

14th Annual Edition

2021 Tech Trends Report

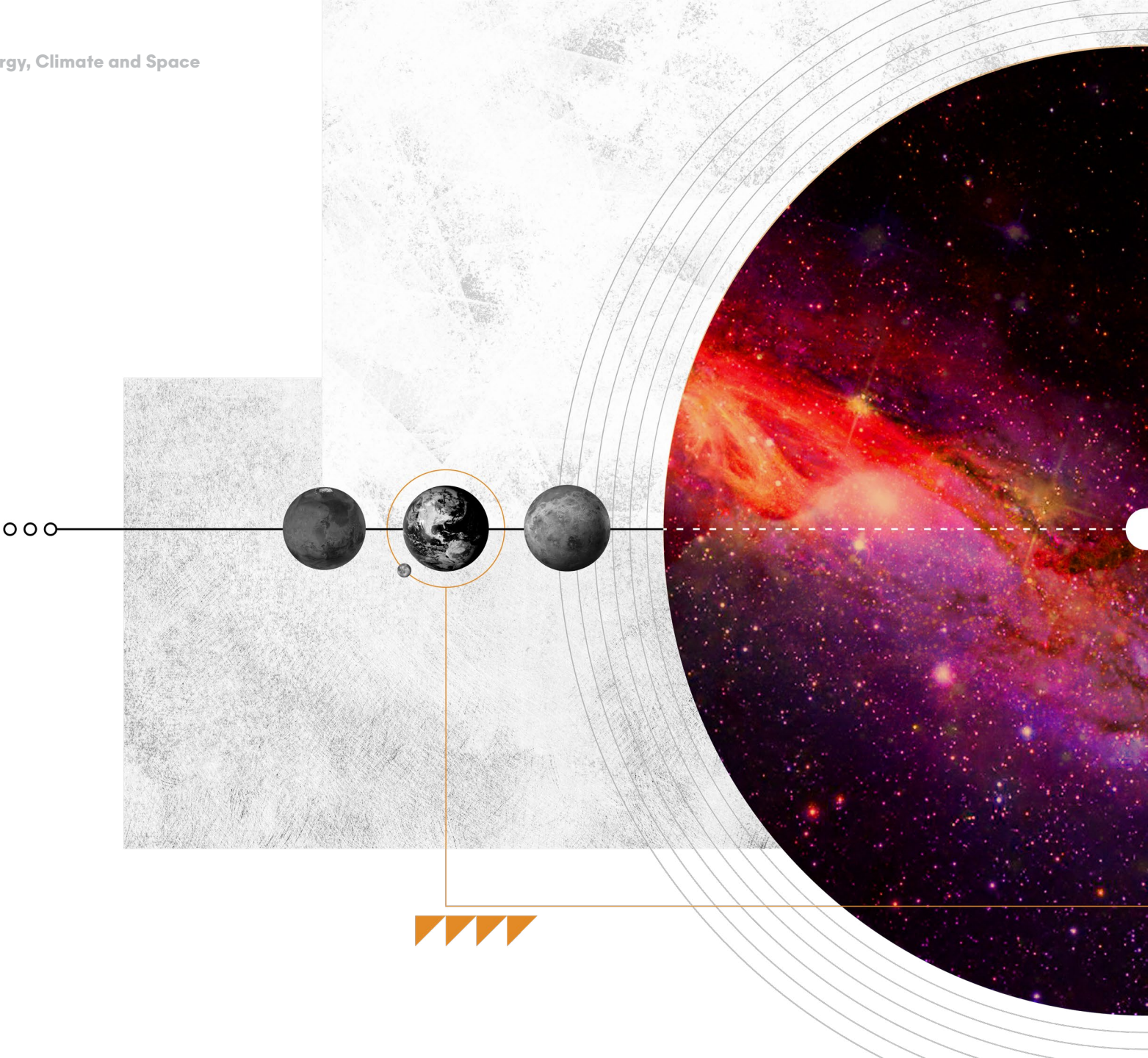
Strategic trends that will influence business, government, education, media and society in the coming year.



Energy
Climate
Space

03	Overview
04	Macro Forces and Emerging Trends
06	Summary
07	Energy
08	Million-Mile Batteries
09	Fusion Power
10	Clean Hydrogen
11	Grid Management
12	Charging Stations
13	Renewable Energy
14	Ultra-High-Voltage Direct Current and Macro Grids
15	Zero-Carbon Natural Gas
16	Floating Nuclear Power Plants (FNPPs)
17	Climate
18	The Anthropocene Epoch
19	Reversing Environmental Rules and Regulations
20	Green Stimulus Plans
21	Large-Scale Direct Air Capture
22	Unpredictable Sea Level Rise
23	Extreme Weather Events
25	Human Migration Patterns Shift
26	Plastic Rain
27	Plummeting Biodiversity
28	Rewilding
29	Seasteading
30	Green Tech
30	Bacterial Storage for CO2
30	CO2-Based Industrial Materials
30	Plastic-Eating Enzymes
30	Smart Ocean Filters
30	Ocean Fertilization
30	Sandcastling Glaciers
30	Reflecting Sunlight

30	Solar Radiation Management
30	Cloud Injections
30	Bioengineered Trees
33	Environmental, Social, and Corporate Governance (ESG)
34	Strategic Sustainability Plans
34	Supply Chain Sustainability
34	Shipping Industry ESGs
36	Space and Off-Planet Exploration
37	Scenario: New World Spores
38	Space Mining
38	Space Junk
39	Space Sustainability Initiatives
39	Space Imaging
39	Satellite Megaconstellations
40	Self-Steering Satellites
40	Space-Based Internet
40	The Space Economy
40	Space Tourism
40	Galactic Ride Sharing
40	Galactic Refueling Stations
41	Off-Planet Living
41	Mercury Rain
42	Space Forces
42	China's Space Ambitions
42	Ultra-Long Space Missions
43	Application
44	Key Questions
45	Sources
46	Authors
50	Why FTI
51	About FTI
52	Disclaimer
53	Creative Commons License



Overview



The 1920s began in chaos. Cataclysmic disruption resulting from the first world war and the Spanish flu shuttered businesses and provoked xenophobia. Technological marvels like the radio, refrigerator, vacuum cleaner, moving assembly line and electronic power transmission generated new growth, even as the wealth gap widened. More than two-thirds of Americans survived on wages too low to sustain everyday living. The pace of scientific innovation—the discovery of insulin, the first modern antibiotics, and insights into theoretical physics and the structure of atoms—forced people to reconsider their cherished beliefs.

The sheer scale of change, and the great uncertainty that came with it, produced two factions: those who wanted to reverse time and return the world to normal, and those who embraced the chaos, faced forward, and got busy building the future.

It's difficult not to see striking parallels to our modern world. A tumultuous U.S. election, extreme weather events and Covid-19 continue to test our resolve and our resilience. Exponential technologies—artificial intelligence, synthetic biology, exascale computing, autonomous robots, and off-planet missions to space—are challenging our assumptions about human potential. Under lockdown, we've learned how to work from our kitchen tables, lead from our spare rooms, and support each other from afar. But this disruption has only just begun.

With the benefit of both hindsight and strategic foresight, we can choose a path of reinvention. Our 2021 Tech Trends Report is designed to help you confront deep uncertainty, adapt and thrive. For this year's edition, the magnitude of new signals required us to create 12 separate volumes, and each report focuses on a cluster of relat-

ed trends. In total, we've analyzed nearly 500 technology and science trends across multiple industry sectors. In each volume, we discuss the disruptive forces, opportunities and strategies that will drive your organization in the near future.

Now, more than ever, your organization should examine the potential near and long-term impact of tech trends. You must factor the trends in this report into your strategic thinking for the coming year, and adjust your planning, operations and business models accordingly. But we hope you will make time for creative exploration. From chaos, a new world will come.

Amy Webb

Founder
The Future Today Institute

Macro Forces and Emerging Trends

For nearly two decades, the Future Today Institute has meticulously researched macro forces of change and the emerging trends that result. Our focus: understanding how these forces and trends will shape our futures. Our 14th annual Tech Trends Report identifies new opportunities for growth and potential collaborations in and adjacent to your business. We also highlight emerging or atypical threats across most industries, including all levels of government. For those in creative fields, you will find a wealth of new ideas that will spark your imagination.

Our framework organizes nearly 500 trends into 12 clear categories.

Within those categories are specific use cases and recommendations for key roles in many organizations: strategy, innovation, R&D, and risk.

Each trend offers six important insights.

1. Years on the List

We track longitudinal tech and science trends. This measurement indicates how long we have followed the trend and its progression.

2. Key Insight

Concise description of this trend that can be easily understood and repeated to others.

3. Examples

Real-world use cases, some of which should be familiar to you.

4. Disruptive Impact

The implications of this trend on your business, government, or society.

5. Emerging Players

Individuals, research teams, startups, and other organizations emerging in this space.

6. Action Scale

FTI's analysis of what action your organization should take. Fields include:

Watch Closely

Mounting evidence and data, but more maturity is needed. Use it to inform your vision, planning, and research.

Informs Strategy

Strong evidence and data. Longer-term uncertainties remain. Use it to inform your strategic planning.

Act Now

Ample evidence and data. This trend is already mature and requires action.

00010203040506070809101112

Health, Medical, Wearables

6

Watch Closely

Informs Strategy

Act Now

1ST YEAR ON THE LIST1

Doctorless Exams

Record EKG

Great Signal2670 BPM

How are you feeling?
For example, say "Okay"

AliveCor's personal EKG monitoring system.

59

KEY INSIGHT2

Advancements in diagnostic testing and remote monitoring, supported by cloud computing, machine learning, and low-cost technology are upending traditional doctor visits. Patient data are triaged by algorithm, rather than human doctors alone.

EXAMPLES3

Smartphones and smartwatches now take blood pressure readings and perform electrocardiograms, using apps approved by the U.S. Food and Drug Administration. Phones don't just record data; they interpret it. People who wear an Apple Watch know that an unusually high or low heart rate or irregular rhythm may suggest atrial fibrillation. The VROR system, a VR-based eye exam, emulates an eye doctor's ultra-widefield imaging machine but within a compact headset. Data are sent to a mobile app for an understanding of a patient's optic nerve health. StethiO is a mobile stethoscope that uses a smartphone to capture, decode and analyze heart sounds. AliveCor is an FDA-Cleared wireless personal EKG that connects to a phone. Butterfly iQ is a portable ultrasound device that delivers a 2D image. The ParatusPerio Test analyzes different bacteria and sources of inflammation in a patient's mouth.

DISRUPTIVE IMPACT4

Continual monitoring helps patients know their baseline vital stats and track any changes. This disrupts traditional healthcare in a few ways. First, with continual monitoring, patients are more likely to intercept an emerging problem in advance and seek out care. For example, if a patient's smartwatch warns of atrial fibrillation, they can call their doctor for next steps. This reduces strain on emergency departments. It also unlocks new opportunities for healthcare systems and insurers willing to use those data and to make medical records systems interoperable. Financial forecasting that harnesses real-time data could be algorithmically recalibrated, and more accurately assess risk. But connected devices aren't accessible to everyone, which means that a new digital divide could be on the horizon, further reducing health equity in many communities.

EMERGING PLAYERS5

- The Clue period tracking app
- Apple Health
- StethiO
- Healthy.io
- Paratus Diagnostics
- Butterfly Network
- AliveCor

© 2021 Future Today Institute

Macro Forces and Emerging Trends

Scenarios Describe Plausible Outcomes

You will find scenarios imagining future worlds as trends evolve and converge. Scenarios offer a fresh perspective on trends and often challenge your deeply held beliefs. They prompt you to consider high-impact, high-uncertainty situations using signals available today.

1. Headline

A short description offering you a glimpse into future changes.

