TAGCLIMATE

SPRING 2023

ANNUAL

CLIMATE SCIENCE STARTUPS

ARTICLES / OPINIONS / INTERVIEWS

TAGCLIMATE ANNUAL

CLIMATE SCIENCE STARTUPS

INTRODUCTION

Society benefits when entrepreneurs and investors work together to create innovative ways to make our lives better. One example is cybersecurity, where solutions to malicious hacking can enable new online services for citizens and groups. Another example is artificial intelligence, where innovations can lead to new products, such as autonomous vehicles, that can save lives and enable new types of businesses.

Perhaps the most obvious example of entrepreneurial innovation leading to an improved society is in the area of *climate science*. Regardless of politics, position, or culture, every person alive will agree that developing new means for generating different forms of energy, as well as reducing unwanted emissions and being gentler to the global environment as we go about our lives, is a noble and desirable goal.

TAG Climate's *2023 Annual Report on Climate Science Startups* celebrates this notion. It does so from the perspective of the entrepreneurial startup company focused on some aspect of the climate challenges facing our globe. We organize the analysis based on 51 different categories. Along with the startups, we include several innovative larger companies that still exude the spirit of a startup.

Within each of the nine groups and 51 categories, referred to collectively as the *TAG Climate Taxonomy*, we map companies that have been identified by our research team. These startups range from tiny outfits working on the germ of a new idea to massive companies with creative groups developing something truly new. Information about these companies is also included in the report.

As professional analysts, we also include guidance on each of the areas of the *TAG Climate Taxonomy*. We are confident that investors, buyers, chief sustainability officers, interested parties mulling over a potential career in climate science, and government policy makers will find the discussions and startup mappings useful. This report is made possible by sponsorships from climate science vendors designated as *TAG Climate Distinguished Vendors*.

– Dr. Edward Amoroso, Founder & CEO, TAG Climate

TAG CLIMATE ANNUAL

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Climate science experts and practitioners must recognize that best practices, technologies, and information about the industry and its participants will always be changing. Such experts and practitioners must therefore rely on their experience, expertise, and knowledge with respect to interpretation and application of the opinions, information, advice, and recommendations contained and described herein.

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May 10, 2023

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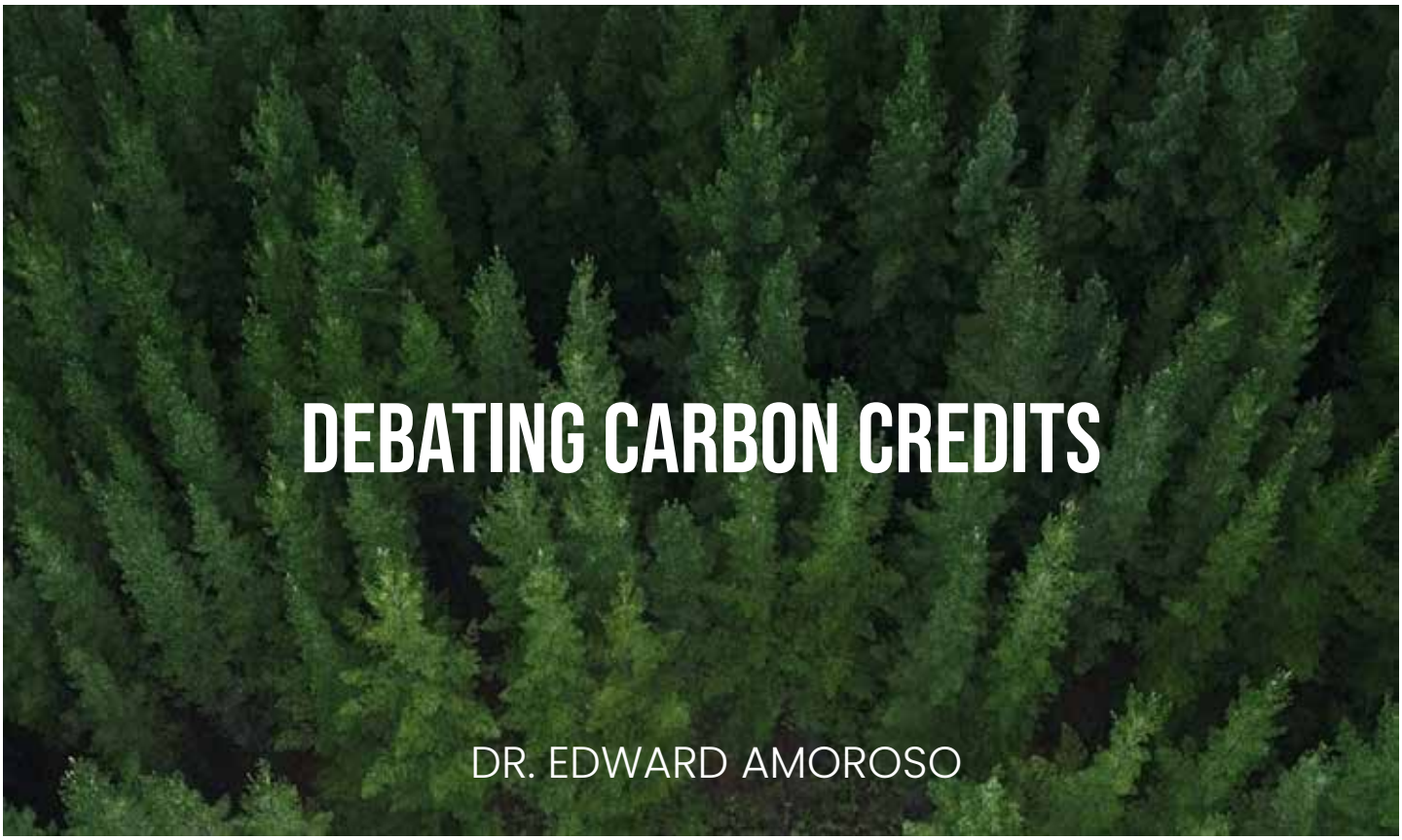


DEBATING CARBON CREDITS

DR. EDWARD AMOROSO

If you visit my home in New Jersey, we can walk over to a gorgeously landscaped farm just down the road called the **Hudson Farm Club**. Every year, they sponsor a little hike through their grounds for all the local residents. My wife and I always go with friends. After the hike, we get a free hot dog and little cup of juice. It's very nice.

Owned by the billionaire son of **James Kellogg III**, former chairman of the Board of Governors of the New York Stock Exchange, the club takes advantage of a process involving something called carbon offsets. Basically, this involves taking payment from carbon emitters in return for promising not to fell any trees on the Hudson property.

Now, here's where it gets interesting. Since we've started **TAG Climate**, we've been getting emails from companies asking if we'd help them market their carbon credits and offsets. So, we started digging to learn more of the details. And while it's always nice to rescue, plant, and protect a tree, something seemed wrong with this offset process. Here is what we learned.

Let's say you run Acme Manufacturing, and that you would like to brag on your website that you are a carbon neutral company. Everyone knows this is good for

It's always nice to rescue, plant, and protect a tree, but something seemed wrong with this offset process.

business, but the problem is that Acme generates ten million metric tons of carbon dioxide every year. This is clearly bad, and you obviously have a problem.

But hold on—there is a solution. Rather than rethink your manufacturing plant that emits carbon dioxide, all you have to do is purchase carbon offsets from some nice landowner. I sold my second home to a lovely woman who is involved with the New Jersey Nature Conservancy. I'm pretty sure those people would sell you some credits.

And the result is that if you buy enough credits, you can claim carbon neutrality on your website. Let's work a real example: In 2020, **Netflix generated** 1.05 million tons of carbon dioxide, and this grew to 1.54 million tons in 2021, a 50% increase. To account for this, Netflix bought 1.5 million carbon credits to stop Kenyans from logging trees.

Now I don't know about you, but this seems wrong to me. It seems to give license to carbon emitters, offering an easier means (writing a check) to avoid making substantive changes. And I suspect they are paying a lot of organizations that were never planning to chop down their trees anyway. The nice lady who bought my home doesn't seem like much of a logger.

But things are not always so simple. We've also reviewed many excellent startup companies developing direct air capture (DAC) and other excellent solutions that remove CO2 from the air. A major portion of their business model is to sell carbon credits to firms that would like to use the offset in their sustainability calculation.

This is a better situation, and does not smack of greenwashing because carbon is actually being removed. This is not a pay-me-or-else situation, but instead involves funding an on-going process that is welcome for the environment but needs the funding.

So, our position is that carbon credits are complicated. We know that green washing is bad, and that when offsets enable bad behavior, this is not acceptable. But when companies gain credits for funding DAC and other initiatives, it's hard not to encourage such action.

Last Week Tonight with John Oliver

PS: As I was developing this article, the John Oliver production team created a truly **wonderful piece** on carbon offsets that bizarrely connects with my personal situation. I really do live down the road from Hudson Yards (mentioned in their video) and I *really did* sell my home to someone from the Nature Conservancy (also mentioned in their video). So yes, I decided to align the examples from this article with their piece. I hope they don't mind. I was there first.

FROM PHYSICS TO CLIMATE CHANGE: A SCIENTIFIC ODYSSEY

DR. DORK SAHAGIAN

Dork Sahagian

Allow me to introduce myself. I am a curious person, "born" as a physicist with subsequent evolution to geology and then geophysics. Looking around me and wondering how things work, but getting woefully inadequate information, I started trying to answer a few questions myself (with a little help from my friends). Why don't we know why volcanoes explode? Why do earthquakes happen when they do? How and why has sea level been changing? Why do rivers meander instead of just going straight downhill to the ocean? What could life possibly have to do with the physical environment? And what's all this about climate change?

Academically, because I could "do" physics in high school, I majored in physics at Rensselaer Polytechnic Institute and then talked myself into grad school at Rutgers, where I discovered I might prefer something a bit more "down to Earth." So I applied the background I had by then to the geological sciences for a master's.

Publishing my first paper in Nature on the distribution of hot spot volcanoes and their relation to mantle convection, I moved on to the University of Chicago to explore the interaction between the Earth's mantle and crust. Realizing I needed real data, I gravitated to a wonderful advisor, Fred Zeigler, who was constructing

In college, I majored in physics because I could "do" it in high school. But in grad school, I wanted something more "down to Earth."

a Paleogeographic Atlas of the world, and a volcanology monitor, Fred Anderson, who knew more about volcanoes than pretty much anybody (but that was still not everything there was to know).

At Chicago, I began to realize the depth of our actual ignorance. We don't understand volcanoes or anything much about the deep interior of the Earth, but we also don't even understand what is going on right here at the surface, upon which we run around. So I figured out a little bit about how the continents have deformed vertically (epeirogeny) over geologic time, and corrected that for how sea level changed (we measure elevation relative to sea level, but we measure sea level relative to the land surface. Hmmm…). So I made sea level curves, maps of deformed continents, and generally tried to sort it all out.

"As we continue to scratch away at the monolith of our ignorance, I face the fact that we know practically nothing about anything—at least not compared to what we need to know…"

Then, working for the Navy after graduation, I looked into the "tectonics" of the Arctic icepack. Well… we don't have to worry about THAT anymore, do we? Summer sea ice will be gone in our lifetimes. While I struggled along on "soft money" (universities were happy to "hire" me as long as I paid my own salary from National Science Foundation grants and paid a hefty overhead to the institution as well), I eventually began to wonder about the Earth system. So I took a position as director of the Global Analysis Integration and Modelling Task Force of the International Geosphere Biosphere Progamme (IGBP-GAIM) at the University of New Hampshire. Our mission was to develop a suite of prognostic biogeochemical Earth system models by gathering together many of the world's leading scientists. Call it herding cats. Big cats.

Meanwhile, I realized that people were moving water around to such an extent as to actually be changing the rate of sea level rise. Crazy! This (and the papers I published about it with various colleagues) led to my involvement in the Intergovernmental Panel on Climate Change (IPCC). A series of monumental volumes encapsulating the science and implications of climate change emerged from the work of thousands of scientists, and we all said the same thing in increasingly strong words. Climate is changing, we are causing it, and it is not a good thing.

Who knew that Al Gore would go and write a book (followed by the movie "An Inconvenient Truth") that would explain the realities of climate change to the public more effectively than all the scientists (big cats) in the world had done in over 30 years? So Gore and a few thousand of my closest colleagues and I all shared a Nobel Peace Prize in 2007. Surprise! (And rather than a check, or a scroll, or even an email, all I got was the coffee mug from my cousin shown in the photos above.)

By this time, I had completed my two terms as director of IGBP-GAIM and moved on to serve as the founding director of the Environmental Initiative at Lehigh University. Having hopefully demonstrated my administrative incompetence after two terms of that, I stepped UP to the regular faculty, where I have been a kid in a candy store ever since. So many questions! So few answers! (But fabulous students give me hope for the future.)

As we continue to scratch away at the monolith of our ignorance, I face the fact that we know practically nothing about anything—at least not compared to what we need to know to build and maintain a modern society within the constraints of our global environment. We need one that can provide the goods and services required to survive sustainably in the long term. And if the ultimate answer is "42," then we are sunk.

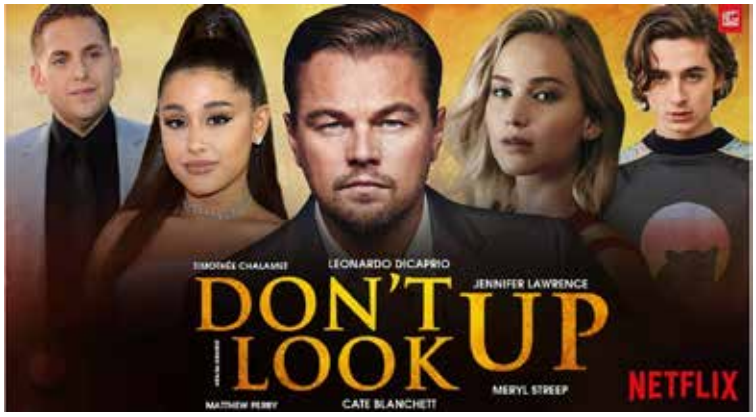
After decades of conducting research, publishing papers, teaching classes, giving lectures, speaking at the UN, and basically remaining confined to the sequestered world of academe, I have come to realize that "regular" people are taking notice and trying to do something about climate change. So onto the global stage steps a growing suite of companies whose products and services are designed to reduce or eliminate the impacts of human activities on our climate system and environment in general. You mean you can make money by doing things that help provide our grandchildren with a healthy and sustainable future? WOW! How does that work?

As Einstein once said (paraphrased and translated): "We can't solve our problems with the same kind of thinking that created them in the first place." So a growing number of industries are now looking at new ways to accomplish our most basic goals. Not by just adding "technologic fixes" to existing products and infrastructure, but by rethinking how we go about accomplishing our goals in the first place. It is only by "thinking outside the box" that we can transcend 20th century consumerism and restructure the world in a way that we hope will suit our grandchildren and beyond.

This is what TAG Climate is all about.

WHAT'S ALL THIS ABOUT CLIMATE CHANGE?

DR. DORK SAHAGIAN



There has been a great deal of discussion lately about climate change, to the point that it has been politicized—to the horror of climate and other scientists. Science seeks to determine truth and seeks new knowledge about the natural world. Politics seeks to determine what decisions will be made and who will make them. They do not mix, so I will limit this discussion to science. By saying that, I am not suggesting that science towers over all other fields. The point of science is that it is NOT perfect. That is why we conduct research to improve our knowledge.

I am a scientist involved in research in climate change, sea level, hydrology, and other aspects of the operation of the Earth system. For decades, I wrongly assumed that everyone thought the way scientists do, and was somewhat taken aback when I finally realized that some people make decisions based on things other than observation, hypothesis development and testing, analysis, and conclusion. How naïve of me! When National Geographic made "THE WAR ON SCIENCE" the cover of an issue (March, 2015), I knew that we, as a scientific community, had long failed in appropriately communicating to the public about what we do.

So, what do I say to colleagues and concerned citizens who ask me how I respond to climate contrarians who claim that they don't "believe" in climate change—or have fallen prey to disinformation publicized by those with vested interests in fossil fuels and related industries? In some cases, simple facts and logic can help them understand the realities of the Earth system and how it is responding (and will respond further) to human-caused perturbations such as greenhouse gas emissions. Basic questions and answers I wrote in an AGU Editors' Vox can be found here.

"I wrongly assumed that everyone thought the way scientists do.... How naïve of me!"

These questions include:

IS CLIMATE CHANGING?

Until this is acknowledged, there is no sense going on to subsequent questions.

ARE PEOPLE CAUSING IT?

If a person believes that observed changes are natural, then there would be no reason to change human behavior.

IS CLIMATE CHANGE A BAD THING?

Many people may like warm weather, dislike snow, and prefer a warming planet, without realizing that this involves disruptions that they would dislike more than cold winters.

CAN WE DO ANYTHING ABOUT IT, OR IS IT TOO LATE TO CHANGE COURSE?

Some folks may think it is too late, and thus give up on solutions.

IS IT WORTH DOING ANYTHING?

How much will it cost to change what we do? It is important to compare the cost of mitigation to that of adaptation. The latter is far more expensive!

Answering these questions may help some people understand more about climate change and its impacts. However, some people have a worldview that does not use direct observation, evidence, or science in general as their primary basis for decision-making (see, for example, the recent film "Don't Look Up"!). No amount of factual education can alter this worldview.

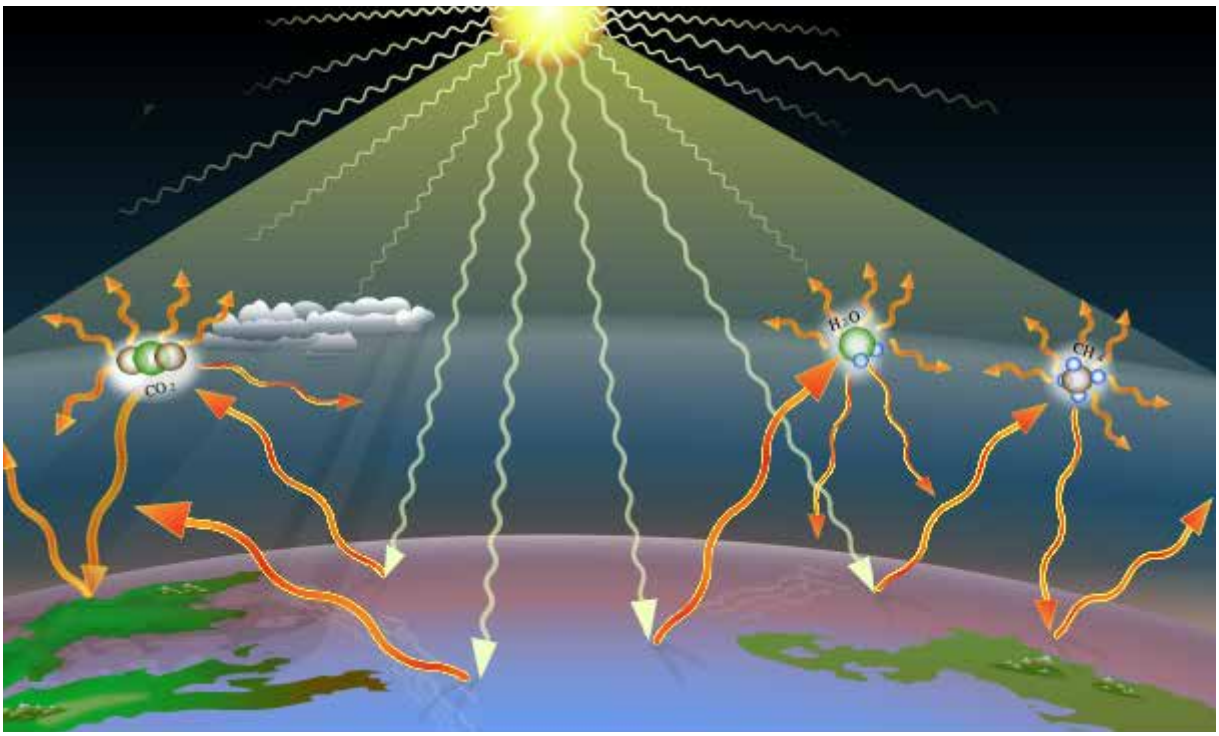
Communicating with people such as these requires a different approach, and one that engages not their logical center, but rather, their emotions. Any Madison Avenue ad man would tell you this. They don't sell more cigarettes by telling you the facts about smoking. As such, when discussing climate change with someone who has an emotional attachment to a perspective provided by social media to support their pre-conceived notions, you need to acknowledge that they have a viewpoint and that you can relate in some way. If you don't show that you understand where they are coming from, they will listen no more. Then, you actually have to address the issue in terms they can appreciate, and in their own language. Finally, you need to help lead their thoughts to what follows. This could alter their consumption patterns in some way, or their travel, purchasing, and even voting.

What I have found is that climate contrarians are generally more concerned about other issues such as "the southern border," or "the welfare state," or "threats to the Second Amendment." These and other issues are being stressed on the broadcast and social media that support a suite of their opinions. We should not assume that they share the same concerns as we do (whoever "we" are). We might assume that they believe that science should be defunded because we need funds to support our lagging public education system, or broader access to affordable health care, or even cybersecurity. In my experience, these have not been concerns of the many climate contrarians I have encountered.

In any case, communicating with the public about climate change and its impacts is a multifaceted challenge—and one that has stumped the scientific community for decades. It is high time that we, as scientists, learn how to more effectively address climate change in terms that resonate with a broad set of public audiences. If we fail, the cost and harm will not be limited to them or us. It will fall on all of our children and grandchildren. And it will no longer matter what THEY believe.

THE BASICS OF CLIMATE CHANGE

DR. DORK SAHAGIAN



GREENHOUSE GASES: COURTESY WIKIPEDIA

While there are some basic questions and political discussions, it is now time to turn to the actual science of climate change. We know that climate has been changing over geologic time for lots of reasons. Glaciers come and go every 100,000 years due to periodic variations in Earth's orbit around the sun. This leads to simple solar forcing and is perfectly natural on those timescales. Atmospheric chemistry also plays a role because greenhouse gases trap infrared radiation emitted from Earth's surface within the atmosphere, thus warming things up. This "trapping" occurs because outgoing infrared excites the bonds within molecules that have the corresponding energy, which then "relax" and emit the same infrared in all directions (including back down).

The most important long-term greenhouse gas is carbon dioxide (CO2), which is the result of all burning (of fossil fuels, wood, etc.). Over geologic time, CO2 in the atmosphere has gradually declined. The carbon is

"Can you really feel the difference between 25˚C and 26˚C? I can't. However, the Earth System certainly can..."

increasingly stored in the ground in carbonate rocks and also as fossil fuels. This has counteracted the effect of a warming sun (like any main sequence star), and has thus kept the planet at a comfortable temperature for life as we know it (except for a few **"Snowball Earth"** events). You can explore the **Gaia hypothesis** about this, but there is no indication that life in general has done this on purpose. Our living Earth is merely a homeostatic system in which negative feedbacks rule the day (fortunately for us).

Since the industrial revolution, however, we have been removing carbon from underground storage in the form of fossil fuels and putting it back into the atmosphere as CO2 (in spite of the warmer sun). We have thus observed a dramatic increase in atmospheric temperature and circulation, storms, sea level, etc. Simple physics demands that temperatures rise when greenhouse gases are absorbing and radiating infrared.

But there is more to the picture! The concentration of CO2 in the atmosphere is currently about 420 parts per million, which does not seem like much. But compare this to the pre-industrial interglacial concentration of 280 ppm and the full glacial concentration of 180 ppm. We have not seen this much CO2 in the atmosphere for millions of years—long before humans as we know them evolved. The main thing about CO2 over the long-term is that one must keep in mind that water (H20) is also a greenhouse gas. In fact, it's the one that keeps the planet 33˚C warmer than it would be with a dry atmosphere. (Actually, the stratosphere and above is indeed dry, which is why all weather happens in the troposphere.) Without water vapor in the **troposphere**, we would all be in a deep freeze! However, the solubility of water (but not CO2) in air depends on the temperature (think hot, humid summer days versus cold, dry winter days).

This is where the all-important CO2-H2O positive feedback kicks in. A little bit of warming by a slight increase in the trace gas CO2 means the air is able to evaporate and dissolve more water from the oceans, which makes it warmer still. This, in turn, leads to more evaporation and more warming. Then the ocean spits out more dissolved CO2 because warm water cannot hold as much CO2 as cold water (think warm seltzer or beer). This hugely amplifies the tiny warming from the original CO2. Indeed, if not for the existence of those pesky oceans (and some water on land), CO2 from fossil fuel burning would not be such a climate issue.

So temperature increase is triggered by fossil fuel burning. Now one might ask, "So what? What's so bad about a warmer or otherwise different climate?" We have already warmed by 1˚C since 1850, when we started burning fossil fuels in earnest. That doesn't seem like much, does it? Temperature changes much more than that between day and night, and certainly between summer and winter. Can you really feel the difference between 25˚C and 26˚C? I can't. However, the Earth System certainly can, with its atmospheric circulation, ocean currents, biome distributions, precipitation patterns, and storm tracks! While there is much, much more we can learn about the Earth system, climate change, and its impacts, we already know more than enough to begin to take action to mitigate future climate change and restore a climate close to pre-industrial conditions.

Our civilization developed over the last 10,000 years with a certain Earth System configuration. Farms, seaports, cities and populations all adapted to a very stable climate. Altering that is a scary prospect. In effect, we are doing a grand experiment: Take a planet, change the atmospheric chemistry to alter the radiative balance with its star, and see what happens. This is a scientist's dream come true. What fun! (If only we didn't have to live on this experimental planet and deal with the consequences.) Some of these consequences are the floods and droughts that we "enjoy" these days; wildfires at unprecedented levels; hurricanes that reach not only New York City but now Canada; and, of course, the inexorable specter of sea level rise, flooding our coastal cities where most people live.

Now the picture doesn't seem so rosy, does it?

TAG CLIMATE TAXONOMY

Our *TAG Climate Taxonomy* was developed iteratively based on research into various aspects of the entrepreneurial landscape around climate science. Care was taken to focus on areas where founding teams (or creative group leads within larger companies) are trying to innovate for the dual purpose of making the world a better place, as well as creating a profitable new business for stakeholders, including investors.

Based on our research, we identified 51 areas of climate science entrepreneurship, organized into nine different groupings. We stayed away from initiatives, no matter how potentially attractive, that are designed to advance climate science objectives, influence policy makers, or drive buyers toward responsible decisions—unless such initiatives were part of some new startup plan to create business value. Our goal is to focus on entrepreneurship, not evangelism.

1.0 Sustainable Energy	**4.0 Alternative Fuels**	7.02 Recycling
1.01 Next Generation Fission	4.01 Carbon-Free Hydrogen	7.03 Solid/liquid waste purification
1.02 Fusion	4.02 Advanced Biofuels	7.04 Water treatment technologies
1.03 Solar Energy	4.03 Electrofuels	7.05 Life Cycle Analysis for production
1.04 Wind Energy	4.04 F-gas Free Coolants	**8.0 Food Systems**
1.05 Hydropower	**5.0 Energy storage**	8.01 Plant-based Meat
1.06 Geothermal Energy	5.01 Battery Technologies	8.02 Lab-grown animal protein
1.07 Biomass	5.02 Thermal storage	8.03 Vertical farming
1.08 Marine Hydrokinetic	5.03 Fuel cells	8.04 Tolerant food crops
2.0 Carbon Capture & Sequestration	**6.0 Sustainable materials**	8.05 Precision Ag-tech
2.01 Direct Air Capture	6.01 Energy efficient materials	8.06 Composting
2.02 Point source capture/storage	6.02 Energy efficient technology	**9.0 Technology & Services**
2.03 Soil-based Sequestration	6.03 Carbon neutral fertilizer	9.01 Sustainable building management
2.04 Carbon mineralization	6.04 Zero Carbon plastics	9.02 Sustainability/ESG consulting
3.0 Electrification	6.05 Zero Carbon steel	9.03 Climate industry advisory
3.01 Electric vehicles	6.06 zero carbon concrete	9.04 Climate intelligence software
3.02 EV charging infrastructure	6.07 Sustainable building materials	9.05 Climate Insurance
3.03 Smart Grid	6.08 zero carbon oils	9.06 Forest Management
	6.09 Sustainable Packaging	9.07 Carbon Accounting/Verification
	7.0 Repurpose & Reuse	9.08 Green Biotechnology
	7.01 Electronic Waste	9.09 Sustainable infrastructure

Figure 1. TAG Climate Taxonomy

In the sections that follow we provide overviews of each group and set of categories, with mappings of startups. Brief descriptions of each startup are included to offer insight into their approach and value proposition. While every effort was made by TAG Climate researchers to identify a full slate of startups, readers can be assured that only a representative subset is included here. Subsequent issues of this report will increase coverage of mapped startups.

METHODOLOGY

Our TAG Climate Methodology is driven by the needs of three constituents. First, we use our taxonomy research and insights to help commercial vendors developing solutions toward a more sustainable future to tell their unique stories to customers. Our Content as a Service (CaaS) and associated advisory services are designed to complement vendor content marketing teams.

Second, we direct the focus of our research and writing in a manner that will assist chief sustainability officers (CSOs), Environmental, Social, and Governance (ESG) teams, and other organizational groups to make the best possible decisions about sustainability and climate-relevant issues. This includes selecting the best vendors for inclusion in their supply chains.

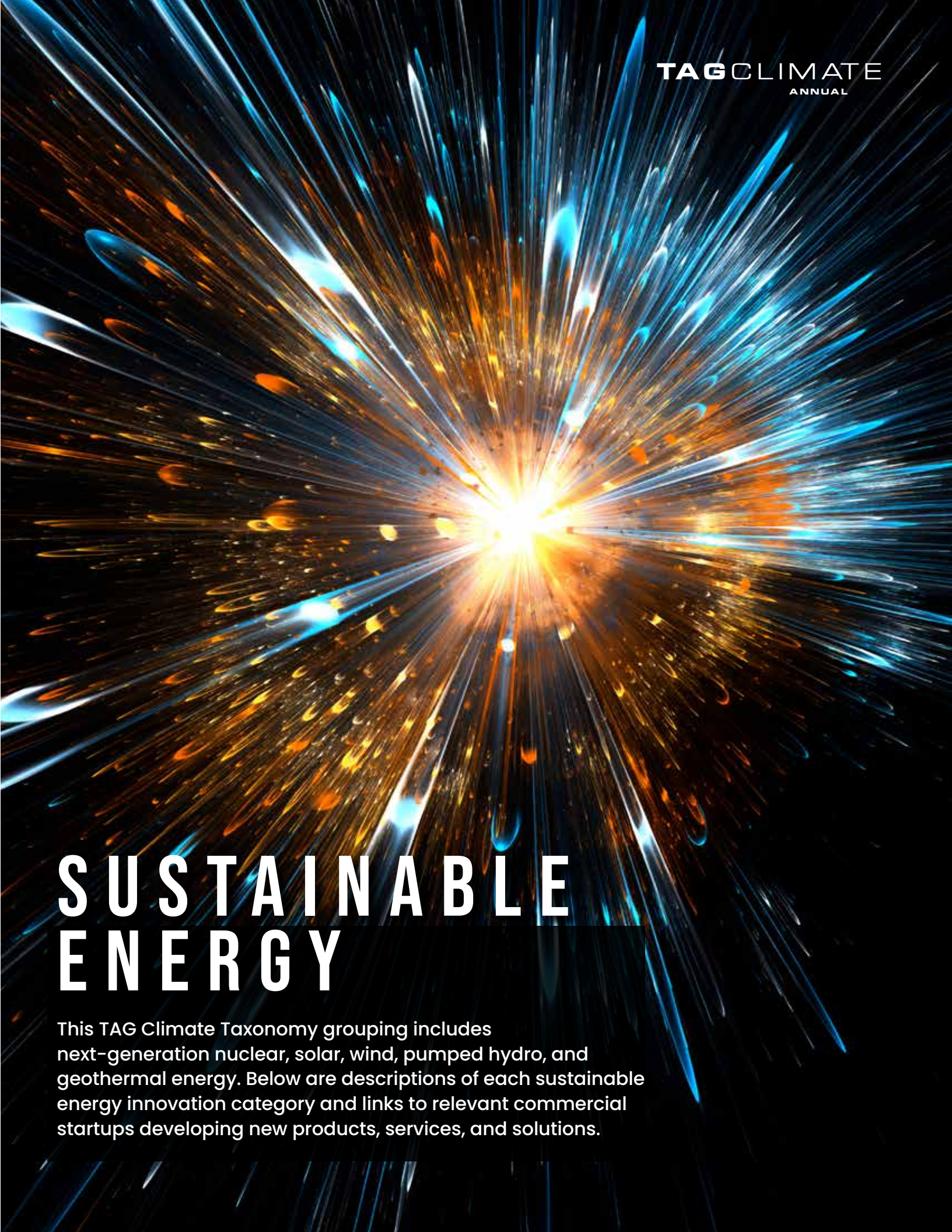
And third, we are devoted to helping all citizens, groups, governments and other advocates benefit from our climate science research, analysis and writing. We believe that the best approach to a sustainable future will be to combine the energy of citizens with the creativity of startups and businesses to drive optimal solutions to a zero carbon future.

