CLEANTECH
50TOWATCH

A global list of early-stage companies taking action on the climate crisis

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CLEANTECH GROUP EXECUTIVE EDITOR:

Anthony DeOrsey — Research Manager

MAJOR CONTRIBUTORS:
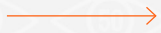
Arianna Bernas — Analyst, Data & Ecosystems

Parker Bovee — Associate, Waste & Recycling

Sasha Bukhari — Associate, Data & Ecosystems

Natalie Cox — Junior Events & Programs Manager

Alex Crutchfield — Associate, Resources & Environmental Management

Jack Ellis — Senior Associate, Agriculture & Food

Zainab Gilani — Associate, Energy & Power

Carole Jacques — Director of Marketing

Buff Lopez — Associate, Materials & Chemicals

Sarah O'Connell — Director of Events & Programs

CLEANTECH50TOWATCH

2024TRENDWATCH

By Anthony DeOrsey, Research Manager

INTRODUCTION

It is our pleasure to bring you this sixth edition of the Cleantech 50 to Watch. As our last edition of the early 2020s, I predict that we will some day look back at this list and the associated analysis behind it with great reflection. Just a few weeks from now, the U.S. presidential election will be decided, and the ensuing months will involve a flurry of activity – in one direction or another – to react to the reset expectations for the second half of this decade. With that in mind, I believe we have a terrific indicator of today's state-of-play here with us now, in a Cleantech 50 to Watch list that spans 15 sectors and has taken on opinions from over 34 global experts.

If venture investments are taken as a proxy for confidence in innovation, the first half of 2024 played out mostly to a similar rhythm as 2023 – in a continuation from last year's trend, the spread of companies receiving investment continues to get "younger", i.e., early-stage deals are a larger percentage of the overall activity.

The scope certainly is wider now, too, and beyond the innovation themes we have come to consider mainstream in recent years – we can start to see new layers of climate priorities crystallizing in the themes that innovators are targeting (look closely at the themes of grid resilience, textiles, and plastics for some early indications). Encouragingly, we are also seeing a world where the harder challenges and more risky technology gambits are more receptively engaged than just a few years ago.

Fig. 1: Cleantech Venture & Growth Investments by Investment Stage

Source: Cleantech Group
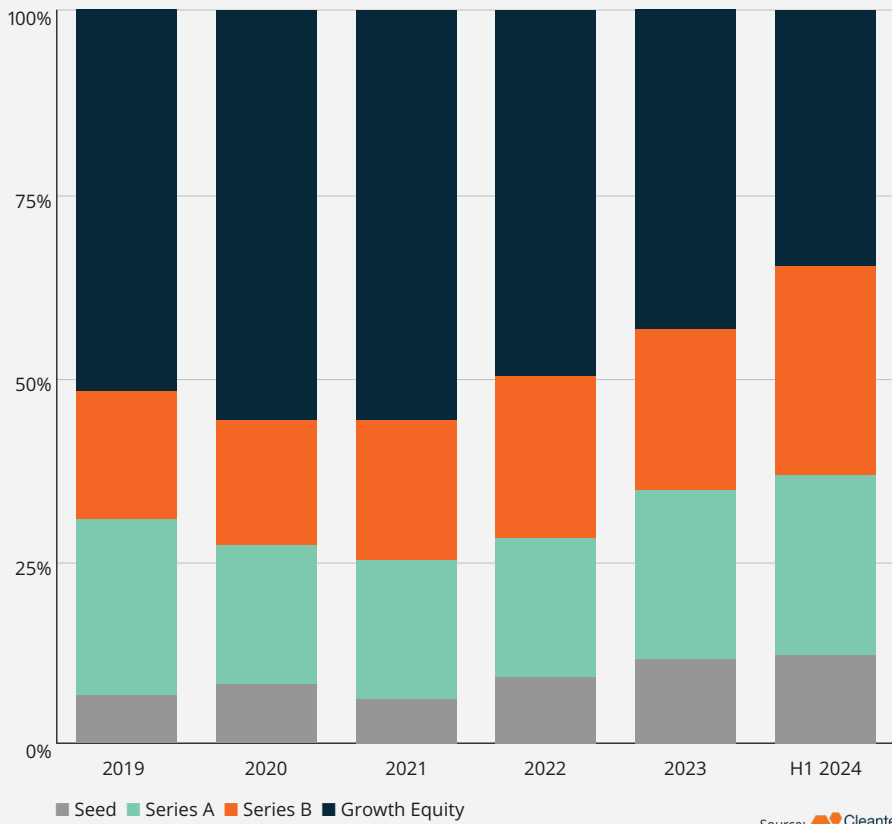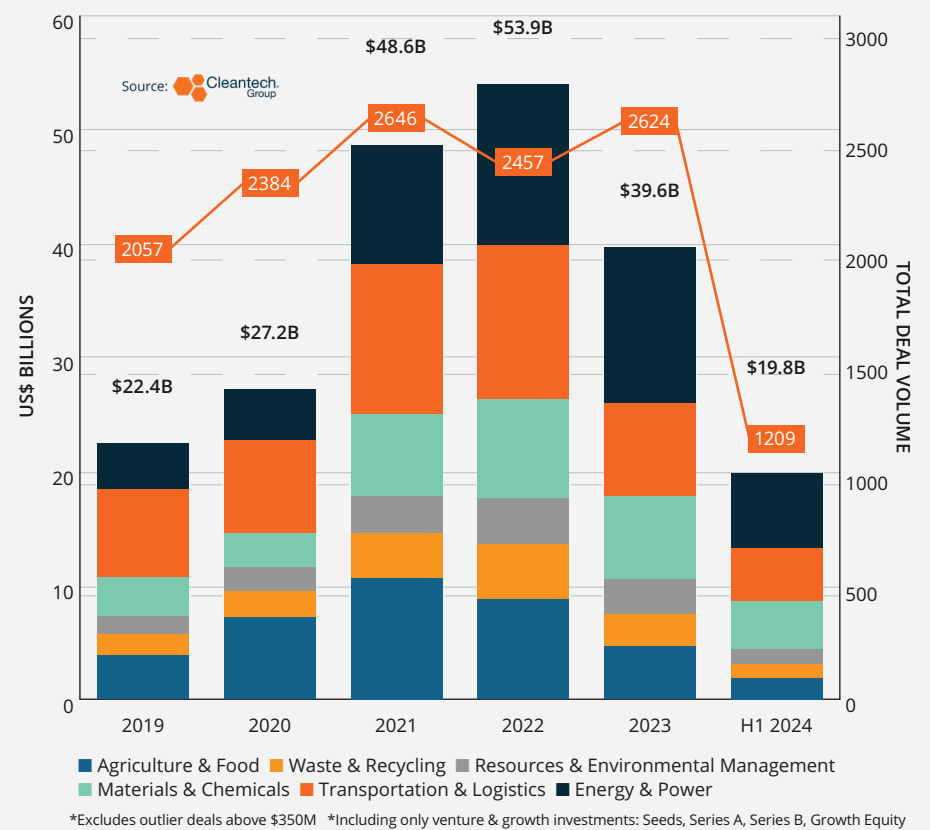
Fig. 2: Cleantech Venture & Growth Investments by Deal Count by Industry Group

Source: Cleantech Group

*Excludes outlier deals above $350M   *Including only venture & growth investments: Seeds, Series A, Series B, Growth Equity

THE DEEP TECH DYNAMIC CONTINUES TO EVOLVE

We noted with enthusiasm last year that, from what we're observing, an important reality had begun to sink in that the lowest hanging fruit had already been picked, and deep tech innovation was slowly becoming recognized as the long-term growth frontier in cleantech. This trend has only strengthened in the first half of 2024 – some areas even outpacing their 2023 totals already.

Deep tech ambitions are well reflected throughout this year's Cleantech 50 To Watch list – this is not just the theme "du jour" right now. The learnings from a wave of first-of-a-kind projects over the past few years are reducing perception of risk in many of these spaces. Take, as an indicator, the fact that when compared to recipients of funds in deals across cleantech, deep tech innovators are raising funds at slightly lower TRLs (technology readiness levels). There is, of course, a degree of multicollinearity here (only those investors confident in deep tech will make the investments), but the fact that the past 18 months are the strongest demonstration of this trend is likely not a coincidence.

