



### FutureTech Series

## Net Zero by 2050: Industrial Decarbonization Gains Momentum to Fight Climate Change

**A data-driven report highlighting the current state of play and future potential of industrial decarbonization to accelerate net zero efforts**

December 2021





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## TECHNOLOGY DECODING



**Decarbonizing Industry Picks Up Steam As a Key Lever to Achieve Global Goals**

- Impact of climate change • Facts and figures • Need for industrial decarbonization • Technology overview
- Notable efforts • Key disruptors

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## MEDIA & TREND ANALYSIS



**Large Enterprises and Tech Titans Double Down on Net Zero Commitments**

- Popular news publications • Decarbonization commitments • Thought leadership • Social media traction
- Mentions in company filings • Key hiring trends

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## INVESTMENT RADAR



**VCs Target Low-Hanging Fruits to Pour Millions into Industrial Decarbonization Startups**

- VC investment trends by value, volume, and geography • Leading investors
- Active startup accelerators • CVC investors and investees

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## THE ROAD AHEAD



**Will industrial decarbonization become the next frontier to achieve World's Most Urgent Mission?**

- Drivers and challenges • COP26 pledges
- Corporate commitments • Digitization
- Emerging concepts • Potential policies
- Future utilization of CO2 • Outlook

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**Corporate Giants Focus on Deep Decarbonization Solutions for a Carbon-Free Planet**

- Trends in patent filings & grants • Top patent filers • Technology leaders • Key filing trends by technology and industries
- Interesting patents

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## INNOVATION EXPLORER



**Startups Develop Novel CCUS and Hydrogen Technologies to Promote Industrial Sustainability**

- Game-changing innovations • Key tech vendor solutions • Strategic corporate partnerships to accelerate the development of decarbonized solutions

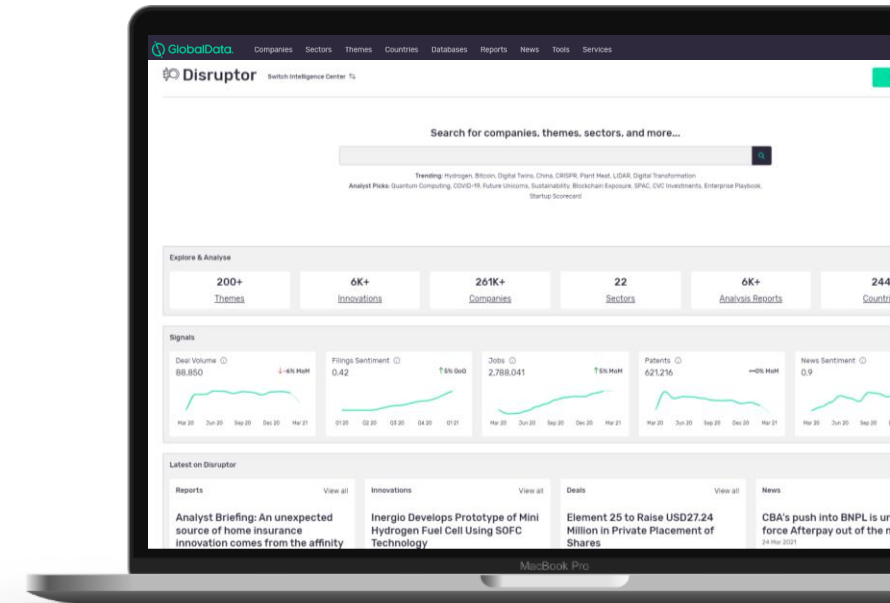
# What is Disruptor?



Identify the themes that are disrupting global industries and successfully navigate through an increasingly uncertain world, turning threats into opportunities with informed strategies that tackle disruption head on.



Disruptor provides the tools you need to understand tomorrow's technology threats so you can digitally transform your business today. The only platform providing a 360 degree view on the themes impacting the future of over 20 industries globally and giving you a clear picture of the key technology players delivering the tools and services that can drive change in your digital transformation initiatives



## Disrupt, Or Be Disrupted

Understand how your industry will be disrupted and what you can do about it. Anticipate the evolution of your market and plan your strategy accordingly



## Market Leading Competitor Intelligence

Track all themes your competitors are investing in whether by patents, acquisitions, strategic partnerships or new hires.



## Build Resilience Into Your Strategy

Assess the impact of disruptive themes on your business and identify which tech companies can help you address your biggest challenges.

# The Only Data Source You Need to Turn Disruption into Success



Disruptor thematically tags gold standard datasets and combines this insight with expert analysis to give you unparalleled cross-industry thematic intelligence

## 200 THEMES ACROSS 20+ INDUSTRIES WITH THEMATIC TAGGING COVERING:

**700,000** Companies

**40,000+** Companies' Filings Analysed

**650,000+** Deals

**8,000+** Innovations Tracked

**110M+** Patents

**10,000+** Influencers

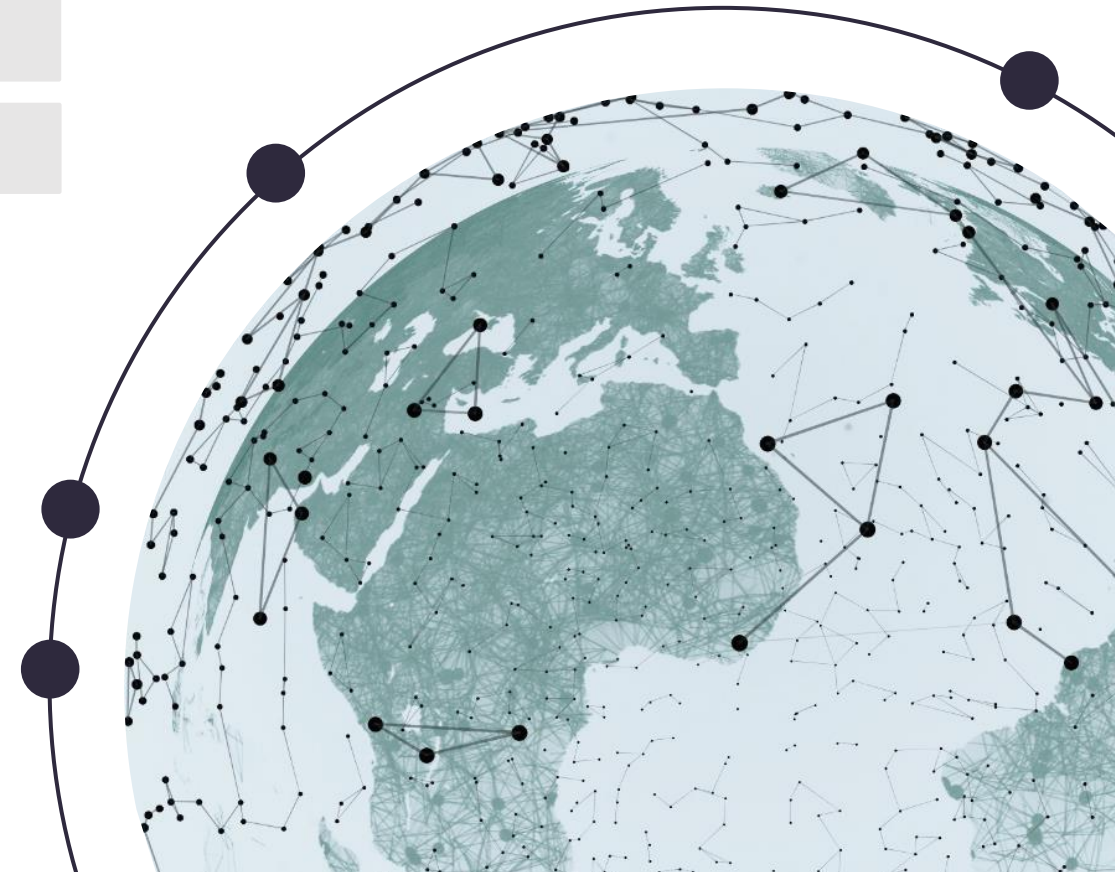
**2.8M+** News Items

**4M+** Job Openings

**7,000** Analyst Reports

**25,000** Consumer Survey Responses

**5M+** Economic Indicators



# 1

TECHNOLOGY DECODING

**Decarbonizing Industry Picks Up Steam As a Key Lever to Achieve Global Goals**



# Climate change is the single biggest threat to mankind



Global warming due to the greenhouse (GHG) effect, largely influenced by human activities such as the burning of fossil fuels and deforestation, is primarily responsible for climate change which can, among others, result in increased health risks, droughts, food shortages, poverty, and displacement.