Our TAG Climate team was created based on these three objectives. We've combined a group of experienced academics from the best universities, with experienced analysts who understand the startup ecosystem, along with practitioners who understand the needs of business and government. The result is a unique and powerful mix of talent focused on sustainability.

The TAG Taxonomy is obviously a major centerpiece of our work, because it provides the playing field for our analysis. It is driven by our work on a day-to-day basis with entrepreneurs, innovators, and business leaders working hard to develop amazing and effective solutions to an improved future.

Our hope is that through this TAG Climate research, analysis, and content, we can play a modest role in shaping how things unfold in the coming years. We cannot think of a more urgent initiative for our world, and we are proud to make our contribution.

"I'm all for carbon reductions, but will it fly?"



SUSTAINABLE ENERGY

This TAG Climate Taxonomy grouping includes next-generation nuclear, solar, wind, pumped hydro, and geothermal energy. Below are descriptions of each sustainable energy innovation category and links to relevant commercial startups developing new products, services, and solutions.

NEXT GENERATION FISSION

Next-generation, fission-based nuclear power provides a secure, cost-effective solution for current and future energy demands without contributing to conventional carbon emissions. This innovation is particularly crucial in the United States, where most operating nuclear plants are forty years old.

OVERVIEW OF FISSION

The fission process starts when a uranium atom collides with a neutron and splits into two smaller atoms, releasing additional neutrons that collide with other uranium atoms to trigger a chain reaction.

This process generates two energy byproducts: heat and radiation. While heat energy is valuable, safely disposing of nuclear waste remains a long-standing concern.

TECHNOLOGY ADVANCES IN NEXT-GENERATION FISSION

Many safety initiatives exist to address these concerns, including the Generation IV program, established by the U.S. Department of Energy in 1999. After gaining traction, this program formed the Generation IV International Forum (GIF) with participation from multiple countries.

The GIF identified six strategies for nuclear power generation. Specifically, gas-cooled fast reactors, lead-cooled fast reactors, molten salt reactors, sodium-cooled reactors, supercritical water-cooled reactors, and very high-temperature reactors.

Through ongoing research and commercial investment, molten salt reactors exhibit good safety properties, with successful sodium fast reactors gaining further commercial funding. However, existing reactors still rely on traditional second and third-generation methods.

The **Tokamak** is a device that controls fusion reactors in hot plasma. However, keeping the plasma core hot enough for fusion while preventing the tokamak walls from melting is a significant challenge—as is creating a steady flow of energy from the plasma.

While fission and fusion both receive significant research funding and investment, fusion is safer as there's zero risk of runaway nuclear reactions.

SELECT COMMERCIAL VENDORS SUPPORTING NEXT-GENERATION FISSION

The next-generation fission market will likely expand as part of the continued push for zero-carbon emissions. The following companies offer solutions to support next-generation fission technology. Investors, energy officials, and enterprise sustainability officers should review this list to determine suitability for current and future projects. The **TAG Climate team** is also available to assist with these selection decisions.

BHP Group – Australian company that mines uranium and other minerals.

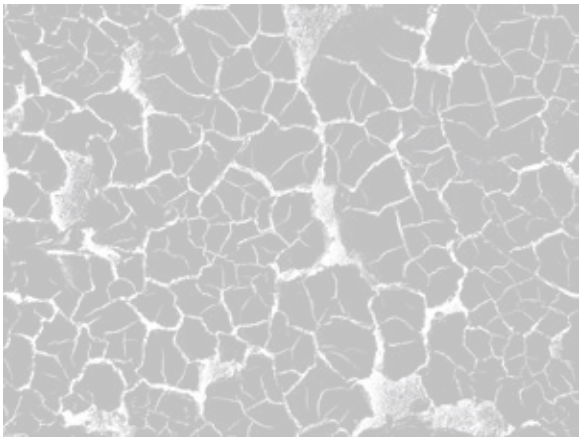
Cameco Corp – Produces uranium fuel for nuclear reactors.

Kairos Power - Developing advanced reacor technology.

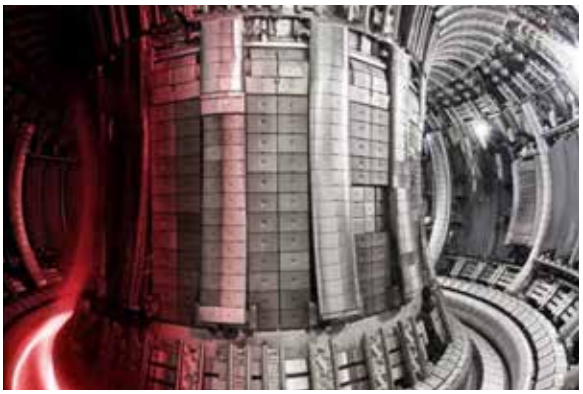
NuScale Power – Creates small modular reactor (SMR) technology.

Seaborg – Develops compact molten salt modular reactors.

Terra Power – Bill Gates-funded nuclear power company that uses liquid sodium for cooling.



FUSION



Nuclear fusion holds great promise as a sustainable and emission-free source of electricity. With some notable recent successes, scientists and entrepreneurs are accelerating their efforts to make fusion reactors a cost-effective and scalable solution for generating power.

OVERVIEW OF FUSION

Fusion is a process where two light atomic nuclei merge to form a heavier nucleus, resulting in a massive release of energy. Physicists often explain fusion by drawing parallels to the energy-producing process of the sun and other stars.

In a standard fusion setup, magnetic confinement heats a gas of deuterium and tritium (two hydrogen isotopes) within a magnetic field until the nuclei merge. However, generating energy like this requires extreme temperatures to enable fusion amidst repulsive nuclear forces.

The benefits of fusion technology include avoiding radioactive waste, using less fuel to drive the reaction, and the abundance of deuterium in seawater, which supports scalability. In addition, fusion reactors are safer to operate and shut down than conventional reactors.

TECHNOLOGY ADVANCES IN FUSION

In 2022, scientists at **Lawrence Livermore Laboratory** created a fusion reaction that produced more energy than the amount that triggered the process. This is a crucial milestone, as positive energy output is essential for fusion's use as a practical energy source.

The Livermore approach used 192 massive lasers in the National Ignition Facility to strike a tiny frozen diamond encased in hydrogen. This process required approximately 2 megajoules of energy to blast the hydrogen, generating roughly 3 megajoules of fusion byproduct.

The historic achievement of Nuclear Fusion Ignition establishes fusion as a feasible and promising method of large-scale electricity generation. The responsibility now falls on entrepreneurs and innovators to engineer practical systems.

The prospects for fusion entrepreneurship appear promising, with numerous commercial startups with diverse funding approaches emerging in the U.S., U.K., Spain, France, Japan, Israel, Australia, Germany, and Canada.

SELECT COMMERCIAL VENDORS SUPPORTING FUSION

The fusion market will likely expand as part of the continued push for zero-carbon emissions. The following companies offer solutions that support fusion technology. Investors, energy officials, and enterprise sustainability officers should review this list to determine suitability for current/future projects. The **TAG Climate team** can also help with selection decisions.

Avalanche Energy – Developing a 5kWe micro-fusion power pack called Orbitron.

Brilliant Light Power – Creating new plasma-based power sources.

Commonwealth Fusion – Produces smaller, lower-cost tokamak fusion systems.

First Light Fusion – Develops projectile-based inertial fusion systems.

Focused Energy – Powers fusion using high-energy lasers.

Fusion Reactors – Developing a fusion reactor to deploy by 2032.

General Atomics – Supports work in magnetic fusion research.

General Fusion – Canadian company that uses magnetized target fusion (MTF).

HB11 – Uses laser technology to fuse hydrogen and boron-11.

Helion – Building the world's first fusion power plant in Everett, WA.

Kyoto Fusioneering – Japanese fusion company.

LPPFusion – NJ-based fusion research company.

Marvel Fusion – Developing laser-driven fusion technology.

NearStar Fusion – Creating a modular approach to pulsed fusion.

NT-Tao – Working on plasma technology to unlock higher density.

Pulsar Fusion – Creating clean space propulsion systems using fusion.

Pulsotron – Building the Pulsotron-3 Reactor using fusion.

Renaissance Fusion – Building efficient nuclear fusion reactors.

TAE Technologies – Fusion power clean energy company.

Tokamak Energy – Uses high-temperature superconducting (HTS) magnets.

Type One Energy – Working on high-field superconducting magnets.

Zap Energy – Low-cost fusion system that requires no magnets.

SOLAR ENERGY

Solar energy is recognized as the most popular form of renewable energy and plays a critical role in reducing greenhouse gas (GHG) emissions. Over 30% of GHG emissions in the United States arise from **fossil fuel electricity generation,** and lowering this output is where concentrated solar power (CSP) and photovoltaic (PV) technologies can make the difference.

According to the **Solar Energy Industries Association (SEIA)**, the U.S. generated over 92 gigawatts of cumulative installed solar electric capacity in the first half of 2020—enough power to support 18 million homes and offset over 110 million metric tons of CO2 emissions.

METHODS FOR SOLAR ENERGY

The physics behind solar energy is **straightforward:** when sunlight hits a solar panel (like those on residential rooftops), photovoltaic (PV) cells absorb the energy. This creates electrical charges that move in response to an internal electrical field, resulting in the flow of electricity.

Concentrating solar-thermal power (CSP) is a related technology (primarily used in large power plants) that utilizes mirrors to reflect and concentrate sunlight onto receivers. The energy is then stored for later use or converted into heat to generate electricity.

According to the **Solar Energy Industries Association (SEIA)**, the U.S. generated over 92 gigawatts of cumulative installed solar electric capacity in the first half of 2020—enough power to support 18 million homes and offset over 110 million metric tons of CO2 emissions. As of 2020, the U.S. Department of Energy **estimates** that the solar industry supports more than a quarter of a million jobs in the following categories:

- **Manufacturing**
- **Installation**
- **Project Development**
- **Trade**
- **Optimization**
- **Distribution**
- **Research and Development**

SELECT COMMERCIAL VENDORS SUPPORTING SOLAR ENERGY

Asoleyo – Supports the design of solar cells using artistic and graphic principles.

BlueDot Photonics – Makes advanced photonics and optoelectronic devices.

Brite Solar – Manufactures a new class of glass materials.

CubicPV – Creates powerful tandem solar modules.

ET Solar – Provider of PV modules and smart energy.

First Solar – Offers comprehensive PV solar solutions.

Insolight – Manufactures translucent solar modules.

Jinko Solar – Solar power manufacturer.

Leading Edge – Innovates in new silicon wafer manufacturing technology.

Morgan Solar – Uses big data to optimize solar assets.

mPower – Solar panel startup company.

Oxford PV – Works in perovskite solar technology.

Q-Cells – Delivers solar energy solutions to customers.

Renkube – Develops technologies to improve solar panel efficiency.

Solantro Semiconductor – Makes technology for intelligent solar systems.

SolarCube – Designs and produces PV mounting equipment.

SoloPower – Thin film PV manufacturer.

SunDensity – Improves PV efficiency with nano-optical coating.

Swift Solar – Manufactures lightweight solar panels.

Toledo Solar – Solar manufacturer using cadmium telluride (CdTe) thin film technology.

WIND ENERGY

The goal of achieving high levels of sustainability by 2050 requires the active participation of the wind energy community, namely electricity generators, business and consumer users, and government advocates. Entrepreneurs and innovators—often supported by investors—can also play a part in developing new and advanced methods for generating cost-effective wind energy.

METHODS OF WIND ENERGY

A fossil fuel alternative, wind energy is a sustainable and renewable form of electricity that relies on kinetic energy generated by wind turbines and other methods. Wind arises through a combination of factors, including the heating of the atmosphere by the sun, the earth's rotation, and irregularities on the earth's surface. Although wind energy can face intermittent challenges, it also provides **significant benefits**, including:

- **Cost Advantages – With a production tax credit, United States customers can expect a charge of 1 or 2 cents per kilowatt hour. Stable pricing mitigates the uncertainty of fuel costs from other sources.**
- **Economic Advantages – Wind energy is an excellent source of new jobs (perhaps as many as 600,000 by 2050) and accounts for around $10 billion in investments in the U.S. economy. This figure is comparable to some mobile phone operators' annual wireless infrastructure investment.**
- **Clean, Renewable Energy – Wind is abundant, domestically produced, assists rural farmers, and free of damaging emissions. The goal is to ensure that wind energy can compete with other less environmentally sustainable forms of energy production.**

There are many challenges to using wind energy as a reliable source of electricity, including the distance between rural farmers and high-demand areas. In addition, noisy turbine blades are often dangerous to birds and bats. Despite these drawbacks, weighing the disadvantages against the corresponding advances in sustainable energy production is crucial.

TECHNOLOGICAL ADVANCES IN WIND ENERGY

Ongoing innovations are improving wind energy efficiency, economics, and practicality. Some areas of improvement include:

- **Blade Design – In recent years, turbine blade length has doubled from around 115 feet to the size of a commercial jet's wingspan, increasing torque and energy generation.**
- **Tower Design – Towers are also larger and taller, with turning diameters measuring the length of two American football fields. Engineers typically design wind turbine towers at heights where winds blow at an ideal rate.**
- **Assembly Process – Improved construction and assembly now allow companies to transport blades to deployment sites in separate pieces. Additionally, the turbine recycling process is also improving.**

SELECT COMMERCIAL VENDORS SUPPORTING WIND ENERGY

Atlas Renewables – Operates wind and renewable energy projects.

Eurocape – Operates wind and renewable projects.

Goldwind – Wind turbine company headquartered in China.

Hydro Wind Energy – Includes SEEDRS hydro wind energy.

Kite Power Systems – Leader in airborne wind energy systems.

Orsted – Focused on creating offshore wind farms.

ReNew Power – Wind power company located in India.

Ryse Energy – Manufactures wind turbines.

HYDROPOWER

Pumped storage hydropower (PSH), also known as pumped hydro, is a widely recognized hydroelectric storage method. PSH functions as a giant battery by transferring water between discharge and recharge reservoirs and will likely play a crucial role in future sustainability. Listed below are some salient aspects of this technique.

METHOD FOR HYDROPOWER

HYDROPOWER is currently the dominant energy storage method for most electric grids in the United States. The process involves a hydrologic connection to a natural body of water in open-loop configurations, with a slightly different approach in closed-loop setups. In both cases, generating hydropower is the ultimate goal.

The most prevalent PSH configuration is the open-loop system, which continuously pumps and releases water between two reservoirs at varying elevations. Closed-loop PSH is a new process that lowers environmental risks to aquatic and terrestrial ecosystems. Ongoing studies aim to **compare and contrast** the relative benefits of both approaches.

TECHNOLOGICAL ADVANCES IN HYDROPOWER

Ongoing PSH innovations are improving the efficiency, economics, and practicality of this important renewable resource. Geomechanical pumped storage (GPS) deployment is a significant advance in PSH as it adapts wells and other underground features for energy storage. GPS utilizes the pressure in underground wells to generate electricity, eliminating the need to locate **high and low elevations for water pumping in close proximity**.

Following this process, some companies are now creating **bidirectional Injector-Generator** (INGEN) systems, which significantly improve the efficiency of existing PSH systems. Bill Gates's Breakthrough Energy Ventures is currently backing projects initiated in this area.

As with all PSH systems, the goal is to create a highly efficient reversible pumped storage turbine that competes effectively with other forms of energy generation.

SELECT COMMERCIAL VENDORS SUPPORTING PUMPED HYDRO

Big Moon – Develops coastal hydropower plants to create energy.

Black & Veatch – Infrastructure company that supports PSH deployment.

BladeRunner Energy – Creates small-scale hydropower.

Emrgy – Creates renewable energy using water infrastructure.

Gravity Renewable – Develops small hydroelectric projects.

Hace – French company that uses wave energy for power generation.

Hydro Green Energy – Fabricates hydropower solutions.

Natel Energy – Develops climate-resistant hydropower.

Quidnet Energy – Energy company that supports modular pumped storage.

Smart Hydro Power – Creates smart hydropower solutions.

Turbulent – Creator of sustainable hydropower using whirlpool turbines.

Verdant Power – Generates renewable water power.

Voith Hydro – Supports pumped hydro products and services.

GEOTHERMAL ENERGY

The energy community has developed various geothermal techniques for extracting steam from heated reservoirs and pumping high-pressure recycled water into wells to absorb the heat. Using powerful heat sources to power turbines and generate electricity is an appealing method, but digging wells to heat water requires further innovation to ensure efficiency.

BASICS OF GEOTHERMAL ENERGY

Geothermal energy **works** by pumping water deep below the earth's surface to absorb heat from the magma (molten rock), THAT surrounds pools of reservoir water.

Using magma as an energy source is a promising area of sustainable innovation as it eliminates the need to burn fossil fuels during the heating process. Indeed, Turkey, Indonesia, and other countries, are embracing this method in their national energy plans.

Geothermal energy has a long history in the United States, with the earliest plants constructed sixty years ago in California. Today, the well-known **Geysers Complex** houses 22 geothermal power plants, making it the largest installation of its kind in the world.

The climate science community generally recognizes geothermal energy as a practical and feasible solution to the problem of high-carbon energy production.

METHODS FOR GEOTHERMAL ENERGY

There are three practical methods for geothermal energy production:

- **Dry Steam Power Plant – The most common method is pumping hot steam from magma-heated underground reservoirs into turbines to generate electricity.**
- **Flash Steam Power Plant – Pumping heated water into a storage tank, which generates steam to drive turbines.**
- **Binary Cycle Power Plant – Pumping heated water into a heat exchanger and then pumping it back down to be heated and used again.**

Geothermal heat pumps come in several variations, including closed and open-loop systems. Enhanced Geothermal Systems (EGS) are now available and involve pumping cold water underground to access heat sources more efficiently.

SELECT COMMERCIAL VENDORS SUPPORTING GEOTHERMAL ENERGY

AltaRock Energy – Provides enhanced geothermal systems (EGS) starting in Oregon.

Dandelion Energy – Supports local upgrades to geothermal (Google X spin-off company).

Eavor – Supports scalable baseload power using geothermal technology.

Fervo Energy – Delivers next-generation geothermal projects.

GreenFire Energy – Offers an advanced geothermal system (AGS).

Hybrixcel – Supports disruptive bubbling fluidized beds (BFBs).

Loki Geothermal – Icelandic company that supports geothermal power.

Quaise – Energy company that unlocks geothermal energy.

Sage Geosystems – Geothermal development company.

Strada Global – Uses smart drilling techniques for zero-carbon energy.

Terrapin Geothermics – Converts waste heat and geothermal energy into value.

BIOMASS

Biomass (or biorenewables) is organic, renewable material from trees, plants, and animals. Widely used in many countries as a cooking and heating fuel, biomass has the potential to support global sustainability objectives as an alternative to fossil fuels for electricity or heat generation.

OVERVIEW OF BIOMASS

The main benefit of biomass is the reduced reliance on fossil fuels. Biomass sources include:

- **Corn, soybeans, and other crops.**
- **Animal manure and human sewage.**
- **Municipal waste, including paper and cotton.**
- **Wood waste.**

Biomass is a sustainable alternative to coal as it contains chemical energy recently absorbed from the sun. Plants, for example, create biomass through photosynthesis. Direct combustion of biomasses produces heat, but other heat production methods include thermochemical, chemical, and biological conversion.

The best scenario is to burn existing biomass used for other purposes, such as wood, paper, and other products. However, using biomass sustainably requires it to grow at the rate it burns to produce energy.

Renewable diesel, gasoline, and jet fuels are produced, for example, by a hydrotreating process that combines bio-oil (created through pyrolysis) with hydrogen under high heat and pressure and in the presence of a catalyst. Additionally, cooking oils can be easily filtered and used as biodiesel.

In 2021, the U.S. consumed about 5% of its total energy from biomass, with 75% utilized in the industrial and transportation sectors. The remaining 25% went towards residential, commercial, and electric power.

INDUSTRY ISSUES WITH BIOMASS

The use of biomass for energy production is a topic of debate among scientists, particularly regarding environmental impact. While the industry asserts that biomass harvest always exceeds forest growth, verifying this claim is problematic. Moreover, deforested areas must grow back and remain intact to sequester carbon to achieve a pre-industrial climate.

In addition, biomass industry certification, such as the Sustainable Biomass Program (SBP), is often industry-controlled. This lack of independence raises questions about the autonomy and objectivity of these certifications.

The major hurdle with biomass use and biofuels for sustainability is the production of CO2 and other harmful gases during the burning phase, such as nitrogen oxide and volatile organic compounds. This aspect of biomass usage demands further research and scrutiny.

Biorenewables offer promise in the reuse of plant-based materials for creating products and materials, promoting a sustainable lifecycle without the release of carbon. Another related field is electrobiology, which explores the potential for harvesting the electrical phenomena of living organisms, including plants and animals.

SELECT COMMERCIAL VENDORS SUPPORTING BIOMASS

The biomass market will likely expand as efforts to achieve zero-carbon emissions gain momentum. The following companies offer solutions to support biomass use. We advise investors, energy officials, and enterprise sustainability officers to review this list to determine suitability for current and future projects. The TAG Climate team is available to assist with these selection decisions.

Lallemand Biofuels and Distilled Spirits – Develops lactic acid bacteria for biofuels.

Ossus Biorenewable – Electrobiology startup focused on biohydrogen.

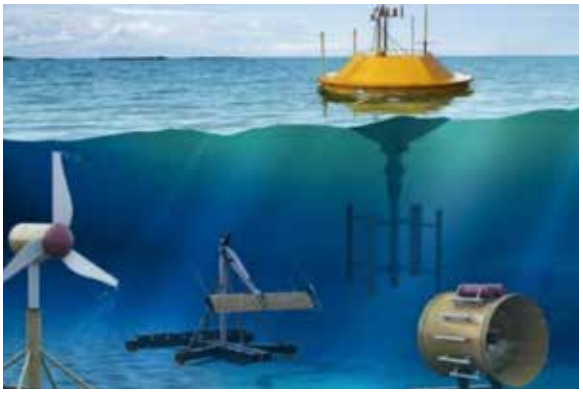
Spero – Converts biomass to chemicals.

Starbons – Produces products from biorenewables.

Trillium Renewable – Replaces oil and gas-derived propylene with biorenewables.

Xylome – Supports bioconversion of unconventional feedstocks.

MARINE HYDROKINETIC



Marine hydrokinetic energy utilizes the natural movement of the ocean's waves, tides, and currents to generate power. This form of energy can also harness thermal energy by capitalizing on the ocean's temperature differences.

OVERVIEW OF MARINE HYDROKINETIC

By some estimates, the U.S.'s total available marine energy equaled roughly 57% of all 2019 power generation. This abundance highlights the opportunity to leverage marine energy to drive an essential kinetic and thermal power source.

The process works through conversion—using buoys to capture energy from fluctuating water movement and turbines to convert energy from the ocean's tides and natural currents. Both methods are already in use today

Globally, many people live close to a coastline, so building the infrastructure for big marine energy delivery makes sense. Moreover, the seasonal and predictable patterns of the oceans make marine energy a reliable energy source, particularly as a supplement to less predictable renewable sources such as solar and wind power.

TECHNOLOGY ADVANCES IN MARINE HYDROKINETIC

Wave energy converters (WECs) are the most commonly used technology for marine hydrokinetic energy, focusing on cost-effective deployment for large-scale use. Additionally, innovation is required to connect marine energy sources and the power grid.

Often funded by government grants or other programs, Universities and research organizations developing optimal solutions for marine energy. Projects include:

- **Modeling and simulating marine energy collection and delivery.**
- **Testing programs for open water facilities.**
- **Improving marine energy device design.**

An innovative method involves constructing semi-permeable barrages across estuaries, which operate like dams to collect and release energy through turbines. Additionally, windmill-like submerged rotating devices are effective in harnessing hydrodynamic power.

SELECT COMMERCIAL VENDORS SUPPORTING MARINE HYDROKINETIC

The marine hydrokinetic market will likely expand as efforts to achieve zero-carbon emissions gain momentum. The following companies offer solutions to support marine hydrokinetic energy use. We advise investors, energy officials, and enterprise sustainability officers to review this list to determine suitability for current and future projects. The **TAG Climate team** is available to assist with these selection decisions.

AW-Energy – Offers Waveroller, which harnesses the power of the ocean.

Bombora – Provides patented mWave products in Australia.

CorPower Ocean – Supplier of wave energy systems for clean electricity.

Eco Wave Power – Develops floaters that draw energy from incoming waves.

Emrgy – Generates onsite clean energy using hydropower.

Floating Power Plant – Harvests limitless wind and wave energy.

Hydrokinetic Energy Corp – Develops hydrokinetic turbines for energy.

Littoral Power Systems – Works in the area of hydropower and ocean energy.

Marine Power Systems – Revolutionizing how energy is harvested from the ocean.

Ocean Power Technologies – Develops PB3 PowerBuoy for uninterruptable power.

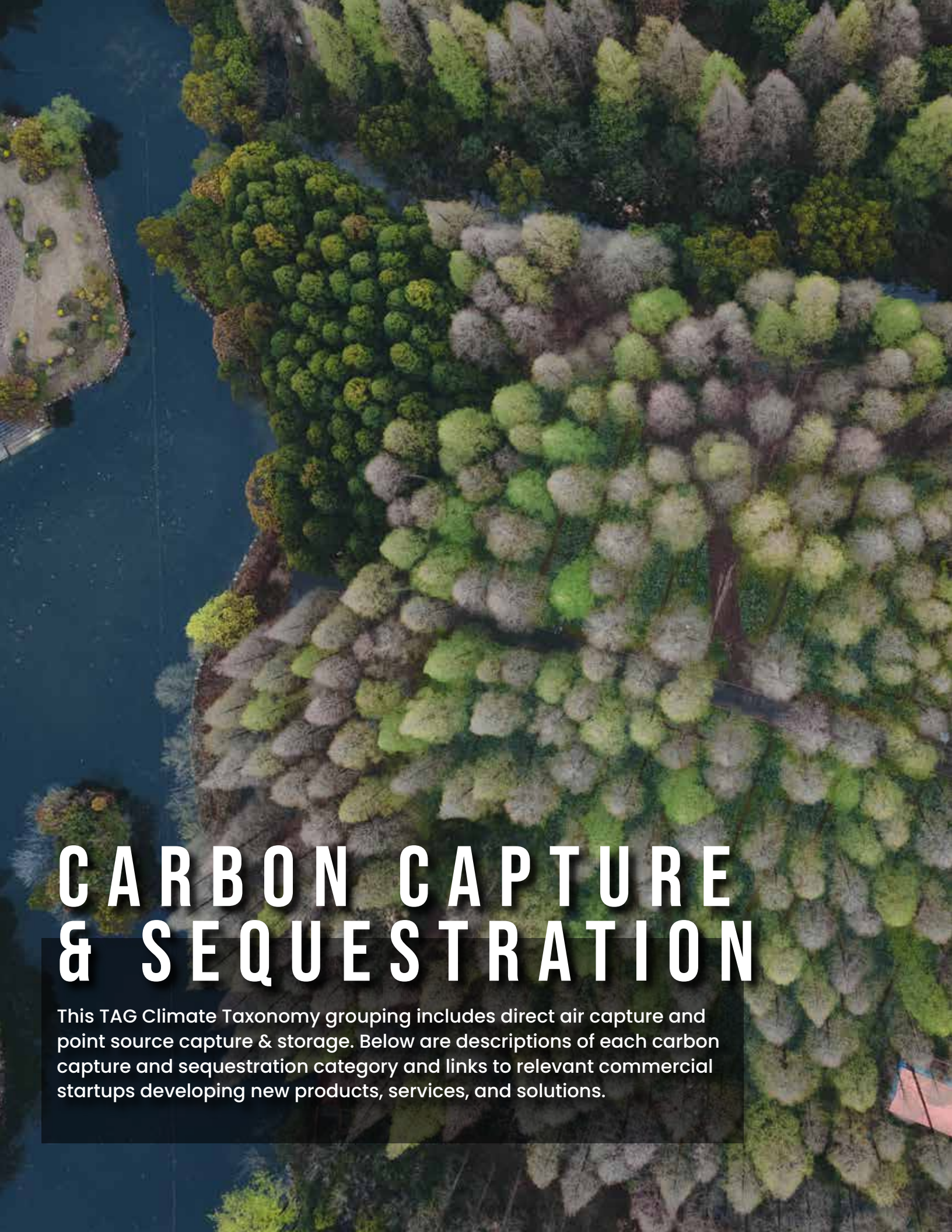
Ocean Renewable Power Company – Delivers energy using free-flowing rivers and tides.

Oscilla Power – Developing an advanced wave energy converter for oceans.

Schottel Hydro – Specializes in developing instream turbines.

Wavepiston – Harvests wave energy for competitive renewable sources.

Westergaard Solutions – Extracts energy via marine hydrokinetics.



CARBON CAPTURE & SEQUESTRATION

This TAG Climate Taxonomy grouping includes direct air capture and point source capture & storage. Below are descriptions of each carbon capture and sequestration category and links to relevant commercial startups developing new products, services, and solutions.

DIRECT AIR CAPTURE

Direct air capture (DAC) techniques are valuable for balancing global emissions. Carbon capture is a logical step toward a healthier atmosphere, and while trees offer a natural way to capture carbon dioxide, they cannot scale up to address 51 billion tons of emissions. As such, research and development are imperative to establishing DAC's viability and commercial and economic prospects.

