



GLOBAL CLEANTECH **100**

Leading companies and themes in sustainable innovation

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The list would not have been possible without the 80 expert panelists (See pages 49-50) who gave up their time to provide input and opinion. This is in addition to the many hundreds who made company nominations.

We also wish to acknowledge the support we receive all year round from members of our international Advisory Boards, all of whom are leading players in this innovation ecosystem.

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FOREWORD

Radical progress in transitioning industries

Richard Youngman
CEO, Cleantech Group

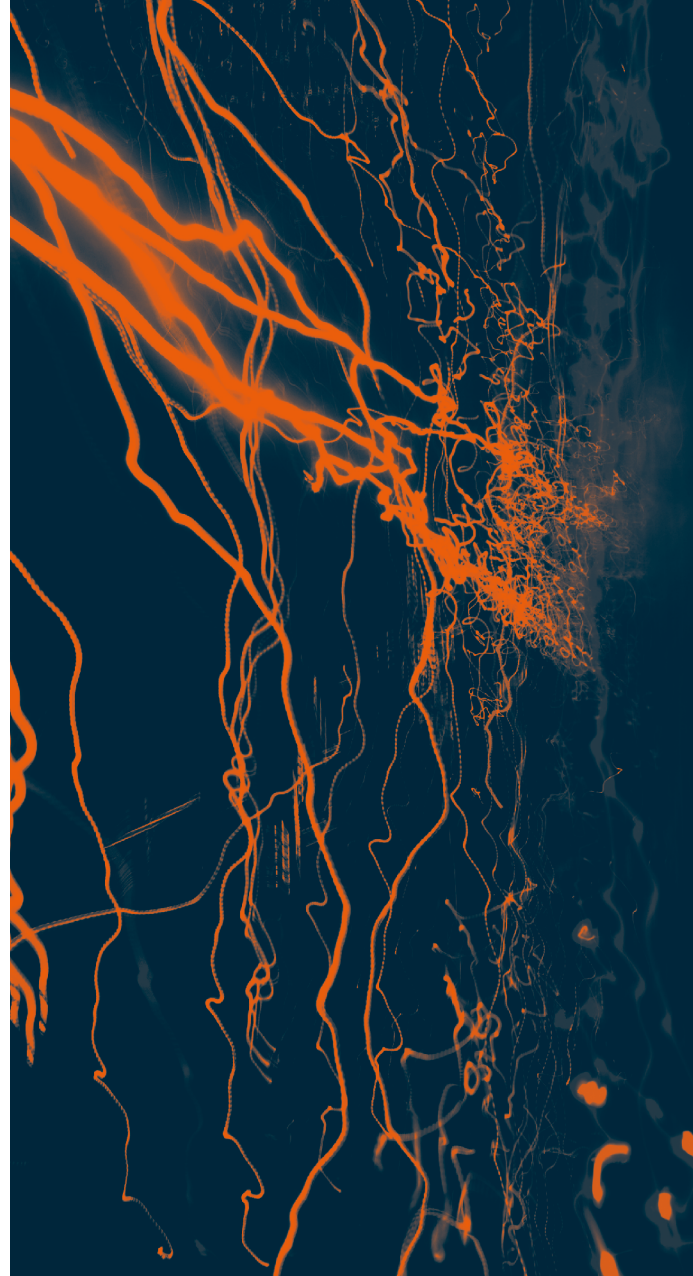
In search of a second, but different, Roaring 20s

The Roaring twenties, a U.S. term, still evokes a spirit of freedom and adventure, a decade of great inventions and creativity – even though economically, in the West at least, it all ended in a crash. Arguably, most aspects of modernity were given life in the 1920s by the arrival of mass production and consumerism - automobiles, chemicals, electrical appliances, movies, radio, telephones and more.

And culturally, traditions were challenged and broken, be that through the extension of the vote, most notably to women, or expressed through the arts - Art Deco, dance, Expressionism and jazz, for example. Lindbergh made the first solo transatlantic flight.

What of the 2020s? I don't see how, unless you dismiss the consensus viewpoints of global climate scientists, there could be a more important decade for our collective mission.

During this decade, we need to make major, indeed radical, progress in transitioning many of those same 1920 fledgling industries to a de-carbonized and resource-efficient future. If not, expect future Global Cleantech 100s in the late 2020s to have transitioned from mitigation to adaptation solutions.



"I don't see how, unless you dismiss the consensus viewpoints on the global climate crisis, there could be a more important decade for our collective mission."

The supply of innovation is encouraging

The rate of company formation in our cleantech theme has increased significantly during the 2010s. There are 45 debutant companies in the list this year; it feels like there is very healthy competition for places and no doubt each of us will have favorites who we feel should have made it this year.

The marked increase of investors and corporations willing and able to work with and to support the growth of these companies has also markedly increased, and continues to do so, as we hit the 2020s. A few of them are mentioned in our sector-by-sector analyses.

And with a record 18 previous Global Cleantech 100 alumni “graduating” (via a listing or being acquired) over the last 12 months, it now feels we are at a stage where the public capital markets support and understand acquisitions and IPOs of companies with sustainable innovations as strategically important and necessary.

The 2019 Beyond Meat IPO, I see as a particularly important milestone, signalling as it did that there is backing for the need to transform key daily activities – in this case diet – towards more climate-friendly future versions.

In addition to those there are a further five companies who remain private and independent but carry \$1 B+ valuations and, as Unicorns, will no longer feature on future Global Cleantech 100 lists. We hope their own graduation moments might not be so far away either.

Time is not on our side - the 20s need to roar as never before

The inconvenient truth is that the problems being tackled by these 100 companies and the hundreds of others beyond unfortunately have a timer attached to them. That timer is monitoring whether humanity, having enjoyed and prospered from all the incredible benefits of 20th century industrialization and technology, now proves

able and willing to pull back from the irreversible destruction of the very environment which enabled that progress and prosperity, and to course correct all our industrial activities, such that we halve carbon emissions by 2030, are at net zero by 2050 and are sequestering the gigatons we have already put in the atmosphere.

As we enter the last quarter of a game that has been running for decades, my sobering conclusion is that we are clearly not winning. We need a remarkable turnaround – and fast.

Human ingenuity and innovative spirit are match-fit for the herculean tasks ahead. Our innovation community can be a great contributor, but we cannot do it alone in the time available. To roar, these 20s need people in power to act with urgency and intent. Our leaders must have long-term vision and the conviction to face up to vested interests, naysayers and doubters. They must direct the best of capitalism to our greatest threat, namely that of securing the survival of the modernity seeded in the 1920s, before it is too late.

On this journey, every one of us can be a leader in our own small way and within our own networks, personal and professional. It's not all resting on the 2020 Global Cleantech 100, as much as we salute their efforts! It's on every one of us to lead.



CEO, Cleantech Group

How we select the Global **Cleantech** 100

The question we seek to answer:

According to the world's cleantech community, which 100 private companies today are most likely to make significant market impact over the next five to ten years?

We answer this question in three phases.

PHASE 1 NOMINATIONS

Nominations come from five sources:

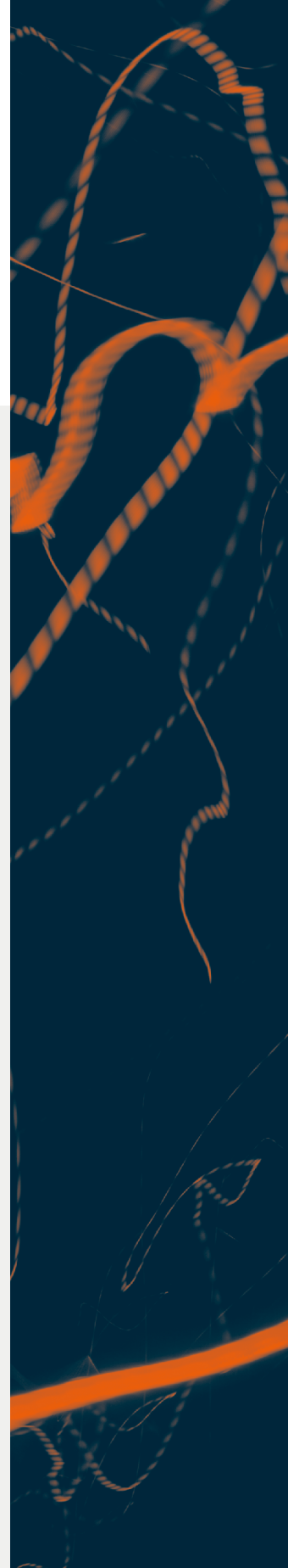
- The expert panel of 80 investor and multi-national corporation representatives
- Our i3 platform tracking the investment and partnership history of thousands of relevant companies
- Over 250 third-party awards where expert assessment has been applied
- Our sector analysts
- The global ecosystem * (i3connect.com/gct100/nominate).

PHASE 2 EVALUATION

Since our aim is to objectively synthesize and represent consensus, nominations are scored in a system rewarding companies that have multiple validations from our nomination sources. From this, a shortlist is created and sent to our panel of 80 industry experts comprised of investor and multi-national corporation representatives. The panel votes positively or negatively based on their knowledge of the company's innovation, market and ability to execute.

PHASE 3 THE FINAL 100

A combination of data from Phase I and Phase 2 are pooled and adjusted for geographic or other biases. Companies with the highest points overall make it to the final 100.



How we select the Global **Cleantech** 100

EXPLORING THE DEPTH AND BREADTH OF THE CLEANTECH COMMUNITY

The total number of 2020 nominations from the public, our expert panel, i3, awards and Cleantech Group totaled 8,312 from over 80 countries. These companies were weighted and scored to create a short list of 322 companies that were reviewed by the 80 members of Cleantech Group's Expert Panel.

The list offers a fair representation of global innovation and private company creation. It is not Cleantech Group's editorial voice, but the collective opinion of hundreds of individuals within the wider global cleantech innovation community.

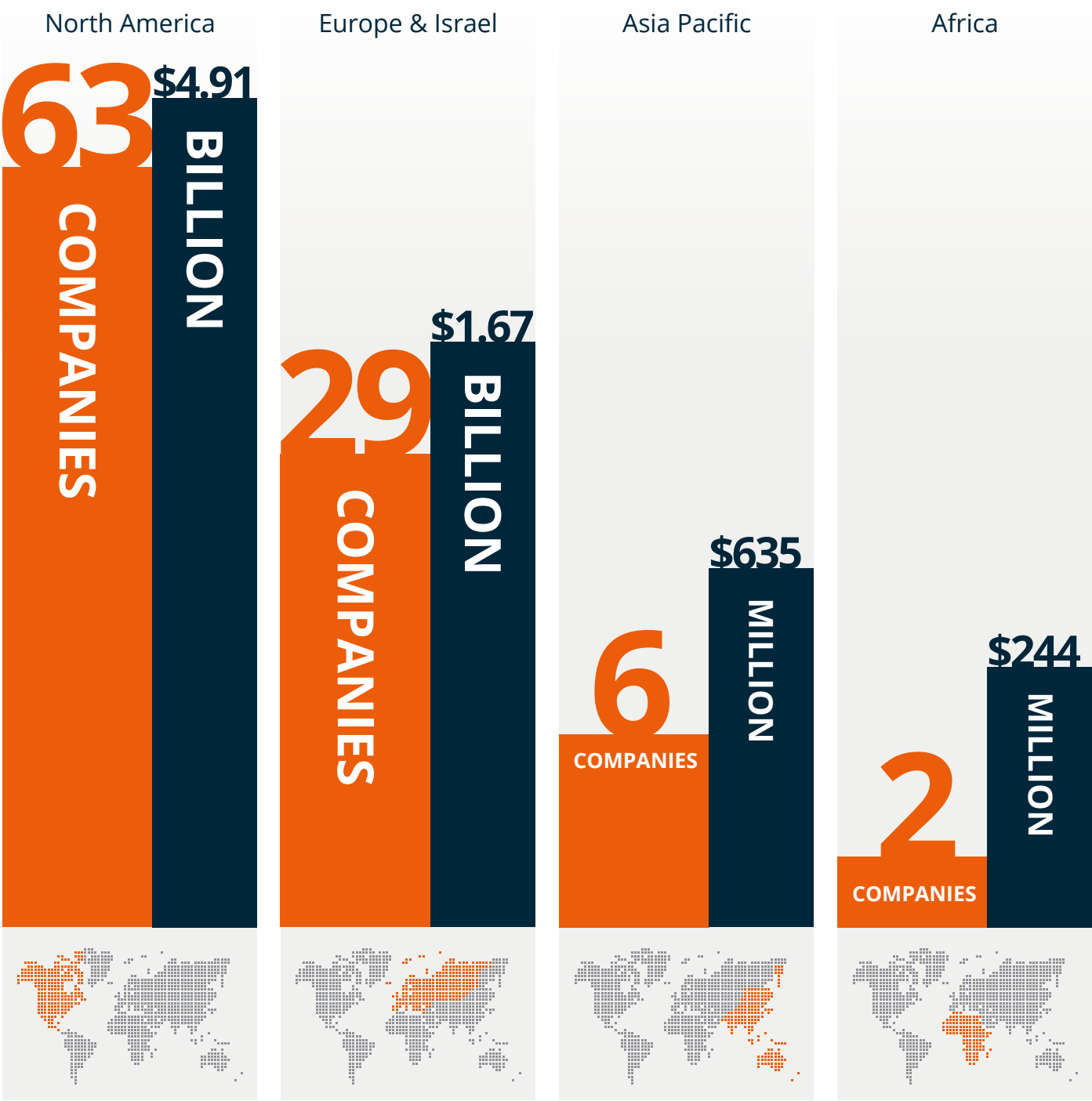
*To be valid, nominations of your own company (or one you are part owner of), be they made by the expert panel or the open call to the ecosystem, must be accompanied by nominations of at least two other companies you admire and with which you have no commercial association.

Any independent, private, for-profit cleantech company can qualify for the Global Cleantech 100. These companies must have a knowledge-based offering that embodies doing more with less (provides superior performance at lower costs, greatly reduces or eliminates negative ecological impact and improves the productive and responsible use of natural resources). We exclude those who we know to have reached Unicorn status and/or those who have been in the list seven times before.

