Carbon Markets & Carbon Capture, Utilization and Storage (CCUS)

Angel Salazar
Real Assets, January 2022

Executive Summary

Introduction & Overview – Carbon Markets
- State of Carbon Markets
- Strategic Value of Carbon Markets
- Carbon Market Challenges

Introduction & Overview – Carbon Capture, Utilization and Storage (CCUS)
- State of CCUS
- Strategic Value of CCUS
- CCUS Challenges

Global Energy Decarbonization
- Carbon Markets in a Global Context
- CCUS in a Global Context

U.S. Energy Decarbonization
- Carbon Markets in a U.S. Context
- CCUS in a U.S. Context

Conclusion and Considerations

Appendix

Bibliography

Carbon Markets Overview

- Carbon markets enable the trading of carbon credits, also known as carbon offsets
- 1 carbon credit = 1 metric ton of greenhouse gas emissions (GHG)
- Value of carbon markets increased by 20% in 2020 to $272 Billion
- Carbon markets have expanded fivefold since 2017 as nations continue to implement them as a form of reducing aggregate emissions

Types of Carbon Markets

Market Elements	Compliance (ETS) Carbon Markets	Voluntary Carbon Markets	International Carbon Markets
Description	• Mandatory participation to large emitters • Some allow limited amount of Clean Development Mechanism (CDM) credits	• Independent Markets for non-regulated entities to voluntarily reduce emissions • Variety of industry created standards	• The CDM was the first major international market under the Kyoto Protocol • Emissions reductions transferred across countries
Current Status	• Covers 8% of global emissions, growing to 14% with the launch of the China ETS	• Mainly used for corporate social responsibility (CSR) activities • Attractive for small projects	• Large market, currently stagnating • Article 6 of the Paris Agreement aims to reignite international markets
Regulation	• High regulated with robust monitoring, reporting, and verification (MRV)	• Low to no regulation, different accounting methodologies with varying degrees of rigor	• UN recognized accounting methodologies, such as Gold Standard (GS) accounting
Liquidity	• Highly liquid • In 2020, approximately $261 billion traded in the WCI, RGGI and EU ETS	• Low liquidity • In 2020, $473 million traded • In 2021, market value set to exceed $1 billion	• Medium liquidity • Average of $14 billion traded per year since 2006
Carbon Prices	$\$1.12 - \$49.78\ per\ tCO_2e$	$\$1.00 - \$3.80\ per\ tCO_2e$	$\$0.08 - \$137.24\ per\ tCO_2e$

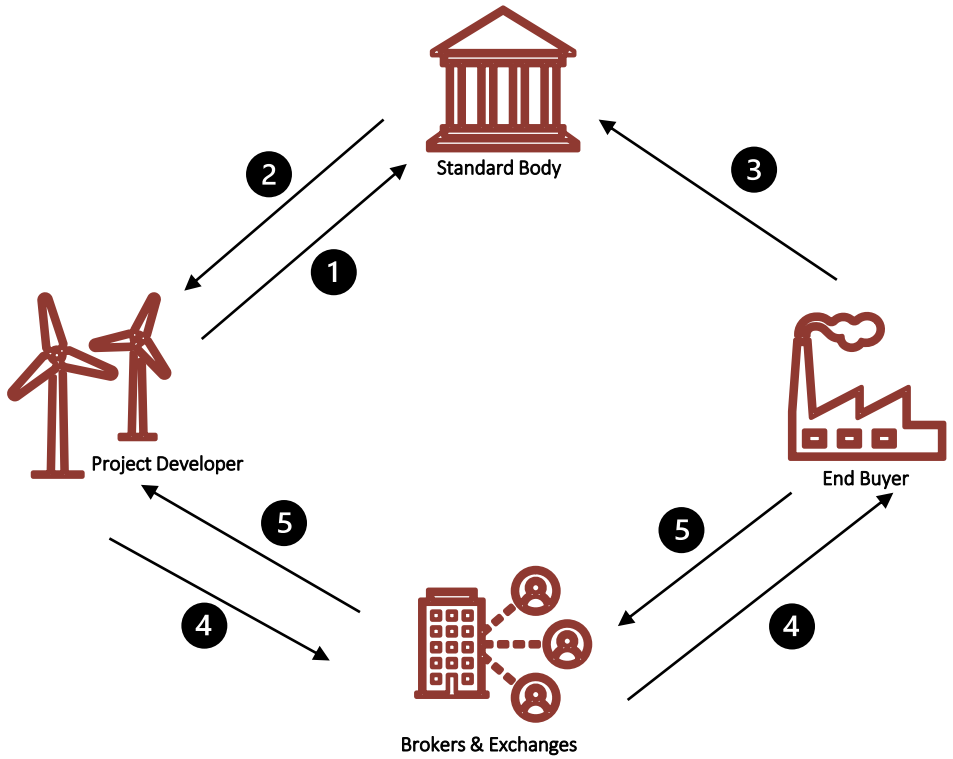
Source: CFA Institute, Climate Change Analysis in the Investment Process / S&P Global Platts, Energy Transition

Voluntary Carbon Markets

- **Project Developers**
  - Create carbon offset projects, selling carbon credits that represent emissions reductions or removals in the process
- **Standard Bodies**
  - Entity that set and certify standards for carbon offsets
- **Brokers & Exchanges**
  - Intermediaries that facilitate carbon credit exchanges between buyers and project developers
- **End Buyers**
  - Entities looking to offset their carbon emissions through carbon credit purchasing

- **Advantages**
  - Relatively flexible
  - Far less regulated than compliance markets (private sector)
- **Disadvantages**
  - Insufficient Governance
  - Lack of Trust

Voluntary Carbon Markets Visualization

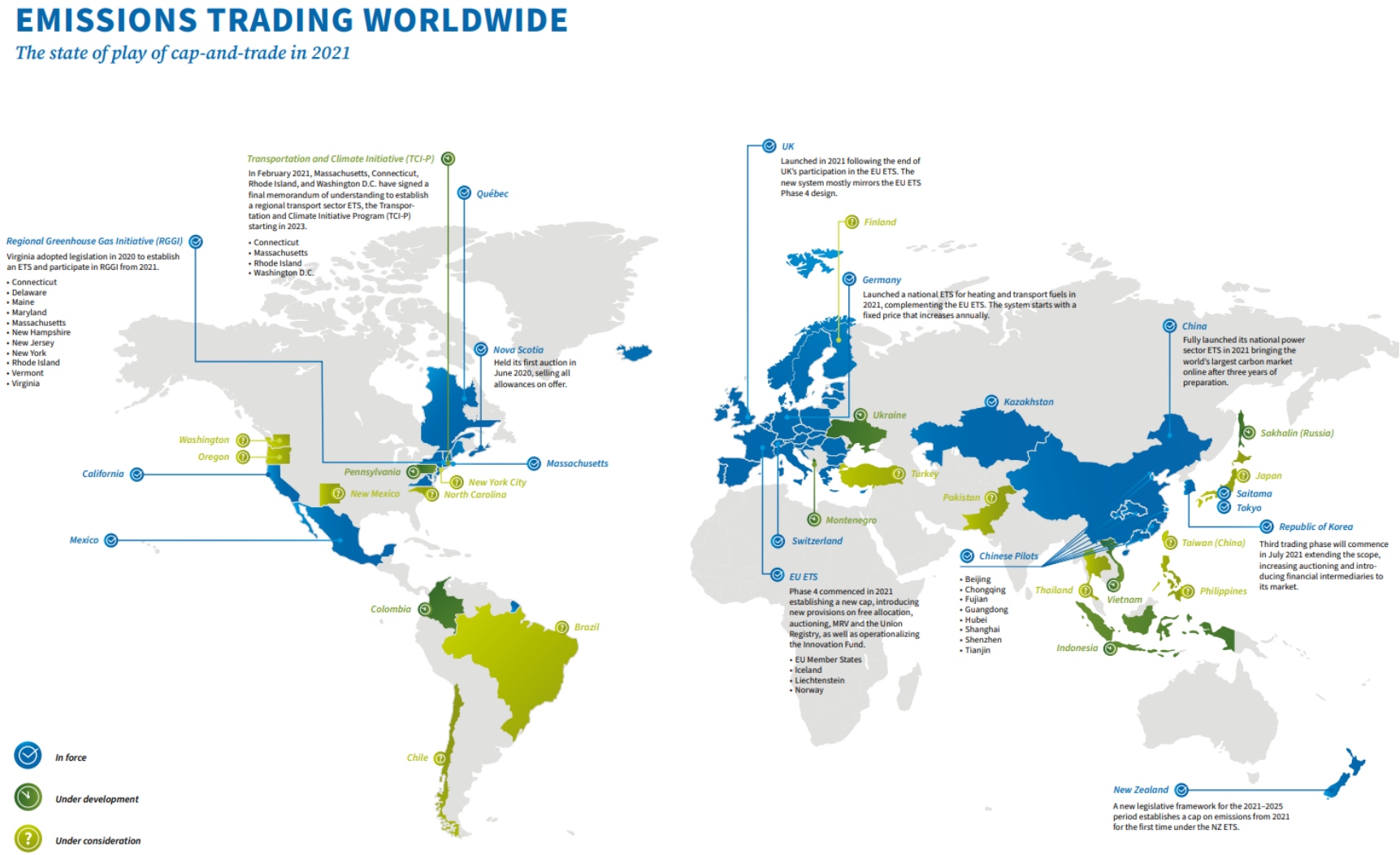


Index	Process
1	Application for project and company registration
2	Grant of carbon credits
3	Application for company registration
4	Carbon credit exchange
5	Payment transaction

Source: EY, *Voluntary Carbon Market: Challenges and Promises of the Green Transition Tool*

Compliance Carbon Markets

- In essence, compliance carbon markets are mandatory systems overseen by government organizations for the purpose of implementing caps on emissions for specific industries (Cap and Trade)
- Organized by governments to target certain industries or sources that emit Greenhouse Gases (GHGs)
- Emitters obtain pollution permits or allowances in order to meet the emission cap limits
- Compliance offset market carbon credits may be purchased by voluntary, non-regulated entities *in specific cases*
- Typically experience commodity pricing given compliance/regulated nature
  - For instance, all offsets' credits in a particular program may be priced similar based on supply and demand



Source: Carbon Offset Guide, *Compliance Offset Programs / International Carbon Action Partnership, Emissions Trading Worldwide*

Drivers of Carbon Market Demand

- By 2030, carbon prices will need to exceed $100/tCO2e in order to align with Paris Agreement goals
- Carbon Offset Project Categories
  - **Reduction Focused:** preventing or reducing the release of carbon emissions into the atmosphere
  - **Removal & Sequestration Focused:** removing carbon emissions from the atmosphere
- Advantages of carbon offset project implementation
  - Biodiversity: protecting wildlife through reforestation and reduction of deforestation
  - Economic: creating job opportunities for local communities
  - Educational: providing educational awareness of carbon mitigation within local areas

Main Drivers of Carbon Market Demand Worldwide

Paris Agreement

Companies seeking alignment with Paris Agreement goals and standards

Time Gaps

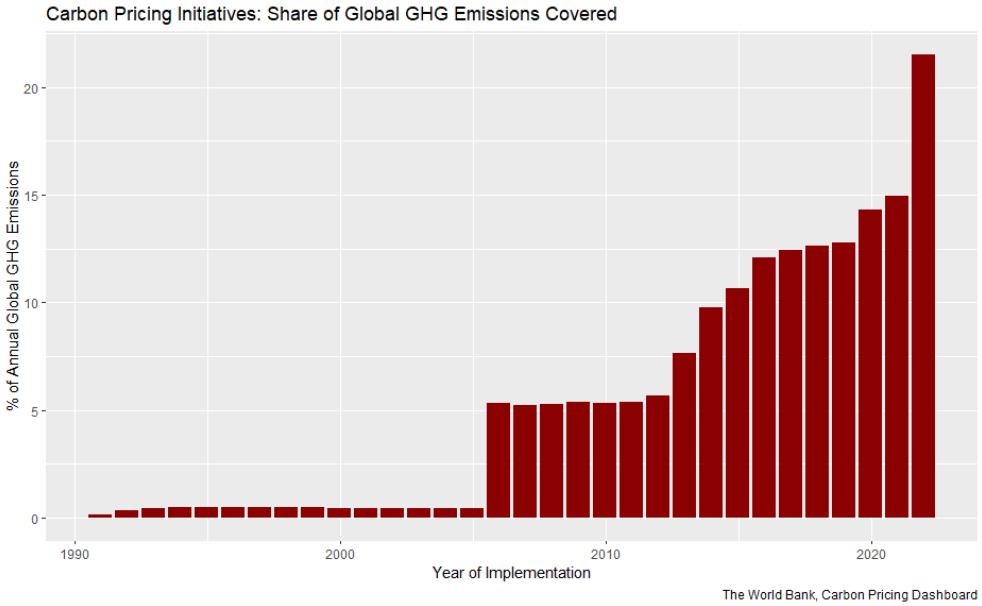
Companies do not have the means to eliminate all emissions today

Technological Gaps

Companies are limited by technologies that are available at scale and not cost-prohibitive

Shareholder Pressure

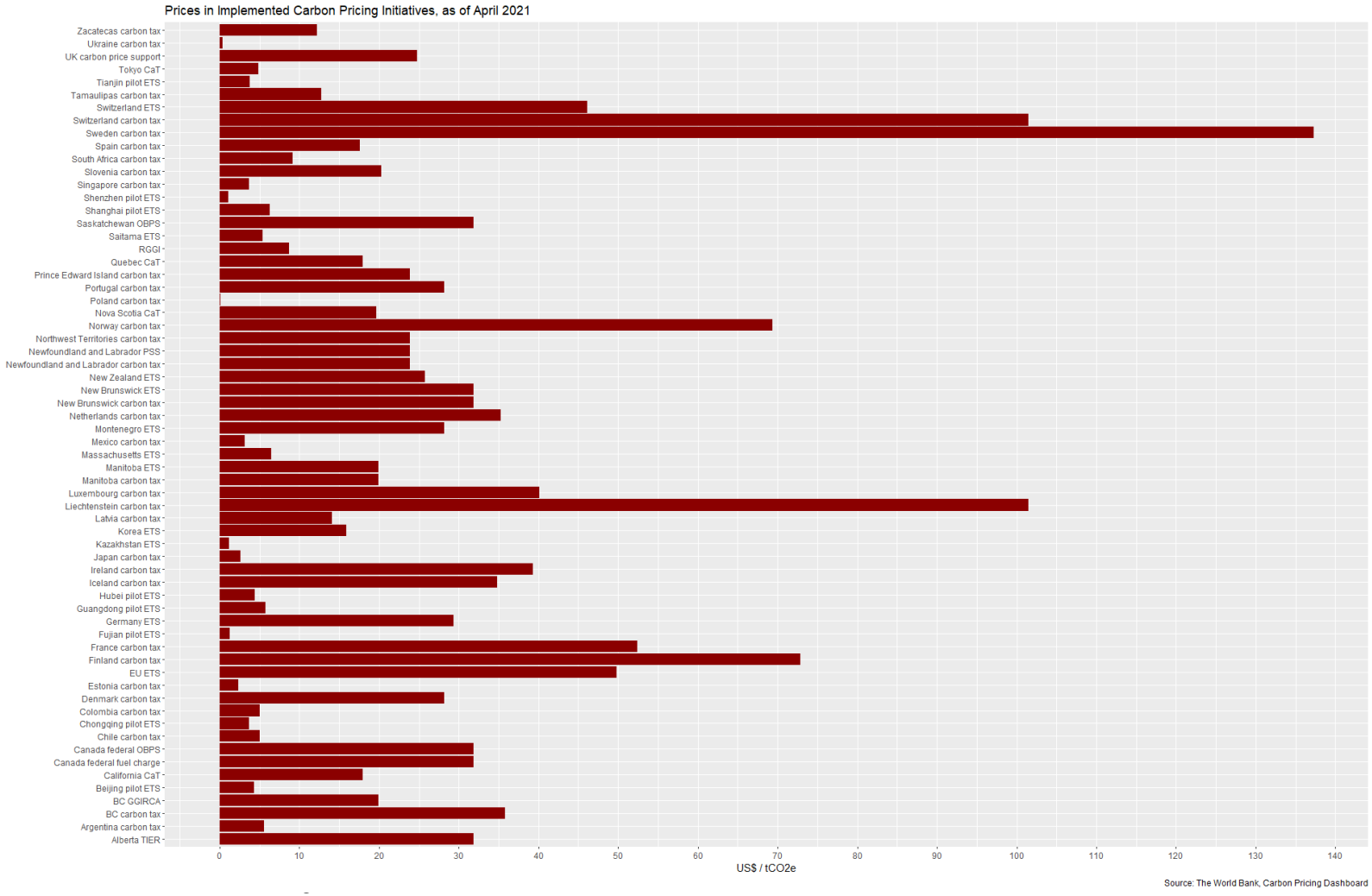
Companies are facing pressure from shareholders as it relates to emissions