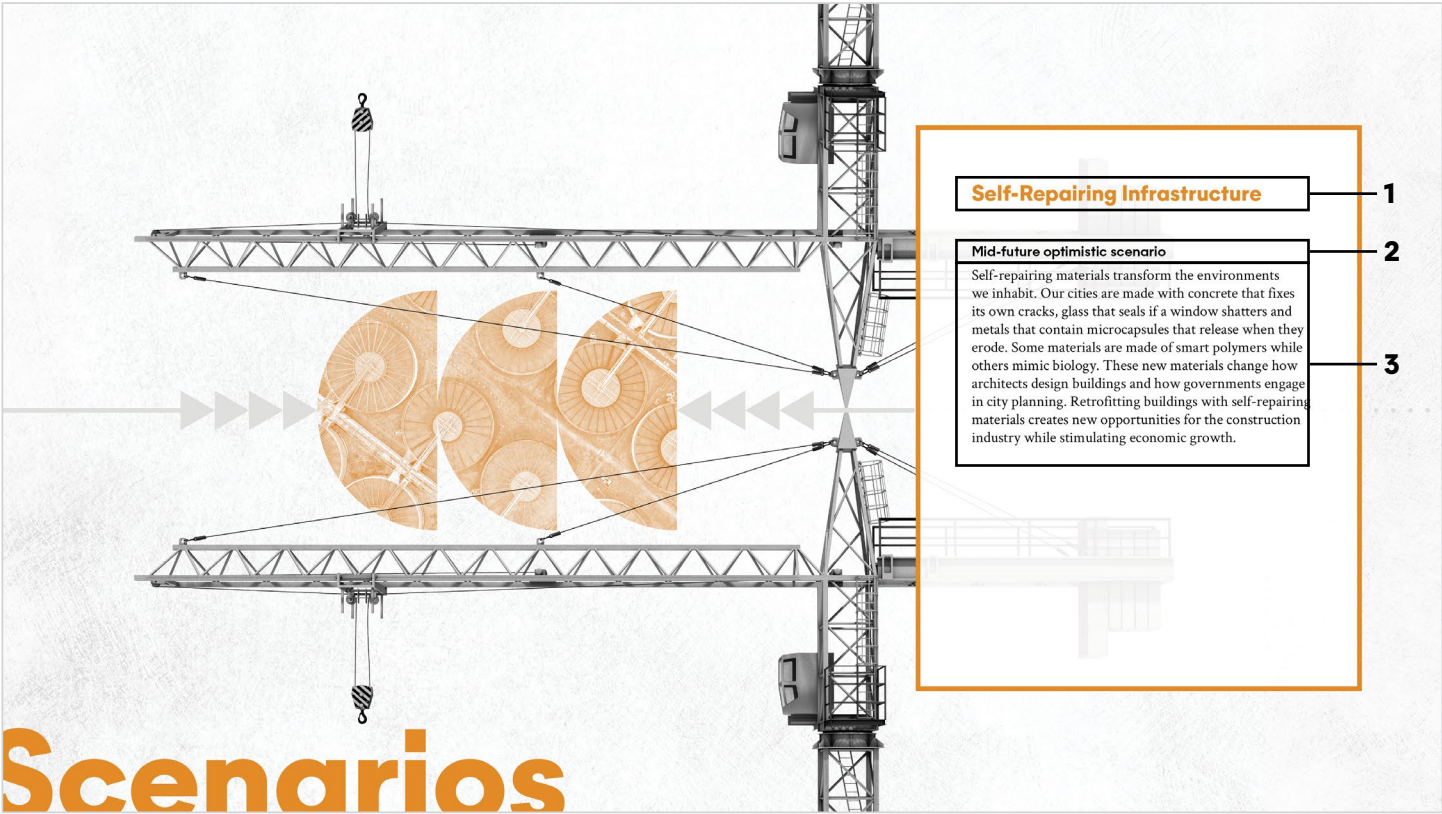
2. Temporal and Emotive Tags

A label explaining both when in the future this scenario is set and whether it is optimistic, neutral, pessimistic, or catastrophic.

3. Narrative

The descriptive elements of our imagined world, including the developments leading us to this point in our future history.

Scenario sources: The Future Today Institute uses a wide array of qualitative and quantitative data to create our scenarios. Some of our typical sources include patent filings, academic preprint servers, archival research, policy briefings, conference papers, data sets, structured interviews with experts, conversations with kids, critical design, and speculative fiction.



Energy Climate & Space Summary

- + With the new Biden Administration, the U.S. will reverse course on recent energy, climate, and sustainability policy.
- + The lasting economic consequences of climate change are dire, which is why so many start-ups are promising to mitigate climate change.
- + Several countries will debut green stimulus packages, unlocking new business opportunities.
- + Innovative energy research is well underway, ranging from smart grids powered by artificial intelligence to million-mile batteries.
- + This is an important year for space missions, including tens of thousands of satellites deployed in megaconstellations promising to beam internet connectivity from space.
- + A new space economy is forming, and tensions are arising as China aims to become a major driver of space-related commerce and trade.

Energy

2ND YEAR ON THE LIST

Million-Mile Batteries



Million-mile batteries could revolutionize the electric vehicle market.

KEY INSIGHT

As more devices and vehicles rely on battery power, the race to produce a lighter, more efficient battery is more competitive than ever. New technology promises to extend the life of car batteries, which could reduce the degradation process and allow batteries to outlive the vehicles they power. Ultimately the industry strives to produce a battery that could power up to a million miles of drive time before needing replacement.

EXAMPLES

Tesla launched its “million mile” project last year to power a vehicle’s entire life cycle on a single battery. Contemporary Amperex Technology will make ultra-capacity batteries that last 16 years for Audi, Porsche, and BMW. General Motors is working on a similar battery. Researchers are working to improve battery design, composition, and storage: The U.S. Department of Energy’s Pacific Northwest National Laboratory discovered how to make a more efficient and stronger single-crystal, nickel-rich cathode. The University of Münster in Germany found a way for single-use zinc-air batteries to be recharged hundreds of times. And Spanish startup Graphenano built a battery out of graphene that charges a car in eight minutes. Japan’s Ritsumeikan University and Panasonic are trying to squeeze the last bits of untapped energy out of lithium-ion batteries, particularly because they don’t recycle well.

DISRUPTIVE IMPACT

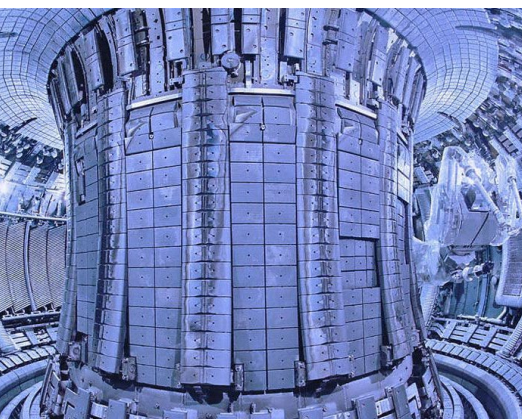
Batteries, essential to our everyday lives, will become more important as climate change worsens. Better, longer-lasting batteries not only improve energy usage and efficiency, they allow us to communicate, connect, and continue daily activities during energy disruptions. Researchers at Daimler, Fisker, Jiangxi Ganfeng Lithium, Massachusetts Institute of Technology, Stanford University, and Tokyo Institute of Technology are working on replacing flammable liquids in batteries with solid materials. The result may be safer, cheaper batteries with greater storage and greater drive range for electric vehicles. If successful, the tech could drop electric vehicle charging times from several hours to 10 minutes. By 2027, the lithium-ion battery market could hit \$129.3 billion, and the electric vehicle battery market could expand to \$133.46 billion.

EMERGING PLAYERS

- Contemporary Amperex Technology
- Tesla
- General Motors
- Panasonic
- LG Chem
- Aurora
- BYD

1ST YEAR ON THE LIST

Fusion Power



Inside a nuclear fusion reactor.

KEY INSIGHT

Fusion power plants could produce carbon-free electricity by harnessing the same nuclear process that powers the sun. In the next decade, fusion researchers will discuss and prototype ideas to design a fusion reactor.

EXAMPLES

Researchers and government agencies from 35 countries are collaborating to build the largest tokamak, the central component of a magnetic fusion project that will prove the feasibility of fusion as a large-scale and carbon-free source of energy. Construction on the ITER (“the way” in Latin) is already happening in southern France. The project, featuring the first device that can maintain fusion over long periods of time, could lay the groundwork for the commercial production of unlimited, fusion-based electricity. The U.S. National Academies of Sciences, Engineering, and Medicine introduced a road map to fusion power in late 2020, identifying technological gaps and near-term facilities to fill them. It calls for the U.S. Department of Energy to build a prototype in the 2040s to produce our electricity from fusion rather than fossil fuels.

DISRUPTIVE IMPACT

Fusion research has primarily been funded through basic science initiatives from government agencies (such as the DOE’s Office of Science.) But fusion research has gained support from outsiders, and efforts to use a practical, applied approach are growing. This could unlock a new value chain: facilities, advanced lasers, and computer systems that need to be built.

EMERGING PLAYERS

- DOE’s Fusion Energy Sciences program and Federal Fusion Energy Sciences Advisory Committee
- ITER
- SLAC National Accelerator Laboratory

1ST YEAR ON THE LIST

Clean Hydrogen



Ørsted launched a pilot for green hydrogen.

KEY INSIGHT

Hydrogen is abundant, ubiquitous, and a versatile energy carrier. It can be produced from a wide range of sources and used in many ways across the energy sector. Clean hydrogen could play an important role in transitioning much of the world away from carbon-based energy sources.

EXAMPLES

There are different types of hydrogen. For example, hydrogen produced industrially from natural gas results in high carbon emissions; it’s known as “gray” hydrogen. But a different process, which captures and stores emissions, results in a cleaner “blue” hydrogen. “Green” hydrogen is generated by renewable energy sources and never results in carbon emissions. Because hydrogen burns at very high temperatures, it is an effective replacement for fossil fuels in industrial applications.

France invests heavily in producing green hydrogen. Out of a 2020 stimulus package worth 100 billion euros, the country dedicated 7.2 billion euros to a project that will create green hydrogen by 2030. The French government has set a target of 10% green hydrogen use in industry for 2022 and 20% to 40% for 2027.

DISRUPTIVE IMPACT

Right now, clean hydrogen is expensive, and traditional energy sources are simply more affordable, especially when used at scale. But government investments could spur a new clean hydrogen economy. Some estimates show that green hydrogen prices could fall from today’s \$6 per kilo to less than \$1 by 2050, making it competitive with the current prices of natural gas. Green hydrogen could someday be shipped around the world to places with less access to cheap renewable energy sources. Japan is already working on the supply chain for a clean hydrogen market: It has pilot projects underway with Saudi Arabia, Brunei, and Australia.

EMERGING PLAYERS

- Ørsted
 - Vattenfall
 - European Renewable Energy Directive
 - NextEra Energy
 - Siemens Gamesa
 - Everfuel

2ND YEAR ON THE LIST

Grid Management



Smart technologies will help balance the power grid.

KEY INSIGHT

In many countries, government agencies and private companies distribute energy to citizens via an electric grid that's made up of a sprawling network of generators and connectors. Increased demands for power, combined with a failure to maintain or expand these grids, will pose new challenges over the next two decades.

EXAMPLES

China rationed electricity in December as unexpected cold temperatures and rapid post-COVID-19 economic recovery created a surge in energy demands. More than 67 million people had reached the electricity grid's maximum load in the province of Hunan, and local media reported a 3 million to 4 million kilowatt deficit of energy during winter's peak period. While the cold challenges China, increasing temperatures strain California. Rolling blackouts in 2020 and early 2021 impacted hundreds of thousands of homes and businesses. Coupled with wildfires that strain the grid and create solar energy shortages, California faces a growing energy crisis. Climate change has introduced drier, hotter weather to some unexpected parts of the world, while in other areas ice and subzero temperatures have suddenly become more common. Our power networks were never designed with these fast-changing environmental realities in mind.

DISRUPTIVE IMPACT

Grid failures cost millions and put lives in danger. Utility company equipment isn't being repaired or modernized fast enough, and maintenance will become more difficult amid climate change and new power demands. The U.S. hasn't engaged in long-term planning and has no comprehensive national electricity policy. Remote work may help alleviate strain—U.S. power consumption dropped 4% in the first half of 2020—but it won't offset the impact of climate change. Massachusetts Institute of Technology outlined steps to preempt problems, including incentivizing renewables, artificial intelligence-based predictions about usage, expanding wide-area transmission planning, and conserving energy. AutoGrid and Origami Energy make software to help optimize grids. XENDEE and Worley created cloud software for microgrids. Energy storage will continue to evolve: Northwestern University and German scientists are developing "singlet fission" technology to generate more electricity from solar cells.