BASICS OF CARBON CAPTURE

Each year, the earth deals with 51 billion tons of global emissions, which raises the obvious question of whether direct capture and removal are possible. As many people learn in grade school, trees absorb carbon dioxide. Most estimates suggest that even *with* a deforestation halt, there are not enough trees to tackle the sheer volume of emissions. Those who recommend planting trees to address emissions are simply not doing the math.

While reducing carbon and related emissions remains a priority, exploring potential methods of extracting harmful by-products from the air and atmosphere makes sense. However, global politics complicates the issue, as countries will inevitably debate balancing emission creation and removal.

METHODS FOR DIRECT AIR CAPTURE

Direct air capture (DAC) techniques are promising, but engineers are still developing practical and efficient DAC plants. According to the International Energy Agency:

"Direct air capture is a technology to capture CO2 from the atmosphere. The CO2 can be permanently stored in deep geological formations or used in the production of fuels, chemicals, building materials, and other products containing CO2.

"When CO2 is geologically stored, it is permanently removed from the atmosphere, resulting in negative emissions. There are currently 15 direct air capture plants operating worldwide, capturing more than 9000 tCO2/year, with a 1 MtCO2/year capture plant in advanced development in the United States.

"In the SDS, direct air capture is scaled up to capture almost 10 MtCO2/year by 2030. This is within reach but will require several more large-scale demonstrations to refine the technology and reduce capture costs."

Creative partnerships have emerged between large companies and engineering firms addressing the DAC challenge. For example, Carbon Engineering, which manages a sustainability fund that invests in startups, is partnering with Shopify to capture carbon emissions.

SELECT COMMERCIAL VENDORS SUPPORTING DIRECT AIR CAPTURE

1PointFive – Develops direct air capture technology.

C-Capture – Designs chemical processes for carbon capture.

Carbon Clean Solutions – Global company working on carbon capture technology.

Carbon Collect – Builds passive scalable carbon capture technology.

Carbon Engineering – Develops technology that supports DAC to reduce CO2.

Carbon Infinity – Creates carbon collection machines.

Climeworks – Develops DAC technology with high efficiency.

Global Thermostat – Develops solutions for extracting carbon from the air.

Heirloom – Uses DAC to enhance carbon mineralization.

Inventys – Supports carbon capture technology solutions.

LanzaTech – Offers carbon recycling technology.

Mission Zero – Develops DAC solutions that require low energy.

Sustaera – Uses an alkali metal-based carbon capture agent.

Verdox – Develops adsorption-based DAC solutions.

POINT SOURCE CAPTURE/STORAGE

Point source capture (PSC) involves collecting and storing emitted carbon from industrial sources. Research and development (R&D) teams design PSC projects to achieve high yields, and some sources claim that the method can capture up to 95% of the emitted carbon. The typical process entails bubbling the emitted gas through a solvent that absorbs, traps, and releases the CO2.

BASICS OF POINT SOURCE CAPTURE/STORAGE

The goal of PSC is to mitigate the harmful effects of industrial infrastructure emissions by safely capturing, storing, or using the emitted CO2. Target infrastructure point sources include natural gas power generation and other large CO2 emitting industrial sources.

TECHNOLOGY ADVANCES IN POINT SOURCE CAPTURE/STORAGE

Point source capture methods include absorption, adsorption, chemical looping, membrane gas separation, and gas hydration. Numerous promising PSC projects are underway, demonstrating new capture and storage methods in practical settings, targeting blast furnaces, cement plants, methane-reforming H2 plants, and many others.

Here are some prominent examples of PSC being applied in live industrial settings:

- **Power Generation – PSC is successfully applied to fossil fuel-based power production plants to separate CO2 from exhaust gases.**
- **Mineral Production – PSC is used in cement and lime production to separate CO_2 from emissions.**
- **Residual Reuse – PSC is also improving the safe disposal and management of inactive or legacy residual impoundments.**

SELECT COMMERCIAL VENDORS SUPPORTING POINT SOURCE CAPTURE/STORAGE

Aker Carbon Capture – Provides PSC solutions.

Carbfix – Converts CO2 into stone as permanent storage.

Carbon Clean – Supports solvent-based carbon capture from refinery point sources.

Cormetech – Supports the lifecycle management of carbon dioxide.

Clean Coal Technologies – Supports PCS to reduce carbon emissions in coal production.

CO2 Capsol – Provides carbon capture technology, including standalone units.

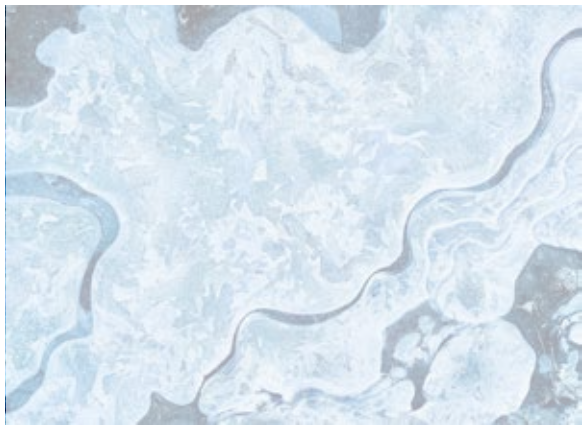
Dakota Gasification Company – Natural gas company that uses PSC in operations.

Equinor ASA – State-owned energy company in Norway that uses PSC.

Fluor Corporation – Engineering company that supports PSC engineering projects.

FuelCell Energy – Platform that can capture carbon while generating power.

Siemens – Utilizes PSC across various aspects of its businesses.



SOIL-BASED SEQUESTRATION

The goal of soil-based carbon sequestration is to safely store CO2 in the soil carbon pool. With proper management, soils can sequester over a billion tons of carbon yearly. The method increases the efficiency and capacity of natural CO2 storage by injecting CO2 into the soil after a direct air capture process.

OVERVIEW OF SOIL-BASED CARBON SEQUESTRATION

Estimates suggest that approximately ten percent of the Earth's land is used for crops, making it a suitable target for soil-based carbon sequestration. However, implementing this strategy requires updated farming methods to prevent the release of carbon during routine tilling.

A useful fact sheet provided by American University lists four important considerations related to the support of carbon sequestration:

- **Soil Disturbance Reduction – Switching to low-till or no-till practices and planting perennial crops.**
- **Crop Schedule Rotation – Changing or rotating planting schedules as opposed to leaving fields unsown.**
- **Managing Grazing – Actively managing and planning livestock grazing on farmland.**
- **Compost Management – Applying compost or crop residues to farmland.**

TECHNOLOGY ADVANCES IN SOIL-BASED CARBON SEQUESTRATION

According to a major study, soil-based carbon sequestration research methods include:

1. **Biological processes to increase carbon in soils.**
2. **Capturing and storing CO2 in soil as part of biomass generation.**
3. **Capturing CO2 directly and storing it in soil, and other methods.**

Areas that require additional technology and research advances include:

- **Land Use – Technology is required to help farmers optimize land use to ensure good carbon sequestration.**
- **Soil Analysis – Technology and research are needed to help farmers understand sequestration variations across different soil types and climates.**
- **Monitoring – Better technology will help farmers reliably monitor and manage carbon sequestration.**

Many U.S. federal government initiatives are expanding research and development in this area. For example, the U.S. Department of Agriculture (USDA) recently announced expanded research funding for soil carbon monitoring.

SELECT COMMERCIAL VENDORS SUPPORTING SOIL-BASED CARBON SEQUESTRATION

1PointFive – Supports carbon capture, utilization, and sequestration.

Aigen – Focuses on regenerative agriculture using a robotics platform.

GuildOne – Provides analytics to support credits for sequestration and other tasks.

Indigo Agriculture – Supports farmers with sustainable objectives.

Loam – Works with farmers to support carbon farming.

Nori – Offers solutions for carbon removal.

Perennial – Provides a verification platform for soil-based carbon removal.

TierraSpec – Measures carbon sequestration in agricultural soils.

Toucan Protocol – Offers carbon infrastructure for credits and verification.

CARBON MINERALIZATION

Carbon mineralization transforms carbon dioxide into a carbonite mineral like calcite or magnesite, effectively extracting atmospheric CO2 for secure storage. Although carbon mineralization occurs naturally, current research aims to replicate and hasten the process to combat greenhouse gas emissions.

OVERVIEW OF CARBON MINERALIZATION

Carbon mineralization requires dissolving carbon dioxide in solution, sufficient alkalinity, and favorable conditions for mineral dissolution and carbonate precipitation.

Carbon dioxide is **readily available** through combustion, gasification, and anaerobic digestion through coal, natural gas, biomass, or waste plastics. Techniques also exist to extract emitted CO2 using Ca and Mg-based substances to form carbonates.

This process, which **some observers** call "growing rocks," can potentially store 3,000 metric gigatons of carbon dioxide via basalt and ultramafic—two primary rock types with high levels of magnesium and iron.

TECHNOLOGY ADVANCES IN CARBON MINERALIZATION

Excluding natural processes, **laboratory studies** form the basis of most research on carbon mineralization and typically involve exposing carbon dioxide to ultramafic rocks or basalt at the surface, often using them as crushed mining waste.

Early pilot projects indicate that carbon mineralization in deep underground formations may cost approximately $30 per metric ton of CO2. However, utilizing crushed rocks at the surface can significantly reduce the cost to roughly $8 per metric ton.

Therefore, areas with plentiful basalt (such as Hawaii, which is abundant in volcanic basalt) are the most viable options for carbon mineralization. Meanwhile, areas with mine tailings and ultramafic rocks (like the upper Midwest) offer good prospects for surface storage of carbon mineralization.

SELECT COMMERCIAL VENDORS SUPPORTING CARBON MINERALIZATION

The carbon mineralization market will likely expand as part of the push for zero-carbon emissions. The following companies offer solutions that support carbon mineralization. Investors, energy officials, and enterprise sustainability officers should review this list to determine suitability for current and future projects. The **TAG Climate team** is also available to help with selection decisions.

44.01 – Provides CO2 storage.

Blusink – Supports carbon capture (including calcifying CO2 into rock).

Carbfix – Turns CO2 into stone for storage.

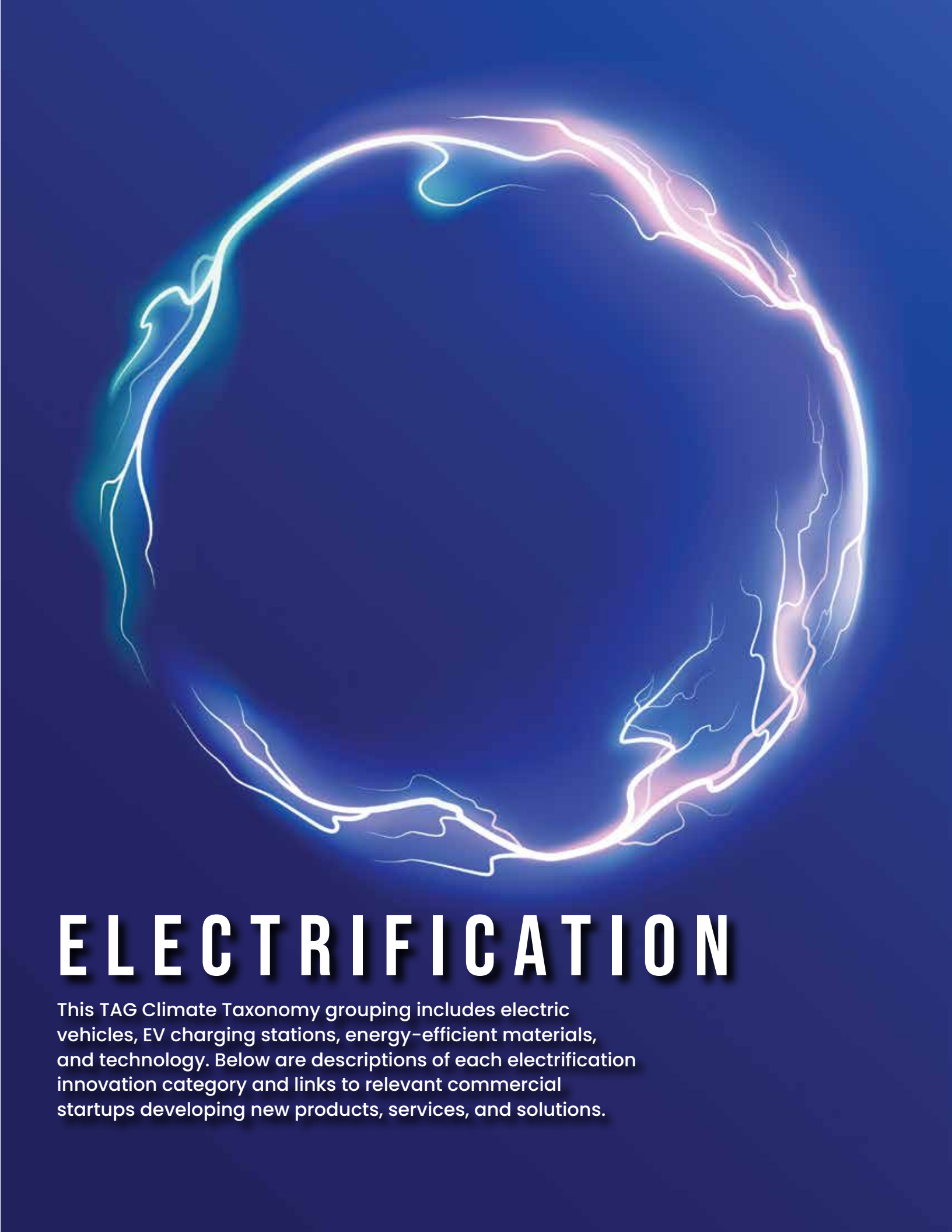
Carbin Minerals – Supports carbon mineralization.

Heirloom – Works in the area of carbon mineralization.

Lithos – Support mineral weathering via basalt.

Rushnu – Includes a process for carbon mineralization.

Travertine – Converts carbon into minerals.



ELECTRIFICATION

This TAG Climate Taxonomy grouping includes electric vehicles, EV charging stations, energy-efficient materials, and technology. Below are descriptions of each electrification innovation category and links to relevant commercial startups developing new products, services, and solutions.

ELECTRIC VEHICLES

Electric vehicles (EVs) regularly receive global attention for their low emissions and sustainability. While EVs emit fewer harmful pollutants than combustion engines, their environmental impact depends on the source of electricity. Although fossil fuel-generated electricity undermines the touted benefits of EVs, this growing market continues to attract investment from startups and traditional auto manufacturers.

OVERVIEW OF ELECTRIC VEHICLES

The objective of electric vehicles (EVs) is two-fold: firstly, manufacturers and consumers alike are motivated to reduce vehicle emissions. Secondly, buyers desire modern, quiet, and advanced features. EVs exemplify a product that advances climate objectives and generates significant consumer interest based on brand image and features.

The defining EV characteristic is its electric motor, powered by batteries, fuel cells, and solar panels. Electric power—often cheaper than gasoline—means EVs are emission-free, making them critical for global sustainability. There are three types of electric vehicles:

- **All-Electric: Exclusive reliance on a battery pack for power.**
- **Hybrid Electric: Uses an electric motor or a gasoline engine.**
- **Plug-In Hybrids: Operate with both traditional and electric motors.**

Consumers are increasingly choosing EVs, creating a vibrant market for these options.

TECHNOLOGY ADVANCES IN ELECTRIC VEHICLES

Many see EVs as environmentally friendly option, but several misconceptions exist about their impact. Some sources suggest that climate science goals link to these aspects of EV usage:

- **Emissions – EVs produce lower emissions than gas engines as they eschew the use of fossil fuels. This is non-controversial.**
- **Electricity – The method of electricity generation impacts the benefits of EVs. As countries decarbonize, there will be a commensurate decrease in EV emissions.**
- **Battery Production – The battery production process also influences EV emissions. Optimal battery production occurs in regions with low-carbon electricity or factories using renewable energy.**

Developments in electricity generation and battery production raise questions about the impact of EVs on sustainability goals. However, any reasonable analysis confirms that EVs offer significant long-term climate benefits.

Despite ongoing debates, lawmakers are rapidly moving towards implementing EV mandates. Multiple recent reports highlight California's push for mandate laws, while President Biden actively promotes EV usage across the United States, and this trend is likely to continue.

SELECT COMMERCIAL VENDORS SUPPORTING ELECTRIC VEHICLES

Aptera – Creates solar cars requiring no charging for most daily use.

Arrival – Creates reimagined urban EVs.

Bollinger Motors – Manufacturers electric trucks.

Canoo – Engineers EVs and trucks.

Fisker – American EV company.

Lucid Motors – Manufactures luxury EVs.

Mullen – Southern California EV company.

Nikola – Makes heavy-duty battery-electric vehicles.

Nio – Makes high-performance EVs.

Rivian – Manufactures electric adventure vehicles and trucks.

Tesla – Famous and pioneering EV company.

WM Motor – Chinese EV company.

XPeng – Global EV company.

EV CHARGING INFRASTUCTURE

Electric vehicle (EV) **charging stations** are a convenient, cost-effective, and sometimes free (ad-supported) way to charge EVs. Traffic patterns usually dictate station locations, with chargers drawing power from a 240V outlet or the grid. EV popularity will increase the demand for EV charging stations, creating exciting new business opportunities.

OVERVIEW OF ELECTRIC VEHICLE CHARGING STATIONS

EV charging locations include homes, businesses, roadsides, and destination points. Features required for EV charging startups include locator apps, charging monitoring, and support for fleets, drivers, and other users.

As of early 2023, China has over 200,000 charging stations, mostly in larger cities. The U.S. has 21,000 charging points in California, New York, Texas, and Florida, while Germany, France, and the U.K. have 50,000, 30,000, and 25,000, respectively.

Tesla drivers can have a **wall connector** installed by a Tesla-certified electrician. In addition, the mobile connector option plugs into a standard three-prong 120-volt outlet and provides approximately 2 to 3 miles of driving range per charge hour. For greater efficiency, adapter bundles work with 240-volt outlets, providing a range of 30 miles per charge hour.

TECHNOLOGY ADVANCES IN ELECTRIC VEHICLE CHARGING STATIONS

EV charging stations are moving toward application programming interface (API)-connected support for multiple charging networks. There is also a shift towards cloud-based operations to manage the charging network and the vehicles. Modern touchscreen interfaces continue to emerge, especially in corporate locations. Overall, the basic charging process remains: park the EV and plug it into the charging station.

The EV charging process involves transferring electrical energy to a battery, with differences based on speed and plug type.

Level 1 charging stations use a standard 120-volt outlet, with an 8 to 20 hours charge time. Level 2 charging stations use a 240-volt outlet to complete a charge in 4 to 8 hours, and 480-volt DC charging stations can fully charge an EV in less than an hour.

SELECT COMMERCIAL VENDORS SUPPORTING EV CHARGING STATIONS

ChargePoint – Offers a large network of EV charging stations.

EV Connect – Locates EV charging stations with payment options.

EVBox – Offers smart EV charging stations and software.

FreeWire Technologies – Provides faster and more powerful charging stations.

InstaVolt – Public EV rapid charging network across the U.K.

POD Point – Offers EV charging in the U.K.

Tesla – Operates 40,000 superchargers accessible 24/7.

Ubitricity – the U.K.'s leading public EV charging provider.

Volta – Supports EV charging in the U.S.

Wallbox – Smart electric car charging stations supporting many countries.

SMART GRID

A smart grid is an electricity network with intelligent automated support that manages and optimizes electricity usage and delivery to promote climate stability and a sustainable future. Smart grids facilitate electricity and data flow and detect, react to, and proactively address usage changes. Since sustainability relies heavily on electricity optimization, smart grids are essential to climate science initiatives.

OVERVIEW OF SMART GRIDS

Several organizations note that smart grid methods significantly enhance renewable energy generation. The advantages of employing a smart grid for sustainable energy include:

- **Usage – Improved utilization of the power system.**
- **Operation – Increased efficiency across the grid.**
- **Amount – Increased capacity for grid-connected clean energy.**

At TAG Climate, we view sustainable smart grids as positive for climate change, especially with the increasingly strong interrelationship with solar, wind, and photovoltaic systems.

ADVANCES IN SMART GRIDS

The technological developments that enable a smart grid include increased wireless-based remote monitoring, local sensor operation, and collecting, managing, and analyzing data. These advances benefit all types of energy, but integration with sustainable sources can increase clean energy efficiency.

Some additional advances in smart grid technology include:

- **Renewable Integration – The continued integration of renewable energy sources into smart grid operation.**
- **Smart Metering – Accurate, real-time energy usage data by utility and energy company customers.**
- **Distributed Sources – The increased distribution of energy storage and microgrids into complex networks.**

An essential part of smart grid operation is creating homeowner and business distribution networks to participate in net metering programs. This distributed approach to grid augmentation is scalable and expandable and will lower utility payments and reduce grid energy usage.

SELECT COMMERCIAL VENDORS SUPPORTING SMART GRIDS

ABB – Provides digital technologies for utilities and energy.

Cisco – Supports networking solutions for smart grids.

Enphase Energy – Global energy management company using solar.

IBM – Provides smart grid technology.

Invenia – Team of scientists and engineers addressing the environment.

Itron – Utilities for energy and water.

Materials Zone – Materials and manufacturing provider.

Raptor Maps – Advanced software for the solar lifecycle.

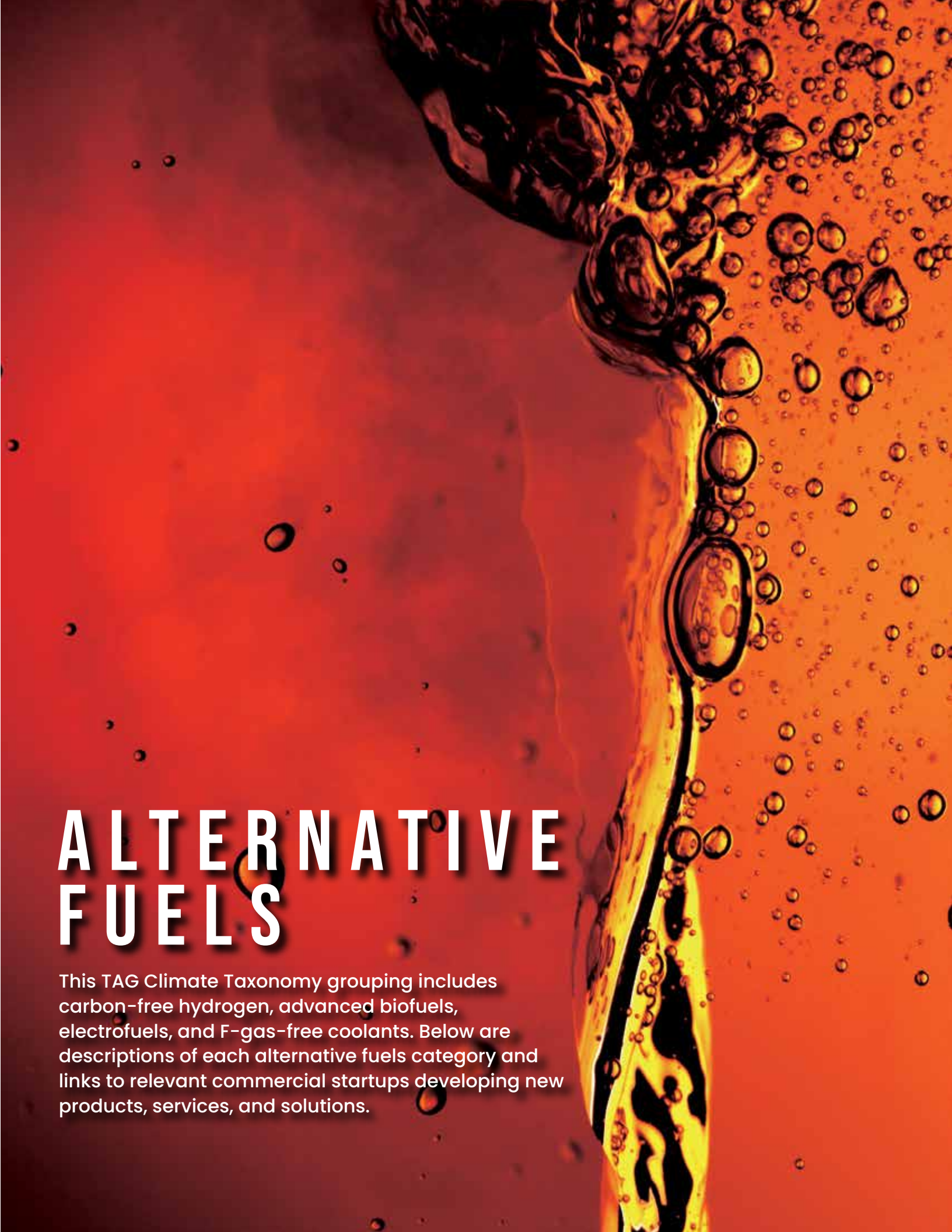
S&C Electric – Provider of equipment and services for power.

Siemens – Supports energy distribution automation.

Stem – AI-driven clean energy solutions.

Sunverge – Provides an energy platform.

Uplight – Connects energy ecosystems.



ALTERNATIVE FUELS

This TAG Climate Taxonomy grouping includes carbon-free hydrogen, advanced biofuels, electrofuels, and F-gas-free coolants. Below are descriptions of each alternative fuels category and links to relevant commercial startups developing new products, services, and solutions.

CARBON-FREE HYDROGEN

Certain methods of carbon-free hydrogen production can prevent greenhouse gas emissions. During electrolysis, for instance, electricity passes through water to separate hydrogen and oxygen atoms, which can produce carbon-free hydrogen when powered by sustainable or renewable sources. In addition, burning or using carbon-free hydrogen in fuel cells produces water as a by-product, which is cost-effective and highly significant in promoting clean energy worldwide.

OVERVIEW OF CARBON-FREE HYDROGEN

The green hydrogen economy **offers the potential for carbon-free options** in many difficult-to-decarbonize sectors, such as steel and transportation. Working towards this goal, the U.S. Department of Energy unveiled in 2020 its **Hydrogen Program Plan**, a strategic framework for green hydrogen in all U.S. energy sectors.

The plan's key aspects include applications for transportation, chemical processes, power generation, and hybrid energy, plus hydrogen:

- **Production using fossil resources.**
- **Delivery through tube trailers.**
- **Storage via physical and material-based methods**
- **Conversion through combustion and fuel cells.**

ADVANCES IN CARBON-FREE HYDROGEN

Hydrogen is obtainable from **renewables, fossil fuels with carbon capture, and nuclear power** via thermochemical techniques like reforming, gasification, pyrolysis, and electrolysis.

The goal is to enable the generation, storage, and delivery of hydrogen at a massive scale, with a primary focus on sustainable generation.

Ideally, a lifecycle will emerge where renewables power electric grids and enable hydrogen extraction from water and waste products. Possible uses include power generation, transportation, synthetic fuels, oil upgrades, ammonia and fertilizer, metals production, chemical/industrial processes, heat, and distributed power. Gas infrastructure can also contribute to hydrogen production, but sustainability is far from optimal.

Common commercial products that utilize hydrogen include:

- **Compression systems.**
- **Fuel cell electric vehicles (FCEVs).**
- **Fuel cell electric generators.**

Zero-emission vehicles offer the potential to maintain a longer range and faster fueling than battery electric vehicles.

SELECT COMMERCIAL VENDORS SUPPORTING CARBON-FREE HYDROGEN

Air Products – Large company that utilizes hydrogen production.

Adani Green Energy – Produces green hydrogen.

Bloom Energy – Develops green hydrogen fuel cells.

DiviGas – Supports clean-up of hydrogen production systems.

FuelCell Energy – Produces hydrogen from natural gas or biogas.

H2X – Manufactures zero-emission hydrogen fuel vehicles.

Heliogen – Delivers solar solutions to deliver renewable energy (including hydrogen).

Hydrox Systems – European company that researches hydrogen to reduce emissions.

HySiLabs – Develops solutions for transporting liquid hydrogen.

Linde – Manufactures gases (including hydrogen).

Loop – Offering hydrogen fuel cell technology.

Plug Power – Develops hydrogen fuel cell systems.

Reliance – Large company whose work includes hydrogen.

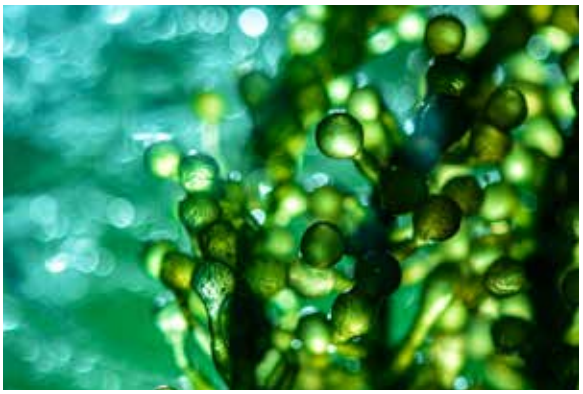
Shell – Large company that invests in green hydrogen generation.

Skyre – Develops scalable hydrogen recycling solutions.

SunFire – Supports modular plants and hydrogen electrolysis systems.

SunHydrogen – Uses sunlight to produce renewable hydrogen.

ADVANCED BIOFUELS



Despite the development of advanced zero-carbon biofuels, the shift towards using non-food to achieve a zero-carbon footprint remains challenging. The goal is for advanced biofuels to replace carbon-heavy biofuels like ethanol and biodiesel and offer an seco-friendly substitute for vehicles.

OVERVIEW OF ADVANCED BIOFUELS

Most people are familiar with ethanol as a gasoline additive in their cars. Unfortunately, ethanol production (from corn in the U.S. and sugars in Brazil) is not a zero-carbon process. Nonetheless, using advanced **second-generation biofuels** is crucial in utilizing carbon dioxide with a low or zero carbon footprint during production.

In 2016, the Gates Foundation invested $14 million in **Renmatix,** a biomass conversion company, to develop an efficient, zero-carbon advanced biofuel product. Expanding advanced biofuels to the aviation industry provides a clear commercial incentive for innovative new companies to research this crucial area.

ADVANCES IN BIOFUELS

Recent advances in biofuel production include:

- **Using algae to create fuel.**
- **Developing biofuels from organic waste.**
- **Utilizing synthetic biology to increase biofuel yield.**
- **Biogas production from organic waste.**
- **Conversion of carbon dioxide into biofuels.**

The most common process for developing second-generation advanced biofuels involves sustainably extracting biochemicals and materials from agriculture and business waste. Popular methods include:

- **Thermochemical Methods – Includes heating carbon-based materials to produce gases for synthesis into jet and diesel fuels. Gasification of waste wood is another typical process.**
- **Biochemical Methods – Involves processes that expedite hydrolysis to isolate ingredients (like cellulose) for fermentation into alcohols like ethanol and butanol.**

SELECT COMMERCIAL VENDORS SUPPORTING ADVANCED BIOFUELS

Enerkem – Manufactures biofuels and renewable chemicals.

Evergaz – Develops and operates biogas plants.

GreenFuel – Supplies car components for alternative gas fuels in India.

Inventure Chemical – Makes chemicals from agribusiness residue and waste streams.

LanzaTech – Uses microbes to produce material commodities from pollution.

NewCO2Fuels – Produces fuels from carbon dioxide.

Nexterra – Makes renewable fuels from waste.

NULIFE GreenTech – Transforms wet organic waste into low-carbon fuels.