The Global **Cleantech** 100 in numbers

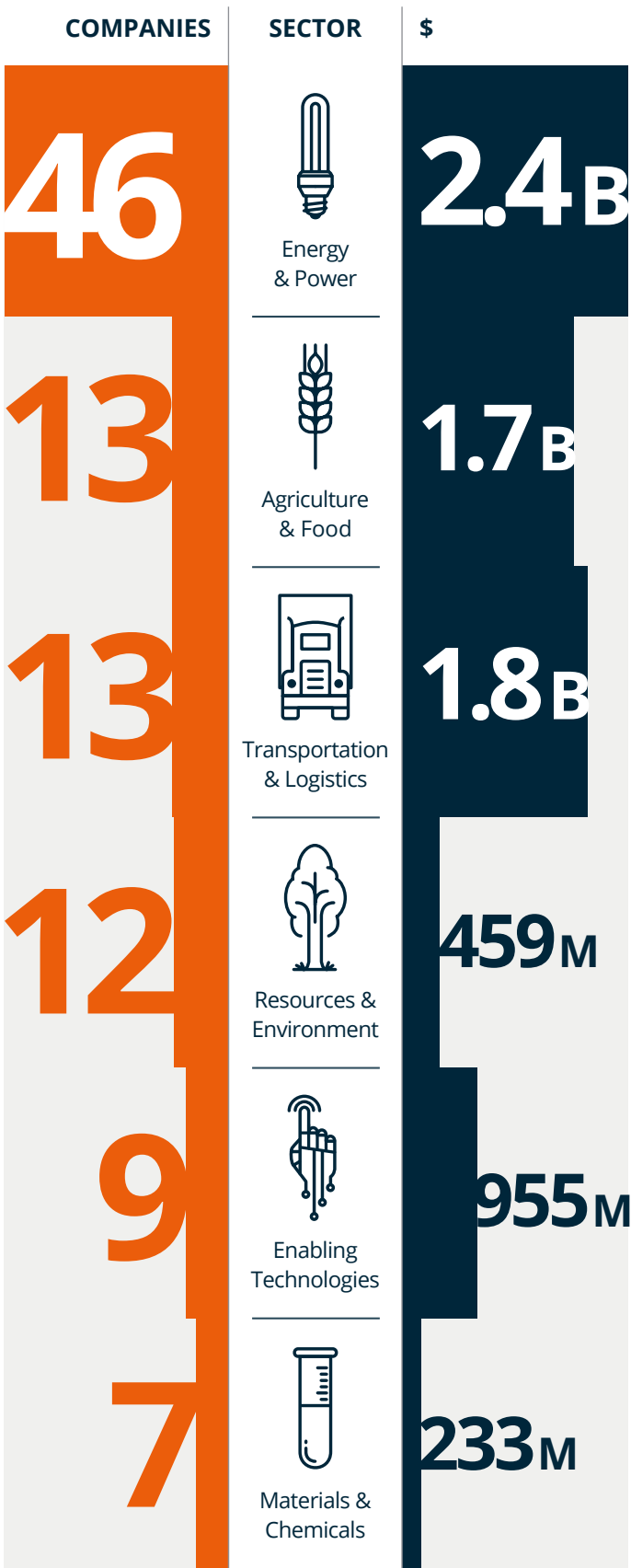
Uncover the story behind the companies included in the 2020 Global Cleantech 100. How much money have they collectively raised? How many investors have they attracted? Which sectors dominate?*

The number of companies and level of investment by region

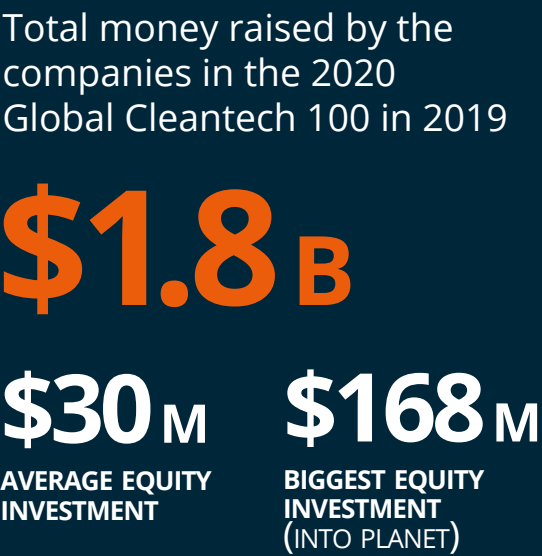


*All investment figures based on data collected up to 31 December, 2019. Source: Cleantech Group

Scale of investment by sector



Scale of total investment










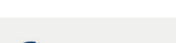
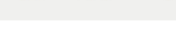

THE2020 GLOBALCLEANTECH100

The 2020 Global Cleantech 100 companies
listed in alphabetical order by sector
















| <div></div> <div>Agriculture & Food</div> | | 13 COMPANIES  |
|--|--|--|
| | | 5 COUNTRIES  |
| COMPANY | DESCRIPTION | COUNTRY |
|  AeroFarms | Developer of aeroponic systems to grow leafy greens at high yield densities in urban vertical farms | United States |
|  AgriProtein | Developer of alternative protein feed products from organic waste ingested by insects | South Africa |
|  Apeel Sciences | Developer of organic, non-toxic food coatings which lengthen shelf-life and protect against pests | United States |
|  BENSON HILL | Developer of biotechnology solutions to increase crop yields | United States |
|  CALYSTA | Developer of fish and animal nutrition products and industrial materials via methane conversion | United States |
|  FARMERS BUSINESS NETWORK | Developer of a membership website for farmers to upload datasets and share information | United States |
|  infarm | Developer of indoor farming systems for grocery stores, restaurants, and local distribution centers | Germany |
|  PIVOT BIO | Developer of microbe-powered technology to improve agriculture productivity | United States |
|  Plenty | Developer of vertical farms that use AI, data analytics and IoT sensors to create high-yield, low space and water agricultural systems | United States |
|  ripple | Developer of a dairy-free, plant-based milk alternative | United States |
|  semios | Developer of precision crop management systems | Canada |
|  VESTARON THE POWER OF PEPTIDES | Designer of next generation biopesticides from naturally occurring peptides | United States |
|  Ynsect Premium natural feed | Developer of bioconversion solutions of organic resources by insects to produce feed, organic fertilizers and bioenergy | France |

KEY: ↑ Increase on 2019 figures ↓ Decrease on 2019 figures ↔ Same as 2019 figures












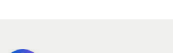
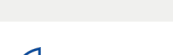
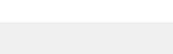
|  | Enabling Technologies | | NEW CATEGORY |
|---|---|--|---------------|
| | COMPANY | DESCRIPTION | COUNTRY |
|  | CITRINE | Provider of large-scale data infrastructure and advanced analytics for R&D and manufacturing in the materials industry | United States |
|  | ELEMENT | Developer of an industrial software analytics platform for asset-intensive industries | United States |
|  | FOGHORN | Developer of edge intelligence software for industrial and commercial IoT applications | United States |
|  | KONUX | Developer of sensor and digital twins solutions for improved industrial operations | Germany |
|  | Orbital Insight | Developer of advanced geospatial data analytics and processing software | United States |
|  | planet. | Operator of a network of observation satellites to provide open-source information on the earth's changing climate | United States |
|  | SIGHT MACHINE Powering Digital Manufacturing | Developer of manufacturing analytics software capable of processing industrial big data | United States |
|  | sparkcognition™ | Developer of data-driven analytics platform for industrial and energy IoT | United States |
|  | VIA | Provider of big data analytics for IoT solutions in agriculture, energy and security | United States |














KEY: ↑ Increase on 2019 figures ↓ Decrease on 2019 figures ↔ Same as 2019 figures






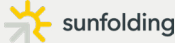




“GEOSPATIAL DATA, MACHINE LEARNING AND OTHER ENABLING TECHNOLOGIES ALLOW INDUSTRIES TO ACCELERATE THEIR SUSTAINABLE TRANSITION, AND GIVE US BETTER TOOLS TO EVALUATE ENVIRONMENTAL CHALLENGES.”
JULES BESNAINOU, DIRECTOR, CLEANTECH GROUP

|  | Energy & Power | | 46 COMPANIES ↑ |
|---|--|----------------|----------------|
| | | | 13 COUNTRIES ↑ |
| COMPANY | DESCRIPTION | COUNTRY | |
|  Alpha-ESS | Developer of advanced lithium ion battery storage products | China | |
|  Arcadia | Provider of a clean energy management software platform | United States | |
|  aurora | Provider of a cloud-based platform that enables solar engineering design and supports operations and customer acquisition for solar installers, financiers and utilities | United States | |
|  AutoGrid | Provider of software applications for utilities to better integrate distributed energy resources | United States | |
|  AXIOM ENERGY | Provider of thermal storage retrofit systems for industrial refrigeration applications | United States | |
|  azuri | Developer of pay-as-you-go solar products for off-grid households | United Kingdom | |
|  BBOXX the solar revolution | Developer of technologies and services to solve energy access needs in areas with no or unreliable electricity grids | United Kingdom | |
|  CARBON Lighthouse | Provider of an actively managed energy service for buildings that reduces energy consumption and leverages renewable power | United States | |
|  COMMONWEALTH FUSION SYSTEMS | Developer of advanced fusion technology | United States | |
|  DANDELION | Installer of residential geothermal systems for heating, cooling and hot water | United States | |
|  DEPSYS Rethink energy | Developer of hardware and software to manage smart grids | Switzerland | |
|  ecobee | Developer of Wi-Fi-enabled smart thermostats for residential and commercial applications to maximize residents' comfort and savings | Canada | |




KEY: ↑ Increase on 2019 figures ↓ Decrease on 2019 figures ↔ Same as 2019 figures

|  | Energy & Power <i>(continued)</i> | |
|---|---|----------------|
| COMPANY | DESCRIPTION | COUNTRY |
|  | Provider of demand side energy management services | Canada |
|  | Developer and licensor of silicon-dominant Li-ion battery technology for electric vehicles (EVs) | United States |
|  | Developer of a platform for grid operators to digitize energy planning and operation processes | Germany |
|  | Developer of an advanced flow battery technology that utilizes earth-abundant iron as its energy storage medium | United States |
|  | Developer of a linear generator technology to produce energy from a variety of fuels | United States |
|  | Developer of low-cost, long-duration energy storage to replace existing baseload generation | United States |
|  | Developer of intelligent energy systems from second-life electric vehicle batteries | United States |
|  | Developer of gallium nitride (GaN) semiconductors | Canada |
|  | Provider of home energy IoT solutions for distributed energy resources management | Germany |
|  | Developer of cloud-based energy services at the grid edge for utilities, microgrids and large businesses | Australia |
|  | Developer of energy management solutions that control and optimize energy consumption | United Kingdom |
|  | Developer of distributed mini-grids which utilize solar PV, biomass gasification and batteries | India |
|  | Developer of efficient hydrogen storage for multi-megawatt energy systems in the form of Liquid Organic Hydrogen Carriers | Germany |

|  | Energy & Power <small>(continued)</small> | |
|---|---|----------------|
| COMPANY | DESCRIPTION | COUNTRY |
|  | Developer of real-time energy monitoring and prediction software for energy retailers and utilities | United States |
|  | Developer of an energy exchange platform (Virtual Power Plant) for distributed energy resources | United States |
|  | Developer of Commercial and Industrial (C&I) procurement process for utility-scale renewable projects | United States |
|  | Developer of lithium-ion battery recycling technology | Canada |
|  | Developer of energy management services based on AI, allowing companies to maximize the value of their energy resources | France |
|  | Provider of pay-as-you-go solar energy systems for off-grid customers | Kenya |
|  | Developer of smart batteries and software to manage, optimize and aggregate batteries, including EVs, for grid services | United Kingdom |
|  | Operator of virtual power plants connecting decentralized renewable energy producers and large scale power consumers | Germany |
|  | Developer of real time control and optimization solutions for generation, storage and electric vehicle resources | Canada |
|  | Developer of perovskite thin-film solar cells | United Kingdom |
|  | Developer and manufacturer of phase change materials for reducing energy consumption in buildings | United States |
|  | Developer of a home energy monitor that gives residents real-time information on the energy use of their devices | United States |

|  | Energy & Power <i>(continued)</i> | |
|---|---|---------------|
| COMPANY | DESCRIPTION | COUNTRY |
|  | Manufacturer of graphene-based ultracapacitors and modules with high energy and power density | Germany |
|  | Provider of peer-to-peer solar energy trading platforms and pay-as-you-go solutions to low-income households | Bangladesh |
|  | Developer of energy storage and software solutions to help businesses better manage electricity use and enhance grid operations | United States |
|  | Provider of energy conversion technologies, including solid oxide fuel cells and renewable synthetic fuels based on solid oxide electrolyzers | Germany |
|  | Developer of innovative solar tracking for commercial and utility systems | United States |
|  | Developer of a smart thermostat and SaaS platform allowing users to control their home heating and cooling systems from their smart phones | Germany |
|  | Developer and provider of a mobile metering technology and billing platform for EV smart charging infrastructure | Germany |
|  | Developer of a blockchain-based green energy trading marketplace | Lithuania |
|  | Provider of smart storage and solar power solutions for remote energy access | Netherlands |












**“AS A RENEWABLE ENERGY INTEGRATOR,
HYDROGEN PROVIDES A HUGE OPPORTUNITY
TO REACH DEEP DOWN INTO SOME OF THE
MOST CARBON-INTENSIVE INDUSTRIES.”**
**LOUIS BRASINGTON, ENERGY & POWER ANALYST,
CLEANTECH GROUP**

|  | <h2>Materials & Chemicals</h2> | |
|---|--|---------------|
| | | |
| | 7 COMPANIES  2 COUNTRIES  | |
| COMPANY | DESCRIPTION | COUNTRY |
|  | Developer of proprietary technology to create cell factories capable of industry-scale chemical production | United States |
|  | Developer of a molten oxide electrolysis technology for steel making | United States |
|  | Developer of low-cost building materials from industrial carbon dioxide emissions | Canada |
|  | Developer of materials with improved physical properties based on advances in predictive molecular biology and chemistry | United States |
|  | Developer of bacteria producing bioplastics from methane gas | United States |
|  | Developer of polymerization technology to convert greenhouse gases to valuable biodegradable plastics | United States |
|  | Manufacturer of sustainable building materials | United States |

KEY: ↑ Increase on 2019 figures ↓ Decrease on 2019 figures ↔ Same as 2019 figures

“THE MATERIALS & CHEMICALS SECTOR, DRIVEN BY DEMAND FOR SUSTAINABILITY, PERFORMANCE AND COST, IS INNOVATING FOR CLIMATE CHANGE RESILIENCE WHILE REDUCING ITS IMPACT ON OUR NATURAL RESOURCES. CREATING RENEWABLES IN THE BIOTECH SECTOR, DEVELOPING SUSTAINABLE BUILDING MATERIALS AND PRODUCING BIOPLASTIC ALTERNATIVES ARE AMONG THE KEY FOCUS AREAS IN THIS DECADE.”

CHRIS DAWE, ASSOCIATE DIRECTOR, RESEARCH

|  | Resources & Environment | | 12 COMPANIES ↓ |
|---|---|----------------|----------------|
| | | | 7 COUNTRIES ↑ |
| COMPANY | DESCRIPTION | COUNTRY | |
| ALTERED: [®] | Developer of water-saving nozzles for everyday use | Sweden | |
|  AMP ROBOTICS [™] | Developer of machine learning and robotic technology for waste recycling | United States | |
|  axine WATER TECHNOLOGIES | Developer of a chemical-free solution for treating high concentrations of toxic organics and ammonia in industrial wastewater | Canada | |
|  BreezoMeter | Developer of location-based, real-time air quality data and pollen information solutions | United States | |
|  Carbon Engineering | Developer of technologies for the capture of carbon dioxide from the atmosphere at industrial scale | Canada | |
|  CARBON CURE. | Producer of carbon-sequestering equipment for ready mix and pre-cast concrete production | Canada | |
|  ELeather. LEATHER - EVOLVED | Provider of engineered materials based on leather waste from the traditional leather industry | United Kingdom | |
|  mine sense | Developer of sensor technology to bring operational efficiency to the mining industry | Canada | |
|  ORGANICA | Developer of biological wastewater treatment plants in urban and residential environments | Hungary | |
|  phenix | Developer of a platform and services for the repurposing of end-of-life products | France | |
| Svante | Developer of energy- and capital-efficient technology for capturing carbon dioxide from industrial sources | Canada | |
|  TIPA [®] Sustainable Packaging | Developer of biodegradable and recyclable packaging solutions | Israel | |












KEY: ↑ Increase on 2019 figures ↓ Decrease on 2019 figures ↔ Same as 2019 figures



Transportation & Logistics

13 COMPANIES ↑

7 COUNTRIES ↔

| COMPANY | DESCRIPTION | COUNTRY |
|---|---|---------------|
|  AMPLY FLEET CHARGING SIMPLIFIED | Provider of electric fleet charging services | United States |
|  ATHER | Developer of electric scooters | India |
|  bestmile | Developer of a fleet management platform to operate and optimize fleets of autonomous vehicles | Switzerland |
| E/NRIDE | Developer of autonomous electric trucks | Sweden |
|  EVgo | Installer and servicer of fast-charging stations for electric vehicles | United States |
|  gogoro | Developer of electric scooters and battery swapping infrastructure | Taiwan |
|  JOBY AVIATION | Provider of electric aircraft mobility systems | United States |
|  LILIUM | Developer of a battery-powered, fan-propelled vertical takeoff and landing commuter aircraft | Germany |
|  NUVE | Developer of a vehicle-to-grid (V2G) solution enabling EV batteries to store and resell unused energy back to the grid while providing high-powered, smart charging | United States |
|  Peloton | Developer of vehicle-to-vehicle communication systems for truck fleets | United States |
|  PROTERRA | Developer of zero-emission, battery-electric buses that help fleet operators eliminate fossil fuel dependency and reduce costs | United States |
| VOLTA | Promoter, installer and operator of free electric vehicle charging stations enabled by advertising and sponsorship | United States |
|  vulog CARSHARING TECHNOLOGIES | Developer of hardware and software solutions for public and corporate carsharing services | France |

KEY: ↑ Increase on 2019 figures ↓ Decrease on 2019 figures ↔ Same as 2019 figures



RESEARCHOUTLOOK

Climate crisis, geopolitics and corporates:
The changing backdrop of the Global Cleantech 100

Jules Besnainou
Director, Cleantech Group

Keep an eye on four macro trends

At Cleantech Group, we help corporates, investors and governments understand innovation themes, access opportunities and develop tools to make assessments. Our connection to the clean innovation ecosystem is deep, and we're in constant contact with the entrepreneurs, investors, incumbents and enablers in these markets. In our discussions, we cover the ABCs: attractiveness of the market, business models and the competitive landscape. In addition to the sector insights that follow, there are four macro trends that cut across the cleantech ecosystem.