Fig. 3: Cleantech Venture & Growth Investments by Deep Tech

Source: Cleantech Group
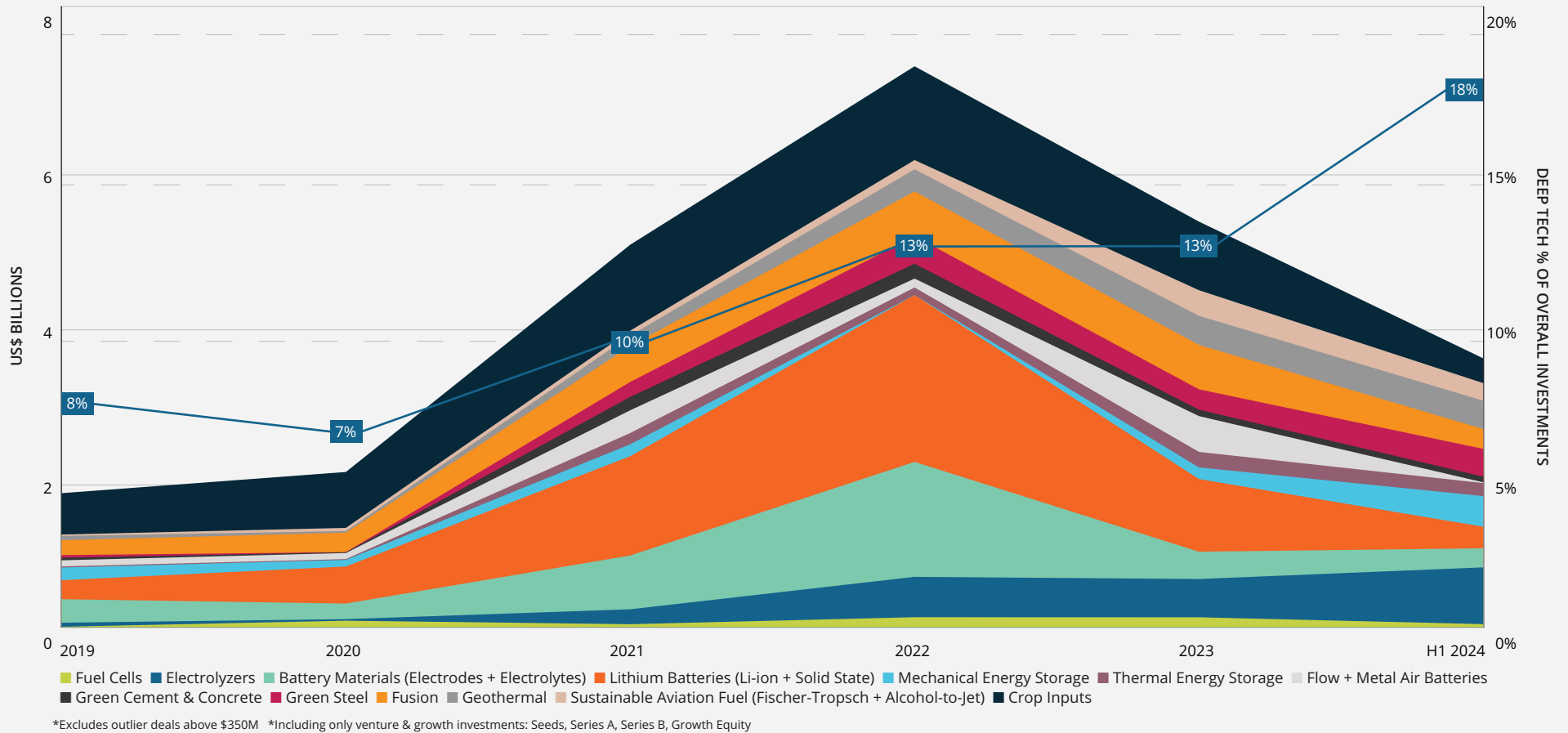
Legend: Fuel Cells · Electrolyzers · Battery Materials (Electrodes + Electrolytes) · Lithium Batteries (Li-ion + Solid State) · Mechanical Energy Storage · Thermal Energy Storage · Flow + Metal Air Batteries · Green Cement & Concrete · Green Steel · Fusion · Geothermal · Sustainable Aviation Fuel (Fischer-Tropsch + Alcohol-to-Jet) · Crop Inputs

*Excludes outlier deals above $350M *Including only venture & growth investments: Seeds, Series A, Series B, Growth Equity

A critical dynamic to recognize here is that the favorable policy environments that many new cleantech innovations have enjoyed in recent years have begun to stimulate a leapfrog effect as the successes and failures of the current "wave" of innovation are borne out. Take hydrogen as an example – much of the focus in recent years has been on cost reduction in on-site electrolysis technologies. While that is still important, we see some innovators cropping up that are pursuing alternative approaches:

- Hydrogen carriers for conventional infrastructure – Cleantech 50 to Watch companies like Ayrton Energy (converts hydrogen into room temperature and pressure carrier oils) and Rift (produces iron fuel with a hydrogen input for storage in standard steel tanks) can be an unlocking agent for geologic hydrogen and other centralized sources

Low or no-hydrogen ammonia production – a key beachhead market for clean hydrogen is ammonia for fertilizers (and potentially shipping fuels).

- Cleantech 50 to Watch companies NitroFix and Swan-H are synthesizing water directly without an external hydrogen input

- Nitrovolt has developed a "Nitrolyzer" that pioneers the use of a lithium-mediated ammonia synthesis process, also with the goal of eventual ammonia production from air, water, and electricity

Below are a few more welcome surprises from this year's list.

Fig. 4: Technology Readiness Level of Venture Funding Recipients

Source: Cleantech Group

ALL CLEANTECH

DEEP TECH FOR CLEANTECH

TRL: ■ 0 ■ 1-3 ■ 4-6 ■ 7-8 ■ 9
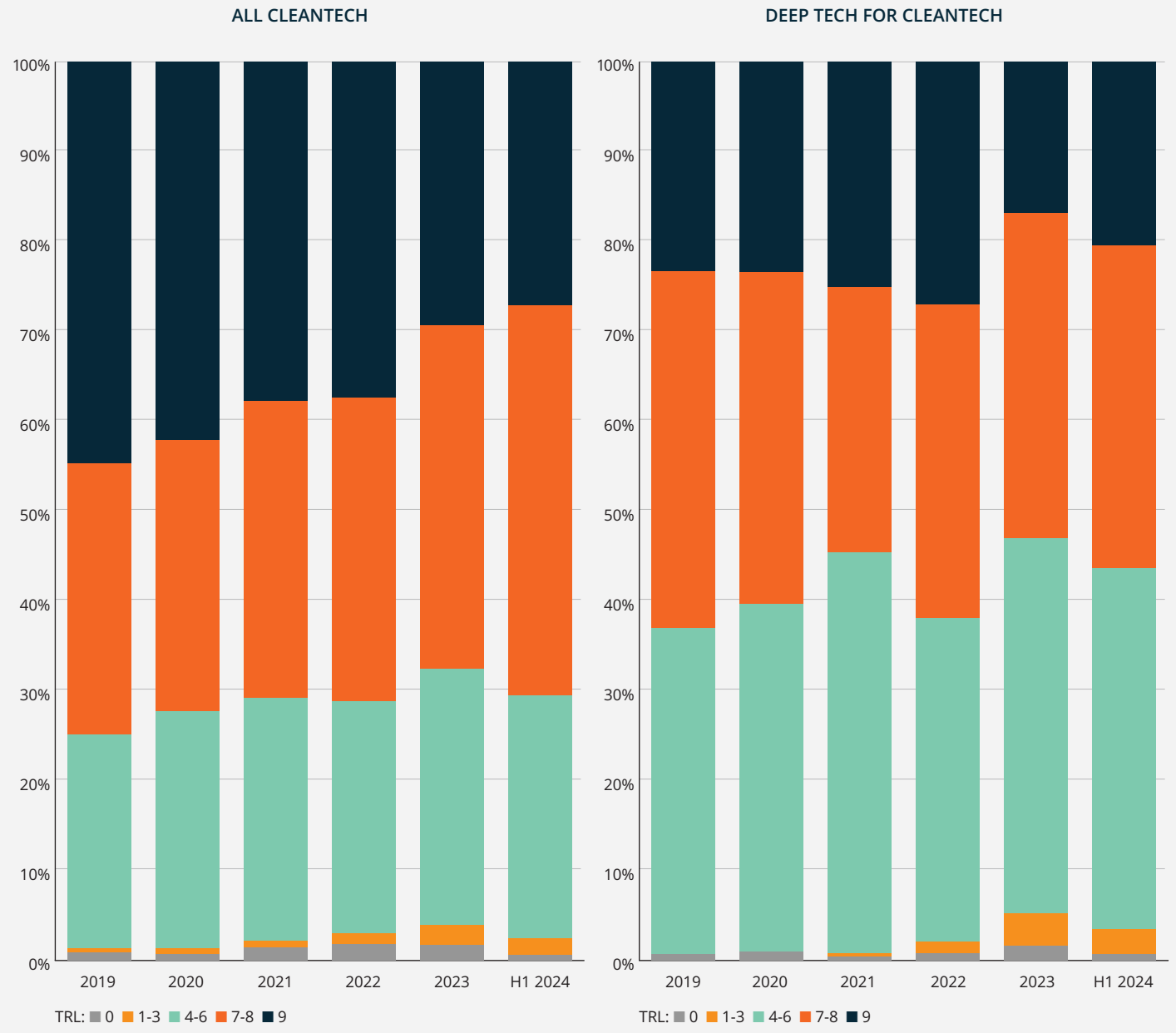
GRID RESILIENCE URGENCY WELL REFLECTED IN INNOVATION

As the world gears up to add an estimated 3,700 gigawatts (IEA) of renewables through 2028 and serve a generational growth in power demand from data centers, electrification of industry, and EVs, there remains an overarching threat of weather events toward existing and future grid infrastructure. Innovators are getting the message loud and clear.

Just in this year's Cleantech 50 to Watch, we see innovation spanning from smarter grid planning and optimization to reinvention of fundamental grid hardware. The role of AI can be traced throughout all the companies landing on this year's list.