Pond Technologies – Converts waste into useful output.

Renmatix – Transforms plants into biofuels.

Sierra Energy – Converts biomass into renewable energy.

Viridos – Uses photosynthesis to transform algae into biofuels.

Woodland Biofuels – Creates renewable gas and ethanol.

ELECTROFUELS

To combat climate change, scientists and engineers are developing techniques for producing synthetic electrofuels that offer a carbon-neutral alternative to petroleum. Creating electrofuels involves storing renewable energy in the chemical bonds of liquids or gases like butanol, biodiesel, hydrogen, methane, and butane.

OVERVIEW OF ELECTROFUELS

Electrofuels offer a carbon-neutral, cheaper, or price-neutral alternative to petroleum, with **e-diesel and e-gasolines becoming particularly desirable options.** Another driving force behind this innovation is concern over the political conflict and global supply chain issues associated with **traditional fuel pipelines**. Applications for synthetic electrofuels include:

- **Transportation – Replacing gasoline, diesel, and aviation fuels across the transportation and delivery industries.**
- **Energy Storage – Easier storage and transportation than electricity to help balance the energy grid.**
- **Chemical Production – Use of synthetic fuels as feedstock for chemical and material production.**
- **Military Applications – Potentially useful for more sustainable military vehicles and aircraft.**

The **eFuel Alliance** advances and intensifies the production of synthetic carbon-neutral fuels and promotes eFuels to policymakers and other stakeholders.

ADVANCES IN ELECTROFUELS

Scientists synthesize electrofuels from renewable sources like water and CO2 from the air. The process uses electricity but differs from conventional fuel creation as there's no CO2 by-product. Most electrofuels are compatible with internal combustion engines, making them suitable for use in planes, ships, and cars that prioritize climate-friendly operation.

The typical e-fuel creation process involves using electrolysis to break down water (including seawater) into hydrogen and oxygen and combining it with CO_2 to produce storable and transportable e-fuel. This process facilitates the production of ePetrol, eDiesel, and eKerosene, which customers can use in a climate-neutral manner.

Converting carbon dioxide and hydrogen into synthetic fuels is referred to as power-to-liquids (PTL). It produces a versatile output suitable for transportation or as a feedstock for the chemical industry.

SELECT COMMERCIAL VENDORS SUPPORTING ELECTROFUELS

Arcadia – Produces eFuels focused on net carbon-zero.

Carbon Engineering – Offers DAC for use in synthesizing liquid fuels.

E-Fuel Corp. – Converts combustion engine exhaust gases into oxygen.

Elcogen – Develops solid oxide (SOC) technology.

HIF Global – A global eFuels company with a focus on decarbonization.

Infinium – Creates clean burning electrofuels.

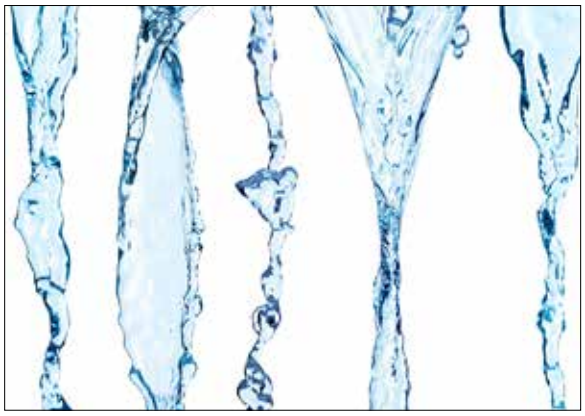
Liquid Wind – Produces carbon-neutral fuel.

Neste – Produces renewable fuels.

Sunfire – Produces industrial electrolyzers.

Topsoe – Supports the production of synthetic fuels and chemicals.

F-GAS-FREE COOLANTS



Initially developed to protect the ozone layer, fluorinated gas (F-gas) is a potent greenhouse gas with a more damaging climate impact than CO2. Improving coolants in refrigeration (to contain emissions) is the primary method of reducing F-gas usage.

OVERVIEW OF F-GAS-FREE COOLANTS

Ironically, F-gas initially addressed the issue of ozone depletion. Given its negative environmental impact, the new goal of F-gas-free (FGF) coolants is to avoid harmful gases, especially in cooling systems.

Most sustainable coolants comprise alternative refrigerants like hydrofluoroolefins (HFOs), carbon dioxide, ammonia, or propane. The main objective is to produce coolants safe for typical refrigeration applications using processes with minimal environmental impact. With regulatory authorities attempting to limit F-gas, FGF coolants are now a vital initiative.

ADVANCES IN FGF COOLANTS

F-Gas Regulation (EC) No. 842/2006 (later revised) governs FGF coolants in Europe. The regulation demands **measures and restrictions on the marketing and use of products and equipment using F-gases**. As a result, commercial entities must deal with the issue by addressing the following requirements:

- **Labeling of equipment containing F-gases.**
- **Reporting on imports, exports, and production of F-gases.**
- **Avoiding F-gases in applications with environmentally improved alternatives.**

The EPA's Significant New Alternatives Policy (SNAP) program regulates F-gases in the United States. SNAP evaluates alternative refrigerants, sets restrictions on using gases with high global warming potential (GWP), and drives the eradication of hydrochlorofluorocarbons (HCFCs) and chlorofluorocarbons (CFCs).

SELECT COMMERCIAL VENDORS SUPPORTING F-GAS-FREE COOLANTS

Carrier – Large company that offers CO2 refrigerants.

Chemours – Global firm that includes HFOs for refrigeration.

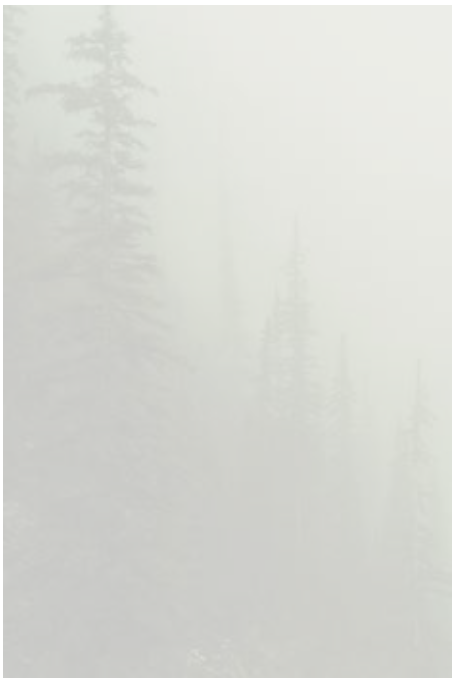
Daikin – HVAC company that uses sustainable refrigerants.

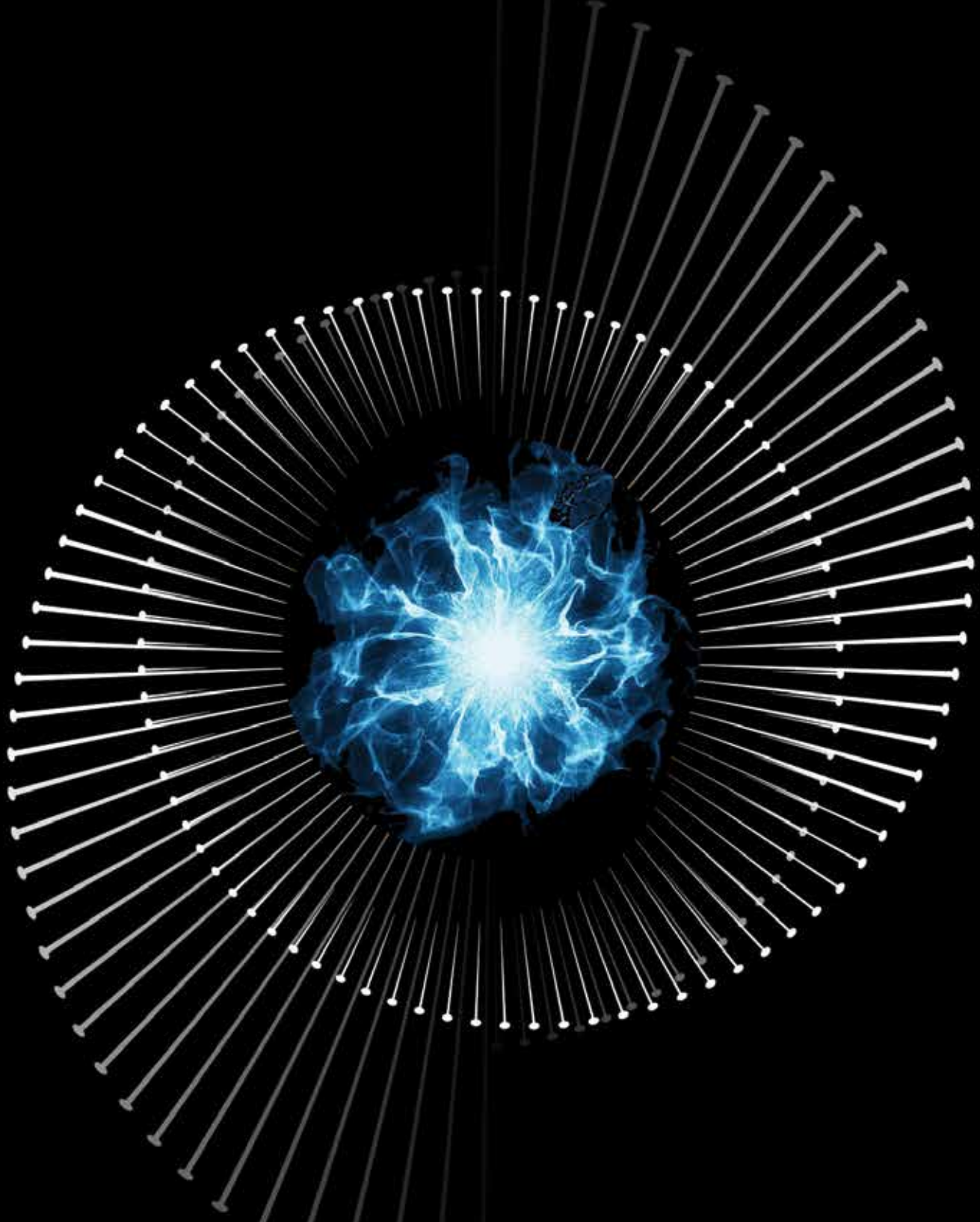
Gradient – AC company with sustainable options.

Honeywell – Provides HFOs and other refrigerants.

Linde – Provides a range of sustainable refrigerants.

Phononic – Cooling company with sustainable options.

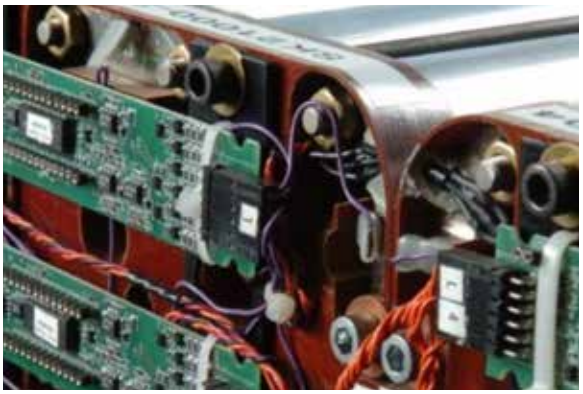




ENERGY STORAGE

This TAG Climate Taxonomy grouping includes thermal storage, fuel cells, and electricity storage. Below are descriptions of each energy storage category and links to relevant commercial startups developing new products, services, and solutions.

BATTERY TECHNOLOGIES



Techniques for battery-based electricity storage require major innovation to make them cost-effective and scalable. While natural sources of stored electricity are useful, they often suffer from intermittent generation. Addressing this challenge is crucial for the widespread adoption and integration of renewable energy sources into the existing power grid.

OVERVIEW OF BATTERIES

Some argue that inexpensive electricity generation, storage, transmission, and consumption are key to achieving zero carbon emissions. Batteries are the most apparent current solution, but the economic viability of large-scale battery-based electricity storage remains limited.

Batteries work by converting stored chemical energy into electrical energy through the flow of electrons from one electrode to another. This electron flow process powers everyday applications, such as powering appliances, devices, and other components.

ADVANCES IN BATTERIES

Most battery research today focuses on enhancing the density of lithium batteries, which rely on the movement of lithium ions between the anode and cathode. However, scaling this approach is challenging as lithium can pose safety concerns and is **highly flammable under specific conditions.**

Researchers are actively exploring new battery technologies that offer enhanced efficiency, safety, and improved thermal stability. For instance, Sila Nanotechnologies is experimenting with silicon particles for the graphite anodes in lithium-ion batteries. Deep cycling to improve lithium metal electrode performance is another promising method.

SELECT COMMERCIAL VENDORS SUPPORTING BATTERIES

The electricity storage market will likely expand as efforts to achieve zero-carbon emissions gain momentum. The following companies offer solutions to support this objective. We advise investors, energy officials, and enterprise sustainability officers to review this list:

Advano – Scalable solution for Li-Ion batteries.

Ambri – Long-duration clean energy storage solution.

Aquion Energy – Deep cycle batteries for reliable energy storage.

EnPower – High-performance battery company.

H2GO Power – Clean, accessible, and reliable hydrogen energy.

Highview Power – Technology delivers simultaneous energy storage.

Ion Storage Systems – Safe solid-state battery.

Nanotech Energy – Single-layer graphene products.

Northvolt – Supports sustainable Li-ion battery cells.

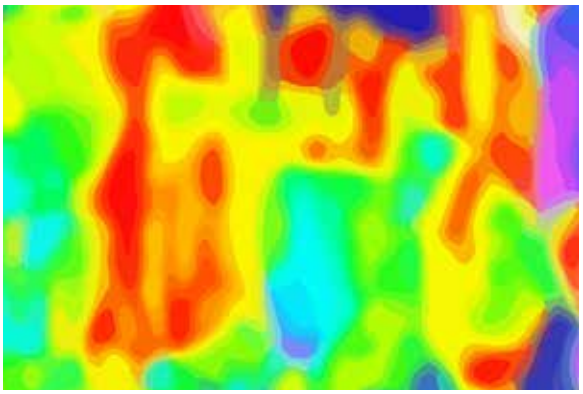
QuantumScape – Builds solid-state Li-metal batteries for energy storage.

RedFlow – Produces a safe, scalable zinc-bromine flow battery.

Sila Nanotechnologies – Engineered materials company working in energy storage.

Solid Power – Develops all-solid-state battery cells.

THERMAL STORAGE



Thermal storage is a crucial technique for utilizing low-cost electricity to heat materials for use when energy demand arises. Many startups are adopting this approach to help the transition towards a zero-carbon future.

OVERVIEW OF THERMAL STORAGE

Thermal energy storage (TES) development for beneficial purposes coincides with the reality of global warming, where our atmosphere traps heat radiating toward space. Carbon dioxide (CO2), water vapor (H20), nitrous oxide (N2O), and methane (CH4) prevent the heat from escaping, which consequently causes changes in temperature and climate.

Thermal energy storage methods share a similar concept of integrating renewable energy into various applications, including power generation, industrial usage, and building applications. The global TES market may triple by 2030, with investments in TES applications set to reach $28 billion. Additionally, molten salt storage may expand from 491 GWh to 631 GWh by 2030.

ADVANCES IN THERMAL STORAGE

Molten salts are widely used for thermal storage as they can accumulate and preserve energy effectively. When paired with solar power, they hold promising commercial potential. Molten salt possesses desirable characteristics, including a melting point of 268 degrees Fahrenheit, liquid maintenance at 550 degrees Fahrenheit, and efficient circulation through solar panels at **a staggering 1,051 degrees Fahrenheit**.

Various complex methods exist to store energy for electricity and heat production, including molecular solar thermal (MOST) systems. MOST systems use photoisomerization to convert molecules into higher-energy isomers, storing energy until triggered by a specific action. This is one of many chemical processes with the potential to increase the commercial viability of thermal energy storage.

SELECT COMMERCIAL VENDORS SUPPORTING THERMAL STORAGE

Azelio – Swedish company that develops clean energy storage systems.

Bloom Energy – Works in the area of electricity generation and distribution.

Coolsys – Develops innovative energy solutions (acquired Axiom).

Energy Vault – Creates long-duration energy storage solutions.

EOS Energy Storage – Produces zinc-powered energy storage solutions.

Fluence – Siemens and AES company that supports energy storage.

Form Energy – Multi-day energy storage system company.

Highview Power – Offers energy storage through renewable power stations.

Ice Energy – Energy storage company that serves utility companies.

Off Grid Box – Develops off-grid clean water and renewable energy.

Phase Change Solutions – Supports energy-efficient solutions.

Skeleton Technologies – Supercapacitor and battery energy storage.

Stem – Develops AI-enabled smart energy storage.

Sunamp – Manufactures thermal storage systems.

TerraPower – Provides nuclear carbon-free energy for medical use.

Viking Cold Solution – Thermal energy management company.

Zenobe – Delivers zero-carbon power and transport systems.

FUEL CELLS

Fuel cells use hydrogen's chemical energy to generate low or zero-emission electricity. While similar to batteries in terms of energy storage capabilities, fuel cells offer a distinct advantage by storing energy and directly converting it into usable electrical power, creating an eco-friendly alternative to traditional combustion-based power generation methods.

OVERVIEW OF FUEL CELLS

Fuel cells are essentially electrochemical devices that efficiently convert chemical energy into electrical energy with minimal emissions. Many expect fuel cells to be the future replacement for gas-powered combustion engines.

Fuel cells typically involve an electrochemical arrangement that generates electricity from oxygen and hydrogen. The key to this process is redox reactions that change the oxidation states of the substrates. Unlike batteries, fuel cells can continuously produce electricity as long as fuel and oxygen are available.

The proton exchange membrane fuel cell (PEMFC) operates by supplying hydrogen gas to the anode side of the fuel cell and oxygen to the cathode side. Hydrogen molecules then split into protons and electrons, with protons traveling through the electrolyte to the cathode while electrons pass through a circuit to generate electricity.

ADVANCES IN FUEL CELLS

Researchers and scientists are making significant progress in fuel cell development. According to the U.S. Department of Energy, improvements in membrane electrode assemblies (MEAs) are helping new fuel cells reach operation times of up to 8,000 hours for light-duty vehicles, 30,000 hours for heavy-duty trucks, and 80,000 hours for distributed power systems.

SELECT COMMERCIAL VENDORS SUPPORTING FUEL CELLS

Amogy – Develops ammonia-based fuel cells.

Ballard Power – Provider of clean energy fuel cells.

Bloom Energy – Offers a range of electricity and energy solutions.

Bramble Energy – Developer of proton exchange membrane-based fuel cells

Ceres Power – Develops clean energy technology.

Convion – Leading fuel cell system designer.

Doosan – Makes environmentally friendly fuel cells.

FuelCell Energy – Manufactures fuel cells.

GenCell – Creates hydrogen and ammonia fuel cells.

Horizon – Liquid-cooled and air-cooled PEM fuel cells.

Intelligent Energy – Develops air-cooled and evaporatively cooled fuel cells.

Ionomr Innovations – Develops advanced anion-exchange membranes.

Plug Power – Manufactures hydrogen-based fuel cells.

SolidPower – Makes all-solid-state battery cells.

Sunfire – Produces high-temperature solid oxide fuel cells.

SUSTAINABLE MATERIALS

This TAG Climate Taxonomy grouping includes carbon-free fertilizer, plastics, cement, steel, and oils. Below are descriptions of each zero-carbon materials category and links to relevant commercial startups developing new products, services, and solutions.

ENERGY-EFFICIENT MATERIALS

Energy-efficient materials include LED lighting, windows, insulation, thermostats, sustainable building materials, and more. The practicality of energy efficiency lies in using less energy to accomplish a particular job, such as maintaining a comfortable home temperature or improving energy usage.

OVERVIEW OF ENERGY-EFFICIENT MATERIALS

Energy-efficient materials aim to reduce energy usage in daily activities to save money, minimize energy demand, and reduce the negative environmental impact of electricity and other energy sources. As part of the drive toward sustainability, several industries are switching focus to eliminate energy waste.

The energy-efficient materials industry promotes the research, development, manufacture, installation, and use of materials with a more energy-efficient lifecycle. As governments implement more regulations and incentives for efficient energy use, this industry has the potential for massive growth.

In the U.S., energy policy-related regulations and laws include the Energy Policy Act (2005), the Energy Independence and Security Act (2007), the Energy Efficiency Resource Standards (EERS), the Energy Star Program (by the EPA), the Federal Energy Management Program (FEMP), and various local building energy code programs.

TECHNOLOGY ADVANCES IN ENERGY-EFFICIENT MATERIALS

Many useful reports outline the benefits of energy-efficient materials, with an emphasis on:

- **Light Bulbs – The lighting industry is moving toward improved light bulb design, including labeled certifications such as ENERGY STAR that designate lower energy usage.**
- **Windows – Improved manufacturing materials create windows that reduce heat exchange and air leakage in and out of the home.**

- **Insulation – Better insulation products are enhancing energy efficiency in the home.**
- **Thermostats – WiFi-enabled smart thermostats ensure that energy usage matches the need.**

Smart glass is attracting significant attention from energy-efficiency startups and investors due to its potential for energy savings, use of sustainable materials, good business prospects, and support for climate initiatives.

Additionally, AI technologies require more processing power from larger computer complexes, so designing data centers with energy-efficient materials is increasingly crucial.

ENERGY EFFICIENT MATERIALS

Albotherm – Develops glass coatings that reduce solar gain in hot weather.

CleanFiber – Creates high-performance cellulose insulation.

Echogen – Uses heat exchange to improve energy efficiency.

Gauzy – Manufactures glazed smart glass for solar control and energy efficiency.

Halio – Develops smart glass for energy savings

Heliatek – Develops solar films for building photovoltaics.

Heliogen – Uses mirrors to control heat for industrial processes.

SageGlass – Develops smart windows for energy savings.

SWITCH – Develops ESG-compliant data centers.

Tecnoglass – Industry leaders in smart glass coatings and configurations.

View – Makes smart glass and display solutions.

ENERGY-EFFICIENT TECHNOLOGY

Energy-efficient technology optimizes energy usage through lighting, heating, ventilation, air conditioning, insulation, windows, appliances, solar panels, wind turbines, and various software and technology applications. Alongside that, energy management systems drive cost efficiencies through smart apps and other commercial options, helping families and businesses improve overall cost-effectiveness and efficiency.

OVERVIEW OF ENERGY-EFFICIENT TECHNOLOGY

Energy optimization apps enable power management with common features like cost and usage calculators, energy tracking, personalized savings, device scheduling, and remote outlet control. These apps are usually available for iOS and Android and often depend on cloud-based support.

ADVANCES IN ENERGY-EFFICIENT TECHNOLOGY

Energy-efficient technology solutions include:

- **Forecasting – Technology that allows energy consumption forecasting to improve efficiency.**
- **Control – Helping businesses and organizations control local energy generation and consumption.**
- **Cost Savings – Technology to help consumers and businesses reduce energy consumption costs.**
- **Measurement – Helping businesses measure energy consumption to optimize usage.**

Some modern solutions now use artificial intelligence (AI) to predict energy usage optimization, which paves the way for smart technology to develop autonomous control of energy usage. Observers expect AI to significantly enhance forecasting, building management, and renewable energy integration while optimizing costs and decision-making efficiency.

SELECT COMMERCIAL VENDORS SUPPORTING ENERGY-EFFICIENT TECHNOLOGY

Bamboo Energy – Supports the efficient management of energy resources.

Budderfly – Offers Energy-as-a-Service (EaaS) to ensure cost savings.

Carbon Masters – Carbon management consultancy with support for efficient tech.

ClearTrace – Provides hourly emissions tracking.

Correlate – Identifies cash flow positive energy solutions.

DEXMA – Supports energy intelligence and management.

Ecoligo – Supports financing and management of solar tech.

CARBON NEUTRAL FERTILIZER

Zero-carbon (or carbon-free) fertilizer supports large-scale fertilizer production without generating carbon dioxide as a by-product. Innovative new methods currently being implemented include utilizing shining light to move the production process towards carbon neutrality.

OVERVIEW OF ZERO-CARBON FERTILIZER

Carbon-free fertilizer aims to eliminate CO2 generation during production, including ammonia synthesis and other steps. Methods include improved nutrient technology (for better plant absorption efficiency), fertilizer generation using zero-carbon biomaterials, carbon-free nitrogen production, and enhanced farm monitoring.

Most zero-carbon fertilizers use new and sustainable production methods, such as:

- **Renewable Energy Sources – Rejecting fossil fuels in favor of wind, solar, or hydropower for fertilizer production.**
- **Carbon Capture – Capturing production-generated CO2 for safe storage (usually underground).**
- **Sustainable Materials – Using sustainable raw materials (like agricultural waste biogases) for fertilizer production.**

After years of use, organic fertilizers remain an excellent alternative to chemical enhancement. Creating eco-friendly fertilizers is **a huge market,** with many companies innovating in this area.

ADVANCES IN ZERO-CARBON FERTILIZER

Carbon-free fertilizer production plays a vital role in reducing carbon emissions. Startups addressing this issue employ a diverse array of methods, including:

- **Substitution – Using replacement fertilizers to avoid carbon-producing synthesis.**
- **Production – Improving processes to eliminate CO2-emitting steps.**
- **Efficiency – Monitoring and improving nutrient absorption to reduce fertilizer production demand.**

One initiative under discussion is using "green ammonia" to mitigate the environmental impact. This method entails electrifying and decarbonizing processes to support carbon-free fertilizer production.

SELECT COMMERCIAL VENDORS SUPPORTING ZERO-CARBON FERTILIZER

Anuvia – Focuses on granular plant nutrient manufacturing.

Biostar Organics – Produces organic fertilizers.

Ginkgo Bioworks – Advanced biomanufacturing company.

Hexas – Produces sustainable biomaterials.

Midwestern BioAg – Creates organic fertilizers.

Nitricity – Electrifies and distributes the production of fertilizer.

OneSoil – Farming application for precision agriculture.

Pivot Bio – Transforms fertilizer use and production.

Primary Ocean – Seaweed biotechnology company.

Scotts – Makes organic fertilizers.

Yara – Large fertilizer company.

ZERO-CARBON PLASTICS

Carbon-free plastic production aims to support mass production without generating CO2 as a by-product. Innovative new methods to create zero-carbon ethylene and polyethylene (including converting gas emissions) are essential to reducing the global carbon footprint while still allowing the use of plastics for consumers, businesses, and critical applications.

OVERVIEW OF ZERO-CARBON PLASTICS

In addition to their continued use in society, further goals of carbon-free plastics include capturing CO2 and improving processing methods to convert harmful gases more effectively.

From production to incineration, carbon emissions are a concern at every stage of the plastics process. According to some estimates, the plastics industry burns through 13% of the carbon budget to limit global temperature increases to 1.5 degrees Celsius.

Packaging companies play a critical role in reducing the use of plastics, with many now offering paper-based containers, biodegradable films, and easily-recyclable aluminum cans. Indeed, **according to the U.S. Environmental Protection Agency**, the U.S. recycles over 50% of aluminum products, which dwarfs the **8.7% recycling rate** for plastic bags.

ADVANCES IN ZERO-CARBON PLASTICS

Carbon-free plastics are often viewed as unattainable because plastic itself is carbon. As such, significantly reducing plastic production and mitigating usage with offsetting measures appears to be the only reasonable solution. Many **observers**, however, are skeptical of this approach, arguing that reduction or total elimination is the only way to **address the problem.**

Recent **proposals** and approaches suggest that bioplastics may help to mitigate the plastics problem. Bioplastics struggle to biodegrade, but they offer the distinct advantage of deriving from sources like corn, potatoes, and food waste. Additionally, efforts are underway to improve **recycling processes**, clean up landfills, and explore the use of algae to create sustainable alternatives to traditional plastics.

Numerous companies are now committed to becoming plastic-free and improving their overall carbon footprint. Furthermore, companies such as Dow plan to build zero-carbon plastic manufacturing plants, creating a unique situation where producing environmentally harmful plastics reduces carbon emissions.

SELECT COMMERCIAL VENDORS SUPPORTING ZERO-CARBON PLASTICS

AquOm – Supports the use of algae to create plastic alternatives.

BioBag – Produces compostable bags.

Bio-On – Chinese bioplastics company.

Carbonauten – Uses less petroleum in plastics.

Cardia Bioplastics – Creates sustainable resins for packaging and plastics products.

Dow – Large company that manufactures bio-based plastics.

Empower – Recycles plastics into unusual items.

EnviGreen – Makes biodegradable substitutes for plastics.

FKuR – Creates biodegradable materials and bioplastics.

NatureWorks – Bioplastics company that uses renewable resources.

Novamont – Produces compostable plastics from renewables.

Plantic Technology – Manufactures bio-based materials.

Purac Biomaterials – Creates bioresorbable polymers and monomers.

ZERO CARBON STEEL

The goal of producing carbon-free steel (also known as zero-carbon steel, pure iron, or elemental iron) is to support the mass production of steel without generating CO2 as a by-product. With global steel demand expected to double by 2050, driving sustainability through carbon-free steel production is crucial. However, the absence of carbon in steel facilitates ease of workability but may compromise its strength.

OVERVIEW OF ZERO-CARBON STEEL

Steel is created from iron (5% of the earth's crust), with carbon added for strength. The iron rock (also known as ore) is heated, releasing oxygen atoms that bind with the carbon to produce carbon dioxide.

Once companies solve the challenge of achieving economically feasible and widely available production, zero-carbon steel is likely to have reduced strength. Consequently, typical uses may include wire, pipes, sheets (and other products with less reliance on high-strength materials), and the production process for stronger steel.

The primary production method under investigation is degassing, which involves melting the steel into molten steel to purge carbon and all other impurities and then introducing a deoxidizing agent (like aluminum) to remove any remaining oxygen. Next, the molten steel is processed in a vacuum induction furnace to further eliminate carbon and other impurities. The resulting zero-carbon steel is then cooled and molded into the final product.

ADVANCES IN ZERO-CARBON STEEL

The process of carbon-free steel production is still in the experimentation phase, with multiple methods on the table. One such method involves substituting hydrogen for carbon during ore heating, which leads to hydrogen binding with oxygen, and creating water.

Many countries are pursuing zero-carbon steel processes, including China, which **produces and consumes more than half the world's steel.** China's hybrid strategy involves reducing demand, recycling steel, and adopting lower-carbon alternatives to address the short-term growth in steel demand, which may peak in 2024.

The **Swedish Hydrogen Breakthrough Ironmaking Technology (HYBRIT) project** has proposed the following improved production process:

1. **Place iron ore in a furnace with hydrogen gas.**
2. **At 1500 degrees, direct reduction occurs to produce solid iron with almost no carbon.**
3. **Pass the solid iron through electrodes, melting it into steel with minimal CO2 emissions.**

However, it remains challenging to manufacture zero-carbon steel at scale. Steel production significantly contributes to greenhouse gas emissions, so finding zero-carbon solutions is a priority. Promising recent advances include **commitments** from major businesses to use zero-carbon steel by 2050. Numerous innovative **manufacturing methods** are also emerging, signaling a bright future for carbon-neutral steel.

SELECT COMMERCIAL VENDORS SUPPORTING ZERO-CARBON STEEL

ArcelorMittal – Large company that builds steel plants with zero-carbon emissions

BHP Group – Works in the low-carbon steel sector.