1. Increased public pressure to act on the climate crisis

Over the past 18 months, public pressure on governments and corporations to change the environmental status quo increased sharply. This is mostly due to the reality of the climate crisis sinking in. Extreme weather events are becoming more and more frequent, with wildfires, droughts, torrential rains and hailstorms now a constant danger in regions such as Australia, India, California or Southern Europe. Scientific reports from organizations including the United Nations keep sounding the alarm, making it clear that we have not even started to get on the right path. Concerned citizens (and their consumer alter egos) are demanding change.

2. The pursuit of impact/net-zero

In response to increased public pressure, large corporates in consumer goods, energy, agriculture and transportation are starting to pursue sustainability more aggressively. Commitments to reach carbon neutrality are multiplying, and some are setting aggressive goals, such as Siemens pledging to cut emissions in half and go carbon neutral by 2030. Others are giving themselves more runway, such as Repsol with a target of carbon neutrality by 2050. More discreetly, limited partners and high-net worth individuals are increasingly investing with an environmental impact mandate. This macro trend is bound to favor early-stage companies that can help larger organizations on their journey to carbon neutrality – be that through high tech in energy and mobility, or low tech in reforestation, ocean preservation or other environmental offset opportunities.

3. Value chain cooperation

Faced with entire industries to reform, some corporates are choosing a cooperative approach to innovation. This is the case in construction, where cement majors such as Lafarge Holcim are partnering with upstream materials companies and downstream construction companies to identify relevant innovation along the value chain. This is increasingly the case in plastics too, where petrochemicals' corporates must work with packaging, consumer goods' companies and recyclers, if their commitments to bioplastics and circularity are to hold water. The Alliance to End Plastic Waste is an example of such cross-value chain cooperation. Whether it will be enough to address a challenge of that scale remains to be seen.

4. The changing composition of global participation

Over the past five years, we have seen investors based in Asia Pacific nearly triple their participation in European cleantech deals. According to our data, in 2019 they made up 8.5% of the investor base in European cleantech deals, compared with less than 3% in 2014. We have also tracked a simultaneous increase in LP participation from Asian corporates into European cleantech venture funds. Conversely, Asian participation in North American cleantech venture rounds has only grown from 5% to 6.5% from 2014 to 2019, and it has sharply fallen from the 9% record of 2018. This trend and a tumbling deal count in China in 2019 signal the impact of a marked cooling in U.S.-China relations and the difficulty of doing cross-border deals.



Director, Cleantech Group



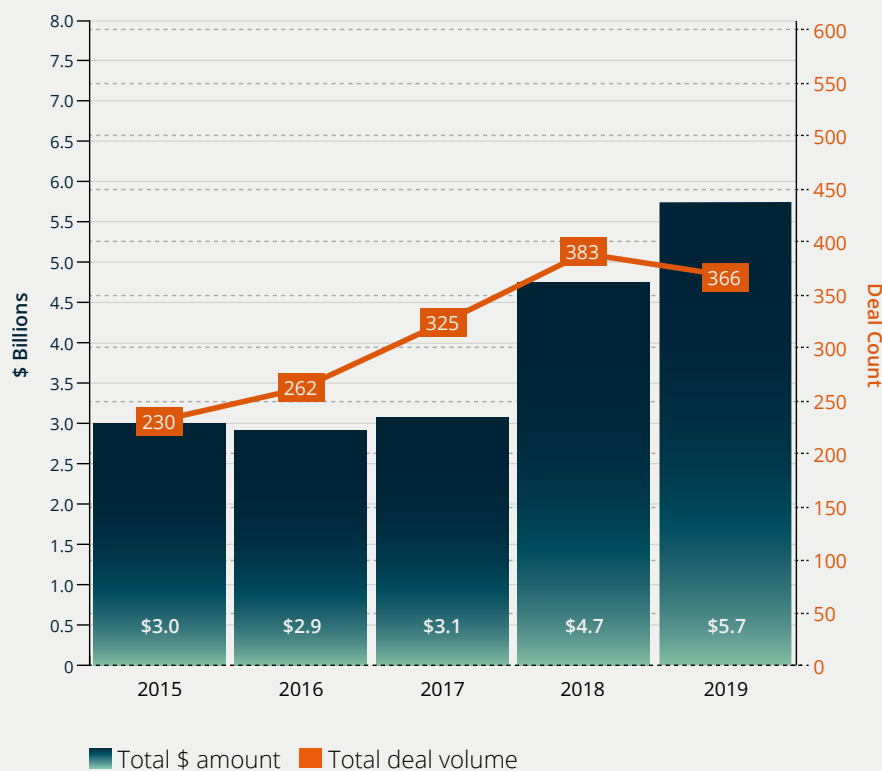
Agriculture & Food

Chris Sworder, Agriculture & Food Analyst, Cleantech Group

→ GLOBAL CHALLENGE:

Over the next thirty years, we need to grow more food than has ever been grown on earth by humans. To achieve this, we need to optimize a food industry that is wasteful and reform an agricultural system that is harmful to the environment.

VENTURE AND GROWTH CAPITAL INVESTMENTS



* Excludes outlier deals above \$350M

INVESTMENT SNAPSHOT

Take away 1: 2019 saw a year-on-year increase in venture investment in Agriculture & Food companies from \$4.7 billion to \$5.7 billion.

Take away 2: Europe and Israel saw the largest increase in dollars invested, more than doubling its 2018 total of \$550 million to reach \$1.2 billion invested in 2019. North American investment totals stagnated at \$2.9 billion, having increased from \$1.9 billion from 2017 to 2018.

Take away 3: Consumer food sourcing businesses drove high investment totals in 2019, accounting for more than a fifth of dollars invested. This was buoyed by consolidation in the takeaway and food delivery sector as companies merged to gain economies of scale, reduce competition and increase profitability.

Overview

While venture investment totals in Agriculture & Food will tend to draw focus on consumer-facing technologies where customer acquisition is expensive, 2019 was a strong year for three technology areas that are well represented in the 2020 Global Cleantech 100; alternative protein feedstocks, controlled environment agriculture (CEA) and biological crop inputs and protection. Leading investment signals in these sectors include; Ynsect's \$125 million round to build out insect-based feed alternatives, infarm and AeroFarm's \$100 million growth equity rounds and Provivi's \$85 million to develop bio-pesticide solutions.



Segment 1 Alternative protein feedstocks

Definition: This segment includes protein-based nutrition for livestock and aquaculture consumption.

Market dynamics

The United Nations Food and Agriculture Organization (FAO) estimates that by 2050 the demand for food will grow by 60%, with meat production projected to rise by nearly 70%, aquaculture by 90% and dairy by 55%. Driving this growth is global population increase combined with increasingly high-protein diets.

While plant-based protein developers such as Impossible Foods and Beyond Meat are growing fast, lowering traditional meat production's resource intensity will be critical. This includes finding alternatives to soy and fishmeal by using inputs such as insects (AgriProtein, Ynsect, two companies returning to the 2020 Global Cleantech 100) or natural gas (Calysta, another returnee to the list).

Today, the main goal of insect farming is to develop a product to replace fishmeal as an ingredient in fish feed. Fishmeal currently has a global production of three to four million tons and was worth \$6.3 billion in 2017. Eventually, insect farmers want to compete in the pet food (\$91 billion) and even animal feed (\$400 billion) markets. However, with Ynsect's first commercial scale plant coming online next year at 20,000 tons/year in an animal feed industry that produced over 1.07 billion tons, this technology is still in its early stages.

Insect developers compete on the choice of insect. While France-based Ynsect uses a beetle, South Africa-born AgriProtein uses Black Soldier Fly (BSF). The beetle may provide a higher protein content and have the advantage that it can't fly, but it requires a dry feed input whereas the BSF can be fed on organic waste streams. Competition tends to focus on the health and nutrition benefits of the product, but the efficiency of the farming system itself will determine margins and profitability.

Lessons from leaders

Agriprotein has shown that rather than building, owning and operating (BOO) each insect farm, a licensing model is possible. Insect farming is highly automated and usually carried out in a clean environment, putting a company's value as much in the process as it is in the product. For a BOO developer like Ynsect to build commercial-scale facilities requires raising project finance based on signed supplier and customer contracts to de-risk the investment. Customers are motivated to sign the contracts before the production facility is built to avoid the increasing price volatility of fishmeal.

Keep an eye on

In the 2019 edition of the Global Cleantech 100, we noted there would be an increasing number of feedstocks being trialed to produce protein feed, including 'methane, CO₂ and even coal'. This year we can add thin air (Solar Foods) and volcanic gases (Sustainable Bioproducts) to the list. These companies are on a growing list of innovators looking in every corner of the earth's biological system to create digestible protein in the most resource efficient way.

Segment 2 Controlled environment agriculture (CEA)

Definition: This segment includes a combination of engineering, plant science, vertical growing systems and computer managed greenhouse control technologies used to optimize plant quality, and production efficiency.

Market dynamics

CEA is predicted to be a \$40+ billion industry by 2022, with a compound annual growth rate of 9.65%.¹ In a controlled environment, it is easier to grow food with less water, less fertilizers and no pesticides. Automation and computer-based management can optimize growing conditions and produce high-density output that can be placed in or near urban demand.

In an agriculture system that will need to support another 3.25 billion city-dwellers over the next thirty years, the high volume of investment in this sector is justified. In order to offset the CAPEX required to build a controlled farm, developers have focused on high-value greens and herbs and the ability to provide a consistent predictable volume of produce all year round. Reduced water use is particularly important in markets such as Singapore or California, where water is more expensive or scarce.

Food safety is another key value proposition of controlled environment farming, as food-borne illness is estimated to cost the U.S. economy \$15.6 billion per year. Indoor farms are controlled growing environments making washing or spraying of the product unnecessary, which reduces the risk of contamination dramatically. This is particularly true in high-value, short shelf-life, leafy-greens which are a key market for controlled environment agriculture.

Early investment in high-tech growing systems has led to a boom in indoor growing start-ups, but many are struggling to reduce the cost of production to competitive prices. Innovation in automation, business models and partnerships are key elements to bringing production costs closer to competitive.

¹ 2018, "Indoor Farming Technology Market to Grow to \$40.25 Billion," *Markets and Markets*.



Lessons from leaders

Infarm is one of two new Agriculture & Food companies on this year's list. The company announced a \$100 million Series B round in June 2019 to scale growth in Europe and the U.S. The company is a good example of business model innovation – working with supermarkets to install their small-scale, remotely-monitored farms directly in the shopping aisle. This distributed farming-as-a-service model is a 'sell once and service' offering that suits venture capital investors' models. Other CEA innovators in the 2020 Global Cleantech 100, such as **AeroFarms** and **Plenty**, are pursuing highly automated medium-scale farms located near urban centers. These companies therefore compete on product alone, in the low-margin fresh produce industry.

Keep an eye on

In the U.S. there is a growing labor shortage on farms. In CEA, 50-80% of the cost of vertical farming is human labor. Therefore, CEA systems with high degrees of automation, or innovators that are developing picking robots and automation systems specifically for indoor applications, are likely to grow. A good example is Iron Ox, a developer of farm automation systems, which raised over \$13 million in July 2017, according to a regulatory filing.

Segment 3 Biological crop inputs and protection

Definition: This segment focuses on the replacement of chemical fertilizers, pesticides and herbicides with biological alternatives.

Market dynamics

Global pressure for more responsible use of chemicals in agricultural systems keeps building. The EU recently banned the use of neonicotinoid pesticides, for fear that they harm pollinator populations. Nitrogenous fertilizer production causes 3% of worldwide GHG emissions and uses 3% of global methane supplies while overuse has created over 500 environmental dead-zones through run-off. In herbicides, Monsanto (now part of Bayer), is currently being sued for claims that its glyphosate-based product Roundup is consistently giving farmers cancer.

Biological fertilizer alternatives to chemicals are being discovered in two ways. Some innovators, such as **Pivot Bio**, featured on this year's list, are using high throughput machine learning techniques to sift through a database of naturally occurring microbes to find ones that have desirable traits. Other developers, such as the Bayer and Ginkgo Bioworks joint venture Joyn Bio, are using gene editing techniques to place the desirable trait in carrier microbes.

Typically, large corporate R&D departments look for projects that can offer a return on investment, or a marketable product, within 24 months. Microbial solutions often take longer to develop, and so are unattractive to internal corporate R&D managers. However, microbial startups are looking to engage with corporate sales teams by licensing products that can act as bio-complements. This means microbial solutions can be mixed with products that already exist in the corporate portfolio to extend the products' lifetime, increase their potency, or change their mode of action. In a sector where it typically costs \$300 million and ten years to bring a new product to market, this offers incumbents the opportunity to innovate on a much shorter timescale and at a reduced cost.

Few microbial developers will try to build a sales force and distribution network themselves due to high risk and cost. To meet global demand, these companies will have to work with Bayer, Syngenta, Corteva or the challengers to these crop input incumbents such as Indigo and **Farmers Business Networks**, as channel partners. Increasing the market share of biological crop inputs will be a challenge as previous generations of biological solutions had difficulty with efficacy and lost customer trust leading to a >10% market share in crop inputs today.

Lessons from leaders

Vestaron, a developer of biopesticides from naturally occurring peptides, discovers natural peptides that are insecticidal before taking the genes of that peptide and putting them in a yeast strain which can be fermented into the final product. Their products have proven to be as effective as chemical neonicotinoids but without being toxic to beneficial insects, birds or mammals.

Keep an eye on

Microbes, being living organisms, can have short shelf lives. Global Cleantech 100 company, Pivot Bio, recently announced a partnership with 3Bar Biologics to manufacture and package its flagship product PROVEN™. The company develops on-site fermentation of microbial fertilizers. Using a two-chamber system, the farmer can release the microbes into a growing solution when s/he is ready to use the product, and the product itself is ready to use in 24 hours. This increases the shelf life of up to one year before the two chambers are mixed, and up to a month after the microbes are re-invigorated. The company's growth model is to partner with microbial developers to develop custom packaging solutions.