EMERGING PLAYERS

- AutoGrid
- Bloom Energy
- Lition
- Origami Energy
- Stem

4TH YEAR ON THE LIST

Charging Stations



Infamous gas-guzzler Hummer will return in 2022 as an electric vehicle.

KEY INSIGHT

In the coming years, an unprecedented number of charging stations for electric vehicles will come online, driving demand for a new kind of car and disrupting the supply chain and retail business of traditional gasoline.

EXAMPLES

Governments, utilities, and third-party companies are installing networks of charging stations, a process that involves lots of red tape and requires dealing with local utilities and real estate owners. The U.S. had more than 78,000 charging outlets and 25,000 charging stations for plug-in electric vehicles in March 2020. California, Oklahoma, New York, and Colorado also plan to invest in networks of electric charging stations. Electrify America will install charging stations at 100 Walmart stores in 34 states. ChargePoint will open 2.5 million charging stalls by 2025, up from 53,000. EVgo created a modular fast-charging station that can be installed in a matter of days. Google Maps, ChargePoint, and PlugShare use smartphone apps to show the prices, locations, and types of charging ports available, and let people rate and review them.

DISRUPTIVE IMPACT

Auto manufacturers will invest an estimated \$225 billion to electrify their fleets in the next few years, including the new Audi e-Tron; Ford Mustang Mach-E; Mercedes EQS; BMW i3, i4, iX3, and iNext; Volvo Polestar 2; and General Motors’ Hummer.

The expansion of charging stations will have a chilling effect on independent and corporate gasoline station chains and the local communities they support. The demand for oil took a significant hit in 2020, and car sales dropped. But the shift toward electric vehicles accelerated. The pandemic may be a turning point for the electric car industry.

EMERGING PLAYERS

- Blink Charging
- ChargePoint
- Electrify America
- Envision Solar
- Wawa

3RD YEAR ON THE LIST

Renewable Energy



Geothermal energy offers an alternative to petroleum.

KEY INSIGHT

Renewable energy is collected from sources that can be replenished on a reasonable timescale. Renewable sources include wind, tides, geothermal heat, and sunlight. In many markets around the world, renewable energy is already cheaper than nonrenewable energy.

EXAMPLES

Renewables are “the fastest growing source of electricity generation,” according to the U.S. Energy Information Administration. In 2019, 400 global corporations committed to climate protection and sustainability goals, while 63 promised to convert 100% of their energy use to renewables. The amount of clean, renewable energy bought by some of the world’s largest companies tripled between 2018 and 2020, and more than 100 global cities report they get 70% of their energy from renewables. In September 2020, Chinese President Xi Jinping announced that his country is committed to becoming carbon neutral by 2060. The Biden administration is poised to roll out an ambitious \$2 trillion plan to reach net-zero domestic carbon emissions by 2050. Even oil-rich Saudi Arabia is working on a detailed, long-term plan to diversify its economy and move away from oil.

DISRUPTIVE IMPACT

Renewables will have greater importance in the coming decade. On his first day in office, President Biden signed executive orders signaling a commitment to renewables. Interest in cleantech is growing in China, Singapore, the Middle East, and Norway amid a global shift toward energy efficiency and lower carbon emissions. The International Energy Agency projects that those regions and countries will account for about 40% of energy distributed through the global power grid by 2040. A new value chain is emerging, buoyed by policy, and representing new business opportunities—and headaches for traditional petroleum companies.

EMERGING PLAYERS

- Energy Vault
- First Solar
- NextEra Energy
- SolarEdge Technologies
- Sunrun

4TH YEAR ON THE LIST

Ultra-High-Voltage Direct Current and Macro Grids



Macro grids could be the future of distributed, renewable energy.

KEY INSIGHT

In the near future, we will transport clean energy from production sites to destinations in need using a new kind of power grid now being tested in China.

EXAMPLES

China invested \$88 billion to build macro grids and a new kind of transmission system—ultra-high-voltage direct current (UHVDC). The nation turned on its first 800,000-volt line, covering the east-west expanse of the country and carrying enough energy to power half of Spain. China plans to transport clean energy all around the world, and its Belt and Road Initiative could facilitate that effort. Fifty years from now, we may rely more on China than on OPEC countries (Saudi Arabia, the United Arab Emirates, Venezuela, Iraq, Iran, Kuwait, Libya, Nigeria, Qatar, Algeria, Angola, and Ecuador) for our energy needs.

DISRUPTIVE IMPACT

A national direct-current macro grid could drastically lower emissions in an affordable way without compromising access to electricity. It could also redistribute power to areas experiencing energy shortages and blackouts. The ability to generate and transport energy in times of crisis could become a critical political and economic advantage and could impact where businesses operate.

EMERGING PLAYERS

- ABB
- TransWest Express Transmission Project
- Macro Grid Initiative
- State Grid Corp. of China

2ND YEAR ON THE LIST

Zero-Carbon Natural Gas



Net Power's demonstration plant in La Porte, Texas.

KEY INSIGHT

Zero-carbon natural gas is produced at plants that capture all carbon dioxide byproduct, neutralizing the carbon output of the process.

EXAMPLES

Natural gas plants of the near future may capture all of their emissions at zero cost using a technology called carbon capture and storage, or CSS. While the tech has been around for decades, it has not been deployed at scale. In 2019, startup Net Power successfully built a prototype plant that ran a full cycle without releasing troublesome emissions into the air. The company hopes to scale up to a full-size plant by 2021. New tax credits of up to \$50 for each metric ton of emissions captured and stored by a power plant or factory will likely help accelerate wider adoption of this technology. Net Power is a collaboration between Exelon Generation, energy construction company McDermott International, technology developer 8 Rivers Capital, and Oxy Low Carbon Ventures.

DISRUPTIVE IMPACT

Natural gas produces roughly 32% of U.S. electricity and 20% worldwide. That translates to a significant amount of carbon emissions. With new CSS technology, carbon-free energy could be produced from fossil fuels much more cheaply than via nuclear power plants, and new plants could be booted up as needed without having to wait for power sources that are in long-term development (such as fusion). The popularity of net-zero natural gas will be driven by demand for all that captured and stored CO2. Industrial manufacturers that work with carbon-based materials are prime buyers.

EMERGING PLAYERS

- Net Power
- Exelon Generation
- McDermott International
- 8 Rivers Capital



2ND YEAR ON THE LIST

Floating Nuclear Power Plants (FNPPs)



The Akademik Lomonosov is a floating nuclear power plant that holds two nuclear reactors and is stationed in the Chukotka Autonomous area on Russia's Arctic coast.

Photo courtesy of Lev Fedoseyev/TASS.

KEY INSIGHT

Floating nuclear power plants (FNPPs) are a new kind of energy plant that can float and move with currents, while also withstanding harsh environmental conditions.

EXAMPLES

In an attempt to increase nuclear proliferation, Russia launched an FNPP called the Akademik Lomonosov in 2020. It is loaded with two nuclear reactors and began producing energy last year. Now, Russia is planning a new fleet of FNPPs that have even greater power capacity and could operate for up to 10 years without requiring maintenance of any nuclear reactors. The plants' crews would be stationed onshore. Rather than FNPP barges being stationed off the coast of cities with high power demand, they would deploy on a project basis. For example, Russia hopes to construct an FNPP to generate power for one of the world's largest copper and gold deposits, the Baimsky Mining and Processing Plant.

DISRUPTIVE IMPACT

Nuclear power generation is risky, but it presents an advantage: You can fix the cost of electricity for the duration of a project, since this type of energy is not subject to market risks and volatility.

EMERGING PLAYERS

- Akademik Lomonosov
 - RusHydro
 - Rosatom

Climate

7TH YEAR ON THE LIST

The Anthropocene Epoch



Humans have left a permanent mark on the planet.

KEY INSIGHT

We are in a new geological epoch defined by the permanent impact that humans have had on Earth: The “Anthropocene” (anthro for “man,” and cene for “new”). Our previous epoch, the “Holocene,” began 11,700 years ago just after the last ice age. By defining our current stage of history and the change it represents, we can set a different—and hopefully improved—trajectory for life on Earth.

EXAMPLES

A new epoch follows a cataclysmic event. (For example, mass extinction of the dinosaurs followed an asteroid colliding with Earth.) Such events significantly and permanently alter the underlying sedimentary and rock layers beneath the surface of the planet. In 2018, an international, independent team of scientists, called the Anthropocene Working Group, found enough evidence to support the official declaration of a new geological epoch. Despite early debate, concrete, publicly available research now corroborates the designation. Humans have left a permanent mark on the planet with chemicals and industrial waste, pavement, plastic, nuclear fallout, everyday garbage, pesticide runoff.

DISRUPTIVE IMPACT

The United Nations Development Programme has noted that the Anthropocene is the era “in which the dominant risk to our survival is ourselves.” Recognizing that humans have made a permanent, visible mark on the earth is the first step in studying the implications for our planet’s future. Every aspect of life on Earth could be affected. We will need collective and collaborative action from governments and industry if we hope to counteract the planetary damage already done.

EMERGING PLAYERS

- Anthropocene Working Group
- International Union of Geological Sciences
- The Nature Conservancy
- Union of Concerned Scientists
- U.S. Geological Survey

2ND YEAR ON THE LIST

Reversing Environmental Rules and Regulations



President Joe Biden signed an executive order on the international Paris climate agreement just hours after his inauguration on Jan. 20, 2021.

KEY INSIGHT

While citizens demand action on climate change, some world governments are now relaxing or eliminating rules and regulations designed to mitigate human-caused environmental damage.

EXAMPLES

The Trump administration rolled back more than 100 environmental rules and regulations during its single term, according to U.S. Environmental Protection Agency research. In June 2020, Trump repealed the 50-year-old National Environmental Policy Act, which requires federal agencies to consider the environmental effects of proposed projects before approvals. This effectively cut the timeline for reviews and eliminated requirements meant to limit environmental harm. The Trump administration also replaced the Obama-era Clean Power Plan, which set strict limits on carbon emissions from coal- and gas-fired power plants, and instead allowed states to set their own rules. It cut the reach of the Clean Water Act, removing federal protections for millions of miles of streams and about half of America’s wetlands. On his first day in office, President Biden re-joined the Paris Climate Accord, undoing the Trump administration’s exit.

DISRUPTIVE IMPACT

Scientists warn that as temperatures and sea levels rise faster than originally projected, climate change will drastically change life as we know it, disrupting our global food supply, threatening human health worldwide, and limiting our ability to work and travel. Before COVID-19, the World Health Organization identified climate change as the greatest threat to global health in the 21st century, noting that environmental degradation might allow a spectrum of diseases to flourish. Many international initiatives aim to combat and mitigate the effects of climate change, but each country ultimately designs and implements its own regulations. As calls for climate action grow, the public and private sectors may increasingly conflict with one another—but perhaps also align.

EMERGING PLAYERS

- C40 Cities
 - Climate Justice Alliance
 - Extinction Rebellion
 - Indigenous Environmental Network
 - Union of Concerned Scientists

2ND YEAR ON THE LIST

Green Stimulus Plans



Rep. Alexandria Ocasio-Cortez (D-NY) speaks as she and Sen. Ed Markey (D-MA) unveil the Green New Deal resolution.

KEY INSIGHT

Green stimulus plans are government measures to stimulate the economy while promoting clean energy, responding to climate change, encouraging biodiversity, and protecting the environment.

EXAMPLES

Green stimulus plans have been introduced in China and Europe. In China, both electric vehicle charging and mass transit were identified as new infrastructure that will receive priority stimulus investments. China has also published a number of energy-efficient infrastructure goals—though it has rolled back regulations on coal power capacity. The European Union’s executive branch developed a stimulus plan of 750 billion euros, with 100 billion euros allocated to efforts at reaching zero carbon emissions. Meanwhile the U.S. Senate passed a \$2.2 trillion stimulus package with no earmarks for green technology or initiatives. But that’s going to change: With unified control of Congress and the White House, Democrats plan to pass a version of the Green New Deal that was previously introduced.