Boston Metal – Builds scalable decarbonization for steel.

Electra – Green iron company.

GravitHy – Sustainable iron company.

HYBRIT – Joint venture and green steel manufacturer.

Kobe Steel – Develops low-carbon blast furnaces.

Mitsubishi Heavy – Builds zero-carbon steel plants.

Nippon Steel – Produces low-carbon raw materials called reduced iron.

Nucor – Offers zero-carbon steel product called Econiq.

U.S. Steel – Plans to achieve net-zero greenhouse gas emissions by 2050.

ZERO-CARBON CONCRETE

Carbon-free concrete supports large-scale cement production without generating CO2 as a by-product. After potable water, concrete is the second most consumed product worldwide, so reducing emissions is crucial in the ongoing quest for environmental sustainability.

OVERVIEW OF ZERO-CARBON CONCRETE

Traditional concrete production is a major source of greenhouse gas (GHG) emissions, with CO2 released by the chemical reaction that creates cement powder. Conversely, zero-carbon cement production process significantly reduces carbon emissions.

Zero-carbon concrete production aims to maintain global cement usage while addressing high-temperature calcination emissions. The main focus is lowering CO2 emissions during cement production, specifically when heating raw materials in a kiln during pyro-processing.

ADVANCES IN ZERO-CARBON CONCRETE

Reducing cement demand can play a crucial role in lowering cement-related emissions. Possible methods of achieving this goal include utilizing alternative materials (like laminated timber), **modular construction, and other practical methods** can.

Direct carbon capture and other sustainable building approaches can also reduce carbon emissions and decrease cement demand. For example, using technology to add CO2 to the cement actually strengthens the concrete.

Common zero-carbon concrete elements include magnesium oxychloride cement, geopolymer cement, and carbonated rice husk ash cement. The use of these elements in cement production is still in its early stages, but the construction industry is slowly moving in this direction.

SELECT COMMERCIAL VENDORS SUPPORTING ZERO-CARBON CONCRETE

Calera – Develops processes to capture carbon in cement production.

Carbicrete – Makes carbon-negative concrete.

CarbonBuilt – Directly converts carbon dioxide into concrete products.

Carbon Clean – Focuses on reducing cement emissions.

CarbonCure – Creates carbon removal for the concrete industry.

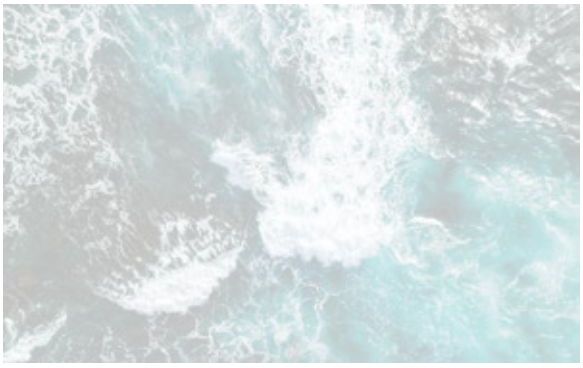
CEMEX – Buildings materials company that reduces cement emissions.

Central Concrete – Bay area concrete company.

Heidelberg Materials – Develops low-carbon cement mixtures.

Holcim – Works to reduce carbon in cement.

Solidia – Makes sustainable cement.



SUSTAINABLE BUILDING MATERIALS

Sustainable building materials, often called green materials, are produced using local and renewable energy sources in a bid to minimize greenhouse gas (GHG) emissions. These materials include bamboo, cork, straw bales, recycled plastic or wood, precast concrete slabs, and more.

OVERVIEW OF SUSTAINABLE BUILDING MATERIALS

Sustainable construction is achievable through producing, selecting, utilizing, and recycling building materials to minimize harmful emissions. Although builders often choose eco-friendly materials for their clients, they must also be affordable, high quality, and readily available. Common examples of sustainable building materials include:

- **Timber – Biodegradable materials with visual appeal are desirable, the origin is crucial, and reclaimed wood is preferred.**
- **Recycled Steel – A promising way to harness steel's strength while ensuring the material is recycled and reused.**
- **Earth – Clay and other types of earth are durable and provide a lovely aesthetic appeal.**
- **Bamboo – Strong, durable, renewable, and best when sourced locally.**

Concrete plays a crucial role in sustainable building design, but builders should aim for zero-carbon concrete in their projects. TAG Climate considers sustainable concrete a separate taxonomy category.

TECHNOLOGY ADVANCES IN SUSTAINABLE BUILDING MATERIALS

Green construction advances include developing new eco-friendly technologies, such as bio-degradable paint, glass that tints on demand, and stormwater management systems that optimize the collection and reuse of rainwater or runoff.

Green insulation techniques are also emerging, with repurposed denim scraps, recycled cellulose, and cotton gaining popularity as sustainable alternatives to fiberglass, which typically contains less recycled materials.

Advancements in the paint industry involve incorporating milk proteins and mineral pigments in producing organic paints. One benefit of organic paints is their ability to prevent soil pollution when disposing of building materials — a problem that often arises with traditional paint products and their associated chemicals.

SELECT COMMERCIAL VENDORS SUPPORTING SUSTAINABLE BUILDING MATERIALS

The sustainable building materials market will likely expand as efforts to achieve zero-carbon emissions gain momentum. The following companies offer solutions to support the use of sustainable building materials. We advise investors, energy officials, and enterprise sustainability officers to review this list to determine suitability for current and future projects. The **TAG Climate** team is available to assist with these selection decisions.

AI Shading – Creates new window covering controls to optimize energy use.

Blue Jeans Go Green – Program to collect denim for recycling and insulation.

Carbon Craft – Creates tiles from carbon black waste materials.

DTE Materials – Develops eco-friendly insulation products.

Ecovative – Uses mushroom mycelium to produce sustainable materials.

Healthy Materials Lab – Provides a learning hub for sustainable building and housing.

Lamboo – Produces sustainable bamboo products.

Myceen – Uses mycelium to create sustainable materials.

Nucor – Provides sustainable steel for multiple uses.

Pivot Materials – Manufactures sustainable materials from bamboo and other materials.

Real Milk Paint Co. – Produces milk-based paint.

Transaera – Offers ultra-efficient air conditioning for green buildings.

ZERO-CARBON OILS

Carbon-free oils play a crucial role in enabling the large-scale production of palm and vegetable oils without generating CO2 as a by-product. However, it is imperative to implement new approaches that effectively address the issues of deforestation and greenhouse gas emissions associated with traditional oil production.

OVERVIEW OF ZERO-CARBON OILS

Carbon-free oil extraction aims to meet the exponentially increasing demand for vegetable oils while addressing climate-related production challenges. Carbon-free oils are essential for food consumption, cosmetics manufacturing, and biofuel production.

Indonesia and Malaysia are dominant palm oil producers, and their governments have imposed moratoriums on new forest clearing to sustain the industry. Other techniques include producing algae-based oils, which entails cultivating algae in ponds or bioreactors and extracting oil from the resulting biomass.

ADVANCES IN ZERO-CARBON OILS

Carbon-free oil production often falls into upstream or downstream categories, with upstream issues related to the plantation and mill and downstream issues revolving around refineries and oleochemical plants.

Downstream advances include converting palm oil emissions into carbon-free energy. **Good engineering practices can reduce steam, water, electricity, and fuel consumption.**

Meeting the demand for over 70 million metric tons of palm oil (used in products like toothpaste, oat milk, biodiesel, and laundry detergent) poses cost and scalability challenges for zero-carbon oil production. And as **many sources** suggest, developing microbial oil alternatives is a daunting task.

Some companies are utilizing yeast to produce oils. Genetically modified yeast can allocate a significant portion of its weight to lipids, which are similar to the palm oils required for zero-carbon substitutes.

SELECT COMMERCIAL VENDORS SUPPORTING ZERO-CARBON OILS

C16 Biosciences – Produces next-generation oils and fats.

Kiverdi – Manufactures yeast oil using captured carbon.

Locus Fermentation Solutions – Makes biosurfactant solutions.

NoPalm – Creates sustainable microbial oils.

Unilever – Large company that uses sustainable products.

Xylome – Makes a palm oil alternative called "Yoil."

SUSTAINABLE PACKAGING

Sustainable packaging involves developing and implementing eco-friendly methods to minimize environmental impact. Emerging techniques in this field include detoxifying packaging materials, using biodegradable materials, emphasizing reuse and refilling, and more.

OVERVIEW OF SUSTAINABLE PACKAGING

In light of legislation, such as the 2020 **sustainable packaging laws** in the U.S., vendors acknowledge the limitations of existing recycling systems in promoting a sustainable future. Consequently, they are actively devising numerous innovative and environmentally friendly methods to meet the demands of modern sustainable packaging.

The goal of sustainable packaging is to develop environmentally-friendly packaging methods and combine legislation-influencing behavior among producers and consumers. Truth in labeling is a crucial aspect of the recyclability claim process. The California legislature, for example, recently passed a truth in labeling law for recyclable materials. The **Sustainable Packaging Coalition** is also working to advance sustainable packaging practices.

ADVANCES IN SUSTAINABLE PACKAGING

Major advances in sustainable packaging include shipping in smaller packages, sharing disposal, and avoiding over-packaging. Techniques for sustainable package design are varied and include:

- **Plant-based packaging materials.**
- **Compostable packaging.**
- **Plantable Packaging.**
- **Edible packaging.**

Typical materials include cornstarch, cellulose, mushroom, and other eco-friendly materials.

To achieve sustainable packaging, design, sourcing, manufacturing, transport, and packaging disposal need economically viable innovation that aligns with environmental goals in the following areas:

- **Biodegradable packages made from cornstarch or sugarcane.**
- **Recyclable packages made from paper, glass, metal, or plastic.**
- **Packages made from previously recycled materials like cardboard or paper.**
- **Reusable packaging using glass.**
- **Renewable packaging typically made from wood.**
- **Compostable packaging made from mushroom mycelium.**
- **Packaging made from waste materials.**

SELECT COMMERCIAL VENDORS SUPPORTING SUSTAINABLE PACKAGING

Air Sea Containers – Sells many types of packaging supplies.

Amcor – Leader in developing packaging solutions.

Earthpack – Customized eco-friendly retail packaging.

Ecoenclose – Sells sustainable packaging.

Emmerson Packaging – Sustainable supply chain partner.

LimeLoop – Sells reusable packaging.

Mondi – Sells sustainable packaging solutions.

Noissue – Sustainable, eco-friendly boxes and bags.

Paper Mart – Industrial and retail packaging company.

Paradise Packaging – Custom packaging company.

Returnity – Reusable shipping and delivery packaging.

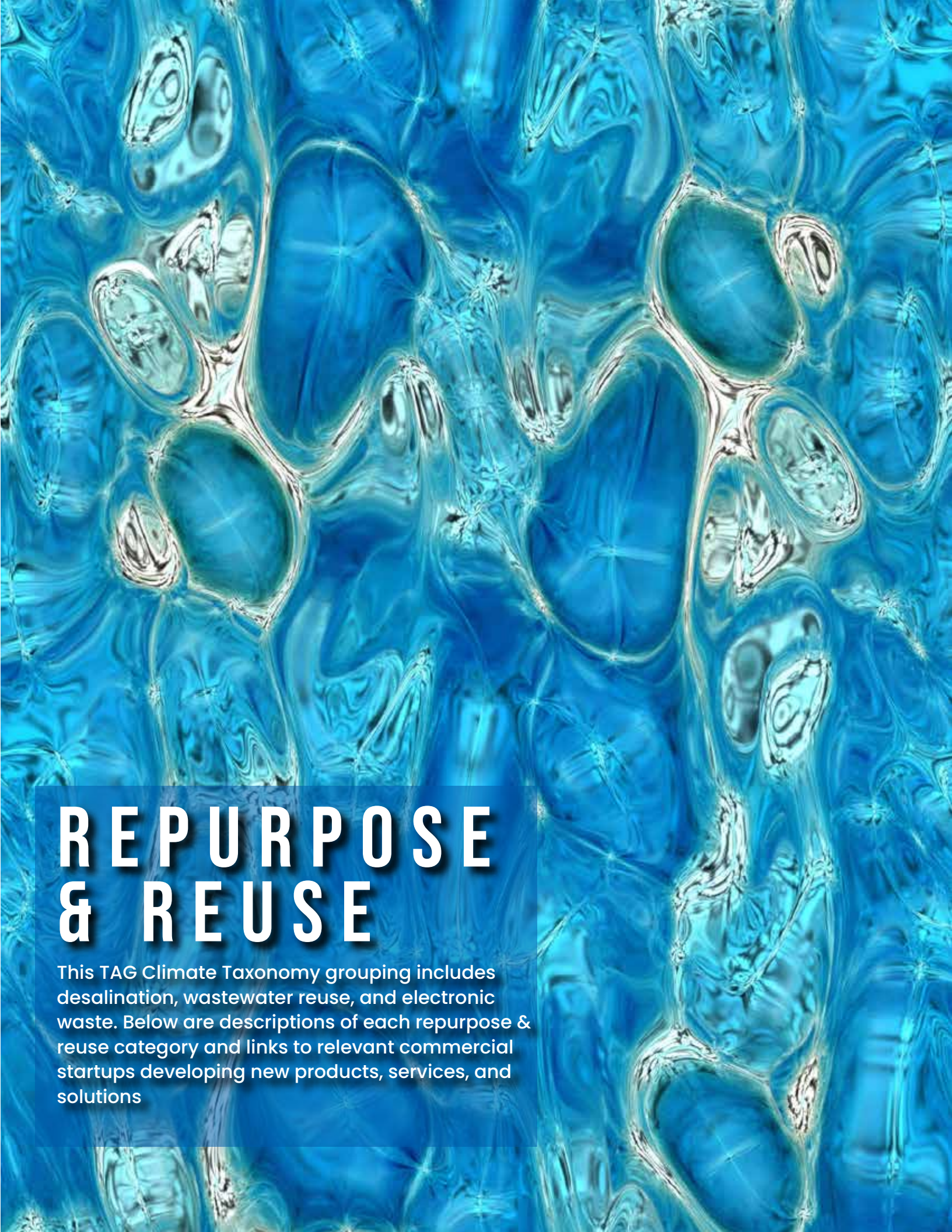
Rocket Industrial – Packaging equipment, materials, and supplies.

Sealed Air – Provides protective food packaging.

TemperPack – Offers sustainable insulated packaging.

Uline – Shipping boxes, packing materials, and more.

Wynalda Packaging – Sells high-quality retail packaging.



REPURPOSE & REUSE

This TAG Climate Taxonomy grouping includes desalination, wastewater reuse, and electronic waste. Below are descriptions of each repurpose & reuse category and links to relevant commercial startups developing new products, services, and solutions

ELECTRONIC WASTE

End-of-life electronics, also known as electronic waste (e-waste), are discarded devices at the end of their intended lifespan. Effective e-waste management involves adopting best practices to mitigate the environmental impact across multiple countries, including North America, Asia, Africa, Latin America, and the Caribbean.

OVERVIEW OF ELECTRONIC WASTE MANAGEMENT

Electronic waste management aims to address the environmental consequences of discarding used electronics in landfills or unprotected dumps to reduce waste by reusing, recycling, or refurbishing. Although the level of e-waste exported to developing countries from the U.S. is uncertain, some estimates suggest it's close to 2.37 million tons.

The primary approaches to electronic waste management include:

- **Collecting e-waste from users.**
- **Sorting of e-waste into categories (e.g., metals, glass)**
- **Dissembling e-waste into its constituent parts.**
- **Shredding e-waste for security reasons.**
- **Purifying e-waste to eliminate contaminants.**
- **Refurbishing e-waste for potential reuse.**

The challenge with e-waste disposal is that burning electronic devices (containing copper, aluminum, iron, and other metals) contributes to climate change by discharging harmful substances into the air, including polybrominated diphenyl ethers (PBDE) and polybrominated biphenyls (PBBs).

TECHNOLOGY ADVANCES IN ELECTRONIC WASTE MANAGEMENT

Typically, policymakers and organizations implement e-waste mitigation programs at the country, region, state, and community levels. Companies that improperly dispose of e-waste are also subject to fines. E-waste reduction strategies include:

- **Re-evaluating the need for extra gadgets.**
- **Extending the lifespan of electronics**
- **Buying Energy Star-labelled devices to reduce environmental impact.**
- **Donating electronics to social programs.**
- **Proper recycling of batteries and electronics.**

Startups in this field usually focus on the following:

- **Efficient e-waste disposal, refurbishment, screening, and recycling of devices and solar cells.**
- **Extracting minerals and rare earth elements from e-waste.**
- **Supporting asset recovery and repairing electronics to expand lifespan.**
- **Transforming old refrigerators.**
- **Reselling electronic gadgets like mobile devices and computers.**

SELECT COMMERCIAL VENDORS SUPPORTING E-WASTE MANAGEMENT

All Green Recycling – E-Waste recycling company.

Appcyclers – Trusted e-waste management partner.

Attero Recycling – Reinvents waste management.

Aurubis – Processes scrap metal.

Back Market – Marketplace for refurbished devices.

Binbag – E-waste recycling in India.

Boliden – Electronic recycling company.

Call2Recycle – Battery recycling company.

Cartlow – Online sales of refurbished goods.

Cashify – Resale of old and used mobile phones in India.

CyberCrunch – Secure electronics recycling and hard drive shredding.

Eco Recycling Systems – Scrap metal yard.

Envirometal – Sustainable recovery of metals from electronic devices.

eRecyc – Secure e-waste recycling center.

Green Place Recycling – E-Waste recycling center.

Homeboy Electronics – IT asset disposal in California.

Jiva Materials – Recyclable PCB substrate.

Mint Innovation – E-Waste recycling for metal extraction.

Pyrocycle – E-waste recycling company in Montreal.

Recycling Villa – Recycles electrical and electronic waste.

Redwood Materials – Recycles lithium-ion batteries.

Reebelo – Refurbished tech company.

Refurbed – Refurbishes technology and devices.

Retrievr – Recycles used technology.

Rubican Global – Software for smart waste recycling.

Sims Metal Management – Global metal recycling company.

Stena – Recycling company.

TerraCycle – Recycles hard-to-recycle materials.

Tetronics – E-Waste company.

TG Companies – Solar cell and module recycling.

Umicore – Focuses on recycling and other areas.

RECYCLING

Recycling reduces landfill use by collecting and converting waste into new and usable materials. Recycling conserves limited natural resources and minimizes raw material use, but limitations and challenges exist, such as expensive capital costs for recycling units and issues with overall recycling efficiency.

OVERVIEW OF RECYCLING

Most people are aware of **recycling** as it's now an essential part of our daily lives. Recycling steel cans, aluminum, paper, glass, and plastic are common daily practices, which is good news in the ongoing drive for sustainability.

Recycling is a fundamental component of most waste management processes and frameworks. For instance, the European Union's **waste framework directive** prioritizes high-quality recycling and includes a waste hierarchy model comprising five elements: prevention, reuse, recycling, recovery, and disposal.

Credible sources confirm that recycling offers significant sustainability benefits. For instance, recycling one aluminum can **reportedly** generates energy to power a 100-watt bulb for four hours. Likewise, recycling 20 pounds of glass can save up to 700 pounds of carbon emissions.

ADVANCES IN RECYCLING

Scientists are continuously researching innovative methods to improve recycling circularity. The ultimate goal is to establish an **endless loop** of recycling materials into their original materials to reuse them, with obvious benefits. Numerous reports highlight ongoing trends in innovative recycling techniques, with one **report** citing the following promising areas:

- **Pyrolysis – Extracting oxygen from shredded plastics, heating them to vaporize the hydrocarbon plastics, adding catalysts, condensing the material, and producing fuel.**
- **Recyclates – Developing materials more suitable for recycling to create post-consumer recycled (PCR) plastics that reduce reliance on fossil fuels.**

- **Advanced Gasification – Thermal treatment under oxygen-starved conditions to produce gas for chemical manufacturing, hydrogen production, and other applications.**

Numerous other recycling approaches exist, including recycling automation and the tracking of plastics throughout their life cycle. These innovations often originate from startups addressing process inefficiencies. The good news is that high recycling awareness results in positive business cases for startups in this field.

SELECT COMMERCIAL VENDORS SUPPORTING RECYCLING

Aqua Metals – Metal recycling company.

Circular – Enables an efficient value chain for recycled plastics.

Cirplus – Marketplace for circular plastics.

Clean Energy Enterprises – Includes **Ways2H**, which drives waste transformation.

DePoly – Rethinks recycling using PET plastic.

Ecoplasteam – Implements processes for transforming waste into raw materials.

Greyparrot – A.I. waste analytics platform for a circular economy.

OBBOTEC – Chemical recycling company.

PureCycle Technologies – Recycles plastics.

Recycllux – Develops chains for recycling and materials.

Redwood Materials – Develops circular supply chain.

ReSolved Technologies – Hybrid recycling technology.

Resynergi – Converts waste plastic into usable products.

RoadRunner Recycling – Tech-powered solutions for recycling.

Rubicon Global – Waste and recycling solutions.

Scindo – Sustainable renewables and recycling.

SmarterX – Machine learning for waste.

Vanguard Renewables – Developing organics for renewable energy.

Veridis – Develops a plastic analysis machine.

Wecycle – Clothing recycling group.

SOLID/LIQUID WASTE PURIFICATION

Purifying solid and liquid wastes (including wastewater reuse) supports numerous vital environmental functions, including aquifer recharge, crop irrigation, resource conservation, aquatic ecosystem protection, and the conversion of unwanted substances into valuable resources.

OVERVIEW OF SOLID/LIQUID WASTE PURIFICATION

All sustainable liquid and solid waste purification methods fall under the climate science innovation classification. This category also encompasses wastewater reuse and emerging techniques that use catalysts to transform solid waste.

Wastewater reuse (also known as water recycling or water reclamation) aims to tackle water scarcity by facilitating applications such as green space irrigation, firefighting, street cleaning, and other uses. The comprehensive list of wastewater reuse applications includes:

- **Agriculture and landscape irrigation.**
- **Toilet flushing and other indoor uses.**
- **Dust control or surface cleaning.**
- **Environmental restoration.**

Accepting the idea of wastewater reuse is a vital example of a more holistic approach to water management. This approach is fundamental in regions with scarce water resources, such as the Middle East and North Africa.

TECHNOLOGY ADVANCES IN SOLID/LIQUID WASTE PURIFICATION

Solid/liquid waste purification often includes using catalysts to convert waste into useful output while avoiding environmental hazards. These catalysts are also helpful for regeneration in industrial processes.

Wastewater reuse methods are categorized as planned or unplanned. When planned, a community creates a recycling process for a **specific purpose**, such as potable water collection or groundwater supply management. When unplanned, the reclamation involves treating wastewater before discharging it into rivers, lakes, and other existing water sources.

SELECT COMMERCIAL VENDORS SUPPORTING SOLID/LIQUID WASTE PURIFICATION

Agriwater Tech – Wastewater treatment systems for livestock farmers.

Aquacycl – High-strength organic wastewater treatment.

BluAct Technologies – ETH spinoff that works on water purification.

BOSAQ – Water technology company.

CertusBio – Continuous monitoring to mitigate waste during food processing.

Cormetech – Focuses on cleaning air pollutants.

Demizine Technology – Clean tech products for energy, water, and waste.

Epic Cleantec – Water recycling technology company.

Hydraloop – Greywater recycling company.

Swirltex – Offers wastewater treatment.

WASE – Decentralized sewage and sludge treatment in the U.K.

WATER TREATMENT TECHNOLOGIES

Water treatment technologies aim to maximize the reuse, filtering, and treatment of wastewater and salt water. Desalination aims to remove salts, minerals, and contaminants from seawater and wastewater to create **fresh water for human consumption.** There are roughly 21,000 desalination plants operating today across the globe, **with the largest in UAE, Saudi Arabia, and Israel.**

OVERVIEW OF WATER TREATMENT TECHNOLOGIES

Note: Desalination is the primary focus of this article, as solid and liquid waste treatment is a separate category in TAG Climate's taxonomy.

The two most common desalination methods are thermal distillation and reverse osmosis. Desalination provides significant sustainability benefits, including:

- **Helping drought-afflicted and/or climate-challenged regions obtain clean drinking water.**
- **Reducing the demand for freshwater resources, especially in coastal areas where freshwater is often scarce.**
- **Mitigating the problem of saltwater intrusion into freshwater reserves.**

ADVANCES IN WATER TREATMENT TECHNOLOGIES

Desalination technologies include using solar energy (powered by photovoltaic cells) to produce potable water, vacuum, vapor-compressed, wave-powered distillation, and osmosis, using a semi-permeable membrane to filter minerals from saline water.

Due (in part) to transportation costs, desalination remains relatively expensive, which negatively impacts poorer regions.

SELECT COMMERCIAL VENDORS SUPPORTING WATER TREATMENT TECHNOLOGIES

The water treatment/desalination market will likely expand as part of the continued push for zero-carbon emissions. The following companies offer solutions that support these goals. Investors, energy officials, and enterprise sustainability officers should review this list to determine suitability for current and future projects. The **TAG Climate team** is also available to help with selection decisions.

Acciona – Supports sustainable solutions for energy and water.

Adionics – Uses a patented process to extract salt.

Aquatech – Water treatment and purification company.

Biwater – Develops long-term sustainable water infrastructure.

Consolidated Water – Supplies potable water for reuse.

Desolenator – Supports solar thermal desalination.

Doosan Heavy – South Korean conglomerate.

Elemental Water Makers – Solar desalination for sustainable access to clean water.

Hitachi Zosen – Japanese waste treatment company.

IDE Technologies – Israeli desalination company.

Metito – Intelligent water management solutions.

Salinnova – Produces seawater desalination by reverse osmosis.

Sealeau – Uses circular and carbon neutral desalination.

Suez – Large desalination firm.

Useful Wastes – Supports reuse of waste from reverse osmosis.

Veolia – Large company supporting water projects.

Watly – Thermodynamic computer to provide clean water.

Wetico – Saudi water and environment company.

LIFE CYCLE ASSESSMENT FOR PRODUCTION

The life cycle analysis (LCA) process involves evaluating the environmental impact of a product, service, or infrastructure throughout its life cycle, from extracting materials through processing, manufacturing, distribution, use, and disposal.

OVERVIEW OF LIFE CYCLE ASSESSMENT

The need for a full assessment of a product's environmental impact throughout its life cycle drives the adoption of life cycle assessment. This evaluation involves reviewing the product's ecological burden and associated processes compared to other sustainable alternatives.

Typically, LCA involves a stepwise approach with the following steps:

1. **Defining the assessment's scope to establish the LCA process's overall purpose.**
2. **Creating an inventory of the product's materials, energy, and flows.**
3. **Assessing the product's impact by weighting inventory data towards sustainability goals.**
4. **Interpreting results to develop a summary analysis.**

An ISO environmental management standard (ISO 14040) drives a more common industry-wide approach to LCA. Applying LCA to a standard normalizes the results and enhances observers' ability to compare the environmental impact of various products across different application areas and contexts.

TECHNOLOGY ADVANCES IN LIFE CYCLE ASSESSMENT

According to experts, an increasing number of products are subject to LCA at earlier stages of development. Consequently, advanced tools and methodologies are necessary to support LCA's expanded scope. Additionally, the range of products that undergo LCA is increasing due to the growing focus on sustainability goals.

A crucial part of conducting LCA research is the requirement to evaluate all sustainability-related factors, and neglecting this can lead to an inadequate and potentially misleading analysis. Advancements in LCA include improved product information gathering (typically through product team inquiries) and enhanced use-case examples showcasing relevant factors.

Quantifying the output of LCA for numerical assessments that facilitate comparisons is desirable, as this indicates the possibility of using automated tools—such as machine learning and artificial intelligence—to drive LCA's future progress.

SELECT COMMERCIAL VENDORS SUPPORTING LIFE CYCLE ASSESSMENT

The LCA market will likely expand as part of the continued push for zero-carbon emissions. The following companies offer solutions that support LCA. Investors, energy officials, and enterprise sustainability officers should review this list to determine suitability for current and future projects. The **TAG Climate** team is also available to help with selection decisions.

Anthesis Group – Offers major LCA methodologies and software systems.

Carbotech AG – Environmental consulting firm.

ClimatePartner – Climate consulting and cloud-based software.

DNV – Offers LCA services for environmental impact.

EarthShift Global – Sustainability consulting firm.

Echochain – Performs a range of services, including LCA.

EcoAct – Offers life cycle assessment services.

EPD International – Supports LCA for manufacturers.

iPoint – Supports LCA and carbon footprints.

Intertek – Offers LCA services, including objectives, compliance, and review.

myclimate – Provides a range of sustainability services.

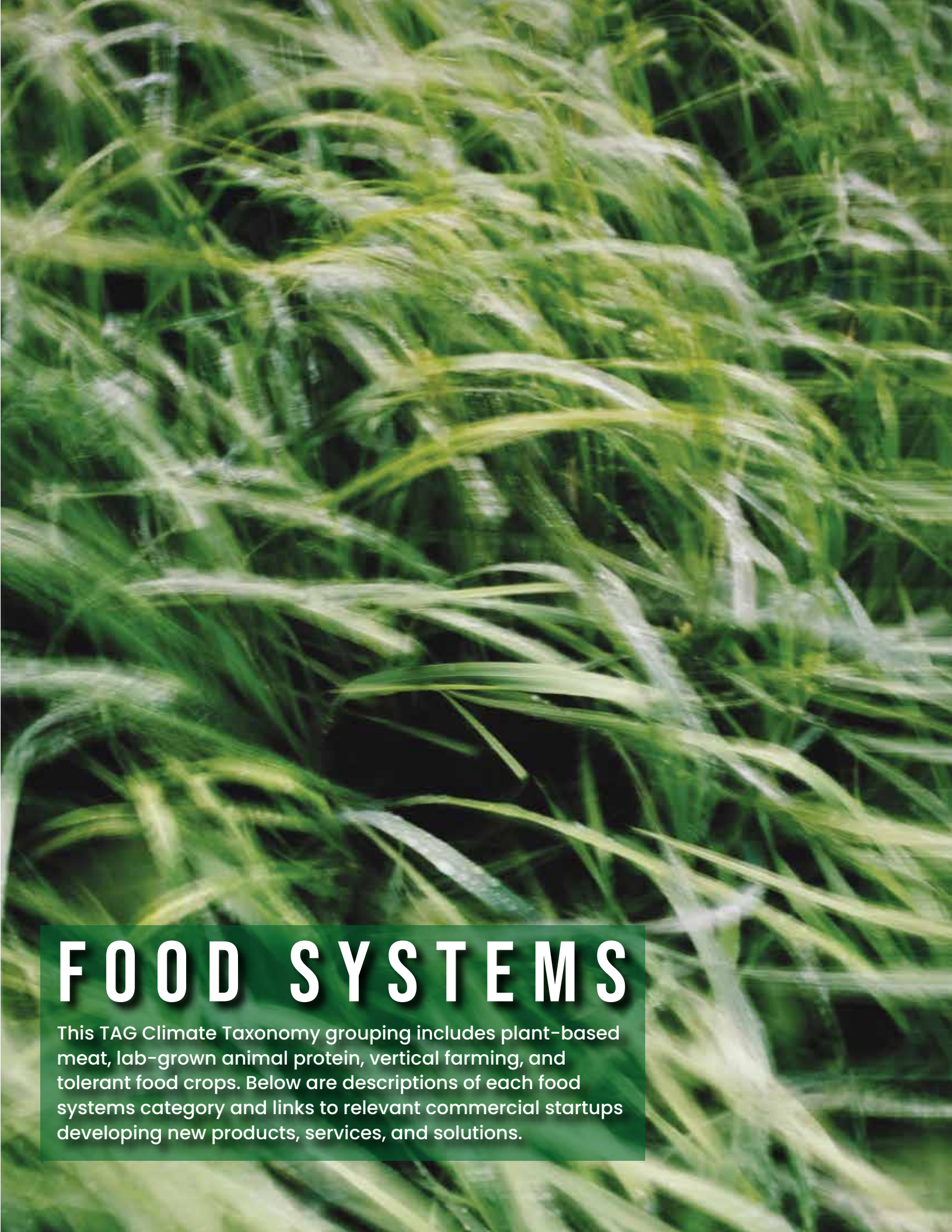
OneClick LCA – Product that supports LCA projects.

