BIEE webinar

Future of industry: Green, connected and circular

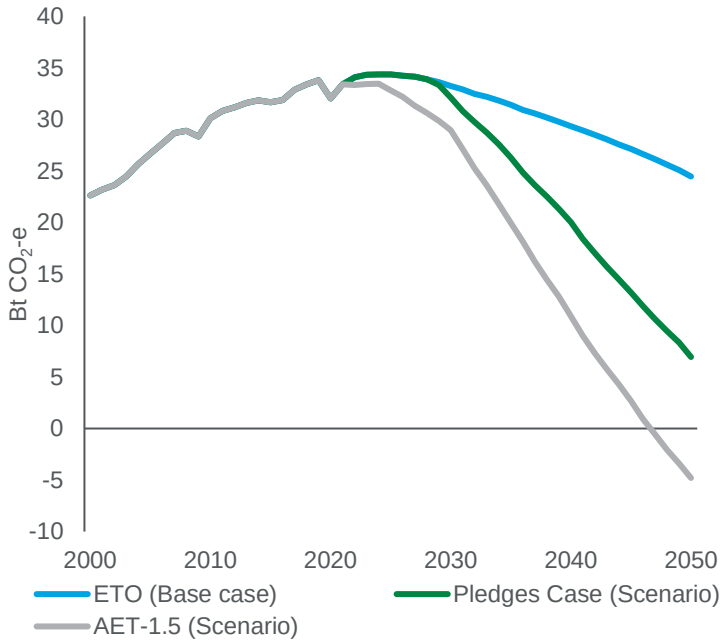
Prakash Sharma | 24th May 2023

Contents

Three radically different views are emerging in the world of energy and resources

The world needs to reach net zero before 2050 to meet the most ambitious goals of the Paris Agreement

Global energy-related CO_2 emissions



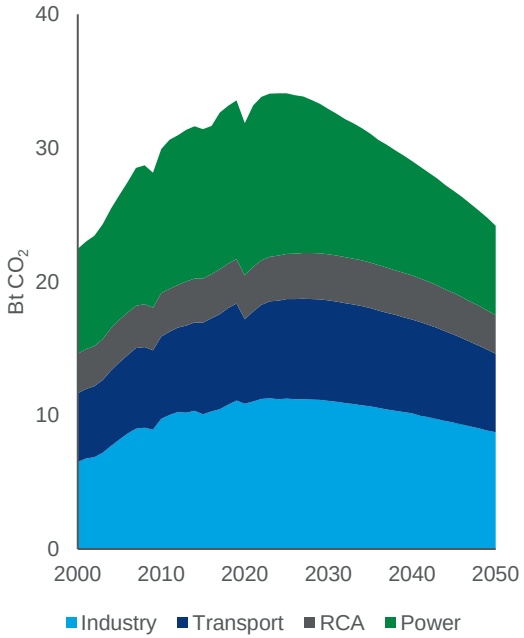
Scenario	Trajectory	Policy	Enablers
Energy Transition Outlook **(WM ETO)**	Consistent with 2.5 ˚C global warming	Evolution of current policies	Steady advancement of current and nascent technologies
Global Pledges Case Scenario **(WM AET-2)**	Consistent with below 2 ˚C warming (Global net zero by 2060)	Aligned with NZE pledges announced in the run up to COP27	Incorporates policy response to the current energy crisis, and geopolitical challenges facing global economy
1.5 °C Scenario **(WM AET-1.5)**	Consistent with 1.5 ˚C warming (Global net zero by 2050)	Aligned with most ambitious goal of Paris Agreement	Early peak energy; rapid hydrogen and carbon removal deployment; consumer shift