DISRUPTIVE

At the moment, job creation for green R&D investments is low relative to other industries. However, public funding in the U.S., Europe, and China for clean energy research and infrastructure development will lead to new job creation and produce high long-term economic returns—while mitigating climate and environmental challenges. Carbon capture and removal, industrial decarbonization, water reuse, desalination, and energy storage are just a few areas that can be targeted with green stimulus plans, which mean new opportunities for businesses.

EMERGING PLAYERS

- League of Conservation Voters
 - ClearView Energy Partners
 - U.S. Federal Electricity Regulatory Commission
 - U.S. Rep. Alexandria Ocasio-Cortez (D-N.Y.)
 - U.S. Sen. Edward Markey (D-Mass.)
 - International Energy Agency
 - Data for Progress
 - The Democracy Collaborative’s Climate and Energy Program

1ST YEAR ON THE LIST

Large-Scale Direct Air Capture



The world's largest Direct Air Capture (DAC) and sequestration facility.

KEY INSIGHT

Direct air capture technology extracts carbon dioxide directly from ambient air rather than capturing it at sites where it is created, like factories and certain power plants. The CO₂ can be permanently stored in deep geological formations or used to produce new industrial products, such as fuels and chemicals.

EXAMPLES

Climeworks, Global Thermostat, and Carbon Engineering are developing direct air capture systems to vacuum CO₂ molecules from the air. Aiming to spur the reusable CO₂ marketplace, CarbonX offered a \$20 million prize to companies that develop innovative ways to use captured CO₂. In 2020, Microsoft announced a new \$1 billion fund for “carbon reduction, capture, and removal technologies” to help offset the company’s historic emissions. In January 2021, Tesla CEO Elon Musk announced a \$100 million prize for carbon capture technology.

DISRUPTIVE IMPACT

In early 2021, the concentration of CO₂ in the atmosphere was the highest ever recorded in human history. CO₂ leads to global warming, and that has a cascading effect on business and society. Increasing attention to direct air capture through big investments will galvanize movement in the near future. As startups prove their technology, new and bigger markets will be built, which means a greater value for captured gas—and ultimately another tool to help mitigate the effects of climate change.

EMERGING PLAYERS

- Climeworks
- Global Thermostat
- Carbon Engineering
- Microsoft
- Elon Musk
- Intergovernmental Panel on Climate Change
- Southern Green Gas
- Commonwealth Scientific and Industrial Research Organisation
- Occidental Petroleum
- Bill Gates

3RD YEAR ON THE LIST

Unpredictable Sea Level Rise



A mother and child wade through dangerous waters in Jakarta, Indonesia.
Image courtesy of the World Meteorological Organization/Flickr.

KEY INSIGHT

We’re getting better at understanding how ice sheets and sea levels change over time. In the years ahead, there will be more focus on trying to measure, interpret, and intervene in the rate of change.

EXAMPLES

In 2020, Eastern Siberia recorded the hottest temperatures ever in the Arctic Circle, which melted sea ice and delayed by two months the usual Arctic freeze. Meanwhile, historic floods ruined millions of acres of farmland, and coastal flooding wrought havoc in Alabama and Mississippi. In 2019, 100 scientists began studying the Thwaites Glacier and its melt-off that threatens coastal areas, including Manhattan.

New scientific models and artificial intelligence may help us understand and predict sea levels and human migration patterns: The University of Southern California predicts mass migration to Atlanta, Houston, Dallas, Denver, Las Vegas, and other landlocked urban centers as well as rural Midwestern areas. The federal Global Change Research Program predicts heavier rainfall, 8-foot sea level increases in the next century, earlier spring snowmelt, reduced snowpack, and chronic, long-term drought.

DISRUPTIVE IMPACT

It is difficult to overstate how significantly rising sea levels will impact human and animal migration, the global supply of food, and our ability to move around. It could reshape countries and trigger mass-scale human migration. Scientists at the Grantham Institute—Climate Change and Environment at Imperial College London warn that the sea could rise higher than the current 2100 estimates if climate change proceeds unchallenged.

To protect against flooding, the San Francisco International Airport will build a 10-mile-long wall, and the U.S. Army Corps of Engineers may create a 6-mile-long barrier in New York City. Fast-rising sea levels along the Gulf and East coasts of the U.S. may lead to \$1 trillion in mitigation, repair, and relocation costs. Insurers, city planners, businesses with global supply chains, and any business that relies on or provides logistics should be monitoring this trend carefully.

EMERGING PLAYERS

- British-American International Thwaites Glacier Collaboration
- ClimaCell
- Opti
- Piccard.ai
- Union of Concerned Scientists

3RD YEAR ON THE LIST

Extreme Weather Events



Extreme weather events will continue to plague communities in the future.

Image courtesy of @bwc/Flickr.

KEY INSIGHT

An extreme weather event falls outside the statistical norms of typical fluctuations in weather patterns. Such events became a more frequent and pronounced worldwide phenomenon in 2017, and we have been experiencing them since.

EXAMPLES

The past five years on Earth have been the hottest on record, with average temperatures having risen 1.8 degrees Fahrenheit in the past 115 years, the warmest period in modern civilization. The Oeschger Centre for Climate Change Research at Switzerland’s University of Bern analyzed global temperatures over 2,000 years and found that, despite short periods of cooler temperatures, the Earth is warming faster than at any other time in the past two millennia.

The result: extreme weather. A 2019 Bulletin of the American Meteorological Society report confirmed the link between the earth’s rising temperature and extreme weather events, based on the views of 120 scientists from 10 countries and 17 peer-reviewed analyses with historical observations and model simulations.

The repercussions have been devastating. The 2019–2020 Australian bushfires killed millions of animals, destroyed more than 12 million acres, and cost \$110 billion in damages. Last year, 22 U.S. weather and climate disasters caused \$1 billion in losses each, and California’s fires alone scorched 4.1 million acres, up from the previous state record of 1.9 million in 2018. India, meanwhile, has experienced 310 climate events in the past 15 years, after only 250 climate events from 1970 to 2005.

23

© 2021 Future Today Institute

fi

Extreme Weather Events continued



A historic snowstorm hit Texas in 2021.

DISRUPTIVE IMPACT

Extreme weather is the new normal. NOAA's National Centers for Environmental Information also found that tropical storms move more slowly than they did 40 years ago, lingering longer and causing more damage. The United Nations' scientific panel on climate change issued a dire report warning that environmental disruption may lead to a dystopian future of food shortages, wildfires, extreme winters, spread of diseases, a mass die-off of coral reefs, and more—as soon as 2040. That's less than 20 years from now.

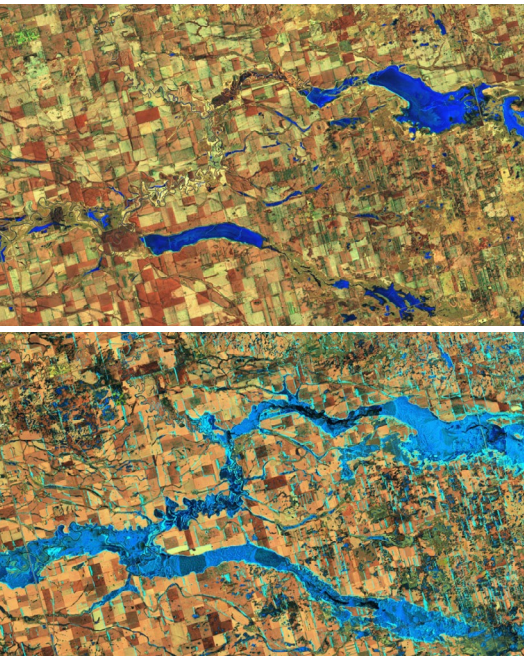
Large natural disasters can slow regional economic growth for decades, hinder corporate and industrial productivity, and lead to post-traumatic stress among survivors. Extreme weather can shift infectious disease patterns and compromise food security, safe drinking water supply, and clean air. It can drive up construction costs and cause flight cancellations and will challenge insurers to build new models to better estimate risk and repercussions. New R&D initiatives, emerging green technologies, climate-focused investment strategies, and global coalitions could help mitigate extreme weather. Businesses can do right by their investors and the planet by curtailing contributions to climate change.

EMERGING PLAYERS

- Chooch Intelligence Technologies
- DroneSeed
- Jupiter
- Ladera Tech
- Severe Weather Information Centre

4TH YEAR ON THE LIST

Human Migration Patterns Shift



These images show a portion of the James River in eastern South Dakota. The 2015 image depicts the river in a typical spring, while the 2020 image shows its banks overflowing; this and other sections of the river had been at flood level since spring 2019.

Image courtesy of NASA Earth Observatory.

KEY INSIGHT

There’s no official designation for “climate change refugees,” but there may be one soon, as climate change forces more people from their homes and communities, undermining the economic stability of those regions. Europe could receive 1 million climate refugees annually by 2100, forcing unimaginable changes to cities and infrastructure.

EXAMPLES

Last year, climate disasters uprooted 9.8 million people and became the leading cause of internal displacement around the world. Climate change will force 63 million South Asians and 1.7 million Mexicans from their homes by 2050, while another 1.5 million Ethiopians will have to search for new sources of food and water. Expect a wave of migration from Africa, the Indian subcontinent, and from island nations into Europe and the U.S. Meanwhile, the U.S. joined Bangladesh, Italy, Ethiopia, Hungary, Greece, and Lebanon in implementing historic limits on refugee resettlement. Pushbacks of asylum seekers at the border, curfews in refugee camps, and anti-migrant rhetoric have risen alongside displacement.

DISRUPTIVE IMPACT

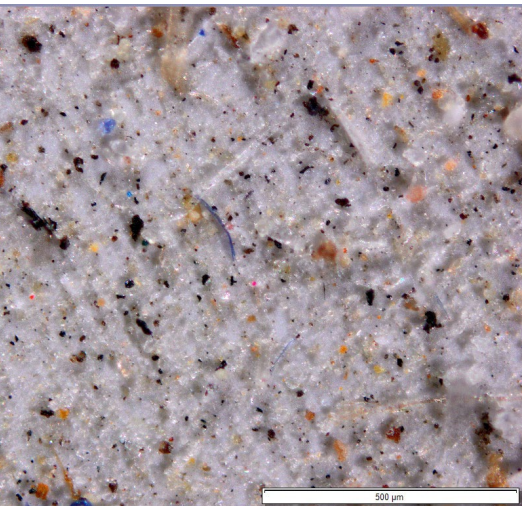
Throughout the world, climate change is becoming a national security issue as monsoons, droughts, and scorching heat drive millions of people away from their homes in search of more hospitable environments. A recent World Bank report projected climate change could result in 143 million “climate migrants” by 2050, as people escape crop failure, water scarcity, and rising seawater. Most of them will flee developing countries in sub-Saharan Africa, Latin America, and South Asia. The World Bank offered a glimmer of hope: The future may not be as bleak if we work now to cut greenhouse gas emissions drastically and lay plans to increase education, training, and jobs for migrants. Intergovernmental organizations need to adopt an official designation—as well as necessary protocols—for near-future waves of climate refugees.

EMERGING PLAYERS

- Chatterbox
- Funzi
- Jobs4Refugees
- Mygrants
- Startup Refugees

1ST YEAR ON THE LIST

Plastic Rain



Microplastics found in rainwater, collected by researchers in the Western U.S.
Image courtesy of Utah State University.

KEY INSIGHT

Plastic rain is the new acid rain. Microplastics are floating through our waterways, being carried into seawater and evaporating into clouds, which then disperse and redistribute the plastics in rain—even in protected natural habitats like the French Pyrenees.

EXAMPLES

In 2020, the journal Science published alarming new research: After a 14 month study of rainwater, scientists found more than 1,000 metric tons of microplastic particles in the water—or about the equivalent of 120 million plastic water bottles. That’s a stunning amount of plastic given the small and remote area the researchers covered in the Western U.S. Microplastics present unique challenges, because they can’t be easily captured in a big net, and we can’t apply current water filtration technology at an oceanic scale.

