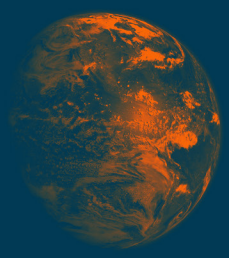
Cleantech Group

2022

GLOBALCLEANTECH100



From Commitments to Actions:

Leading companies and trends in sustainable innovation

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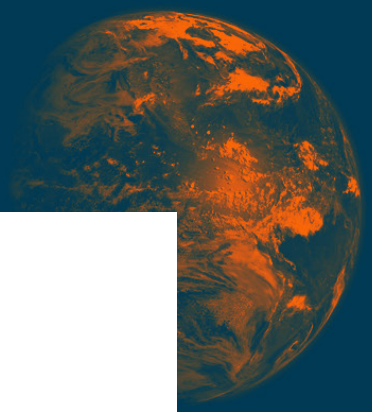

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Acknowledgements

We firstly wish to express our gratitude for the ongoing support of Chubb, the world's largest publicly traded property and casualty insurance company. Chubb has been the headline sponsor of the annual Global Cleantech 100 program for nine consecutive years now.

The list would not have been possible without the 86 expert panelists (See pages 51-52) 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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Cleantech Group

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Foreword

Richard Youngman
CEO

2021 made some strides towards keeping the dream of 1.5 degrees alive. But the path to net zero by 2050 has become narrower and steeper.

2021, building on the momentum of 2020, saw a strengthening stream of net zero pledges from corporations. The Science-Based Targets initiative (SBTi) recorded a 63% increase in companies "taking action", in the first three quarters of 2021.

Inherent in those corporate pledges, taking them at face value, is the creation of a series of billion-trillion-dollar markets, coming in the next ten to thirty years. Even more so, if the remaining 80% of global corporations also pledge and get serious about the sprint to net zero.

This is the backdrop against which we proudly present the 2022 Global Cleantech 100, our 13th annual edition.

The companies, even more the themes these companies represent, speak to a buoyancy on the solution supply side of the equation. We have the science and ingenuity to solve most of the issues and there is the investment capital, in both private and public markets, to propel a three-decade transformation, to net zero.

But we are only part of the puzzle, with but a finger on the steering wheel.

The pace at which the purchase orders are written and the speed with which the key new technologies go down the cost curve, is very much in the hands of governments, regulators, and policy-makers – and how brave and innovative they find it in themselves to be.

After the disappointments of COP-26 in Glasgow and the late u-turn on phasing out coal, what will 2022 bring in these regards?

As you will read in our report, there are more and more businesses and investors stepping up. Excitement is palpable in an innovation community that well remembers the toughest of years, 2009-15 and how little attention the mainstream gave it.

> "Let's hope 2022 is memorable, as a year of action, as a year for converting commitments into credible plans, and as a year of building on Glasgow to significantly increase the ambition levels."

In the innovation world, we are in as healthy a place as we have ever been. Support from both the private and public sector is helping to propel deep-tech technologies into the play-zone, albeit concerns about bubbles and greenwashing abound.

Let's hope 2022 is memorable, as a year of action, as a year for converting commitments into credible plans, and as a year of building on Glasgow to significantly increase the ambition levels.

We salute not only the 2022 Global Cleantech 100 companies, but the thousands beyond, who are fighting the good fight.

Richard Youngman
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 86 investor and multi-national corporation representatives
- Our i3 platform tracking the investment and partnership history of thousands of relevant companies
- Over 75 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 86 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.

Exploring the depth and breadth of the cleantech community

The total number of nominations from the public, our expert panel, i3, awards and Cleantech Group totaled 10,950 from over 94 countries. These companies were weighted and scored to create a short list of 303 companies that were reviewed by the 86 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 list was struck on 1 October 2021.

The Global Cleantech 100 in numbers

Uncover the story behind the companies included in the 2022 Global Cleantech 100. How much money have they collectively raised? How many investors have they attracted? Which sectors are leading the way?*

The number of companies and level of investment by region

North America

BILLION $ 8.7

COMPANIES 63

Europe & Israel

BILLION $ 2

COMPANIES 30

Asia Pacific

MILLION $ 628

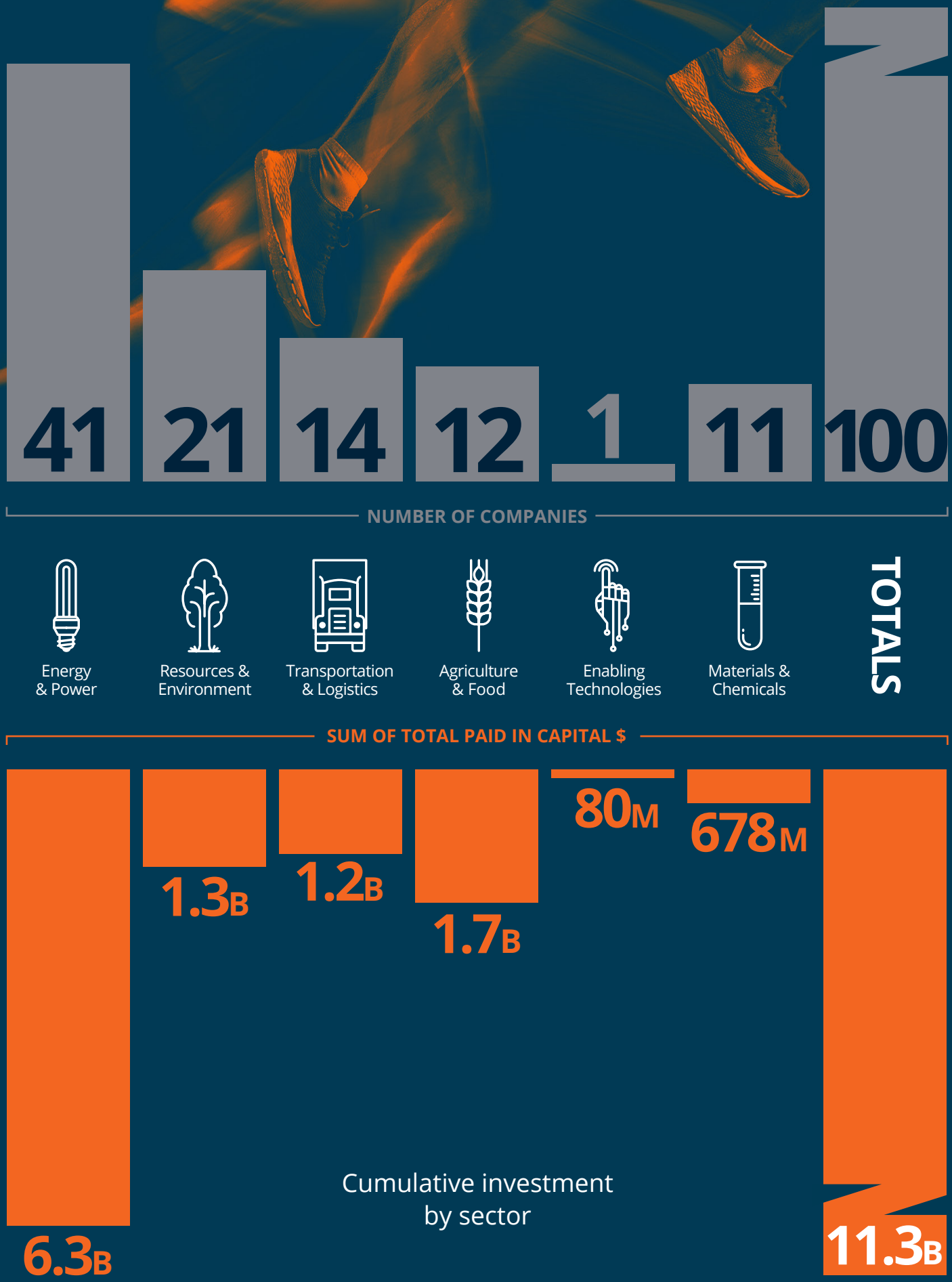
COMPANIES 7

TOTALS

BILLION $ 11.3

COMPANIES 100

*All investment figures based on data collected as of 7 December 2021. Source: Cleantech Group.


41
21
14
12
1
11
100
NUMBER OF COMPANIES
Energy & Power
Resources & Environment
Transportation & Logistics
Agriculture & Food
Enabling Technologies
Materials & Chemicals
TOTALS
SUM OF TOTAL PAID IN CAPITAL $
6.3B
1.3B
1.2B
1.7B
80M
678M
11.3B
Cumulative investment by sector

Companies

OLDEST COMPANY FOUNDED IN

2002

GENERAL FUSION

NEWEST COMPANY FOUNDED IN

2020

REMORA CARBON

Scale of total investment

92

2021 INVESTMENT ROUNDS

20

COUNTRIES REPRESENTED BY COMPANIES

358

INVESTORS PARTICIPATED

454

VENTURE INVESTMENT ROUNDS

$1.8 B

BIGGEST EQUITY ROUND IN 2021

COMMONWEALTH FUSION SYSTEMS

$89 M

AVERAGE EQUITY ROUND IN 2021

Raised

$11.3 B

by Global Cleantech 100 Companies

Total raised by Global Cleantech 100 companies in 2021

$6.9 B

THE2022 GLOBALCLEANTECH100

2022 Global Cleantech 100 companies

listed in alphabetical order by sector

CONTENTS

Agriculture & Food

12 COMPANIES ↓ / 7 COUNTRIES ↑

Company	Description	Country
FUTURE MEAT	Developer of scalable production solutions for cultivated meat	Israel
green monday	Developer of a platform of plant-based food brands	Hong Kong
Gro Intelligence	Provider of AI-powered weather and agricultural data for farmers, financial institutions and governments	United States
hazel technologies, inc.	Developer of biodegradable capsules that have the potential to provide control of produce freshness, eliminating waste in the food supply chain and shrinkage for produce distributors	United States
MOLEAER ADVANCING NANOBUBBLE TECHNOLOGY	Developer of nano-scale aeration technology for transferring gas into liquids	United States
Mosa Meat	Researcher, developer, and manufacturer of a cultured beef burger	Netherlands
Fynd	Manufacturer of alternative meat and dairy products using fungi protein production methods	United States
PIVOT BIO	Developer of microbe-powered technology to improve agriculture productivity	United States
PROLupin	Provider of advanced food materials obtained from the isolation of protein and roughage fractions from lupine seeds	Germany
Too Good To Go	Developer of an app to connect users with unsold food from shops and restaurants	Denmark
TRACE GENOMICS	Provider of soil analytics using genomics and machine learning	United States
Tropic Biosciences	Developer of high-performing varieties of tropical crops using gene-editing technologies	United Kingdom

KEY: ↑ Increase on 2021 figures ↓ Decrease on 2021 figures ↔ Same as 2021 figures

Enabling Technologies

1 COMPANY ↓ / 1 COUNTRY ↓

Company	Description	Country
Urbint	Provider of predictive maintenance solutions for city applications, using AI to solve infrastructure issues	United States

KEY: ↑ Increase on 2021 figures ↓ Decrease on 2021 figures ↔ Same as 2021 figures