According to the World Health Organization, “climate change is expected to cause approximately 250,000 additional deaths per year” between 2030 and 2050.



The global temperature rose 1.67 °F above the 20th century average of 60.4 °F. July 2021 is the hottest month in the last 142 years.



40% of amphibian species, ~33% of reef-forming corals, and more than a third of all marine mammals are threatened.



At 417 parts per million currently, atmospheric carbon dioxide is at its highest in 65,000 years to make the air toxic.



Glaciers and ice sheets are losing mass every year, a major cause of the rise in sea level by 7-8 inches over the last century.

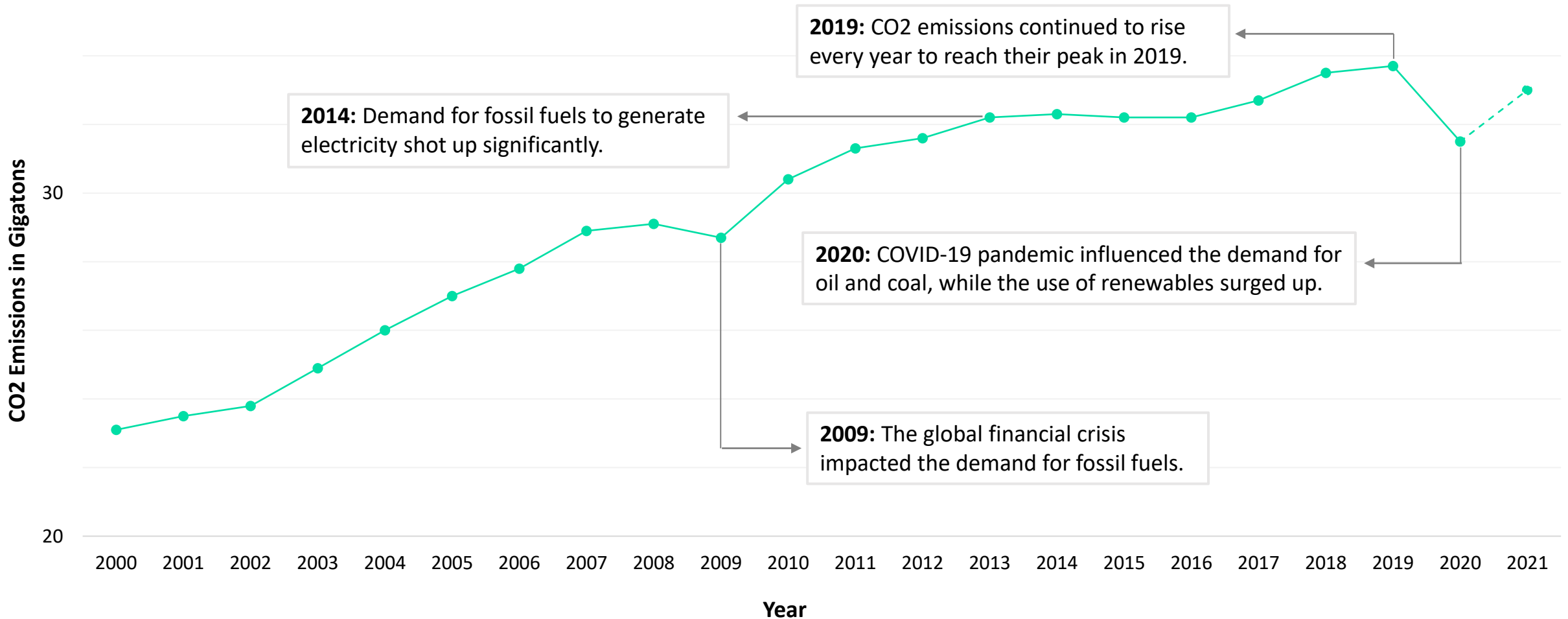


# Carbon dioxide (CO2) has been the biggest contributor to climate change



Scientists conclude that rapid global warming cannot be explained by natural cycles alone. They blame greenhouse gas emissions, especially CO2, to trap heat in the earth's atmosphere and raise the planet's average temperature.

## Global energy-related CO2 emissions: 2000 - 2021





## What is industrial decarbonization?

In a world where climate change is increasingly influenced by industrial emissions, decarbonizing the industrial sector becomes the immediate priority to phase out CO2 emissions from the use of fossil fuels.

As countries and companies target net zero emissions by 2050, the term industrial decarbonization gathers momentum as an amalgamation of emerging technologies, advanced materials, smart policies, bold investments, and new business models to push some of the largest industries to avoid the combustion of fossil fuels and remove carbon from the process chain.

## What are the key strategic priorities?

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Expand global knowledge on green technologies

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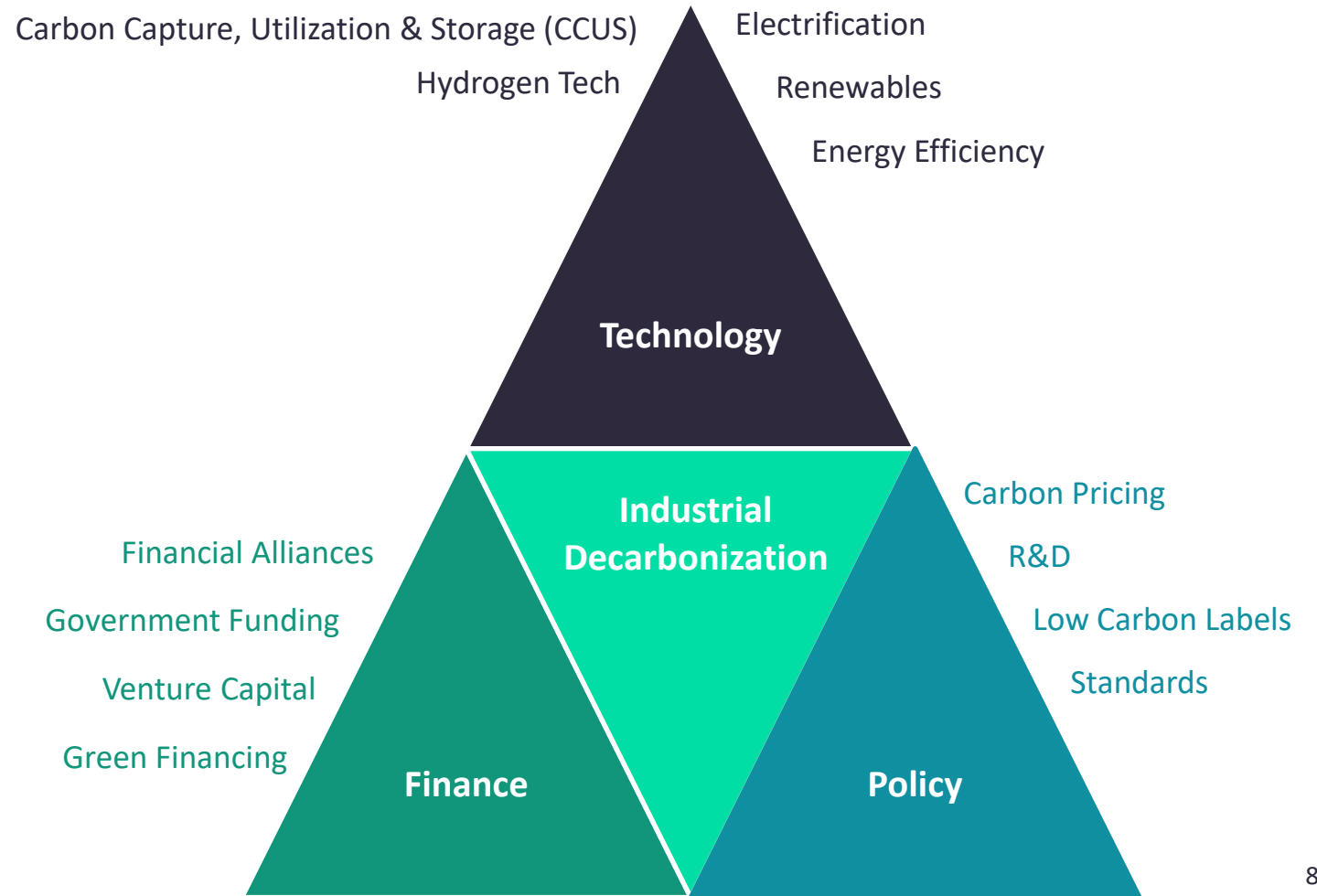
Develop incentive models to inspire quick breakthroughs

3

Stimulate partnerships for implementation at scale

# Industrial decarbonization emerges as a strong opportunity to fight climate change

Reicher triangle gains popularity as an ideal combination of technology, finance, and policy to make a tangible impact on industrial decarbonization.