■ **Rhizome** is a grid planning and monitoring platform that models resilience threats up to 50 years in the future, for deep de-risking of grid investments
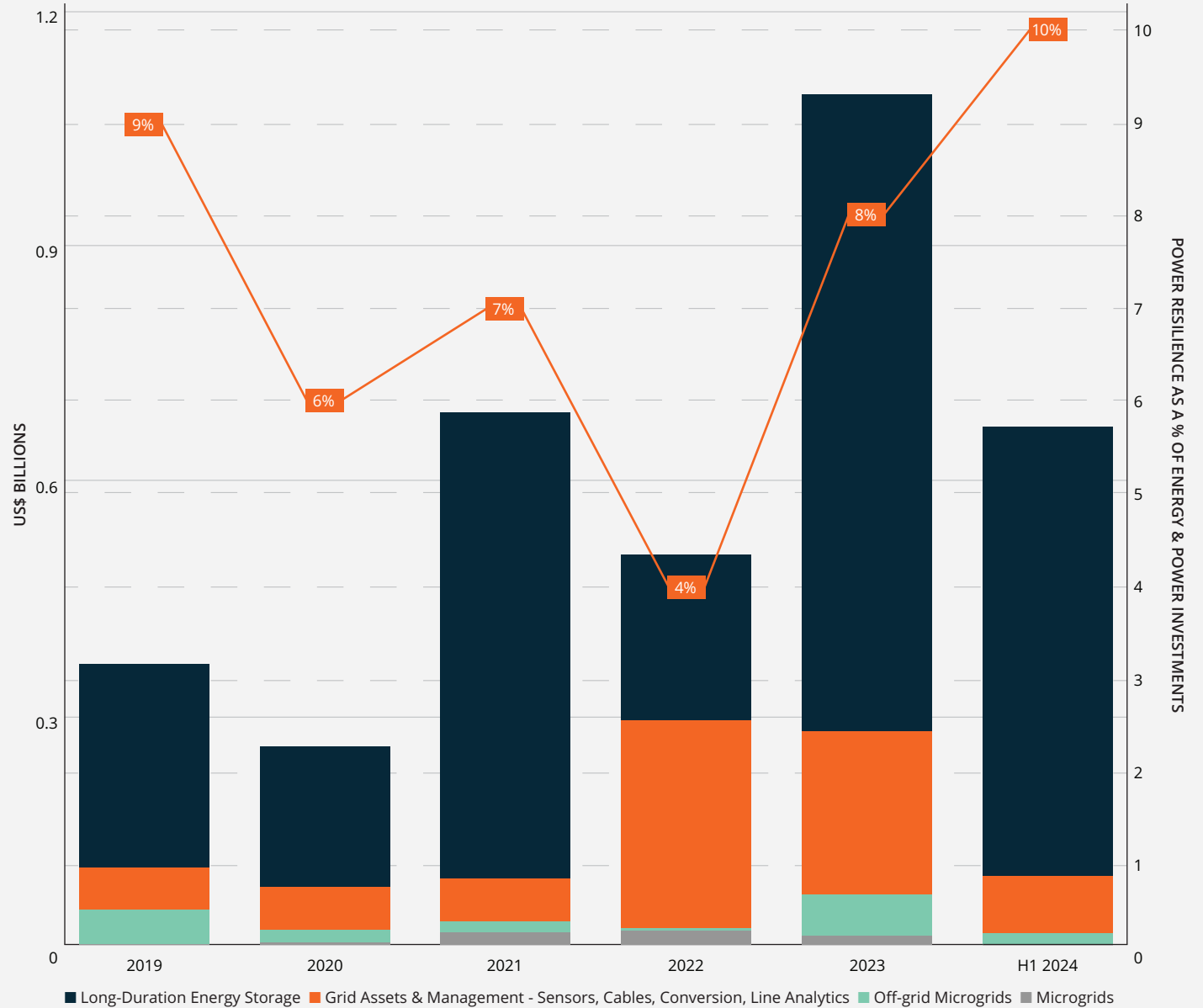
■ **ThinkLabs** is providing physics-based digital twins for critical renewable energy and grid infrastructure

■ Also leveraging digital twins, **Grid Raven** models wind impacts to the meter to provide granular dynamic line ratings, supporting better grid capacity and resilience

■ **Ionate** is reinventing the electrical transformer inner workings without reinventing the form factor through high-precision electromagnetic power flow controls

Fig. 5: Venture & Growth Investments in Power Resilience

Source: Cleantech Group

Legend:
■ Long-Duration Energy Storage ■ Grid Assets & Management - Sensors, Cables, Conversion, Line Analytics ■ Off-grid Microgrids ■ Microgrids

*Excludes outlier deals above $350M   *Including only venture & growth investments: Seeds, Series A, Series B, Growth Equity

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Fig. 6: Venture & Growth Investments in Textiles Sustainability

Source: Cleantech Group

Legend:
- Distribution, Traceability, Sourcing
- Alternative Production
- End of Life & Recycling
- Leather Alternatives
- Bio-derived Textiles
- Advanced Fibers
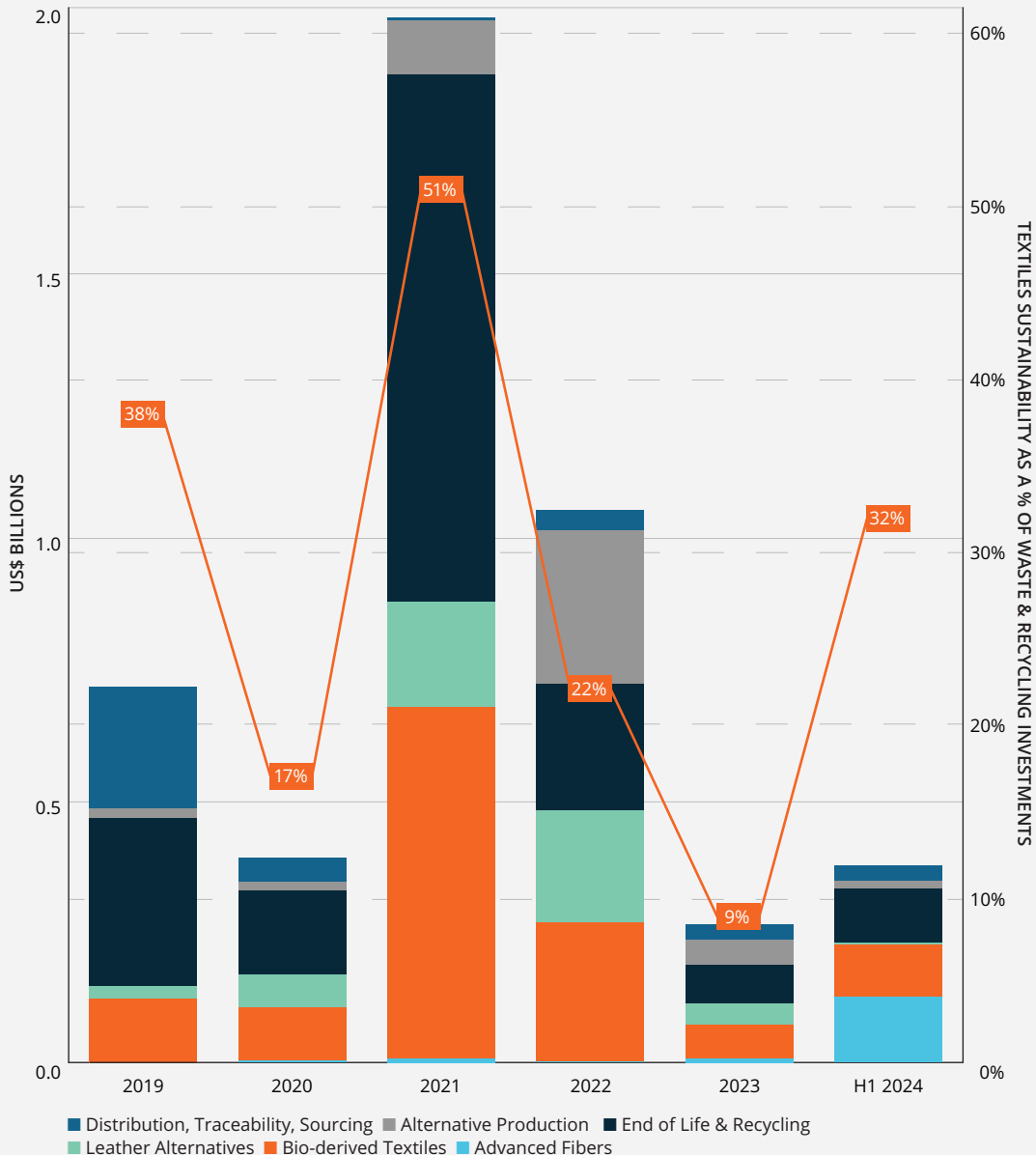
*Excludes outlier deals above $350M   *Including only venture & growth investments: Seeds, Series A, Series B, Growth Equity

TEXTILES & PLASTICS – A NEW INNOVATION CYCLE BEGINS

After decades of e-commerce and the growth of the fast fashion segment, an accumulation of textiles waste has become a global challenge to be reckoned with. Policy changes are on the horizon, most recognizably in the EU, with visible strategies to mandate more sustainable design of textiles and intensify support of circular supply chains. Innovators are responding to the challenge, and, while the absolute investment figures don't show it, this has quickly become a core area of waste and recycling innovation.

The textiles sustainability theme shows up in a few places in this year's Cleantech 50 to Watch list, with companies seeking to impact the recycling of textiles and production of virgin textiles.