"ENABLING TECHNOLOGIES ARE CONTINUALLY REQUIRED AS THE NEED FOR CLEANTECH BECOMES MORE EVIDENT THAN EVER. AS REMOTE AND ONLINE WORKING BECOME THE NEW NORMAL, MAINTAINING AND SECURING ASSETS AND SYSTEMS WILL TAKE CENTER STAGE."
NISA MIRZA, ANALYST, CLEANTECH GROUP

Energy & Power

41 COMPANIES ↑ / 10 COUNTRIES ↑

Company	Description	Country
75F	Developer of a predictive building automation system that addresses HVAC, lighting and equipment control requirements	United States
Arcadia	Provider of a direct-to-consumer clean energy subscription 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
BayoTech	Provider of on-site hydrogen production solutions using gas-as-a-service	United States
BLOC POWER	Provider of data-enabled, financed heating and cooling retrofit services for multifamily buildings	United States
Commonwealth Fusion Systems	Developer of advanced fusion technology utilizing a high temperature superconductor	United States
C||ZERO	Developer of a decarbonization technology to break down methane into hydrogen and solid carbon	United States
depsys	Developer of hardware and software to manage and optimize smart grids	Switzerland
EKONA	Developer of process for production of industrial scale hydrogen, clean power and pure CO_2	Canada
Electrochaea	Developer of a power-to-gas energy storage technology that converts excess electricity from wind and solar into renewable gas (SNG)	Germany
Enpal	Provider of rental solar systems and installation services	Germany
ezinc	Developer of zinc reactor technology, which stores electricity in zinc metal for large-scale energy storage	Canada
FERVO ENERGY	Developer of a technology for power generation using enhanced geothermal systems	United States

KEY: ↑ Increase on 2021 figures ↓ Decrease on 2021 figures ↔ Same as 2021 figures

Energy & Power

Company	Description	Country
Form energy	Developer of an iron-air battery capable of delivering long-duration energy storage for 100 hours to replace existing baseload generation	United States
FSIGHT ENERGY FLOWS	Developer of an AI system that automates, predicts, optimizes and trades energy behind the meter	Israel
generalfusion	Developer of private fusion energy systems, specializing in magnetized target fusion	Canada
Gridwiz	Provider of a software platform for integrating gigawatt-scaled DERs (DR, energy storage, renewable energy, EV) to provide flexibility to the grid	Korea Republic
innowatts	Developer of real-time energy monitoring and prediction software for energy retailers and utilities	United States
IONMR INNOVATIONS	Developer of durable anion-exchange membrane for fuel cells, fuel production and metal recovery	Canada
leap.	Developer of a flexibility aggregation platform for distributed energy resources	United States
Level10 Energy	Provider of transaction infrastructure for renewable energy buyers, advisors, sellers and financiers	United States
Mainspring	Developer of a linear generator technology to produce energy from a variety of fuels	United States
METRON	Developer of an energy management platform allowing industrial groups to optimize their energy performance and decarbonize their activities	France
monolith	Developer of plasma pyrolysis technology, transforming natural gas into turquoise hydrogen and producing carbon black	United States
NATEL ENERGY	Developer of hydroEngine, a low-head and fish-friendly hydro power system	United States
Natron Energy	Developer of battery-based energy storage technologies with electricity grid applications	United States
NUSCALE	Developer of a modular, scalable 45 megawatt electric light-water reactor nuclear power plant	United States

Energy & Power

Company	Description	Country
OhmConnect	Provider of a residential virtual power plant using gamification and financed hardware solutions	United States
OMNIDIAN	Provider of protection plans for investments in residential solar energy systems	United States
opus one solutions	Developer of real-time control and optimization solutions for generation, storage and electric vehicle resources	Canada
OXFORD PV	Developer of plug-and-play perovskite-on-silicon tandem solar cells that enable solar energy cost reductions	United Kingdom
piclo	Developer of a B2B flexibility auction marketplace, facilitating flexibility contracts	United Kingdom
REDAPTIVE	Provider of energy efficiency building services	United States
RELECTRIFY	Developer of a cell-level battery management system	Australia
SKELETON TECHNOLOGIES	Manufacturer of graphene-based ultracapacitor energy storage solutions	Germany
SPAN	Developer of smart electrical panels and paired software to provide visibility and control at the edge-of-grid	United States
sunfire	Provider of energy conversion technologies, including solid oxide fuel cells and renewable synthetic fuels based on solid oxide electrolyzers	Germany
tado°	Developer of a smart thermostat and SaaS platform allowing users to control their home heating and cooling systems from their smart phones	Germany
tibber	Provider of energy supply services and smart home energy systems	Norway
TURNTIDE	Developer of smart electric motor systems	United States
TWAICE	Developer of predictive analytics software for battery management	Germany

Materials & Chemicals

11 COMPANIES ↑ / 5 COUNTRIES ↑

Company	Description	Country
Bluepha	Developer of bio-based polymers and chemicals including PHA bioplastic	China
BOSTON MATERIALS	Manufacturer of advanced composite materials for light-weighting in transportation, aerospace, consumer electronics and industrial applications	United States
BOSTON METAL	Developer of a molten oxide electrolysis technology for steel making and production of other metals and alloys	United States
CarbiCrete	Developer of low-cost building materials from industrial CO_2 emissions	Canada
Checkerspot	Developer and producer of biobased performance materials leveraging advances in genomics, biology and materials science	United States
EnginZyme	Developer of a cell-free synthetic biology platform for production of alternatives to plastics, nylons and rubbers	Sweden
H2green steel	Developer of large-scale, integrated, digitalized and automated steel plants with lower carbon impact	Sweden
Lactips	Producer of water soluble and biodegradable thermoplastic pellets based on milk protein	France
MODERN MEADOW	Developer of bio-fabrication processes and materials including lab-grown leather	United States
SOLIDIA	Manufacturer of sustainable cement and concrete	United States
SYZYGY PLASMONICS	Developer of a photocatalyst technology for chemical conversions to produce low-cost, low-emission hydrogen	United States

KEY: ↑ Increase on 2021 figures ↓ Decrease on 2021 figures ↔ Same as 2021 figures

Resources & Environment

21 COMPANIES ↑ / 7 COUNTRIES ↑

Company	Description	Country
AIRQUALITY	Provider of air purification equipment and services using Micro-electrostatic Precipitator (MESP) technology	China
AMP ROBOTICS	Developer of waste sorting AI-guided robotics, computer vision and deep learning to transform the economics of recycling	United States
BATTERY RESOURCERS	Provider of lithium-ion battery recycling services	United States
BreezoMeter	Provider of environmental intelligence including air quality, pollen and active fires data	Israel
carbon clean	Developer of CO_2 capture technology that significantly reduces the costs and environmental impacts of CO_2 separation	United Kingdom
Carbon Engineering	Developer of technologies for the capture of CO_2 from the atmosphere at industrial scale	Canada
CARBON CURE	Developer of a permanent carbon removal technology for concrete production	Canada
Circulor	Developer of traceability software for materials in industrial supply chains, including e-waste and plastic	United Kingdom
climeworks	Developer of direct air capture technology that safely and permanently removes CO_2 from the air	Switzerland
GHGSAT	Provider of satellite-based remote sensing technology for detection of greenhouse gas emissions from industrial facilities	Canada
INOPSYS SIDE STREAM SOLUTIONS	Developing on-site wastewater treatment solutions for toxic, non-biodegradable compounds in water	Belgium
Lilac solutions	Developer of lithium extraction technology from brine	United States
minesense	Developer of sensor technology to bring operational efficiency to the mining industry	Canada

KEY: ↑ Increase on 2021 figures ↓ Decrease on 2021 figures ↔ Same as 2021 figures

Resources & Environment

Company	Description	Country
Pachama	Developer of satellite and LiDAR-based carbon storage estimation solutions	United States
pani	Developer of AI-powered water treatment operations and management software	Canada
PERSEFONI	Developer of carbon footprint management and reporting platform for businesses	United States
REMORA	Developer of direct carbon capture technology for long-haul trucks	United States
SINAI	Provider of a service which uses AI to measure, price and evaluate carbon risk	United States
Svante	Developer of energy-efficient technology for capturing CO_2 from industrial sources	Canada
Watershed	Developer of software tools to enable businesses to measure, reduce and report carbon emissions	United States
Xpansiv	Developer of global marketplace for ESG-inclusive commodities and other green finance products	United States

"THE MARKET FOR EMISSIONS MONITORING, REPORTING AND VERIFICATION TOOLS AND CARBON OFFSETS HAS BALLOONED IN 2021 AS THE BUSINESS AND FINANCE INDUSTRIES BEGAN TO GRAPPLE WITH THEIR CLIMATE CHANGE COMMITMENTS AND CLIMATE RISK. THESE CHANGES ARE VERY MUCH REFLECTED IN THE 2022 GLOBAL CLEANTECH 100."
HOLLY STOWER, LEAD ANALYST, CLEANTECH GROUP

Transportation & Logistics

14 COMPANIES ↓ / 9 COUNTRIES ↓

Company	Description	Country
AMPLY POWER	Provider of charging-as-a-service solution and charge management software for electric vehicles	United States
ATHER	Developer of smart, connected electric scooters	India
deepsea	Provider of an AI-based software platform for monitoring and optimizing shipping	Greece
DST 地上铁 New Energy Logistical Vehicles Digital Platform	Provider of charging and management solutions for new energy vehicle fleets	China
effenco	Designer, manufacturer and marketer of technologies for the electrification and connectivity of heavy-duty vocational vehicles	Canada
evconnect	Provider of a flexible cloud-based platform for managing the electric vehicle ecosystem	United States
Highland	Provider of turnkey solutions to electrify medium and heavy duty fleets	United States
MATTERNET	Provider of on-demand drone-based delivery and logistics solution	United States
ONTRUCK	Developer of an on-demand platform to digitize freight logistics	Spain
oxbotica	Developer of autonomy software for vehicles	United Kingdom
SEEGRID	Developer of machine vision software and sensors for autonomous vehicle applications	United States
VIRTA	Operator of an electric vehicle charging network	Finland
Wirelane	Provider of full-service e-mobility software and hardware solutions including chargepoint services and billing processes	Germany
ZEROAVIA	Developer of a hydrogen-based powertrain to enable zero-emission aviation	United States

KEY: ↑ Increase on 2021 figures ↓ Decrease on 2021 figures ↔ Same as 2021 figures

Trend Watch 2022

With all the noise around climate change and net zero, it is easy at times to lose sight of some of the more subtle shifts going on, and what they might mean for the years to come.

This annual Global Cleantech 100 report, coinciding as it does with the passing of one year and the starting of the next, acts as our annual exercise to draw breath. Indeed, it was explicitly set up in 2009 to act as a "barometer on the changing face of global cleantech innovation".

Here is our guide to some of the key investment trends to be paying attention to, with more detailed contributions, from our sector analysts to follow in the sections beyond.

The 2021 investment numbers speak to the increasing allocations of investment capital to mitigating the climate crisis. They are nothing short of staggering

Had you told us in 2018, say, that 2021 would represent a $66.3 billion year for cleantech venture and growth capital, we would not have believed you. As with the weather events, every year is now a record-breaking year, it seems.

