Energy
Million-Mile Batteries

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.
- 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

Million-mile batteries could revolutionize the electric vehicle market.
Fusion Power

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
Clean 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

Ørsted launched a pilot for green hydrogen.
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
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

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

**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
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
Zero-Carbon Natural Gas

**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 bootstrapped 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
Floating Nuclear Power Plants (FNPPs)

**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