Source: Wood Mackenzie

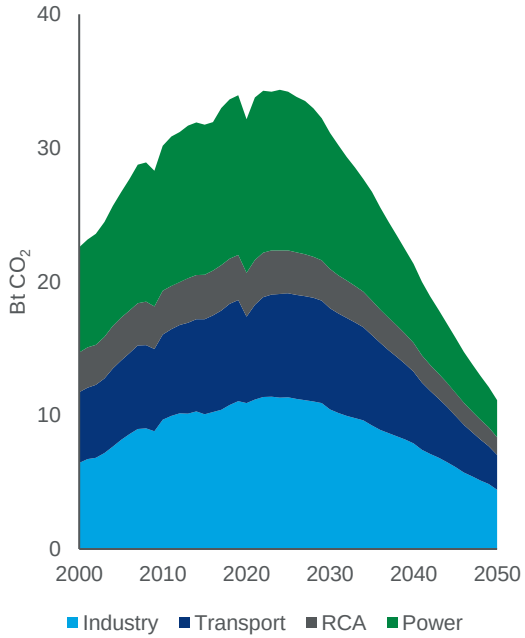
Emissions fall across sectors

Electrification is the primary tool adopted by countries to deliver reductions

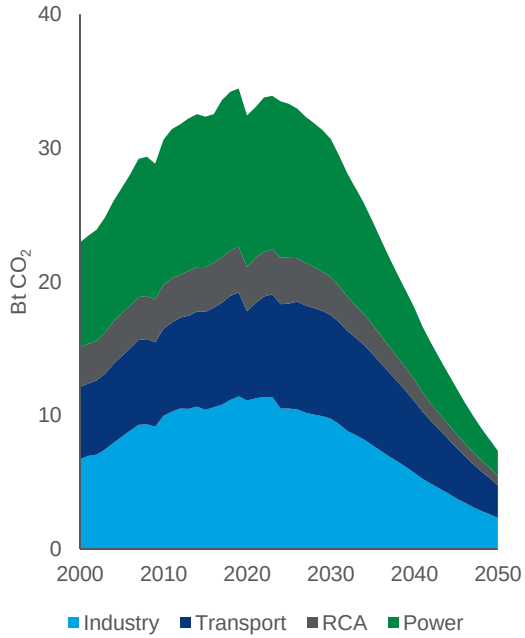
ETO emissions by sector



AET-2 emissions by sector



AET-1.5 emissions by sector

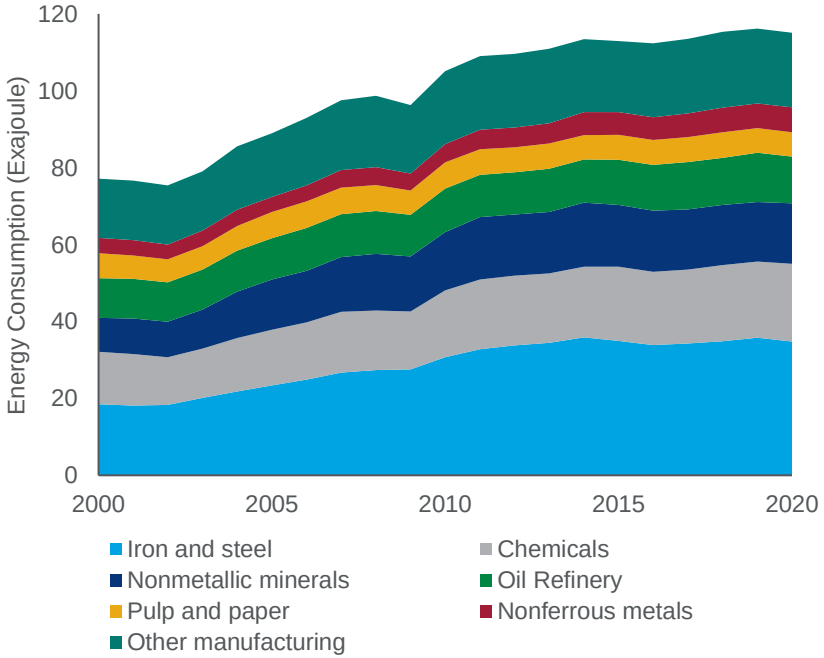


Source: Wood Mackenzie

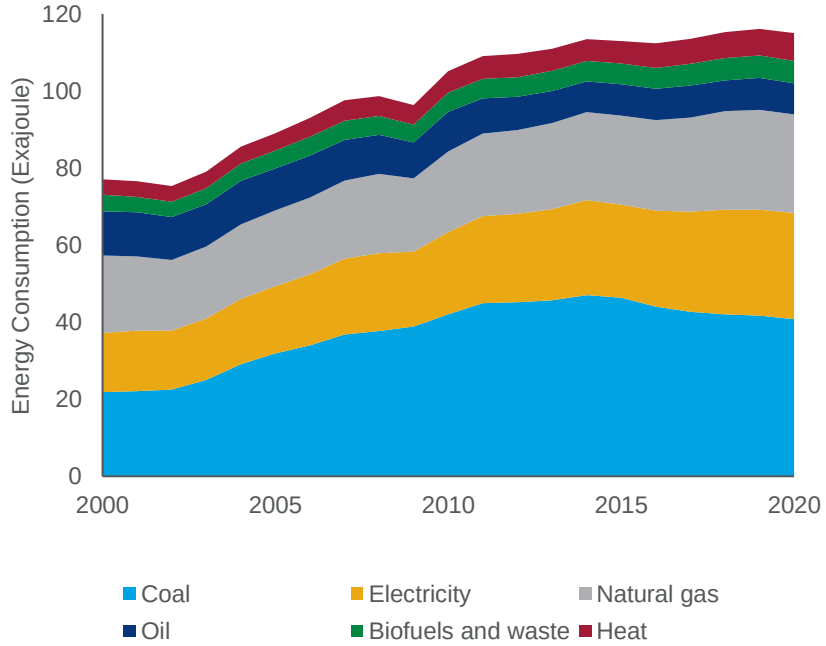
Rapid industrialisation in developing countries contributed to energy demand growth between 2000 and 2020