The rise in expectation and valuation levels is palpable, as the volumes of ESG and impact capital looking for a home increases at a pace that the supply end of the equation is not truly ready for. As a result, we are seeing ever-larger investment rounds, with companies at so-called Series A and B stages sometimes raising hundreds of millions.

One of our 2022 Global Cleantech 100 companies, Commonwealth Fusion Systems, recently announced (beyond the cut-off date) a staggering $1.8bn Series B!

We are seeing Unicorns created more quickly than ever, with more than half the 40+ cleantech unicorns ever created, reaching Unicorn status in 2021

This likely explains why the two largest investment sectors – Agriculture & Food and Transport & Logistics - are not necessarily the most heavily represented in the 2022 Global Cleantech 100. It is in these areas more than any others where companies are springing into high valuations and large investment numbers very early in their cycles.

Rivian was a case in point three years back; Wallbox was this year's example. Both out-grew the Global Cleantech 100 before they'd been recognized as a rising star in their pre-Unicorn, pre-IPO days.

Tesla was the first major graduate of the Global Cleantech 100 program when it went public in 2010

It never reached unicorn status as a private company. But during 2021 it did become cleantech's first trillion-dollar company, prompting Bill Gates to suggest that we will get 8-10 Teslas in this space in an October interview.

If the IT revolution of the last 30 years has spawned five or six trillion dollar companies, surely it will take the creation of many more than 8-10 Teslas, if we are to truly succeed in decarbonizing the whole of the world's industrialized economy in 28 years? There's room for another one in the field of EVs/batteries alone, no?

Across 2021, we counted more than 65 cleantech business types announcing definitive mergers to list via a SPAC, representing approximately one third of all SPAC activity

In Q3 2021 alone there were 34 listings completed via SPACs for cleantech businesses. Approximately 25% of the cleantech-relevant listings to date have been Global Cleantech 100 alumni.

Transportation and Logistics has been the dominant industrial sector area of SPACs to date, with electrification of transport the most heavily invested sub-theme within it. M&A was busy too, with some like Chargepoint leveraging their new-found public company status to create further scale through aggregation.

Was this the year when the electrification mega-trend reached its tipping-point? With so much capital and vested interests now behind it, is it now too big to fail? I believe so (even if I also believe some individual companies are set for spectacular falls).

This will have a strong pull-through effect on many other sorts of businesses – from battery recyclers through to alternative lithium mining techniques, and in new forms of battery materials and chemistries.

With electrification set to join renewables in the mainstream, what of other emerging areas?

This has been a year when we started to see a much wider appreciation of just how many changes and inter-related solutions are needed, often on different trajectories and timescales, if we are to get serious about deep decarbonization and net zero by 2050.

This is well illustrated by a look at the composition of the 2022 Global Cleantech 100 and some of the subtle shifts in the wider investment numbers.

Our Resources and Environment category has 21 companies, nearly double what it was only five years ago. This speaks to a much stronger focus on the importance of all our resources - air, CO_2, waste and water, as lead examples.

The promise of cultivated and fermented proteins has taken over from plant-based alternatives, at the Global Cleantech 100 stage of company lifecycle. Early-stage markets believe these more resource-efficient production systems are set for a big future.

A link to CO_2 and GHG emissions is everywhere across the 100 – along with the sense that the future carbon economy is starting to take some early shape. A new-found appreciation for the importance of soil quality is evident. And solutions are needed to do carbon accounting, measure emissions, and manage risk robustly, along with ensuring that voluntarily purchased offsets shake off their green laundering reputation. Such companies are apparent in this year's 100 like never before.

In the darker days of the early 2010's – when our theme was in the trough of disillusionment, - software businesses predominated the 100 companies which investors were most excited about. The 2022 list is striking for its deep-tech and hardware nature, plus how well-represented leading emergent solutions are for some of the hardest to abate industrial sectors – be that aviation, cement and concrete, chemicals and plastics, heating/cooling.

What to look out for in the coming years?

In each of their sections, our lead sector analysts provide a few things they have their eye on. At a more macro level, I'd point to two to keep an eye on.

Mitigation solutions still predominate the portfolio, be it the 100 or the whole of the global cleantech portfolio. There are some early movers with adaptation solutions but, given the relentless march of climate change and the relatively weak response to date, we expect to see a rising tide of solutions, based on resilience and adaptation, based on living in a climate crisis world.

Whisper it quietly – as options narrow, I believe attitudes will soften towards the perceived downsides of advanced nuclear reactor solutions. Here is a low carbon energy alternative that has the ability to scale and provide baseload energy in an ever more power-hungry and space-limited world. It also has rather unique potential to help alleviate the stranded assets problem represented by existing global coal. NuScale, representing an emerging class of new small modular reactor companies, not only made the list for the first time, alongside an ongoing faith that Fusion will eventually deliver, but now is also set to go public via a SPAC in 2022.

Interesting times ahead. Watch this space...

Agriculture & Food

Chris Sworder, Lead Analyst, Cleantech Group

The 2022 Global Cleantech 100 companies represent sectors such as alternative proteins, crop and soil science, and biological inputs that are key areas driving the transformation of agriculture and food (A&F) over the next ten years. We feel there are under-represented sectors where we see growing investment in innovation. These include food logistics and supply chain innovation, controlled environment growing systems and soil mapping technologies.

COMMENTS ON SELECT COMPANIES

WHAT THE EXPERT PANELISTS HAD TO SAY

Production is more resource efficient than for other proteins.
Nature's Fynd

Advancements in fermentation might allow costs to come down and open up a huge market for the technology.
Mosa Meat

Commercializing a new crop, taking guts to do it.
ProLupin

The company has launched its first product and combines this product with a direct to farmer sales network, a rarity in the agriculture start-up arena.
Pivot Bio

Technology now being used across such a diverse array of industries.
Moleaer

Business model that has four winners; consumer, seller, the company, and the environment.
Too Good To Go

OBSERVATIONS

Efficient protein production over product

The 2022 cohort signals a change in the alternative proteins sector as cultivated and fermented proteins outnumber plant-based alternatives for the first time. The market favors more resource-efficient production systems offering more flexible feedstock and production.

A focus on soil health

With Trace Genomics' return to the Global Cleantech 100 alongside biological fertilizers such as Pivot Bio, the market is looking to manage soil health and improve soil inputs. The inclusion of Gro Intelligence enforces this trend, as management and monitoring of soil becomes a more prominent part of the sustainable agriculture, and precision agriculture, revolution.

Downstream innovation is under-represented

While Hazel Technologies and Too Good To Go highlight the importance of supply chain innovation, this theme is under-represented. With key legislative, consumer preference and economic drivers increasing the importance of supply chain tracking, shelf-life extension and consumer food sourcing solutions, we expect this theme to see greater representation in future Global Cleantech 100s.

INVESTMENT TRENDS TO PAY ATTENTION TO

Supply chain solutions scaling fast

Start-ups focused on the supply chain such as last mile delivery marketplaces (Picnic) and shelf-life extension innovation (Apeel Sciences) are often at unicorn valuations, taking them beyond inclusion in the Global Cleantech 100. This area is showing strong growth.

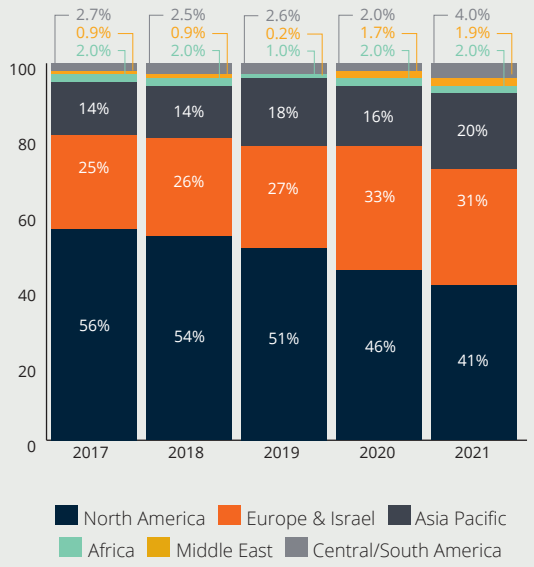
Corporate innovation is driving growth

We are seeing an influx of corporate investment in innovation, with 44% of all deals made in 2021 containing at least one corporate venture investor.

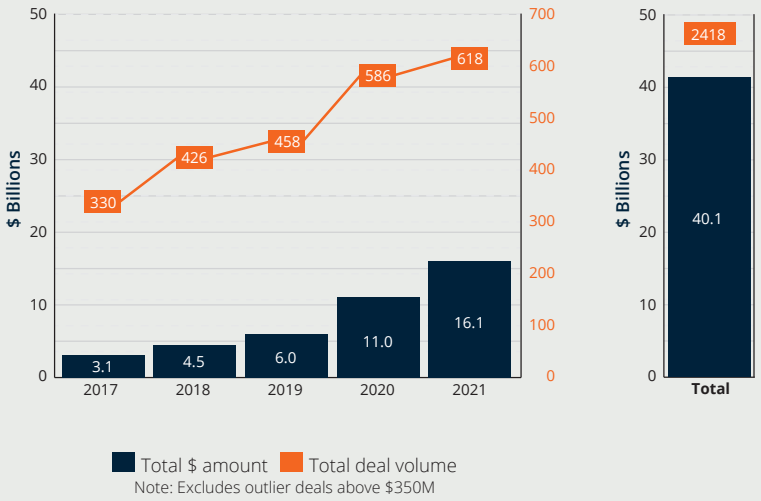
Consumer-facing sectors raising large-rounds

As the majority of value is captured at the retail and consumer end of the value chain, the highest growth sectors are for consumer-facing products and services such as fresh produce delivery and alternative protein brands.

Share of deal volume by geography



Venture investment five-year trend, $ total and deal count



Note: Excludes outlier deals above $350M

BEYOND THE GLOBAL CLEANTECH 100: TRENDS TO WATCH

Here we highlight some key trends, activities and innovations that will have a significant impact on the next decade of Agriculture & Food innovation

Measuring, managing and monetizing soil health

Trace Genomics' presence in the Global Cleantech 100 is an indicator of one of the fastest growing investment destinations in agtech. The value in measuring, monitoring and mapping soil to improve crop varieties, biological inputs, carbon sequestration and price ecosystem services has driven investment.

This trend has been supported by elements of the Green Deal in the European Union focusing on reduced fertilizer use and soil health. Similarly, Biden's Agricultural Carbon Bank is set to incentivize investment.

Measure	Manage	Monetize
TRACE GENOMICS	NORI	regrow
BIOME MAKERS	SOIL CAPITAL	reNature.
cloud agronomics		

Exit opportunities are increasing

More exit routes become available with focus drawn to SPAC mergers such as Global Cleantech 100 graduate Aerofarms. While opportunities are increasing, the route to successful exit remains unclear as this merger collapsed due to lack of funding in October.

More direct exit routes include acquisition by corporates such as Telus, the Canadian telecom giant, which continued to add agricultural services by acquiring companies such as farm management software company Conservis. John Deere also acquired its first new tech company since Blue River Robotics in 2017 by acquiring Bear Flag Robotics in October 2021.