Carbon Markets – Global Carbon Pricing in Early 2021

- **Lowest Carbon Price**
  - $0.08 / tCO2e (Poland Carbon Tax)
- **Highest Carbon Price**
  - $137.24 / tCO2e (Sweden Carbon Tax)
- **Average Carbon Price**
  - $24.52 / tCO2e
- There are 60+ Carbon Pricing Initiatives as of April 2021

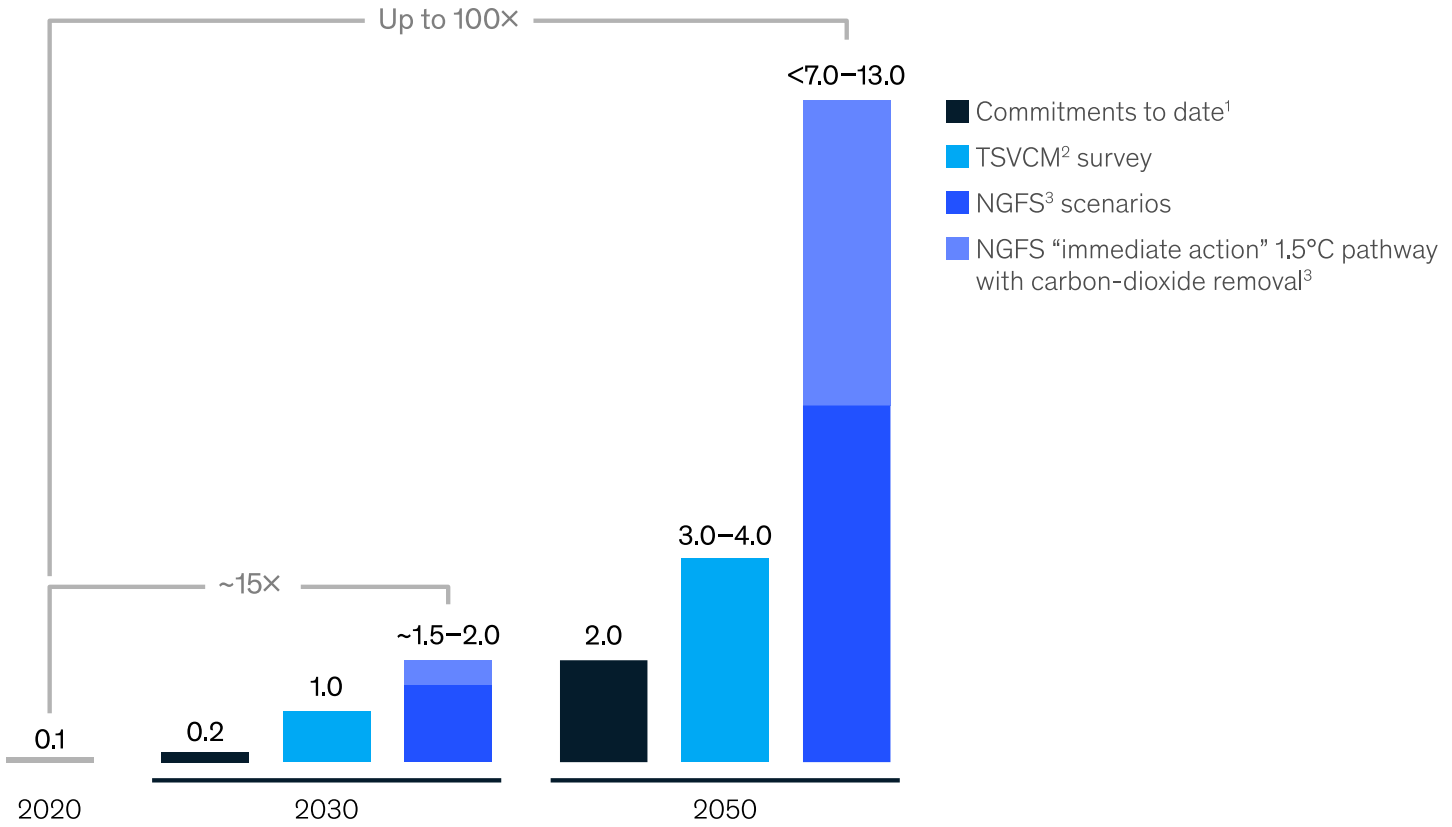
Prices in Implemented Carbon Pricing Initiatives, as of April 2021



Strategic Value of Carbon Markets

- Demand for carbon credits could increase by a factor of 15 or more by 2030
- Demand for carbon credits could increase by a factor of up to 100 by 2050.
- Overall, the market for carbon credits could be worth upward of $50 billion in 2030
- Carbon credits can help companies to meet their climate-change goals

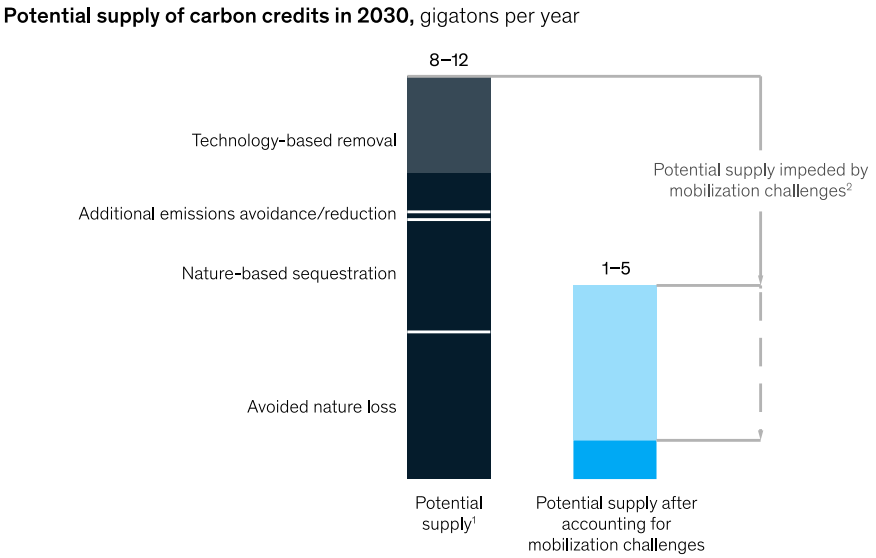
Voluntary demand scenarios for carbon credits, gigatons per year

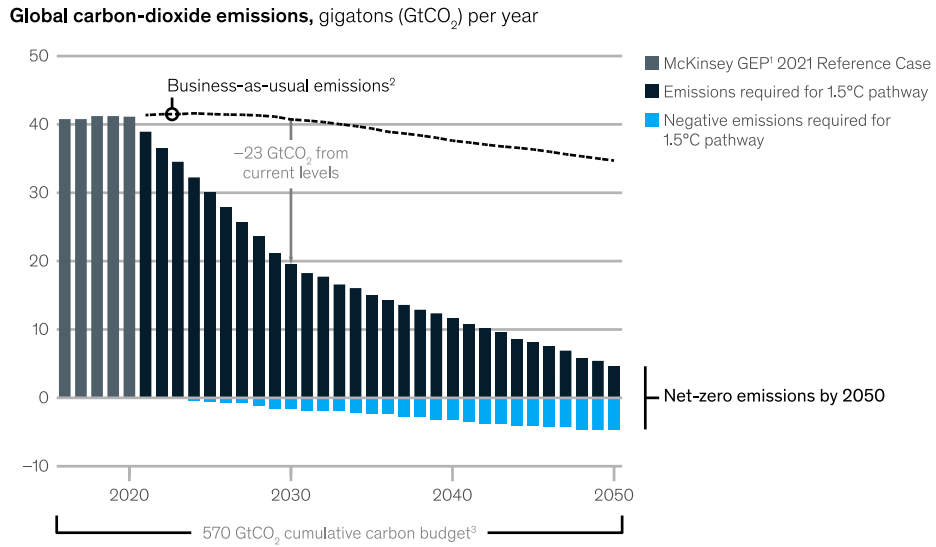


Source: McKinsey Sustainability, *A blueprint for scaling voluntary carbon markets to meet the climate challenge*, Jan. 2021

Carbon Market Challenges

- Some carbon credits have turned out to represent emissions reductions that were questionable in terms of validity
- Limited pricing data make it challenging for buyers to know whether they are paying a fair price
- For some firms it is prohibitively expensive to reduce emissions using today's technologies
- Mobilization challenges can potentially cut the potential supply of carbon credits in 2030 by roughly 50%
- **Necessary Future Efforts**
  - Creating a standard for defining and verifying carbon credits (homogenous carbon credit structure)
  - Developing contracts with standardized terms (creation of uniform core contracts to generate reliable daily price signals)
  - Establishing robust trading infrastructure
  - Creating consensus about the proper use of carbon credits
  - Implementing mechanisms to uphold carbon market integrity
  - Transmitting clear signals of demand



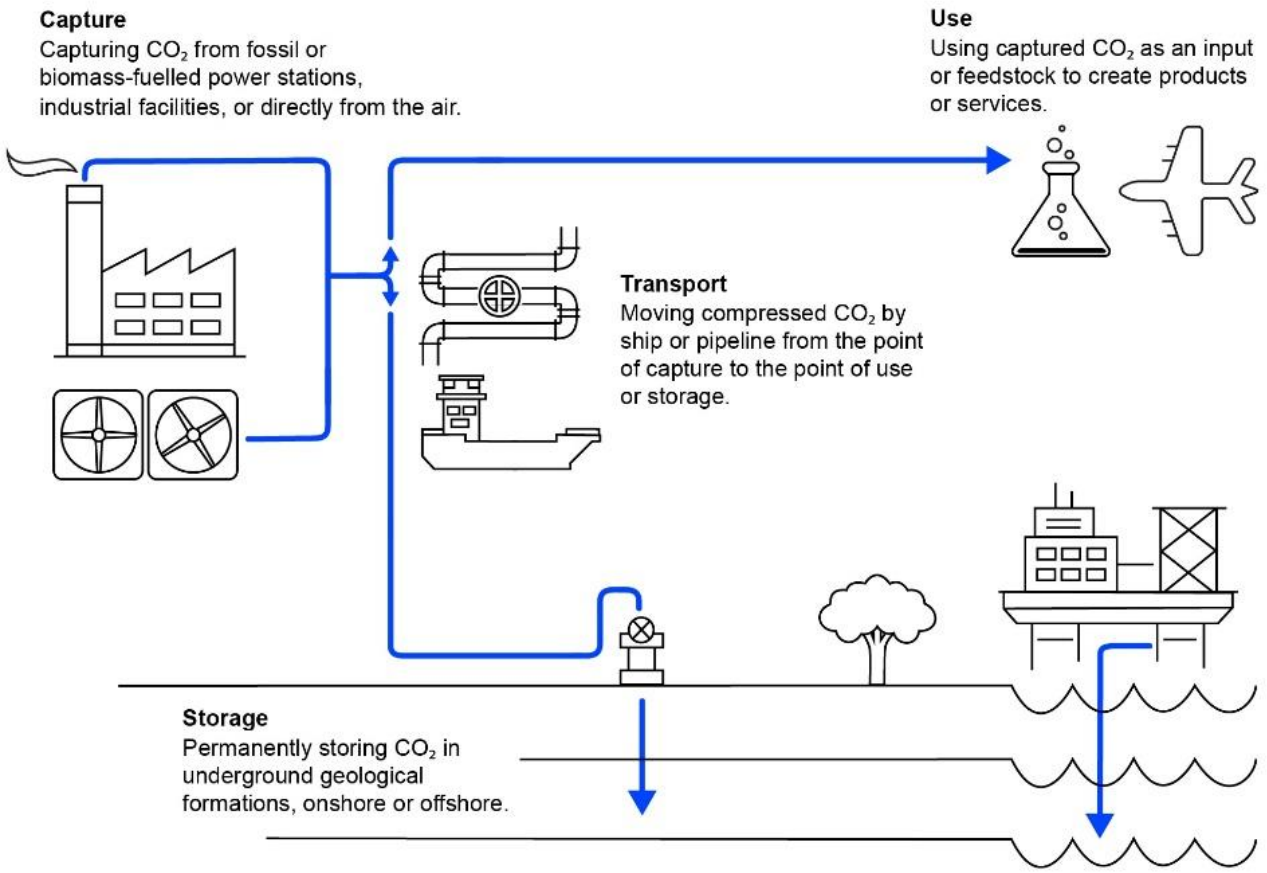


Source: McKinsey Sustainability, *A blueprint for scaling voluntary carbon markets to meet the climate challenge*, Jan. 2021

Carbon Capture Utilization and Storage (CCUS) Overview

- Principal Carbon Capture Technologies
  - Chemical Absorption
  - Physical Separation
  - Oxy-Fuel Separation
  - Membrane Separation
  - Calcium Looping
  - Chemical Looping
  - Direct Separation
  - Supercritical CO2 Power Cycles
- Carbon Sources
  - Fossil Fuels
  - Biomass
  - Air
  - Industrial Process
  - Underground Deposits
- Carbon Conversion Types
  - Fuels
  - Chemicals
  - Building Materials
- Carbon Non-Conversion Types (Direct Use)
  - Yield Boosting
  - Solvent
  - Heat Transfer Fluid

What is CCUS?