- **Refiberd** is leveraging AI and hyperspectral imaging for textile sorting

- **Simplifyber** is flattening the leather manufacturing process through an additive manufacturing process that enables use of biobased and recyclable materials

While improved plastics sortation and recycling processes like depolymerization and dissolution are increasing plastic recycling rates, virgin plastic production and plastic-related emissions are set to triple and double, respectively, by 2060. However, a look through this year's Cleantech 50 to Watch shows an encouraging diversity of approaches entering development, both on plastics supply and management:

- **Mushroom Material** is upgrading mycelium agricultural waste into a biodegradable Styrofoam replacement

- **FlexSea** has developed novel biomaterials derived from renewable marine resources to replace plastic packaging

- **Macrocycle Technologies** has developed a plastics recycling-to-product process using synthesis of cyclic macromolecules (macrocycles)

- **Atacama Biomaterials** is pioneering an AI-driven formulation engine to develop biomaterials without natural feedstock restraints

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Fig. 7: Early-stage Ecosystems: Where are Cleantech 50 to Watch Companies Emerging From?
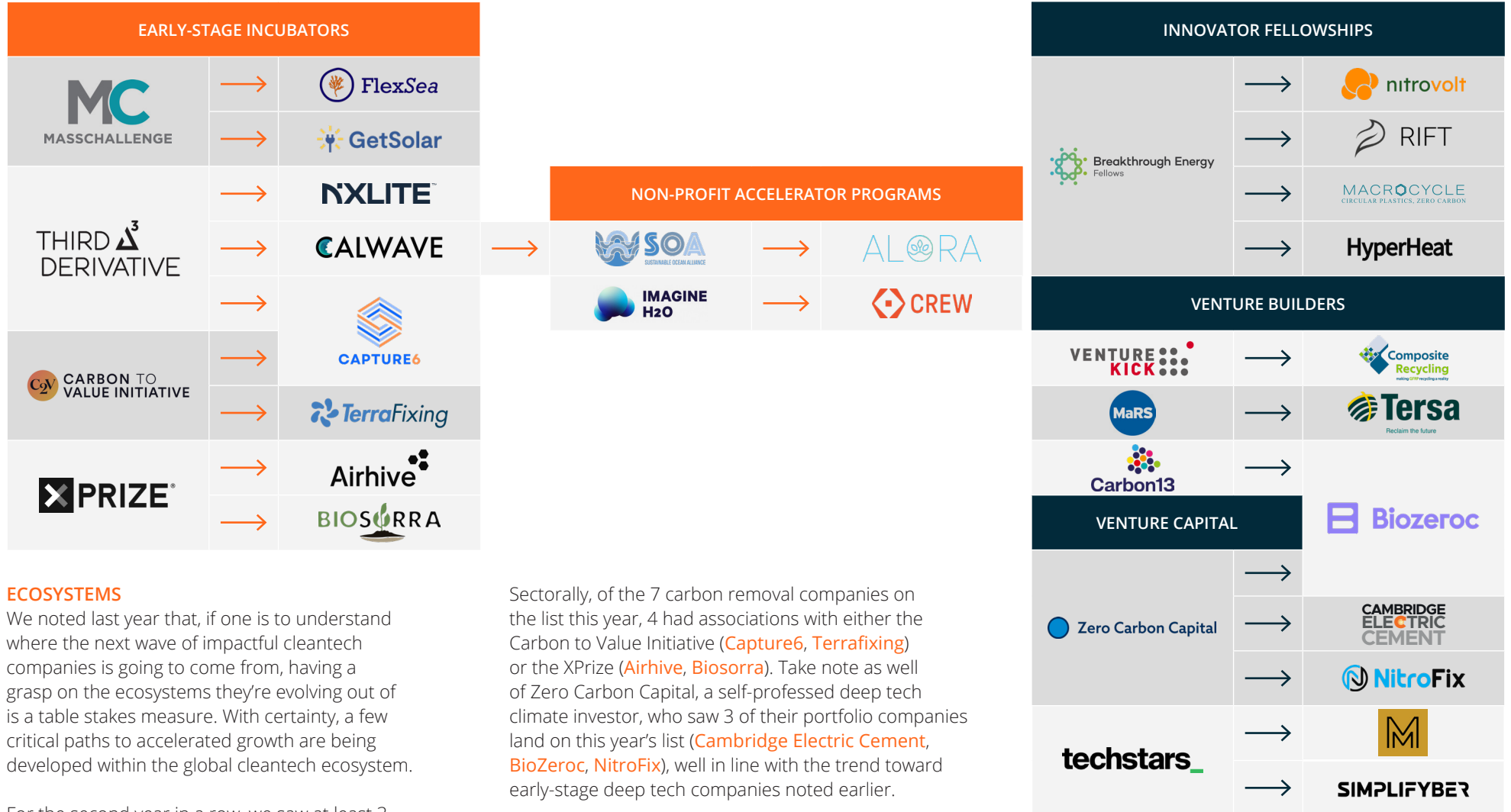
ECOSYSTEMS

We noted last year that, if one is to understand where the next wave of impactful cleantech companies is going to come from, having a grasp on the ecosystems they're evolving out of is a table stakes measure. With certainty, a few critical paths to accelerated growth are being developed within the global cleantech ecosystem.

For the second year in a row, we saw at least 3 participants in Third Derivative (NXLite, Calwave, Capture6) and Breakthrough Energy Fellows (Nitrovolt, Rift, Macrocycle, HyperHeat) programs land on the list, indicating the global competitiveness of the companies accepted to and graduating out of those programs (Note: Breakthrough Energy Fellows is a client of Cleantech Group).

Sectorally, of the 7 carbon removal companies on the list this year, 4 had associations with either the Carbon to Value Initiative (Capture6, Terrafixing) or the XPrize (Airhive, Biosorra). Take note as well of Zero Carbon Capital, a self-professed deep tech climate investor, who saw 3 of their portfolio companies land on this year's list (Cambridge Electric Cement, BioZeroc, NitroFix), well in line with the trend toward early-stage deep tech companies noted earlier.

We are grateful to all the expert panelists who nominated and deliberated on the list this year. Even more so, we are appreciative of the increasingly bold innovators who are taking enormous risks to solve bigger problems than ever – congratulations to those who have landed on this year's list.

Source: Cleantech Group

COMPANY MAP

Presenting the 2024 Cleantech 50 to Watch by Sector

AGRICULTURE & FOOD

RESOURCES & ENVIRONMENTAL MANAGEMENT

CARBON REMOVALS

Airhive

CREW

CAPTURE6

CYANOSKIN

Aquarry

TerraFixing

BIOSURRA

INDUSTRIAL MATERIALS

Biozeroc

CAMBRIDGE ELECTRIC CEMENT

Limelight Steel

MATERIALS & CHEMICALS

BUILDING MATERIALS

NXLITE

SUPER BAMBOO

CLEAN FUELS & CHEMICALS

NitroFix

AYRTON ENERGY

CETOGENIX

nitrovolt

RIFT

SWAN-H

ENERGY & POWER

Source: Cleantech Group

10

COMPANY MAP

Presenting the 2024 Cleantech 50 to Watch by Sector

ENERGY STORAGE
- HyperHeat
- smartville
- GREEN GRAVITY®

MATERIALS & CHEMICALS

RESOURCES & ENVIRONMENTAL MANAGEMENT

ENERGY & POWER

CRITICAL MATERIALS & MINING

SLSEnergy	Litus
MagREEsource — THE GREEN RARE EARTH MAGNET COMPANY	Tersa — Reclaim the future
cling	tozero

PLASTIC ALTERNATIVES & RECYCLING
- Atacama Biomaterials
- M
- FlexSea
- MACROCYCLE — CIRCULAR PLASTICS, ZERO CARBON

GRID ENHANCEMENTS

Grid Raven	IONATE
ThinkLabs	RHIZOME

WASTE & RECYCLING

Source: Cleantech Group

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COMPANY MAP

Presenting the 2024 Cleantech 50 to Watch by Sector

AGRICULTURE & FOOD

FOOD RESILIENCE
phagos

TEXTILE ALTERNATIVES & RECYCLING
SIMPLIFYBER
refiberd.

WASTE MANAGEMENT
ANTFARM
Supercharged recycling
Composite Recycling
making GFRP recycling a reality
MYCOCYCLE
NILO

ENERGY & POWER

WASTE & RECYCLING

CROP SCIENCE
ALORA

RENEWABLE ENERGY
CALWAVE
GetSolar
CWS

TRANSPORTATION & LOGISTICS

RESOURCES & ENVIRONMENTAL MANAGEMENT

WATER
ACWA ROBOTICS
FLOCEAN
OceanWell

MARITIME SUSTAINABILITY
CAT solar power the world

CASE**STUDY**

ALORA

Country: United Kingdom
Company Founded: 2019
Number of Employees: <15
TRL: 4-6

AGRICULTURE & FOOD

ALORA

"FROM ABOUT 0-200 KILOMETERS OFF EVERY SINGLE COASTLINE IN THE WORLD, THERE ARE PLENTIFUL NUTRIENTS TO BE ABLE TO GROW THESE CROPS. IN CERTAIN LOCATIONS, THERE ARE EVEN MORE NUTRIENTS THAN YOU'D EVER NEED. SO THE QUESTION BECAME: SINCE WE HAVE MORE THAN ENOUGH NUTRIENTS TO PRODUCE FOOD IN THE OCEAN, HOW DO WE ACTUALLY CREATE THE STRUCTURES TO DO THAT?"

