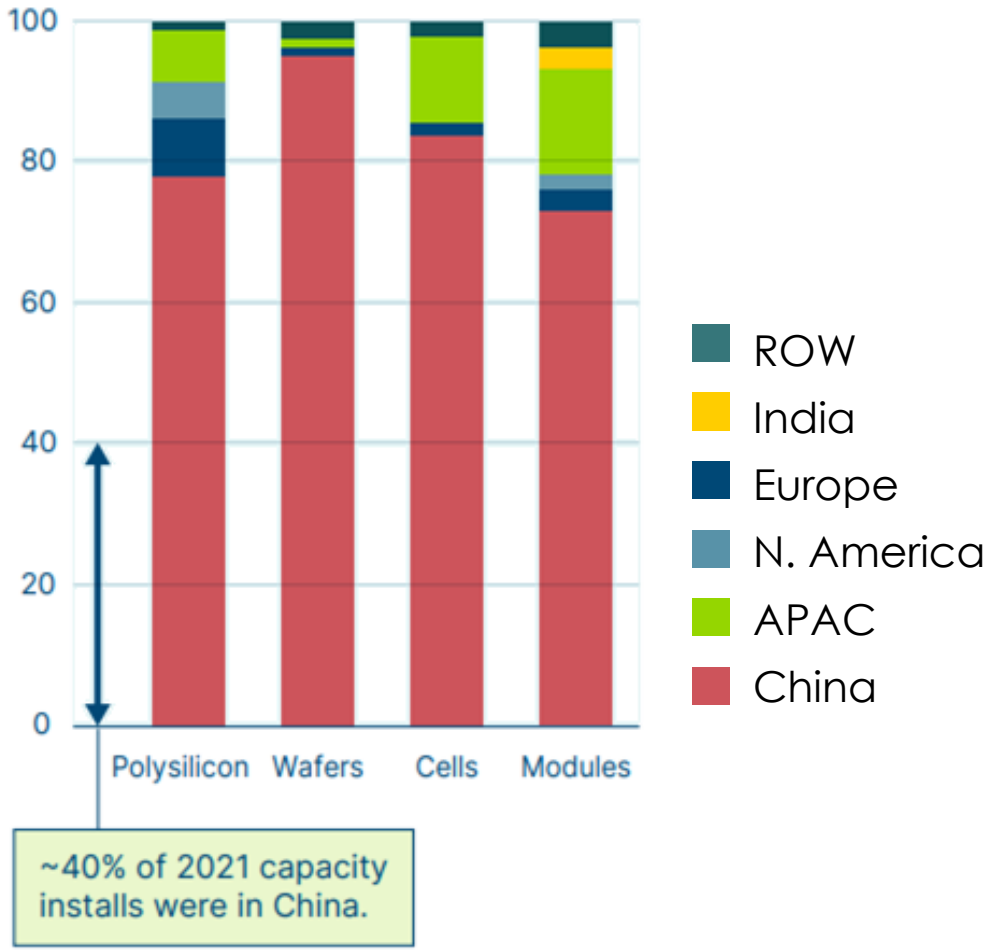
Source: IEA (2023), *Energy technology perspectives*; BNEF (2023), *Interactive data tool*; BNEF (2022), *Localizing clean energy supply chains comes at a cost*