# Startups have ignited the race to develop decarbonization technologies



Many companies, primarily startups, are broadly offering decarbonization solutions revolving around CCUS, renewable power generation, electrification, and hydrogen production and storage to accelerate net zero efforts.

## Select companies in the race to decarbonize industry



\*includes Agriculture, Consumer (covers Electronics), and Paper & Pulp

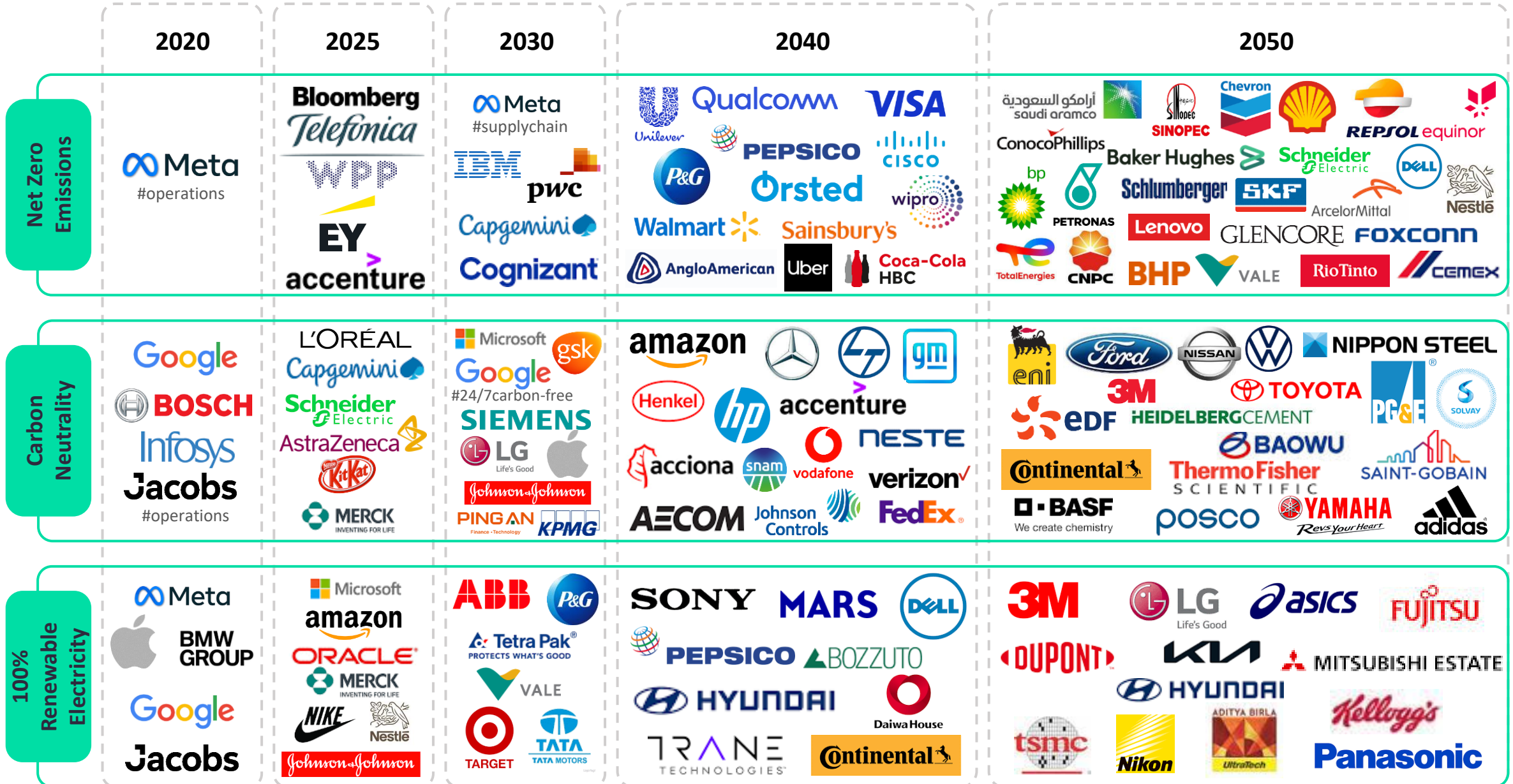
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MEDIA & TREND ANALYSIS

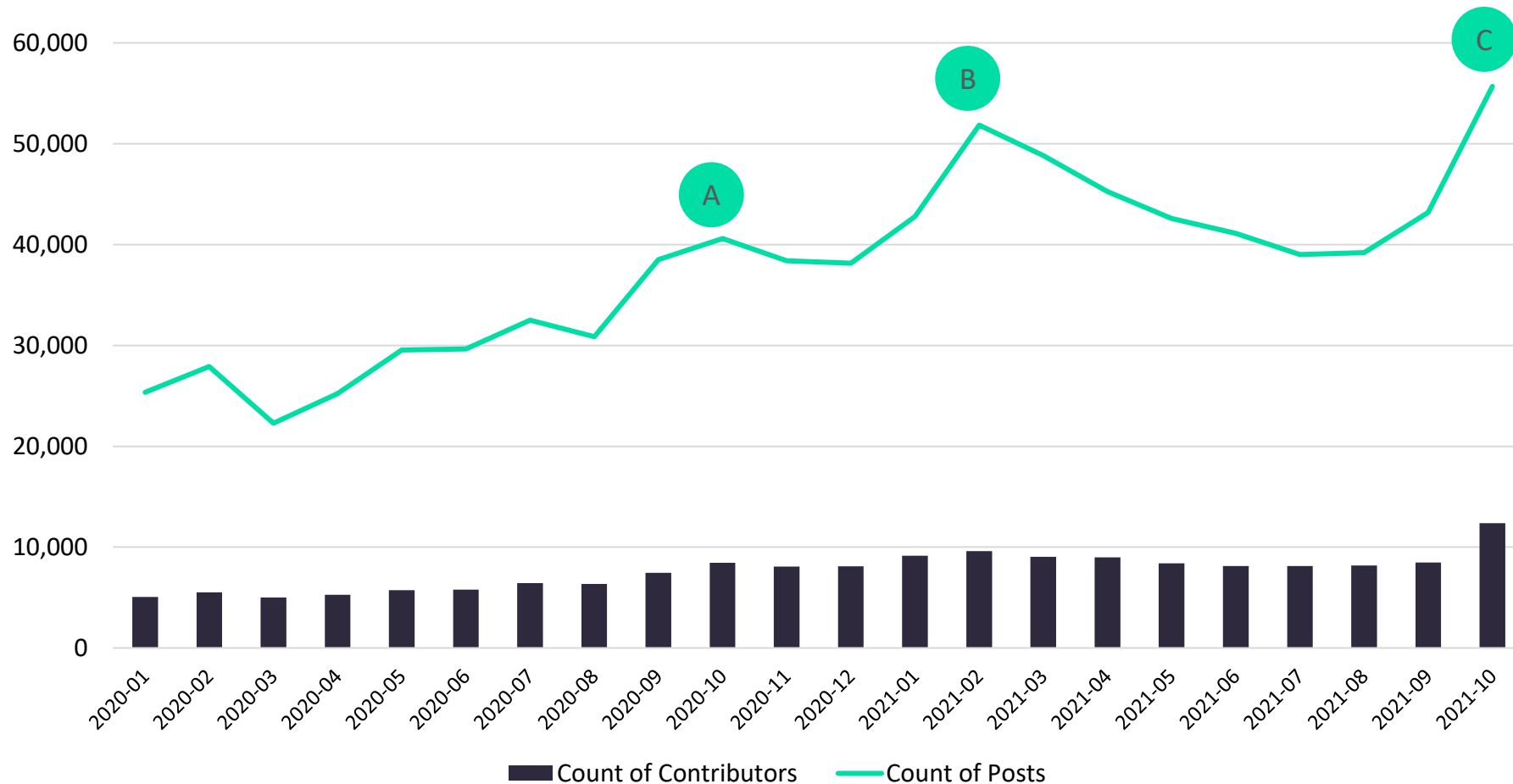
**Large Enterprises and Tech Titans Double Down on Net Zero Commitments**