PRe – Offers LCA analysis.

Quantis – Offers environmental and LCA services.

Sphera – Includes LCA services for product companies.

WAP Sustainability Consulting – Helps companies with LCA objectives.



FOOD SYSTEMS

This TAG Climate Taxonomy grouping includes plant-based meat, lab-grown animal protein, vertical farming, and tolerant food crops. Below are descriptions of each food systems category and links to relevant commercial startups developing new products, services, and solutions.

PLANT-BASED MEAT

Plant-based meat is crucial for fightingclimate change. The emergence of high-quality meat substitutes minimizes land and water usage and decreases livestock emissions, which is good for the environment. Advancements in plant-based meat technology are reducing environmental impact and inspiring new products with the taste and texture of meat.

OVERVIEW OF PLANT-BASED MEAT

Meat consumption has deep cultural, habitual, and traditional roots, but raising livestock is environmentally damaging. For example, methane gas emitted by cows can potentially trap up to **thirty times more heat than carbon dioxide**. It's clear that to achieve the goal of zero-carbon emissions, humans must modify their dietary habits.

Food choices are personal, but marketing and advertising strongly influence public opinion. Plant-based meat substitutes using soy, potato, and pea proteins mimic the taste and texture of meat. However, widespread adoption remains challenging due to different taste preferences across regions. Individuals, sustainability officers, and food decision-makers should monitor the potential scalability of these products. As a comparison, veggie burgers are already a typical menu item in many U.S. diners and casual restaurants.

The U.S. Department of Agriculture (USDA) is reviewing guidelines for plant-based products and meat substitutes. TAG Energy sees this becoming a standard aspect of federal policies, benefiting companies and startups developing plant-based foods. However, economic incentives, lobbying and industry groups, and other influential forces pose a challenge and will inevitably resist these initiatives.

ADVANCES IN PLANT-BASED MEAT

Plant-based meat (and the cultivation of meat from animal cells) eliminates the need to raise and slaughter animals, improves animal welfare, and reduces the environmental resources required to support livestock. In addition, unlike many innovations in climate science, plant-based meat is relatively straightforward to conceptualize, design, and create.

The primary challenge is to replicate meat's taste, texture, preparation, storage, and appearance to appeal to regular meat-eating consumers. This process is a unique area of innovation because taste and visual preferences vary across regions and countries. Nonetheless, plant-based meats aim to address the following critical issues:

- **Cattle ranching's recent 80% deforestation of the Amazon rainforest.**
- **Soy, palm oil, and cattle ranching causing up to 70% of deforestation in Latin America.**
- **Animal agriculture causing 14.5-18% of global greenhouse gas emissions.**

SELECT COMMERCIAL VENDORS SUPPORTING PLANT-BASED MEAT

Amy's Kitchen – Organic food pioneer.

Before the Butcher – Makes plant-based proteins for retail and food service.

Beyond Meat – Creates sustainable protein.

Gardein – Provides plant-based meat substitutes.

Gold & Green Foods Ltd. – Food technology startup in Finland.

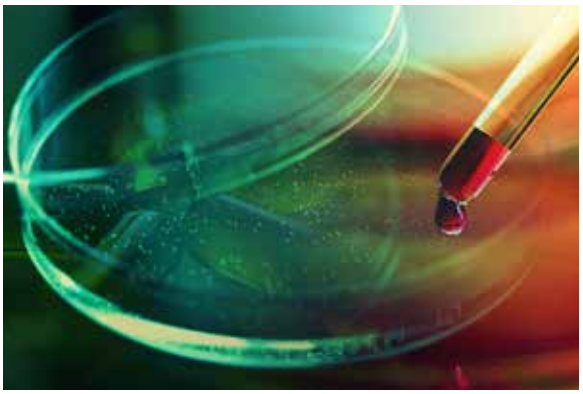
Impossible Foods – Makes plant-based meats.

Morningstar Farms – Division of Kellogg's that offers vegetarian products.

Quorn Foods – Vegetarian and vegan products.

Vbites Group – Pioneer of vegan meat, fish, and cheese.

LAB-GROWN ANIMAL PROTEIN



Lab-grown animal protein offers a solution to the inefficiency of traditional animal farming for producing edible protein. This cellular agriculture method involves using in vitro cell cultures of animal cells to create cultured meat.

OVERVIEW OF LAB-GROWN ANIMAL PROTEIN

Cell-cultured meat, produced through cellular agriculture, aims to **reduce the environmental impact of traditional animal meat production.** The cost of producing cell-cultured meat can be as low as $2.50 per pound—**a 4000-fold reduction** from the $10,000 per pound price of earlier production methods.

ADVANCES IN LAB-GROWN ANIMAL PROTEIN

In addition to meat, lab-grown animal protein **includes dairy products** as alternatives to animal and plant-based options. Innovations center around cell-based meat, seafood, and acellular cultured pet food. While regulators have approved these technologies in places like Singapore, the FDA and USDA are still reviewing their usage in the U.S.

Recent advances in the production, development, and use of lab-grown animal protein for human and domesticated animal consumption include:

- **Cost Reductions – Reducing the cost of cultured meat creation by up to 90%.**
- **Improved Product – Many cultured meat products now have significantly improved taste and texture.**
- **Cell Types – Diversifying the muscle cell culturing process to include fat cells, connective tissue, and blood vessels.**
- **Production Advances – The capacity of companies to produce cultured meats at a larger scale.**
- **Regulatory Advances – Countries such as Singapore approving the use of cultured meats for human consumption.**

SELECT COMMERCIAL VENDORS SUPPORTING LAB-GROWN ANIMAL PROTEIN

Aleph Farms – Cultured meat company in Israel.

Avant Meats – Sustainable meat and fish products in Singapore and Asia.

Balletic Foods – Focuses on sustainable protein ingredients.

Because Animals – Makes sustainable dog and cat food.

Biftek – Produces growth medium supplements to make cultured meat.

BioBQ – Cultured meat company.

BioFood Systems – Offers a sustainable supply of protein products.

Biotech Foods – Develops technology to produce cultured meats.

BlueNalu – Supports cellular aquaculture.

Bond Pet Foods – Offers sustainable proteins for pet food.

Clear Meat – Cell-based meat initiative in India.

Cubiq Foods – Cultivates fats for industrial clients.

Finless Foods – Plant-based and cell-cultured seafood.

Future Meat – Offers cultured meats.

GELATEX – Enables innovation through nanofibers.

GOOD Meat – Cultivated meat company.

GOURMEY – Offers cultivated meats.

Higher Steaks – Develops cultured meats.

Integriculture – Japanese startup focused on cellular agriculture.

Meatable – Offers cell-based meats.

Mission Barns – Cultivates meat using cells.

Mogale Meat – Offers cell-cultivated meats in Africa.

Mosa Meat – Food technology company

New Age Meats – Berkeley-based cultured meat company.

Peace of Meat – Cultivates meat.

Shiok Meats – Offers cell based cultivated meat and seafood.

Steakholder Foods – Develops 3D bioprinting in advanced biology.

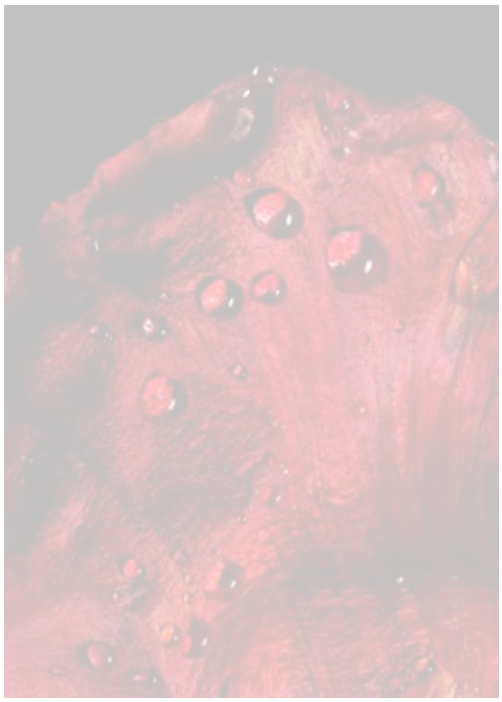
SuperMeat – Offers cultured chicken.

UPSIDE Foods – Growing meat from animal cells.

Vow – Australian cultured meat company.

Wild Earth – Creates sustainable dog food.

Wild Type – Develops cellular agriculture.



VERTICAL FARMING

Vertical farming (or indoor farming) rejects the conventional method of horizontal crop growing in favor of vertical crop cultivation. This practice promotes sustainable goals by generating higher food yields with less land usage.

OVERVIEW OF VERTICAL FARMING

Vertical farming uses less land, water, and energy and enhances food production efficiency, yield, and sustainability by growing crops in vertical stacks within tower-like structures. This approach is particularly advantageous in dense urban areas with high food demand. Additionally, it promotes chemical-free food production and prevents food deserts (**heavily populated regions lacking access to fresh foods**).

Recent vertical farming trends include:

- **Improved LED lighting to offer an optimal light spectrum for plant growth**
- **Robots seeding, harvesting, and fertilizing.**
- **Renewable energy to enhance sustainability.**
- **Modular designs to adjust the size and layout of a vertical farm.**
- **Data analytics to improve operational efficiency.**

ADVANCES IN VERTICAL FARMING

First introduced in 1999 at Columbia University, vertical farming has evolved into an effective farming technique prioritizing productivity and sustainability. Common vertical farming methods **include**:

- **Hydroponics – Zero-soil plant growth, cultivated through plants submerged in nutrient and mineral-rich liquids.**
- **Aquaponics – Using nutrient-rich wastewater from fish tanks to nourish plants, which in turn filter the water for the fish.**

- **Aeroponics – A technique originated at NASA that involves the nutrient misting of plants in air chambers to support growth.**

The MIT Media Lab is doing excellent work in vertical farming research, including developing sensors and robotics to automate farming tasks. The University of Arizona is also researching renewable energy sources in vertical farming.

SELECT COMMERCIAL VENDORS SUPPORTING VERTICAL FARMING

AeroFarms – Indoor vertical farming company.

AgriCool – French indoor farming firm.

Altius Farms – Denver-based company that delivers freshly harvested products.

App Harvest – High-tech indoor farms.

Babylon Micro-Farms – Onsite vertical farming.

Bowery Farms – Indoor farming company.

BrightFarms – New York-based indoor farming company.

Crop One – Provides fresh food for a sustainable future.

CubicFarm Systems – Agriculture technology company.

Dream Harvest – Sustainable indoor farming.

Eden Green Technology – Supports hydroponic vertical farming.

Farm.One – Vertical farm in NYC.

Freight Farms – Hydroponic farming.

Gotham Greens – Urban agriculture company.

Grow Pod Solutions – Stackable vertical farming.

Hydrofarm – Indoor agriculture company,

iFarm – Vertical farming technology.

Infarm – Supports environmentally friendly food systems.

Iron OX – Robotics and AI to support plant health.

JCN Farms -Innovative, year-round, vertical farming

Kalera – Supports vertical community farms.

Plenty – Indoor vertical farming.

Square Roots – Tech-enabled vertical farming.

Upward Farms – Indoor vertical farming.

Vertical Harvest – Urban hydroponic farming.

Vertical Roots – AgTech company.

Village Farms – Controlled environmental agriculture.

TOLERANT FOOD CROPS

Drought and flood-resistant food crops are crucial for impoverished communities across the globe as they reduce the risks of famine and disease wrought by droughts, floods, and storms. These crop innovations mitigate the detrimental impact of climate change and help to reduce human suffering.

OVERVIEW OF TOLERANT FOOD CROPS

General global trends suggest that storms are getting worse. While evidence links the intensification of hurricanes, tornadoes, and other natural disasters to the rise in global temperatures, some scientists are still researching to establish a more explicit connection. Irrespective of the cause, storm severity is increasing, and the impact is uneven across various regions worldwide.

Water vapor is less problematic than other greenhouse gases, and it eventually condenses and falls as snow or rain when it rises into the atmosphere. Although it quickly dissipates before causing problems, water vapor can still intensify the impact of powerful storms.

A surprising global trend is that some regions are witnessing increased storm precipitation while others are experiencing severe drought conditions. This has significant consequences, particularly in California, where massive forest fires are becoming a major problem.

The impact of droughts and floods on food production can lead to severe problems. Corn, in particular, is susceptible to adverse climate changes, and numerous regions worldwide rely heavily on this crop for sustenance. A **recent study suggests** that escalating temperatures may cause a decline in global corn production

ADVANCES IN TOLERANT FOOD CROPS

Carbon-friendly farming practices have led to the development of drought and flood-tolerant food crops. Despite the challenges of a changing climate, these crops help farmers achieve higher yields, leading to improved nutrition and reduced poverty.

CGIAR, established after World War II to **feed a growing population**, innovates by promoting various carbon-friendly initiatives. Its research focuses on developing more resilient crops, including maize, wheat, legumes, cereals, rice, roots, tubers, and bananas. Avenues for innovation are plentiful, with significant commercial opportunities for companies to engage in product development with benefits for their business and the world.

SELECT COMMERCIAL VENDORS SUPPORTING TOLERANT FOOD CROPS

Arable – Supports decision agriculture.

Avalo – Supports AI-based natural crop assistance.

BioLiNE – Develops solutions for sustainable farming.

CropX – Aggregates data from soil and sky to help farmers.

DuPont – Large company that focuses on drought-tolerant crop support.

Evogene – Supports computational predictive biology for life science products.

Livestock Water Recycling – Manure treatment technology.

O2 Company – Develops a monolayer to stop water evaporation.

Syngenta – Focused on improving the global food supply.

Terramera – Sustainable agriculture cleantech company.

Verigrain – Supports agricultural innovation.

Wetterheld – Offers crop insurance.

PRECISION AGTECH

Precision AgTech, also known as AgTech or agricultural technology, involves using technology-based solutions in agriculture, horticulture, and aquaculture to optimize yield and profits consistent with the primary goals of carbon reduction and sustainability.

OVERVIEW OF PRECISION AGTECH

AgTech encompasses various methods ranging from drones, sensors, and soil and disease analysis software. Promising techniques for AgTech include advanced weather forecasting techniques, automated irrigation, and improved biotechnology methods.

Sometimes, the objective of maximizing output and minimizing waste can sustainably align. For instance, deploying drones to identify irrigation leakages can boost productivity and curb water waste. Likewise, AgTech measures can safeguard farmer finances and preserve resources. For example, Biocontrols to combat pest infestations or weed growth can prevent crop losses and resource waste associated with crop failures.

TECHNOLOGY ADVANCES IN PRECISION AGTECH

AgTech's numerous advances benefit farmers and reduce waste, making categorizing or grouping them challenging. Some noteworthy and inventive AgTech advances that assist farmers in achieving success and reducing waste include:

- **Weed elimination using electronic shock devices.**
- **App-based support for farmers, including open-source online resources.**
- **High-tech soil sampling tools using artificial intelligence.**
- **Support for protecting bees through bee vectoring technology (BVT).**
- **Food shipping and shelf-life extension products using organic compounds.**
- **Safer biological pesticides to replace harmful alternatives.**

- **Restoration of farmlands.**
- **Creation of more organic and sustainable feed, including the use of insects.**
- **Utilizing drones to improve field and crop monitoring.**

SELECT COMMERCIAL VENDORS SUPPORTING PRECISION AGTECH

Aerobiotics – Supports precision growing and crop insurance.

Apeel Sciences – Keeps moisture inside produce and oxygen out.

Augmenta – Part of Raven. Helps farmers with AgTech.

Bayer – Large company that supports AgTech (acquired Combyne AG).

CIBO Technologies – Sustainable and regenerative agricultural solutions.

FoodLogiQ – Monitors and optimizes food safety.

Greenlight Bioscience – Addresses agriculture and human health.

Hazel Technologies – Reduces waste in the agricultural supply chain.

Indigo Ag – Improves farmer profitability and sustainability.

Mootral – Natural feed supplement to reduce methane emissions.

ProducePay – Empowers growers from seed to sale.

RootWave – Uses electricity to kill weeds in a sustainable manner.

TerViva – Alternative protein and sustainable agriculture.

Terramera – Vancouver-based sustainable agriculture company.

COMPOSTING

Composting is a sustainable activity that involves breaking down organic material into its component nutrients and then adding it to the soil for farming, agriculture, and gardening purposes. It is widely encouraged across the globe for individuals, families, and businesses alike.

OVERVIEW OF COMPOSTING

The composting business operates through three primary approaches.

1. **Commercial composting – Allows restaurants, stores, and other businesses to transform waste into valuable resalable compost.**
2. **Residential Composting – Families commonly deposit food scraps and other waste into containers for conversion into compost, by themselves or through a composting service.**
3. **Government or community-based initiatives – These offer drop-off locations for local residents to deposit waste for composting and resale/reuse within the community.**

It's important to note that the compost output takes various forms. Soil amendments are the most common, but different mixes and products are possible depending on time, effort, and capital availability.

TECHNOLOGY ADVANCES IN COMPOSTING

The objective of advancing composting technology is to make the process more cost-effective, efficient, and sustainable. According to TAG Climate analysts, recent innovations among entrepreneurs in this field include:

- **In-Vessel Approach – A sealed container composting system that generates compost quickly, making it perfect for small or urban spaces.**
- **Innovative Toilets – An alternative to current sewage treatment that converts human waste into compost.**

- **Worm Composts – Using worms to break down organic waste efficiently.**
- **Aerated Piles – Pushing air through compost to drive higher quality composting output.**
- **Insect Composts – Using black soldier flies to break down organic material in compost.**

SELECT COMMERCIAL VENDORS SUPPORTING COMPOSTING

The entrepreneurial market for composting will likely expand due to the broad consensus on composting value and cost-effectiveness, particularly for businesses that generate organic waste. The following companies offer solutions to support composting. We advise investors, energy officials, and enterprise sustainability officers to review this list to determine suitability for current and future projects. The TAG Climate team can help with these selection decisions.

CompostNow – North Carolina startup providing residential composting services.

OneThird – Composting and food industry waste.

Full Cycle Bioplastics – Startup working on turning compost into biodegradable plastics.

Litterless – Subscription service for remote composting.

Orbisk – Trash can camera monitor to scan for food disposal.

Matsmart – International online food retailer focused on reducing food waste.

Maeko – Offers a machine that produces compost in an anaerobic environment.

Mill – Offers a kitchen trash can that dries and shrinks food waste.

Mosaic – Develops tech to convert waste into fertilizer (acquired Plant Response).

Reencle – Metal bin that supports hyper-fast composting.

The Compost Company – Aerated pile composting company.

Winnow – Develops smart kitchen tech to reduce food waste.

TECHNOLOGY & SERVICES

This TAG Climate Taxonomy grouping includes climate science, green biotechnology, sustainable building management, and ESG consulting. Below are descriptions of each technology and services category and links to relevant commercial startups developing new products, services, and solutions.

SUSTAINABLE BUILDING MANAGEMENT

Sustainable Building Management (SBM) supports local and global sustainability objectives by addressing occupants' and visitors' environmental, health, and safety concerns during the design, construction, and operational phases of a building's lifecycle.

OVERVIEW OF SUSTAINABLE BUILDING MANAGEMENT

Local, remote, or third-party management companies are usually responsible for SBM, with the overarching goal of achieving local and global sustainability objectives. Vendors play a crucial role by supporting SBM in various areas, including, but not limited to:

- **Waste Management – Minimizing waste by instituting reduction solutions, such as recycling programs and composting services.**
- **Sustainable Materials – Reducing environmental impact by using sustainable building materials, such as FSC-certified wood, recycled steel, and eco-friendly insulation.**
- **Green Procedures –Supporting sustainability objectives with green procedures, including eco-friendly landscaping, transportation, and cleaning.**
- **Green Supply Chain – Prioritizing sustainable suppliers and procurement solutions.**
- **Energy Monitoring – Reducing energy consumption in buildings, such as high-efficiency lighting, HVAC systems, and renewable energy sources.**

ADVANCES IN SUSTAINABLE BUILDING MANAGEMENT

Four different complementary forces are driving the most significant recent advances in SBM:

- **Tenants - Nowadays, tenants demand to work with landlords and owners who prioritize sustainability.**
- **Government - Local, state, and national governments are increasingly pressuring building owners to adopt sustainable practices and offering incentives.**

- **Citizens - The general public is becoming more vocal about their desire for more sustainable buildings in their community.**
- **Innovators - Startups and other innovators now offer companies new options to reduce energy costs and adopt sustainable practices.**

SELECT COMMERCIAL VENDORS SUPPORTING SBM

75F – Provides IoT building air management solutions.

Abraxas Energy – Consults on energy audits and waste reduction.

BrainBox AI – AI powered HVAC optimization.

eWorkOrders – Offers smart asset management software.

FaciliWorks – Offers CMMS Software.

Fiix – Paper Work order software replacement.

MaintainX – Work order software and app.

Nomad Go – AI inventory management.

Premier Facility Management – Green facility management software.

SIG Earth – Green building services and consulting.

Sine – ESG and sustainability-focused facility management software.

Upkeep – CMMS dashboard and app.

TMA Systems – Web-based MMS.

SUSTAINABLITY/ESG CONSULTING

Sustainability/Environmental, Social, and Corporate Governance (ESG) consulting is a professional service that helps enterprise teams, government groups, vendors, researchers, and academics achieve sustainability goals through ESG programs and other methods.

OVERVIEW OF SUSTAINABILITY/ESG CONSULTING

The professional services offered in this category assist clients in achieving sustainability goals as part of a larger professional services engagement or through a consulting relationship with a smaller boutique climate science or ESG firm/expert.

Sustainability and ESG consulting is a growing area of interest for many professional services firms, drawing in established and new consulting companies. A key focus of these services is to provide clients with guidance and expertise on reducing or mitigating their carbon footprint.

ADVANCES IN SUSTAINABILITY/ESG CONSULTING

Sustainability/ESG Consulting is now integrating its guidance into more extensive professional service offerings. Accenture, for example, recently acquired and incorporated Carbon Intelligence, Greenfish, and other climate science consultancies. This integration will benefit enterprise buyers in the field and make sustainability/ESG consulting more accessible for consulting firms. Sustainability services often include a range of advances, including:

- **Methodologies and systems for measuring and reducing emissions.**
- **Emissions and carbon reduction support for engineering projects.**
- **Environmental health and safety support.**
- **Regulatory and Environmental Compliance.**
- **Water management practices.**

SELECT COMMERCIAL VENDORS SUPPORTING SUSTAINABILITY/ESG CONSULTING

The ongoing development of carbon-zero initiatives will continue to drive growth in the Sustainability/ESG Consulting market. The following companies offer solutions that support this goal. Investors, energy officials, and enterprise sustainability officers should review these industry participants to support their sustainability goals:

Accenture - Professional services consulting.

AECOM - Engineering and management consulting.

Anchor QEA - Sustainability and supply chain management.

Bain & Company - Management and ESG training and consulting.

Benchmark - Management and ESG training and consulting.

ClimatePartner - German consulting firm specializing in offsets and reporting.

Deloitte - Big 4 accounting firm moving into ESG consulting.

ERM - Supply chain sustainability.

GZA - Geotechnical and ecological services.

Haley & Aldrich - Sustainability risk management.

ICF - Sustainability consulting.

Jacobs - Sustainable engineering.

Partner Engineering - Green-minded engineering.

PwC - Big Four accounting firm moving into ESG consulting.

TetraTech - Environmental consulting.

TRC - Environmental impact reporting.

Watershed - Global sustainability consulting.

CLIMATE SCIENCE INDUSTRY ADVISORY

Climate Science Industry Advisory (CSIA) services are a new branch of the industry analyst profession. They offer insights into the commercial trends and value propositions for vendors that buyers should consider during their selection and procurement process.

OVERVIEW OF CLIMATE SCIENCE INDUSTRY ADVISORY

CSIA is an emerging field that draws upon existing analyst practices and incorporates some practices from the broader industry, including using ranked quadrants by advisory firms. However, ranked quadrants have some drawbacks, such as the potential for pay-for-play support and a tendency to evaluate vendors based on their suitability for general applications rather than how they fit specific customer needs.

Climate science is a logical extension of the advisory services prevalent in IT, procurement, and cybersecurity. Specialized advisory firms like TAG Climate are leading the way in providing guidance and insights to the commercial climate science industry.

The goal is to address misinformation about climate science innovations and provide impartial resources for enterprise leaders to access valuable information about new technologies, capabilities, sciences, and other sustainability and zero carbon innovations.

ADVANCES IN CLIMATE SCIENCE INDUSTRY ADVISORY

CSIA is making significant progress in emphasizing the business aspect of sustainability. Analysts like TAG Climate drive the idea that ESG and sustainability are admirable goals and financially sound decisions in almost every scenario.

SELECT COMMERCIAL VENDORS SUPPORTING CLIMATE SCIENCE INDUSTRY ADVISORY

3BL Media - Provides sustainability communications and reporting services.

Climate Analytics - Offers climate science and policy research and consulting.

Gartner - Provides legacy climate risk and resilience advisory services.

Forrester - Offers climate change and sustainability research and advisory services.

ICF - Provides climate adaptation and mitigation strategy consulting services.

Moody's Analytics - Provides legacy climate risk assessment and management services.

TAG Climate - The authors of this publication!

Verdantix - Offers environmental, social, and governance (ESG) services.

CLIMATE INTELLIGENCE SOFTWARE

Climate intelligence software supports the monitoring and analysis of climate-related data. It often uses artificial intelligence to identify trends and actionable insights and inform management decisions about future sustainability and adaptation.

OVERVIEW OF CLIMATE INTELLIGENCE SOFTWARE

Climate intelligence involves the analysis of information to manage climate risk. While many organizations, including the World Economic Forum, use this approach, our research at TAG Climate focuses on vendors who support this activity, particularly for commercial use.

Climate intelligence software benefits from vast amounts of data now available on climate, environment, and weather. Artificial intelligence-based algorithms help make substantive predictions about trends and future adaptation needs. Key issues related to climate intelligence software include:

- **Decision-Making Role - The importance of precise climate intelligence is evident in organizational and governmental decision-making related to future sustainability.**
- **Data Accuracy – To ensure proper decision-making, climate intelligence data must be accurate. For instance, adaptation plans may require extensive planning to avoid misleading data.**

The commercial potential of climate intelligence software remains an area of ongoing growth. Major corporations will likely utilize this software to better plan for the future, particularly in industries where weather and environment play a critical role.

ADVANCES IN CLIMATE INTELLIGENCE SOFTWARE

The progress in climate intelligence corresponds to developments in artificial intelligence. Enhancements include CPU processing, big data analytics, and machine learning algorithms, allowing for the processing of massive amounts of data to generate valuable insights.

SELECT COMMERCIAL VENDORS SUPPORTING CLIMATE INTELLIGENCE SOFTWARE

Cervest - Climate risk intelligence and prediction software.

ClimateAI - Climate data analytics and prediction software.

Climavision - Weather intelligence and risk management software.

Gro Intelligence - Climate and agricultural data analytics software.

Jupiter Intelligence - Climate risk and impact assessment software.

OneConcern - Climate and disaster risk modeling software.

TerrafuseAI - Climate data analytics and modeling software.

CLIMATE INSURANCE

Climate insurance (or **climate risk insurance**) transfers financial and operational risks associated with climate change from a buying entity to the insurance company. This helps individuals and businesses deal with the growing threat of extreme weather conditions.

OVERVIEW OF CLIMATE INSURANCE

Climate insurance addresses climate change's financial, recovery, and restoration costs and related environmental issues. In the context of climate change, flood insurance is the primary type of climate insurance currently undergoing global re-examination.

Individuals, small businesses, and large enterprises can benefit from climate insurance, particularly post-disaster relief. Standard climate insurance policies, like those covering floods, often place a financial burden on communities not responsible for carbon emissions causing the problem.

Some observers have effectively summarized the following key climate insurance issues:

- **Economics and Politics – Climate insurance has implications for regional economies and politics that Governments cannot ignore.**
- **Tailoring – Climate insurance does not work well as a one-size-fits-all due to varying regional conditions.**
- **Subsidy – Governments and insurance buying pools can and should subsidize payouts to assist the poorest and most vulnerable victims.**
- **The societal value of climate insurance is likely to continue growing. However, this risk management tool does not reduce climate change – it merely transfers the payout risk to an insurance company.**

ADVANCES IN CLIMATE INSURANCE

Innovations in climate insurance typically aim to make it more accessible and affordable for the most vulnerable populations. One approach is the creation of regional risk pools, while others have explored the use of new insurance for assets (IFA) programs to manage climate-related disaster risks.

SELECT COMMERCIAL VENDORS SUPPORTING CLIMATE INSURANCE

Arbol - Climate risk insurance and derivatives platform.

Descartes Underwriting - Parametric insurance solutions for climate risks.

Floodbase - Flood risk and resilience analysis for insurance.

Kettle - Parametric insurance solutions for climate risks.

Risilience - Climate risk insurance and mitigation solutions for businesses.

Understory - Weather and climate risk data analytics for insurance.

FOREST MANAGEMENT

Effective forest management involves critical decision-making, strategizing, daily forest planning operations, sustainability planning, and the prevention and management of fires and other environmental disasters.

OVERVIEW OF FOREST MANAGEMENT

According to the USDA, forests are critical to climate management as they store more carbon than anything other than oceans. However, wildfires can negatively impact the carbon cycle, forest structure, and species composition, even with recolonization covering some carbon loss.

Forest management is crucial for protecting the role of forests in storing carbon and preventing fire disasters, with biomass removal often a feasible method. The U.S. Forest Service supports a coordinated resource offering protocol (CROP) to even the outflow of small trees and other biomass.

ADVANCES IN FOREST MANAGEMENT

Advances in forest carbon management are necessary to maintain the carbon sink effect offered by forests, which, according to some observers, offset about 15% of U.S. fossil fuel emissions. Typical strategies range from sequestration and adaptation to fire avoidance response planning. Some estimates suggest that recolonizing plants in burned areas can remove significant levels of carbon, potentially making a major fire carbon neutral.

Nevertheless, fires can have catastrophic effects on ecosystems and the balance of living species, highlighting the importance of prevention measures. Furthermore, larger fires may result in irreplaceable greenhouse gas emissions.

Commercial offerings to support forest management focus on strong situational awareness, risk analysis, detection, and spread prediction services based on advanced technologies and tools.

The Sustainable Forestry Initiative (SFI) maintains a database of products certified as consistent with forestry sustainability goals. Their information requires a paid membership for access.