Enabling Technologies

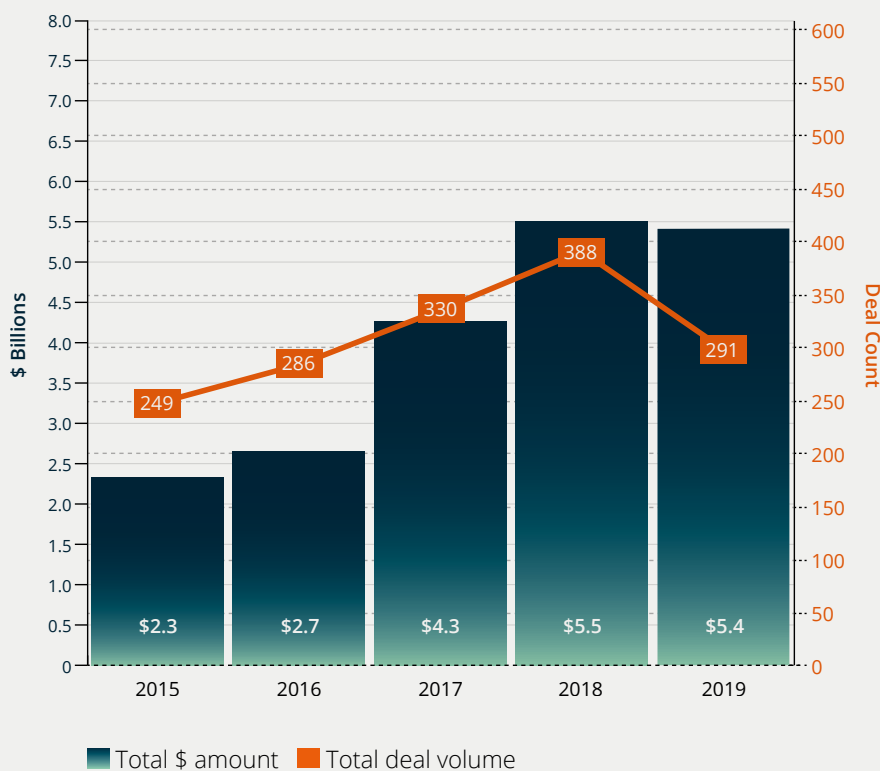
Jules Besnainou, Director, Cleantech Group



GLOBAL CHALLENGE:

Transforming industries requires enabling technologies that can drive down resource use and maximize efficiency of manufacturing and operation processes.

VENTURE AND GROWTH CAPITAL INVESTMENTS



INVESTMENT SNAPSHOT

Take away 1: Investment volume for companies in Enabling Technologies fell from 388 to 291 in 2019, while amounts plateaued at \$5.4 billion. The average deal size shot up from \$14 million to \$18 million.

Take away 2: North America dominated the sector as an investment destination in 2019, with \$3.8 billion dollars invested over the total of \$5.4 billion, compared to \$3 billion in 2018.

Take away 3: Amounts invested in late-stage deals (Series B and above) increased from \$3.8 in 2018 to \$4.1 billion in 2019, while early-stage (seed and Series A) decreased from \$1.7 to \$1.3 billion over the same period.

Overview

A new section this year, Enabling Technologies covers advances in technologies such as geospatial data analytics, artificial intelligence, robotics, sensors and digital technologies that are having an impact across multiple industrial sectors. An example mentioned by our Expert Panel is leveraging AI to predict how a new material will behave by analyzing datasets of existing materials before producing the new one.



Segment 1 Industrial Internet of Things and Analytics

Definition: This segment includes technologies to gather, normalize and leverage industrial datasets to improve processes, create new products and design new usage-based business models.

Market dynamics

As billions of IoT sensors continue to be deployed globally in industrial contexts, software solutions are increasingly important to derive value from the resulting datasets collected. However, industrial companies are increasingly considering this space as strategic and building their own solutions. As one Expert Panelist put it, to be successful, companies in this space will need a differentiated solution, merely helping large companies clean their data won't be enough.

Lessons from leaders

This category welcomes three new entrants this year. **Konux** develops digital twin solutions for industries with a speciality in rail optimization. Based in Germany, the company was lauded for its easily retrofitted solution and its ability to attract a prestigious international investor base, such as Alibaba and New Enterprise Associates. California-based **FogHorn** is developing a competitive advantage in edge computing and analytics for industrial and commercial applications. Clients include General Electric, which leveraged FogHorn's solution to detect and reduce defects in the production of capacitors. **Citrine Informatics** is focusing on the materials industry, specializing in the design and manufacture of new materials with tailored properties. An early customer, BASF is using Citrine's platform to identify and screen new materials for capturing CO₂.

Sight Machine returned to the list in 2020, having closed a significant growth equity round in 2019 with existing investor E.ON and new ones such as Sony. Expert Panelists pointed to the strength of their technology, especially in the manufacturing space. **Element Analytics** and **SparkCognition** also made the 2020 list, with the latter closing a \$100 million growth equity round in 2019, with new investors such as National Grid.

Keep an eye on

Companies that enable the sharing of valuable data between companies facing similar challenges are growing in importance. **Via Science**, a newcomer to the list, is using a combination of AI and blockchain to clean datasets from large energy players and share them anonymously with peers to accelerate problem-solving in the space.

Segment 2 Geospatial data and applications

Definition: Using satellites to collect data on the planet, and developing the analytics tools to turn this data into actionable insights for multiple industries.

Market dynamics

Geospatial data solutions are emerging as an input into existing industrial systems. Examples include construction, where geospatial data can be an input for BIM and 3D modeling, insurance (to quickly assess damages and pay insurance claims), and disaster response solutions, which can help emergency services act faster with better data. There was a surge of investment in this space in the last three years, driven by companies applying geospatial data to specific use cases.

Lessons from leaders

Two companies are returning to the list in this space. **Planet**, which operates a network of observation satellites to provide open-source information on the Earth's changing climate, made the list for the fourth time. After a successful fleet deployment in 2018, which gave the company the ability to monitor the globe 24/7, Planet has undertaken a move downstream to propose analytics on the data it produces. The company closed a \$74 million round in 2019 from Singapore's EBDI fund, in a bid to expand its activities to Asia.

Orbital Insight, which focuses on data analysis for the finance and energy industries, made the list for the third time. The company closed a \$50 million growth equity round in late 2019, with new investors from Chevron and Goldman Sachs.

Keep an eye on

Companies leveraging geospatial data for environmental remediation and restoration are increasingly important. Pachama, which made our inaugural 50 to Watch list this year, is a good example. The company is helping governments and landowners to monitor forests and track the progress of reforestation programs.



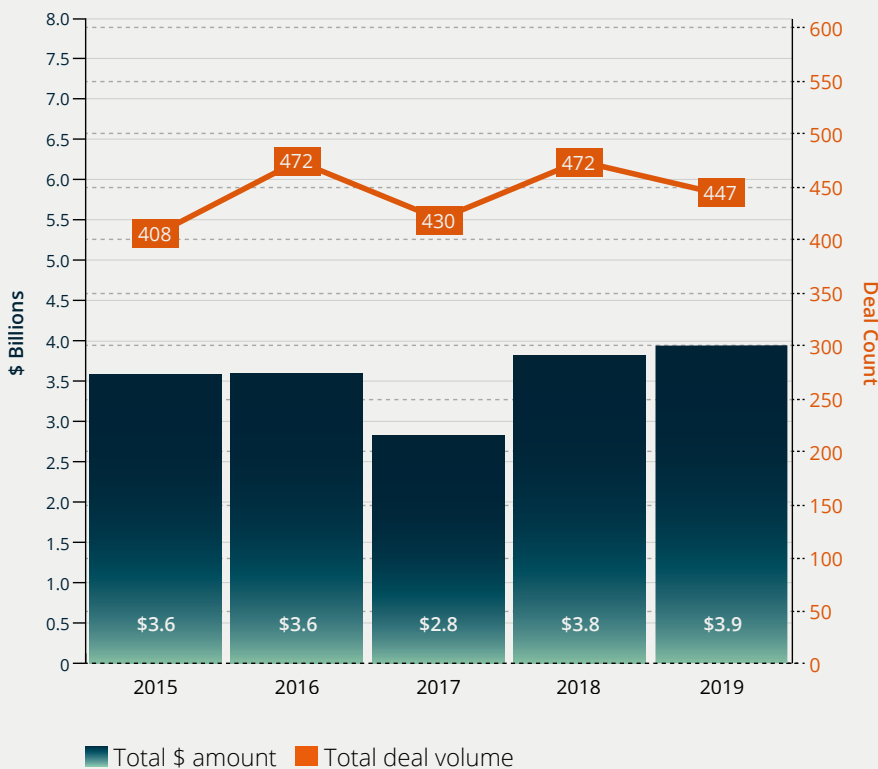
Energy & Power

Louis Brasington, Energy & Power Analyst, Cleantech Group

→ GLOBAL CHALLENGE:

Beyond the growth of renewables, achieving long-term climate, air quality and energy access goals means finding the balance between infrastructure deployment, supportive regulation and data management.

VENTURE AND GROWTH CAPITAL INVESTMENTS



* Excludes outlier deals above \$350M

INVESTMENT SNAPSHOT

Take away 1: Two thirds of the \$3.85 billion invested in 2019 went into the energy storage, energy efficiency and solar sub-sectors.

Take away 2: Europe, Israel and Central/South America were the only regions to see an increase in amounts invested in 2019, speaking to the geographic diversification of capital going into energy innovators this year.

Take away 3: While deal volume dropped by 5.5%, the average deal size of late-stage rounds (series B and above) increased from \$21 million to \$31 million, a sign that innovators in energy are reaching large-scale commercialization and seeking deployment capital.

Overview

Nations and large corporations are setting increasingly aggressive clean energy targets, while solutions are getting better and cheaper at a faster rate. Despite this, utilities and energy majors lack security, and remain unable to manage large volumes of data or deal with critical network bottlenecks. Changes in consumer demand are reshaping traditional roles within the energy sector and decentralization is becoming an integral part of the opportunity for grid participation. We are observing an intensification of innovation in distributed energy resource management, hydrogen and building energy management.



Segment 1 Distributed Energy Resource (DER) Management

Definition: This segment covers hardware, software and services providing visibility to control grid networks. These innovations enable grid optimization and real-time valuation services delivered to customers¹, creating opportunities for new business models. The smart grid market today is valued at around \$25 billion, and the DER management segment is growing at an annual rate of 16.5%.²

Market dynamics

With the fast rise of DERs, real-time flexibility on both sides of assets load and systems is becoming instrumental to complete the system integration of renewables. Advanced DER management systems are assisting existing physical grid networks, reducing the reliance on grid energy during peak energy consumption, when electricity prices are too high. Large energy corporates are investing in and acquiring DER management companies to compete in managing the future network.

DER management is also helping improve resiliency and reliability for ageing grid infrastructure. For utilities, smart asset control serves as a low-cost, non-wire alternative to infrastructure upgrades. This is leading even the least progressive grid participants to invest in DER management solutions.

Business models for DER management vary geographically, as they tend to follow local regulation. The virtual power plant model is proving successful in parts of Europe and North America, owing to favorable government support and a large renewable deployment. With more progressive regulation being implemented across Asia Pacific in 2019, the region is anticipated to show the highest DER growth, especially in India, China, Japan and Singapore.

Lessons from leaders

Increasing penetration of renewables is starting to show the real opportunity of delivering dynamic and multi-service DER management. Successful innovators can efficiently monitor, manage and optimize energy assets. Fourteen of the forty six Energy & Power companies in the 100 are offering DER Management and are differentiated by business model type.

Innovators aggregating load (2020 Global Cleantech 100 companies [Leap](#), [Next Kraftwerke](#), [GridBeyond](#)) are helping enable wholesale market participation and short-term savings where traditional market structures remain an integral component of system design. Building on its domestic success, load aggregator Next Kraftwerke is now offering VPP-as-a-service to large C&I customers and utilities in emerging markets in Asia where demand is high but established VPP solutions are few.

DER management innovators have typically specialized in solving particular grid problems for utilities and operators in different geographies where needs vary depending on regulation and competition. However, 2020 Global Cleantech 100 players such as [Enbala](#), [GreenSync](#) and [Opus One Solutions](#) are increasingly bundling different DER products into a single multi-service platform to cater for a range of customers who sit at different stages of the energy transition.

Lastly, innovators are creating opportunity for DER flexibility in industrial and commercial energy usage for savings, revenues and sustainability. [GridBeyond](#), for instance, is focusing on aggregating and optimizing heavy industry loads, and [Metron](#), another company on the list, is gaining commercial traction with an AI solution analyzing data generated by industrial facilities in real-time to optimize and control energy usage and assets.

Keep an eye on

Technology is now bringing DER management closer to the edge of the grid and away from centralized control rooms. Peer-to-peer energy trading platforms are moving from pilot to commercial level in energy markets where regulatory conditions allow for it. Players on the list such as [WePower Network](#) and [Opus One Solutions](#) have a number of ongoing large-scale pilots, where grid operators at the distribution level are given a more active role in DER management alongside prosumers.

The lines between energy assets and energy efficiency measures continue to blur as innovators get better at turning loads on and off at the right time. [Axiom Exergy](#), included in this year's list and also supported by [Leap](#), can control a customer's refrigerator temperature, turning it from a load to a battery at will.

¹ Fernandes, Edwyne. 2019. "Smart Grid Market Size 2019." *Financial Planning*.

² Sawant, Abhishek. 2019. "Distributed Energy Resource Management Market Size." *Market Research Future*.



Segment 2 Hydrogen

Definition: The segment includes solutions producing hydrogen from blue and green generation solutions, used for fossil fuel processing, ammonia production and a range of emerging applications including power generation, transportation, energy storage and heating. From generation to utilization, the hydrogen market today is a \$145 billion market³ growing at a CAGR of 25%.⁴

Market dynamics

Despite multiple false starts, hydrogen's versatility as a renewable energy source is attracting increasing interest from corporates and governments. Over the past 18 months, there has been an acceleration across all things hydrogen: water electrolysis, infrastructure build up and the emergence of new applications such as rail and shipping. Today, 80% of the hydrogen market is used mostly in oil refining and for the production of fertilizers processing, of which, 95% is produced via carbon-based production methods. It has an estimated potential to provide 18% of energy demand within a two-degree world, providing 78 exajoules of annual energy, up from eight exajoules in 2015.⁵ There seems to be strong traction and enthusiasm for hydrogen, however the generation of clean hydrogen faces several challenges including cost, efficiency and infrastructure scaling.

Policy support for hydrogen is growing, with around 50 targets, mandates and incentives already in place globally supporting hydrogen deployment. The majority of these incentives focus on hydrogen as a fuel for vehicles.

Northern Europe and the UK are good examples, with strong growth in public and private investment into hydrogen in earlier stages. Australia and other Asia Pacific countries are starting to pursue green hydrogen production and export, based on wind and solar production. China is aggressively driving hydrogen and fuel cell development and is on track to outpace development in the EU and U.S. with a focus on hydrogen buses and trucks. Their goal is for hydrogen to account for 10% of the Chinese energy system by 2040.

Lessons from leaders

For low-carbon hydrogen to become a cost competitive energy source, leaders in the space need to address the cost and efficiency of electrolysis, which remains one of the key barriers for wide-scale hydrogen adoption. Outside of carbon-based generation, water electrolysis remains the current frontrunner, despite only accounting for approximately 4% of global hydrogen production.⁶ Germany-based [sunfire](#),

a 2020 Global Cleantech 100 returnee, has managed to maintain high efficiency using electrolysis operating with high temperature, creating opportunities where heat feedstock is readily available, such as in heavy industry. Partnering with large steel and energy majors, the company is helping to decarbonize these industries.

Storing hydrogen is also a costly process. Pressured gas and liquid hydrogen are the current frontrunner solutions, but demand for increased efficiency and density, and decreased cost and chances of leakage is creating challenges for innovators in the space. [Hydrogenious LOHC Technologies](#), a 2020 Global Cleantech 100 Company, has developed a Liquid Organic Hydrogen carrier which enables safer and more cost-efficient high-density hydrogen storage in an easy-to-handle oil, eliminating the need for pressurized tanks for hydrogen storage and transportation.

Keep an eye on

The increasing demand to replace carbon-intensive energy will create opportunities for other renewable energy carriers such as methanol and ammonia as replacements for CO₂ alternatives. Energy carrying molecules can act as productive means of low-cost energy transfer which may be better suited to a specific customer or end use. Green ammonia has strong potential as an energy carrier, given its established supply chain, high demand in the fertilizer industry and high energy density (three times that of compressed hydrogen). Countries such as Australia are looking at ammonia for its energy export potential and pilot projects are underway across the country with leading energy players and ammonia producers. Innovators developing low-cost green ammonia production solutions should have an impact in the next 10 years.

Other Innovators are focusing on novel hydrogen generation solutions to further decrease cost and increase roundtrip efficiency of commercialized systems. Solutions such as Anion Exchange Membrane electrolysis, which removes some of the material costs, are gaining interest. Additionally, biomass gasification and microbial conversion technologies can capitalize on the opportunity to create hydrogen from waste and further decrease costs.