Platform building through acquisition strategies is being used by Semios, CropX and iUNU to increase their range of features and enter new geographies.

Acquirer	Target	
Spring Valley Acquisition Corp	AEROFARMS Agriculture, Elevated.	
TELUS Agriculture	conservis	
JOHN DEERE	BEAR FLAG ROBOTICS	
iUNU	ARTEMIS	CROP WALK

BEYOND THE GLOBAL CLEANTECH 100: TRENDS TO WATCH

Crop genetics business model innovation

Ten years on from the invention of CRISPR gene editing technologies, we are seeing commercialization of the technique in agricultural applications. Innovators are looking to capture value by working with downstream food companies or take on commercialization risk for new products.

Business models include:

1. Genetic editing and engineering services.
2. Variety/trait co-development projects with royalty payment on sales.
3. Crop variety design, breeding and distribution.

Genetics Services → Co-development → Seed company

Phytoform Labs

HUDSON RIVER Biotechnology

Tropic Biosciences

BENSON HILL™

Significant fundraising activity targeting Agriculture & Food

2021 saw many significant fund announcements targeting different parts of the agricultural value chain in different geographies.

VC funds such as Big Idea Ventures, Five Seasons Ventures and Blue Horizon received LP support from major food and agriculture supply chain players.

2021 also saw corporate venture arms launched by Trimble to invest in agriculture, construction and transportation services as well as Cargill relaunching Cargill Ventures.

Mirova Environment Acceleration Capital fund is looking to scale mature businesses in environmental protection across smart cities, natural resources, agri-agro technologies, circular economy and clean energy.

Investor	Amount	Target
Flagship Pioneering	$3.4 billion	Ag., nutrition, health
mirova (Investing in sustainability)	$350 million	Resources, agritech, smart cities
blue horizon	$225 million	Sustainable food
FIVE SEASONS	$208 million	Food supply chain
Trimble	$200 million	Ag., construction, transportation
omnivore	$150 million	India-based agtech
BIG IDEA VENTURES	~$175 million	Protein, agtech, foodtech

Enabling Technologies

Nisa Mirza, Lead Analyst, Cleantech Group

The 2022 Global Cleantech 100 list highlights predictive asset management, a solution with applications in utilities, critical infrastructure and networking & communications. AI-powered robotics, spacetech and cybersecurity have been key themes in enabling technologies (ET) beyond the list. Here we highlight some key enabling technology trends, activities, and innovations that will have a significant impact in the next decade.

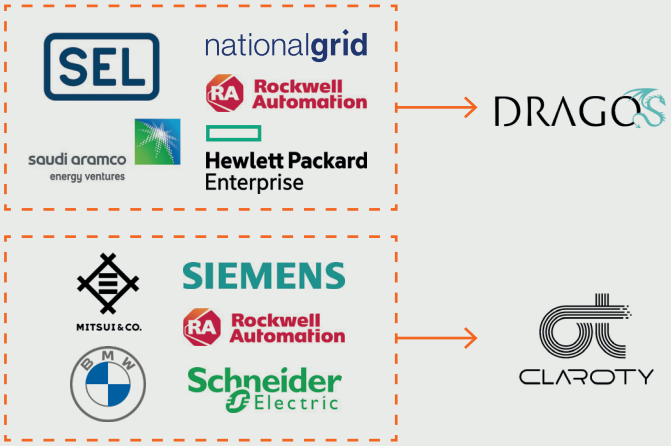
BEYOND THE GLOBAL CLEANTECH 100: TRENDS TO WATCH

Here we highlight some key enabling technology (ET) trends, activities, and innovations that will have a significant impact in the next decade

Protecting assets and data

With industries continuing to digitalize, cyber security solutions will retain high demand going forward. End-to-end encryption, identity management and device and cloud security are areas opening to early-stage innovation.

Corporates have been increasingly active in establishing strategic partnerships with innovators in the cyber space, either directly or through their VCs. Corporate participation is expected to increase as risk increases.



Ramping processing and computational capabilities

Quantum computing can drive innovation in security, material science, communications and simulation among other applications. With current advances in the technology, quantum is headed for exponential growth with its market projected to reach $64+ billion by 2030. Quantum cryptography and Quantum Superposition are solutions to watch out for.

Google and IBM lead the race in quantum, but with start-ups such as Rigetti Computing announcing a SPAC merger at $1.5 billion valuation, innovators are surfacing. Keep an eye on PsiQuantum, Xanadu and NanoSys.

XANADU	Photonic quantum computing	$ 100 million
QUANTUM MACHINES	Quantum Orchestration platform	$ 50 million
PASQAL	Programmable quantum simulators	$ 27 million

BEYOND THE GLOBAL CLEANTECH 100: TRENDS TO WATCH

SPACs still an attractive route for SpaceTech

Spacetech companies have dominated IPOs through SPACs in the enabling technology sector this year with six announced and are poised to continue to do so with the need for climate and earth monitoring and networking solutions on the rise. Two quantum companies and one cyber company have also announced their SPACs in 2021.

Internet-of-things encryption and high-connectivity semiconductors providers have also been a target for SPACs this year.

ARQIT	Centricus Acquisition Corp	$1.4 billion
Valens	PTK Acquisition	$1.16 billion
Airspan	New Beginnings Acquisition	$822 million

Standardization across smart devices

Standardization of technologies may see a drive from legislative bodies to uphold quality and safety of solutions. Internet-of-things and other connected devices will be directed towards a base system to ease adoption.

Partnerships between device developers and security providers are expected. Full-stack developers of secure smart devices may also gain traction. Corporate collaboration will also increase, as evidenced by Matter.

GOV.UK

- UK Government planning new cyber laws for all incoming smart devices.

European Commission

- EU to require all imported wireless devices to have embedded security by 2023.

matter

- Matter is a collaborative agreement between Google, Apple, Amazon and other corporates to promote device compatibility. It is guided by the Connectivity Standards Alliance.

Energy & Power

Louis Brasington, Lead Analyst, Cleantech Group

The group of next-generation renewables, hydrogen, heating and cooling and energy storage companies in this year's 2022 Global Cleantech 100 Energy & Power sector reflects a plea for meaningful decarbonization across grids, in industry and for consumers. While cleaner and cheaper energy systems are crucial for transforming the energy network, under-represented areas include floating offshore wind power, energy carbon traceability, local energy networks and clean energy access.

COMMENTS ON SELECT COMPANIES

WHAT THE EXPERT PANELISTS HAD TO SAY

Long-duration storage is an important part of the future energy mix.
E-Zinc

Fusion Power is likely to see increasing investment as the world gets more desperate for low carbon solutions.
General Fusion

Renewable hydrogen will decarbonize hard-to-electrify sectors and Sunfire's technology offers the highest conversion efficiency.
Sunfire

Low-cost ionomers for electrolysis that are not fluoropolymers would allow for using non-precious metal catalysts, driving down the cost of Clean Hydrogen.
Ionomr Innovations

OBSERVATIONS

Renewed confidence in hard energy technology

Support for hard-tech innovators over software in the 2022 Global Cleantech 100 cohort signals a renewed willingness and urgency to decarbonize as well as overcome capital intensive commercialization hurdles. Challenging themes such as fusion, long-duration storage, marine energy and geothermal are also represented.

Emphasis on clean hydrogen production

Strong presence of hydrogen production innovation is well aligned with cost reduction requirements over the next 5-10 years. Renewable production innovators are scaling to drive down costs and to address expensive critical metallurgy bottlenecks. Low carbon hydrogen production innovators are increasing the percentage of CO_2 captured, while decreasing capture costs.

Alternative refrigerant systems are under-represented

Despite the presence of heating and cooling innovators 75F, Blocpower and Redaptive, innovators using alternative refrigerants are missing. Given hydrofluorocarbons refrigerants are the most harmful components in buildings, regulation across the world is accelerating phase out and driving demand for low-carbon alternative options for use in heat pumps.

INVESTMENT TRENDS TO PAY ATTENTION TO

Record investment in Energy & Power

Record levels of late-stage round (Series B +) have resulted in record annual investment totals. This was driven largely by support for technologies and business models such as batteries, long-duration storage and solar-as-a-service, which are all well represented in the 2022 Global Cleantech 100.

Corporates are driving commercialization efforts

Aligning strategy with climate goals means corporates are investing more than ever (55% more in 2021) into innovators to support the transition to consumer-centric business models at the grid edge.

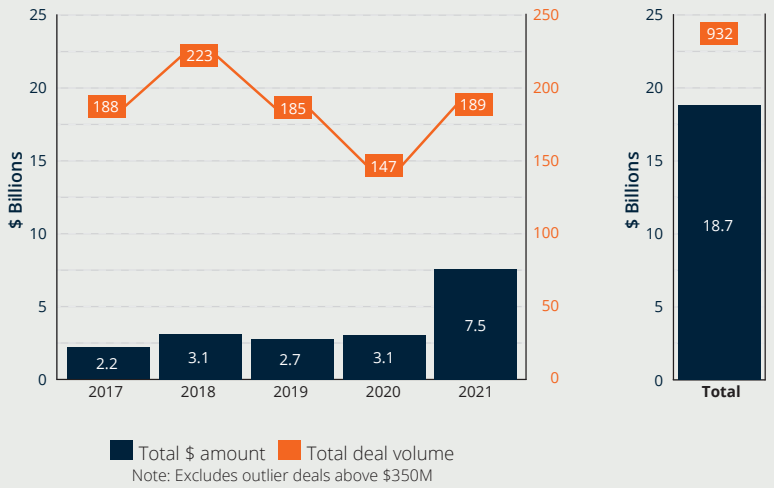
Batteries

Driven by automotive Original Equipment Manufacurers' desire to reduce the cost of electric vehicles, li-ion battery manufacturing and advanced battery technology including silicon anodes and metal battery technology, have received $6.1 billion of total investment in 2021.

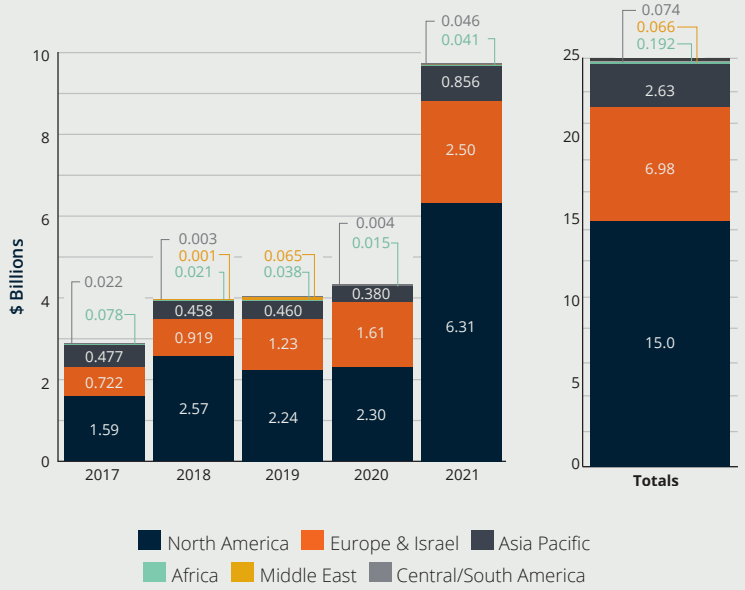
US remains key, but watch out for Europe and APAC

Responsible for many later-stage rounds and M&A, the US remains an important innovation hub. However, increased investment activity in Europe and APAC, particularly for early-stage investment, shows the region is no longer the only essential market to play in.