# Global momentum builds up to achieve net zero in GHG emissions by 2050



# Decarbonization surged up in Twitter mentions as anticipation builds around COP26



- The first peak in mentions (A) was primarily around China’s pledge to be carbon neutral by 2060, Petrofac securing Australia’s largest commercial-scale hydrogen project, and 200 of the world’s largest corporations committing to net zero emissions by 2050.
- Another peak (B) in mentions was mainly around South Korea’s plan to build the world’s largest offshore wind farm by 2030, Shell’s plan of developing 500,000 EV charging stations by 2025, and Elon Musk announcing a \$100M donation for best carbon capture technology.
- Peak C illustrates discussions around the COP 26 UN Climate Change Conference held in Glasgow, and Saudi Arabia’s announcement to use the world’s biggest natural-gas projects to make blue hydrogen, among others.

## Trending keywords in the last 90 days in industrial decarbonization space\*



Source: GlobalData Disruptor Intelligence Center – Social Media Analytics: January 2020 – October 2021

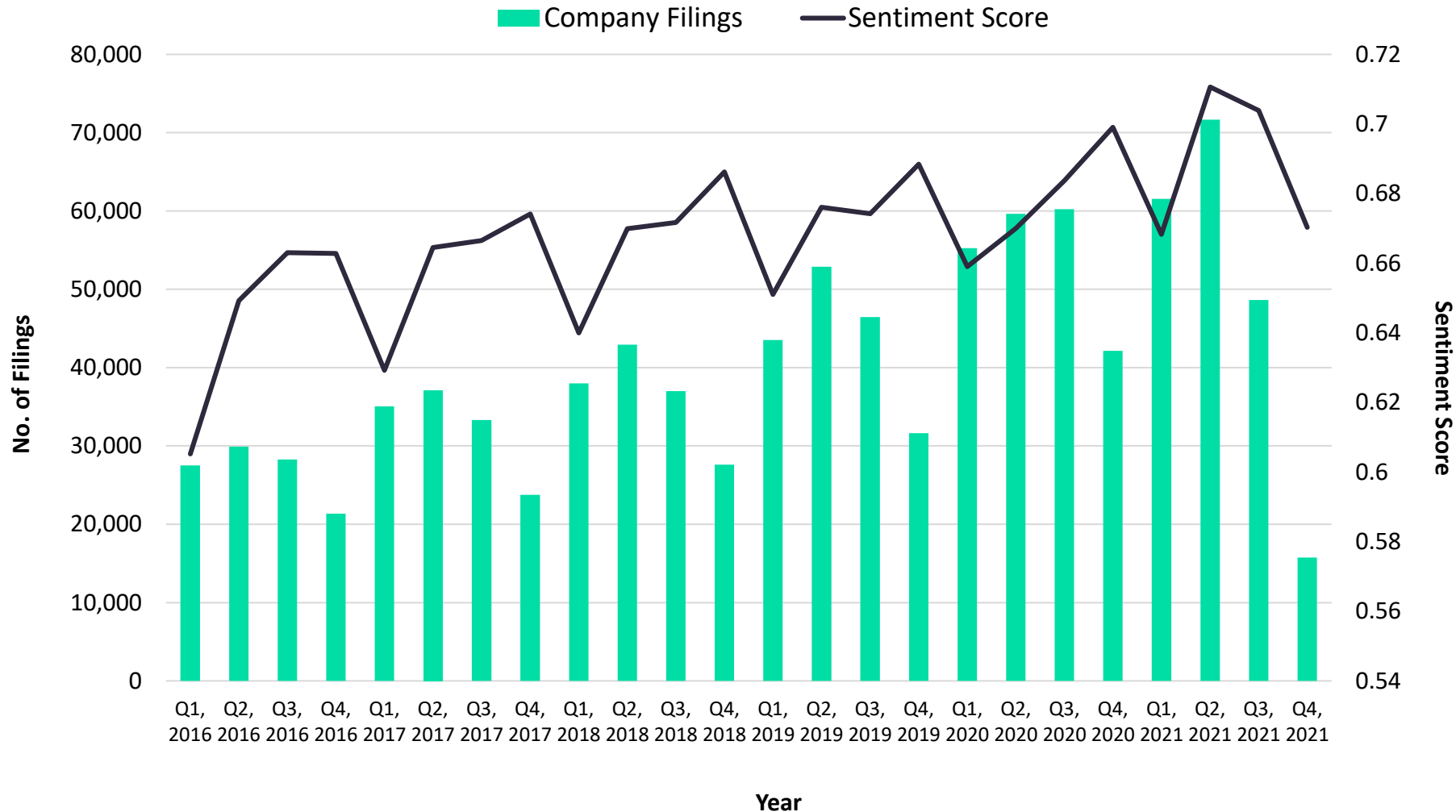
\*Timeline for trending keywords: August 2021 – October 2021



# The mentions of decarbonization and net zero efforts in company filings are on the rise



Mentions of decarbonization and related keywords in company filings: 2016 - 2021 (as of October)



- Company filings and investor presentations witnessed a steady year-on-year increase in the mentions of decarbonization and its related keywords to showcase company strategic focus, future products & services, efforts made to reduce carbon emissions, and top executive responses to investor questions on the need for industrial decarbonization.
- In 2021, the leading mentions in company filings and other presentations include renewables, net zero emissions, carbon footprint, carbon emission reduction, electrification, and energy efficiency.

Source: GlobalData Disruptor Intelligence Center – Company Filings Analytics

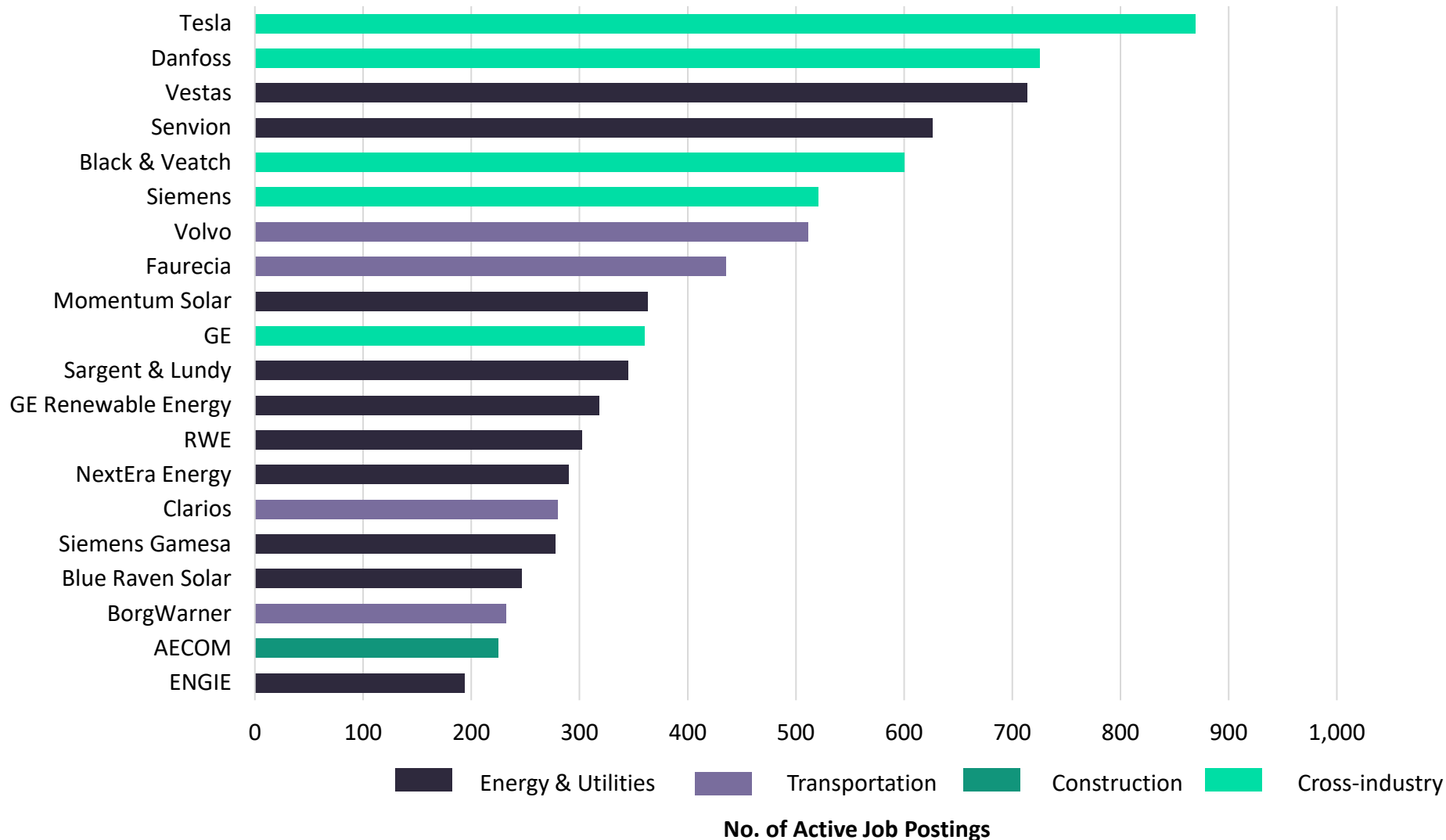
Note: Sentiment score is the average value of scores for all documents within a specific time frame