However, environmental concerns and economic maturity dampened energy demand in developed countries

Sub-sector trends



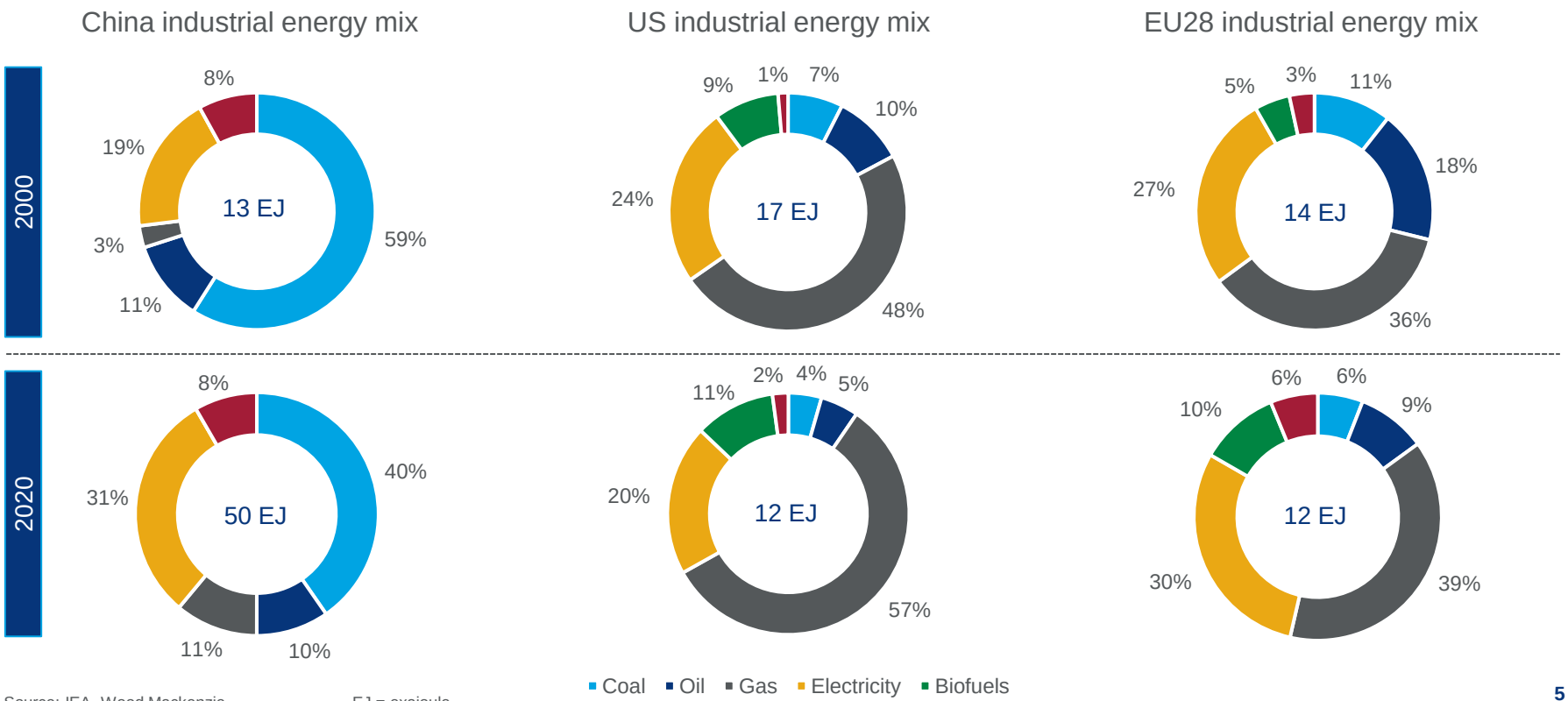
Fuel-mix trends



Source: IEA, Wood Mackenzie

Policy support and resource availability drove fuel choices

China's rise in global industry and manufacturing has increased the overall use of coal despite declining usage in OECD markets