DISRUPTIVE IMPACT

As emerging markets grow, water bottles will follow. And as the middle class grows in developing countries, the use of plastics in packaging, food, and drinks is expected to double our current use in 10 years. Plastic particles are just about everywhere: our deep-sea ecosystems, our freshwater reservoirs, our commercial farms, and our wildlife. Microplastics eventually degrade into nanoplastics, making them impossible to detect but no less environmentally damaging. Worse, scientists don’t yet know the long-term effects of breathing in or swallowing nanoplastics—though microbes and viruses are certainly capable of hitching a ride on tiny plastic particles. A new crop of startups hopes to tackle the dual problems of particle identification and smaller-scale filtration. Parverio is developing a rapid testing and filtration system to pull microplastics out of local water supplies.

EMERGING PLAYERS

- U.S. National Oceanic and Atmospheric Administration
- European Chemicals Agency
- Parverio
- Nanomembrane Research Group

1ST YEAR ON THE LIST

Plummeting Biodiversity



Tiny, inconspicuous purple burrowing crabs feast on cordgrass and threaten local ecosystems.

Photo courtesy of Mark Bertness.

KEY INSIGHT

We're living through a strange contradiction: It may seem as if we're in close contact with an ever-increasing number of wild animals and novel pathogens, but in reality our planet's biodiversity has plummeted.

EXAMPLES

The human race accounts for less than 0.01% of the biomass on Earth. We physically make up less than one ten-thousandth of all life, in other words—and yet we've already wiped out 83% of the planet's animal species. The U.N.'s Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services published an apocalyptic dataset last year: 1 million animal and plant species are at risk of destruction. Not 1 million rabbits, or 1 million daffodil plants, but 1 million species. Annihilated. A mass extinction event that is so incomprehensible, no metaphor or analogy suffices. The dramatic decline in species populations is related to habitat loss and degradation, including deforestation, driven by how we produce food.

DISRUPTIVE IMPACT

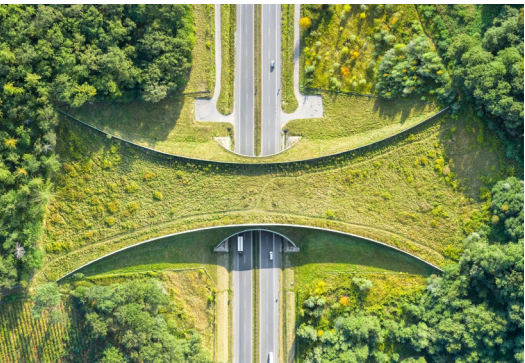
The recent collapse of insect populations in Puerto Rico and Germany had a cascading effect: Pollinators disappeared, plants failed to germinate and grow, and wildlife lost their habitats and food sources. Last year, a tiny, inconspicuous purple burrowing crab bred at high levels in places like coastal Massachusetts, feasting on native plants that kept marshland in place, and eventually leading to more sediment in the local water streams, increased flooding during harsh storms, a loss of recreational space for water sports, and the loss of commercial fishing grounds. In fact, the crabs have done so much damage already, you can see it from space. The crabs are now considered a “keystone species,” meaning they have a disproportionate impact on the natural environment, and the other species in the ecosystem now depend on them to maintain the current order.

EMERGING PLAYERS

- International Union for Conservation of Nature and Natural Resources' Red List
- Yale University Office of Sustainability
- The Convention on Biological Diversity

1ST YEAR ON THE LIST

Rewilding



The construction of nondisruptive corridors or “ecoducts,” like this wildlife crossing in Poland, is a key component of rewilding.

KEY INSIGHT

Rewilding is an integrative approach to environmental conservation and rehabilitation that focuses on the reintroduction of keystone species and the creation of safe corridors by which species can freely migrate. With climate change increasingly disrupting wildlife habitats and newly accessible technologies offering innovative rewilding techniques, the decades-old approach is taking on renewed significance.

EXAMPLES

The restoration of apex predators, keystone species (so-called ecosystem engineers), and beneficial plant life in native habitats can help revive natural communities, even after decades of drastic decline. Jaguars have been reintroduced to Argentina’s wetlands, lynx to the Scottish Highlands. Fish and sea life were even brought back to a dead coral reef using underwater speakers broadcasting the sounds of a thriving reef. The restoration process is facilitated by technological innovation, including the use of biomimicry devices to non-invasively influence animal behavior, and the replacement of radio receivers with GPS trackers to enable superior monitoring systems. Another key aspect of rewilding is to preserve corridors that provide safe passage for nature to spread from one region to another. These efforts include the rehabilitation of natural corridors such as the Côa Valley in Portugal, as well as the construction of “ecoducts” like the crossings at Canada’s Banff National Park and the crab bridges and tunnels of Christmas Island.

DISRUPTIVE IMPACT

Environmental conservation will require a suite of new technologies to actively reverse human-made damage and facilitate coexistence between nature and the industrialized world. If an integrative approach becomes the standard for corporate sustainability initiatives, rewilding will lead to market growth that benefits landscape architects, agriculture executives, automotive engineers and real estate agents, among others.

EMERGING PLAYERS

- The Rewilding Institute
 - Rewilding Europe
 - Yale School of the Environment
 - Zoological Society of London’s Instant Wild platform
 - Peace Parks Foundation
 - U.S. National Park Service Office of International Affairs

2ND YEAR ON THE LIST

Seasteading



An artist's rendering of Oceanix City, an adaptable, sustainable solution for human life at sea.
Image by Oceanix/Bjarke Ingels Group.

KEY INSIGHT

Seasteading is a colonization process wherein permanent human dwellings and settlements are constructed at sea, outside the reaches of most governments.

EXAMPLES

The pandemic has accelerated what had been a very small anarcho-capitalist movement to build new communities that operate outside any traditional government. The threats of government-enforced lockdowns, mandatory contact tracing, and digital surveillance have been cited as motivating factors for seasteading groups. In 2008, Google engineer Patri Friedman (grandson of Nobel Prize-winning economist Milton Friedman) founded the Seasteading Institute with funding from venture capitalist Peter Thiel. The goal: to set up a permanent community that could experiment with novel political and legal systems. Danish architect Bjarke Ingels is working on Oceanix City, an interlocking system of hexagonal islands powered by renewable energy. In Panama, Ocean Builders is laying the foundations for a factory that will house the largest 3D printer in Central America, and produce the materials necessary for floating homes.

DISRUPTIVE IMPACT

Whether or not the utopian dream of new governments and innovative legal systems pans out, the architectural research being conducted now could prove fortuitous: With sea levels rising, future communities may need to be built at sea, incorporating renewable energy sources, indoor vertical farms, and underwater communications systems.

EMERGING PLAYERS

- Seasteading Institute
- Ocean Builders
- Oceanix

8TH YEAR ON THE LIST

Green Tech



Concept of a future green living space by Vincent Callebaut.

KEY INSIGHT

To counteract extreme weather and climate change, researchers are looking to green technologies to reduce our short- and long-term impacts on the environment.

EXAMPLES

Siemens will build a wind farm in Ethiopia that will power more than 400,000 households. In the U.S., a clean power agreement could spur \$1.2 billion in wind and solar energy projects in Nebraska. Pandemic and blackout fears catalyzed a \$50 billion market for rooftop solar panels. Amazon will buy a fleet of electric vans to start delivering packages to customers in 2021, with 100,000 operating by 2030. More green tech projects are on the horizon, as sustainability becomes a post-COVID-19 recovery strategy. Apple co-founder Steve Wozniak launched Eforce, a blockchain-based energy platform to fund energy-efficiency projects. Its token offering hit a market cap of \$950 million in 13 minutes. DroneSeed is tackling rapid reforestation with heavy-lift drone swarms that spread patented seeds in wildfire-ravaged areas.

DISRUPTIVE IMPACT

Climate change and new regulatory efforts could force the world to look for new, sustainable sources of energy. Green tech is still a young market, but plenty of new technologies and scientific breakthroughs have generated significant buzz. Investments are growing as more governments pledge funding for green tech solutions that double as economic recovery efforts.

EMERGING PLAYERS

- CO2 Solutions
- Blue Planet
- Eforce
- Fuergy
- Facedrive
- Lilium
- Power Ledger
- OceanX

Green Tech Trends



The greatest danger to our future is apathy.

— Jane Goodall, primatologist

Bacterial Storage for CO2

Scientists are building tubular bioreactors, filling them with green algae and letting them eat away at the carbon captured from the environment. Quebec City-based CO2 Solutions genetically engineered a strain of E. coli bacteria to produce special enzymes capable of eating carbon dioxide and converting it into a harmless bicarbonate.

CO2-Based Industrial Materials

Carbon dioxide captured from factories can be repurposed as building materials. Startup Blue Planet developed a way to convert carbon dioxide into a synthetic limestone that can be used as an industrial coating or mixed in with concrete. The company's bicarbonate rocks were included in the reconstruction of San Francisco International Airport.

Plastic-Eating Enzymes

In 2019, researchers at the University of Portsmouth accidentally discovered a plastic-eating enzyme that could help break down larger pieces of plastic and aid in recycling efforts. French biotech company Carbios will produce a new generation of plastics for bottles, packaging and film that include enzymes that trigger biodegradation after use. Recycling Technologies, based in the U.K., hopes to deconstruct traditionally unrecyclable plastics into “plaxx,” or virgin plastic, wax and oils.

Smart Ocean Filters

The notorious pile of trash floating in the Pacific Ocean is bigger than we thought. It is actually two distinct collections of garbage, collectively also known as the Pacific Trash Vortex. In 2018, researchers found that it is 16 times larger than original estimates, at least three times the size of France, or a total of 617,763 square

miles. An estimated 5 trillion pieces of plastic float in the ocean, an amount so large that environmentalists called on the United Nations to declare the garbage patch its own country dubbed “The Trash Isles.” A recent report by the British government warned that the amount of plastic in the ocean could triple by 2050. The problem prompted some innovative approaches to cleaning up the trash. In the fall of 2018, the Dutch nonprofit Ocean Cleanup launched an ambitious effort to clean up half of the garbage patch within five years by using a fleet of 60 autonomous floating “screens,” or nets that collect debris as small as a centimeter in diameter. Algorithms pinpoint where to deploy the screens, and real-time telemetry monitors the condition, performance, and trajectory of each one, before boats eventually retrieve them. The system relies on natural ocean currents for energy; the rest of the electronics are powered by solar energy. Another effort, The Seabin Project, cleans up oil and trash using

floating garbage cans with pumps and filtration centers set up in harbors, marinas, and other busy areas. The project retrieves plastic that otherwise could have trapped animals and caused problems if ingested.

Ocean Fertilization

Oceanic iron fertilization involves dumping enormous amounts of iron sulfate into large swaths of the ocean. Theoretically, it would stimulate the growth of phytoplankton, the tiny sea life that absorbs carbon dioxide, releases oxygen, and gets gobbled up by other creatures. This is key, because every year the ocean absorbs about a quarter of global carbon dioxide emissions—which in turn changes water chemistry and harms marine ecosystems.

Sandcastling Glaciers

Sand is stronger than we once thought. A conservation project from Princeton University seeks to build massive piles of



Green Tech Trends

sand or other materials on the seafloor to serve as walls around glaciers—like scaffolding to prevent them from collapsing. Warm seawater far beneath the surface of the ocean can destabilize the foundations of glaciers, causing pieces to break off and melt. Shoring up their foundations could keep glaciers submerged in the icy upper layers of water, and—theoretically—prevent them from melting. It’s not a perfect method for all glaciers, but it can help.

Reflecting Sunlight

Some scientists are working on building enormous, mirrored parasols in the stratosphere, which would reflect sunlight back into space and theoretically cool the Earth’s atmosphere over time. The Keutsch Research Group at Harvard University is hoping to launch the first ever aerosol injection experiment known as the Stratospheric Controlled Perturbation Experiment. The scientists will use a high-altitude balloon to inject aerosols,

or extremely fine particles, into the upper atmosphere, where they can reflect sunlight. Once it is in place, the balloon can release enough material to create a perturbed air mass roughly 1 kilometer long and 100 meters in diameter; the same balloon can then measure resulting changes in the perturbed air mass, including changes in aerosol density, atmospheric chemistry, and light scattering.