Late-stage venture investment five-year trend, $$ total and deal count



$$ amount invested by region



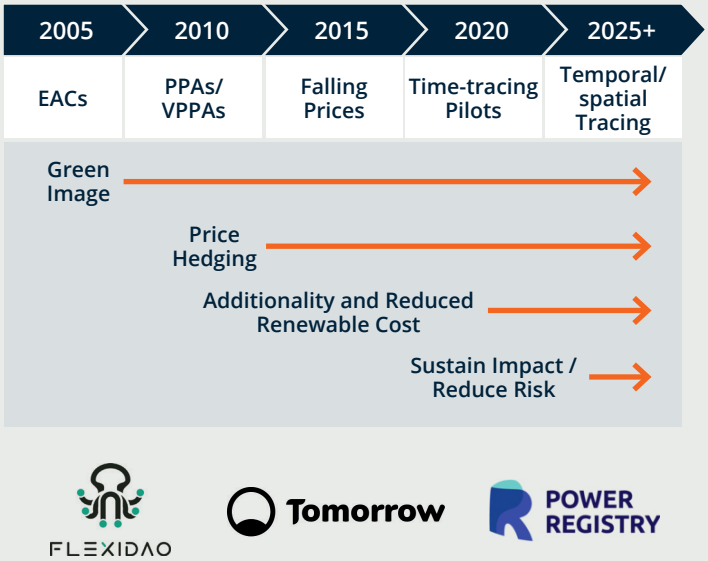
BEYOND THE GLOBAL CLEANTECH 100: TRENDS TO WATCH

Here we highlight some key trends, activities and innovations that will have a significant impact on the next decade of Energy & Power innovation

Creating carbon-aware energy networks

Electricity grids, hydrogen and heat networks are just a few examples of where carbon intensity needs to be tracked and accounted for in real-time for corporates to accurately account for their CO_2 impact.

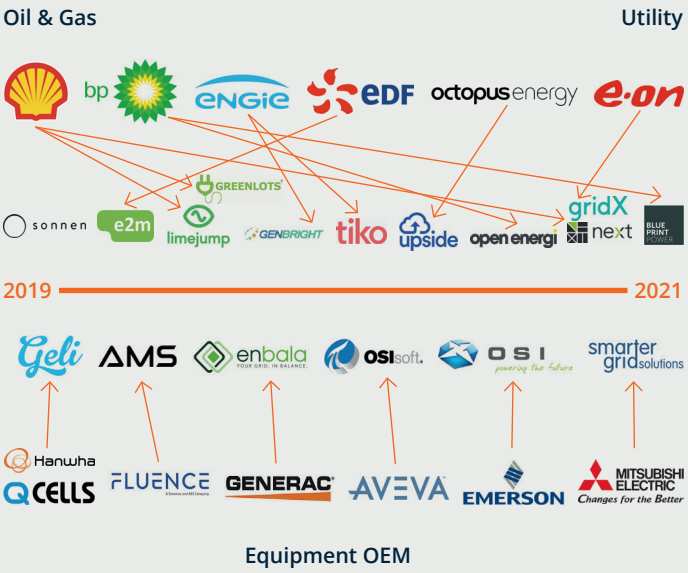
Tech corporations including Google and Microsoft are among the first movers creating carbon-aware energy transactions while transitioning towards 24/7, 365 renewables, matching renewable supply and demand in real-time.



Significant acquisitions in DER management

Historically the most popular Global Cleantech 100 theme, consolidation is rampant as corporates look to have a foot in emerging consumer facing DER aggregation, dispatch and optimization services.

The US FERC Order No. 2222 and alignment on the role of independent aggregators in the EU Clean Energy Package creates opportunities for value-driven DER participation in energy markets.



BEYOND THE GLOBAL CLEANTECH 100: TRENDS TO WATCH

Tapping into deep-water renewable markets

80% of the world's offshore wind resource potential obtainable in waters deeper than 60 meters remains an untapped market. After a decade of pilots and demos, deep-water wind is entering a rapid scale-up phase. Globally, the market is projected to reach 26GW installed capacity by 2035. Floating technologies will see significant consolidation in the next five years.

The Biden administration plans to install 30GW of offshore wind by 2030 and South Korea has a $31 billion plan for a 6GW floating wind project for 2030.

Technology | Development | Operations

XWIND, Stiesdal, GAZELLE WIND POWER, AKER OFFSHORE WIND, OW OCEAN WINDS, TRIDENT WINDS, Simply Blue Group, CERULEAN WINDS, CoensHexicon, Principle Power, hexicon, BW ideol

Hardware-as-a-Service for consumer facing business models

Consumer willingness to pay remains a challenge for scale deployment. Innovators are increasingly tapping third-party financiers to provide a pay-as-you-save model, which will remain important until green premiums reduce.

Green mortgages are another innovative financing mechanism for incentivizing investment in consumer-facing energy efficiency solutions.

As-a-service innovators

- Heating & Cooling → BLOC POWER
- Distributed Energy Resources → REDAPTIVE
- Hydrogen → BayoTech
- Residential Solar → Enpal

Local and national flexibility marketplaces

Growing deployment of DERs require better national and local coordination, and DER aggregators need support with energy market interaction.

National or local market exchanges will become an essential layer within the distributed energy networks.

DERs | Dispatch, Control | Marketplace

leap., piclo, LO3 ENERGY, opus one solutions, GreenSync, POWER LEDGER

BEYOND THE GLOBAL CLEANTECH 100: TRENDS TO WATCH

SPACs target multiple technology segments

The frequency and number of successful listings of E&P related companies has continued to accelerate with a total of 15 innovators listing, a 400% increase from 2020. Eight other innovators also filed in 2021.

SPACs are not just targeting battery and electric vehicle innovators. Both alternative hardware including hydrogen, long-duration storage and fuel cells and software related sectors including DER management and home automation are new targets.

Expect to see increasing target diversity, but also a cooling down of SPAC activity with more realistic valuations.

Company	Valuation	SPAC
ReNew POWER	$8bn	RMG Acquisition Corporation II
SmartRent	$2.2bn	Fifth Wall Acquisition Corp
FREYR RENEWABLE ENERGY STORAGE	$1.4bn	Alussa Energy Acquisition Corp
stem Energy Superintelligence™	$1.35bn	Star Peak Energy Transition Corp
view	$1.6bn	CF Finance Acquisition Corp. II
hexicon	$358mn	AMCI Acquisition Corp

Increased availability of late-stage funding

Access to commercialization funding has historically been a hurdle for capital intensive hardware. Both the private and public sector are announcing late-stage patient capital war chests, particularly important for sectors such as storage, hydrogen and next-generation renewable power.

Investor	Amount	Target
WORLDFUND	$400M	Solutions with emissions reduction potential > 100 Mt CO_2e per year
Breakthrough Energy, UK Government	$545M	Hydrogen, long term storage, aviation fuels, direct capture
FiveTHydrogen	$1.2BN (target)	Hydrogen value chain
TEMASEK, BlackRock.	$1BN (target)	Late-stage growth renewable and mobility tech.
Breakthrough Energy, European Investment Bank, European Commission	$950M	High-capex energy innovation

Materials & Chemicals

Ian Hayton, Lead Analyst, Cleantech Group

The Global Cleantech 100 companies represent key hard-to-abate industrial sectors including steel production, cement and concrete, chemicals and plastics. Looking to the future, policy actions, increasing investment activity of corporates are worth watching carefully, along with innovation in industrial biotech and battery materials.

COMMENTS ON SELECT COMPANIES

WHAT THE EXPERT PANELISTS HAD TO SAY

Truly breakthrough technology to address the hard to decarbonize steel sector.
Boston Metal

Huge potential positive impact on CO_2 emissions in the plastic industry.
Lactips

Carbicrete's carbon negative concrete provides a lower cost way for concrete manufacturers to reduce their emissions.
Carbicrete

OBSERVATIONS

Progress in hard-to-abate sectors

This year, innovation focused on addressing emissions in hard-to-abate sectors has made it to the Global Cleantech 100. Interest in basic materials is increasing with a return for Boston Metal and Carbicrete. H2 Green Steel joined the list for the first time. Biotechnology continues to feature in 2022, but with renewed focus on materials with Blupha making the list for the first time and a return for Checkerspot and Lactips.

Chemical industry under represented

Apart from the addition of Syzygy Plasmonics and Enginzyme, the chemical industry is under-represented considering the impact of chemicals and decarbonization trends in other challenging sectors. I expected to see more entrants from innovators focused on electrification, efficient separations and biomanufacturing targeting higher volume chemicals.

Looking further up the value chain

Looking to the future, basic material production innovations are likely to remain well represented as high emissions are likely to persist. We may also see entrants from companies active further up the value chain of currently impactful cleantech sectors such as superior and low impact battery materials, and solar PV components.

INVESTMENT TRENDS TO PAY ATTENTION TO

Record dollar total invested in this sector

Total venture investment reached new highs for Materials and Chemicals in 2021, increasing by $1.7 billion vs 2020, a 74% increase from 2020 and triple the amount 5 years ago. Key venture investors include Breakthrough Energy Ventures, Prelude Ventures, The Engine and High-Tech Gründerfonds Management.

Average deal size is growing

In 2021 there were several large venture rounds for biotech and biobased chemicals innovators including Solugen, Spiber, Genomatica and Bota Bio. Investors are likely encouraged by improving exit conditions as innovators including Ginkgo Bioworks, Origin Materials and Zymergen achieved public listing. Newly listed companies are making acquisitions.

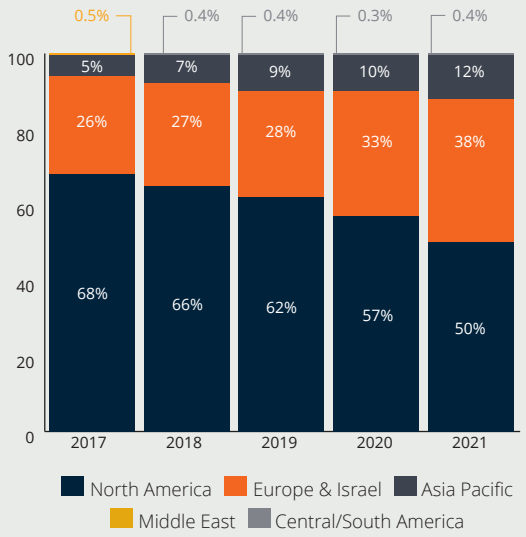
Corporate engagement is growing

Corporate venture participation in venture investment reached a new high of high of 27%, up from 20% in 2020. Leading materials & chemicals investors include Saudi Aramco Energy Ventures (SAEV) and Novo Holdings.