LUKE YOUNG, CO-FOUNDER & CEO, ALORA

WHAT IS THE COMPANY AND WHAT DO THEY DO?
Alora is an early-stage start-up headquartered in Norwich, UK, with operations in Orlando, U.S. The company was founded in 2019 by CEO Luke Young and Chief Operating Officer Rory Hornby.

HOW IT WORKS
Alora is working on several technologies to enable more sustainable crop production; however, its initial focus is on developing saltwater-tolerant varieties of key crops, starting with rice. To do this it is leveraging gene-editing technologies including CRISPR.

KEY DIFFERENTIATOR
The start-up claims its rice is twice as salt-tolerant as competing varieties on the market. It is also differentiated from the competition by some of the other, complementary technologies it is working on. These include a floating oceanic farm designed for cultivation of its gene-edited crops at sea, as well as inputs optimized for its salt-tolerant varieties.

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Concept art of Alora's seaborne rice farm. Credit: Alora

KEY**FACTS**

In trials, Alora was able to increase rice yields by as much as 75% when growing the crop in the proprietary synthetic substrate it has developed for its floating farm, as compared to conventional soil-based cultivation

Alora has successfully grown its gene-edited rice in water containing 8 grams of salt per liter, compared to other salt-tolerant varieties which have reportedly struggled to thrive in water with more than 4 grams per liter

By late 2023 the start-up had raised $3.72M in Seed funding from investors including Toyota Ventures, Mistletoe, and Sustainable Oceans Alliance

POTENTIAL IMPACT

Alora's initial focus is on distributing its saltwater-tolerant rice to farmers on land, targeting regions where seawater flooding and infiltration are impacting yields; a problem that is set to get worse as the world continues to warm. In the future, it aims to grow its specialized crops on the open seas, offering the opportunity to reduce the negative impacts of on-land agriculture and land use change such as freshwater overuse, soil erosion, and eutrophication.

NEXT STEPS

Beyond rice, Alora aims to produce saltwater-tolerant cultivars of other key crops including wheat, soybean, and sugarcane. It will also explore commercialization opportunities for a biofertilizer it has developed to optimally deliver the nutrients its crops need.

KEY THINGS TO WATCH IN THE AGRICULTURE & FOOD SPACE

Expect to see greater adoption of gene-editing tools to develop climate-resilient crop varieties and more targeted pesticides and biostimulants. This will be driven in large part by increased regulatory clarity around these technologies in key jurisdictions such as the EU.

WHY ALORA MADE THE LIST

Alora has been selected for the 2024 Cleantech 50 to Watch because of its multi-strategy approach, leveraging innovations in genetics, crop inputs, and marine architecture to grow food more sustainably. Its early focus on adopting an international outlook means that it is well-placed to deliver impact in regions of the world that need more sustainable agricultural solutions as quickly as possible.
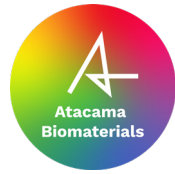
CASESTUDY

Country: United States
Company Founded: 2022
Number of Employees: <15
TRL: 7-8

MATERIALS & CHEMICALS

ATACAMA BIOMATERIALS

"ATACAMA'S WPK DOESN'T LOOK OR FEEL LIKE PLASTIC, YET IT PERFORMS JUST AS WELL. IT STRIKES THE PERFECT BALANCE BETWEEN PERFORMANCE AND ENVIRONMENTAL IMPACT, MAKING IT A TRANSFORMATIVE MATERIAL FOR THE INDUSTRY."
OLIVIER RATTIN, EMEA PACKAGING DEVELOPMENT DIRECTOR, MCCORMICK & CO.

WHAT IS THE COMPANY AND WHAT DO THEY DO?

An MIT spin-out, Atacama Biomaterials was founded by Dr. Paloma González-Rojas and Jose Thomas Dominguez in 2022. Its differentiated technology produces low-carbon materials powered by robotics and AI. The start-up is named after the Atacama Desert in Chile that is unfortunately known as "the great fashion garbage patch." From discarded clothing to bags, plastic bottles, and garbage, the region is known to attract over 39,000 tons of unwanted clothing each year—and this figure is only climbing. Even more disturbing is that this is not unique to the Atacama Desert, rather it is a global waste management issue.

HOW IT WORKS

Atacama Biomaterials uses its MarieCurie AI platform to accelerate the discovery and optimization of sustainable materials. By analyzing thousands of potential formulations from proprietary biomass data, MarieCurie identifies the ideal combinations of natural fibers and biomass binders to meet specific performance requirements. Working closely with partners, the AI optimizes material properties to meet strict quality standards, enabling tailored, high-performance solutions.

KEY DIFFERENTIATOR

Atacama offers a high-performance, low-impact alternative to plastics that is both cost-competitive and scalable. This value is achieved through the MarieCurie AI platform, which enables precise optimization of material formulations to meet specific client requirements without sacrificing performance or sustainability. By leveraging the natural compatibility of its biomass components, Atacama's solutions use low-energy production processes and maintain a minimal carbon footprint, making them an effective tool in the global effort to reduce plastic waste and emissions.

CONTENTS

CASE**STUDY**

KEY**FACTS**

MarieCurie AI Platform: Atacama's proprietary AI tool optimizes material formulations, reducing development time to less than 6 months and enabling rapid adaptation for global supply chains

Woodpack (WPk) is a fully compostable, recyclable, high-performing paper film that matches plastic performance while eliminating carbon emissions

Atacama has secured nine paid pilots with major companies, including McCormick and Roche—validating WPk's potential as a sustainable plastic alternative

POTENTIAL IMPACT

WPk can replace unrecyclable Mylar, offering comparable barrier performance at a fraction of the carbon footprint, enabling industries to reduce millions of tons of plastic waste annually. WPk allows food and pharmaceutical industries to transition seamlessly from environmentally harmful materials, drastically cutting plastic usage and emissions. This is a critical step toward mitigating the global plastic crisis and achieving long-term sustainability goals.

AMBITION / NEXT STEPS FOR COMPANY

Building on positive pilot feedback and strong client support, Atacama is strategically transitioning these relationships into full-scale commercial deployments. Atacama is creating financial tools like carbon credits to help clients reduce scope 3 emissions, positioning itself not only as a materials provider but as a strategic partner in achieving long-term sustainability goals and maximizing environmental impact. At the same time, Atacama plans to monetize its MarieCurie AI platform to deliver advanced material insights and customized formulations that optimize cost and performance for its clients.

KEY THINGS TO WATCH IN THE MATERIALS & CHEMICALS SPACE

Atacama's key challenge is successfully scaling its sustainable packaging solution to meet growing industry demand, providing a significant opportunity to prove its commercial viability. To see greater incorporation of biomaterials at scale, we'll need to see broader embrace and trust-building with corporates and major players seeking decarbonization routes. Majors like McCormick are signaling to the rest of the packaging industry that biomaterials can be integrated without sacrifice in quality all while achieving reductions in cost, energy, and carbon emissions.

WHY THIS COMPANY MADE THE LIST

Atacama is well-positioned to become a global leader in sustainable packaging, having already secured partnerships with local Chilean suppliers and Fortune 500 companies like McCormick and Roche Pharmaceuticals. Its strategic embrace of AI and robotics represents a unique approach to creating bespoke, high-value products from a customer's own data. As AI continues to reshape the materials landscape, companies partnering with Atacama are gaining a technological, strategic and impactful edge.

CASE**STUDY**

NILO

WASTE & RECYCLING

NILO

Country: New Zealand
Company Founded: 2017
Number of Employees: 30
TRL: 4-6

"YOU CAN'T SUSTAIN IN THE MARKET AS
A GREEN PRODUCT IF YOUR ECONOMICS
WITHOUT SUBSIDIES ARE IN THE RED."
TIM WILLIAMS, MANAGING DIRECTOR, NILO

WHAT IS THE COMPANY AND WHAT DO THEY DO?

NILO is a chemical technology company specializing in adhesives derived from plastic waste (mainly plastic types 2, 4, 5, and 6). The core problem NILO solves is two-fold: 1). finding valuable applications for waste plastic and 2). reducing use of industry standard toxic adhesives. The NILO adhesive is a drop-in replacement for Urea Formaldehyde (UF), the primary adhesive in wood fiber boards.

HOW IT WORKS

NILO works with a variety of sortation and waste managers to acquire high purity plastic waste. The process starts with shredding waste to reduce plastic size, improving chemical reactivity through a patented treatment upgrading system that creates the adhesive, and adding a setting agent that easily bonds to wood. The team identified a unique feedstock and offtake niche based on plastic's largely unused ability as a bonding agent.

KEY DIFFERENTIATOR

Industry standard UF adhesives leach toxins throughout their lifetime use and as waste. These adhesives are understood to have a variety of health and safety concerns yet legislation banning them is rare. NILO's product achieved price parity with UF without the safety concerns, high GHG emissions, or energy requirement of UFs. Furthermore, no competitor has been identified with comparable scale using a plastic-based adhesive. In this case, NILO has expanded on a competitive advantage against the industry standard adhesive without any significant competitors in the alternative adhesive marketplace.