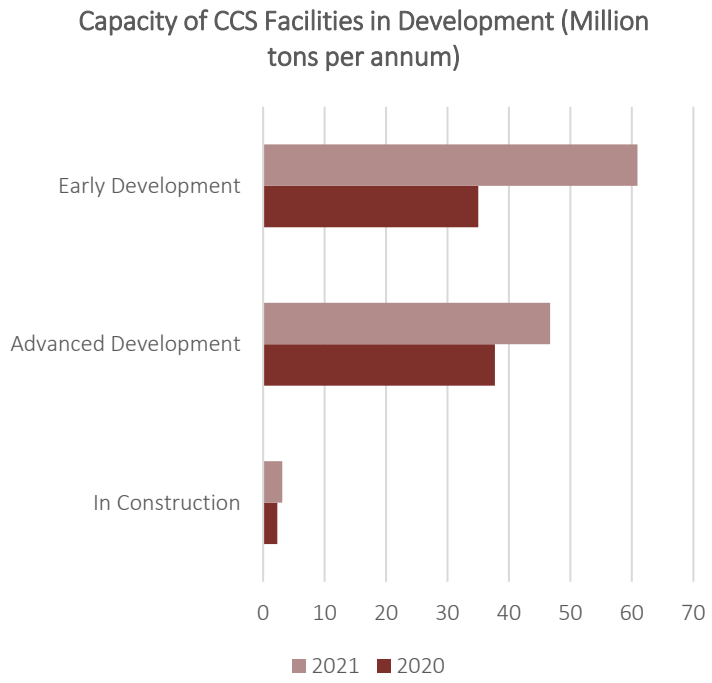


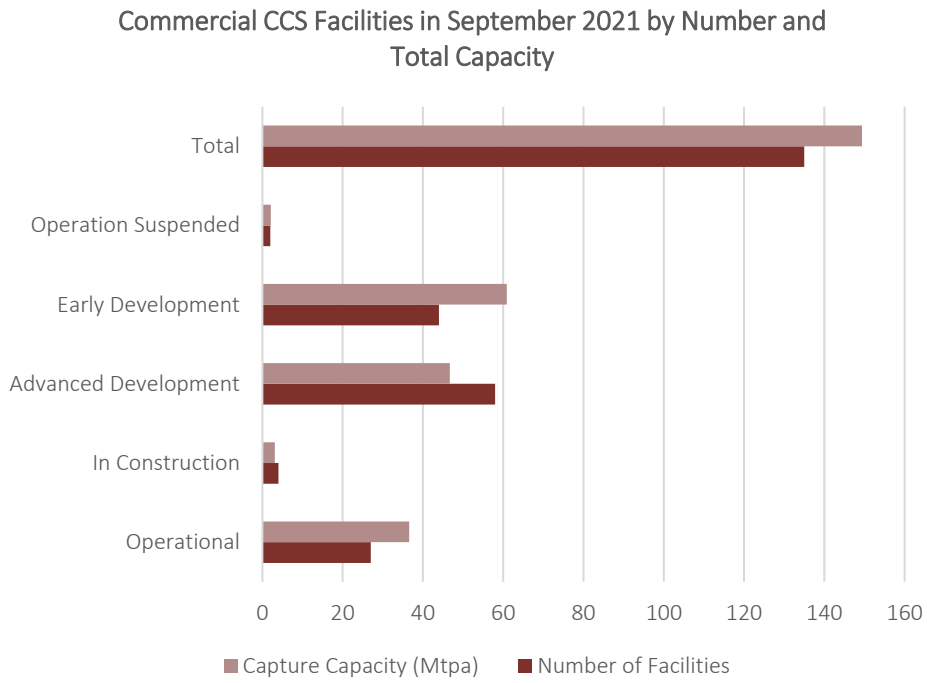
Source: International Energy Agency, *About CCUS*, Technology Report – April 2021

Drivers of CCUS Demand

- Climate Change (Climate Risks)
  - Sectors like steel, cement, chemicals, and energy produce high emissions while providing essential goods and services
  - CCUS technology allows for the reduction of emissions in which emissions intense sectors do not have to take a hit to their profitability
- Paris Agreement
  - The aim to eventually align with Paris Agreement standards will be a key driver for private CCUS Investments
- CCUS enhances resource efficiency and climate neutrality through
  - Carbon Dioxide capture processes
  - Productive use
  - Permanent storage
  - Integrated value chains
- Market incentives such as carbon price signals
  - Strengthening case for investing in CCUS across power sector and industry value chains

Global CCS Facilities Update and Trends, September 2021





Source: Global CCS Institute, Global Status of CCS 2021 / International Energy Forum, Strategies to Scale Carbon Capture, Utilization and Storage

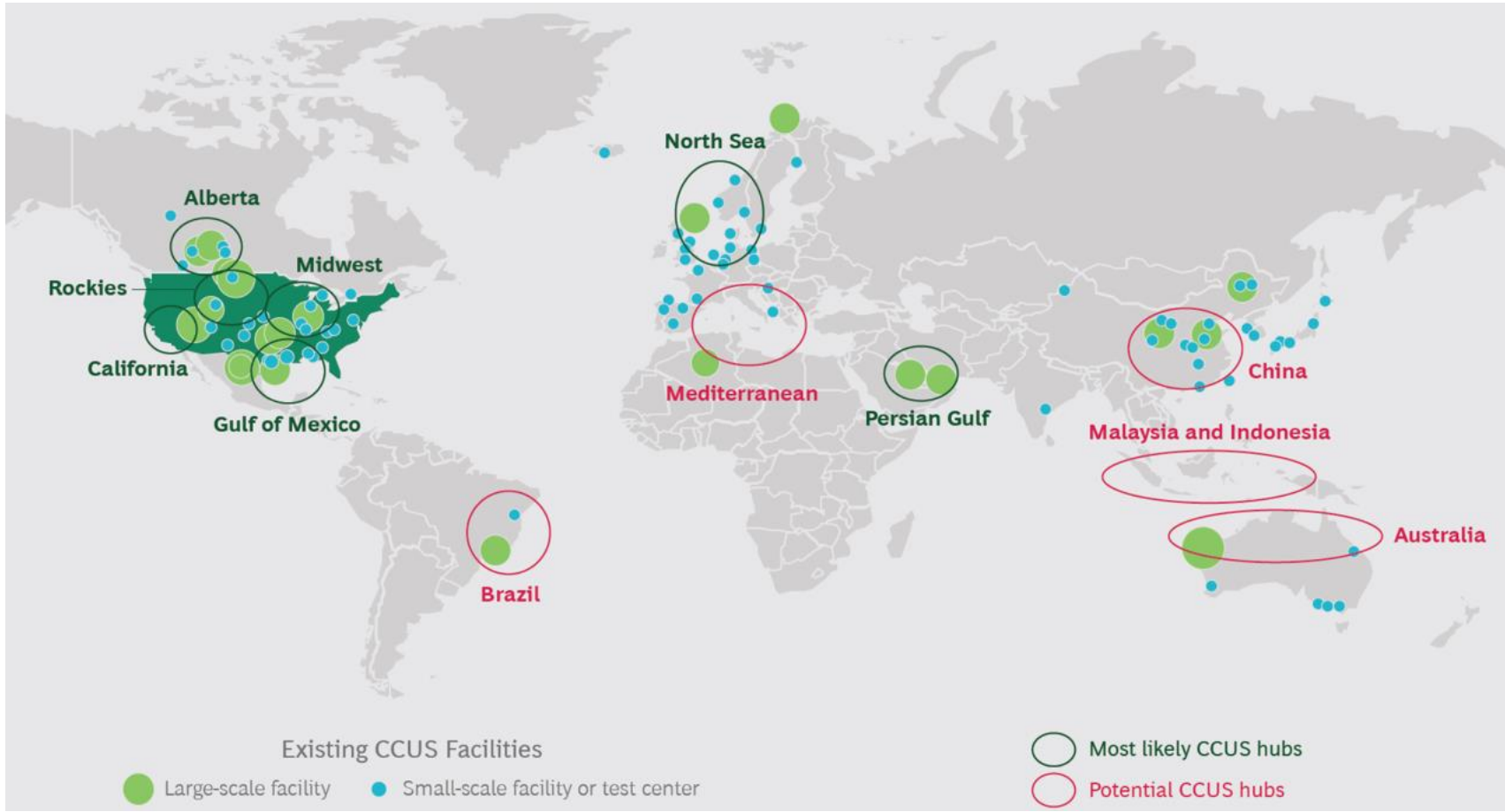
Strategic Value of Carbon Capture, Utilization and Storage

- Venture Capital backed CCUS startups took in $340 million last year (Pitchbook Data)
- The Global CCUS industry will develop first in geographical regions that offer costs advantages because of
  - Proximity to geological storage
  - Existing pipeline infrastructure
  - High concentration of stationary emitters
  - Market incentives due to enhanced oil recovery
- Up to $90 billion could be invested in CCUS in the next 10 years (globally)

Three Potential CCUS Markets

1. *Low-Cost Industries*: $30 per ton of CO2 captured
   - Industrial processes that emit highly concentrated CO2 streams
2. *Hard to Abate Industries*: $50-$200 per ton of CO2 captured
   - Petroleum refining and manufacturing of cement, lime, aluminum, iron, and steel
3. *Power Generation*: $40-$170 per ton of CO2 captured
   - Retrofitting of existing plants

CCUS Capacity – Development Hubs



Source: Boston Consulting Group, *The Business Case for Carbon Capture*, 2018

Carbon Capture, Utilization and Storage Risks and Challenges

- **Technology Risks**
  - On average, capture capacity of less than 3 million tons of Carbon Dioxide (MtCO2) has been added worldwide each year since 2010
  - Most recent annual capture capacity: 40 MtCO2
  - In order to align with a pathway to net zero by 2050, annual capture capacity must increase to 1.6 billion tons (GtCO2) in 2030 [7.6 billion tons (GtCO2) in 2050]
- **Political Risks**
  - Lack of standard framework and business models to facilitate CCUS projects
- **Economic Risks**
  - Immaturity of CCUS technologies means there is an uncertainty in estimating costs (replicability barrier)
  - Uncertainty in future fuel prices, plant energy consumption, and equipment lifetime
  - High risk and thus requires high ROI
  - Demand in industry is less certain than power
  - Industries are unable to be competitive given CCUS costs cannot be passed on to consumers via globally traded commodities

CCUS Key Challenges

CO2 Transport and Storage Network Efficiency

- Design and implementation of a CO2 transport and storage network is a highly difficult task
- Designing a safe and efficient CO2 pipeline network at the necessary scale presents many challenges
- Inconsistencies in CO2 streams may negatively influence transport and storage efficiency
  - ❖ Streams of CO2 are likely to vary in composition, pressure, flow rate, and fluid phase
  - ❖ Higher costs may result from reduced transport efficiency of CO2
  - ❖ Increased risk of pipeline blockage
  - ❖ Possible reduction in storage efficiency overall

Fostering CCUS Clusters & Emissions Capturing

- Designing effective business models to support industrial CCUS can be complicated by
  - ❖ Dispersal of carbon emission sources
  - ❖ Variability in operations
  - ❖ Irregularity of carbon emissions output
- Dispersed CCUS sites will lead to commercial risks of CO2 transport
  - ❖ Higher capital costs for infrastructure development
  - ❖ High operation costs for various modes of transport across large distances
  - ❖ Limited opportunities to benefit from economies of scale

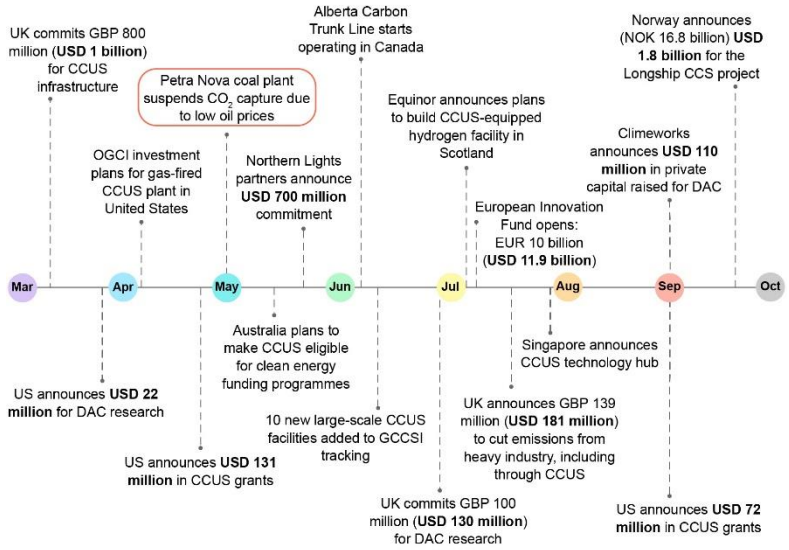
Realizing Negative Emissions Technologies

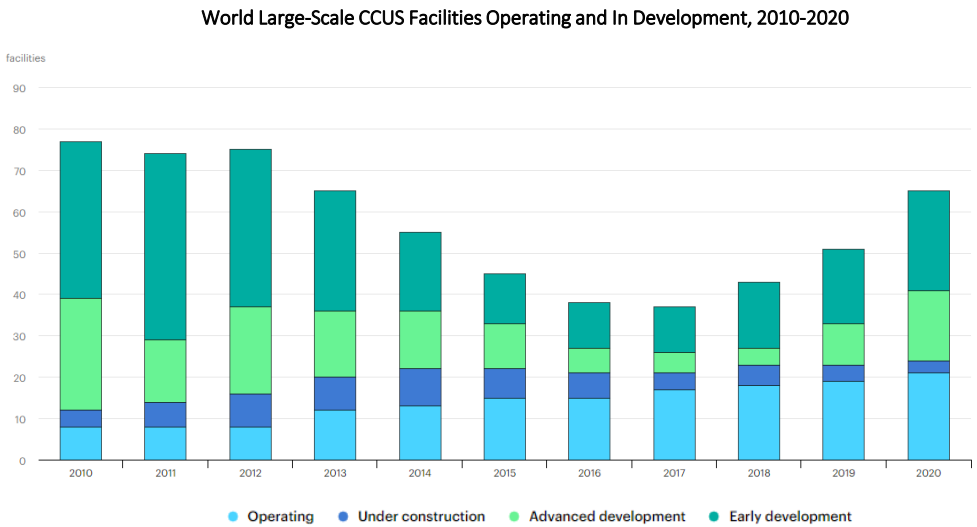
- Technologies with the potential to remove up to 50 MtCO2/Year by 2050 (Bioenergy + CCUS) are currently in pre-commercial stages
- Technology development is hindered by the development of supply chains
  - ❖ in the case of Bioenergy + CCUS, supply chains of biomass feedstock
- Another technology, Direct Air Capture, is hindered in efficiency due to
  - ❖ low CO2 concentrations in air, resulting in slow emissions + air separation process
  - ❖ high energy requirement
  - ❖ being 6x more costly than current carbon credit prices (no economic incentive yet)

Source: IEA, *Carbon Capture in 2021: Off and Running or Another False Start?*, Nov. 2021 / CRAI, Carbon Capture Utilisation and Storage in the 2020s

State of Technology – Carbon Capture, Utilization, and Storage (CCUS)

- As can be seen from the March-September 2020 timeline included in this section,
  - CCUS investments remain above a billion in terms of aggregated investments
  - As is stated in the report extract, CCUS holds investor appeal in that is offers high strategic value moving forward in the energy transition
  - As of Q4 2020, a total of $27 Billion has been invested in Carbon Capture, Utilization, and Storage (CCUS) technologies; this value represents advanced stage projects
- An important detail to note however, is that on an annual basis, investment in CCUS compared to other clean energy technologies has been relatively low
- CCUS investment has consistently accounted for less than 0.5% of global investment in clean energy technologies.
- From 2017-2020 it can be observed that there was a significant increase in early development CCUS projects (rightmost figure).