# Demand for electrification and achieving sustainability goals fuel decarbonization jobs



**Top 20 organizations by active job postings for industrial decarbonization: 01 January 2021 - 26 November 2021**



- Job postings are primarily by corporate giants such as Tesla, Danfoss, and Vestas to hire EV assembly technicians, software engineers, EHS specialists, senior R&D engineers, production operations technicians, lead blade engineers, and wind service technicians.
- In the energy & utilities and transportation industries, companies are on the lookout for field operations managers, power systems engineers for hybrid power plants, and plant quality engineers for electrification efforts.
- In construction, companies focus on hiring sustainable energy consultants for buildings and senior renewables engineers.



# 3

INVESTMENT RADAR

**VCs Target Low-Hanging Fruits to Pour Millions into Industrial Decarbonization Startups**

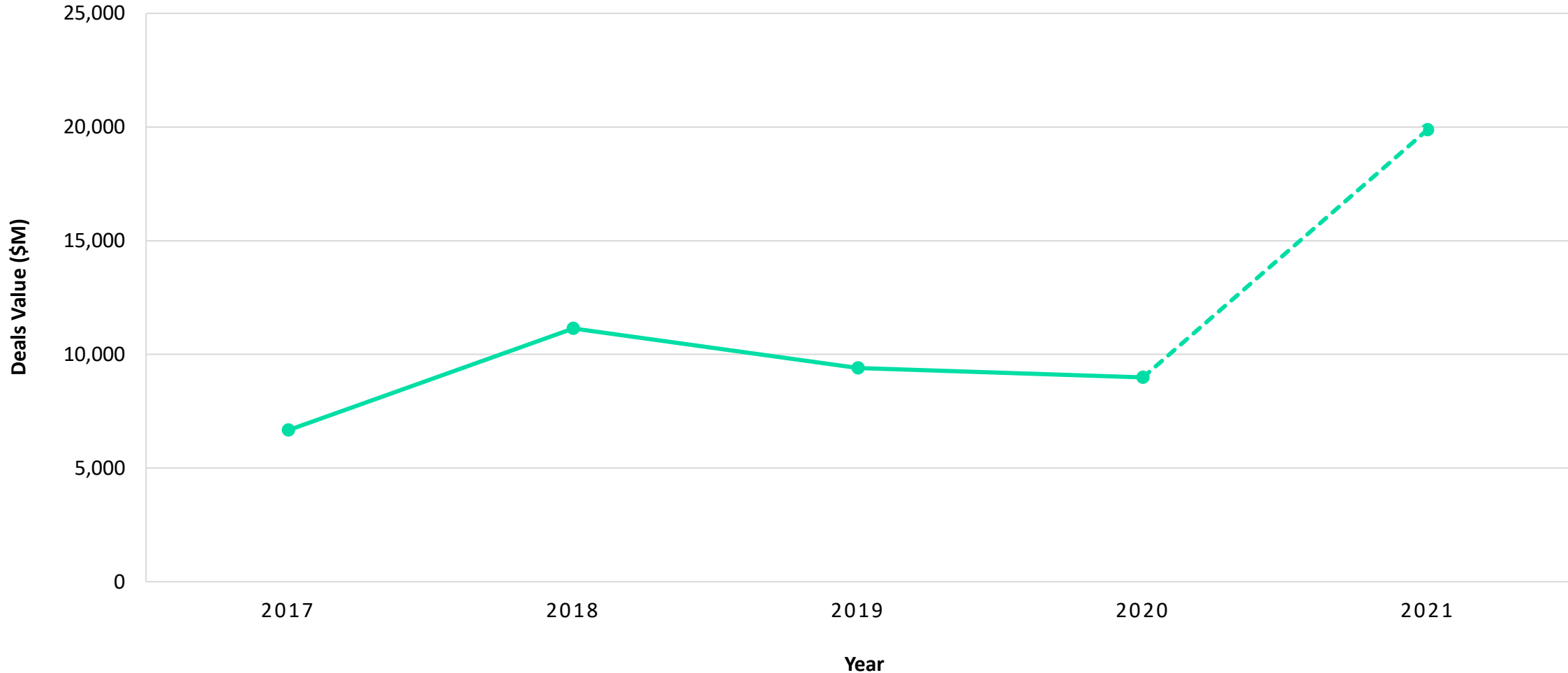


# 2021 proves to be a record-breaking year for decarbonization investments



Total funding in industrial decarbonization has surpassed \$19B by November 2021, primarily aimed at EVs, renewable energy projects, hydrogen fuel cell systems. M&A activity is dominated by green energy projects, waste-to-energy investments, and solutions for a greener and efficient industries.

Year-wise trend of total investment activity in decarbonization: 2017 - 2021 (as of November 26)