CASE**STUDY**

POTENTIAL IMPACT

Nilo's product is uniquely positioned to reduce waste reduction and safety concerns. NILO achieves this by eliminating toxic, polluting adhesives in the furniture industry while reducing plastic pollution. Their wood particle boards are also fully recyclable when ground in new particle board production, creating a circular resource.

AMBITION/NEXT STEPS FOR COMPANY

NILO is finalizing a Series A in late 2024. Ambitions for this new funding round center on new client acquisition in Southeast Asia and the Middle East, possibly through government contracts or extending and acquiring new corporate contracts. The company is also looking to expand legal protections on their chemical discoveries, opening up licensing opportunities.

KEY THINGS TO WATCH IN THE WASTE & RECYCLING SPACE

NILO hopes that new post-life applications for plastic outside of recycling and energy use will spur massive collection campaigns as waste plastic is slowly viewed as a real raw resource. Looming plastic taxation through Extended Producer Responsibility legislation will guide the direction of companies looking to fill similar voids. Regardless, NILO has made it a core pillar of their business activities to avoid any reliance on green premiums or carbon reduction credits for their technology to be commercially viable. This technoeconomic balance is a key challenge for all plastic waste innovators.

WHY THIS COMPANY MADE THE LIST

NILO is a chemical research company who created a straightforward solution based on an impressive chemistry achievement. While low cost now, discovering adhesive applications and wisely narrowing feedstock selection were two serendipitous moments that forged a strong foundation for NILO to commercialize through.

KEY**FACTS**

12% increase in resistance to deformation, 43% increase in strength—NILO adhesives improve particle board resistance to deformation and improve board strength all while eliminating toxic adhesives

66% increase in resistance to moisture—NILO's adhesive far outperforms Urea Formaldehyde (UF) in reactivity to water making it a superior choice in high moisture settings

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CASESTUDY

ENERGY & POWER

RHIZOME

"THE INFRASTRUCTURE INVESTMENT JOBS ACT WILL DIRECT $11B TO UTILITY OPERATORS OR FOLKS THAT ARE DEPLOYING RESILIENT SOLUTIONS ON THE GRID."
MISHAL THADANI, CEO, RHIZOME

RHIZ⬡ME

Country: United States
Company Founded: 2023
Number of Employees: 8
TRL: 7-8

WHAT IS THE COMPANY AND WHAT DO THEY DO?

Rhizome is an AI-powered software platform that helps electric utilities identify vulnerabilities from climate threats to quantify risk and to measure the economic and social benefits of grid-enhancing investments.
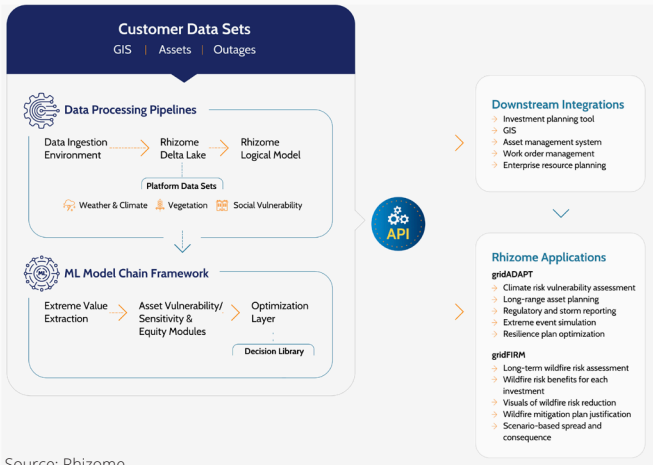
HOW IT WORKS

The software can conduct a granular analysis to produce a high-resolution risk analysis for utilities to make prescriptive investments according to their respective pain points on the grid. These could include vegetation management, asset replacement, battery storage, and more. By coupling data from lessons learned in past events with climate forecasting models, Rhizome's decision intelligence is a boon for resilience for utilities.

KEY DIFFERENTIATOR

Up until now, infrastructure investment planning has relied primarily on historical data. Rhizome's decision intelligence platform is a disruptor in the industry.

Source: Rhizome

CASE**STUDY**

POTENTIAL IMPACT

Rhizome has the potential to have a sizeable positive influence on national resilience strategies as various states are ramping up their multi-billion-dollar plans. The company will be able to provide utilities a full picture backed by scientific evidence to prove to regulators what the impact of a disaster event would be had investments not been made, and the fragility of a particular area of a system for future development.

AMBITION/NEXT STEPS FOR COMPANY

Rhizome plans to expand its client base to more utilities throughout the U.S. Internally, the company wants to grow its talent base in ML climate data and business development.

KEY THINGS TO WATCH IN THE ENERGY & POWER SPACE

Collaboration, particularly in the wildfire resilience space, is the key to success. In the future, we expect more partnerships and consolidation of services as solutions often need to stack to succeed.

WHY THIS COMPANY MADE THE LIST

Rhizome is a prime example of how machine learning is becoming essential in preparing for and responding to extreme weather events and their catastrophic effects. Rhizome is tackling one of our most pressing global challenges with decision intelligence that could extend even beyond the utilities sector in the future.

KEY**FACTS**

The U.S. alone was battered by an unprecedented 28 weather and climate disasters in 2023, resulting in a staggering $93B in damages. And 2024 is shaping up to be even more destructive with the long-term effects on communities and the environment difficult to quantify

Rhizome can predict power outages on a specific part of a grid system going out to 2070 with the likelihood of an extreme weather event

CASE**STUDY**

Country: France
Company Founded: 2021
Number of Employees: <15
TRL: 7-8

ENERGY & POWER

SWAN-H

"SWAN-H WAS FOUNDED TO BE IMPACTFUL. THIS IS ONE OF THE LARGEST PROBLEMS THAT NEEDS TO BE SOLVED AND IF WE CAN SCALE AND ADDRESS EVEN A SMALL PART OF THE CURRENT AMMONIA MARKET, WE'LL BE ABLE TO HAVE A REAL IMPACT."
STEVE VAN ZUTPHEN, CEO, SWAN-H

WHAT IS THE COMPANY AND WHAT DO THEY DO?

Swan–H is developing a carbon-free process to produce green ammonia which can replace the emissions-heavy Haber-Bosch process. The lower temperature and pressure process used can unlock electricity produced from intermittent renewables such as wind and solar for decentralized, modular ammonia production plants, which is technically impossible with the green Haber-Bosch process that needs to run 24/7 at an immense scale to be competitive.

HOW IT WORKS

The Mezailles reaction is based on boron-mediated radical chemistry. Their patented chemical mediator enables nitrogen to react with water. The mediator is reduced on the cathode with green electrons and then reacted with nitrogen. Next, protons sourced from water are added to the reaction that reform the mediator and produce ammonia in a fully renewable and cyclic process.

KEY DIFFERENTIATOR

Traditional ammonia production processes require high pressure, high temperatures, and large factories that use methane and must be running 24/7. In contrast, the Swan-H reaction can take place close to room temperature and pressure. Therefore, the process does not need to run continuously and can operate in factories of any size, powered by locally available renewable energy sources. Hence, Swan-H technologies could maintain ammonia production decentralized across the globe.
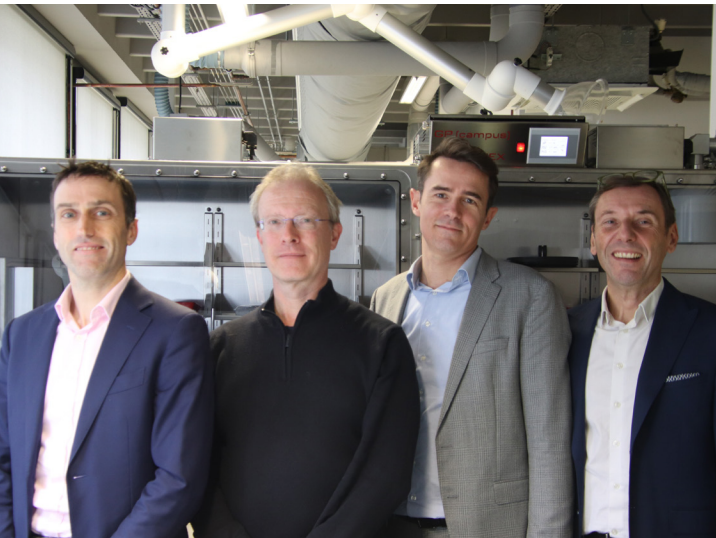
CASE**STUDY**

KEY**FACTS**

Ammonia production generates around 500 million tons of carbon dioxide and constitutes roughly 1.8% of global emissions each year
(Royal Society)

Swan-H raised $1.5M Equity financing to support lab-scale research and prototypes

POTENTIAL IMPACT

Ammonia production is an emissions-heavy industry. Global production capacity of ammonia is expected to grow from the current annual production of 180 million metric tons per year (Argus 2023). Depending on how other industries decarbonize, demand for ammonia could triple by 2050 if ammonia becomes widely used in newer markets as an energy carrier, power generation chemical, and maritime fuel.

Ammonia production generates around 500 million tons of carbon dioxide and constitutes roughly 1.8% of global emissions each year (Royal Society). If Swan-H can capture even a small segment of this large market, the emissions reduction potential is immense.