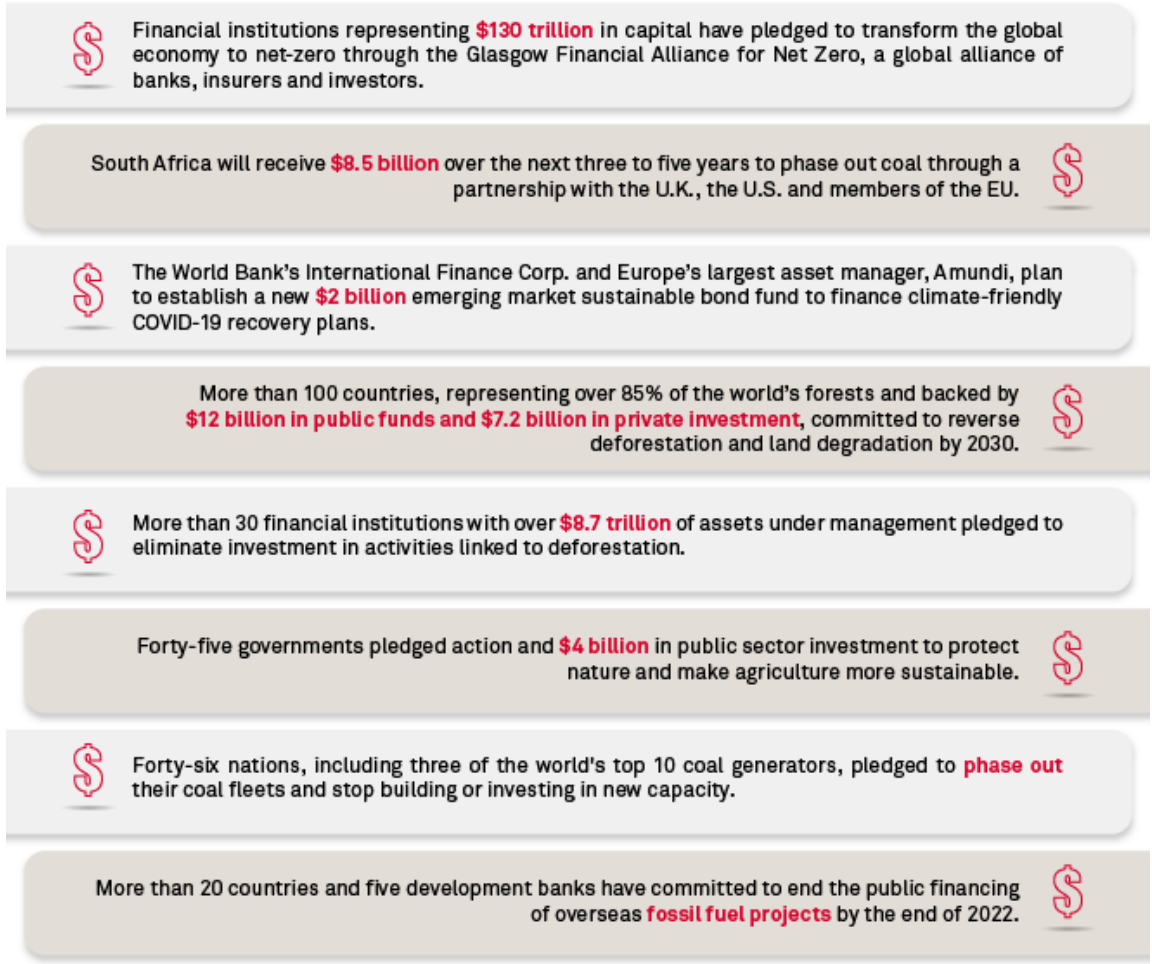


Source: International Energy Agency, Report Extract: A New Era For CCUS

State of Climate Change Policy – COP26

- Country Pledges
  - India set goal to reach net-zero by 2070
- Methane Related Pledges
  - More than 100 countries agreed to cut emissions
  - However, there are no specific targets for each nation
- Forest Related Pledges
  - 100 countries signed a pledge to end deforestation
  - A similar pact in 2014 failed to meet its goals
- Coal Related Pledges
  - G-20 says it will stop funding coal plants abroad
  - However, smaller deal to end domestic coal has loopholes
  - Developing economies want to phase out coal but they need financial and technological support
- Global Carbon Market
  - Brazil expressed willingness to compromise on Article 6
- Countries reached a deal on Article 6 of the Paris Agreement
  - Will govern international carbon markets
  - Will increase emissions reduction standards and efficiency

Major Green Finance Announcements From COP26

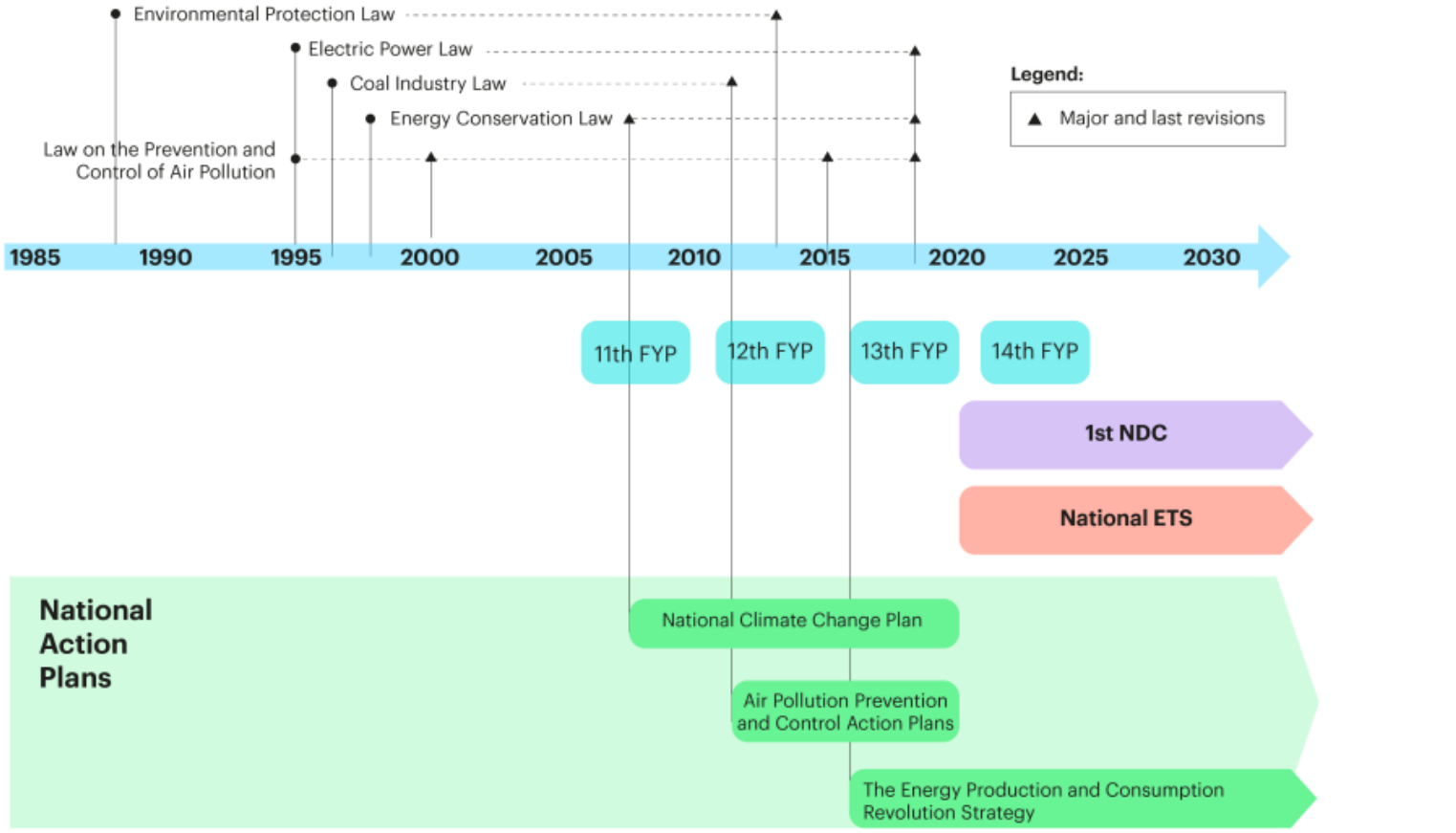


Source: Bloomberg, COP26 Daily, Protestors Expose Stark Reality of Climate Progress: COP26 Daily / S&P Global Sustainable: Global Market Intelligence

China Carbon Market – Case Study

- China launched the world's largest carbon market in July 2021
  - Known as Tradable Performance Standard (TPS)
- China has set a dual carbon national goal
  - To reach peak emissions by 2030
  - To achieve carbon neutrality by 2060
- TPS currently only covers the **power** sector
  - Once fully implemented, will covers **8** carbon intensive sectors
- TPS differs from other Carbon Markets
  - Intensity based instead of mass-based system
  - Facility's compliance thus depends emissions intensity and not on absolute level of emissions
- TPS Compliance Methods
  - Reducing emissions intensity
  - Purchasing emissions allowances
  - Reducing intended output
- TPS Advantage: levels of production can change without directly changing compliance costs when macroeconomic conditions change
- TPS Disadvantage: reduction in CO_2 emissions are achieved at a higher cost than cap and trade carbon market systems

Timeline of Key Policies and Measures Covering Coal-Fired Plants



Source: World Economic Forum, China's New Carbon Market Aims to Substantially Reduce its Emissions / IEA, China's Emissions Trading Scheme

EU (ETS) Carbon Market – Case Study

- **EU Goals**
  - 2050: achieve carbon neutrality
  - 2030: achieve a 55% minimum net reduction of GHG emissions
- **Market Stability Reserve**
  - Surplus of emissions allowances (largely due to economic crisis and high imports of international credits) has built up since 2009
  - **Short term**: undermines function of ETS
  - **Long term**: hinder ETS ability to meet targets in a cost-efficient manner
- **Emissions Cap and Allowances**
  - Overall volume of emissions allowances (1 ton CO2/N2)/PCFs) is capped and decreased annually. Firms trade allowances as needed.
- **Use of International Credits**
  - EU does not currently plan to continue the use of international credits for EU ETS compliance as of 2020

Development of EU ETS (2005 -2020)

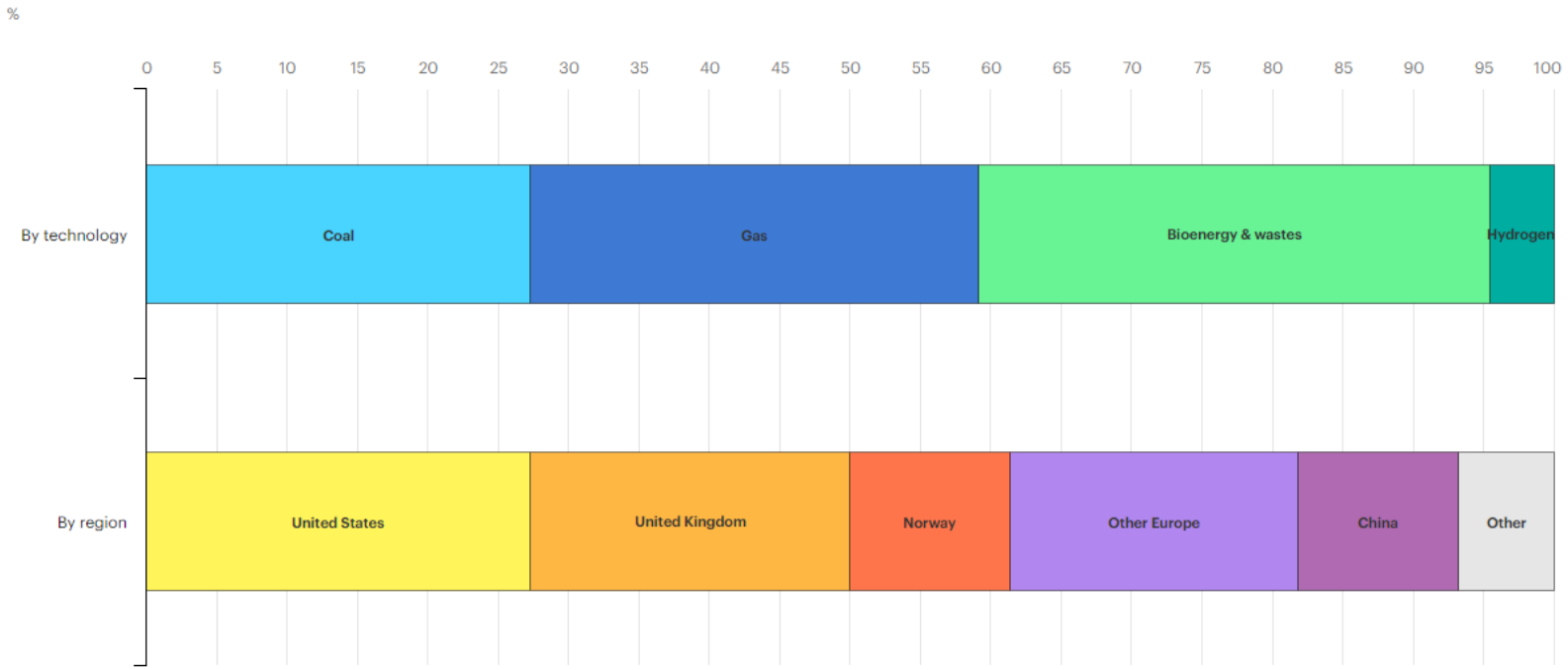
First Steps	Phase 1 2005 – 2007	Phase 2 2008 – 2012	Phase 3 2013 - 2020	ETS Evolution
• 1997: Kyoto Protocol sets legally-binding emissions reduction targets for 37 industrialized countries • 2000: EU commission presents a green paper with ideas on the design of EU ETS • 2003: EU ETS Directive is adopted in 2003 and system is launched in 2005	• 3-year pilot for phase 2 • Covered only power generators and energy-intensive industries • Established a price for carbon • Established free trade in emission s allowances across the EU • Established infrastructure needed to monitor, report, and verify emissions	• Coincided with first commitment period of Kyoto Protocol (concrete emissions targets) • Lower cap on allowances • Nitrous Oxide (N2) included by a handful of countries • Proportion of free allocation falls to ~90% • Penalty for non-compliance : 100 Euros • Firms allowed to buy international credits	• National caps are changed for EU-Wide caps • Auctioning is now the default method of allocating allowances (no more free allocation) • More sector and GHG are included • 300 million allowances set aside to fund deployment of renewable energy technologies and CCUS through NER 300 Program	• Phase 1: Trading volume rises from 321m (2005) to 2.1bn (2007) • Phase 2: EU ETS is and remained main driver of the international carbon market • Phase 2: EU allowances account for 84% of the value of total global carbon market • Phase 2: Trading volume rises from 3.2bn (2008) to 7.9bn (2012)

Source: EU Emissions Trading System (EU ETS)

CCUS in a Global Context

- 40+ CCUS generation projects are currently being developed worldwide
  - Potential combined capture capacity of ~60 Mt CO2 per year
  - Successful completion of projects will have potential to act as anchor projects, resulting in industrial CCUS hubs and creating economies of scales for shared infrastructure development
- Governments and Industry have committed $18bn+ to CCUS specific projects and programs since early 2020
- 2021 CO2 capture capacity from power and industrial facilities: **40 million tons**

CO2 Capture Projects in Power Generation Under Development by Technology and Region, 2021



Source: IEA, CCUS in Power, November 2021 | IEA, Carbon Capture, Utilization and Storage