Source: GlobalData Disruptor Intelligence Center – Deals Database

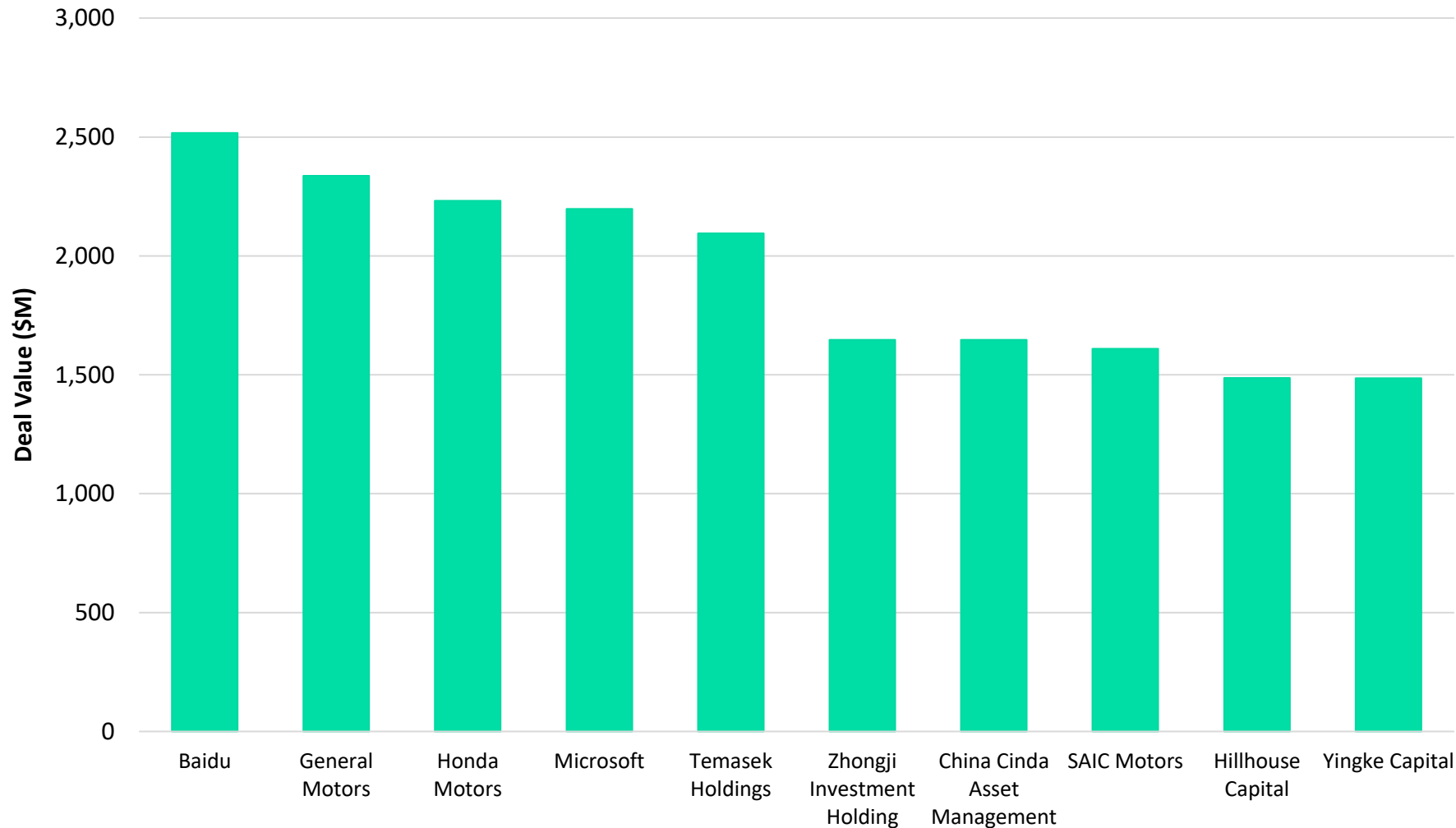




# Baidu, General Motors, and Honda Motors are the top three investors to promote startup funding in decarbonization



Top investors seeking potential industrial decarbonization startups for financing: 2017 - 2021 (as of October)



- The top investors by value, including Baidu, General Motors, Honda Motors, and Microsoft are investing in startups primarily to manufacture EVs and their charging infrastructure, solid-state Li-metal batteries, and smart battery solutions for efficient use of renewables.
- Microsoft is investing in startups to develop CO2-infused cement to reduce carbon footprint, a platform for carbon credits, and AI-powered flexibility management software for the energy industry. Temasek Holdings is investing in a battery-swapping technology platform for two-wheel scooters and motorcycles.



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INNOVATION EXPLORER

**Startups Develop Novel CCUS and Hydrogen Technologies to Promote Industrial Sustainability**



# Chemicals & Petrochemicals: companies leverage synthetic biology and transform industrial emissions to create carbon-negative chemicals



## LanzaTech converts industrial off-gases into sustainable chemicals



Technology:  
#CCUS

Total Funding:  
\$310M

US-based LanzaTech fuses synthetic biology, AI technologies, and precision engineering to produce carbon-negative chemicals using a carbon recycling process that captures carbon rather than emits it. It recently achieved a significant milestone by partnering with BASF to produce n-octanol at a laboratory scale from gases such as carbon monoxide and hydrogen depleted from industrial facilities. The company is also working with giants in the personal care segment such as Unilever, COTY, and L’Oreal.

## CarbonFree transforms cement flue gas into carbon-negative chemicals



#CCUS

Texas startup CarbonFree develops technologies that capture carbon from industrial plants and converts it into carbon-negative chemicals such as sodium bicarbonate, precipitated calcium carbonate, and hydrochloric acid. Its SkyMine plant in Texas captures around 50,000 tons of carbon annually from cement flue gas and converts it into carbon-negative baking soda.



#CCUS  
\$435M

Houston startup Solugen has a patented BioForge process that combines synthetic biology with metal catalysis to develop carbon-negative chemicals. Unlike fossil fuels-based chemical production, the startup’s process can sequester up to 30,000 tons of carbon equivalents annually. It has received funding from Singapore investment firm Temasek and has plans to expand its reach by establishing new R&D and production facilities in Southeast Asia.



#CCUS

Massachusetts startup Osmoses has developed a molecular filtration membrane to capture carbon to increase the efficiency of chemical separation. It is targeting gas and vapor separations in the conventional and renewable natural gas processing area. The startup claims that its solution can assist companies to reduce product loss by 85% and create additional fuel that could power seven million homes annually across the US.

## Solugen uses Bioforge process to develop carbon-negative chemicals

## Osmoses develops filtration membrane for carbon capture



# Chemicals & Petrochemicals: startups utilize natural gas to produce hydrogen and leverage renewables and software platforms to introduce carbon-free chemicals



## Via Separations uses filtration membranes for energy efficiency



#CCUS  
#energyefficiency  
\$43M

Massachusetts startup Via Separations uses graphene-oxide-membrane systems to transform energy-intensive thermal separations into more efficient mechanical separations and boasts 90% energy efficiency. This technology can be applied across a range of processes in the chemicals and petrochemicals industries including solvent recovery, acid concentration, azeotropic recovery, organic separation, or small molecule separation.

## Lectrolyst utilizes electricity and CO2 to create carbon-negative chemicals



#CCUS  
#renewables

US startup Lectrolyst builds a chemical synthesis platform that uses electricity and waste CO2 from renewable sources such as wind and solar to create carbon-negative chemicals. It has received funding from the US Department of Energy to further its research and prototyping to develop an electrochemical platform.



#CCUS  
#energyefficiency  
\$14M

San Francisco startup SINAI Technologies (SINAI) offers a decarbonization software platform to assist enterprises with carbon reduction strategies. Its platform tracks various departments of a company to create suggestions on where to minimize carbon emissions to meet internal and external objectives. The startup caters to multiple industrial sectors including chemicals and petrochemicals to mitigate their carbon emissions.

SINAI develops software for companies to reduce carbon emission



#hydrogen  
\$12M

California startup C-Zero develops technology that converts natural gas into hydrogen and solid carbon. Hydrogen offers cost-efficient and clean energy, whereas carbon can be permanently captured. The resultant can be used to produce chemicals such as ammonia synthesis and refining processes. The technology is a form of methane pyrolysis that utilizes thermocatalysis to extract the carbon in natural gas as a dense solid.

C-Zero converts natural gas to hydrogen and solid carbon



# Big technology vendors develop sophisticated platforms to track carbon metrics



**Digital Green Advisory and Platform:** Tracks digital emissions status  
**AtoZero - Tackling Climate Change:** Calculates total GHG emissions  
**AtoZero - Carbon Offsetting:** Helps achieve carbon positivity



**Now Platform:** Helps activate ESG strategies, programs, and initiatives  
**ESG Management and Reporting:** Elevates ESG programs  
**Integrated ESG Solution:** Helps to plan, manage and report sustainability strategies

Major clients



**IBM Environmental Intelligence Suite:** Combines weather, climate, and operational data and environmental performance management for AI-driven solutions  
**IBM Supply Chain Intelligence Suite:** Helps build more sustainable and resilient supply chains



**Energy as a service:** Collects data from multiple energy assets and use AI to optimize the energy supply and demand  
**Infosys EcoWatch:** Decarbonization, PLM circularity, and ESG Financial as a service

Major clients



**Sustainability IT:** Reducing IT's impact on environment  
**Green Core:** Real-time dashboards and sustainability reports of data from IT estate, business operations, supplier base, customers, and more.