Source: IEA, Wood Mackenzie

EJ = exajoule

No one-size-fits-all solution exists for industrial energy and emissions

Heat recovery and secondary material usage are the most immediate and practical interventions while breakthrough technologies reach scale and commerciality

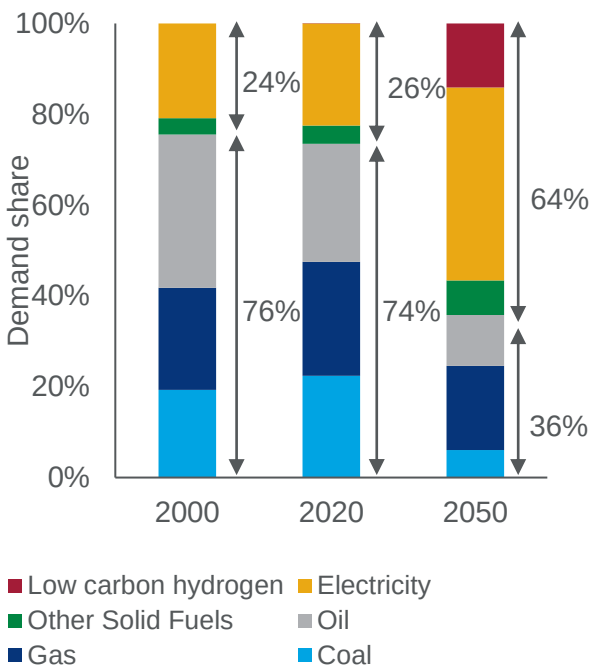
Themes		Process efficiency		Emissions abatement options			Circular materials	
Intervention	**Temp. heat requirement**	**Heat recovery**	**Alternative production pathway**	**Electrification**	**Carbon capture**	**Green hydrogen**	**Secondary materials**	**Biobased feedstock**
Iron and steel	*Up to 2200 °C*	*Tail gas recovery Feed preheating*	*DRI-EAF commercial LTE & MOE in R&D*	*Possible electrolytic primary production BOF and EAF already electrified*	*Moderate cost, but displaced by H2*	*Replaces fossil-based reducing agent*	*Already highly recycled*	*Not applicable*
Nonferrous metals	*Up to 1000 °C*	*Low quality heat Few output options*	*Electrolytic process improvements Other pathways in R&D*	*Already electrified*	*Low process gas CO_2 concentration*	*Not applicable*	*Already highly recycled*	*Not applicable*
Cement	*Up to 1450 °C*	*Modern plants already efficient*	*No breakthrough technology*	*High temp heat requirement*	*High concentration low capture cost*	*Blend or displace natural gas*	*BF-slag and fly ash displace clinker*	*Not applicable*
Pulp and paper	*Less than 200 °C*	*Efficient plants can run CHP, export excess power*	*No breakthrough technology*	*Mechanical electrified; Chemical expensive compared to black liquor*	*Moderate capture cost*	*Energy source either electricity or black liquor*	*Moderately recycled, regional challenges*	*Sustainable forestry practices*
Chemicals	*300-800 °C Varies by product*	*Iterative efficiency improvements*	*Varies by product*	*Varies by product*	*Varies, but high potential for some chemicals*	*Ammonia and methanol production*	*Plastic recycling faces economic and technical Challenges*	*Economic challenges*
Oil refinery	*Up to 500 °C*	*Iterative efficiency improvements*	*No viable alternative to distillation*	*Difficult to displace refinery byproducts*	*Capture from hydrogen plant*	*Difficult to displace refinery byproducts*	*Produced through pyrolysis, small quantities*	*Economic challenges*

Strong potential Moderate potential Low potential

Electrification, low carbon hydrogen and biofuels will be needed to decarbonise industry