US Decarbonization Efforts

- Emissions Reduction Target: 50-52% reduction in GHG pollution from 2005 levels in 2030
- Emissions Reduction Target: net zero emissions by 2050
- Carbon pollution free power sector by 2035
- Biden administration has launched a whole-of-government process known as *Nationally Determined Contribution*, to formally establish 2030 emissions target to the United Nations Framework Convention on Climate Change (UNFCCC)
- Biden administration launched Justice40 Initiative: Deliver 40%+ of the overall benefits from federal investments in climate and clean energy to disadvantaged communities
- Announcement of Build Back Better World Infrastructure Initiative to
  - mobilize billions of dollars between G7 members and the private sector in sustainable, infrastructure investment for low- and middle-income countries
  - Achieve the goals of the Paris Climate Agreement

Reducing Emissions and Accelerating Clean Energy

Transportation Sector

- Set a target of 50% EV sales share by 2030
- Accelerate deployment of EV and Chargers
- Move US federal fleet to zero-emissions vehicles

Buildings Sector

- DOE launched Initiative for Better Energy, Emissions and Equity on RDD&D of clean heating and cooling systems
- EPA updated ENERGY STAR standard to promote innovative heat pump technologies and increase electric appliances

Power Sector

- Supported solay deployment through new National Community Solar Partnership
- Jumpstarted offshore wind energy projects
- DOE is financing construction of transmission lines throughout the Western Area

Industry Sector

- EPA finalized a federal plan to limit methane emissions from municipal solid waste landfills
- Outlined framework for responsible scaling of CCUS
- DOE launched the Energy Earthshots Initiative to drive clean energy breakthroughs (Hydrogen, Storage)

Lands and Waters Sector

- America the Beautiful Initiative to conserve 30% of US Lands & Waters by 2030
- DOI suspended all oil and gas leasing activities in Arctic National Wildlife Refuge
- USDA launched a new Climate-Smart Agriculture and Forestry Partnership Initiative

Source: The White House, April 22, 2021 – Statement and Releases | The White House, National Climate Task Force

US Carbon Market Case Study – California Cap-and-Trade (CaT) Program Progress and Development

- Sets a statewide limit on sources responsible for 85% of California's GHG emissions
  - Establishes a price signal needed to drive long-term investment in cleaner fueled and more efficient use of energy
- Program covers ~450 entities
  - 2013: Electricity generators and large industrial facilities emitting 25,000+ MTCO2e
  - 2014: California & Quebec combine to form one market
  - 2015: Distributors of transportation, natural gas, and other fuels
- Cap of Emissions
  - 2013: ~2% below emissions level forecast for 2012
  - 2014: Declined by ~2%
  - 2015-2020: Declined by ~3% annually
- Milestones
  - 2012: ARB conducts first auction of allowances
  - 2013: compliance obligation for GHG begins
  - 2014: Linked with Quebec's CaT System
  - 2014: program achieves 100% compliance at first compliance event

Summary of California-Quebec Joint Auction Settlement Prices and Results

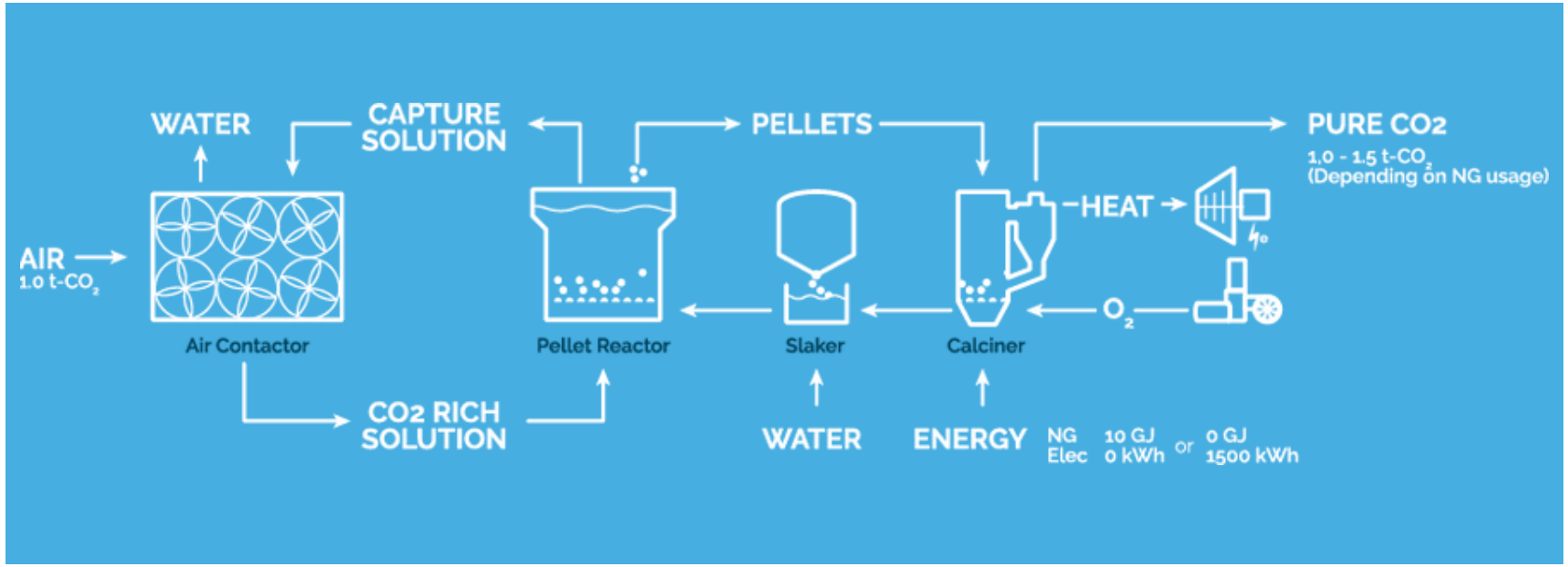
Auction	Total Current Auction Allowances Offered	Total Current Auction Allowances Sold	Current Auction Settlement Price	Total Advance Auction Allowances Offered	Total Advance Auction Allowances Sold	Advance Auction Settlement Price	% Change Current Allowances Offered	% Change Advance Allowances Offered	% Change Current Settlement Price	% Change Advanced Settlement Price
November 2021	68,598,217	68,598,217	$28.26	8,306,250	8,306,250	$34.01	-3.74%	0.00%	21.29%	43.6%
August 2021	71,261,536	71,261,536	$23.30	8,306,250	8,306,250	$23.69	-0.54%	0.00%	23.94%	24.4%
May 2021	71,647,138	71,647,138	$18.80	8,306,250	8,306,250	$19.04	30.81%	0.00%	5.62%	5.7%
February 2021	54,773,607	54,773,607	$17.80	8,306,250	8,306,250	$18.01	-2.83%	-4.22%	5.14%	3.8%
November 2020	56,366,432	56,366,432	$16.93	8,672,250	8,672,250	$17.35	-4.87%	0.00%	1.50%	3.7%
August 2020	59,250,484	52,627,000	$16.68	8,672,250	8,672,250	$16.73	2.97%	0.00%	0.00%	0.3%
May 2020	57,540,731	21,161,000	$16.68	8,672,250	1,763,000	$16.68	-	-	-	-

Source: California Air Resources Board, Summary of Auction Settlement and Prices | ARB Emissions Trading Program | 1PointFive, Technology

CCUS in a US Context

- Only **ONE** commercial power plant equipped with CCUS remains in operation as of November 2021
- Potential capture capacity of all CCUS deployment in power is projected to reach ~60 Mt CO2 in 2030
  - Fails to meet 430 Mt CO2 per year in NZE2050 Scenario (Refer to IEA Scenarios in Appendix)
- Plans for ~30 new CCUS equipped powerplants (30 Mt CO2 per year) were announced between 2020 and 2021
  - Largely due to new investment incentives in the United States
- Technological Innovation: **DAC 1**
  - Will begin operation in 2024
  - World's first largest direct are capture (DAC) facility
  - Located in Permian Basin of the US
  - FEED Phase: 0.5 MtCO2/year
  - Total Capacity Post Feed Phase: 1 MtCO2/Year

DAC 1 – Carbon Engineering Technology: How it Works



Source: IEA, CCUS in Power, November 2021 | IEA, CCUS Around the World, DAC 1

Measuring Emissions – Barrier Moving Forward

- Fewer than 1 in 10 companies are measuring GHG emissions correctly
- 81% of companies do not report emissions related to their own activities
- 66% of companies omit emissions from their suppliers and customers
- More than half of the companies surveyed acknowledged an error rate of as much as 40%
- Only 11% of companies surveyed (1,290 organizations) hit their emissions reduction targets over the past five years
- Possible solutions
  - simulation tools to help predict future emissions
  - accurate measurement through AI to increase efficiency and reduce emissions by as much as 40%

Analysis of UNFCCC Emissions Reporting, 2019

Emissions Claimed by Countries (in billion metric tons)	Independent Inventories Floor (in billion metric tons)	Independent Inventories Ceiling (in billion metric tons)	Reported Emissions Gap Floor (%)	Reported Emissions Gap Ceiling (%)	Reported Emissions Gap, Average (%)
44.2	52.7	57.4	16	23	19.5

Source: Bloomberg Green, Finance, "Over 90% of Firms Aren't Measuring Emissions Correctly, BCG Says" | The Washington Post's Analysis of UNFCCC Emissions Reporting

Energy Transition and Global Finance - Risks

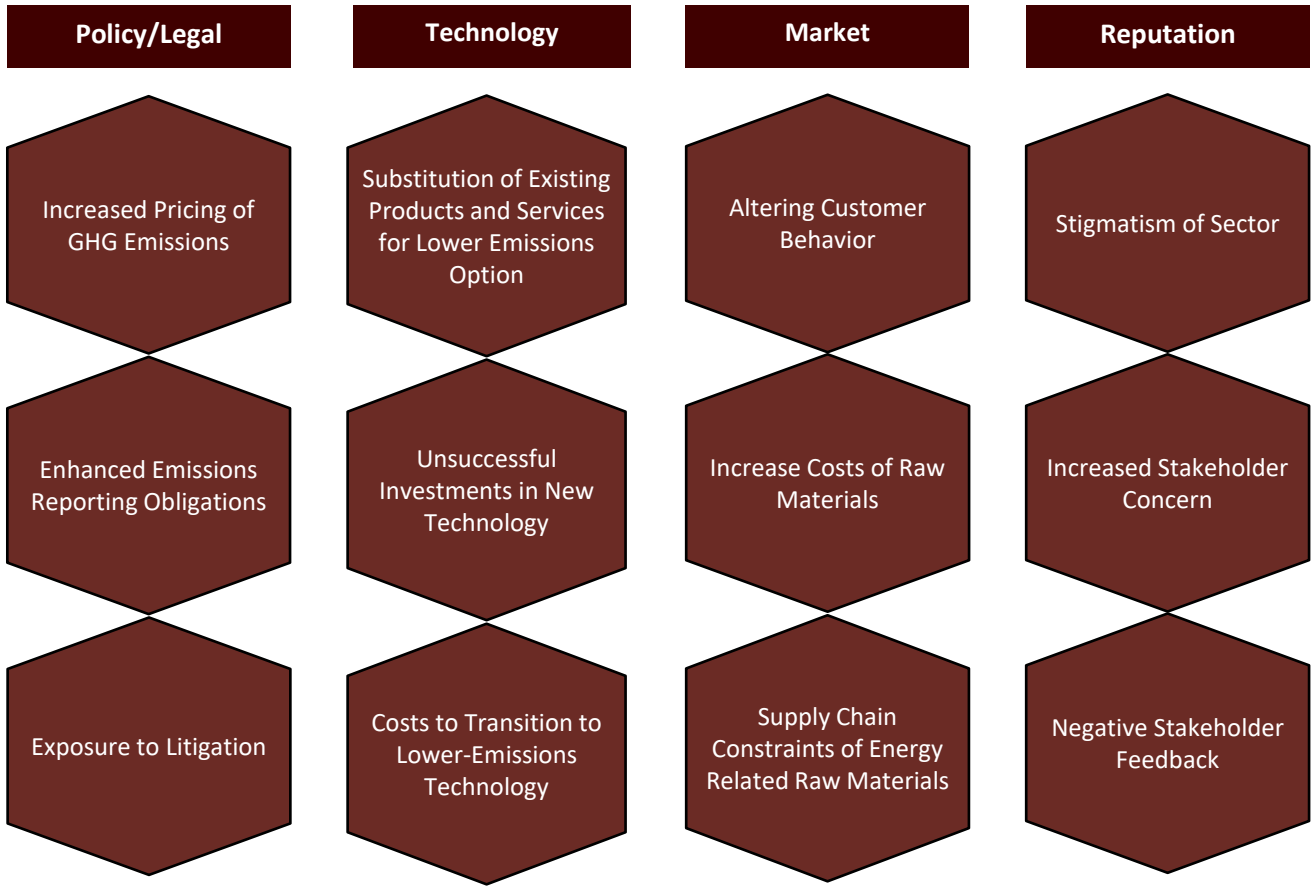
Potential Financial Impacts

Policy/Legal: An increase in a higher level of compliance and judgement is expected to lead to an increase of operating costs for products and services leading to negative financial impact

Technology: An energy transition to cleaner technologies is expected to lead to early retirements of existing assets that fail to meet sustainability standards. Moreover, high amounts of capital investments in technology development will be required. With unprecedented levels of investments in the next decades, companies may experience an erosion of liquidity needed to service short-term and long-term debt commitments.

Market: Increased production costs as a result of changing input prices (e.g. energy and water). Reduction in goods and services demand.

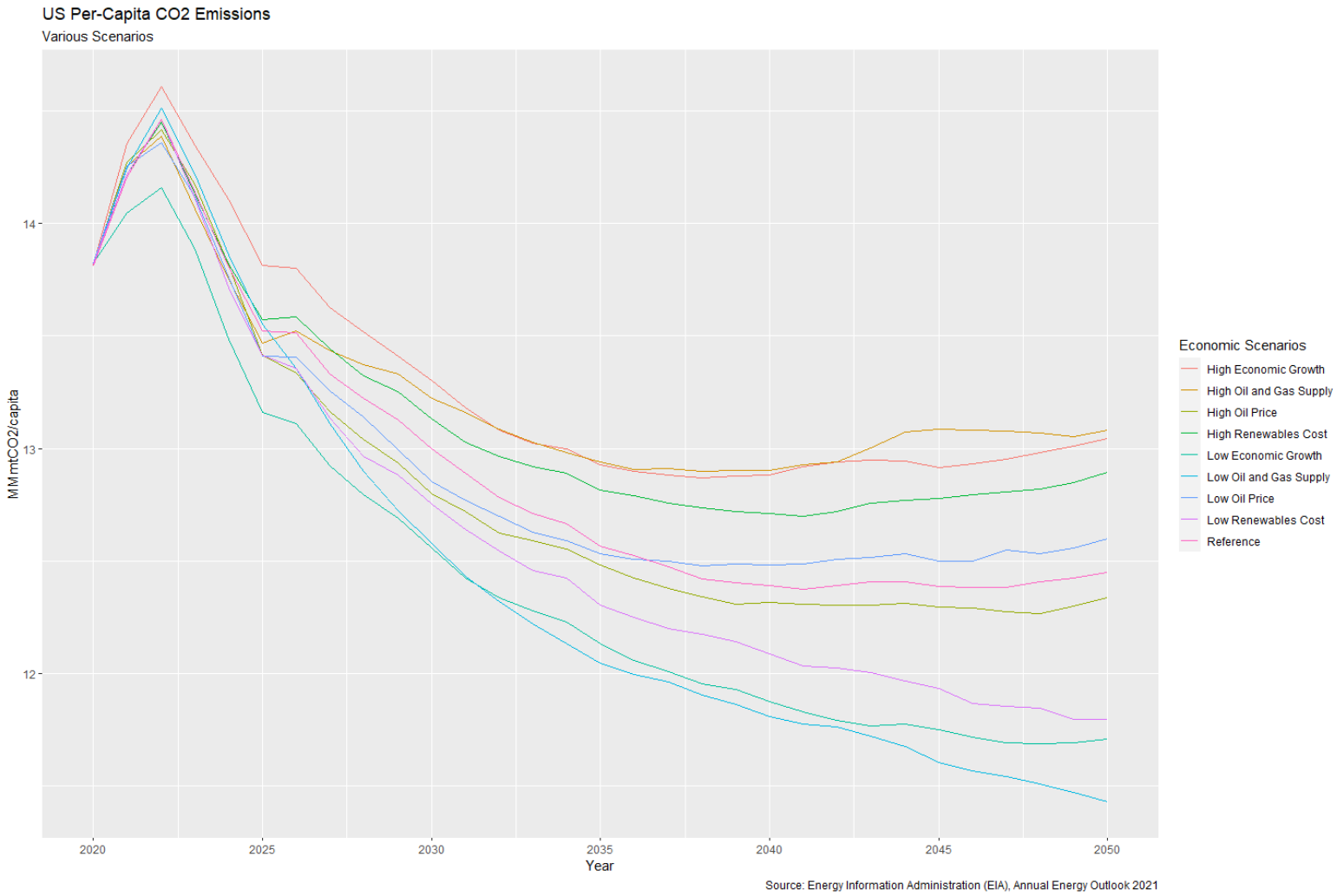
Reputation: Reduction of revenue from decreased demands for goods and services. Moreover, a decreased productivity capacity.