Hydrogen is poised to play a larger role in the electrification of heavy industry. Innovators are looking to profit from the decarbonization targets set out in the steel sector, utilizing low-carbon hydrogen as a replacement for coking coal in iron ore production. The UK recently announced a Clean Steel Fund to support the iron and steel industry using hydrogen, and players such as SSAB, Tata Steel, and Paul Wurth are engaged in multiple related pilots.

³ John, Joel. 2018. "Global Hydrogen Market." *Zion Market Research*.

⁴ "Hydrogen and Fuel Cells Market 2019 Global Size." *Global Banking and Finance Review*.

⁵ 2019. "The Future of Hydrogen." IEA.

⁶ Ibid.



Segment 3 Building Energy Management

Definition: For this segment, solutions connecting, monitoring and controlling buildings, including hardware, software and services, used to improve operational and energy efficiency of assets are the focus. The building automation market today is estimated to be worth \$75 billion and growing at a CAGR of 10-12% annually.

Market dynamics

The building energy management market is undergoing rapid change. Buildings account for 28% of global emissions and increased regulatory pressure is forcing owners and operators to rethink how they manage energy. At the corporate and government level, rising awareness in energy use within commercial, residential and industrial buildings is creating more opportunity for innovators.

Software innovation such as AI and machine learning, combined with low-cost IoT sensors are enabling better monitoring, control and automation of lighting and HVAC systems as well as driving comfort for users. Innovators base their value propositions on the strength of their algorithms and the positive impact on CO₂ reduction and bottom lines. Corporates have been keen to invest in the sector, especially through acquisitions, to remain competitive. Start-up acquisition in the space has increased by 27% in the last two years. Former Global Cleantech 100 Companies, Powerhouse Dynamics and Enlighted for example, have both now been acquired by large corporates.

North America is seeing the most activity, driven by state-level regulation in combination with corporate renewable goals. Market dynamics tend to differ by region. Customers in North America and Europe prioritize energy savings. In Asia Pacific they prioritize the productivity gains for people working in the buildings.

Lessons from leaders

Retail electricity suppliers in the U.S. are looking for new approaches to improve customer engagement and compete in deregulated retail markets. Innovators like **Sense** and **Innowatts** have strong value propositions there.

In the residential and commercial building market, non-intrusive load monitoring is providing more opportunities for insights into the energy usages of consumers, further deduced from customers' consumption behavior. A key movement in the space this year was the formation of Uplight, a company that was formed from the merger of former Global Cleantech 100 companies Tendril and Simple Energy, which acquired other Global Cleantech 100 award winners First Fuel Software, EnergySavvy as well as EEme to position itself as a market leader in the non-intrusive load monitoring market.

In the residential space, consumers are coming back to smart Wi-Fi enabled thermostats capable of demand response control. These smart thermostats are increasingly integrated with virtual assistants like Amazon's Alexa or Google Assistant to control and monitor building temperature. Global Cleantech 100 returnee **tado** is a key innovator in the European heating and cooling market, and **Ecobee**, also on the list, is well-established in North America, claiming their device can save an average of 23% on energy bills.

Incumbent energy providers, and some innovators looking to compete with them, are now offering more actively managed energy efficiency services, covering the cost of infrastructure upgrades. One returnee to the list, **Carbon Lighthouse**, has services that are currently deployed in about 500 buildings in 16 states, offering customers a savings guarantee on their utility bills covering any required CAPEX costs. Energy-Efficiency-as-a-Service is pursued by energy majors such as Shell as a stepping-stone to becoming vertically integrated power companies, and by legacy utilities retreating from independent power production positions and looking for new business models.

Keep an eye on

As the market consolidates, innovators will succeed by establishing partnerships with incumbents and by optimizing their algorithms to identify further cost savings. Look out for automated, prescriptive closed-loop control solutions which dynamically predict requirements in buildings. Advanced analytical capabilities will produce predictive models for system reliability and energy capacity, unlocking applications like optimized cooling management.



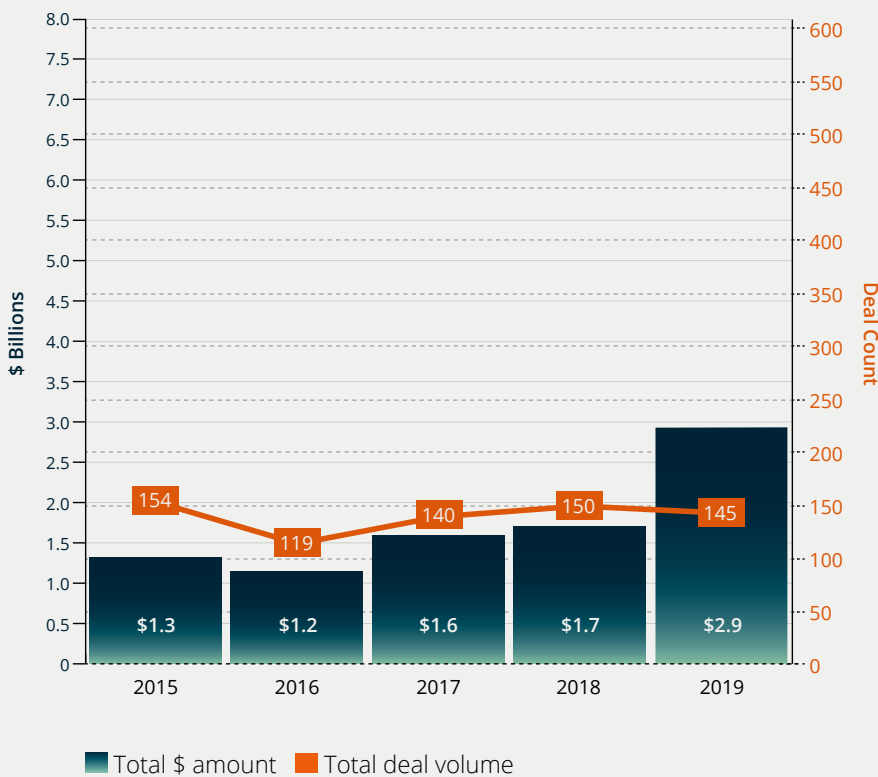
Materials & Chemicals

Chris Dawe, Associate Director and Irene Boghdadi, Junior Analyst

→ GLOBAL CHALLENGE:

Even with the clean energy and energy efficiency technologies available today, the steel, cement, aluminum and plastics industries alone are projected to cause at least 1.5 times the total allowable greenhouse gas emissions (GHG) budget for a 1.5C future by the turn of the century.¹ Significant innovation in materials and chemicals is needed to overcome this challenge.

VENTURE AND GROWTH CAPITAL INVESTMENTS



* Excludes outlier deals above \$350M

INVESTMENT SNAPSHOT

Take away 1: The deal volume in the M&C sector in 2019 is only about 5% less than in 2015, which saw the highest deal flow in the past five years. However, the total deal amount is the highest at \$2.9 billion, slightly more than double the amount in 2015. This reflects an interest in scaling more established companies, with 2019 seeing the highest average Series B+ investment amounts.

Take away 2: North America is slowly losing share to Europe and Israel but continues to be the dominant investing region at about \$2.3 billion in 2019 (80% of the total amount of \$2.9 billion).

Take away 3: Corporate participation in M&C deals remains relatively low at 22% of the total deal volume on average from 2015 to 2019. However, the percentage of deals with corporate participation in 2019 was above average and the second highest in (at 23%) after the year 2017 (at 27%). The average number of corporates participating per round was the highest in 2019, reflecting increased corporate co-investments in larger deal amounts.

Take away 4: The year 2019 followed a similar pattern as 2018 in terms of deal volume in Seed & Series A, Growth Equity and Series B+, with the most investments in Seed & Series A (79 deals), followed by Series B+ (51 deals) and finally Growth Equity at about a third of Series B+ (15 deals).

Overview

The Materials & Chemicals sector covers the creation of new materials and chemicals that consume fewer resources, or the search for increased resource efficiency across the value chains of the industry, including circular economy models. Drivers for innovation in this industry include the need for performance and cost, as well as social demand for environmentally sustainable practices. There is also regulatory and governmental pressure, with increasing commitments and legislation for sustainable development goals. Governments and corporates also seek to build resilience in the face of climate change and finite natural resources. The challenge in this sector is the high initial investment cost needed to create and scale new materials, and develop the corresponding supply chain.

¹ 2019. "Completing the Picture." Ellen MacArthur Foundation and Material Economics.



Segment 1 Enabling Industrial Biotech

Definition: The Industrial biotechnology market includes biofuels, biochemicals and biomaterials. For the purpose of this section, we will focus on technologies that enable the development and scale of fuel, chemical and material products that can be used as renewable alternatives to traditional ones. According to a research report by Global Market Insights in 2018, the biotechnology Market will expand at 9.9% CAGR to \$775 billion by 2024.²

Market dynamics

Large incumbents in pharmaceuticals, food, agriculture and textiles are increasingly partnering with innovators to increase the ROI of their existing R&D activities. The need for advanced biotechnology products will continue to increase. Further investment, key partnerships and government support will help drive biotechnology market growth.

Innovation examples include rapid sequencing, high-throughput screening (HTS), process automation and synthetic material production. Companies that will have the greatest impact will be defined by their ability to design, develop and test high-performance industry-scale biotechnology to improve both efficiency and competitiveness. Many are doing so by providing new data sources/management tools and personalized inputs/products to accelerate the discovery-to-post-launch process, making it more economical and process efficient for the industry.

Lessons from leaders

Global Cleantech 100 returnee and cell factory engineering start-up **Arzeda** uses a computational approach to protein design to produce tailored, synthetic proteins capable of industry-scale chemical production. The company works in partnership with incumbents to optimize their existing bio-product manufacturing processes and product features or to produce novel materials targeting untapped markets. Clients include DuPont Pioneer, Invista and Amyris to develop proteins that could go into seeds, nylon and fragrances. Arzeda has also partnered with BP to develop a process for producing a renewable chemical for a wide range of applications.

Leveraging chemistry and biology to develop material building blocks, **Checkerspot**, debuting in the 2020 Global Cleantech 100, designs and tests high performance materials using microbes. The company focuses on bio-based oils and aims to expand existing chemical building blocks such as polyurethanes. Checkerspot has piloted applications in textile and agricultural chemicals and raised a Series A round led by Builders VC in 2019 to expand into different industrial verticals.

In 2018, the company formed a joint development partnership with DIC Corporation, a Japanese leader in fine chemicals, to develop a new class of high-performance polyols.

Keep an eye on

While still in early stages, quantum computing could have a strong impact in the Materials & Chemicals sector. It is expected to solve computational questions that cannot be answered by existing technology. A few companies are exploring applications of quantum computing for chemicals. For instance, HQS Quantum Simulations is using quantum algorithms to forecast molecular reactions for high performance materials, specialty chemicals and pharmaceutical companies. The company raised seed funding in 2019 from UVC Partners and btov to strengthen its quantum simulation team. Zapata Computing is another company using quantum to develop chemistry-based solutions. The company is looking to develop solutions for antibiotic-resistant bacteria and water pollution.

Segment 2 Bioplastics

Definition: Bio-derived or biodegradable alternatives to traditional petrochemical-based plastics, bioplastics are produced from post-consumer waste, greenhouse gases and extracts from biomass products or by-products such as algae, mycelium and lignin. The global bioplastics market generated \$24 billion in 2017 and is expected to hit about \$69 billion by 2024, with a CAGR of about 19%.³

Market dynamics

The growing demand for bioplastics is driven by public pressure on environmental crises including plastic waste threatening oceans and marine wildlife. A growing base of multi-national corporates, particularly in the oil and gas, materials and chemicals and fast-moving consumer goods, are looking to deploy solutions to gain a license to operate, and simultaneously lower their carbon emissions. Incumbents like Solvay, BASF and DuPont have taken the lead on the mass production of PLA bioplastics and enabling materials. Start-ups are paving the path for the widespread deployment of PHA bioplastics, sometimes in partnership with the incumbents. Finally, companies are experimenting with a variety of inputs, from natural fibers to inorganic solid waste to greenhouse gases, to find solutions that can be both cost competitive and with petrochemical based products and integrated into existing processes. However, the existing supply chain and economies of scale of traditional plastic will make it hard for bioplastics to become competitive without governmental or regulatory support.

2 2018. "Biotechnology Market Size by Application." *Global Market Insights*.

3 2019. "Bioplastics Market by Type." *Allied Market Research*.



Lessons from leaders

A key challenge for bioplastics is sourcing feedstocks at the necessary quantities and quality to compete with petrochemicals. For example, PLA, derived from sugar cane or corn starch, is unsuitable for high temperature applications such as coffee cups and certain automotive parts. PHAs are currently too expensive for large scale applications. Moreover, bio-based materials often rely on biomass raw materials which might be better utilized for human or animal nutrition. Looking to move past these challenges, several companies have piloted and commercialized a variety of bioplastics using alternative raw materials from inorganic or organic materials/waste. They are also developing new materials and changing existing plastic compositions to make them more eco-friendly. 2020 Global Cleantech 100 debutant, **Mango Materials** and two-time returnee **Newlight Technologies** use greenhouse gases as a feedstock for their bioplastics. Mango Materials, for example, formulates PHA pellets from methane captured in landfills in California. The company currently serves several industries looking to incorporate biodegradable materials in their supply chains such as niche cosmetics and sportswear brands. Many of the companies are looking to diversify their waste streams to include input from dairy farms, oil and gas operators and other established commercial markets to mitigate the risk of relying on a few sources.

Keep an eye on

Flexible packaging for fast-moving consumer goods has been widely available and steadily growing since the mid-20th century. Its consistent growth is credited to several functional properties including being re-sealable, microwaveable, lightweight and more environmentally friendly compared to its rigid counterparts. However, flexible packaging is produced from a wide range of resins and polymers, and is often challenging to collect, sort, recycle and resell. One of the approaches that innovative companies are starting to pursue, is to develop technologies to recycle these multi-polymer packages for applications that could handle a mixed-material feedstock. For example, Seattle-based Arqlite, has developed a technology to produce construction materials, including gravel and light concrete, from flexible packaging. Radical Plastics manufactures biodegradable plastic compounds by mixing conventional plastics with its proprietary naturally occurring catalyst. In 2020, it plans to produce flexible packaging.

Segment 3 Sustainable Building Materials

Definition: This segment covers materials that go into the sustainable design, delivery and assembly of buildings and other infrastructure. The global green building materials market size was estimated at \$192.3 billion in 2016, growing at a CAGR of 11.2% to 2022 when it was expected to reach \$364.6 billion.⁴

Market dynamics

A growing population and increasing urbanization are driving demand for sustainable building materials in the construction industry.

While the construction industry is slowly adopting innovative solutions to tackle key challenges such as the shortage of skilled workers, cost overruns and waste production, they still suffer from low profit margins largely due to rising labor and material costs as well as increasing competition.

Sustainable building materials will play an important role in helping the industry mitigate the risk of volatile costs and meet environmental sustainability goals. Cement and steel, which form about a third of the construction materials used, emit two to three times more carbon than timber, which is experiencing a rebound in use in construction, especially in the Nordics. The innovation ecosystem in sustainable construction materials is growing fast. In the materials space, companies are developing modular manufacturing, material re-use, materials marketplaces, specialty concrete and other specialty materials. This section will highlight innovators in specialty concrete and other materials.

Lessons from leaders

Companies that can have the greatest impact provide modular, low-cost, easily retrofitted and low/zero-emissions solutions for materials like steel and cement. Moreover, partnerships with industry incumbents to provide turnkey solutions are crucial to unlocking wide-scale deployment of the solutions being developed by innovative companies.

2020 Global Cleantech 100 debutant, **Carbicrete** and two-time returnee, **Solidia** are among more than a dozen companies working on the tail-end of the carbon-

⁴ 2018. "Green Building Materials Market Size, Share & Trend." Grand View Research.



to-value supply chain. Both start-ups are focusing on CO₂ mineralization solutions that sequester carbon for industrial applications. The start-ups license their technologies to pre-cast concrete manufacturers looking to produce sustainable building materials and decrease their carbon footprint. In closing the loop, Carbicrete also adopts a waste management approach by using a by-product of steel production, steel slag, that currently gets landfilled, to produce a cement-free alternative. It is building a pilot plant that is expected to be completed in 2020. In scaling their proof-of-concepts, start-ups in the space tend to pursue turnkey project developments in partnership with large incumbents. For example, in August 2019, Solidia Technologies partnered with LafargeHolcim in the U.S. to provide a turnkey solution to EP Henrys Wrightstown, a New Jersey-based pavement plant.