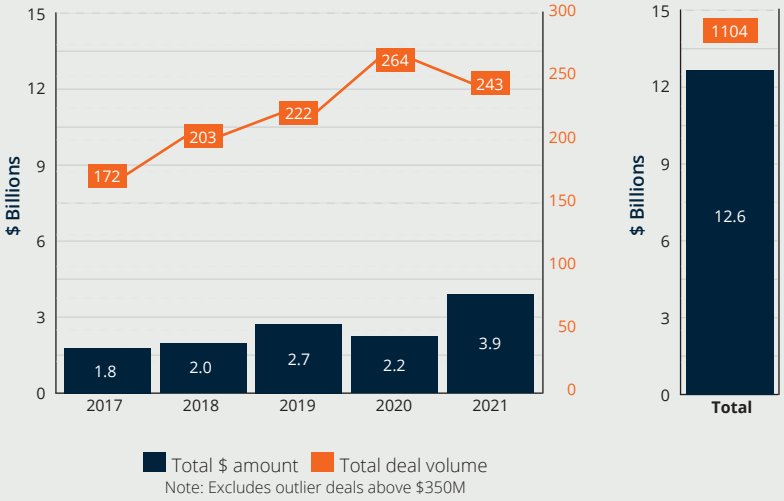
Investment growth fastest outside of North America

A continued geographical shift in investment took share away from North America as growth occurred largely outside of North America, especially in Europe.

Share of deal volume by geography



Venture investment five-year trend, $ total and deal count



Note: Excludes outlier deals above $350M

BEYOND THE GLOBAL CLEANTECH 100: TRENDS TO WATCH

Here we highlight some key trends, activities, and innovations that will have a significant impact on the next decade of Materials & Chemicals innovation

Oil and gas refocus

Oil and gas majors are looking to reimagine themselves in a world beyond peak oil. Many have made commitments to reach net zero by 2050 and have raised funds to invest in a broad range of clean technologies. Saudi Aramco, Shell and BP all have large $500 million+ venture funds. Shell, BP, Repsol are engaging in early-stage innovation via accelerator and incubator programs.

GOV.UK

- HT Materials Science
- Nexwafe

bp

- Solidia

OGCI OIL AND GAS CLIMATE INITIATIVE

- Solidia
- Boston Metal

Carbon pricing driving the market

Carbon pricing is driving investment in emitting industries including steel, cement and chemicals. Record carbon prices in the EU ETS alongside implementation of the Carbon Border Adjustment Mechanism (CBAM) is likely to spur EU emitters into action and support innovation. Procurement policy, predicated on environmental product declarations (EPDs), will be important for stimulation of demand for green steel and low carbon construction materials.

European Commission

- EU Emissions Trading Scheme (ETS) prices hit new highs in 2021 reaching $100/ton CO_2eq.
- Carbon Border Adjustment Mechanism (CBAM) is being implemented in the EU.
- Public procurement policies exist in several US states and are under consideration in California and New Jersey.

BEYOND THE GLOBAL CLEANTECH 100: TRENDS TO WATCH

Key funds raised and deployed in 2021

Venture funds targeting industrial decarbonization are likely to support innovators in hard-to-abate sectors. Breakthrough Energy raised another $1 billion fund. Material Impact finalized a second fund with $200 million. Seed-stage fund High-Tech Gründerfonds Management announced plans for a fourth fund. The Engine continues to deploy funding from its 2020 fund.

Breakthrough Energy
- Boston Metal
- Solidia
- Bloom Biorenewables

THE ENGINE Built by MIT
- Boston Metal
- Syzgy Plasmonics
- Via Separations

High-Tech Gründerfonds
- Ineratec
- Traceless
- Dimpora

Innovation in battery materials

A key element for success in the electric vehicle space remains the cost and performance of batteries. Materials innovations are set to drive improvements. Innovators solving technical challenges associated with silicon anodes to improve energy density will receive further attention. Niobium anodes are set to make fast charge a reality and new materials processing technology is set to address manufacturing waste and lower cost of production.

Component	Technology	Innovators
Anode	Silicon	E-magy
	Niobium	Echion Technologies, nyobolt
Cathode processing	Microwave plasma	6K

Innovation in biotech

Biological manufacturing of chemicals has historically faced economic and technical challenges. Biotech platforms and cell-free manufacturing are both set to address these challenges. Cell-free manufacturing enables manufacturers to synthesize materials from enzymes, which circumvents some of the challenges associated with traditional fermentation approaches.

Biotech platforms	Cell-free manufacturing
Originbio	EnginZyme
Bota	FabricNano

Resources & Environment

Holly Stower, Lead Analyst, Cleantech Group

Climate tech tools for business including emissions monitoring, carbon offset transparency tools and carbon, capture usage and storage innovators took center stage this year as businesses look to meet their net-zero commitments. Beyond the Global Cleantech 100, we are also observing EU regulations, automotive OEMs and plastic producers driving the market for circular solutions such as battery recycling, chemical plastic recycling and circular fashion business models.

COMMENTS ON SELECT COMPANIES

WHAT THE EXPERT PANELISTS HAD TO SAY

Building the carbon marketplace of tomorrow that will help fortune 500 companies reach net zero.
Pachama

The most advanced of the natural gas detection technologies. Able to make a significant impact in the reduction of GHG emissions by identifying and quantifying fugitive emissions.
GHGSat

Carbon management starts with actionable insight, both for consumers and businesses.
Persefoni

Climate change is increasing the number of natural disasters like wildfires, the company's technology helps reduce the health-related risks associated to these events.
BreezoMeter

If they can achieve DAC at scale and economically it will decarbonize the world's supply chains for chemicals, paints and many other materials. High risk / high impact.
Carbon Engineering

Relatively small cost but huge impact for water resources at city and industrial scale.
Pani Energy

OBSERVATIONS

Emissions monitoring

Mandatory disclosure regulations across the globe are forcing large companies to provide high-quality data. From direct monitoring with satellites using companies such as GHGSat, to emissions accounting software like Persefoni and Watershed, 2022 signals a strong market shift towards start-ups helping clients track their climate goals.

Monitoring climate-related physical risk

Similar mandatory disclosure regulations for climate-related financial-risk have boosted the market for risk assessment tools like Sinai Technologies' AI-based software, which puts a price on inaction.

Offsets: ironing out the kinks

The rapidly expanding Voluntary Carbon offset Market (VCM) has come under scrutiny due to incidences of double-counting and failed projects due to forest fires. Corporate buyers are seeking high-quality offsets and transparency, fueling the market for remote monitoring and verification technologies. Pachama, which made the Global Cleantech 100 for the first time, provides forestry carbon storage estimates via satellite and LIDAR data.

OBSERVATIONS

Carbon Capture Usage and Storage (CCUS)

CCUS players are now a regular feature of the Global Cleantech 100. This year saw Direct Air Capture (DAC) companies like Carbon Engineering and Climeworks raising large growth equity rounds for capex-heavy technologies, representing increasing market confidence.

Air quality for health and well being

Covid-19 highlighted the importance of indoor air quality for health and wellbeing. The return to commercial buildings, following lockdowns, has driven building owners and managers to look to tools to assure safety and comfort. For example, new entrant AirQuality provides smart air monitoring and corresponding air purifiers.

Wastewater treatment

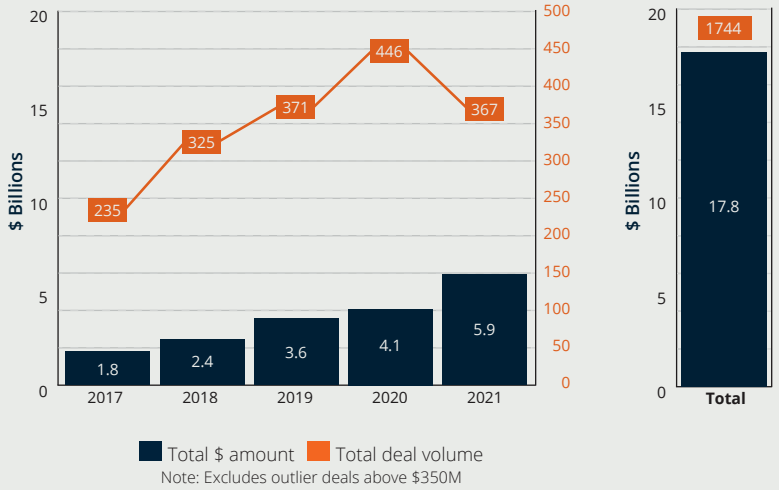
The increasing criticality of water to business alongside corporate goals to reduce the energy intensity of wastewater treatment, continue to fuel the market for wastewater treatment optimization tools like Pani Energy.

INVESTMENT TRENDS TO PAY ATTENTION TO

Record investment year for Resources & Environment

2021 brought two record investment quarters in Q1 and Q2, largely due to circular economy innovators raising large late-stage rounds. Although, B2B material supply chain tracking innovator, CIrculor, made the Global Cleantech 100 for the first time this year, B2C solutions in circular fashion and electronics, which raised high growth equity rounds this year, are notably absent from the list.

Venture investment five-year trend, $ total and deal count



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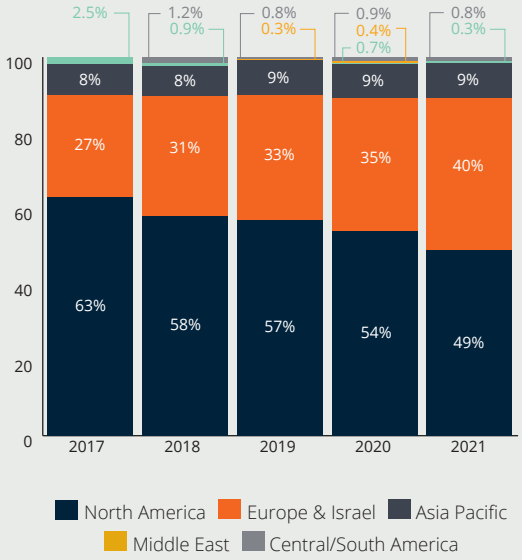
Share of deal volume by geography



BEYOND THE GLOBAL CLEANTECH 100: TRENDS TO WATCH

Here we highlight some key trends, activities, and innovations that will have a significant impact on the next decade of Resources & Environment innovation

EU legislation on circularity

EU legislation has started to transform Europe's waste system with a particular focus on plastics. The EU's waste export ban has incentivized domestic recycling and so autonomous sorting technologies like AMP Robotics. These tools rely less on expensive human labor.

European Commission

- Extended Producer Responsibility
- Waste Export ban
- New EU Batteries Directive

Battery recycling

As the drivers for electric transportation intensify, automotive OEMs and energy majors are entering partnerships with lithium-ion battery recyclers to facilitate circular business models for end-of-life car batteries. Some battery recycling innovators have started to exit, including Li-Cycle via SPAC, highlighting the rapidly maturing market.

Corporate Partnerships

RETRIEV TECHNOLOGIES ⟷ Marubeni

Lithion (Lithium-ion battery recycling) ⟷ HYUNDAI

Li-Cycle ⟷ NEW FLYER

Circular fashion

Circular fashion business models continue to gain momentum as consumer awareness of fast-fashion drives the market for circular business models like second-hand, rental and repair. Corporate venture arms have opted for a different tack, investing in advanced textile recycling and alternative materials e.g. Infinited Fiber Company and Spiber.