Source: Kepler Chevreux Transition Research, Transition Risks: How to Move Ahead

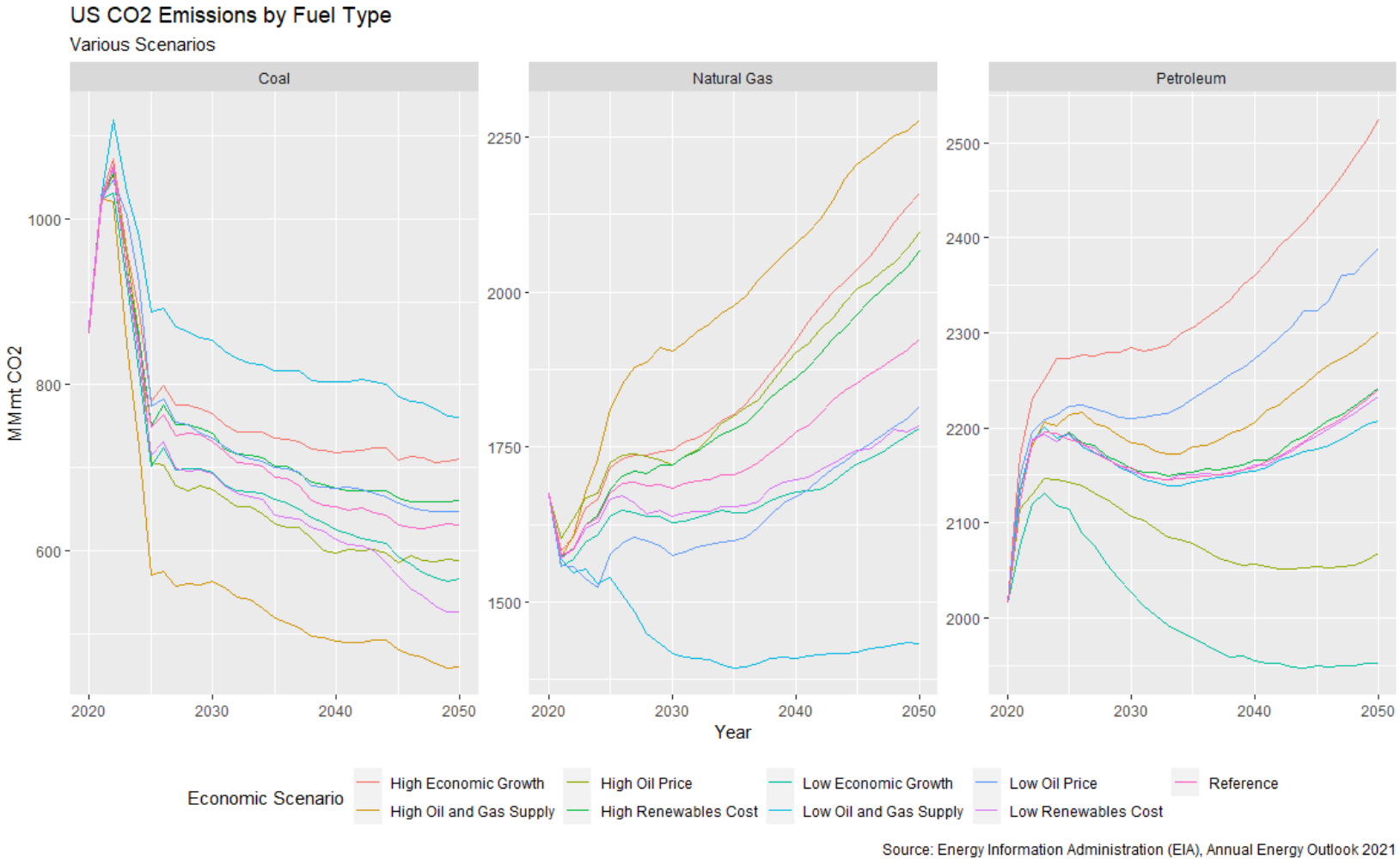
US CO2 Emissions Outlook – Individual Level

- Peak of US per capita carbon dioxide emissions is expected in 2022
- Highest per capita emissions
  - High oil and gas supply scenario
  - ~13 MMmtCO2/capita
- Lowest per capita emissions
  - Low oil and gas supply
  - ~11.5 MMmtCO2/capita
- Reference
  - ~12.5 MMmtCO2/capita



US CO2 Emissions Outlook – Fossil Fuels

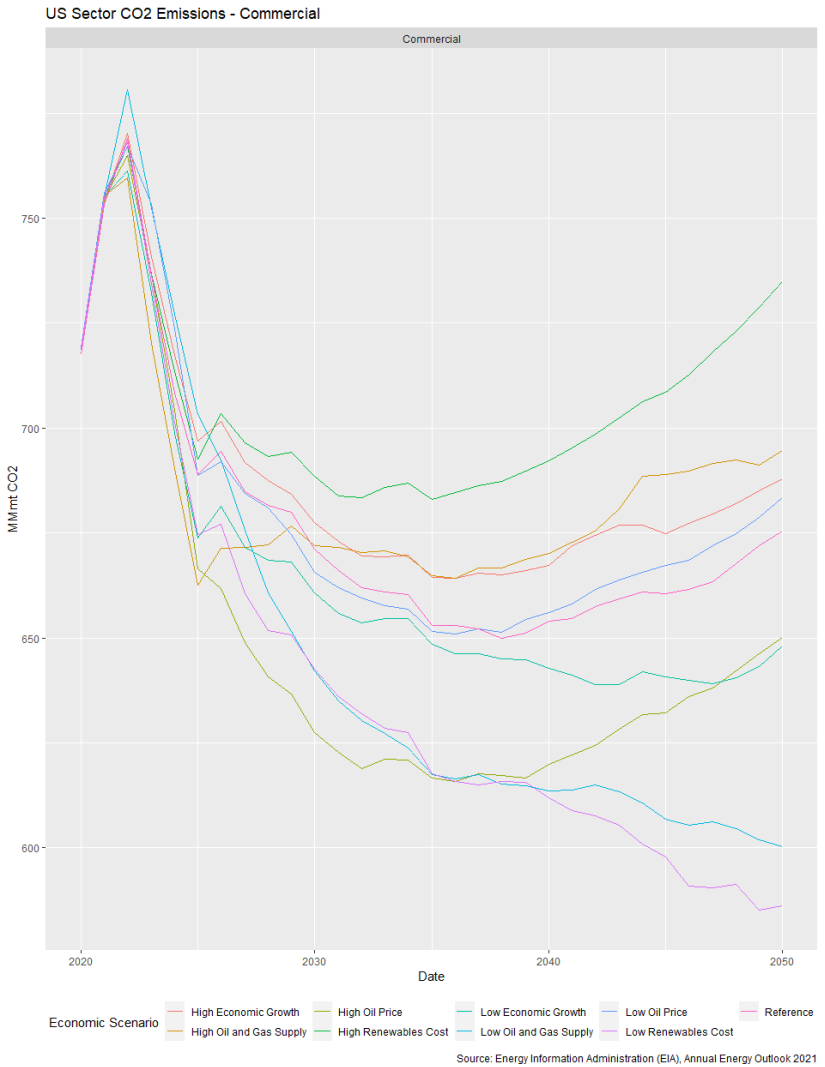
- Coal in 2050
  - Peak expected in 2022 then decreasing until 2050
  - 2050 (Highest): ~750 MMmtCO2 (Low Oil and Gas Supply) to
  - 2050 (Lowest): ~450 MMmtCO2 (High Oil and Gas Supply)
  - 2050 (Reference): ~650 MMmtCO2
- Natural Gas in 2050
  - Overall increasing (except for Low Oil and Gas Supply Scenario)
  - 2050 (Highest): ~2300 MMmtCO2
  - 2050 (Lowest): ~1430 MMmtCO2
  - 2050 (Reference): ~1900 MMmtCO2
- Petroleum in 2050
  - Overall net increase moving forward (except for Low Oil and Gas Supply Scenario)
  - 2050 (Highest): ~2525 MMmtCO2
  - 2050 (Lowest): ~1900 MMmtCO2
  - 2050 (Reference): ~2240 MMmtCO2

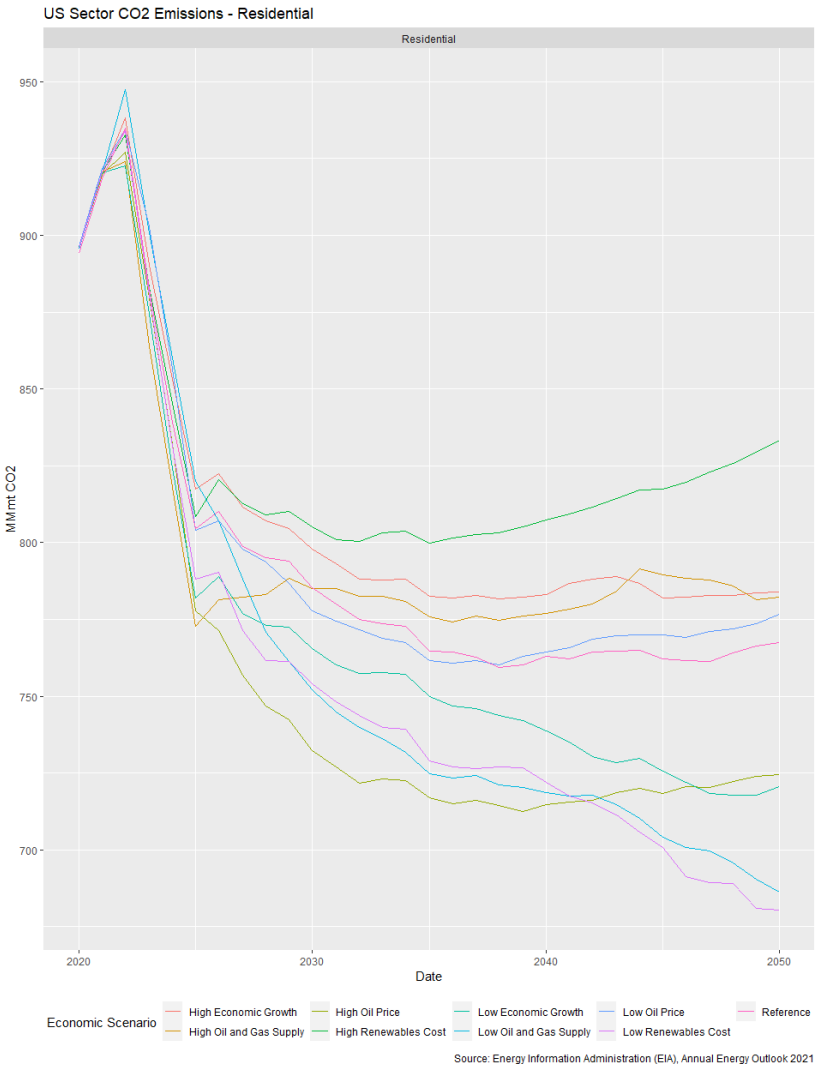


Source: Energy Information Administration (EIA), Annual Energy Outlook 2021

US CO2 Emissions Outlook – Commercial and Residential Sectors

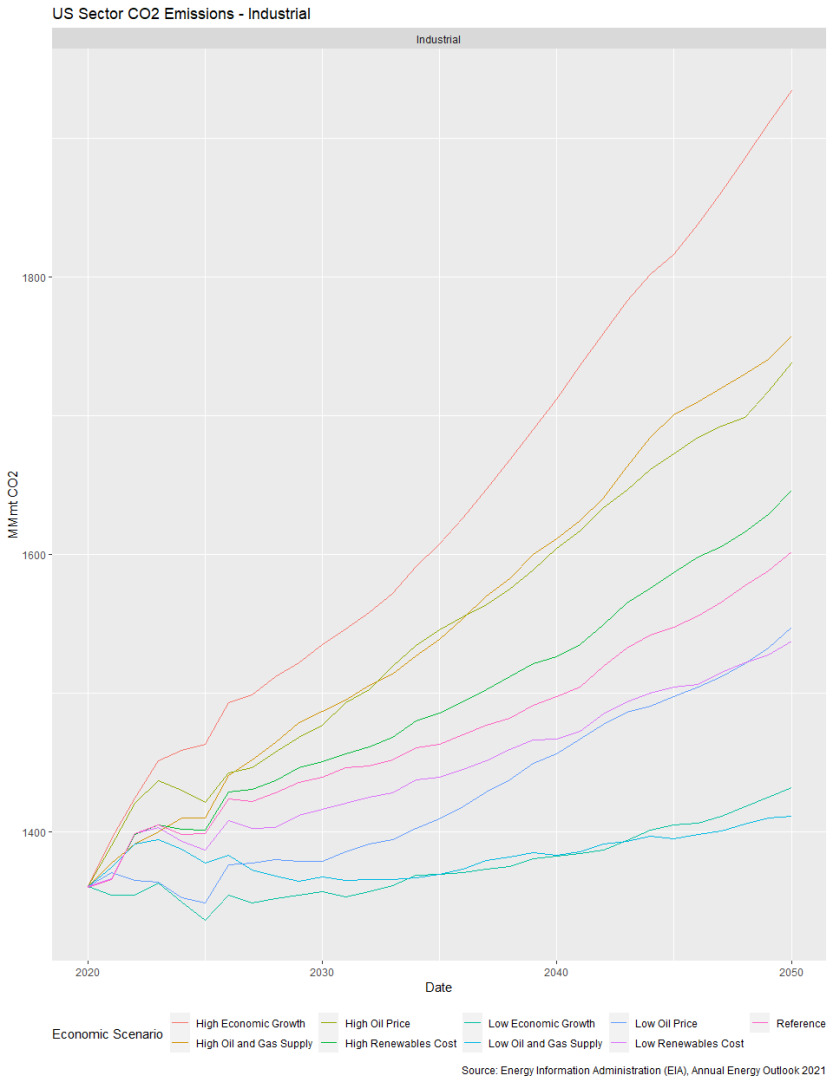
- **Commercial Sector**
  - High (High Renewables Cost): ~760 MMmtCO2
  - Low (Low Renewables Cost): ~585 MMmtCO2
  - Reference: 675 MMmtCO2
- **Residential Sector**
  - High (High Renewables Cost): ~830 MMmtCO2
  - Low (Low Renewables Cost): ~680 MMmtCO2
  - Reference: ~760 MMmtCO2
- **Takeaways**
  - Steep decline of sector emissions from 2020-2025
  - Sector emissions expected to peak in 2022
  - Overall, a decline in Commercial and Residential emissions is expected moving forward (except for High Renewables Cost scenario in Commercial Sector)