Pursuing similar goals in the steel industry, **Boston Metal**, another 2020 Global Cleantech 100 debutant, is scaling its molten oxide electrolysis (MOE) technology to reduce carbon emissions from the production of steel and other ferroalloys. The company received funding from Breakthrough Energy Ventures in early 2019 to deploy their solution on an industrial scale.

2020 first-time Global Cleantech 100 company, **Phase Change Energy Solutions**, is using bio-based materials to tackle the growing global heating and cooling challenge. The company provides thermal storage solutions for buildings using a proprietary non-toxic, non-corrosive phase change material produced from sustainably-grown food grade by-products. In 2018, the start-up received third-party certification for its bio-based material from the USDA's BioPreferred program.

Keep an eye on

As efforts to withstand adverse weather and changing climate conditions become more important and urgent, companies will increasingly focus on building resilience. For example, EONcrete develops propriety bio-enhancing concrete mixtures to produce more resilient materials for coastal developments. Another start-up, Green Basilisk, develops self-healing bio-concrete to minimize concrete degradation in environments regularly exposed to water, where it is often challenging to do maintenance and cracks in the concrete can easily occur.



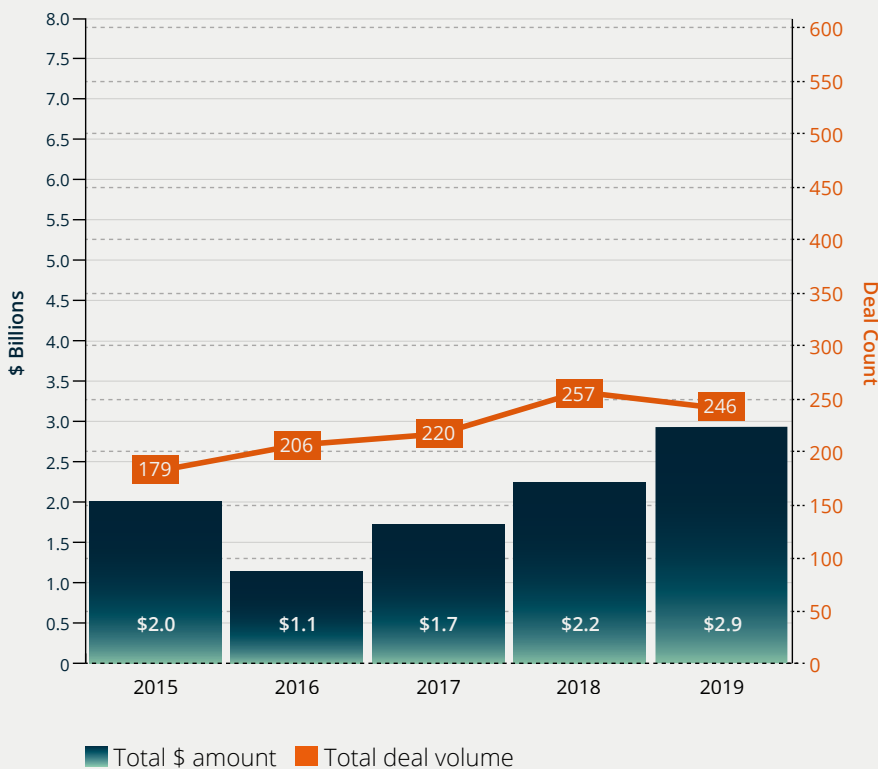
Resources & Environment

Holly Stower, Resources & Environment Analyst, Cleantech Group

→ GLOBAL CHALLENGE:

Using our planet's resources in a more responsible way means reducing our dependence on plastics, coming up with better ways of managing water, and starting to draw value from carbon capture.

VENTURE AND GROWTH CAPITAL INVESTMENTS



* Excludes outlier deals above \$350M

INVESTMENT SNAPSHOT

Take away 1: 2019 saw a significant rise in the amounts invested into Resources & Environment companies, which can be attributed to large deals in the sharing economy and short-term rental sector totaling \$476 million and the construction sector totaling \$490 million. Recycling and waste investments also contributed significant investment this year totaling \$660 million.

Take away 2: Investment into geospatial data capture, compilation and analytics companies have risen considerably this year to over \$330 million as cheaper sensors and satellite launches enable economies of scale for underlying technologies.

Take away 3: The geographical spread of deals has not changed much in the past four years. Most investments go to North American companies, less than a third to Europe and Israel and less than 5% of deals to Asia Pacific.

Overview

In recycling and waste, global regulations are forcing waste incumbents to develop local recycling solutions and reduce exports, while public pressure is encouraging governments and corporates to take greater responsibility for waste streams. Players across the plastics ecosystem are innovating to tackle our global reliance on plastics and mitigate plastic pollution. In water and wastewater, water harvesting and membrane technology investment has shifted to water-saving innovations like smarter water systems and leak detection. Carbon Capture Storage and Usage (CCUS) has also seen a resurgence due to public pressure, combined with new CO₂-to-value business models.



Segment 1 Recycling and Waste

Definition: This segment looks at innovation and investment activity within the recycling and waste sector, with a focus on plastics, digitized recycling and textiles. Innovation in waste technology and business models has created more options for responsible consumer consumption and disposal. However, recycling facilities are struggling to process the high volume of recyclable waste and prevent contamination. A further shift to circular and sharing economy models represents an opportunity for significant cost savings across all industries, projected at between \$340 billion and \$380 billion per annum in the EU alone.¹

Market dynamics

Before 2018, China took in more than half of the world's plastic waste. But the National Sword policy banned plastic and other solid waste imports. As a result, bulk waste prices have declined, while more plastics are ending up in landfill, incinerators and overloaded domestic recycling facilities. This has fostered consolidation in the waste market, with larger firms acquiring assets and smaller competitive companies. For example, the UK's Biffa has acquired \$90 million worth of assets since 2017. GFL Environmental acquired Bestway Disposal; Reconomy acquired Prismm Environmental and Valicor was acquired by Pritzker Group, all in 2019. Incumbents are widening their offerings, investing in domestic recycling facilities and starting to integrate innovation into their processes.

Large-scale material recovery facilities are looking to mitigate higher recycling and labor costs while improving the purity of recycled waste. Robotic sorting, a technology increasingly deployed in such large facilities, offers a solution that reduces the costs of labor for sorting and facilitates local recycling solutions. The global market for waste sorting is predicted to reach \$12.24 billion by 2024, with an annual growth rate of 16.4% between 2019 and 2024.²

In 2018 the EU passed legislation under the EU Waste Framework Directive with a target to recycle 50% of Municipal Solid Waste (MSW) by 2020 in all EU member states. Corporates and distributors have begun to plan for this legislation by looking at the circularity of the products they produce alongside new business models. For example, TerraCycle has partnered with brands like Häagen-Dazs and with retailers like Tesco and Walgreens as well as logistics provider UPS to offer a shopping and collection scheme for products in reusable packaging.

Ocean plastic waste remains a hot topic this year, with new funds such as Sky Ocean Ventures dedicated to tackling the issue. Corporates like Coca-Cola have started to explore plastic alternatives, integrating recycled plastics into packaging and have also invested in innovative recycling schemes. These efforts remain far from enough given the extent of the crisis.

The global fashion industry continues to produce 1.7 billion tons of CO₂ per year with two thirds of clothes being derived from fossil fuels and over 80% of textiles produced ending up in landfill. To counter the fast fashion industry, bio-based materials and dyes are being developed alongside chemical recycling technologies for more sustainable end-of-life solutions.

Lessons from leaders

2020 Global Cleantech 100 debutant **AMP Robotics**, which develops machine learning and robotic technology for waste recycling, received \$3.3 million in Series A funding in January 2019 and then another \$16 million in November. The company also entered a technology partnership with Japanese waste technology company Ryohshin to develop AI-driven industrial robotics for material recovery in the Japanese construction and demolition market.

2017 and 2018 Ones to Watch company, **Tipa**, is back in the Global Cleantech 100 this year after raising \$25 million in growth equity funding in order to expand operations in Europe and Australia. Tipa develops biodegradable and recyclable flexible packaging solutions for the food, health and fashion industries. Tipa's growth is driven by consumer and retailer demand for bioplastics in Europe, the U.S. and Australia.

ELeather is featured in the Global Cleantech 100 for the fifth time in 2020, following a \$100 million investment for a 230,000 square-foot manufacturing facility in 2018 alongside partnerships with Nike, Genomatica and several airlines. This year, ELeather reupholstered seating on 64 aircrafts for Aeromexico, and has plans to reupholster its entire fleet in the coming years. They are also working with bus and train companies.

Keep an eye on

Several earlier-stage companies are developing chemical recycling technologies for textiles. Among them, Finland-based, Infinite Fiber and Australia-based BlockTexx made our new 50 to Watch List. They are looking to license their technology or build processing plants themselves.

While biodegradable packaging solutions have been gaining momentum for some years, we are seeing increased interest in reusable, plastic-free lifestyle product retailers and developers. For instance, Package Free, a New York-based retailer of waste and plastic free products recently raised \$4.5 million in a seed round.

¹ 2019. "An Economic Opportunity Worth Billions—Charting the New Territory." *World Economic Forum*.

² 2019. "Waste Sorting Robots Market Analysis: Overview (Size, Share, Scope, Demand, Trends, Growth Opportunities, Challenges), Segmentation (By Waste, By End User, By Geography)." *Goldstein Research*.



Segment 2 Water and Wastewater

Definition: This segment includes innovations in the municipal water and wastewater market for commercial, industrial and residential consumers. Population increases, pollution, growing incidence of drought and extreme weather events are all putting strain on the global water system. In response, technologies are being developed to manage scarcer and less reliable water sources. The global water and wastewater treatment market is predicted to be valued at around \$211 billion globally by 2025 at a CAGR of 6.5% from 2019.³

Market dynamics

Early-stage investment in emerging solutions for wastewater is diversifying into sectors like agriculture, textiles and oil and gas. Most investors, corporates and entrepreneurs active in wastewater innovation are U.S.-based. However, China and the Middle East, where new infrastructures are being built, are perceived as growth markets for many water innovators. Supportive government schemes exist in these regions as water intensive industries such as chemicals manufacturing continue to expand.

In response to increasingly strict regulatory requirements and limited hardware innovation, businesses are turning to distributed or modular water treatment-as-a-service models of business. For example, Rolute Marine has developed wave-powered, modular desalination technology for water-scarce island nations or coastal cities which they offer to water utilities with a service model.

Commercial products which reduce water use are becoming increasingly popular. **Altered**, developer of water-saving nozzles for showerheads and taps, made the Cleantech 100 list this year. The company started to commercialize its nozzles to hotels and airlines and is now moving to direct consumer sales through a crowdfunding campaign. Innovation in water-saving devices is growing in response to reducing potable water reserves and increasingly frequent droughts.

Lessons from leaders

Organica Water, now a seven-time Global Cleantech 100 company, develops attractive, nature-based wastewater treatment plants in urban and residential population centers. In accordance with the Chinese National regulations, which requires some manufacturing plants to provide wastewater treatment, Organica helped Foxconn Technology Group add such a facility to its manufacturing plant in Shenzhen, China. The plant now serves 18,000 people with potable water, while improving the working conditions for Foxconn employees.

Five-time Global Cleantech 100 company **Axine Water Technologies**, developer of a low-cost, chemical-free solution for treating high concentrations of complex, toxic organics and ammonia in industrial wastewater, is experiencing strong traction in various industries, including electronics and pharmaceutical companies.

Keep an eye on

Early-stage investment into water management software is continuing, despite the long sales cycles with water utilities. AI water management software developer Plutoshift recently raised \$6.7 million in a Series A round. The underpinning technologies of water sensors are benefiting from economies of scale, making applications like leak detection more affordable. For example, Innovators Hero Labs and FloodFlash are partnering with corporates and the financial services sector to prevent water loss and flooding.

Microplastics that pollute our water system are drawing increasing attention, with new startups like machine washing bag developer Guppy Friend and home filtration system developer Umuntu offering domestic microplastic filtration solutions.

Segment 3 Carbon Capture, Usage and Storage (CCUS)

Definition: Despite decades of scientific warnings on climate change, a recent United Nations report found that emissions have continued to rise steadily over the last decade. In recent years, CCUS has drawn increasing attention from policy makers, large energy incumbents and some investors. The global carbon capture and storage market is expected to achieve a CAGR of 9.22% during the forecast period of 2019–2024.⁴

Market dynamics

Early-stage demo projects, supported by governments, are helping build market trust and interest for CCUS solutions. In February 2018, the U.S. Government increased tax credits from \$20 to \$50 for CCS or CCUS projects to spur investment in the technology. This year the U.S. Department of Energy also announced a \$110M fund for CCUS R&D.

The U.S. represents a global hub for CCUS investment. Encouraged by friendly policy, the majority of CCUS projects are currently based there. Canada, the UK and Japan are also investing in the technology, and several projects have emerged in China, Norway, Saudi Arabia and Australia in recent years.

3 2019. "Water and Wastewater Treatment Market by Treatment Technology (Membrane Separation, Membrane Bio-Reactor), Delivery Equipment, Treatment Chemicals, Instrumentation, Application, and Geography - Global Opportunity Analysis and Industry Forecast to 2025." *Meticulous Research*.

4 2019. Carbon Capture and Storage Market - Growth, Trends, and Forecast (2019 - 2024)." *Mordor Intelligence*.



CCUS has passed feasibility stages and companies are emerging with competitive waste-to-value business models. Captured CO₂ can be used as transportation fuel, in enhanced oil recovery and in advanced building materials. These use cases make the economics of carbon capture more favorable. Additionally, smaller scale systems are reducing necessary capital expenditures and could fuel a market expansion.

However, the price of CCUS is expected to be above the market price for the foreseeable future with CCUS expected to drop below \$100 per ton in the next five-to-ten years, where costs range from \$600 to \$800 per ton at present. Governments will need to continue to implement policy measures, including tax credits and grants to foster further investment into the technology.

Lessons from leaders

Carbon Engineering, a debutant on the 2020 list, received \$68 million in growth equity funding this year to allow the company to commercialize and enter mainstream markets with its direct air capture technology. In May this year, Carbon Engineering was awarded \$1.5 million from the Canadian Government to develop aviation fuel from its captured carbon technology. With this waste-to-value business model Carbon Engineering estimate they can reduce the carbon cost down to \$98 per ton. They are also looking to capitalize on the U.S. tax credits for CCUS to bring costs down further.

The majority of CCUS projects capture CO₂ directly from industrial sources or coal fired plants. This is partly due to convenient and concentrated sourcing of raw materials. Canadian based **Svante**, a Global Cleantech 100 returnee and previously known as Inventys, has developed energy- and capital-efficient technology for capturing CO₂ directly from industrial sources. They have continued to partner with large corporates such as Total and Lafarge Holcim to deliver carbon capture projects in Canada. They have also received funding from new investors Chevron Ventures, OGCI Climate Investments and BDC Capital.

Smaller-scale carbon capture technologies are emerging, paired with high-emitting manufacturing and industrial industries to capture carbon at source. Companies like **CarbonCure**, a Global Cleantech 100 returnee, inject air captured carbon back into concrete, permanently fixing the CO₂ and can be retrofitted into existing concrete plants. This close alignment with industry has enabled CarbonCure to commercialize and scale faster than large-scale plants.

Keep an eye on

Natural carbon sequestration from reforestation projects is becoming commercially viable, with an increasing number of large corporates looking to offset their emissions and be seen as taking aggressive steps to protect our environment. For example, Land Life Company, who made our new 50 to Watch List, facilitate end-to-end reforestation and land restoration services by selling the resulting carbon credits to large corporates. In August this year, Land Life Company partnered with Shell to launch a data-driven reforestation project in Spain, planting and monitoring 300 hectares of degraded land.