Solar Radiation Management

This controversial technique, which has not yet been tried at scale, involves injecting tiny sulfur dioxide particles into the sky that would reflect sunlight back into space. The idea comes from volcanoes; scientists point to an eruption 200 years ago that caused an unusual cold snap, triggering unseasonal summertime frosts. The top climate scientist at the U.S. National Oceanic and Atmospheric Administration received \$4 million from Congress—as well as permission—to

develop the technique, as well as another using sea salt particles, if the U.S. and other nations fail to reduce global greenhouse gas emissions.

Cloud Injections

Inspired by maritime observations, this geoengineering technique would try to re-create the long clouds left by ocean freighters passing through open water. An aerosol of sea salt particles and seawater vapor would be injected into these clouds, which would expand and shade our oceans. The director of the chemical sciences division of NOAA’s Earth System Research Laboratories received a \$4 million grant from Congress and permission to study sea salt vapors. Scientists at the University of Washington are working on increasing the whiteness and brightness of the clouds by spraying seawater into them. Swiss scientists, meanwhile, are developing ways to eliminate cirrus clouds—those thin, wispy clouds made

from ice crystals that form at high altitude and trap heat in the atmosphere. Other efforts to reflect sunlight include painting everything from building roofs to mountainsides white, and laying reflective sheets in deserts.

Bioengineered Trees

CO2 is the undisputed culprit when it comes to climate change. But what if we could just suck it out of the air? Trees do that naturally, but after years of deforestation, we simply do not have enough of them to make a sizable impact. Scientists at Columbia University are developing plastic trees that passively soak up carbon dioxide from the air and store it on a honeycomb-shaped “leaf” made of sodium carbonate, similar to baking soda. So far these fake trees prove to be a thousand times more efficient at soaking up CO2 than real trees. The next challenge will be to purify the carbon dioxide or bury it safely beneath the ground or the ocean

floor. One approach is to convert atmospheric CO2 into carbon nanofibers that can be used for consumer and industrial products, including wind turbine blades or airplanes. Another option comes from chemists at George Washington University who are experimenting with what they dub “diamonds from the sky.” The scientists bathe carbon dioxide in molten carbonates at 750 degrees Celsius, then introduce atmospheric air and an electrical current on nickel and steel electrodes. The carbon dioxide dissolves, and carbon nanofibers form on the steel electrode.

3RD YEAR ON THE LIST

Environmental, Social, and Corporate Governance (ESG)



A biowall covers a skyscraper in Sydney.

KEY INSIGHT

Companies of all sizes are leading with sustainability as part of their core values. Environmental, social, and corporate governance (ESG) refers to core factors in evaluating the sustainability and societal impact of a company or an investment.

EXAMPLES

Last year, PepsiCo adopted the United Nations Business Ambition for 1.5 Degrees C pledge, and Allbirds and Kickstarter applied for certification under the Climate Neutral certification program by completing a carbon footprinting exercise and buying offsets to counteract their environmental impacts. General Mills launched regenerative agriculture programs with 24 wheat farmers in Kansas and 45 oat farmers across North Dakota, Saskatchewan, and Manitoba.

DISRUPTIVE IMPACT

A study last year by BNP Paribas showed that sustainability has become a major focus across many industries; since the onset of the pandemic, a quarter of respondents became more focused on sustainability measures within their organizations. Many companies see sustainability as a value-add for all of their key stakeholders. Other companies can follow suit by developing long-term strategy, vision, and R&D plans to create new business opportunities, which create value for shareholders while also helping the planet. Corporate sustainability is a growing concern among consumers and investors who hope to see both economic value and good-faith efforts to mitigate business’s role in climate change.

EMERGING PLAYERS

- Kansas regenerative agriculture program
- Climate Neutral
- Dassault Systèmes
- Autodesk

Environmental, Social, and Corporate Governance (ESG) Trends

There comes a time when humanity is called to shift to a new level of consciousness ... that time is now.

— Wangari Maathai,

environmental activist

Strategic Sustainability Plans

Unilever’s Sustainable Living Plan sets targets for sourcing, supply chain, and production throughout its operations. A decade ago, Unilever announced it would double its business while cutting its environmental impact in half. Allergan, the maker of Botox, developed ways to conserve water and energy in its operations and supply chain. Patagonia sets the pace for every industry: It encourages repairing rather than replacing its products, it uses natural rubbers and upcycled plastic bottles, and it strives to minimize packaging waste. Two years ago, Patagonia took its sustainability efforts a step further, saying it would produce custom-logo vests and jackets only for companies that can prove they align with Patagonia’s corporate values.

Supply Chain Sustainability

Many elements of a supply chain that can hinder sustainability, including energy use, labor conditions, cold-chain carbon emissions, and contamination of local environments. In recent years, the number of companies reporting their environmental, social, and governance (ESG) policies for suppliers has increased dramatically. Refinitiv, a financial and risk solutions company, noted that more than half of the companies in its directory now report ESG policies.

Shipping Industry ESGs

It’s no mystery that the shipping industry is a huge contributor to climate change due to its carbon dioxide emissions and unquenchable thirst for fuel. Shell Oil employs a novel approach to fuel efficiency: air bubbles. The oil company installed a new system on the hull of a ship developed by London-based Silverstream Technologies. Steel boxes welded to the ship’s hull and air compressors create a layer of microbubbles between the vessel and the water. The improved hydrodynamics of this design helped the ship move faster and more easily through the water and resulted in 5% to 12% fuel savings. Meanwhile, the market for hybrid and electric boats is growing. The world’s first electric barges now hum between ports in Amsterdam and Belgium. The vessels, made by Dutch company Port

Liner, have been dubbed Tesla ships. Eventually, the hope is that they will operate autonomously. Hybrid boats are making waves, too. Powered in part by solar energy, they are lighter weight and less noisy while boasting greater passenger capacity and lower emissions.

Space

14TH YEAR ON THE LIST

Space and Off-Planet Exploration



Kyoto University and Sumitomo Forestry are developing satellites out of wood.

KEY INSIGHT

Human ambition, our quest for knowledge, and our curiosity have always driven our rush to explore space, and 2021 promises to be another important year for space initiatives. Some of the missions are crewed by humans, others feature robots, and a handful will bring earthly agriculture into space.

EXAMPLES

Last year was a triumphant one for the space industry. SpaceX successfully launched a mission to the International Space Station—the first such launch from American soil in a decade. Three missions to Mars took flight. And brand-new moon samples were returned to Earth. This year, a number of important missions will further shape our off-planet aspirations. NASA’s Mars 2020 mission successfully reached its destination, a point on the planet called the Jezero Crater. The Perseverance rover will look for microbial life forms and test new technologies required to sustain human life. The Hubble Space Telescope’s successor, the James Webb Space Telescope, is scheduled to launch in the fall. SpaceX will begin further testing its next-generation vehicle Starship, which is built for deep space exploration.

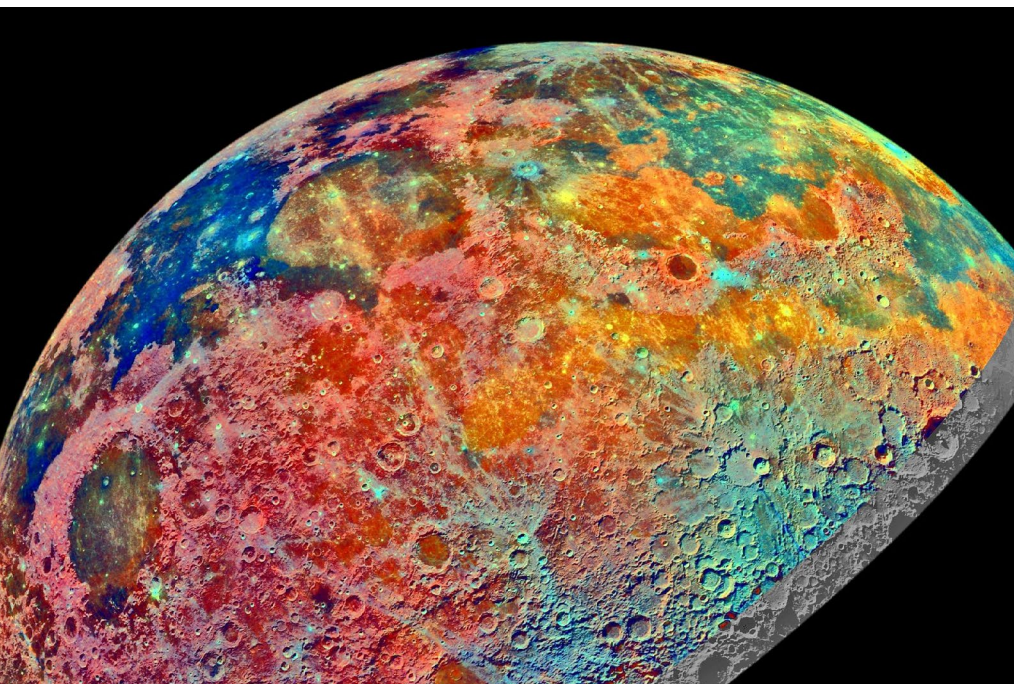
DISRUPTIVE IMPACT

Some estimates say the space industry is worth \$330 billion and could double by 2026. From leisure travel to asteroid mining to telecom, myriad industries and businesses will spring from and benefit from space exploration.

EMERGING PLAYERS

- SpaceX
- Blue Origin
- Moon Express
- Astrocast
- Maxar Technologies
- Kyoto University
- Sumitomo Forestry
- Astroscale
- Advanced Quantum Scientific Technology
- BEI Precision
- SpaceFab
- Data Collective
- Boeing HorizonX Ventures
- Planet Labs
- Rocket Lab

Space and Off-Planet Exploration Trends



The Earth's moon is made up of many different materials, represented here by different colors.

Space Mining

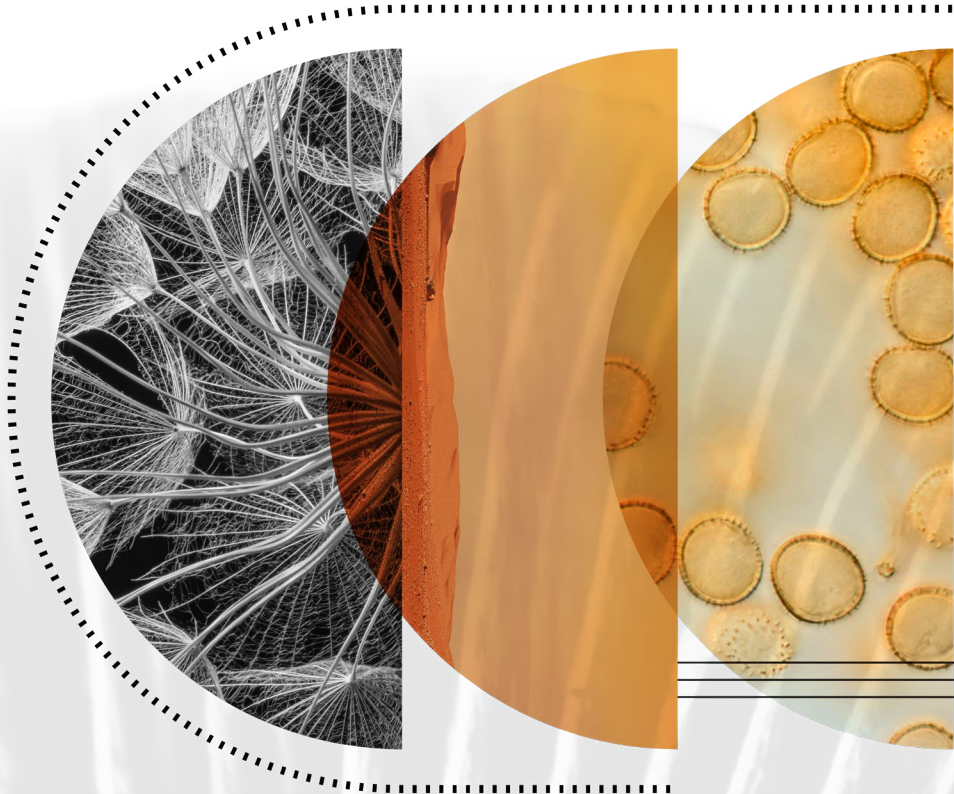
Vast amounts of precious rare-earth elements and metals—which are used in much of today's technology hardware—exist on the moon and in meteors and asteroids. Mining those minerals in outer space could be a lucrative venture as well as a cunning geopolitical strategy, because China currently controls 95% of rare-earth element production. In 1979, several members of the United Nations put forward the Moon Treaty, a framework to guide international space exploration, which, among other things, prohibited mining in outer space. None of the world's spacefaring nations ratified the treaty. In 2020, NASA shared the Artemis Accords, an international agreement for civil space and moon exploration. While the agreement has nine signatories, including some of the United States' closest allies, it has also been criticized for promoting commercial mining of celestial bodies. Notably, the other powerful space nations, including China,

India, Russia, Germany and France, have not signed on. Whether or not celestial mining becomes a viable business practice in the very near term, the idea of commercial space exploration puts pressure on governments to create clear international agreements and frameworks for governing space.