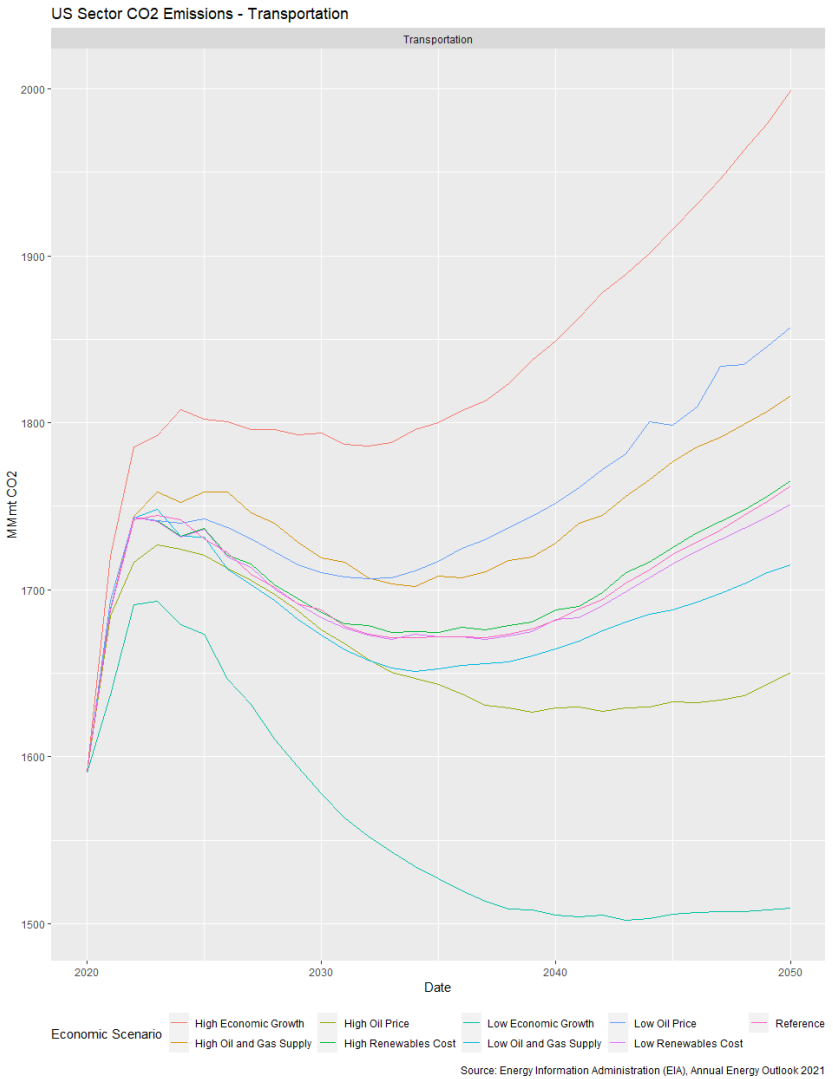




US CO2 Emissions Outlook – Industrial and Transportation Sectors

- Industrial Sector
  - High (High Economic Growth): ~1950 MMmtCO2
  - Low (Low Oil and Gas Supply): ~1410 MMmtCO2
  - Reference: 1600 MMmtCO2
- Transportation Sector
  - High (High Economic Growth): 2000 MMmtCO2
  - Low (Low Economic Growth): ~1520 MMmtCO2
  - Reference: 1750 MMmtCO2
- Takeaways
  - Overall, there is an expected increase in emissions for these sectors
  - Industrial Sector set to experience linear growth moving forward to 2050
  - Transportation Sector set to experience exponential growth between 2020 – 2025 where it will then steadily experience a net increase (except for in Low Economic Growth Case) to 2050





The Future of Carbon Markets

- **Takeaway:** Voluntary carbon credit markets is set to continue to grow dramatically, aided by firm demand in efforts towards carbon neutrality goals
- Key Terms
  - CORSIA: Carbon Offsetting and Reduction Scheme for International Aviation
  - Platts CEC: Publishes daily price for CORSIA eligible credits (in $/mtCO2e). Reflects spot market for specific maturations for delivery in the current year
  - Platts CNC: reflects most competitive nature-based carbon credits (in $/mtCO2e)
- 2022 Optimism
  - Platts carbon price assessments sharply rise last year
  - Participants are hopeful for continued market momentum in 2022
  - Platts CEC assessment up 900% in 2021
  - Platts CNC up 200% since launch
- Voluntary carbon markets played a significant role in decarbonization efforts in 2021

TSVCM's Blueprint for Action

Creating shared principles for defining/verifying carbon credits	• Current voluntary carbon credits lack liquidity due to heterogenous nature pertaining to credit attributes (project, region, etc.) • Matching of buyers and suppliers can be eased via credits becoming uniform (core carbon principles) • Uniform features: quality criteria and standardized additional attributes
Developing contracts with standardized terms	• Uniform carbon credits will allow for consolidation of trading activity around fewer credit types and thus promote liquidity on exchanges • Creation of reference contracts post "core carbon principle" implementation to be used for trading •Reference contracts will allow for bulk trading and the development of a clear daily market price
Establishing trading and post-trade infrastructure	• Resilient trading infrastructure will help facilitate high-volume listing, trading of carbon credits and would support creation of structured finance products for project developers • Post trade infrastructure (clearinghouse and meta-registries) is necessary for carbon market development (futures market, standardized issuance numbers per project, transparency of data, etc.)
Creating consensus about proper use of carbon credits	• Companies benefit from clear guidance emissions offsetting programs and efforts in the overall push toward net zero emissions • Principles for the use of carbon credits would ensure offsetting does not preclude other efforts to decrease emissions (guiding away from simply purchasing carbon credits and not reducing emissions)
Implementing mechanisms to safeguard the market's integrity	• Establishing digital processes by which projects and credits can be registered, verified and tracked • Processes will lead to an increase in the integrity of carbon market and thus have positive impact on market growth
Transmitting clear signals of demand	• Long-term demand signals: commitments to reduce emissions or upfront agreements with project developers to buy credits from future projects •Medium-term demand signals: registry records on commitments to purchase carbon credits • Ensuring industry wide collaboration and better standards and infrastructure for development of credits

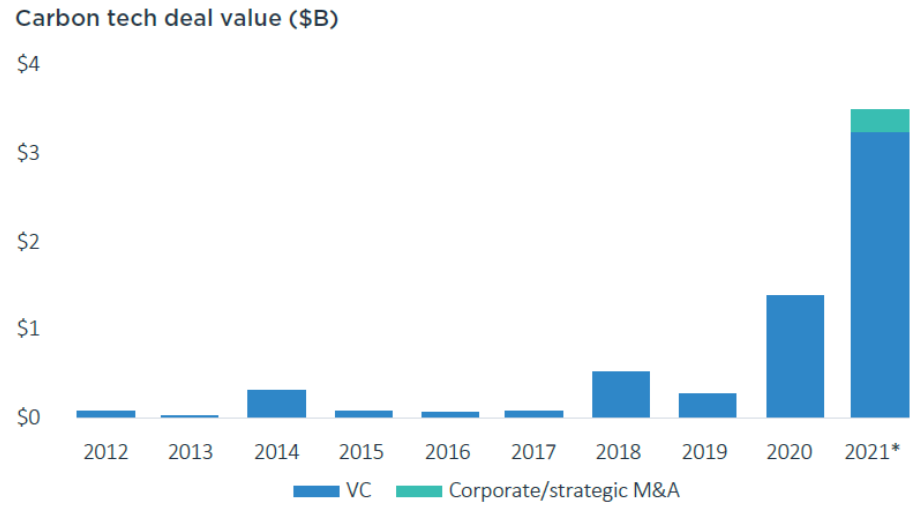
Source: McKinsey Sustainability, A Blueprint for Scaling Voluntary Carbon Markets to Meet the Climate Challenge | S&P Global, Energy Transition

The Future of Carbon Capture Utilization and Storage (CCUS)

- **Takeaway:** Carbon negative technology (especially DAC) represents a long-term mega trend that is set to drive significant VC investments in 2022
- 2021 UN Climate Change in Glasgow highlighted need for greater CCUS advancement
- Climate models now show that decarbonizing society alone will not suffice in effort to reduce emissions to meet 1.5-degree Celsius global goal
  - CCUS is necessary to meet goal
- **Caveat:** DAC is currently an expensive technology to operate (limited by physical separation efficiency of CO2)
- **Caveat:** DAC has not yet reached markets at a large scale
- 19 DAC plants operate worldwide and over 100 CCUS facilities have been announced in 2021
- Globally, CCUS firms have raised $5.4bn from 2018-2021 YTD
  - In the first 3 Quarters of 2021, $3.2bn was raised

VC climate tech startups to watch

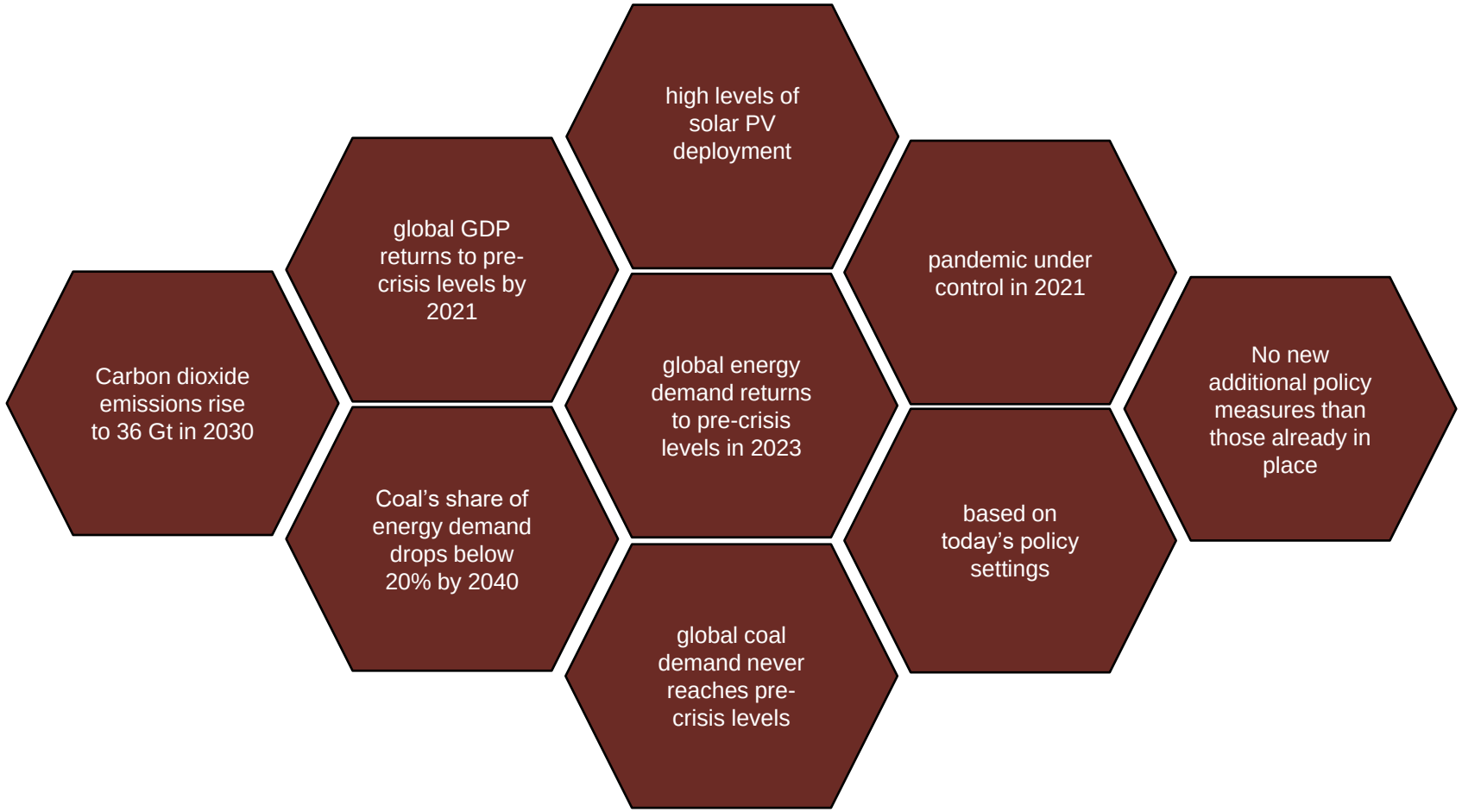
Stage	Company	Last Financing Size ($M)	Total VC Raised ($M)	HQ Country	Reason to Watch
Early	Carbon Capture	35.0	43.6	US	Reduces DAC costs through sorbent tech
Early	AirCapture	Undisclosed	Undisclosed	US	Utilizes a decentralized capture of carbon for downstream applications
Early	1PointFive	Undisclosed	Undisclosed	US	Uses industrial-scale air capture tech
Late	LanzaTech	30.0	579.50	US	Uses Industrial-source carbon recycling technology
Late	ClimeWorks	Undisclosed	155.90	Switzerland	Uses sorbent-based DAC tech
Late	Svante	100.0	154.20	Canada	Utilizes carbon capture from industrial sources at 50% the capital cost



Source: PitchBook Emerging Tech Research, 2022 Emerging Technology Outlook

Global Energy Outlook – Stated Policies Scenario (STEPS)