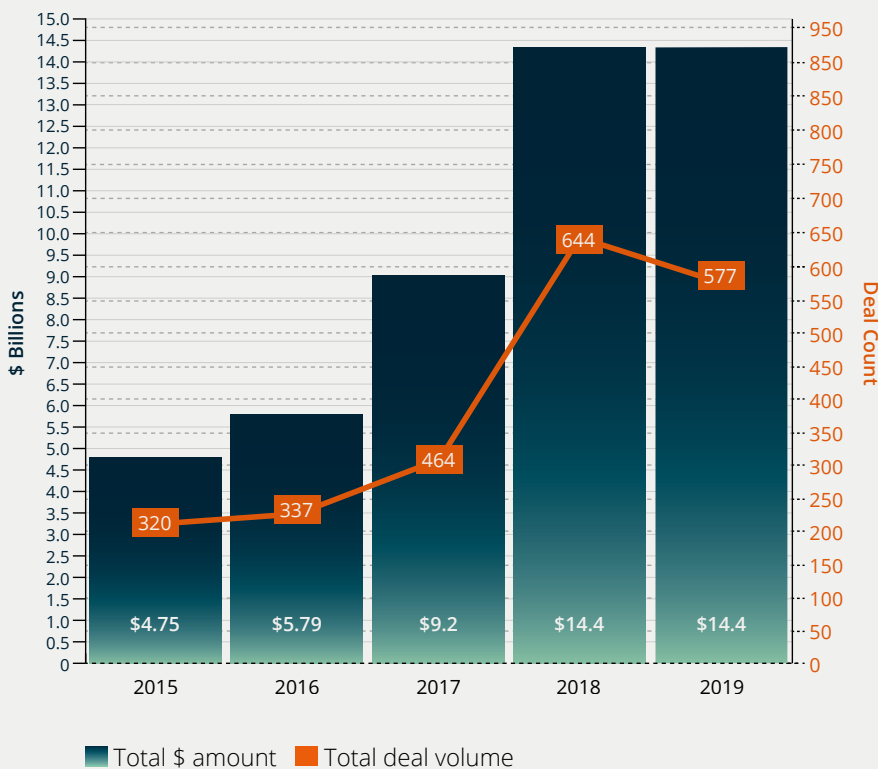
Transportation & Logistics

Cassidy Shell, Transportation & Logistics Analyst, Cleantech Group

→ GLOBAL CHALLENGE:

Transportation accounts for 23% of total energy-related CO₂ emissions globally and emissions are increasing at a faster rate than other energy end-use sectors. As the global population grows and continues to urbanize, transportation needs to decarbonize rapidly to reach global emissions reductions targets.

VENTURE AND GROWTH CAPITAL INVESTMENTS



* Excludes outlier deals above \$350M

INVESTMENT SNAPSHOT

Take away 1: Late stage investments (Series B and later) led deal volume in H2 this year for the first time; late stage deals outnumbered early stage deals 156 to 134.

Take away 2: Auto OEMs continue to invest in autonomous technology startups, develop partnerships and consolidate to gain access to innovation and share technology and the large capital costs necessary to develop autonomous technology.

Take away 3: Investment in electric vehicles and autonomous driving startups increased from H1 to H2, with investment in electric vehicle companies increasing from \$718 million to \$1.325 billion and investment in autonomous driving companies increasing from \$766 million to \$1.165 billion.

Take away 4: Maritime shipping, air transportation and heavy-duty freight shipping are beginning to decarbonize, leveraging electrification, biofuels, efficiency improvements and new fuel sources to reduce emissions.

Overview

Impacted by safety concerns over autonomous vehicles and the current unprofitability of electric vehicles, the Transportation & Logistics sector continues its rocky transition towards Connected, Autonomous, Shared and Electric (CASE) mobility, with the objective to decarbonize and accommodate a growing urban population. Technology innovation is enabling new business models and prompting the development of a new value chain for mobility services. Electric vehicles (EVs) are picking up steam in some markets, led by aggressive national and local emissions reduction targets, and automotive OEMs' push to decarbonize fleets. Corporations are making big bets to remain competitive when the next generation of mobility finally takes shape. Increasing demand for faster, and higher volume, delivery of goods has prompted innovation to digitize air, maritime and land freight logistics for efficiency gains. In addition, these sectors are testing and rolling out low-emission technology to reduce emissions.



Segment 1 Electrification of transport

Definition: This segment includes electric passenger vehicles, micro-mobility, heavy duty vehicles, aircraft and associated charging infrastructure and technology. Business activities in charging technology include testing smart and bi-directional charging to balance increasing numbers of EVs with growing renewable energy penetration and developing charging technology and business models for electric fleets.

Market dynamics

Adoption of EVs, including buses, passenger vehicles and micro-mobility, is increasing. This is being driven by end-user demand, local and national emissions reductions' targets, congestion pricing and internal combustion engine (ICE) vehicle bans in some cities. Automotive OEMs are expanding their ranges of EVs, from sedans to pickup trucks, to reach more customers. Corporations with large fleets of heavy to medium-duty vehicles, such as Amazon and UPS, are exploring and investing in low emission technology to decarbonize fleets and meet customer demand for low-emission supply chains. A range of technologies, including battery electric and hydrogen are being tested in different freight shipping market segments. Energy companies, automotive OEMs and charging station network operators are accelerating station deployment and giving customers access to existing networks to support EV adoption. Chargers themselves are becoming commoditized, and station owners and operators are looking to create new value streams through value-add services, such as smart charging, V2G services and ad-supported stations.

A parallel trend is increasing renewable energy generation. The intermittency of renewables, combined with additional load from EVs can create an imbalance between electricity supply and demand. Pilot projects are testing vehicle-to-grid (V2G) technology to leverage EV batteries as distributed energy storage devices and better balance the grid. Electrification of larger fleets, particularly buses, is opening the door for other innovations, such as wireless charging and more predictable grid services.

Some companies are developing new types of vehicles to decarbonize and solve the challenges of urban transportation. Electric vertical takeoff and landing vehicles (eVTOLs) are being developed and tested by over 100 different companies, and sector leaders are in a race to certify aircraft and begin commercial mobility service operations. eVTOLs feature electric propulsion, multiple rotors and the ability to take off and land vertically and fly horizontally. This design allows for low emission operations and greater efficiency and lower operating costs than helicopters. Although eVTOLs are likely a decade from large-scale commercial operations, this technology has the potential to revolutionize urban transportation.

Lessons from leaders

The electrification of bus fleets is a low-hanging fruit for municipalities looking to decarbonize public transport. Innovators, such as **Proterra**, a returnee to the 2020 list, and BYD are quickly building out electric bus offerings and developing new business models. Proterra, the 2018 Global Cleantech 100 North American Company of the Year, has positioned itself as a leader in the electric bus market, offering everything from electric drivetrains to turnkey fleet services. Proterra Energy fleet solutions is a turnkey approach that offers design, build, financing, operations, maintenance and energy optimization to lower the upfront costs of converting fleets to battery electric. The system includes everything from energy sourcing to charging infrastructure and management to materials reuse and recycling. The company also launched Proterra Powered, a line of electrification solutions that allows other manufacturers to use Proterra's electric powertrain technology in their own vehicles.

Access to charging infrastructure is a bottleneck for EV adoption, as owners remain concerned about range limitations. Increasing investment in charging infrastructure is a key enabler for transport electrification. While most EV charging in the U.S. is done at home, public charging stations are still critical for long road trips and reducing range anxiety. By 2030, approximately half of energy demand for EV charging will occur at public stations in the EU, and this number jumps to over 80% for China. Fast charging is particularly important for public stations, as EV owners are reluctant to disrupt their daily activities for extended periods of time just to charge their vehicles. A key challenge for public charging is establishing an effective revenue and profit model, as the cost of charging typically only covers the electricity itself, not the cost of delivering the electrons.

EVgo, the operator of the largest network of DC fast-charging stations in the U.S., makes its debut on the list this year. In 2019, EVgo expanded its network and developed partnerships to increase interoperability and serve more customers, including partnerships with Uber, Nissan, Chevron, Electrify America, ChargePoint and EV Connect. **Volta Charging**, a company on both the 2019 and 2020 Global Cleantech 100, has developed a solution to enable free public charging and received \$20 million in September 2019 from Schneider Electric, SK Innovation and Energize Ventures to close out a \$100 million Series C round. The company partners with real estate owners and retail businesses to build out ad-supported charging stations in high visibility areas. By coupling digital advertising with EV charging, Volta has developed a successful revenue model for public chargers.



Nuvve, debuting in the 2020 Global Cleantech 100, was founded in 2010 by the inventor of V2G technology and remains a market leader. The company is participating in 14 pilot projects globally and recently launched DREEV, a joint venture with EDF, to develop V2G solutions for businesses and communities, including smart management of vehicle charging and discharging in response to grid signals and energy storage for flexibility. Nuvve is active in Denmark, one of the first viable markets for V2G technology, due to the country's high penetration of renewables and EVs. Nuvve operates on a revenue sharing model with EV owners, creating value for the end user by allowing them to tap into the lucrative frequency regulation market.

Ather Energy, a 2018 One to Watch and debuting on the 2020 Global Cleantech 100, has developed a purpose-built electric two-wheeler for Indian markets. The scooter features a removable battery pack to reduce downtime associated with charging. The company received \$51 million in funding in May 2019 from Hero MotoCorp, Sachin Bansal and Tiger Global Management to expand operations. **Gogoro**, also a developer of electric two-wheelers with swappable batteries, makes the list for the third time this year. The operating models and vehicles developed by these companies are particularly effective for fleets and for the sheer scale of many Asian and emerging markets.

Included in the Global Cleantech 100 for the third year running, **Lilium**, is one of the leaders in eVTOL development and is working on a unique aircraft that can take off vertically, fly horizontally and transition to winged flight. The company is targeting commercial launch in 2025 for an end-to-end service and is focusing on developing a low-noise aircraft, receiving certification from European and American aviation organizations and building out manufacturing capabilities and building a strong supplier network in southern Germany.

Keep an eye on

As more EVs hit the roads, more chargers are deployed and more renewables come online, there will be an increasing need to control and sync load and generation and smooth out intermittency. EVs will become a distributed grid resource enabled by smart, bi-directional chargers and the line between transportation and energy sectors will continue to blur. The initial use case for this will be electric buses. Electrification of bus and heavy-duty fleets will in turn accelerate the electrification of personal vehicles, by driving down battery prices and acting as a testbed for V2G business models.

Alternative, low-emissions fuels have also received attention and investment for their ability to perform better than batteries in some use cases. Corporates in freight shipping and air transport, for instance, are leveraging different types of fuel, from biofuels to hydrogen and ammonia, to reduce emissions. Different fuels will be applicable in different use cases and further investment will help commercialize and build out supply chains for emerging low-carbon fuel sources.

Another underlying trend is new materials and more efficient manufacturing processes being developed to drive the sustainability of vehicle lifecycles and reduce capital intensity. Lightweight materials, such as carbon fiber composites and organic materials, are being explored as cost-effective alternatives for vehicle materials to improve fuel economy and reduce the impact of additional weight from electric platforms. Digital vehicle manufacturers (Toyota, Airbus), or 3D printing, and microfactories (Neorizon) will provide more flexible and efficient vehicle development and decreased capital intensity of manufacturing.

Segment 2 Autonomous Vehicles and Connectivity

Definition: This segment includes hardware and software to enable autonomous driving and vehicle connectivity as well as purpose-built passenger and freight vehicles, aircraft and ships for autonomous operations.

Market dynamics

Carmakers are making big bets into autonomous technology to stay competitive in the transportation transition. Focusing on promising initial use cases, some innovators are developing purpose-built autonomous vehicles, such as cargo transport and autonomous passenger shuttles. However, recent accidents involving autonomous vehicles have raised concerns over their safety and the time and capital-intensive path towards full autonomy. Large investments in autonomous hardware and software have fueled improvements but have not proved sufficient to take the technology to full maturity. As a result, some companies are focusing on developing technology for specific edge cases, such as autonomous operations in adverse conditions and at night. For now, cargo transport, autonomous drone deliveries and autonomous point-to-point shuttles are the only commercial applications of autonomy, thanks to greater control within a geographically "fenced" operating environment.



Lessons from leaders

Einride, a debutant on this year's list, is developing autonomous solutions for trucking, consisting of an intelligent shipping platform and purpose-built electric and autonomous Einride Pods. The Pods are specialized, modular trailers that are designed to be completely driverless. The company raised a \$25 million Series A round in October 2019 to further accelerate its work in decarbonizing freight shipping, a heavily polluting industry ripe for disruption.

Peloton Technology, who made the Global Cleantech 100 for the fourth time, has taken a more incremental approach to autonomous freight shipping by leveraging a key aspect of freight logistics – the driver. By connecting collision avoidance technology on pairs of trucks, Peloton creates a platoon, which improves the safety of freight shipping and can generate up to double-digit fuel savings. Peloton announced the Automated Following Platoon in July 2019, which uses vehicle-to-vehicle (V2V) technology, radar-based active braking systems and vehicle control algorithms to enable a single driver to operate a pair of vehicles. The combination of a driver in the lead truck and a fully autonomous following truck solves many of the challenges of Level 4 autonomy. Possible business models include a usage-based managed service, charging a per-mile fee when trucks are in platoon and saving fuel; one-time fee for system hardware and installation so fleets can equip trucks at a minimal upfront cost with a rapid payback period.

Keep an eye on

Although robo-taxis seem to be a long way off, early use cases are providing market entry points. Full autonomy will be a pillar of future mobility services. Meantime, carmakers are integrating Level 1 and 2 autonomy and vehicle connectivity to improve the safety and efficiency of traffic systems.

Vehicle connectivity includes vehicle-to-everything (V2X) communication via wireless and cellular networks. Due to the low latency and high communication speeds needed to communicate with and operate autonomous vehicles, true autonomous operations will depend on widespread deployment of 5G networks.

Segment 3 Mobility-as-a-Service (MaaS)

Definition: This segment covers mobility service providers, including companies that provide platforms for developing mobility services.

Market dynamics

Mobility service providers are including various modes of transportation into their offering, including public transportation, ride-hailing and micro-mobility to build out comprehensive services and leverage different revenue models. Some innovators and automotive incumbents are creating value for cities and fleet managers by developing platforms to deploy, manage and optimize disparate modes of transportation. Fleet management platforms are leveraging technology advancements to enable new business and operating models.

Lessons from leaders

Bestmile, the 2019 Global Cleantech 100 Europe & Israel Company of the Year and a returnee to the 2020 list, provides a fleet management platform for mobility providers to deploy, manage and optimize fleets with any type of vehicle for any type of service. The company's technology unlocks the real value of new mobility services by enabling fleet operators to transport more people with fewer vehicles, autonomous or human-driven while maintaining efficient and profitable operations. The company is gaining traction and raised a \$16.5 million Series B round in August 2019 with participation from Airbus Ventures and Partech. The company refers to its offering as fleet orchestration, which will be a key enabler in the transition from autonomous vehicles as a product to a service.

Vulog, which also made the list for a second time this year, provides end-to-end solutions for public and corporate free-floating carsharing services. The company's technology enables the mobility-as-a-service model for over 30 carsharing platforms globally. The Mobility-as-a-Service (MaaS) market is moving towards integrating multiple modes of transportation into a single service, allowing users to optimize and simplify trip booking. Vulog is enabling this transition through AiMA, a platform for providing mobility services that was recently updated to allow for multi-modal and multi-city services.























Keep an eye on







EVs and autonomous vehicles are creating new business model opportunities to move people and goods. Mobility service companies, such as Uber and Lyft, are looking to micromobility and autonomy to become profitable. In addition, some are leveraging the large datasets they sit on to develop traffic management services for cities.

2019 Graduates

Global Cleantech 100 graduates are companies who have been included in the Global Cleantech 100 at least once since the first edition in 2009 and then go on to be acquired or become a public company.