**Accenture's Sustainability Services:** Helps to drive the sustainability agenda and optimize ESG performance  
**Green Cloud Advisor:** Recommends cloud solutions that can reduce carbon emissions

Major clients



# 5

IP LANDSCAPING

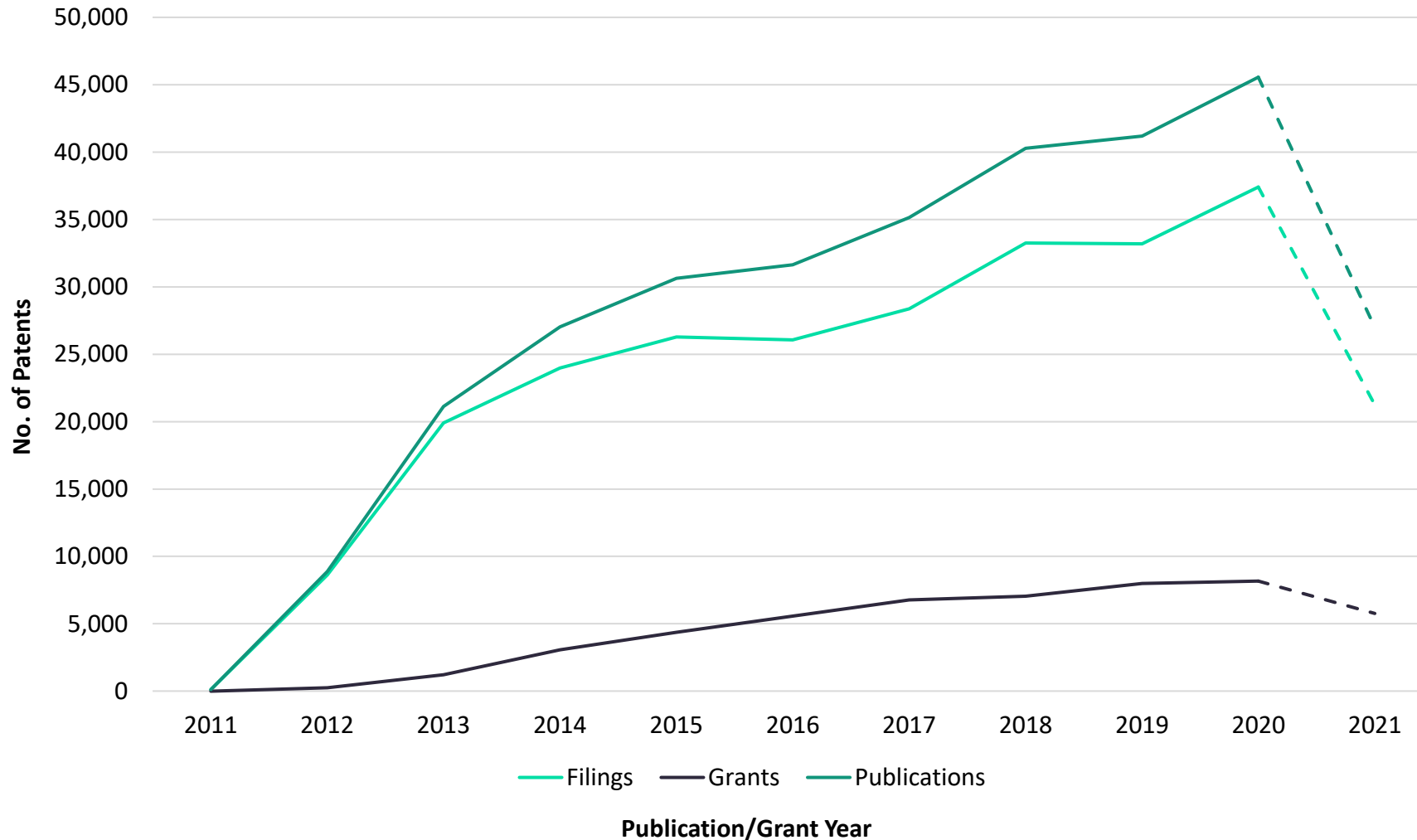
**Corporate Giants Focus on Deep Decarbonization Solutions for a Carbon-Free Planet**



# 2020 witnessed the highest patent grants, GE grabs the top spot



Counts of patent filings, grants and publications related to industrial decarbonization by year: 2011 - 2021



- The filings and grants in industrial decarbonization over the last decade commenced in 2011 with 120 filings and four grants. The initial filings were from Changkun Ding (inventor) and Chinese corporations Zhuhai Guoneng Dingxin Technology and Tianjin Siboke Technology.
- The filings continued growth until 2018 with a CAGR of 101.99% from 2011. They stood highest in 2018 at 33,247.
- Patent grants started in 2011 with four patents, LED Avenue (KR101045891B1–energy-saving signboard) was the first among the filers. Patent grants jumped to their highest of 8,164 in 2020 with a CAGR of 114.28% from 2011.
- GE, LG, Vestas, and Ford have the highest patent grants among the top filers (ref. to slide 52). The focus of GE and Vestas was on renewables, primarily wind, while LG and Ford was on electrification of mobility.

Source: GlobalData Disruptor Intelligence Center – Patent Analytics

Note: Patents data considered is as of November 11, 2021, and hence 2021 is shown in dotted lines



# CO2 collection from mixed gases, AI-enabled wind turbine control, and advanced PV mounting for EVs are some of the interesting patent applications by the leaders in filings



## EP3862561A1 – 5 February 2021

Conventionally, sensor data-fed power curves (graphs) are used to assess wind power output, but they are not optimized under all operating conditions. Thus, an improved control system for wind turbines has been a need. GE has patented a machine learning-based control system that can address the gaps between sensors and wind turbines.



## US20210180967A1 – 31 March 2020

Conventional EV systems can provide information on the distance that the vehicle can travel in agreement with a current battery charge state. However, the information has a low accuracy as the actual battery consumption may vary according to the environment of a road. LG patented an improved system to predict battery consumption based on road conditions and users' driving habits.



## EP3885028A1 – 10 March 2021

In a conventional CO2 collection system, the separated CO2 cannot be collected efficiently. Toyota has patented a CO2 separation system that can separate CO2 from mixed gases efficiently. The system includes a CO2 separator, a CO2 collector, and a pressure difference generator wherein the CO2 separator includes a separation membrane to separate the CO2 from the mixed gas.

## WO2021058194A1 – 13 August 2020

For many electromobility providers (EMPs) and charging point operators (CPOs), it is not economically viable to negotiate individual contracts while charging EV. There is a need for an improved authorization method for the EV charging process.

Siemens has patented an improved method that creates a technical basis for negotiating an indirect contractual relationship between a CPO and EMP.



## US20210053447A1 – 20 February 2020

The conventional PV panel is mounted on the surface of a vehicle and is connected to various electronic systems through conductive wires. However, the narrow interior space in the vehicle panel often makes the connections inefficient. Hyundai has patented an improved PV panel mounting system that can simplify the electrical connection between a PV panel and a vehicle while also protecting the electrical connection when an external force is applied to the PV panel.



## US20210033069A1 – 12 January 2019

The integration of large wind energy parks comprising a multitude of airborne wind energy systems (AWES) with electrical grids often gets complex as it has several constraints including grid instability. Vestas has patented an advanced wind energy park that has AWES connected via an electrical DC network, which can stabilize the power production from wind parks.