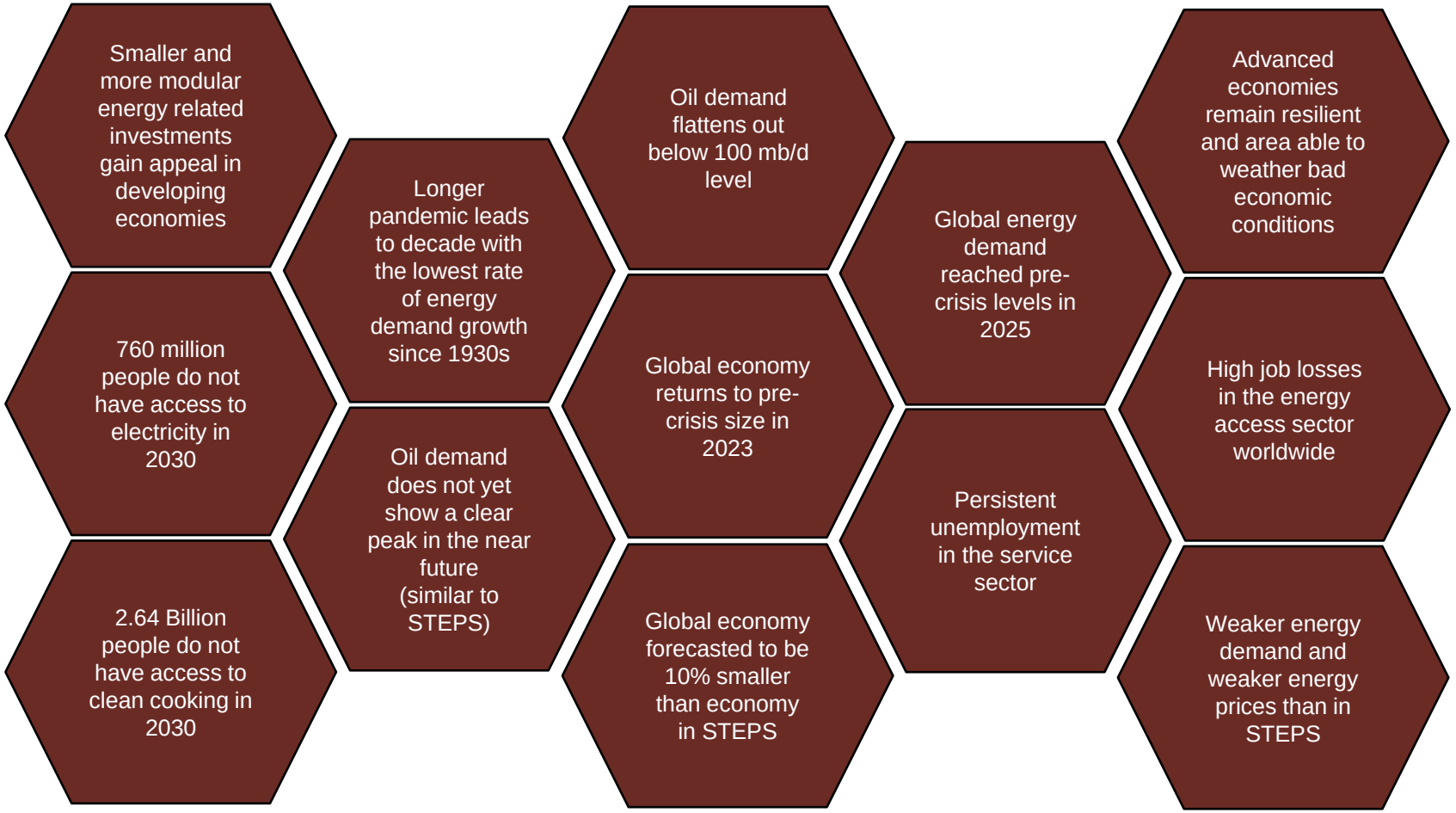
- Reflects all of today's announced policy measures and targets that are backed up by detailed information related to their realization by proposing entities
- Reflects progress with the implementation of corporate sustainability commitments in
  - Outlook for industrial use
  - Emissions
  - Prospects for renewable electricity
- Negative impacts on growth and energy consumption remain in existence in a significant number of low-income countries, leading to a delay in stated goals towards energy access and clean cooking within affected countries
- Major conventional resource holders act to prevent prices from reaching levels that cause
  - A return to very rapid growth in US tight oil production
  - An increase in faster substitution away from oil by consumers



Source: IEA, World Energy Outlook 2020

Global Energy Outlook – Delayed Recovery Scenario (DRS)

- Designed with the same policy foundations as in the Stated Policies Scenario (STEPS) except in this specific scenario the pandemic lasts longer and thus leads to larger economic and social damages
- High debt and political constraints limit the effectiveness of fiscal stimulus and private debt overhang, along with weak confidence results in ineffective monetary expansion in the US
- There exists a lower level of energy consumption as a result of negative near-term economic conditions in emerging markets and developing economies
- Less progress is made in this scenario when compared to STEPS in closing the gap with pre-crisis GDP forecasting; the gap narrows by 2025 in STEPS and there is a less certain date for DRS
- With an attraction in more steady cash flow profiles, renewable power investments should continue to benefit as well as electricity networks

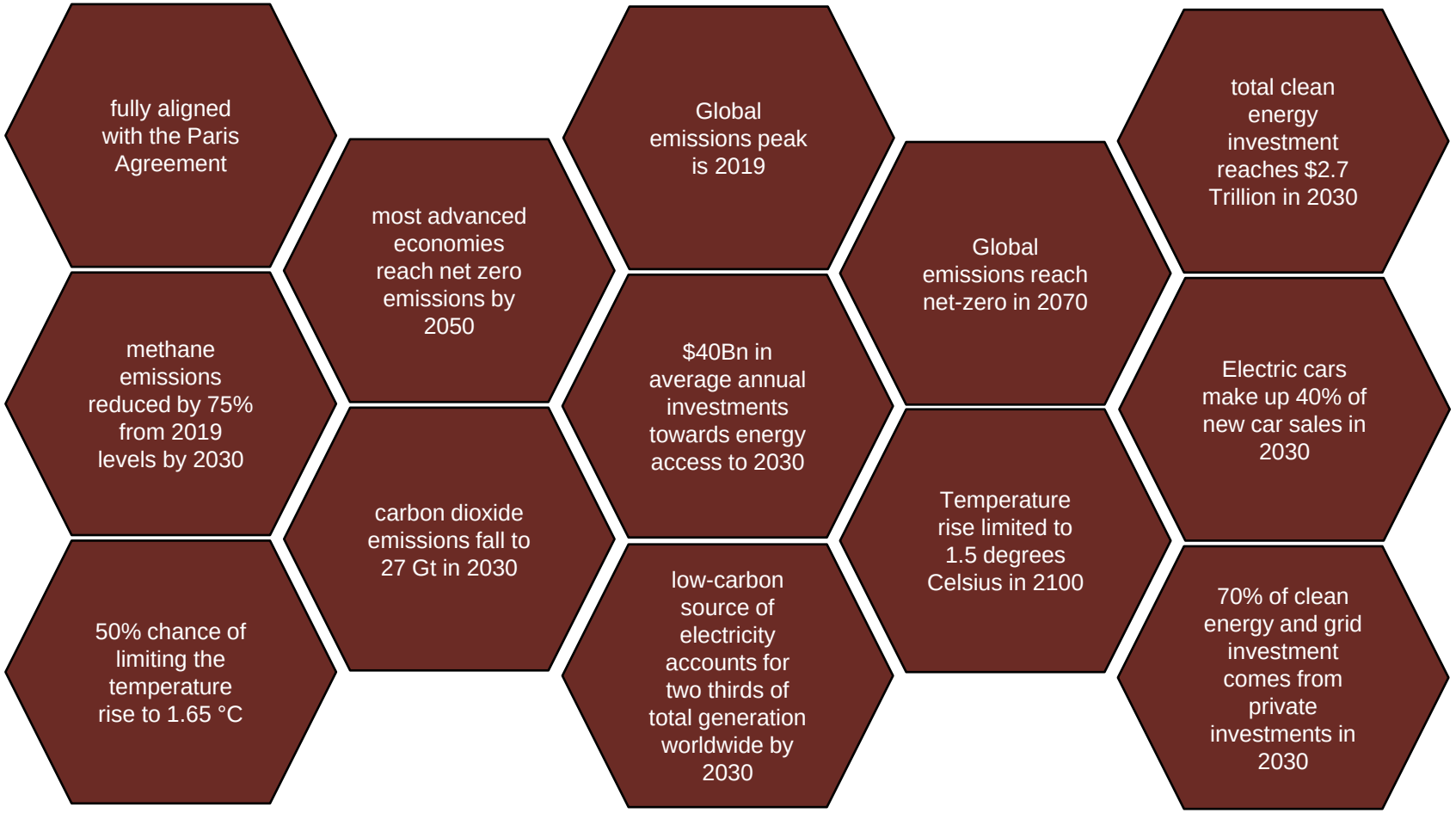


Source: IEA, World Energy Outlook 2020

Global Energy Outlook – Sustainable Development Scenario

- Rapid increase in clean energy policies and investments place energy system on path to achieve sustainable energy objectives in full
- Based on the same economic and public health outlook as in the State Policies Scenario (STEPS)
- Provides a way to explore the impacts of more far-reaching changes in policies aiming to make modern energy services universally accessible, affordable, and reliable by 2030
- Drawn from the IEA Sustainable Recovery Plan, which aims for cost-effective measured to revitalize economies while creating jobs and constructing cleaner and more resilient energy systems
- Spans six key sectors:
  - Electricity
  - Transport
  - Industry
  - Buildings
  - Fuels
  - Emerging Low-Carbon Technologies

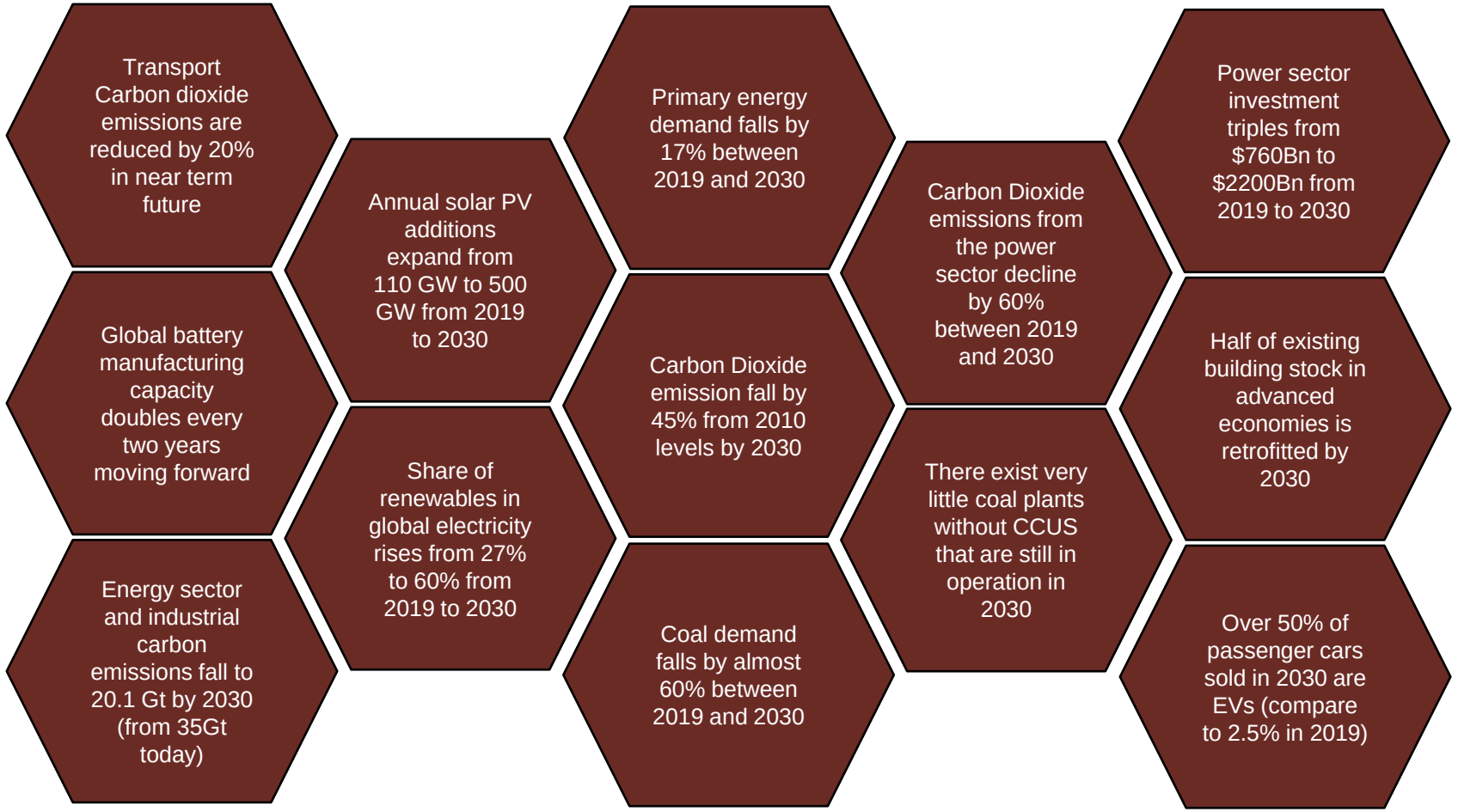
Figure 3: SDS Key Points



Source: IEA, World Energy Outlook 2020

Global Energy Outlook – Net Zero Emissions by 2050 (NZE2050)

- Carbon dioxide emissions in this scenario are 6.6 Gt lower than in the SDS in 2030 (20.1 Gt is the forecasted emissions under NZE2050)
- Global Electricity Supply Make up in 2030
  - Renewables: 60%
  - Nuclear Power: 10%
  - Coal Plants (no CCUS): 6%
- More than one third of forecasted power sector investments from 2019 to 2030 are expected to be used to expand, modernize, and digitalize electricity networks
- Unparalleled transformation of the energy sector and major consumer and entity behavioral changes within the next decade would need to take place to achieve this scenario
- Lessons from existing Net-Zero commitments:
  - Electrification is central to emissions reduction
  - Low-carbon fuels such as hydrogen are still relevant
  - There is an urgent need to boost support for technology innovation
  - It will be critical to engage with consumers to engage public acceptance and energy affordability



Source: IEA, World Energy Outlook 2020

Energy Information Administration (EIA) US Annual Energy Outlook 2021 Scenarios

- Assumptions
  - Current laws and regulations as of September 2020 remain unchanged
  - Current views on economic and demographic trends, and technology improvements
- Key Takeaways
  - Returning to 2019 US energy consumption levels will take years
  - US energy related CO2 emissions fall further before leveling off or rising
  - Renewable energy incentives and falling technology costs encourage high competition with natural gas as coal and nuclear power decrease in terms of electricity mix share
  - Continuing record-high domestic energy production supports natural gas exports but does not entail mean growth in US trad balance in petrol-based products

Reference

- 2.1% compound annual growth rate (real GDP)
- 2050 Brent Price of $95/barrel in constant 2020 USD

High Economic Growth

- 2.6% compound annual growth rate (real GDP)

High Oil Price

- 2050 Brent Crude Oil price of $173/barrel in constant 2020 USD

High Oil and Gas Supply

- More accessible resources and lower extraction technology costs

High Renewables Cost

- No cost reductions in renewable technologies

Low Economic Growth

- 1.6% compound annual growth rate (real GDP)

Low Oil Price

- 2050 Brent Crude Oil price of $48/barrel in constant 2020 USD

Low Oil and Gas Supply

- Fewer accessible resources and higher extraction technology costs

Low Renewables Cost

- Renewables achieve 40% lower overnight capital costs by 2050 compared to reference case

Source: EIA, AEO2021 Release Presentation

Energy Information Administration (EIA) International Energy Outlook 2021 Scenarios

- Assumptions
  - Reference reflects current trends among supply, demand, and price in the future
  - Reference includes existing laws and regulations, and reflects legislated energy sector policies that can be reasonably quantified
  - Includes anticipated changes overtime related to economic, demographic, and infrastructure trends
- Key Takeaways
  - Global energy consumption and related emissions are expected to continue increasing through 2050 as a result of population and economic growth
  - Renewables will be the primary source for electricity generation. However, natural gas, coal and increasingly batteries will be used to help meet load and support grid reliability (reduction in intermittency issues)
  - Oil and natural gas production will continue to increase, primarily due to increasing energy consumption in developing Asian based economies

Reference

- 2.8% annual growth rate (GDP)
- $95 per barrel (Brent Crude Oil in 2020 USD)

High Economic Growth

- 3.7% annual growth rate (GDP)

High Oil Price

- $176 per barrel (Brent Crude Oil in 2020 USD)

Low Economic Growth

- 2.0% annual growth rate (GDP)

Low Oil Price

- $45 per barrel (Brent Crude Oil in 2020 USD)

Source: EIA, International Energy Outlook Full Narrative