The 18 graduating events below involving Global Cleantech 100 alumni represent a record year. A number of these acquisitions did not provide venture-grade returns, nevertheless investors into the macro cleantech theme should be encouraged that there is increasing openness to these new kind of assets, companies illustrative of the general direction of travel for the industrial transitions we all need to see 2020-2050.

| Mergers & Acquisitions | | | | |
|--|---|----------------|---|-------------------------------------|
| COMPANY | ACQUIRER / EXCHANGE | DATE | DEAL NOTES | APPEARANCES ON GLOBAL CLEANTECH 100 |
|  mobisol best life |  | September 2019 | ENGIE's acquisition of Mobisol made it an African market leader in off-grid solar. With the 2017 acquisition of Fenix International, ENGIE has more than 500,000 home solar system clients in Uganda, Zambia, Nigeria, Benin, Ivory Coast and Mozambique. | 2017 |
|  |  | July 2019 | The merger of these three companies with acquirer Tendril creates Uplight, a one-stop-shop for software aimed at utilities' customers. The company counts around 75 North American utilities as customers, including Duke Energy, National Grid and Exelon. | 2018, 2019 |
|  | | June 2019 | | 2012, 2014, 2015, 2017, 2018 |
|  | | June 2019 | | 2015 |
|  |  | April 2019 | The acquisition enhanced Middleby's IoT capabilities to help clients manage operations. | 2018 |
|  |  | February 2019 | Shell acquired 100% of sonnen to accelerate its home energy services market entry. | 2014, 2015, 2017, 2018, 2019 |
|  |  | February 2019 | Wheatsheaf Group, the investment arm of the Grosvenor Estate in the UK, acquired 90% of Purfresh. | 2010, 2011, 2012 |
|  |  | February 2019 | Greenlots' technology and team became the foundation for Shell's continued expansion of electric mobility solutions in North America. | 2019 |
|  |  | November 2018 | CPower continues to operate as a stand-alone entity under the LS Power umbrella of companies. | 2009, 2010 |
|  |  | November 2018 | ENGIE acquired a majority stake of Kiwi Power, buying out founders Yoav Zingher and Ziko Abram. ENGIE plans to leverage Kiwi's flexible platform across its global energy asset portfolio. | 2014, 2015, 2017 |
|  |  | October 2018 | This acquisition, worth EUR 38 million, supports Vaisala's Weather and Environment Business Area's strategy to strengthen its position as a global leader providing remote wind sensing technologies. | 2013, 2014, 2015 |
|  |  | September 2018 | Filterboxx's mobile and modular water treatment technology helped Ovivo to grow its industrial footprint in North America. | 2011, 2012, 2013, 2014, 2015 |

| Initial Public Offerings | | | | |
|---|-----------------------------|----------------|--|-------------------------------------|
| COMPANY | ACQUIRER / EXCHANGE | DATE | DEAL NOTES | APPEARANCES ON GLOBAL CLEANTECH 100 |
|  Cnano | Star Market | September 2019 | Cnano raised around \$130 million. The company's market capitalization has since doubled to nearly \$1 billion. | 2019 |
|  BEYOND MEAT | NASDAQ | May 2019 | Beyond Meat raised upwards of \$235 million at a valuation of around \$1.5 billion. The company's market capitalization has tripled since IPO. The company's market capitalization reached a sky-high record of \$14 billion in July 2019, before stabilizing around \$5 billion at the end of the year. | 2013, 2017, 2018, 2019 |
|  Uber | NYSE | May 2019 | UBER raised over \$8 billion at a valuation of around \$70 billion. The company's market capitalization has since dropped to around \$50 billion. | 2014, 2015 |
|  Lyft | NASDAQ Global Select Market | March 2019 | Lyft raised over \$2 billion at a valuation of around \$22 billion. The company's market capitalization has since dropped to around \$14 billion. | 2018, 2019 |
|  ferroamp | NASDAQ First North Sweden | February 2019 | Ferroamp raised SEK 40 million (\$4.2 million). | 2018, 2019 |
|  NIO | NYSE | September 2018 | NIO raised \$1 billion. Proceeds from the IPO support the expansion of NIO's range of vehicles, including introducing a smaller electric SUV. | 2017 |





“THE 2019 BEYOND MEAT IPO, I SEE AS A PARTICULARLY IMPORTANT MILESTONE, SIGNALLING AS IT DID THAT THERE IS BACKING FOR THE NEED TO TRANSFORM KEY DAILY ACTIVITIES – IN THIS CASE DIET – TOWARDS MORE CLIMATE FRIENDLY FUTURE VERSIONS.”

**RICHARD YOUNGMAN, CEO,
CLEANTECH GROUP**

Global Cleantech 100 Hall of Fame

The Global Cleantech 100 Hall of Fame was created to recognize the achievements of the few companies whose sustained excellence over many years has meant that they have been on the Global Cleantech 100 list an impressive seven times. To maintain the support of a strong percentage of investors and technology scouts in the market year on year (from 2009 onwards) is no mean achievement.






Once inducted into the Hall of Fame, companies will not feature on any future editions of the list. But we will keep a close eye on them, as we do all our alumni. We hope to see great things from these companies in the future, as they live out the promise of Global Cleantech 100 companies as poised to make significant impact in the next five to ten years.

| Hall Of Fame | INDUCTED JANUARY 2020 | PREVIOUSLY INDUCTED |
|--------------|--|--|
| |  AutoGrid |  avantium |
| |  enbala YOUR GRID. IN BALANCE. |  -chargepoint+ |
| |  ORGANICA |  DIGITAL LUMENS |
| |  PROTERRA |  ke bonny |
| | |  LanzaTech capturing carbon. fueling growth. |
| | |  OSTARA |
| | |  TENDRIL® |

NEW

Unicorns

We introduced a new rule this year, whereby companies who have appeared on one of the publicly-available unicorn lists, as having a valuation in excess of \$1 billion, can no longer qualify for a future Global Cleantech 100. This means that the following alumni companies (who made the shortlist again this year) were removed from the running. We introduced this rule in recognition of the changed market conditions from when we started the list in 2009, when global tech companies reaching these kinds of heights and sizes as independent private ventures, were very rare. We wish to retain space in any one year for the up and coming, versus the up and come.

| Unicorns | COMPANY | APPEARANCES ON GLOBAL CLEANTECH 100 |
|----------|--|--|
| |  BlaBlaCar | 2013, 2014, 2015, 2018, 2019 |
| |  Desktop Metal™ | 2019 |
| |  flexport. | 2019 |
| |  IMPOSSIBLE™ | 2015, 2017, 2018, 2019 |
| |  indigo™ | 2019 |

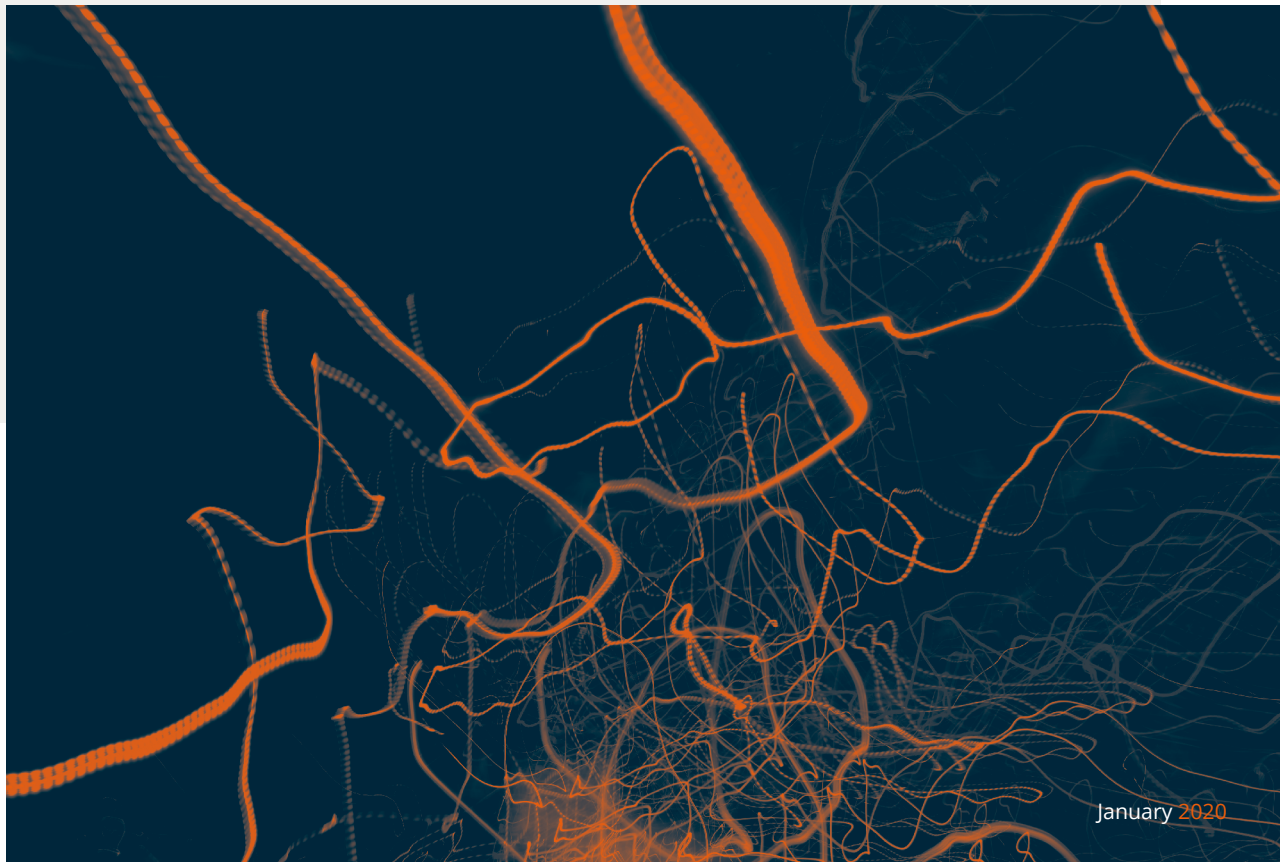


About Cleantech Group

At Cleantech Group, we provide research, consulting and events to catalyze opportunities for sustainable growth powered by innovation. We bring clients access to the trends, companies and people shaping the future, and the customized advice and support businesses need to engage external innovation.

Industries are undergoing definitive transitions toward a more digitized, de-carbonized and resource-efficient industrial future. At every stage from initial strategy to final deals, our services bring corporate change makers, investors, governments and stakeholders from across the ecosystem the support they need to thrive in this fast-arriving and uncertain future.

The company was established in 2002 and is headquartered in San Francisco with a growing international presence based in London. Our parent company, Enovation Partners, is based in Chicago.



Meet the experts

The expert panel plays an important role in shaping the final list. Their knowledge of, and insights into, the companies adds weight to the evaluation process.

For biographies of our expert panel visit our [website](#)

Laura Nereng

New Business Development
Leader, Corporate Research
& Development

3M

Patrick Sagisi

Investment Partner

Acario Ventures

Paul Jordan

Vice President

Activate Capital

Greg Fleming

Investment Director

Air Liquide Venture
Capital - ALIAD

Christian Noske

Head of Alliance Ventures
& Open Innovation

Alliance Ventures

Markus Hökfelt

Fund Manager, GreenTech

Almi Invest

Fabio Lancelotti

Partner

Aster Capital

Tony Van Bommel

Senior Managing Partner,
ICE Fund

BDC Venture Capital

Shaun Healey

Principal

BP Ventures

Ludwig Goris

Senior Investment Manager

Capricorn Venture Partners

David Aitken

Head of Incubation

Carbon Trust

Alla Jezmir

Vice President

CCM Energy

Wal van Lierop

Founder & Managing Partner

Chrysalix Venture Capital

Jamie Butterworth

Partner

Circularity Capital

Richard Youngman

CEO

Cleantech Group

Danielle Joseph

Executive Director

Closed Loop Partners

Peter Kennedy

Head of Clean Resources
Impact Fund

CLSA Capital Partners

Abe Yokell

Co-Founder &
Managing Partner

Congruent Ventures

Andrée-Lise Methot

Founder & Managing Partner

Cycle Capital Management

Mads Møller

Head of Technology
Investments & Acquisitions

Danfoss

Nancy Pfund

Managing Partner

DBL Partners

Kathleen Jurman

Corporate Ventures
Technology Scout

Dow Corporate Ventures

Rodrigo Navarro

Former Venture Director

DSM

(Left DSM as of 1 November 2019)

Dr. Paul-Josef Patt

Managing Partner & CEO

eCAPITAL Entrepreneurial
Partners

Konrad Augustin

Investment Director
& Head of E.ON SCI US

E.ON

Sasha Brown

Partner

EcoSystem Integrity Fund

Luis Manuel

Executive Board Member

EDP Ventures

Gina Domanig

Managing Partner

Emerald Technology Ventures

Glenn Bijvoets

Innovation Lead

Eneco

John Tough

Managing Partner

Energize Ventures

Cassie Bowe

Vice President

Energy Impact Partners

Jeff Clark

Managing Partner

Energy Innovation Capital

Wally Hunter

Managing Director

EnerTech Capital

Johann Boukhors

Managing Director

ENGIE New Ventures

Fabrice Bienfait

Partner

ETF Partners

Marty Reed

Chief Executive Officer

Evok Innovations

Dirk De Boever
Head of Investments

Finindus

Jake Simon
Associate

Fontinalis Partners

Daniel Hullah
Managing Director

GE Ventures

Colin Le Duc
Partner

Generation Investment
Management

Sean Simpson
Investment Manager

GM Ventures

Eric Wang
Managing Partner

GRC SinoGreen

Jamie James
Managing Partner

Greensoil Building Innovation
Fund

Robert Liu
CEO

Huaneng Invesco WLR
(Beijing) Investment Fund
Management Company

Diego Díaz Pilas
Head of New Ventures

Iberdrola

Nicolas Chaudron
Partner

Idinvest Partners

Matias Torrellas
Portfolio Manager

InnoEnergy

Ivo Němejc
Investment Director

Inven Capital

Robert Trezona
Head of Cleantech

IP Group

Tilak Gopalarathnam
Director, Energy
Technology Partnerships

LG Corp

Matthieu van der Elst
CEO Michelin Ventures

Michelin Group

Kevin Kuhn
VP, General Manager
Silicon Valley Branch

Mitsubishi Corporation

Ken MacKinnon
Managing Partner

MKB Growth Equity

Martin Kroener
Managing Partner

Munich Venture Partners

Gert Wrigge
Principal

Next47

Andrew Beebe
Managing Director

Obvious Ventures

Rhea Hamilton
Ventures Director

OGCI Climate Investments

Gabriel Kra
Managing Director

Prelude Ventures

Stefan den Doelder
Investment Director

Robeco Private Equity

Dr. Jay Amarasekera
Senior Technology Manager

SABIC Ventures

Karthik Chandrasekar
Founder

Sangam Ventures

Grant Allen
General Partner

SE Ventures

Matt Gregori
Technology Development
Manager

Sempra Energy

Wouter Jonk
Managing Partner

SET Ventures

Jermaine Saaltink
Venture Principal

Shell Ventures

Dan Baldi
Market Manager - Energy
& Resource Innovation

Silicon Valley Bank

Hee S. Jung
Head of Silicon Valley Outpost

SK Gas

Thierry Piret
Global Investment Strategy

Solvay Ventures

Mark Bonnar
Managing Director

Southern Cross Venture
Partners

Kurt Faulhaber
Partner

Stafford Capital Partners

Matthias Dill
Former Managing Director

Statkraft Ventures
(Left as of September 2019)

Astorre Modena
Managing Partner

Terra Venture Partners

Timothy Wang
Principal

The Westly Group

Cindi Choi
Managing Director

Total Energy Ventures

Steve Kloos
Partner

True North Venture Partners

Qi Lu
Strategy & Research Partner

Tsing Capital

Yann Moreau
Director Open Innovation
& Innovation Services

Veolia

Peter Auner
Partner

VNT Management

Chris Kane
Materials Development
& Technology Scouting

W. L. Gore & Associates

Samer Salty
Managing Partner

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