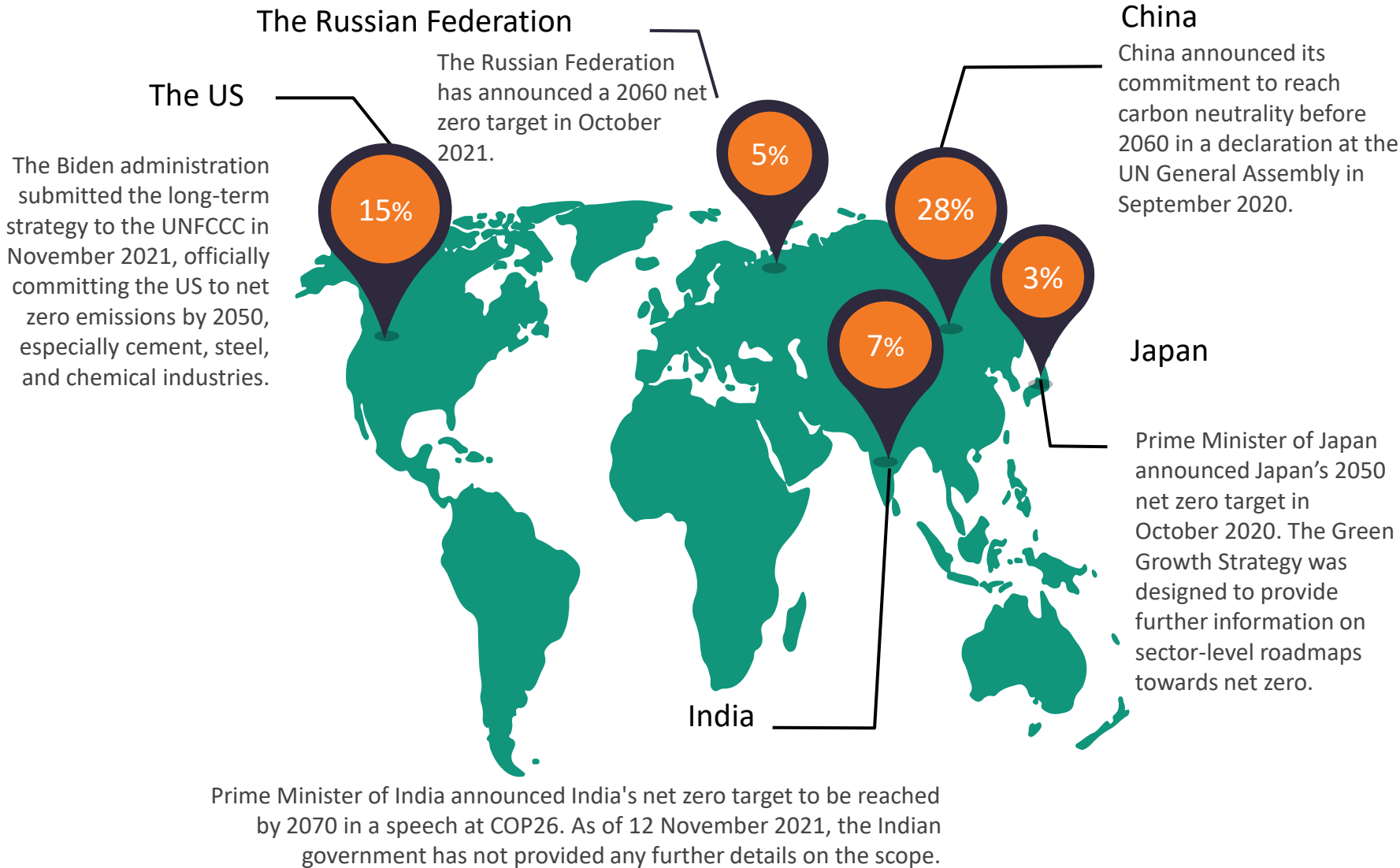
# 6

THE ROAD AHEAD

**Is Industrial Decarbonization the Next Frontier to Achieve World's Most Urgent Mission?**



# NDCs from top CO2 emitting countries in COP26 hint the growing desire to decarbonize



## Glasgow Climate Pact

Called out countries to make more climate-conscious decisions in 2022 and urged countries to phase down coal and fossil-fuel subsidies. New rules were implemented on international carbon markets.

## U.S.-China Pact

China and the US, the world's most emitting countries, pledged to collaboratively combat climate change by decarbonizing their industries through the adoption of renewable energy, developing regulatory frameworks, and embracing CCUS technologies.

## Climate Finance

As a part of the Climate Finance pact, governments pledged to support various countries to manage loss and damage due to climate change.

## No-Emission Vehicles

More than 30 countries including the US, China, and Germany, and several automotive companies such as Volvo, Daimler, and Ford agreed to design new emission-free cars and vans by 2035 in leading markets and by 2040 globally.

## Industrial Deep Decarbonization Initiative

Coordinated by UNIDO, the IDDI is co-led by the UK and India. Additional members are Germany and Canada. The initiative focuses on the increased purchase of low carbon steel and cement.

\*% refer to share of carbon emission on a global front

Source: IEA, 2020 and New Climate Institute

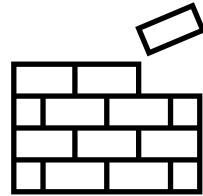


# CO2 would transform into million-dollar businesses to replace synthetic materials



CO2 emitted can be utilized through a variety of chemical processes and converted into low-carbon chemicals, materials, and feedstocks, which can act as a replacement for synthetic petroleum-derived counterparts.

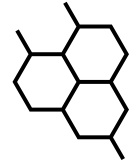
- Cement
- Concrete
- Asphalt
- Aggregates
- Hardwood



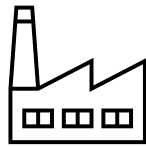
## Building Materials

## Advanced Materials

- Carbon Fiber
- Carbon Nanotubes
- Graphene
- Polyurethane Foams
- Polycarbonates



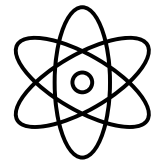
- Enhanced Oil Recovery
- Enhanced Methane Recovery
- Enhanced Water Recovery
- Semi Conductor Fabrication
- Power Cycles



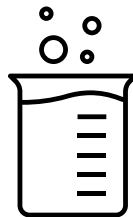
## Industrial Fluids

## Smart Ingredients

- Food Additives
- Feed Additives
- Microbial Fertilizers
- Biochar
- Biocosmetics



- Preservatives
- Carriers
- Medicinal
- Anti-Freeze
- Carbon Black



## Advanced Chemicals

## Smart Fuels

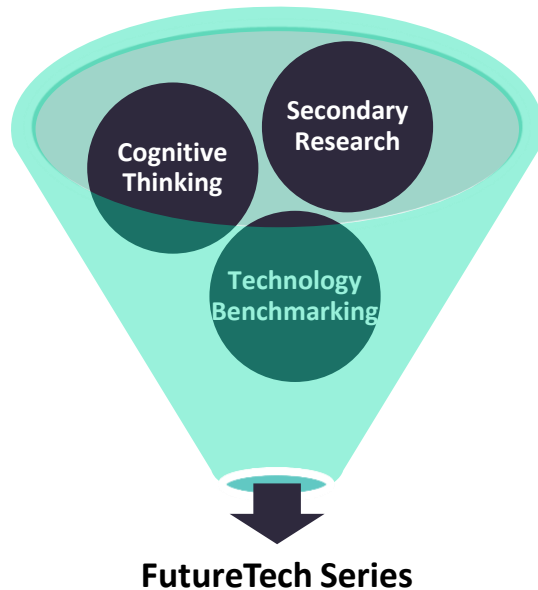
- Synthetic Fuels
- E-Fuels
- Algal Fuels
- Other Biofuels



## About FutureTech Series:

FutureTech Series Reports are aimed at capturing futuristic technologies which have the potential to disrupt tomorrow. These technologies are constantly changing, adapting and progressing to enable a paradigm shift in our daily lives. FutureTech Series highlights powerful and transformative topics that alter the global economy.

**Three major approaches are followed to build our FutureTech Series Reports:**



## Our Specialty

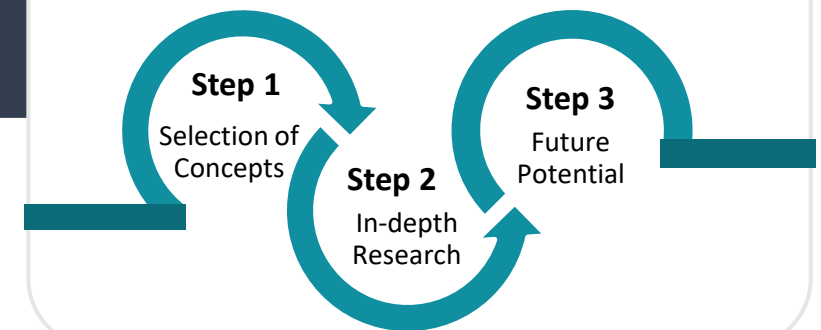
FutureTech Series Reports focus on groundbreaking technologies across sectors that impart structural shifts with irreversible consequences. The awareness, knowledge and expertise on these topics help transform business models, decision making, strategic thinking, and an in-depth understanding of megatrends directly influencing patenting, collaboration, acquisition, and investment decisions.

## Methodology

FutureTech Series topics are selected from a wide pool of interesting emerging technology concepts. Firstly, we select each concept based on a set of criteria to shortlist the most impactful futuristic technologies that can transform the future.

Secondly, we conduct in-depth research on the selected topics to identify the potential factors driving growth, map markets to select the major players, identify interesting deals, evaluate the competitive landscape, present the thought leadership and social media mentions and significant stakeholder initiatives.

Finally, we design a roadmap to assess the growth potential of the technology in the future along with its capability to disrupt the world by overcoming roadblocks.





**For any questions or further enquiries please contact us at:**

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