SELECT COMMERCIAL VENDORS SUPPORTING FOREST MANAGEMENT

As initiatives to drive carbon emissions to zero continue to develop, the market for forest management solutions is likely to expand. Investors, energy officials, and enterprise sustainability officers are encouraged to review the sustainability of the following companies for current and future projects:

Fion Technologies - Develops wildfire detection and alert systems.

Fortress Fire Retardant Systems - Provides eco-friendly fire retardant and fireproofing solutions.

Pano AI - Offers AI-powered wildfire detection and monitoring systems.

Perimeter Solutions - Develops and provides fire management solutions.

Tor Specialty Minerals - Produces and supplies fire-retardant additives and compounds.

Universal Fire Shield - Provides fire suppression and protection systems.

CARBON ACCOUNTING/VERIFICATION

Measuring and analyzing an organization's greenhouse gas (GHG) emissions is a vital part of the carbon accounting process as it supports organizational disclosure of environmental, social, and governance (ESG) commitments. Verification involves providing scientific evidence that reported sequestration (and other carbon capture activities) are valid.

OVERVIEW OF CARBON ACCOUNTING/VERIFICATION

The establishing the **GHG Protocol** in 2001 introduced a worldwide standard for carbon accounting, including scopes that provide guidance for measuring carbon emissions and greenhouse gases (GHGs). Notably, including the supply chain in this accounting process is crucial for comprehensive and accurate assessments of carbon emissions and GHG impacts.

Observers note that suppliers may produce up to 5.5 times the GHG emissions of the sponsoring company, making the exclusion of the supply chain from carbon accounting a significant under-reporting risk. (Scope 3 of the GHG Protocol addresses t he supply chain).

ADVANCES IN CARBON ACCOUNTING/VERIFICATION

Carbon accounting has advanced with automation and artificial intelligence to track GHG emissions. This process involves uploading data and generating emissions reports while allowing for analysis of metrics goals and progress tracking.

The aim is to integrate and embed the collection and analysis of GHG emissions into business operations to enable better decision-making.

SELECT COMMERCIAL VENDORS SUPPORTING CARBON ACCOUNTING/VERIFICATION

Aclymate - Carbon accounting and offsetting for businesses.

Atrius - Carbon and energy management software.

Benchmark ESG - Carbon accounting and sustainability reporting.

CarbonChain - Carbon accounting for supply chains.

Carbon Trust - Carbon accounting and footprinting services.

Emitwise - Carbon accounting and analytics for businesses.

Greenly - Carbon accounting app for individuals and businesses.

Persefoni - Carbon accounting and analytics for businesses.

SCS Global Services - Carbon and sustainability certification and verification.

SINAI technologies - Carbon accounting and sustainability management platform.

Verra - Carbon offset certification and verification.

Watershed - Carbon accounting and sustainability consulting.

WatchWire - Carbon accounting and ESG reporting software.

GREEN BIOTECHNOLOGY

Green biotechnology utilizes plants and other photosynthetic organisms to enhance agriculture, minimize environmental damage, and mitigate environmental pollution through bioremediation techniques. Farmers and manufacturers cultivate the resulting crops for food, medicine, and industrial/household goods, including cleaning agents, biofuels, paper, medicines, textiles, and even decidedly ungreen biological weapons.

OVERVIEW OF GREEN BIOTECHNOLOGY

Biotechnology emerged during the green revolution in the 1960s and 70s, resulting in new crop strains that significantly increased yield. P-resistant and drought-resistant crops subsequently arose, and by the 1990s, farmers started producing herbicide-resistant "roundup-ready" crops. This technology is now the norm in most countries, improving crop yields and mitigating the environmental impact of deforestation and agricultural land use.

The research and development of genetically modified organisms (GMOs) in biotechnology improves human nutrition, increases crop productivity, and enhances crop resistance to floods, droughts, and pests. This use of GMOs reduces the need for fertilizers, pesticides, and land, decreasing agriculture's environmental impact.

With a rapidly growing population and climate change-induced food production disruptions, Governments worldwide increasingly acknowledge green biotechnology's importance.

ADVANCES IN GREEN BIOTECHNOLOGY

One of today's key challenges is using land and oceans efficiently to meet the food and material needs of the growing global population. Besides enhancing food crop yields and resilience to pests and droughts, scientists use bio-generated nanoparticles to control the mosquito vector that spreads dengue fever—without environmentally damaging pesticides.

Similarly, researchers are adopting green biotechnology to reject fossil fuels by producing algae-based biofuels alongside controlling harmful algal blooms in coastal regions. We are experiencing a new "green revolution" and the rapid advancement of green biotechnology's scientific, economic, and social possibilities.

SELECT COMMERCIAL VENDORS SUPPORTING GREEN BIOTECHNOLOGY

Amyris - Biofuels, renewable chemicals, and cosmetics.

BASF - Bio-based materials, chemicals, and fuels.

DSM - Bio-based chemicals, enzymes, and probiotics.

DuPont - Bio-based materials, enzymes, and food ingredients.

Evonik Industries - Bio-based chemicals, specialty materials, and nutrition.

Gevo - Renewable fuels, chemicals, and materials.

INVISTA - Bio-based polymers, fibers, and intermediates.

LanzaTech - Carbon capture and utilization.

Novozymes - Enzymes for industrial and household applications.

Solvay - Bio-based materials, chemicals, and specialty products.

SUSTAINABLE INFRASTRUCTURE

Sustainable infrastructure is planning, designing, constructing, and operating infrastructure to promote low emissions, mitigate climate change, and support sustainability. Common examples of sustainable infrastructure include roads, bridges, telecommunications, power systems, and smart cities.

OVERVIEW OF SUSTAINABLE INFRASTRUCTURE

The advantage of sustainable infrastructure lies in its substantial size, scope, and scale. Common sustainable infrastructure elements include:

- **Utilizing green roofing methods to support vegetation or capture stormwater.**
- **Constructing efficient basins to collect and reuse water from stormwater runoff.**
- **Installing permeable paving to facilitate soil water absorption.**
- **Maximizing renewables and green energy in infrastructure systems, such - as smart cities.**

Many sustainable infrastructure projects consider additional, complementary objectives, including economic sustainability, social responsibility, and institutional governance and management. The Environmental, Social, and Governance (ESG) of such projects is a crucial factor in the ongoing management of sustainable infrastructure.

TECHNOLOGY ADVANCES IN SUSTAINABLE INFRASTRUCTURE

Many believe technological advancements are crucial to sustainable infrastructure planning, delivery, and management. With a focus on airports, highways, hospitals, subways, railways, water utilities, power systems, and telecommunications, these areas can significantly mitigate climate change.

With the increasing availability of sustainable energy from low emissions sources, sustainable infrastructure presents an excellent opportunity to drive a sustainable ecosystem through various lifecycle steps that typically include:

- **Interconnect – Natural and human-built systems interact and interconnect.**
- **Community – Engaging people and groups to work together.**
- **Asset Owners – incentivized to drive green decisions across their assets.**
- **Marketplaces – Should allow profits while driving sustainable objectives.**
- **Innovation – Ensuring that best practice approaches are available.**

Engineering and consulting firms now help large-scale infrastructure project teams to maximize their sustainable footprint, creating a significant business opportunity. This industry will significantly impact all levels, guiding board, C-suite members, and the engineers responsible for constructing and maintaining the infrastructure.

SELECT COMMERCIAL VENDORS SUPPORTING SUSTAINABLE INFRASTRUCTURE

The sustainable infrastructure market will likely expand as part of the continued push for zero-carbon emissions. The following companies offer solutions that support sustainable infrastructure. Investors, energy officials, and enterprise sustainability officers should review this list to determine suitability for current and future projects. The TAG Climate team is also available to help with selection decisions.

Accelerate Wind – Designs turbines for commercial buildings.

BlocPower – Offers clean energy for urban projects.

Climeworks – DAC startup with support for large-scale deployment.

Encamp – Assists big companies with environmental regulations.

Fairmat – Sustainable materials for large infrastructure projects.

First Mode – Addresses sustainable infrastructure solutions at scale.

Northvolt – Gigafactory startup in Europe.

Prescriptive Data – Supports environmental objectives for large buildings.

RUNWITHIT Synthetics – Supports modeling of sustainability decisions.

Storegga – Project developer of green infrastructure.

Urbint – Helps utility and infrastructure operators achieve sustainability.

WeaveGrid – Supports the regulatory needs of large infrastructure operators.

INTERVIEWS

AN INTERVIEW WITH MIKE SMITH,
CEO & FOUNDER, ACLYMATE

HELPING SMALL BUSINESS ACHIEVE SUSTAINABILITY

Large corporations with dedicated sustainability officers and substantial budgets are often associated with addressing sustainability objectives at the corporate level. However, it is important to recognize that small and medium-sized businesses (SMBs) also have a significant role to play in climate change mitigation.

We recently spent time with Aclymate, a creative startup focused on helping small businesses become leaders in the climate space. The company offered valuable guidance in this field, highlighting how their SMB customers can directly benefit from such support, even in their interactions with larger clients.

TAG Climate: Tell us briefly about Aclymate.

ACLYMATE: As a climate software company proudly based in Denver, Colorado, we assist small and medium-sized businesses in measuring, managing, reducing, offsetting, and reporting their climate impact. Our affordable online application empowers users to achieve their desired outcomes without requiring specialized knowledge. Additionally, we seamlessly integrate with their existing data sources to streamline the process.

For businesses interested in purchasing offsets, we provide the leading selection of offsets on the web and the tool to help our customers decide which project is right for them. With just two clicks, customers can purchase offsets, update their accounting, and become eligible for our Climate Leader certification. Our simple, affordable solution empowers SMBs with the powerful climate solution they need.

TAG Climate: What is your approach to carbon accounting, and how does it benefit SMBs?

ACLYMATE: There is compelling evidence to suggest that SMBs play a crucial yet often overlooked role in the climate transition. They face pressure from a climate-conscious consumer base that makes decisions based on environmental factors and financial and regulatory demands from larger customers to report supply chain emissions involving SMB vendors. However, SMBs typically lack the time, energy, and expertise to address these challenges, and existing solutions are either exorbitantly expensive or insultingly basic.

Our solution empowers SMBs to identify emissions sources and then reduce and offset them at an affordable price. We bridge the gap by translating our customers' everyday activities into the language of sustainability, facilitating reporting, and enabling the creation of impactful marketing materials. This positions our customers as

Driven by the incredible demand for offsets to achieve business climate goals, projections indicate that the offset market will increase exponentially and reach a market cap of $50 billion by the end of the decade.

preferred vendors for corporate supply decarbonization and sustainability for the large and growing buying habits of the climate generation.

TAG Climate: Do you sell directly to SMBs or through channel partners?

ACLYMATE: Both! Our direct sales efforts have successfully engaged SMBs across the United States. While we have collaborated with numerous businesses, I thoroughly enjoyed working with Amerant Bank, a prominent regional bank with 26 locations and over 600 employees across Florida and Texas. We played a pivotal role in helping Amerant accomplish its public sustainability objectives and earned their trust as a reliable supplier of offsets.

Conversely, we also work with Planet Bluegrass, a small business with nine employees and a single location. Despite their size, they host the Telluride Bluegrass Festival -- the largest Bluegrass festival in the world. We help to engage the festival's 5,000-plus attendees in tracking and offsetting their travel-related emissions, fostering sustainability awareness and action.

In addition, we cultivate strategic partnerships with channel partners who share our interests. Our longest-standing relationship is with the Green Business Bureau, but we're building relationships with major utilities, trade associations, and service providers. We help our channel partners improve their unit economics, bolster their brand image in sustainability, and transform cost-centers into profit-centers.

TAG Climate: Tell us more about carbon offsets. What are the prospects for this type of business in the coming years?

ACLYMATE: As the developer of a record reforestation-based offset project, I'm keenly aware of the strengths and weaknesses of carbon offsets. Carbon offsets have garnered significant attention recently, with much of it pretty negative. However, a comprehensive examination of the road to our climate future undeniably reveals that carbon offsets, or a similar mechanism, are indispensable for businesses, individuals, and society.

Driven by the incredible demand for offsets to achieve business climate goals, projections indicate that the offset market will increase exponentially and reach a market cap of $50 billion by the end of the decade. Despite the rapid expansion in offset production, the total volume is unlikely to keep pace with escalating demand, leading to a corresponding price increase.

In a more focused sense, the most responsible companies reduce their emissions and offset the rest, which, contrary to the noise around the subject, is the most common behavior associated with offset buying. Companies that buy offsets are

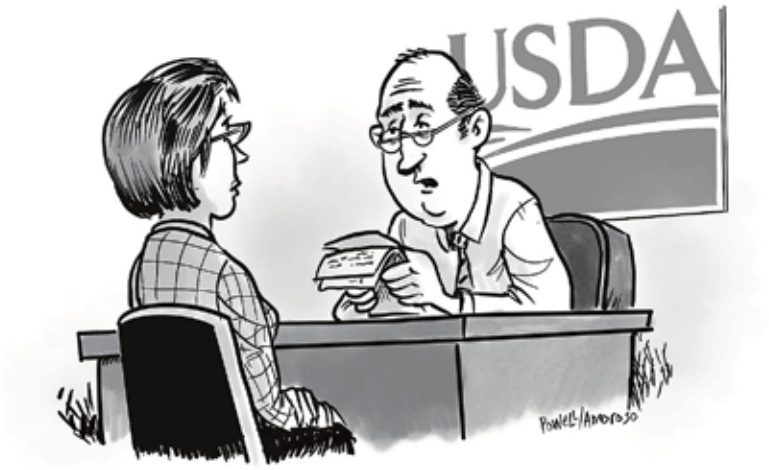
twice as effective as their competitors in emissions reduction activities.

Emissions reductions are essential, and at Aclymate, we help our customers focus on reducing their emissions before engaging them on offsets. This approach is at the core of our values and will always be our steadfast commitment.

TAG Climate: What are your views regarding prospects for our world to meet its net zero objectives for 2050?

ACLYMATE: It is going to be close. While big things have happened in government, finance, and industry, I am most optimistic about the ongoing demographic shift. Notably, the generational divide in our politics seems to fade when it comes to Millennials and Gen-Z's united stance on climate issues. That's a big deal, and they're only starting to enter the peak of their economic and political power.

But in a larger sense, whether we make it by 2050 is irrelevant. The IPCC report in 2018 said it perfectly: "Every fraction of a degree matters. Every year matters. And every decision matters." That's at the core of what we do at Aclymate and, in my opinion, what we all need to do.



"I appreciate your literary background, but 'majestic fields of golden grain' seems an odd reference in our Farming Survey."

AN INTERVIEW WITH MICHAEL CROSBY, CEO, AQUOM INC.

ALL-NATURAL APPROACH TO RESTORING AND CLARIFYING WATER SYSTEMS

Now more than ever, innovative solutions are essential to reversing pollution, healing the environment, and cleaning up our water systems. The world needs new products to support aquaculture, address wastewater concerns, and restore the damage caused by polluted water.

During our recent discussion with AquOm's CEO, Michael (Mike) Crosby, we enjoyed learning about the startup's organic and non-toxic water purification methods. AquOm's innovative solutions cater to various applications, including freshwater and wastewater management, agriculture, and other sectors.

TAG Climate: Tell us briefly about AquOm.

AQUOM: Our mission is to rewrite the "Story of Stuff" – how goods are made and managed – with an all-natural, carbon-negative, regenerative pen. Today, AquOm Inc. is a Kansas City-based manufacturer of organic products and solutions specializing in powerful, scalable, and cost-effective water cleaning and agriculture regeneration. In 2024, we plan to launch a revolutionary range of bioplastics and composites, underlining our commitment to advancing the circular economy by "Helping Nature Restore Balance."

AquOm's nature-based formulations outperform the chemicals and plastics they replace, with associated downstream environmental benefits and lower costs. Our proven global solutions also tackle diverse regional challenges, such as combating harmful algal blooms in Florida, addressing textile wastewater issues in Turkey, and optimizing greenhouse operations in Canada.

Our Kansas City location offers access to organic feedstocks, transportation infrastructure, a skilled workforce, and proximity to customer locations. As of 2023, our growing team is readying our inaugural production and packaging operations and expanding domestic and international operations.

TAG Climate: How do your geo-bio solutions work exactly – and how are they deployed?

AQUOM: Our co-founder and chief scientist, Keith Ervin, is an exceptional bio-mimetic inventor who has successfully developed precise and cost-effective blends of organic and mineral ingredients—time-tested by nature and available on a massive geological scale.

Keith's formulations utilize the most advanced chemistry, biology, hydrology, geology, and soil science principles to safely attract, isolate and remove excess nutrients, heavy metals, and bio-from land, surface water, and wastewater.

Our proven global solutions also tackle diverse regional challenges, such as combating harmful algal blooms in Florida, addressing textile wastewater issues in Turkey, and optimizing greenhouse operations in Canada.

All AquOm products are plug-and-play, designed for existing equipment and infrastructure use, with no incremental CapEx required by our customers.

We apply our water-based, non-pesticide solutions with backpack sprayers or hydroseeders to clean up polluted, algae-laden lakes and ponds. Moreover, our products can be dosed directly into wastewater treatment plants as a cost-effective substitute for harsh industrial chemicals.

In addition, we use spray or drip irrigation methods to apply AquOm products to farmland, water body perimeters, and lawns. These methods control nutrient run-off, improve moisture retention, and increase plant health and crop yields.

TAG Climate: What research and innovation process did you follow to invent your solution?

AQUOM: Our Chief Scientist grew up in the American Midwest, working in agriculture and studying to become a neurosurgeon. Nearly 20 years ago, he shifted gears and took on Mother Earth as a patient, diagnosing a diseased circulatory system (i.e., our severely polluted watershed) as the planet's biggest near-term and life-threatening issue.

At that point, Keith set out to learn how to heal water. Working outside mainstream academia and industry, he developed BLUE Chemistry—a scalable, cost-effective, ecologically-minded approach utilizing all-natural geopolymers and biopolymers to reverse pollution.

Three years ago, the successful deployment of BLUE Chemistry effectively addressed Harmful Algal Blooms (HABs) in lakes, ponds, and canals across the U.S. Since then, numerous countries have used AquOm products to clean their water. Examples include slum ponds in India, drip lines in Canada, and fish farms in Norway. You'll also find AquOm products being used in distilleries, textile finishing plants, metallurgic factories, and olive oil processing operations.

Next, we have trials of municipal wastewater treatment plants in New England to demonstrate that all-natural products can clean up municipal wastewater and eliminate **PFAS and PFOS** (forever chemicals) at a lower cost than industrial chemicals--with better results and no additional CapEx.

It seems too good to be true, but our unwavering confidence stems from laboratory studies, real-world successes, and AquOm's remarkable ability to address two notoriously challenging wastewater issues—purifying olive mill water and textile finishing water—both of which have proven resistant to industrial treatments.

TAG Climate: Tell us more about how the AquOm solution addresses and improves aquaculture.

AQUOM: Our company has worked on aquaculture issues in Norway and South Africa, addressing, for example, the HAB problems afflicting Norway's billion-dollar salmon farming industry and South Africa's abalone farmers.

SINTEF, Norway's state-funded research center, found AquOm to be highly effective in remediating algal blooms without harming marine life. AquOm products are also effective at thoroughly cleansing and eliminating organic deposits from extensive fish feed tube networks, doubling their lifespan.

Similarly, South Africa's leading abalone farming company successfully used AquOm's products to clean the water and surfaces in their recirculating tanks.

TAG Climate: Can you share some insights into other benefits of your approach, including the use of any by-products of your process?

AQUOM: In addition to "helping nature restore balance," we fundamentally believe that "there is no waste in nature." All forms of waste represent untapped potential and overlooked resources, and AquOm's approach can transform these materials into valuable assets.

HABs, for instance, feed on excess nitrogen and phosphorous from over-fertilized lawns and farmland. These chemicals are vital to life, and when treating algal-laden water, we capture them in our geopolymers and return them safely to the soil. These minerally-balanced products improve the soil's ability to retain moisture and grow healthy plants with less fertilizer.

AquOm's new facility in Kansas City will surpass energy requirements through the use of solar panels and biogas. The factory will play a pivotal role in processing food waste and purifying water, generating a surplus of clean water that exceeds our consumption needs.

Lastly, our approach involves procuring food and agricultural waste, coffee grounds, spent grains, and cardboard packaging within a 100-mile radius and transforming these into valuable resources for regenerative agriculture, resins, packaging composites, building materials, and energy storage devices.

AN INTERVIEW WITH AADITH MOORTHY, CEO AND FOUNDER, BOOMITRA

SUPPORTING CARBON REMOVAL THROUGH AGRICULTURAL SOILS

A notable breakthrough in recent years is the ability to leverage cutting-edge technologies like artificial intelligence (AI) and remote sensing to support carbon removal and other crucial global endeavors. This promising development suggests that innovative technological solutions can aid vital sectors like farming and agriculture in enhancing soil carbon levels and boosting crop yields.

Boomitra, a California-based start-up, is revolutionizing the field of soil carbon management with its scalable and sustainable approach. In a recent interview with Aadith Moorthy, the CEO and Founder of Boomitra, we learned about the company's efforts to mitigate climate change, improve agricultural practices, and recarbonize soils.

TAG Climate: Briefly describe Boomitra and how you support modern agriculture.

BOOMITRA: We are the leading international soil carbon marketplace. Powered by AI and remote sensing technology, we empower farmers and ranchers to transform agricultural practices, benefit from new income streams, and create a thriving planet.

Boomitra works with farmers and ranchers worldwide to increase soil carbon through improved agricultural practices while generating internationally certified carbon removal credits. We use proprietary AI and satellite technology to monitor, report, and verify (MRV) soil organic carbon to a 30cm+ depth—without physical soil sampling and reducing measurement costs by 99%.

The process is cost-efficient, time effective, and scalable across various landholding sizes. Boomitra's global reach encompasses 5M+ acres, 150,000+ farmers, four continents, and millions of carbon credits sold to date, which we sell to corporations and governments worldwide to help them meet sustainability goals. Farmers and landowners earn the vast majority of proceeds from each carbon credit sold, empowering them to reinvest in their farms and local communities.

TAG Climate: How does recarbonization work, and why is it important for sustainability?

BOOMITRA: Soil contains around 2,500 gigatons of carbon, more than three times the amount in the atmosphere and four times greater than the carbon stored in all living plants and animals. Modern agricultural practices like intensive tillage, monoculture cropping, and synthetic fertilizers have depleted soil carbon stocks.

However, regenerative agriculture practices, such as cover crops, rotational grazing, reduced tillage, and compost additions, can remove approximately 3.5 GtCO2/eq

Farmers and landowners earn the vast majority of proceeds from each carbon credit sold, empowering them to reinvest in their farms and local communities.

annually (2022 IPCC Report on Climate Change). These practices offer an effective way to replenish soil carbon and mitigate climate change.

Take cover crops as an example. Leaving soil bare means losing the chance to sequester carbon. Bare soil is susceptible to erosion, which can decimate nutrient-rich topsoil, organic carbon, and soil microbes.

Cover crops (which grow during the off-season and serve as soil erosion) prevent erosion, enhance the soil's water-holding capacity, sequester carbon, and deposit nutrients (like nitrogen) into the soil via photosynthesis. Cover crops also suppress weeds, manage pests and diseases, boost biodiversity, and improve cash crop yields. Increasing soil carbon offers numerous benefits. First, they improve soil health and fertility, resulting in higher crop yields and improved food quality. Second, they enhance water retention, minimizing soil erosion, droughts, and floods. Third, they promote biodiversity by providing a thriving habitat for beneficial microbes, fungi, and insects. Fourth, they mitigate climate change by extracting atmospheric carbon and sequestering it in the soil. Lastly, they establish resilient food systems capable of withstanding climate change impacts, ensuring food security and livelihoods for present and future generations.

TAG Climate: How does your company collaborate with farmers, and are there any additional costs incurred compared to conventional methods?

BOOMITRA: Our farmer-first partnership model leverages carbon markets and climate finance to benefit farmers and ranchers. Through our network of global partners, we facilitate the adoption of agricultural practices that enhance carbon sequestration. Boomitra then quantifies the captured carbon with satellite and AI technology and works with international standards bodies to generate Verified Emission Removals (VERs), commonly known as carbon credits.

Adopting new regenerative practices requires additional educational, labor, time, and financial costs. Boomitra minimizes these barriers by providing farmers with educational resources and support and working with local partners to prioritize practices with environmental and economic benefits.

As farmers become more comfortable with these changes, they may incorporate more complex and financially intensive changes that fit their local context. We aim to make carbon finance accessible to all farmers and ranchers, enabling them to establish sustainable and globally beneficial businesses.

TAG Climate: Tell us more about how AI and deep learning technology offer a unique advantage to Boomitra over competitors.

BOOMITRA: With robust datasets and agile models, Boomitra offers a unique, cost-effective solution for measuring soil properties at a scale too expensive for conventional techniques. Our global solutions improve the management and monitoring of regenerative agriculture.

Boomitra's internationally certified technology utilizes a vast archive of 1+ million soil samples collected by professionals and analyzed at accredited soil laboratories. This robust dataset allows for accurate, detailed, and scalable regional soil models.

Boomitra utilizes dozens of satellites across the electromagnetic spectrum to measure beneath the soil in a precise methodology that delivers accurate results. By carefully selecting satellite imagery correlating with soil samples, Boomitra can monitor soil carbon, nitrogen, phosphorus, potassium (NPK), and moisture levels without additional soil sampling.

TAG Climate: Can you share some thoughts on whether you are bullish on our collective efforts to reach net zero and related goals in the coming decades?

BOOMITRA: I am cautiously optimistic about our collective efforts to reach net zero and related goals in the coming decades. Change won't happen overnight; implementing the right technologies and meeting aggressive targets requires significant work, including changing how we live and work.

However, reducing carbon emissions and transitioning to a more sustainable economy is a highly achievable goal. In addition to mitigation, we must also prioritize adaptation strategies to address the current effects of climate change.

Organizations looking to purchase carbon removal credits must ensure they have realistic climate goals and a clear pathway toward net zero. By selling credits to companies committed to action on climate change, we can help support the transition to a more sustainable economy and a healthier planet.

AN INTERVIEW WITH RANDELL MILLS, PRESIDENT AND CEO, BRILLIANT LIGHT POWER

GENERATING ELECTRICAL POWER FROM HYDROGEN TO DARK MATTER

A common reference point in climate science revolves around the sun's energy generation through fusion. This analogy is a valuable tool in explaining the conceptualization and development of next-generation plasma-based power sources into practical solutions. This research reduces radioactive risk and drives the growth of renewable power sources.

During a recent chat with Randell Mills of New Jersey-based startup Brilliant Light Power Inc. (BLP), we learned about the company's quest to develop a commercially viable plasma power source and their unique approach to converting hydrogen atoms in water molecules into lower energy states.

TAG Climate: Briefly describe Brilliant Light Power and your research and development efforts.

BRILLIANT LIGHT POWER: We created a disruptive, non-polluting primary energy source (independent of traditional fuels and grid infrastructure) that converts hydrogen into a stable and previously undiscovered form called "Hydrino®." Our SunCell® harnesses this power source—which releases 200 times more energy than hydrogen combustion—at one-tenth the capital cost of traditional solar technologies.

BLP developed our SunCell® device to convert radiant power into electricity using concentrator photovoltaics (CPV) to power thermal, cooling, electrical, and motive applications. The company began building a SunCell® prototype in 2018, completed and validated a 250kW thermal boiler in 2020, and produced a commercial prototype to produce electricity in 2023.

BLP's SunCell® powers all applications at a projected cap cost of $20/kW and $0.001 kW/h generation cost, with no transmission, distribution, or demand charges and zero pollution or supply chain issues. Our global patent portfolio protects our leading technology position and products.

TAG Climate: How does your solution work, and how viable is the emerging method for commercial deployment?

BRILLIANT LIGHT POWER: Manufactured with commercial vendor-supplied components and standard recyclable materials, the SunCell® is an optical power source with a dense receiver array (DRA) and a collection of CPV cells operating at a thousand times the light intensity of PV cells used in traditional solar farms.

The SunCell® itself consists of a plasma cell fueled by hydrogen and two electromagnetic pumps injecting streams of molten tin from separate reservoirs. The

60 million 250kW SunCell® units can resolve the world's climate crisis in a year. How? By fulfilling the world's peak generating capacity of 15 TW without producing pollution or greenhouse gases.

combined streams carry a high current at a low voltage, creating a plasma in the reaction chamber where the Hydrino®-reaction occurs.

Optical or radiation power transfer exceeds conduction and convection in combustion and nuclear power plants by 10 to 100 times. The SunCell® plasma, operating at 3000-5000K, emits radiation at a power density of 4.6 to 35 MW/m2 through a transparent plasma reaction chamber. Light recycling can convert this radiation to electrical power with over 50% efficiency, resulting in performance, logistical advantages, low capital cost, and projected electricity costs below $0.001/kWh.

Proven UL-approved systems (backed by warranties and manufactured by leading OEMs) can enable the electrification of virtually every power-consuming device worldwide. The SunCell® can power these devices in essentially any environment at greater power density and power-to-weight ratio than any prior known power source.

TAG Climate: Can you explain more about how energy is delivered from hydrogen atoms?

BRILLIANT LIGHT POWER: The SunCell® uses a catalyst to react with atomic hydrogen, prompting the electron to shift into a lower- energy orbital releasing 200 times the energy of burning hydrogen with the formation of Hydrino®, a remarkably stable chemical form of hydrogen.

Following the production of Hydrino® and its capture in crystalline material as well as cryogenic condensation as a gas, we sought independent validation with 23 distinct methodologies and spectroscopic analyses performed at BLP and esteemed universities. In addition, we have published 100+ peer-reviewed journal articles alongside validation studies with leading independent experts.

TAG Climate: Tell us more about how this approach can transform electricity generation in countries like the United States.

BRILLIANT LIGHT POWER: The SunCell® is capable of ubiquitous deployment and rapid proliferation. With no supply chain issues or moving parts, it utilizes reusable/recyclable components and conventional production materials and leverages the vast photovoltaic manufacturing capacity.

The SunCell's® power is modular and scalable, combining the direct DC or power conditioned AC outputs of multiple SunCells®"

When operating independently, the SunCell® can disconnect from the grid (bypassing FERC regulations) and eliminate utility gatekeeper bottlenecks, transmission, distribution, and demand

charges. The manufacturing process involves contract assembly of vendor components, eliminating OEM bottleneck gatekeepers and allowing for multiple sourcing.

The SunCell's® safety standards include a sealed system operating at less than 1% atmospheric pressure, with zero pollution or greenhouse gases, and no issues with fuel availability, storage, pricing, or supply volatility. Plus, the fuel, H2 gas, is generatable on-site through water electrolysis.

Installation of the SunCell® is simple, with no complex duct work, fuel storage, fumes, noise, or toxic exhaust. Plus, unlike traditional power sources, there's no requirement for transmission lines, grids, gas pipelines, or river cooling.

SunCells® offer a significant advantage over solar and wind energy by providing a 24/7 power supply with zero intermittencies. This unique solution stands out as it does not rely on government support.

Instead, market forces will propel its widespread implementation, fueled by low capital costs (1/10th) and generation costs (1/200th). A power lease model allows users to access power without upfront expenses or metering requirements. The projected cost basis is estimated at less than $0.001/kWh DC.