Solar PV costs and resulting concentration

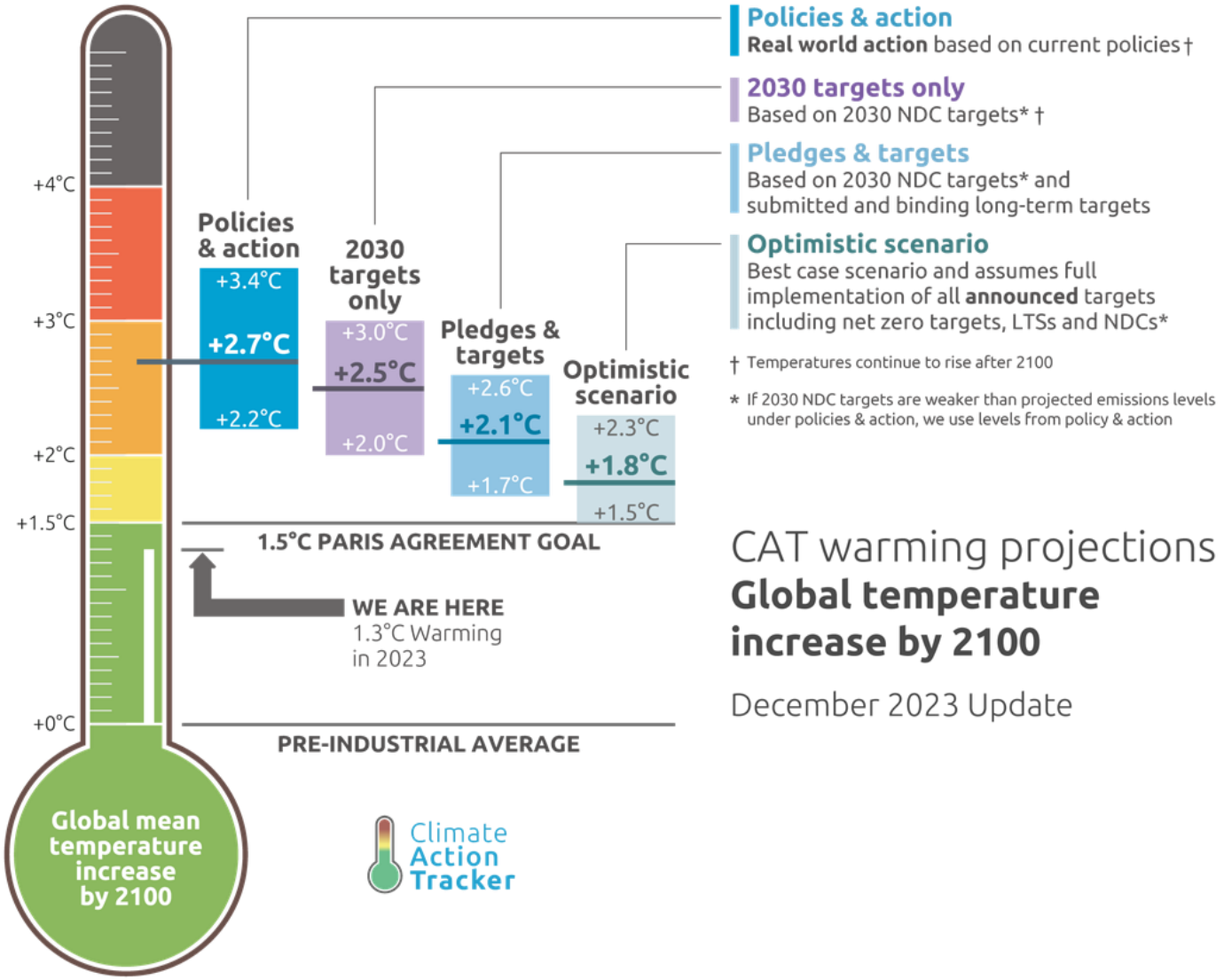
Polysilicon cost curve



PV supply chain concentration, 2021 %



Current policies would put us on track for 2.7°C, and NDCs would only bring this down to 2.5°C



Source: Climate Action Tracker (2023), *Climate Target Update Tracker.*

The COP 28 text: "*transitioning away from fossil fuels to achieve net zero by 2050*"

5th December, 05:00

Calls upon Parties to take further action in this critical decade towards:

...

(c)

Option 1: An orderly and just phase out of fossil fuels;

Option 2: Accelerating efforts towards phasing out unabated fossil fuels and to rapidly reducing their use so as to achieve net-zero CO2 in energy systems by or around mid-century;

Option 3: no text

8th December, 15:30

Calls upon Parties to take further action in this critical decade towards:

...

(c)

Option 1: A phase out of fossil fuels in line with best available science;

Option 2: Phasing out of fossil fuels in line with best available science, the IPCC's 1.5 pathways and the principles and provisions of the Paris Agreement;

Option 3: A phase-out of unabated fossil fuels recognizing the need for a peak in their consumption in this decade and underlining the importance for the energy sector to be predominantly free of fossil fuels well ahead of 2050;

Option 4: Phasing out unabated fossil fuels and to rapidly reducing their use so as to achieve net-zero CO2 in energy systems by or around mid-century;

Option 4: no text

11th December, 16:30

Also recognizes the need for deep, rapid and sustained reductions in GHG emissions and calls upon Parties to take actions that could include, inter alia:

...

(d) Accelerating zero and low emissions technologies, including, *inter alia*, renewables, nuclear, abatement and removal technologies, including such as carbon capture and utilization and storage, and low carbon hydrogen production, so as to enhance efforts towards substitution of unabated fossil fuels in energy systems.

(e) Reducing both consumption and production of fossil fuels, in a just, orderly and equitable manner so as to achieve net zero by, before, or around 2050 in keeping with the science;

13th December

Further recognizes the need for deep, rapid and sustained reductions in greenhouse gas emissions in line with 1.5 °C pathways and *calls on* Parties to contribute to the following global efforts, in a nationally determined manner, taking into account the Paris Agreement and their different national circumstances, pathways and approaches:

...