AMBITION / NEXT STEPS FOR COMPANY

Swan-H has raised $1.5M Equity financing to support lab-scale research and prototypes and are now preparing a $4M Series A round to accelerate their kg-scale pilot reactor and scale outside the lab with industrial partners. Swan-H will work with partners to license out technology to support the production process of ammonia but not make ammonia sales directly.

KEY THINGS TO WATCH IN THE ENERGY & POWER SPACE

Supply of green ammonia beyond current demand has the potential to reshape the fuel and energy market around a carbon-free energy carrier. Many start-ups in hydrogen sectors face challenges with market demand, transporting, and storing chemicals. New technologies to produce green ammonia will be key to unlock the hydrogen economy, as ammonia is more energy dense, easier to store and transport, and can be readily cracked to hydrogen. Swan-H can leverage existing infrastructure for ammonia, to scale their process to enable green ammonia to transform industries beyond agriculture into shipping and fuels.

WHY THIS COMPANY MADE THE LIST

Given the size of the ammonia market, solutions like Swan-H that provide a substitute for emissions-heavy processes like the Haber-Bosch process, have the potential to disrupt entire industries and divert tons of emissions. Swan-H's process runs at ambient temperatures and pressures, uses compounds found in air and water, and does not directly require H_2 gas. Their process is not dependent on complicated supply chains and does not have to run 24/7, allowing for increased flexibility and decentralization.

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CLEANTECH
50TOWATCH

THE **2024** LIST

AGRICUTURE & FOOD

3 COMPANIES ↓ | **3** COUNTRIES ↓

NO.	COMPANY	DESCRIPTION	COUNTRY	FOUNDED
1	ALORA	CRISPR gene-edited crops with specialized traits including salt tolerance.	United Kingdom	2020
2	nitrovolt	Distributed 'Nitrolyzer' units leverage a lithium-mediated ammonia synthesis for on-site green ammonia production from water and air.	Denmark	2023
3	phagos	Bacteriophage solutions that address antibiotic resistance in livestock and seafood.	France	2021

KEY: ↥ Increase on 2023 list   ↧ Decrease on 2023 list   ↔ Same as 2023 list

Source: Cleantech Group

ENERGY & POWER

13 COMPANIES ↓ | **10** COUNTRIES ↑

NO.	COMPANY	DESCRIPTION	COUNTRY	FOUNDED
4	AYRTON ENERGY	Technology that enables hydrogen to be stored within an organic liquid similar to gasoline.	Canada	2021
5	CALWAVE	Technology that harnesses the renewable power of ocean waves to produce electricity and freshwater.	United States	2014
6	GetSolar	Solar-as-a-service system that provides rent-to-own solar programs.	Singapore	2020
7	GREEN GRAVITY	Technology that raises and lowers heavy weights in a mine shaft to capture and release the gravitational energy of the weights.	Australia	2021

CONTINUED

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ENERGY & POWER

13 COMPANIES ⬇ | **10** COUNTRIES ⬆

NO.	COMPANY	DESCRIPTION	COUNTRY	FOUNDED
8	Grid Raven	Digital twin of the grid that provides a detailed forecast of the ability of each power line to safely carry energy.	Estonia	2023
9	HyperHeat	Technology that produces zero carbon industrial heat (up to 1,950°C) from renewable energy.	Germany	2023
10	IONATE	Power transformers leveraging high-precision magnetic power flow controllers, enhanced by an AI control module.	United Kingdom	2019
11	RHIZOME	SaaS platform that designs in reliability and resilience of grid infrastructure projects for utilities.	United States	2023
12	RIFT	Hydrogen energy storage in iron powder that does not require hydrogenation, and can be stored in conventional industrial infrastructure.	Netherlands	2020
13	SLS Energy	Converts real-time and remote monitoring systems into repurposed battery systems that manage energy consumption.	Rwanda	2023
14	smartville	Second-life energy storage systems using used EV batteries.	United States	2019
15	SWAN-H	Decentralized green ammonia produced through the Mézailles reaction, activating nitrogen and reacting it with water, that can be powered using renewable energy.	France	2021
16	ThinkLabs	A physics-informed AI digital twin that provides a foundation model for critical renewable energy and grid infrastructure.	United States	2024

KEY: ⬆ Increase on 2023 list   ⬇ Decrease on 2023 list   ⬌ Same as 2023 list

Source: Cleantech Group

MATERIALS & CHEMICALS

19 COMPANIES ↑ | **8** COUNTRIES ↓

NO.	COMPANY	DESCRIPTION	COUNTRY	FOUNDED
17	Airhive	Hybrid geochemical-DAC technology that leverages fluidization of rocks.	United Kingdom	2022
18	Aquarry	Carbon capture solutions through the use of mine pit lakes.	United States	2023
19	Atacama Biomaterials	Compostable plastic alternatives developed using AI modelling.	United States	2020
20	BIOSORRA	Biochar created via fast pyrolysis for agriculture and carbon sequestration applications in the Global South and tropical regions.	Kenya	2021
21	Biozeroc	Low-cost highly-scalable bioprocess to produce carbon-neutral concrete.	United Kingdom	2021
22	CAMBRIDGE ELECTRIC CEMENT	Low-emissions cement using recycled building materials.	United Kingdom	2022
23	CAPTURE6	Direct carbon air capture (DAC) technology, which produces clean water and other industrial products from seawater.	United States	2021
24	CETOGENIX	Technology to produce biogas, fertilizers and products from organic waste.	New Zealand	2022
25	CREW	Control process pH that facilitates CO_2 removal from wastewater.	United States	2022
26	CYANOSKIN	Algae-based coating designed to transform buildings into carbon dioxide-absorbing structures.	United Kingdom	2023

CONTINUED

MATERIALS & CHEMICALS

19 COMPANIES ↑ | **8** COUNTRIES ↓

NO.	COMPANY	DESCRIPTION	COUNTRY	FOUNDED
27	FlexSea	Novel biomaterials derived from renewable marine resources to replace plastic packaging.	United Kingdom	2020
28	Limelight Steel	Laser-based technology to process iron ore into steel with no emissions and up to 20% energy savings.	United States	2022
29	Litus	Technology that selectively harvests lithium directly from aqueous sources.	Canada	2019
30	MagREEsource THE GREEN RARE EARTH MAGNET COMPANY	Magnets from recycled NdFeB powders using a proprietary recycling technology based on a hydrogenation process.	France	2020
31	M	Mushroom-based packaging.	New Zealand	2020
32	NitroFix	Carbon neutral one step electrochemical process to produce green ammonia.	Israel	2022
33	NXLITE	Thermally and optically smart Diamond-Like Carbon (DLC) coating for windows to control heat and light emission.	Canada	2015
34	SUPER BAMBOO	Engineered bamboo as a sustainable alternative to building construction material.	Hong Kong	2022
35	TerraFixing	DAC technology for cold climates using zeolite-based adsorbent materials.	Canada	2020

KEY: ↑ Increase on 2023 list ↓ Decrease on 2023 list ↔ Same as 2023 list

Source: Cleantech Group

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RESOURCES & ENVIRONMENTAL MANAGEMENT

4 COMPANIES ⬇ | 4 COUNTRIES ⬇

NO.	COMPANY	DESCRIPTION	COUNTRY	FOUNDED
36	ACWA ROBOTICS	Autonomous amphibious devices that improve the management of global clean water infrastructures.	France	2018
37	FLOCEAN	Modular subsea (reverse osmosis) desalination plants that utilize natural ocean pressure to reduce energy consumption.	Norway	2024
38	OceanWell	Modular subsea water harvesting farms using hydrostatic pressure to desalinate.	United States	2019
39	Tersa Reclaim the future	Mining remediation technology that enables 100% acid rock drainage for mining waste and recovering metals.	Canada	2021

KEY: ↑ Increase on 2023 list   ↓ Decrease on 2023 list   ↔ Same as 2023 list

Source: Cleantech Group

TRANSPORTATION & LOGISTICS

2 COMPANIES ↑ | 2 COUNTRIES ↑

NO.	COMPANY	DESCRIPTION	COUNTRY	FOUNDED
40	CAT solar power the world	Anti-fouling and anti-corrosion coating for ship hulls resulting in more energy-efficient marine vessels.	Hong Kong	2022
41	CWS	Technology that produces assymetrical wind sails that can change tack to suit all wind conditions.	France	2016

KEY: ↑ Increase on 2023 list   ↓ Decrease on 2023 list   ↔ Same as 2023 list

Source: Cleantech Group

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WASTE & RECYCLING*

9 COMPANIES – | **6** COUNTRIES –

NO.	COMPANY	DESCRIPTION	COUNTRY	FOUNDED
42	ANTFARM Supercharged recycling	Robotic waste sortation solutions paired with AI-powered algorithms for simple integration in all material recovery facilities (MRFs).	Netherlands	2024
43	cling	A platform for the collection and trading of lithium-ion batteries enabling optimal use and recycling.	Sweden	2020
44	Composite Recycling making GFRP recycling a reality	Pyrolysis specialist targeting tires and plastics for conversion into fuels, oils, and waxes.	Switzerland	2021
45	MACROCYCLE CIRCULAR PLASTICS, ZERO CARBON	PET recycler specializing in a novel semi-depolymerization process that preserves or improves plastic quality.	United States	2023
46	MYCOCYCLE	Waste treatment for construction and demolition waste by remediating toxic constituents using fungus.	United States	2018
47	NILO	Technology that repurposes plastic, construction waste, tires, and solid waste into furniture adhesives.	New Zealand	2017
48	refiberd.	Textile sortation specialist implementing hyperspectral imagery to determine material composition.	United States	2020
49	SIMPLIFYBER	Manufacturer of cellulose-based material for footwear and apparel.	United States	2020
50	tozero	Hydrometallurgy lithium-ion battery recycling technology.	Germany	2022

KEY: ↑ Increase on 2023 list   ↓ Decrease on 2023 list   ↔ Same as 2023 list

Source: Cleantech Group

* The former category of "Resources & Environment" is now two new categories: "Resources & Environmental Management" and "Waste & Recycling".