Space Junk

Space is our next dumping ground. As many as 170 million fragments of metal and astro debris orbit the Earth. That includes 20,000 pieces larger than a softball and 500,000 about the size of a marble, according to NASA. This debris will pose a navigation hazard for many centuries to come as low-Earth orbit becomes more cluttered. At least 200 objects roar back into the atmosphere each year, including pieces of solar panels, antennas, and fragments of metal. All of them pose dangers for future astronauts: One plum-sized piece of gnarled space trash traveling faster than a speeding bullet could rip a

5-foot hole in a spacecraft. That collision, then, would throw off its own share of shrapnel, which would join the rushing river of junk already circling the planet. In space, collisions beget collisions in a chain reaction known as the Kessler syndrome—a phenomenon that could eventually make some of our available orbits unusable. It's not just Americans doing the dumping—China and Russia each have dozens of decommissioned satellites overhead—although the U.S. certainly does it with style. Where all that junk winds up isn't something we can predict accurately. We could be unintentionally wreaking havoc on civilizations far away from Earth, catalyzing future intergalactic wars. Or we might cause far less scintillating problems. Space junk could start to behave unpredictably, reflecting sunlight in disruptive ways, altering our atmosphere, or even challenging our understanding of the universe and the laws of physics.



New World Spores

Far-future neutral scenario

Humanity looks beyond Earth and Mars when people begin to think of their future in terms of civilizations rather than years. But new human colonies in the cosmos cannot simply be built—they must be born. To prepare for future colonies, we send highly resilient spores to far-off planets that are deemed able to support life. The spores then have millennia to develop and evolve into basic life forms that could serve as valuable resources for human settlers later on. Sending these microscopic advance teams might be the kind of foresight that gives the explorers of tomorrow a headstart on our next planetary home.

Space and Off-Planet Exploration Trends



The Artemis Accords are a set of international agreements for civil space and moon exploration that include language around commercial mining of celestial bodies.

Space Sustainability Initiatives

Space junk is becoming a bigger problem as more satellites are launched into the atmosphere. An innovative approach to reducing particulates is already underway at Kyoto University. Sumitomo Forestry, part of Japan's Sumitomo Group, is developing microsatellite constellations with individual units made out of wood. It's not the first time wood has been considered for such a job: NASA's earlier Ranger program sent balsa wood structures to the moon. One benefit is that the wood won't block the electromagnetic waves that satellites use to communicate. The project is set to launch in 2023.

Space Imaging

In 2019, scientists did what they thought was impossible: They captured an image of a black hole's silhouette using the Event Horizon Telescope. A team of international astronomers and computer scientists spent a decade developing a new kind of technique that revealed a dark

black center surrounded by a massive ring of orange and yellow light. In early January, scientists in Maui used the new Daniel K. Inouye Solar Telescope for the first time and took the highest-resolution photos of the sun ever recorded. (The surface looks like the cracked ground of the Atacama desert—if it were oozing and on fire.) New techniques and equipment for space imaging will advance the work of research scientists across many fields.

Satellite Megaconstellations

Within a few years, there will be vast megaconstellations of tiny satellites orbiting the Earth. In August 2020, the U.S. Federal Communications Commission approved Amazon's latest satellite megaconstellation, which included 3,236 microsats built to provide high-speed internet—that's more than double the total number of satellites currently in orbit. In early 2020, the Starlink constellation, a project from Elon Musk's SpaceX, began sending clusters of 60 satellites into orbit

every few weeks. By the end of this year, there could be a fleet of 12,000 overhead. U.K.-based OneWeb is set to launch up to 700. That's just a small selection—it would take several pages to list every company and planned launch over the next five years. These satellite constellations comprise many small "microsats" or "cubesats," which are capable of communicating with each other and continue to work when one satellite in the network goes down. Constellations are used for a variety of purposes, including taking photos and beaming internet access back down to Earth. But with thousands of planned spacecraft launches—carrying microsat and cubesat constellations, in addition to heavier satellites, rockets, and spaceships with rovers and human cargo—astronomers are warning that our view of the sky, and our ability to research the cosmos, is in jeopardy. Scientists have voiced concern that megaconstellations of microsats and cubesats will not only obstruct their view, but that they could also interfere with radio astronomy

Space and Off-Planet Exploration Trends

equipment. Some commercial spacecraft manufacturers, including SpaceX, are developing new coatings that would minimize reflection and other sources of interference.

Self-Steering Satellites

Researchers at the U.S. Naval Research Laboratory are working on a concept that could not only help steer satellites back down to Earth when they’re decommissioned but also clean up space clutter in the process. The idea is to outfit new satellites with thin “umbilical cords” about a kilometer long. Running an electric current through the cord would enable a satellite to steer itself using its own electric field as well as the magnetic field from Earth. Think of it as an invisible sail that could someday enable old satellites to guide themselves home.

Space-Based Internet

Amazon, SpaceX, Google, and others are developing satellite technology that would beam internet services directly to our devices, and in the process bypass our internet service providers (ISPs). OneWeb has plans to power what it calls “fiber-like internet” coverage in the Arctic. New space-based internet services will rely on a complex array of microsat constellations and ground stations. SpaceX and Amazon are working on services to bring internet service to people in areas neglected by traditional wireless carriers and ISPs.

The Space Economy

New spacecraft, rockets, and other technologies are helping private commercial companies achieve liftoff—with plenty of eager investors footing the bill. Investors including Morgan Stanley are eyeing a new space gold rush, now that a critical mass of commercial space companies and their technologies have matured enough

to move beyond proof of concept into testing. Some estimate the space economy will grow to more than \$1 trillion in the next two decades. We anticipate aggressive investment into commercial space companies, especially in the areas of insurance, satellites, defense, and aerospace technologies and materials (manufacturing and mining).

Space Tourism

As of 2020, SpaceX became the only NASA-certified company to send people into orbit. While Elon Musk’s goal is Mars, shorter flights on Starship could begin in the next year or two (initially round trips to and from Earth). Space Adventures is offering private spaceflight to the International Space Station (ISS) and eventually the moon. Already, Space Adventures has ferried more than a half dozen paid trips to the ISS via a partnership with Russia. In December 2021, two Space Adventures tourists will ride aboard the Soyuz spacecraft.

Galactic Ride Sharing

New technologies have spawned a new trend in space transportation: galactic ridesharing. In 2018, Spaceflight Industries launched its first rideshare mission called SSO-A SmallSat Express aboard a SpaceX Falcon 9. The company purchased all available payload space on the rocket to service customers who wanted to launch various items into space. These types of launches often include microsats and cubesats from multiple countries, but unusual items make it to space occasionally, too. A satellite from the Los Angeles County Museum of Art sent up a 24 karat gold jar with a bust of the first African American astronaut to reach space. Artist Trevor Paglen sent a self-inflating sculpture that reflects sunlight and can be viewed by the naked eye on earth. Another craft, the Elysium Star 2 sent by Elysium Space, contained the cremated remains of people who wanted to become shooting stars. As more researchers, artists, and everyday people want to hitch

rides on spacecraft, we anticipate new “rocketsharing” business models—followed by a potential wave of regulation.

Galactic Refueling Stations

Some satellites require fuel, and it turns out fuel is very heavy. After a satellite runs out, it’s no longer fully operational. For that reason, researchers have been developing new refueling stations and new techniques that would overcome some liquid dynamics challenges. Last year, startup Orbit Fab successfully completed the first set of experiments to see if water could be transferred between two satellite test beds. Orbit Fab has been working with satellite manufacturers on something called the Rapidly Attachable Fuel Transfer Interface, or RAFTI, which is a new kind of valve system that would allow satellites to be fueled on the ground before launch and, someday, refueled in space. This would eventually allow more satellites to stay in orbit and help reduce the creation of new space junk.

Space and Off-Planet Exploration Trends



This artist's concept depicts astronauts and human habitats on Mars. NASA's Mars 2020 rover is carrying a number of technologies that could make the planet safer and easier to explore for humans.

Image credit: NASA.

Off-Planet Living

NASA has said it wants to send humans to Mars by 2030, and in 2016 it selected six private U.S. companies, including Boeing, Lockheed Martin, and Bigelow Aerospace, to develop prototypes for deep space habitats. At the beginning of the year, Elon Musk talked about sending 1 million people to colonize Mars by the year 2050 using three Starship launches a day. SpaceX has taken steps to turn what sounds like science fiction into reality—this year, the company will bring astronauts to the ISS. However, astrophysicists have been quick to point out difficult hurdles to overcome in Mars-bound space travel, not the least of which is radiation. As Columbia University astronomer Caleb Scharf explained, “In the worst case scenario (which may or may not be a realistic extrapolation) there’s a chance you’d end up dead or stupid on Mars. Or both.”

Mercury Rain

New rocket propulsion systems for rocket engines would use mercury as a fuel, which could run the risk of spreading toxic chemicals through Earth’s atmosphere. NASA experimented with mercury in the 1960s because it’s a low-cost, high-power option for ion engines. Startup Apollo Fusion has discovered a new approach to using mercury—but there’s a catch. Mercury is heavier than the xenon and krypton powering other ion engines in use today. What customers might save on costs could pollute the atmosphere in potentially harmful ways. While the U.S. government has tried to reduce terrestrial mercury emissions since the 1990s, the rules do not specifically cover spacecraft hovering above us. The U.S. Federal Aviation Administration requires companies to disclose hazardous materials in flight, but its policy also doesn’t address satellites. This is an area where, yet again, technology has sped beyond the limits of the law.

Space and Off-Planet Exploration Trends

Space Forces

The U.S. announced the launch of a new Space Force in 2019. Its purpose: to secure satellite communication networks that not only power our information eco-systems but also control navigation and positioning systems. The new service is expected to employ up to 15,000 military personnel and should benefit from former President Trump’s signing of a \$738 billion defense bill. The U.S. isn’t the only country with a military space program. Both Russia and China maintain their own space forces. It’s unlikely that a traditional war would be fought among the stars. This space race is about securing critical network and communications infrastructure from government-sponsored cyberhacking.

China’s Space Ambitions

China’s space program is well underway. It’s well-capitalized, includes many space startups, and has the full support of the government. In 2021, China will start building a new space station, and it’s planning to send astronauts to the moon by 2030. But the country’s main focus is on the commercial space industry, as its private space business sets up shop manufacturing cubesat megaconstellations, larger satellites, rockets, IT infrastructure, communications networks, and all the other hardware needed by the global business. While China is a little late to the party compared to other world leaders such as the U.S. and Russia, it’s catching up quickly. Last year, China became the first country to land a robotic mission on the far side of the moon. It was a historic accomplishment—and a clear sign of new leadership from China. President Xi Jinping said, “The space dream is part of the dream to make China stronger ... the Chinese people will take bigger strides to

explore further into space.” China doesn’t just want to be seen as a powerful Asian nation—it wants to set the global pace for numerous geo-economic initiatives, environmental causes, and societal development.

Ultra-Long Space Missions

If climate change escalates and we are unable to mitigate its effects, humanity is going to need a plan B. Some scientists think our next best option is a 1,000-year space mission to save future generations from extinction. Their target is a planet called Proxima Centauri b, an exoplanet in a habitable zone of a star like our sun. This means that water might exist in liquid form there and, theoretically, could support human life. We don’t know what the atmosphere is like or whether the planet’s surface is too hot or cold to sustain living organisms as we know them. A program founded by science philanthropist Yuri Milner and the late

Stephen Hawking is building a spacecraft weighing only a few grams that would be propelled by a 100-billion-watt laser fired at it from Earth. The craft would take 20 years to reach the Alpha Centauri solar system, where Proxima b is located. It’s a step toward building a new kind of spacecraft big enough to transport humans deep into space on a journey that would take a millennium to reach humanity’s new home.