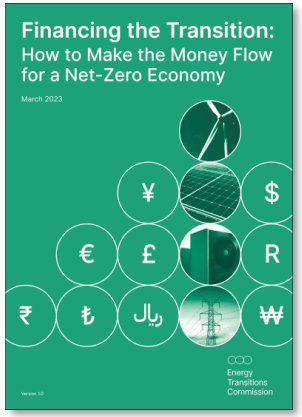
(d) Transitioning away from fossil fuels in energy systems, in a just, orderly and equitable manner, accelerating action in this critical decade, so as to achieve net zero by 2050 in keeping with the science;

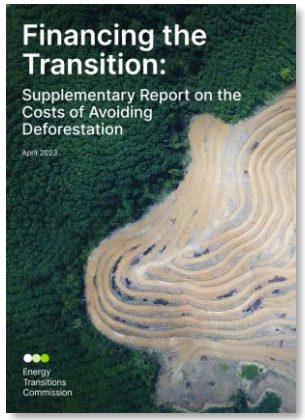
(e) Accelerating zero- and low-emission technologies, including, inter alia, renewables, nuclear, abatement and removal technologies such as carbon capture and utilization and storage, particularly in hard-to-abate sectors, and low-carbon hydrogen production;

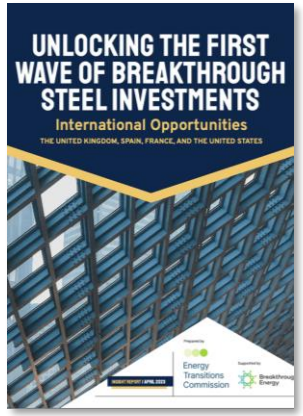
Source: Carbon Brief (2023), *COP28: Key Outcomes Agreed at the UN Climate Talks in Dubai;* UNFCCC (2023), *First global stocktake*.

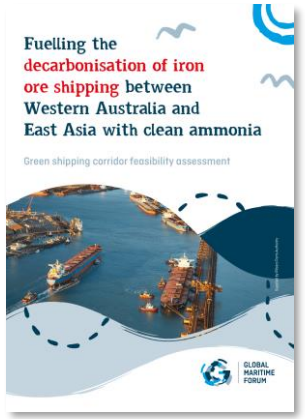
Energy Transitions Commission

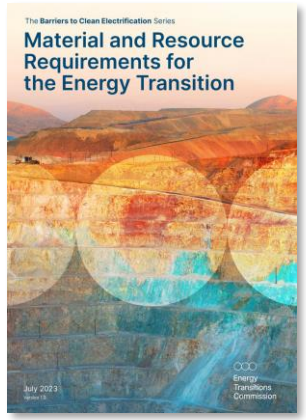
www.energy-transitions.org

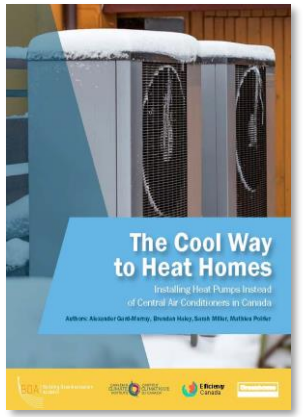


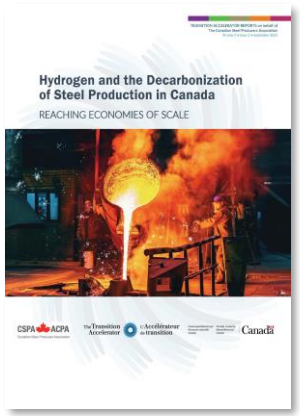


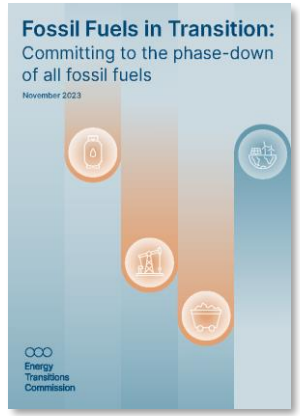


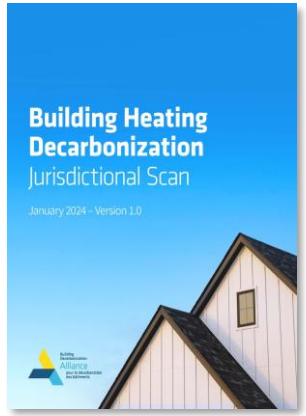


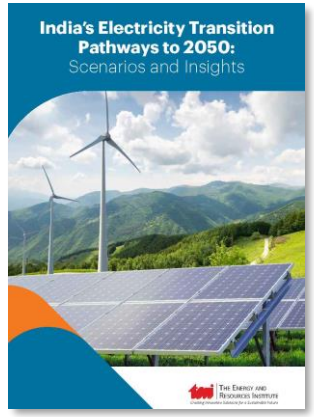












Q&A