	Description	Investment
Vestiaire Collective	Host of second-hand marketplace	$466 million
Spiber	Microbially-fermented protein materials and synthetic spider silk	$312 million
Infinited Fiber	Chemical recycling for cellulose-based raw material	$35 million

BEYOND THE GLOBAL CLEANTECH 100: TRENDS TO WATCH

Venture capital investors support circularity

Circular innovation industries shows signs of maturity with numerous SPAC exits. Lithium-ion battery recycler, Li-Cycle, listed on NYSE via a SPAC, becoming Li-Cycle Holdings Corp and raising $615 million. Many corporate, sovereign bonds and VC funds have emerged this year focused on the circular economy. The Ellen MacArthur Foundation estimates that annual issuance has grown more than five-fold since 2019.

CIRCULATE CAPITAL

June 2021 - Circulate Capital partially closed its Circulate Capital Disrupt Fund at $25 million, planning to raise $50 million to target plastic and enable the circular economy.

ECBF European Circular Bioeconomy Fund

October 2021 - The EU's European Circular Bioeconomy Fund raised over $227 million, which will seek to drive the transformation towards a bio-based circular economy.

Advanced plastic recycling

Chemical, FMCG corporates and plastic producers continue to invest and partner with chemical plastic recycling innovators to provide capex for recycling infrastructure. Corporates are securing long-term partnerships across the value chain to supply waste plastic feedstock, secure a steady supply of recycled plastic and track plastic as it moves through value chains to ensure circularity.

Corporate Partnerships

MURA ⟷ MITSUBISHI CHEMICAL

PLASTIC ENERGY ⟷ سابك sabic Exxon

clariter ⟷ DSM

Construction, Covid and corporate sustainability

The pandemic provided strong tailwinds for prefabricated building design, especially in the US. With prefab, fewer workers will be together, construction can be automated and environments can be controlled. E.g. Mighty Buildings. Building regulations and standards, such as France's RE2020 regulation for energy efficiency in new buildings, are driving the market for efficient design software like Life Cycle Assessment (LCA) tools.

Feedstock	Construction	End-of-life
Timber	3D Printed	Repurpose
Low-Carbon Concrete	Prefabrication	
Life-Cycle Analysis Design		

Transport & Logistics

Cassidy Shell, Lead Analyst, Cleantech Group

The 2022 Global Cleantech 100 list has strong representation from EV charging, low-emission solutions for heavy-duty commercial vehicles and autonomous driving companies. This year's list shows a shift in focus by the market away from passenger cars to capture emerging opportunities in other transport sectors and infrastructure. Beyond the Global Cleantech 100, we have seen a rise in innovation in supply chain technology, EV batteries and other components, fleet management and advanced air mobility.

COMMENTS ON SELECT COMPANIES

WHAT THE EXPERT PANELISTS HAD TO SAY

Managing EV fleets through smart charging is an important part of electrifying transportation.
AMPLY Power

Using AI to reduce CO_2 in the shipping sector is an attractive and impactful area. Both regulation and market is moving in this direction.
DeepSea

Lowest cost carbon mitigation solution in the heavy vehicles market.
Effenco

After the explosion of eCommerce driven by Covid, solutions like the one OnTruck offers are key to lowering emissions from transportation by offering an optimized network of carriers.
OnTruck

Electric aviation is one of many important pieces to the low carbon economy.
ZeroAvia

OBSERVATIONS

Electric vehicle (EV) charging takes center stage

This year's list features six EV charging companies out of thirteen total companies in transportation and logistics. As an increasing portion of the global vehicle fleet electrifies, this signals the importance of infrastructure solutions, both in hardware and software, to scale up electric vehicle adoption.

Going beyond passenger cars

Markets are increasingly looking beyond passenger vehicles to innovate with electrification and develop disruptive business models that move people and goods more efficiently. Companies developing zero-emission solutions in heavy duty vehicles (Highland Electric Fleets and Effenco) and aviation (ZeroAvia) made the list this year. Ather Energy, a micromobility company, also made the list.

Wave of exits

The high volume of SPACs IPOs in the sector since the middle of 2020 has removed many potential Global Cleantech 100 companies from being considered. This has created an attractive exit opportunity in the sector and has brought new innovation to the list, such as Wirelane (EV charging focused on hospitality sector) and Deepsea Technologies (ship monitoring and optimization).

INVESTMENT TRENDS TO PAY ATTENTION TO

Record-breaking investment in 2021

The pace of transformation towards connected, autonomous, shared and electric mobility is accelerating across the industry, driving investment in innovation higher. 2021 saw record-breaking total venture investment of over $51 billion (next highest was 2018 with $41.3 billion).

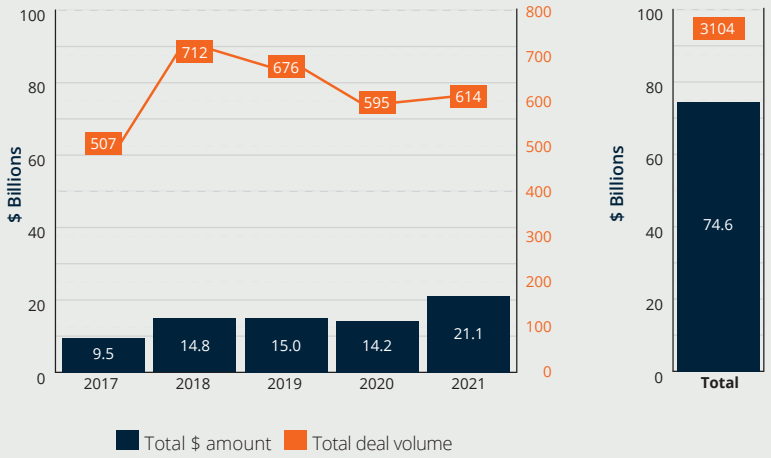
Innovation opportunities are going global

The share of deals in North America continues to fall, from a high of 49% in 2016 to 34% in 2021. Europe and APAC are logging more deals than ever, and while North America is also increasing deal volume, its share of the global cleantech ecosystem is dropping (for the first time below 40%). The number of deals in Africa, Middle East and Central/South America is steadily increasing, indicating that innovation is expanding in emerging markets.

Corporates are investing in decarbonization

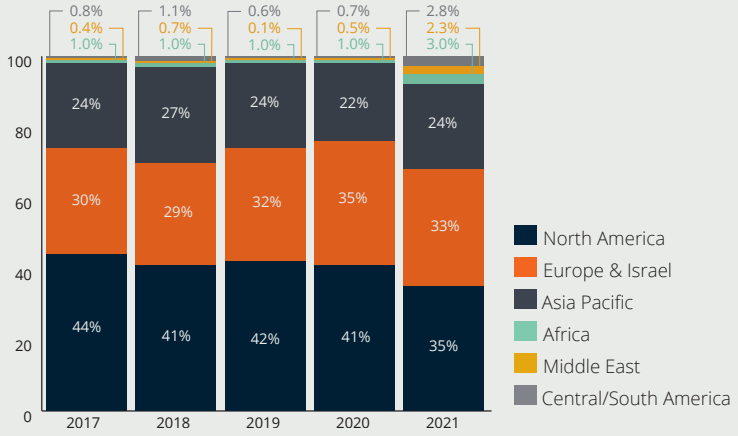
Participation from corporates is increasing, with a record 27% of deals in 2021 including at least one corporate investor. The past year has been particularly active for automaker commitments to ramping up EV production. Automakers are looking for technology partners to expand into new business lines, improve production of EVs, drive down battery costs and improve battery performance.

Venture investment five-year trend, $ total and deal count

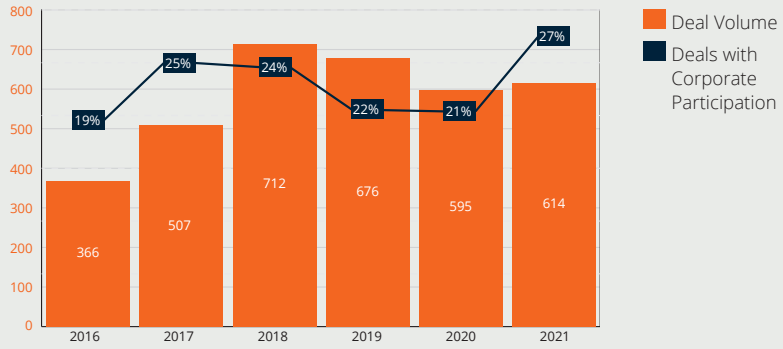


Note: Excludes outlier deals above $350M

Share of deal volume by geography



Corporate participation in venture deals



BEYOND THE GLOBAL CLEANTECH 100: TRENDS TO WATCH

Here we highlight some key trends, activities and innovations that will have a significant impact on the next decade of Transportation & Logistics innovation

Regulation and government targets beginning to drive markets and innovation in hard-to-abate sectors

Government targets for net-zero emissions and accompanying regulations, such as carbon taxes, low-carbon fuel standards and sustainable fuel blending mandates are creating markets for zero- and low-emission solutions in harder to abate sectors, such as maritime shipping and aviation.

Council of the European Union

- The EU's Fit for 55 package includes revisions of the EU emissions trading system that extends the system to shipping and revises the rules for aviation. ReFuelEU Aviation focuses on sustainable aviation fuels and FuelEU focuses on maritime.

CALIFORNIA AIR RESOURCES BOARD

- The California Air Resources Board's Advanced Clean Trucks regulation requires manufacturers to sell zero-emission trucks as an increasing portion of annual sales.

Innovative business models continuing to disrupt incumbents

Electrification, sharing and autonomy are continuing to unlock new business models in mobility services and logistics such as as-a-service offerings and asset-heavy business models that benefit from asset optimization and lower fuel and operating costs of EVs. Incumbent business models are being disrupted faster than ever.

Energy-as-a-service for heavy duty electric fleets → AMPLY POWER

All-electric ride-hailing services with full-time drivers → revel

Battery and battery swapping infrastructure-as-a-service → SUN MOBILITY

Acquisitions abound as incumbents build out electric offerings and evolve business models

The sector has seen a significant number of acquisitions in the past year as automakers, charging providers, oil and gas majors and energy companies expand their offerings across the electrification value chain. As vehicles and the surrounding ecosystem (charging/fueling, maintenance, etc.) become increasingly electrified and digitized, incumbents are looking to own more of the customer experience and generate recurring revenue.

Acquirer	Target
Mercedes-Benz	YASA
chargepoint	VIRICITI
chargepoint	has·to·be eMobility
Ford	electriphi
BorgWarner	AKASOL
Shell	ubitricity
NEXTera ENERGY RESOURCES	eIQ MOBILITY

BEYOND THE GLOBAL CLEANTECH 100: TRENDS TO WATCH

Supply chain constraints, range limitations driving innovations in components

Innovation in batteries, fuel cells and hydrogen storage are becoming critical to unlock longer ranges and overcome supply chain bottlenecks in metals for lithium-ion batteries. Investment in new battery types and chemistries, such as solid state, silicon anode, etc., will likely accelerate in the coming years.