TAG Climate: Can you share some insights into whether you believe our globe can meet net zero emissions targets for energy in 2050?

BRILLIANT LIGHT POWER: 60 million 250kW SunCell® units can resolve the world's climate crisis in a year. How? By fulfilling the world's peak generating capacity of 15 TW without producing pollution or greenhouse gases.

Based on an estimated capital cost of $20/kW, the most optimistic scenario suggests zero greenhouse gas emissions in under a year at a cost of $300 billion, which is $100 billion lower than the climate subsidies permitted by the U.S. Inflation Reduction Act of 2022.

BLP intends to ensure the widespread availability of Hydrino green energy by outsourcing the manufacturing, installation, and maintenance of SunCells® through power generator leasing. Autonomous SunCells® can seamlessly combine at any scale to serve the thermal, cooling, stationary, and mobile electrical markets.

This flexibility allows for meeting industry sustainability objectives at significantly reduced costs and improved logistical adaptability.

AN INTERVIEW WITH RAHUL SHENDURE, CEO, CARBONBUILT

CREATING ULTRA-LOW CARBON CONCRETE FOR SUSTAINABILITY

The concrete production process is widely known for its massive carbon dioxide emissions. Consequently, a new industrial sector has emerged to create concrete using methods that reduce carbon emissions and deliver decarbonized concrete products.

We recently spent time with CarbonBuilt, a Los Angeles-based startup that offers a new technology that effectively reduces carbon emissions without incurring additional costs or compromising the quality of the output. Below is a brief summary of our discussion and CarbonBuilt's insights.

TAG Climate: Tell us briefly about CarbonBuilt and what you develop.

CARBONBUILT: Our company is on a mission to help the built environment become more sustainable and serve as a giant repository for the world's carbon emissions. We achieve this through breakthrough technology, off-the-shelf equipment that enhances existing concrete plants, and a novel business model.

Although the concrete industry is responsible for approximately 10 percent of global emissions, a significant portion arises from industrial cement, the "glue" that holds concrete together. Unfortunately, cement emissions are unavoidable in the near term due to the chemical process of converting limestone into cement.

Our approach is to leverage the existing global concrete industry to reduce emissions and permanently remove atmospheric CO2. Due to its immense scale and continuous expansion, the industry possesses a distinct capability to prevent and eliminate gigatonne levels of CO2.

TAG Climate: How does CarbonBuilt technology work, and what is the benefit over traditional concrete generation methods?

CARBONBUILT: Our technology replaces most of the high-carbon Portland cement used to make concrete blocks. Instead, we utilize a novel low-carbon cement substitute derived from waste materials. These materials undergo solidification through a chemical reaction with CO2, resulting in stronger concrete. Furthermore, this process permanently stores the CO2 emissions in the concrete.

We refer to this new category of concrete blocks as "Ultra-low Carbon Concrete," which has 70-100% less embodied carbon than traditional concrete while meeting or exceeding all applicable standards and

With their low embodied carbon, our concrete blocks are a crucial tool in reducing global emissions. Additionally, their cost-effectiveness provides concrete blocks with an advantage in accelerating the transition to lower embodied carbon in the built environment.

regulations. This circular approach turns waste materials into value-added products crucial in decarbonizing the built environment.

Our technology leverages off-the-shelf equipment (pipes, boilers, valves, etc.), which "bolts on" to existing concrete manufacturing plants with minimal operational impact. For example, we can retrofit and run a typical concrete plant in less than a year.

Notably, our cement alternative costs less than Portland cement, providing immediate financial benefits to concrete manufacturers with narrow profit margins. The financial incentives are further amplified through carbon credit revenue and policy incentives.

Our inaugural customer, Blair Block, in Childersburg, Alabama, is close to commencing commercial production of our ultra-low carbon concrete. The initial converted line at Blair Block is projected to prevent at least 2,000 tons of CO2 emissions annually while simultaneously removing over 500 tons of atmospheric CO2. As we continue to optimize the process and integrate additional lines, we anticipate amplifying the overall impact over time.

If companies made every concrete block in the U.S. with our technology, we could remove 500,000 tons of carbon from the atmosphere and prevent an additional 2,500,000 tons of emissions.

TAG Climate: How does your concrete compare with products developed using conventional production methods?

CARBONBUILT: In essence, we are the same but better. Our ultra-low carbon concrete blocks offer the same appearance and performance while being more cost-effective and significantly reducing embodied carbon. Meeting ASTM C90 standards, our blocks can seamlessly integrate into projects under existing building performance criteria.

Considering the substantial annual production of over 1.5 billion concrete blocks in the US, their significance is evident. These blocks are crucial in constructing resilient and sustainable structures for homes, schools, commercial buildings, and industrial facilities. With the changing climate, concrete blocks are becoming vital to society's efforts to build robust structures. Their strength, durability, fire resistance, energy efficiency, and noise-dampening properties make them compelling options, especially in regions prone to fire, hurricanes, and tornadoes.

With their low embodied carbon, our concrete blocks are a crucial tool in reducing global emissions. Additionally, their cost-effectiveness provides concrete blocks with an advantage in accelerating the transition to lower embodied carbon in the built environment.

TAG Climate: Tell us more about the engineering and chemistry that allow you to capture CO2 inside blocks while curing.

CARBONBUILT: Following concrete batching, mixing, and forming, the blocks are placed into the curing chamber, where dilute CO2 is introduced at ambient pressure and near ambient temperature. The calcium-rich material in the mix reacts upon contact with the CO2, forming calcium carbonate within the concrete.

We source CO2 from various avenues, exclusively prioritizing atmospheric C02, or C02 earmarked for release into the atmosphere. Our initial plant employs waste biomass to generate on-site CO2. Furthermore, we recently announced a partnership to utilize atmospheric CO2 captured through innovative Direct Air Capture technology.

TAG Climate: Can you share some insights into whether you believe our globe can and will make meaningful progress toward sustainability goals in the coming years?

CARBONBUILT: I hope that our approach and experience can inspire and encourage others as they develop climate solutions. We're demonstrating that a high-impact CO2-reducing commodity is possible without a green premium, excessive land use, and within the existing industrial infrastructure. Importantly, our solution does not necessitate code changes, new certifications, or customer adaptation.

We don't have time for moonshots or incremental change. We're proud of our customers, who drive sustainability in the built environment and show a profitable pathway to emissions avoidance and removal—today.

AN INTERVIEW WITH CHRISTOPHER WILDER, CEO & CO-FOUNDER, JCN FARMS

DELIVERING FRESH PRODUCE AND SOCIAL MEDIA CONTENT

Vertical farming benefits the environment in a variety of ways, but how products are delivered can enhance or reverse the gains.

Companies like JCN Farms know they need to focus on these details. They also see eager clients in a younger generation who arrive with different needs and expectations than older shoppers. These clients want to preview products on Instagram, therefore social media can be a necessary component of a marketing strategy.

TAG Climate: Did you start vertical farming to address a business issue or to address a climate issue?

JCN FARMS: It was to address a climate issue. We were looking at the data. There's all these statistics saying that by 2050, topsoil is not going to be arable for land use, or even for production of crops. So we thought, "OK, this is a problem that we want to address." And that's what led us into vertical farming.

TAG Climate: And how did it turn into a business?

JCN FARMS: It turned into a business when we thought, "OK, we can take this produce—what we're growing right now—we can do this year round. And this allows us to be able to provide produce to people all the time." And so it cuts the seasonal cycles which we have to rely on, and allows us to grow more produce each year and each month.

TAG Climate: Is vertical farming more suited to an urban environment or a rural one?

JCN FARMS: The great thing about vertical farming is that it can go in both areas. That's what gets us really excited about this. In an urban area, you can put a vertical farm in the center of the city. Or just outside of the city. You're taking a building, or maybe a warehouse, and you're growing food indoors year round. If you put it in a city center, you're going to reduce food waste, because it gets to people in literally five minutes. That's how quick it can be. In a rural area, where you can build a very large farm, you can have tons and tons of produce. Then that's distributed out to a local city. So I think that's the opportunity we have with vertical farming. It's very flexible.

TAG Climate: Who are your customers and target customers? And do they care how you grow your produce?

JCN FARMS: Our current customers are private chefs, catering companies and restaurants. We do a lot of door to door, so that's a good way for us to connect back to

Microgreen broccoli is 40 times more nutritious than the full head of broccoli, and it only takes seven days to grow.

the community. And soon it will be distribution companies as well as retail. So in terms of why the customer should care—and this goes to our door to door model—is you want to know where your food is coming from. A lot of the produce that you find at the store is days old. And it's traveling from, a lot of the times, South America or from different states. So by the time it gets on the shelves, the retail stores have a large amount of shrink, which is where the produce is dying and they can't use it. We connect to our communities, and we show these people, "Hey, we're growing your food, this is how we do it, and we deliver it to you. So you don't have to go to the store." And it's the best way for us to educate people on how to actually take care of their bodies or implement healthy products.

TAG Climate: What specifically are your products, and how do you market them?

JCN FARMS: Right now, we grow products called microgreens and we do gourmet mushrooms. Microgreens are—the easiest way I can describe this is that they're the most nutritious vegetables that you can consume. It's the second stage of the growth plant's lifecycle, so if you let it grow, it turns into a full head of whatever it's going to be. So you take like a small microgreen of broccoli, you let that grow, that turns into a full head of broccoli. What's cool about microgreens is that they're 40 times more nutritious than the full head of broccoli, and it only takes seven days to grow. So it's a really quick turnaround, and we can continuously and constantly have product for our consumers. In the future, we'll be doing leafy greens, berries and then on-the-vine tomatoes. But right now it's microgreens and gourmet mushrooms.

We sell our products in a variety of ways. Instagram has been huge for us. LinkedIn, we've got a lot of people who are seeing us there. So social media has been one aspect. A lot of it's been word of mouth. And one thing that we weren't able to do, which we thought would help us in the beginning, was go to farmers' markets. But that model slowly changed because our farmers markets didn't like competition [there were already vertical farmers selling there]. So that made us adapt and say, "OK, we aren't farmers. We're running this as a business. So let's find new avenues where we can take our business." We've been providing to B2B, just regular business owners. We give microgreens to these business owners, and they can give them to their customers or their employees as an appreciation gift.

TAG Climate: And how do you get your products into the hands of your customers?

JCN FARMS: We deliver. When we identify the customer that we want to pursue, we can start off by email, but I really like

“We provide you with produce, but we can also create social media content that you can promote, and we can promote.”

doing it face to face. And that just shows people the vision of what we’re trying to achieve with our company. So rather than everything being transactional, especially with private chefs or B2B customers—a lot of our competition just wants to have that transactional relationship, where it’s like, “I’m providing something to you, and then you’re paying me.”—for us, it’s a way to reinvest and elevate our customers, and bring them into our ecosystem. And provide more value.

TAG Climate: Uber Eats is working on a plan it’s announced to deliver food with automated vehicles, driverless cars. Have you thought about that?

JCN FARMS: Yes, of course that’s something that we want to do. Even if a person is still going to drive, we want to move toward electric vehicles, or electric vans, or even electric semis at some point, when we have to do distribution. We love interacting with our customers, we love doing the door to door. But I think for us, we will need to move away from that. So it allows us to work *on* the business rather than *in* the business. And that’s something that we’re really trying to tap into.

TAG Climate: You also have a media component to your business. How does that work?

JCN FARMS: That’s called JCN Media. With private chefs, catering companies and restaurants, what we do is we go, “Hey, we provide you with produce, but we can also create social media content that you can promote, and we can promote.” Because people unfortunately—especially in my generation—when they decide where they want to eat, they’ll go to Instagram first. They’ll see what it looks like. They’ll see what they serve. They like to do their research and due diligence before they go there. So if they have really exciting and unique content that shows people the atmosphere of this restaurant and what the food looks like, that’s just a good way to create more leads for those clients.

AN INTERVIEW WITH SORINA ULEIA, COO, RECYCLLUX

USING AI TO DRIVE MARINE PLASTIC RECYCLING

Plastic waste discarded in open or illegal dumps eventually ends up in the seas and oceans. This environmental catastrophe creates several hundred kilograms of marine plastic per year along every kilometer of coastline. Regrettably, this persistent problem will probably deteriorate significantly in the upcoming decade.

We recently chatted with Sorina Uleia, COO and founder of Recycllux, an innovative Romanian startup utilizing cutting-edge AI technology and earth observation data to pinpoint areas in the marine environment plagued by plastic litter.

TAG Climate: Tell us briefly about Recycllux.

RECYCLLUX: Our final service builds on groundbreaking technologies (Earth Observation, Machine Learning & Blockchain) to create a recycling and material chain optimized for marine plastic litter. Based on a sound scientific/technological foundation, we propose a systemic approach for preserving and restoring marine ecosystems by building an engaged community active in the fight against marine plastic pollution.

Identifying plastic accumulation is just the beginning. Our cross-value chain strategies involve partnering with socially responsible companies on climate change mitigation measures. We collaborate with fishing ships and local NGOs to collect and sort the waste and work with recycling companies to convert this waste into second-generation materials. Leveraging blockchain technology ensures full traceability so companies can share their sustainability efforts with consumers and the general public.

TAG Climate: How is the satellite Earth Observation data used, and how do you gain access to such information?

RECYCLLUX: Building upon our CEO's Ph.D. thesis, we developed an ML algorithm to identify marine litter aggregations, utilizing publicly available Sentinel-1 and 2 Earth Observation data and ground-truth data for accuracy. The EO data becomes valid when analyzed alongside other data sources, such as ground-truth data, to derive valuable insights and knowledge.

To facilitate this process, we create basin-specific datasets that serve as training data for the ML algorithm. Consequently, the algorithm generates a classifier to map and provide information about specific waste accumulations. Additionally, our system can adapt to alternative commercially available satellite imagery sources if necessary.

Identifying plastic accumulation is just the beginning. Our cross-value chain strategies involve partnering with socially responsible companies on climate change mitigation measures.

TAG Climate: How do you use advanced technologies, including AI and blockchain, to support your solution offering?

RECYCLLUX: We offer an accelerated and efficient approach to marine plastic collection and recycling. Using machine-learning algorithms on EO data, we identify marine plastic problem spots. Our unique solution facilitates end-to-end recycling interventions through our online portal, which harnesses the power of blockchain technology to incentivize collectors and establish connections among all key plastic supply chain players.

TAG Climate: Tell us more about your business plans and how you hope to expand.

RECYCLLUX: Our business model is both scalable and replicable, and our primary objective is validating our prototype through a comprehensive end-to-end intervention. Our initial focus is leveraging the proximity of the Black Sea basin and then expanding our business model to other basins worldwide.

Through this process, we'll engage with specific local stakeholders in each region to obtain ground-truth data, facilitate waste collection, and drive recycling efforts.

TAG Climate: Can you share some insights into your views on the likelihood of meeting important sustainability objectives in the coming years?

RECYCLLUX: Marine environments hold immense social, economic, and ecological significance. However, they face significant climate pressures from pollution and detrimental plastic/waste accumulation.

The mismanagement of plastic waste is a pressing global challenge that demands urgent attention if we are to accomplish the Sustainable Development Goals (SDGs) and meet the targets outlined in the 2015 Paris Agreement.

Recycllux helps save natural systems and reduces CO2 emissions by billions of tons. According to an **impact analysis** commissioned by EIT Climate KIC, a typical intervention collecting up to 10 tons of plastic waste saves 35 kg of CO2 eq.

Subsequent projects are expected to avoid over 5 tons of CO2 eq annually, which aligns with SDG13 (Climate Action) and SDG14 (Life Below Water).

AN INTERVIEW WITH GRETCHEN FOELS, DIRECTOR OF MARKETING, TOLEDO SOLAR

MANUFACTURING SUSTAINABLE AND ACCESSIBLE SOLAR TECHNOLOGY

Toledo Solar, a company based in Ohio, is spearheading the manufacturing of solar panels in the United States using patented processes for Cadmium Telluride (CdTe) thin film technology. This innovative approach produces solar panels that perform well and offers many advantages over traditional manufacturing methods and foreign-made Si-based PV modules. Thus, the manufacturing of solar panels is thriving in the U.S.

During a recent conversation, we spoke with Gretchen, who outlined Toledo Solar's vision and growth plans for the future. We were primarily interested in how Toledo Solar is managing its manufacturing operations in the United States amidst the Inflation Reduction Act (IRA) era, specifically, how their CdTe-based approach is performing.

TAG Climate: Briefly describe Toledo Solar and how you were founded.

TOLEDO SOLAR: We are the newest American manufacturer of the world's most powerful, innovative, and durable energy-producing solar glass. The company manufactures CdTe (pronounced "cad tell") Thin Film solar panels and systems for the U.S. residential and commercial/industrial markets in America, in a fully automated factory in NW Ohio, with a supply chain sourced exclusively from North America.

Toledo Solar's inception dates back to 2019, when it was founded by Jim Appold, Dr. Al Compaan, Aaron Bates, Mark Haddad, and Markus Hartel of The Atlas Venture Group. Our company firmly believes that energy independence begins at home. We strive to achieve this through our mission of providing cutting-edge CdTe solar modules, solar racking, and associated systems that are 100% manufactured in the U.S.

Our technology is based on CdTe Thin-Film Photovoltaics (PV) semi-conductors. CdTe technology is domestically sourced, providing for superior energy output and longevity relative to traditional silicon (Si) wafers. Toldeo Solar utilizes patented state-of-the-art manufacturing capabilities in our Perrysburg, OH, facility to produce PV modules for the non-utility markets.

We aim to cater to residential, commercial, and industrial installers in the U.S. and worldwide, utilizing solar power to reduce energy costs and promote sustainability by leveraging a clean and abundant renewable energy source.

TAG Climate: How does CdTe thin film technology work for solar panels, and what is its advantage?

TOLEDO SOLAR: CdTe thin film solar panels offer several benefits. Firstly, they have a spectral advantage over

Compared to traditional Si panels, CdTe thin film solar panels have a superior spectral response, higher energy production in hot conditions, and the fastest energy payback period in the industry.

other technologies, meaning that CdTe panels receive more light per day/month/year than Si-based alternatives. Secondly, CdTe boasts the industry's lowest degradation rate, resulting in prolonged power generation capacity compared to other technologies. Lastly, our panels are entirely manufactured in the United States, making them eligible for the 40% ITC Tax Credit and ensuring compliance with the Buy American, Buy Clean Act (BABA). So, when you purchase from Toledo Solar, you can take full advantage of these benefits.

TAG Climate: How are your products performing against more traditional solar panels made in countries such as China?

TOLEDO SOLAR: Compared to traditional Si panels, CdTe thin film solar panels have a superior spectral response, higher energy production in hot conditions, and the fastest energy payback period in the industry. America must achieve energy security and reach its carbon reduction goals without compromising its values. This means finding solutions that prioritize environmental sustainability and consider economic growth, national security, and the well-being of its citizens.

Unfortunately, the tremendous promise of solar energy has been undermined in recent years by issues such as forced labor and the use of coal-burning power plants in the overseas supply chain—neither of which is ever acceptable. We must stop turning a blind eye to these facts and work towards more ethical and sustainable practices in producing and distributing solar energy.

It is heartening to see that this scourge is finally being tackled by top officials in the finance and government sectors. The use of slave labor has no place in our industry or our country's critical renewable energy supply chain.

TAG Climate: Tell us more about your plans for growth into the future.

TOLEDO SOLAR: Our mission is to manufacture and distribute CdTe solar modules and related systems to residential and C&I Installers in the U.S. and around the world and provide rooftops with safe, recyclable, technically superior American-made Solar.

As we advance, we remain committed to increasing our manufacturing presence in Ohio, with plans to scale up production from the current 100MW per year capacity to an impressive 3GW annually by 2027. As a result, we anticipate a significant increase in our workforce, with the current headcount of 60 expected to grow to over 250 within the next few years.

AN INTERVIEW WITH SHARINA PERRY, FOUNDER AND INVENTOR UTOPIA PLASTIX

CREATING PLANT-BASED COMPOUNDED RESIN

Plant-based compound development has become a crucial aspect of the climate science industry. Utopia Plastix, led by entrepreneur Sharina Perry, is at the forefront of this movement, producing sustainable, plant-based alternatives to plastics. These innovative solutions offer numerous advantages that align with global sustainability initiatives.

During our recent conversation, Sharina generously shared her personal story and outlined how Utopia is expanding to promote climate-related projects. We were eager to gain insights into the company's approach to offering an alternative to petroleum-based plastics and to learn about Sharina's research and development endeavors.

TAG Climate: Tell us briefly about Utopia Plastix and what you do.

UTOPIA PLASTIX: Our company offers a plant-based alternative to traditional petroleum-based plastics. Through our research and development, we have a patent process that allows our resin to be used in any plastic application. We used plant matter in blown film processing, extrusion with a thin wall, and injection mold, thermoforming, blow molding, 3D, etc.

Utopia Plastix resins are 100% recyclable and compostable, and using our products does not necessitate retooling or equipment modifications. Feedback from manufacturers highlights the ease of use, lower production temperatures, improved strength properties, and reduced density. Additionally there are no harmful chemical odors during manufacturing, and products made with Utopia Plastix offer notable moisture barriers and insulation properties.

TAG Climate: You have a wonderful personal story as a founder. Can you share a bit about your personal journey?

UTOPIA PLASTIX: I started studying plant material after my nephew was diagnosed with NF2, and I learned that certain plants could shrink tumors. I then developed a plant-based health and wellness line of products. While studying over 600 white papers, I learned that some of the same crops offered an alternative to petroleum, cotton, and wood.

One day I decided to make a plant-based straw in my kitchen, which led to me making paper made from plants, with Hoffmaster converting the paper into straws and conducting third-party testing. From there, I hired experts and worked with industry leaders in polymers science, engineering, and manufacturing to develop what today is globally known as Utopia Plastix and recognized as a truly sustainable solution.

As part of the production process, unlike many alternatives, we do not extract or molecularly engineer components of plants to make our resins.

To take the next steps, I assembled a team of experts and collaborated with polymer science, engineering, and manufacturing leaders. Together, we worked diligently to refine our innovations, which eventually evolved into what is now globally recognized as Utopia Plastix—a truly sustainable solution that has revolutionized the industry.

TAG Climate: How do you produce your resin, and how is it used for plastics applications?

UTOPIA PLASTIX: As part of the production process, unlike many alternatives, we do not extract or molecularly engineer components of plants to make our resins.Utopia Plastix resins are in pellet or powderThey are a drop in replacement and demonstrate ease of use.

In fact, over 100 different products have been made globally using Utopia Plastix resins, covering a wide range of applications such as blown film, extrusion, injection molding, blow molding, thermoforming, 3D printing, and more.

TAG Climate: Tell us more about your business plans and how you hope to expand.

UTOPIA PLASTIX: Our Utopia Model Companies operate a sustainable eco-system business model that effectively manages and oversees our vertically integrated supply chain. This comprehensive model encompasses farming, processing, manufacturing, and distribution. With a purposeful approach, we developed Utopia Plastix as a solution, ensuring we avoid inadvertently creating new problems when addressing existing issues.

At the core of our business model lies a steadfast commitment to the well-being of our environment, society, and economy. Every decision and action we take is guided by the positive impact we can make in these areas. We plan to establish processing facilities nationwide as we scale to meet growing demand.

TAG Climate: Can you share some insights into your views on whether our globe can manage to meet important sustainability objectives in the coming years?

UTOPIA PLASTIX: Taking a "one size fits all" approach does not lead us to our desired outcome, in my opinion. I firmly believe that certain key factors are crucial to consider.

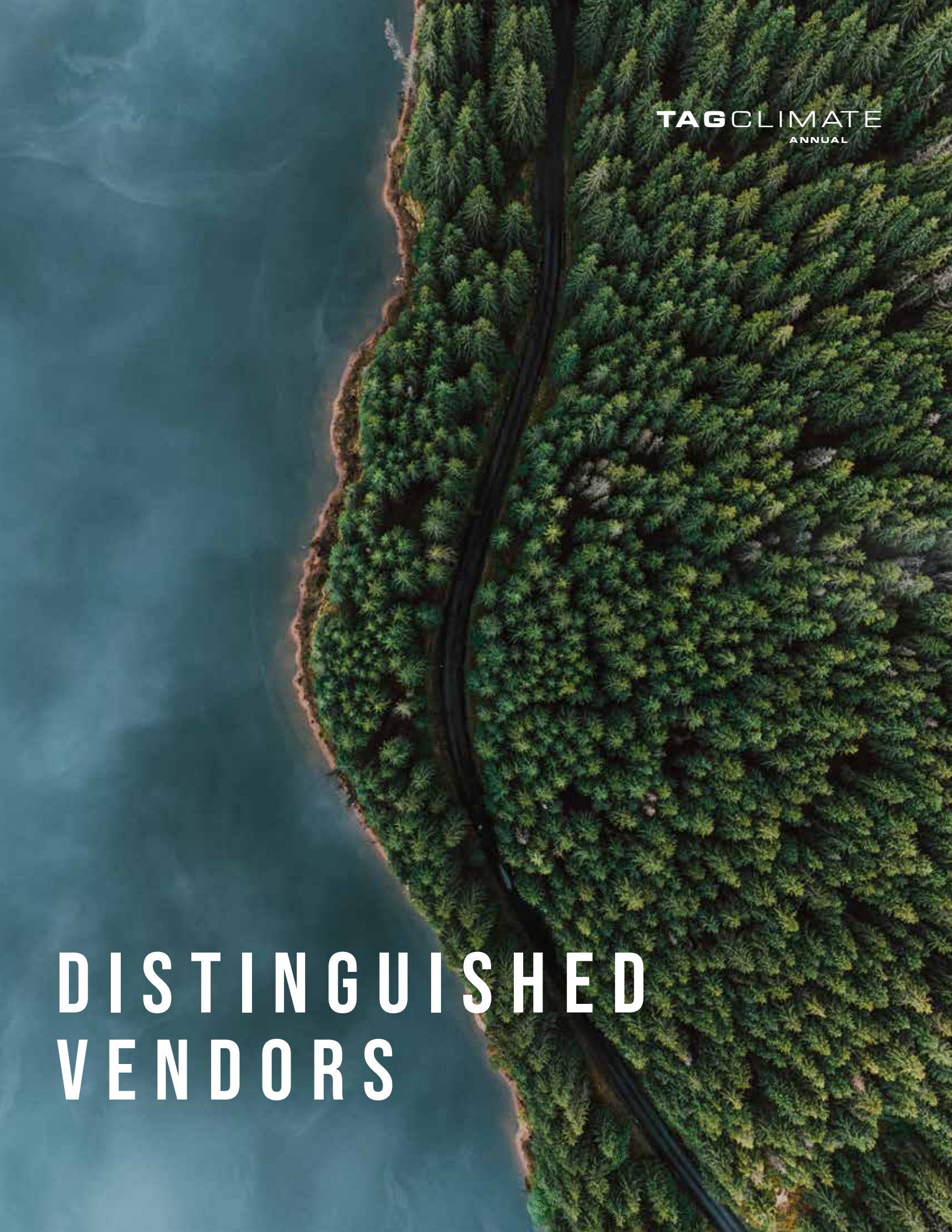
It is crucial to consider the environmental impact of source materials as we explore alternatives.

Corporations must go beyond product-level sustainability and invest in infrastructure for alternative materials and recycling

solutions. They must take responsibility for the harmful effects on health and wellness caused by their production, manufacturing, and distribution processes, particularly in developing countries and marginalized communities.

However, consumers need to understand that this issue is not solely the responsibility of governments and corporations. We must also evaluate our own consumption habits and make necessary changes. While there is a specified time period for meeting objectives, I hope significant progress will still be achieved even if those targets are not met.

"My brew has very low carbon emission ."



TAG CLIMATE
ANNUAL

DISTINGUISHED VENDORS

TAGCLIMATE

DISTINGUISHED VENDORS

SPRING 2023

Working with climate science vendors is our passion. It's what we do every day. Following is a list of the Distinguished Vendors we've worked with the past three months. They are the cream of the crop in their area—and we can vouch for their expertise. While we never create quadrants or waves that rank and sort vendors (which is ridiculous), we are 100% eager to celebrate good technology and solutions when we find them. And the vendors below certainly have met those criteria.

ACLYMATE

Aclymate empowers small and medium-sized businesses to become Climate Leaders. In less than 10 minutes per month, our customers can assess their emissions footprint, identify opportunities for reduction, and offset unavoidable emissions, ultimately earning our coveted Climate Leader certification.

AQUOM

AquOm Inc. is an American manufacturer of the world's most innovative, powerful, and all-natural products and solutions for water cleaning, agriculture regeneration, and non-petroleum-based plastic. The Company develops, produces, and supplies its products using locally-sourced materials from its R&D and manufacturing facilities in Kansas City, MO. AquOm products and solutions are distributed globally through a network of highly qualified distribution partners.

boomitra

Boomitra is the leading international soil carbon marketplace, utilizing satellite and AI technology for monitoring, reporting, and verifying carbon removal worldwide. Working with a network of global partners, Boomitra empowers farmers and ranchers to enhance their soil carbon and yields while earning extra income through carbon credits.

brilliant LIGHT POWER

Brilliant Light Power, Inc. (BLP) has developed an autonomous, zero-pollution primary energy source based on a proprietary hydrogen plasma reaction, which releases 200 times the energy of burning hydrogen from water. Our SunCell® offers a projected $20/kW cap cost and an electricity generation cost of $0.001 kW/h, making it an incredibly efficient new power source.

TAG CLIMATE DISTINGUISHED VENDORS

2023

CarbonBuilt™, the NRG COSIA Carbon XPRIZE winner, develops technology allowing manufacturers to produce ultra-low carbon concrete. By installing our equipment at existing plants, we enable the production of cost-effective concrete blocks that contain 70-100% less embodied carbon and comply with industry standards.

Through innovative, year-round, vertical farming, JCN Farms produces microgreens to bring healthy, affordable and sustainable foods to local communities. Using no pesticides, GMOs or nutrient-deficient soils, JCN Farms creates superior and dependable fresh, nutritious foods: micro-vegetables that contain more nutrients, vitamins, minerals, and enzymes than their mature full-sized counterparts.

Recycllux harnesses Earth Observation, AI, and Blockchain to address the marine plastic waste crisis. Our solution connects socially responsible companies seeking climate change mitigation with fishermen, local NGOs, and recycling companies. Together, we collect, sort, and transform the waste into second-generation materials.

Solar Cube is a cutting-edge technology company that offers a range of portable solar power stations designed for off-grid applications. Their products are built with a commitment to environmental sustainability and energy independence. Solar Cube's solutions are ideal for outdoor enthusiasts, emergency responders, and remote workplaces seeking reliable power sources.

Toledo Solar is the newest American solar manufacturer. Our patented processes for CdTe thin film technology produce more power, deliver a faster energy payback, and are 100% made in the U.S.A. We also offer a 100% lifetime warranty against cell cracking on our PV frameless all-glass construction.

Utopia Plastix is a plant-based alternative to traditional petroleum-based plastics. The crops used to make Utopia Plastix absorb carbon at 4-5 times the rate of trees, remove heavy metals from the soil, and add nutrients to the soil. No pesticides or fertilizers are used during grow cycles. Utopia Plastix resins are a drop-in replacement and do not require equipment modification or retooling. Utopia Plastix resins are 100% recyclable and compostable.

TAGCLIMATE