But for some sub-sectors, CCUS will be the only viable decarbonisation option

Share of industrial demand by fuel



Decarbonisation options for the selected industrial sub-sectors

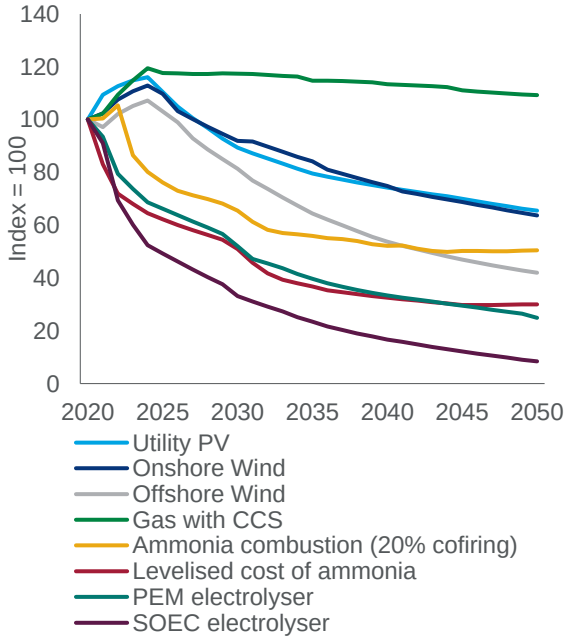
	CO_2		Low-carbon fuel
Oil and gas production	Oil/gas for onsite power generation	Renewable generation	Electricity
Steel	Coal in blast furnaces	Electric arc furnaces, Green Steel; CCUS; biomass	Electricity Low carbon hydrogen
Refining	Hydrogen from fossil fuels; Oil/gas for onsite power generation	Green or blue hydrogen; renewable generation; CCUS	Electricity Low carbon hydrogen
Petrochemicals	Hydrogen from fossil fuels; Oil/gas for onsite power generation	Green or blue hydrogen; renewable generation; CCUS	Electricity Low carbon hydrogen
Construction	Oil products used for onsite power generation and construction vehicles	Onsite renewable generation; electrified / hydrogen fuel cells construction vehicles	Electricity Low carbon hydrogen
Non-metallic minerals (e.g., cement)	Fossil fuels used to heat kilns; CO_2 emitted in calcination process	Use of biomass in kilns; CCUS	Biofuels Low carbon hydrogen
Manufacturing	Oil/gas for heating and drying processes	Electrified processes; high temperature heat pumps	Electricity

Source: Wood Mackenzie

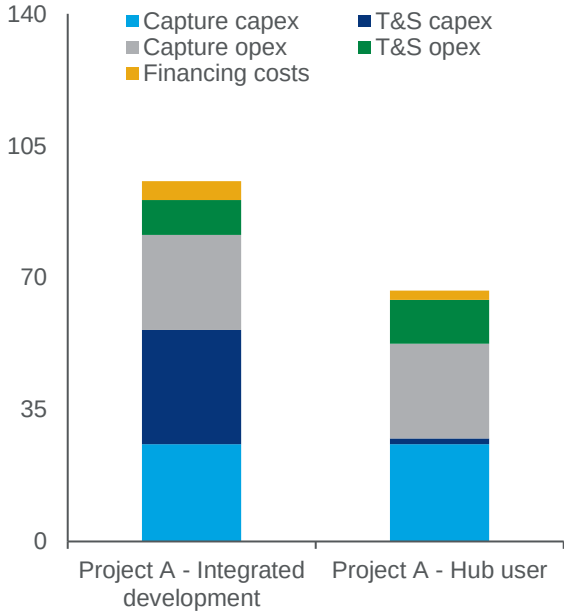
The economic fundamentals for decarbonisation are in place