REDWOOD MATERIALS	Solid Power	Universal Hydrogen
EV battery closed-loop recycling	Solid-state EV batteries	Hydrogen storage for aircraft
$750 million in funding	**$542 million in proceeds from SPAC listing**	**$82 million in funding**

Funds and innovation challenges

A number of new funds and innovation challenges emerged this year to target technologies in decarbonization in vehicles and automotive supply chains, new mobility and batteries.

Volkswagen	$335 million decarbonization fund
Ford	Mobility innovation program
NEWLAB	Battery innovation contest
LG Energy Solution	

The 2021 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.

Below we record the graduation events since the previous edition of the Global Cleantech 100 was finalized, and before this one (whose cut off date was 30 September 2021).

There are two big trends to call out. One is the arrival of the SPAC as a major force in cleantech innovation. Around 35% of all SPACs announced in 2020-21 were cleantech-relevant and of the cleantech targets, nearly 25% were Global Cleantech 100 alumni.

The other key trend is that the 2021 graduate list is not only deep in terms of number of exits, compared to previous years, but also there are more of them returning good, and in some cases exceptional, venture-grade returns to the original investors.

Market conditions and the remarkable rise of investor and corporate enthusiasm around net zero would suggest that the graduate lists of the 2020s will remain strong, testament to how far the macro cleantech theme has traveled toward being mainstream, in the time we have been producing our annual Global Cleantech 100 program.

SPACs in process

Companies which announced a definitive agreement to go public via a SPAC before the cut-off date can no longer qualify, even though the odd one might not complete in the end (e.g. AeroFarms). This prevented, by way of example, Wallbox (which announced its SPAC in June and listed in October) from making the 2022 Global Cleantech 100.

There are a number of Global Cleantech 100 alumni companies currently going public via acquisition by a Special Purpose Acquisition Company (SPAC). Only those which have fully completed and are trading as a public company are included above as graduates. Others that have listed since the cut off date (e.g. ESS) and those that do so before 30 September 2022 will appear in next year's graduates section.

Unicorns

We have a rule, 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 the Global Cleantech 100. This has meant, by way of example, leading private companies, who might otherwise have made the 2022 Global Cleantech 100, such as Back Market, Bowery Farming, Redwood Materials, Spiber and WeRide, can no longer qualify.

Enpal, by way of example, reached Unicorn status in October 2021, after the cut off date for the 2022 list. Presumably Commonwealth Fusion Systems, having recently announced a round in excess of $1 billion, will also be ineligible next year.

Global Cleantech 100 Graduates via IPO's

1 October 2020 - 30 September 2021

Global Cleantech 100 alumnus company	IPO Type	IPO Date	Short Description of the Company	Years on the Global Cleantech 100
BENSON HILL	via SPAC	September 2021	Developer of a synthetic biotechnology platform to develop new crops and food	2018, 2020-21
LILIUM	via SPAC	September 2021	Developer of a battery-powered, fan-propelled vertical take-off and landing commuter aircraft	2018-20
volta	via SPAC	August 2021	Provider of charging stations that provide advertising space to businesses and free charging to drivers	2019-21
otonomo	via SPAC	August 2021	Developer of software to connect autonomous cars with each other and with digital infrastructures and exchange data in real time	2018-19
JOBY AVIATION	via SPAC	August 2021	Provider of electric aircraft mobility systems	2020
Li-Cycle	via SPAC	August 2021	Provider of lithium resource recovery services and supplier of lithium-ion battery materials	2020-21
microvast	via SPAC	July 2021	Manufacturer of battery systems for electric vehicles and large-scale power grid applications	2013
EVgo	via SPAC	July 2021	Installer and servicer of fast-charging stations for electric vehicles	2020
PROTERRA	via SPAC	June 2021	Developer of zero-emission, battery-electric buses	2013-20
stem Energy Superintelligence	via SPAC	April 2021	Developer of energy storage and software solutions to help businesses better manage electricity use and enhance grid operations	2014-20
INNOVIZ TECHNOLOGIES	via SPAC	April 2021	Developer of LiDAR technologies for autonomous vehicles	2019
NUVVE	via SPAC	March 2021	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	2018, 2020
view	via SPAC	March 2021	Developer of energy-efficient glass technologies for buildings	2014
FarmersEdge	Traditional IPO	March 2021	Provider of independent data management solutions for farms and a global leader in precision agriculture	2017-18
chargepoint	via SPAC	February 2021	Provider of electric vehicle charging solutions	2010-18
Desktop Metal	via SPAC	December 2020	Provider of metal and carbon fiber 3D printing solutions	2019
C3.ai	Traditional IPO	December 2020	Developer of AI and IoT solutions for industrial and other sectors	2014
FISKER	via SPAC	October 2020	Developer of plug-in hybrid and solar powered luxury automobiles	2009-11

Global Cleantech 100 Graduates via Mergers & Acquisitions

1 October 2020 - 30 September 2021

Global Cleantech 100 alumnus company	Acquirer	Date	Notes from the Announcements	Years on the Global Cleantech 100
VIRICITI	chargepoint	August 2021	This acquisition's intent was to expand ChargePoint's offerings for electric buses and commercial vehicles	2021
Aqwise	GES water	August 2021	Acquisition to position GES as a leading player in the water, industrial and municipal wastewater market in Israel and worldwide	2009-11
NOVOMER Catalyzing Green Chemistry	danimer	July 2021	By incorporating Novomer's p(3HP) into Danimer's customer solutions, Danimer expects to be able to produce its resins at a substantially lower cost	2010-14
open energi smart revenue generation	bp	July 2021	bp Launchpad will explore how Open Energi, which is currently focused on the UK market, can work internationally across its trading and shipping business and low-carbon portfolio	2009, 2019
electriphi	Ford	June 2021	Ford acquired Electriphi to help commercial fleet operators transition to electric vehicles	2021
Anesco AMAZING ENERGY	Aksiom	June 2021	Ara Partners acquired Anesco through its portfolio company Aksiom Services Group, a rapidly growing platform providing high-value, high-complexity technical and commercial services to the European infrastructure market	2013-17
ONZO	geo	May 2021	UK based smart energy specialist geo acquired ONZO, an energy disaggregation specialist	2018
next		February 2021	The acquisition aligns to Shell's customer-first, digitally-enabled integrated power strategy and ts ambition to become a leading provider of clean power-as-a-Service	2015, 2020-21
varentec	Sentient ENERGY	February 2021	Acquired by Koch Industries subsidiary, Sentient Energy to give its customers visibility and control of grid performance from the utility substation transformer to beyond the service transformer	2014
ubitricity		February 2021	This acquisition broadens Shell's current range of EV charging solutions	2014, 2019-20
solarcentury	Statkraft	January 2021	Statkraft takes on a 6GW global solar portfolio, via this acquisition	2009-10
AMS	FLUENCE	November 2020	Fluence, owned by Siemens and AES, acquired AMS, developer of DER optimization software, on the back of a year long partnership between the two companies	2015-19
enbala YOUR GRID. IN BALANCE.	GENERAC	October 2020	The deal solidified Generac's position in Smart Grid technologies, following acquisitions of Neurio and Pike Energy	2012-13, 2015-20

Stop Press

Since the cut-off date, NuScale has entered a definitive agreement to go public via a SPAC, GE Digital has acquired Opus One Solutions and AMPLY Power has announced it is being acquired by bp. And so, Vic Shao becomes the first CEO to take two companies to Global Cleantech 100 graduate status, having previously been CEO of Green Charge Networks which was sold to ENGIE in 2016.

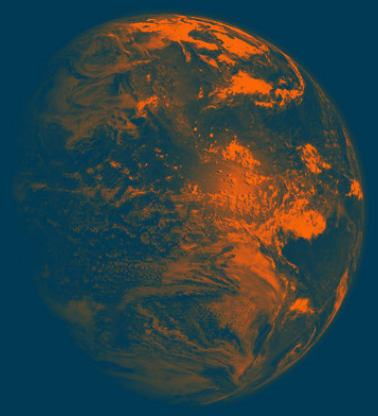
Hall Of Fame

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.

Inducted January 2022	Previously inducted
CARBON CURE	AutoGrid
SKELETON TECHNOLOGIES	avantium
sunfire	chargepoint
	DIGITAL LUMENS
	enbala YOUR GRID. IN BALANCE.
	kebony
	LanzaTech capturing carbon. fueling growth.
	ORGANICA
	OSTARA
	PROTERRA
	TENDRIL



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 people based in London, Paris and Boston.

RESEARCH

CONSULTING

EVENTS

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
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3M

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Investment Partner
Acario Innovation

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Principal
Activate Capital Partners

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Investment Director
Air Liquide Venture Capital - ALIAD

Bastien Gambini
Managing Director
Alantra Partners

Stefan Söderling
Fund Manager & CEO
Almi Invest GreenTech

Michelle Robson
Associate
AP Ventures

Chris Thomas
Co-Founder & Partner
Assembly Ventures

Hendrik Van Asbroeck
Managing Partner
Astanor Ventures

Fabio Lancelotti
Partner
Aster Capital

Susan Rohac
Vice President, Cleantech Practice
BDC Capital

Rhea Hamilton
Managing Director
Beyond Net Zero

Ernst Sack
Partner
Blue Bear Capital

Shaun Healey
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BP Ventures

Kaustubh Pandya
Principal
Brick & Mortar Ventures

Ludwig Goris
Senior Investment Manager
Capricorn Partners

David Aitken
Director, Innovation
Carbon Trust

Matthieu van der Elst
Chief Impact Officer
Cathay Capital

Wal van Lierop
Founding Partner & Executive Chairman
Chrysalix Venture Capital

Alastair Cooper
Head of Venture Investments
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Circularity Capital

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Congruent Ventures

Shounok Sinha
Principal Venture Investments
Constellation Technology Ventures

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Cycle Capital Management

Nancy Pfund
Managing Partner
DBL Partners

Yann Lagalaye
General Partner
Demeter

Kathleen Jurman
Corporate Ventures Technology Scout
Dow

Ubald Kragten
Director Scouting
DSM

Konrad Augustin
Partner
E.ON Future Energy Ventures

Dr Paul-Josef Patt
Managing Partner and CEO
eCAPITAL Entrepreneurial Partners

Sasha Brown
Partner
Ecosystem Integrity Fund

Luis Manuel
Executive Director
EDP Ventures

Gina Domanig
Managing Partner
Emerald Technology Ventures

Glenn Bijvoets
Innovation Manager
Eneco

John Tough
Managing Partner
Energize Ventures

Cassie Bowe
Principal
Energy Impact Partners

Wally Hunter
Managing Director
EnerTech Capital

Johann Boukhors
Managing Director
ENGIE New Ventures

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Partner
ETF Partners

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Eurazeo

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Chief Executive Officer
Evok Innovations

Lutz Stoeber
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Evonik Venture Capital

Dirk De Boever
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Finindus

Jake Simon
Investor
Fontinalis Partners

Colin Le Duc
Founding Partner
Generation Investment Management

John Du
Partner
GM Ventures

Eric Wang
Managing Partner
GRC SinoGreen Fund

Jamie James
Managing Partner
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Huaneng Invesco WLR (Beijing)

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Next47

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