A geologist once said to me, ‘We went to the moon six times. If you had come to New York state six times, would you have thought that you investigated the whole world?’

— Jeanette Epps, NASA astronaut

Application



STRATEGY

Throughout every industry, environmental, social, and corporate governance (ESG) and corporate social responsibility initiatives have taken center stage. With the passage of green stimulus plans there will be new incentives to measure energy usage, sustainability criteria, and environmental impacts. We anticipate new opportunities for companies that strategically map the next two to five years with ESG in mind. Conversely, companies that wait could find themselves regulated in new ways or facing financial penalties. First movers and fast followers could help shape the directions of their industries, which would be a long-term strategic advantage.



INNOVATION

Our observation: Senior executives are prioritizing sustainability broadly across their organizations, and there have been new calls to funnel sustainability concepts into product development. But some organizations or business units see sustainability as a risk, an added expense, or a challenge to existing operations. This presents a unique opportunity for innovation teams, which can resolve those fears with new workflows, products, and services.



R & D

R&D teams within most industries should help executives make decisions about the long-term implications and impacts of ESG plans. Curbing emissions might help meet sustainability goals, for example, while causing unintended complications elsewhere in the business. For teams working in adjacent fields, this year is a good time to hit the white board, especially as green stimulus plans unlock new sources of R&D funding and stimulate outside investment.



RISK

There are clear risks and dangers associated with climate change. Extreme weather events, flooding, and the outbreak of disease can have catastrophic downstream effects on a company's ability to function. Those working in risk will need new models to calculate the value of ESG and CSR goals—and to determine the costs associated with preserving older operational practices. Chief risk officers can develop thought leadership and strategy to solve energy and climate-related challenges in a way that drives value back to the organization.

Key Questions

We recommend using this report to support your strategic foresight activity in the coming year. Every executive team should begin by asking these questions about the futures of energy use and sustainability. And it's never too early to imagine the future impacts of the new space economy on your organization.

1

Is our company tracking disruptions related to energy use?

These include proposed or new regulations, rebates, and green stimulus plans (domestic and international).

2

What parts of our business make us a target for disruption?

How could new business models introduced by new entrants pose a threat? And to stretch your foresight capabilities, ask: How could an emerging space economy unlock new opportunities in our industry?

3

What assumptions must hold true for our current strategy to succeed?

How will we make needed changes?

Selected Sources

<https://foreignpolicy.com/2020/10/02/china-clean-energy-technology-winning-sell/>

<https://corpgov.law.harvard.edu/2020/11/18/the-esg-innovation-disconnect-evidence-from-green-patenting/>

<https://www.nasa.gov/specials/artemis-accords/index.html>

Authors



LEAD AUTHOR
Amy Webb
Founder and CEO
Future Today Institute
awebb@futuretodayinstitute.com

Amy Webb pioneered FTI’s data-driven foresight methodology that is used within hundreds of organizations globally. Her focus is to transform organizations as they prepare for complex futures. She advises CEOs of the world’s most-admired companies, three-star admirals and generals, and the senior leadership of central banks and intergovernmental organizations. She leads FTI’s technology research initiatives on AI, synthetic biology and genetic engineering, next-generation networks, and quantum technologies. Webb is a professor of strategic foresight at the New York University Stern School of Business, where she developed and teaches the MBA course on strategic foresight. She is a Visiting Fellow at Oxford Universi-

ty’s Säid School of Business, was elected a life member to the Council on Foreign Relations and is a member of the Bretton Woods Committee. She is a member of the World Economic Forum where she serves on the Global Future Council on Media, Entertainment and Culture and the Stewardship Board of the Forum’s Platform for Shaping the Future of Media, Entertainment and Culture. Webb is the bestselling author of several books about strategic foresight and emerging technologies. A lifelong science fiction fan, she collaborates closely with writers and producers on films, TV shows and commercials about science, technology and the future.



FTI CONTRIBUTOR
Marc Palatucci
Senior Foresight Associate
Future Today Institute
mpalatucci@futuretodayinstitute.com

Marc Palatucci is a Senior Foresight Associate at the Future Today Institute, with research specializations in new realities (AR/ VR/ MR/ DR), digital fashion, future of work and learning, retail and e-commerce. He co-leads the MBA course in strategic foresight at the New York University Stern School of Business. Palatucci serves on the World Health Organization’s Learning Strategy Advisory Group and is a Senior Deputy to the World Economic Forum’s Platform for Shaping the Future of Media, Entertainment and Culture. He holds an MBA in Emerging Technology from New York University’s Stern School of Business and a

BA in Linguistics and Languages from NYU’s Gallatin School of Individualized Study. Palatucci serves as editor-at-large for an arts, fashion and culture magazine and collaborates with writers, designers and producers on films, TV shows and commercials about science, technology and the future.

Leah Zaidi is an award-winning futurist with specializations in systems thinking, worldbuilding, science fiction prototyping and experiential futures. She is an Associate Editor of the *World Futures Review*. She holds an MDES in Strategic Foresight and Innovation from OCAD University and a BA from York University.

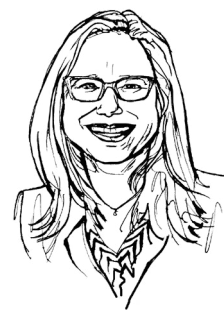


Jennifer Karppinen is a Foresight Associate at the Future Today Institute, with specializations in strategy, technology, systems thinking, and experience design. She advises clients in telecommunications, insurance, health care, energy and retail. Karppinen holds an MBA from Emory University's Goizueta Business School and a BS in Mechanical Engineering from North Carolina State University.



Kristofer “Kriffy” Perez applies years of fintech product design and development to guide new companies strategically. As a Foresight Affiliate at the Future Today Institute, Kriffy specializes in fintech, banking, financial services, transportation, product innovation, and long-term strategy. Previously as a Director of North American Product Innovation and Design at Visa, he led product and design teams to deliver new product solutions and best-in-class customer-centric experiences to market-leading financial institutions. Kriffy has also worked for MasterCard Advisors, the Boston Consulting Group, IBM, and co-founded a paytech startup. Kriffy has played an integral role in more than 120 strategic projects across 8 countries and has filed 15+ patents. Kriffy is a Co-founder and Managing Director at Global PayTech Ventures, where he leads strategic advisory.

Authors



ADDITIONAL CONTRIBUTORS

Sarah Kaufman
Associate Director
NYU Rudin Center for Transportation

Sarah Kaufman leads projects related to smart cities, mobility, urban planning, policy, and improving transportation through technology.



EDITORIAL

Jennifer Alsever
Editorial Director
Future Today Institute
jalsever@futuretodayinstitute.com

Jennifer Alsever is the Future Today Institute’s Editorial Director. She has been a journalist for more than two decades covering tech, biotech, startups and business for such publications as Fortune Magazine, the Wall Street Journal, the New York Times, Wired and Fast Company. A popular young adult fiction writer, Alsever has won multiple YA awards for her Trinity Forest Series.



Cheryl Cooney
Director of Operations
Future Today Institute
ccooney@futuretodayinstitute.com

For over a decade, Cheryl Cooney has served as the Future Today Institute’s director of operations, where she manages workflows, planning and logistics. Cooney is a published poet, with works appearing in American and Australian anthologies.

Tom Foster
Editor

Sarah Johnson
Editor

Authors



CREATIVE
Emily Caufield
Creative Director
Future Today Institute
ecaufield@futuretodayinstitute.com

Emily Caufield is an award-winning designer and illustrator. Serving as FTI’s creative for more than a decade, Caufield applies design thinking to visually communicate complex trends, scenarios and foresight research. Caufield designed all aspects of this year’s trend report. She is a graduate of Boston University’s College of Fine Arts.



Julia Durgee
Artist and Futurist

Julia Durgee is a rare left and right-brained MBA with creative, strategic, analytical, and digital experience at world-class brands. She illustrated the portraits that appear in this year’s trend report.



BUSINESS DEVELOPMENT
Mel Blake
Business Development
mblake@futuretodayinstitute.com

Mel Blake handles commercial development and client relations for FTI. He was formerly founder and managing director of Monitor Talent, a speaker agency he founded at the Monitor Group, a global consulting firm. He is a board member of The Yale Center for Customer Insights. He holds an MBA from the Yale School of Management and a BA in Economics from Wesleyan University.

Why FTI

We answer your most challenging questions using data, creative inquiry, and strategic foresight.

- What are plausible deep (20+ years), long-range (10+ years), and near-term (2+ years) futures?
- What scenarios describe our futures?
- What's happening outside my industry that I should know?
- What companies, startups, and partners make up our future value network?
- What new products, services, or businesses should we build?
- Which tech trends should we monitor? When should we act?
- How can we build an early warning system to see the next disruptive event?
- How do we reduce uncertainty about our futures?

We support executive leaders and their teams.

The Future Today Institute works closely with executive leadership and management teams to transform their strategic thinking on the future. Advisory services include signal mapping, trend identification, scenario development, risk modeling, visioning, and strategic planning.

About the Future Today Institute

Founded in 2006, the Future Today Institute researches, models, and prototypes future risk and opportunity. As the leading strategic foresight and futures management consultants to executive leadership teams worldwide, FTI’s data-driven applied research reveals trends and calculates how they will disrupt business, government, and society.

Together with our clients and partners, FTI is helping leaders achieve their preferred futures. Our pioneering, data-driven forecasting methodology and tools empower leaders to make better decisions about the future, today.

Contact Us

The Future Today Institute
33 Irving Place
10th Floor
New York, NY 10003

hello@futuretodayinstitute.com

267-342-4300

www.futuretodayinstitute.com

Disclaimer

The views expressed herein are the authors' own and are not representative of the greater organizations in which they have been employed. The names of companies, services, and products mentioned in this report are not necessarily intended as endorsements by the Future Today Institute or this report's authors.

The Future Today Institute's 2021 Tech Trends Report relies on data, analysis, and modeling from a number of sources, which includes sources within public and private companies, securities filings, patents, academic research, government agencies, market research firms, conference presentations and papers, and news media stories. Additionally, this report draws from the Future Today Institute's previous EMT Trends Reports, FTI Trend Reports, and newsletters. FTI's reports are occasionally updated on the FTI website.

FTI advises hundreds of companies and organizations, some of which are referenced in this report. FTI does not own any equity position in any of the entities listed in this presentation.

Any trademarks or service marks used in this report are the marks of their respective owners, who do not endorse the statements in this report. All rights in marks are reserved by their respective owners. We disclaim any and all warranties, expressed or implied, with respect to this report.



Using and Sharing The Material In This Report



We invite you to use, share, and build upon the material in our 14th annual Future Today Institute Tech Trends Report. We are making it freely available to the public. This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

You are free to:

Share

Copy and redistribute the material in any medium or format, including in your organizations and classrooms.

Adapt

Remix, transform, and build upon the material for your own research, work, and teaching.

Under the following terms:

Attribution

You must give appropriate credit to the Future Today Institute, provide a link to this Creative Commons license, and indicate if any changes were made. You may do so in any reasonable manner, but not in any way that suggests that the Future Today Institute endorses you or your use.

NonCommercial

You may not, under any circumstance, use the material for commercial purposes.

ShareAlike

If you remix, transform, or build upon the material, you must distribute your contributions under the same license as you see here.

You are prohibited from:

Commercial Sharing

Don't copy and redistribute this material in any medium or format for commercial purposes, including any personal/ corporate marketing and client services.

Representing This Work As Your Own

Do not represent any part of this material as your own without giving credit to the Future Today Institute.

Additional Restrictions

You may not apply legal terms or technological measures that legally restrict others from doing anything this license permits.



This is volume 11 in the Future Today
Institute's 2021 Tech Trends Report. Each
volume covers a different set of topics.

To find additional volumes, visit

www.futuretodayinstitute.com/trends