Costs declines for low carbon technologies are a structural trend

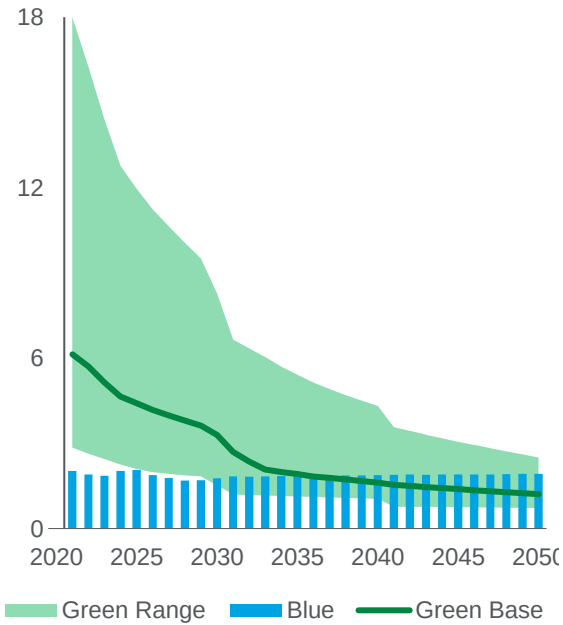
Cost trajectory of key technologies



Levelised cost of CCUS, US$/t



Levelised cost of hydrogen (global average), US$/t

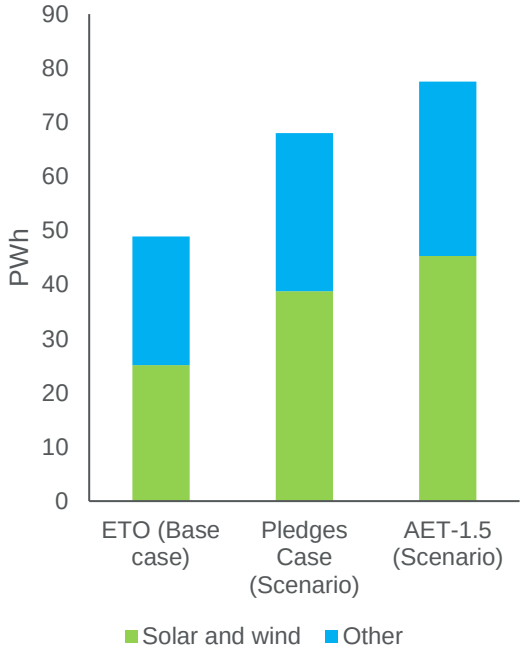


Source: Wood Mackenzie

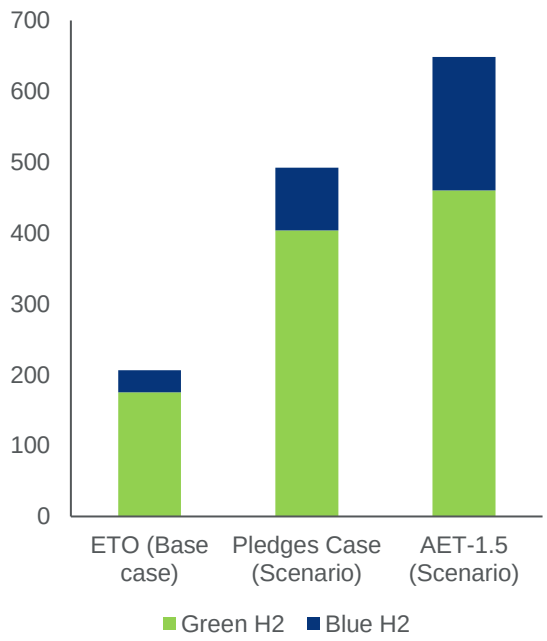
Renewables, hydrogen and carbon removal technologies are deployed at scale

Wood Mackenzie's pledges scenario vs ETO (base case) and AET-1.5 (scenario) in 2050

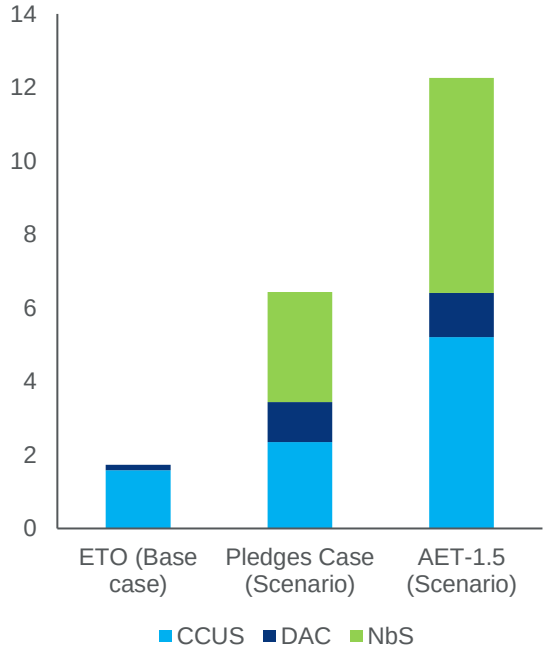
Electricity output, PWh



Low-carbon hydrogen, Mt



Carbon removal, Bt CO_2



Source: Wood Mackenzie

CCUS includes carbon capture in blue H2 production
NbS = Nature based solutions

Q&A

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