ABOUT
CLEANTECH
GROUP

Cleantech® Group is a research-driven company that helps corporates, public sector, investors and others, identify, assess, and engage with the innovative solutions and opportunities that are related to the world's massive, and growing, environmental and climate challenges.

Our insights and expertise are delivered to clients all over the world through our Research, Consulting, and Events. We have been the leading authority on global cleantech innovation since 2002.

Contact us anytime, info@cleantech.com.

RESEARCH

The solution to information overload, our research cuts through the noise to monitor the market and deliver the insight you need on the themes central to your goals on markets, innovators, investments, trends, and the future.

CONSULTING

To de-risk the future and seize opportunities, leaders need to understand the impact the emerging future might have – only when you clearly see what's coming can you plan for the future.

EVENTS

Cleantech Forums empower corporate change-makers, investors, entrepreneurs, and innovative stakeholders to forge connections, change the narrative, make deals, and be part of an unforgettable experience.

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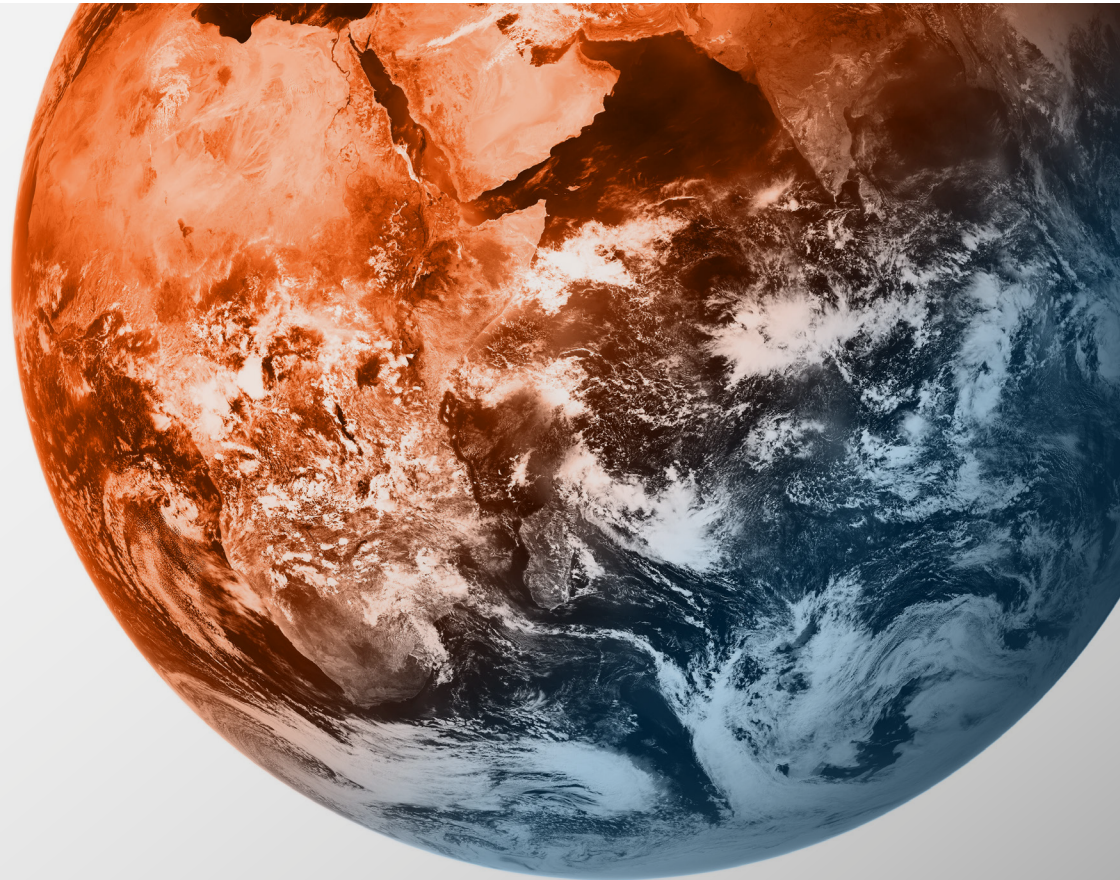
METHODOLOGY

How we select the Cleantech 50 to Watch →

THE QUESTION WE SEEK TO ANSWER

According to the global cleantech community, which 50 private companies across the world 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:

1 The expert panel of 34 investor and multinational corporation representatives. See page 32 to learn more about these individuals.

2 Our i3 platform, which tracks the investment and partnership history of thousands of relevant companies.

3 Third-party awards where expert assessment has been applied.

4 Our analysts, who cover Agriculture & Food, Energy & Power, Materials & Chemicals, Resources & Environmental Management, Transportation & Logistics, and Waste & Recycling.

5 Public nominations from the global ecosystem, as well as additional data points from the Global Cleantech 100 nomination process.

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 industry experts comprised of representatives from investors and multinational corporations. The panel votes positively or negatively based on their knowledge of the company's innovation, market, and ability to execute.

PHASE 3: THE FINAL 50
A combination of data from Phase 1 and Phase 2 are pooled and adjusted for geographic or other biases. Companies with the highest points overall make it to the final 50.

EXPLORING THE DEPTH AND BREADTH OF THE CLEANTECH COMMUNITY

To create the list, we put together a diverse panel of over 30 early-stage innovation and investment experts. We asked them to nominate and review the companies that most impressed them and combined that information with our own nominations and research on early-stage awards.

This year, the number of nominations from the public, our expert panel, i3, awards and Cleantech Group totaled 2,389 from over 58 countries. These companies were weighed and scored to create a short list of 85 companies that were reviewed by the 34 members of Cleantech Group's Expert Panel.

It's not just about ideas; it's about real-world solutions making a tangible difference.

EXPERT
PANELISTS

34 leading specialists in early stage companies from across the world provided their inputs into the process

→ **VIEW BIOGRAPHIES**

Laurie Menoud
Founding Partner

At One Ventures

Ashley Grosh
Vice President

Breakthrough Energy Fellows

Anthony DeOrsey
Research Manager

Cleantech Group

Tien Nguyen
Founding Partner

Earth Venture Capital

Miki Yokoyama
Managing Director

Aurum Impact

Jonathan Cumming
Managing Director & CFO

Carbon13

Jason Anderson
President & CEO

Cleantech San Diego

Yoachim Haynes
Vice President, Strategy

Energy Impact Partners

Iris Jensen
Investment Manager

BayWa r.e. Energy Ventures

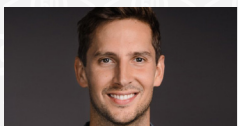**Iain Meager**
Director, Programmes & Innovation

Carbon Trust

Olivier Bordelanne
Partner

Demeter IM

Natharoun Ngo Son
Country Director

EnergyLab Cambodia

Bennet Barth
Managing Director, RESPOND

BMW Foundation

Lou Schick
Director of Investments

Clean Energy Ventures

Sara Chamberlain
Co-Founder & Managing Director

Earth Foundry

Georgia Parker
Innovation Director – Validation

Fashion for Good

CONTENTS →

Jeanette Jackson
CEO

Foresight Canada

Tyler Hamilton
Senior Director, Climate

MaRS

Gabriel VanLoozen
Principal

Powerhouse Ventures

Erki Ani
Founding Partner

Sunly Future Ventures

Sunyoung Suh
Adaptation Portfolio Manager,
Climate Technology Innovation Unit

UNIDO

Alyssa Gilbert
Director of Innovation

Grantham Institute,
Imperial College London

Monali Mujumdar
Startup Engagement Lead
& Program Operations

NREL

Max ter Horst
Managing Partner, Energy

Rockstart Accelerator

Claude-Sebastien Lerbourg
Investment Director

Supernova Invest

Marie Cheong
Founding Partner

Wavemaker

Scott Bryan
President

ImagineH$_2$O

Frederic Clerc
Director, Carbon to Value Initiative
& Interim Managing Director

NYU Urban Future Lab

Sabrina Cipullo
Managing Director - Technical
Expertise & Operations

Solar Impulse Foundation

Ben Lesage
Global Coordinator

Sustainable Ocean Alliance

Pippa Gawley
Founding Partner

Zero Carbon Capital

Victor Ndiege
Chief Executive Officer

Kenya Cimate Ventures

Dr. Ashwath Sundaresan
Associate Partner

Pacific Channel

Demetrius Yuen
Director of Programs

SOW Asia

The expert panel is comprised of pioneers,
leaders, veterans and new entrants in
cleantech and is broadly representative
of the global cleantech community

VIEW BIOGRAPHIES

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The Cleantech Group
Championing sustainable innovation, catalyzing business opportunities

Our team is global
North America | Europe | Asia

Contact us
info@cleantech.com

cleantech.com

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