

Energy Innovation

Promising new technologies are primed to transform our industry and the energy customers use.

Xcel Energy needs new systems and tools to achieve our net-zero energy vision by 2050. The renewable and storage technologies available today can significantly reduce emissions — but we need innovation to tackle that last mile of greenhouse gas emissions reduction.

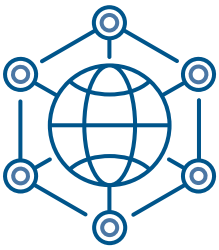
Our most significant need is for new carbon-free energy resources that are economic, resilient and dispatchable — available whenever we need them. We are evaluating six promising technologies that can change the energy we provide and also create future business opportunities:

- Advanced wind and solar energy systems.
- Long-duration storage and advanced demand efficiency.
- Advanced geothermal.
- Zero-carbon fuels, such as hydrogen, renewable natural gas and ammonia.
- Advanced nuclear energy, both fission and fusion.
- Carbon capture, use and storage.

As a regulated energy provider, we can't do it alone because our ability to invest in research and development is limited. We've championed innovation by advocating for supportive public policy, making strategic investments and forming important partnerships between industry, researchers, technology developers and venture investors. With multiple collaborations and demonstrations underway with the Department of Energy and others, we're helping move technology forward, even developing the capacity to conduct inexpensive, rapid demonstrations that assess ideas quickly and advance the promising ones.

Governance

Xcel Energy's Board of Directors oversees the company's pursuit of advanced energy technologies, with the board's Finance Committee overseeing major investments, including those associated with clean energy and technology. Within the company, the chief financial officer oversees Corporate Development and the company's Innovation and Transformation Office. The chief operations officer is responsible for executing clean energy and fuels projects. Both report to the CEO.



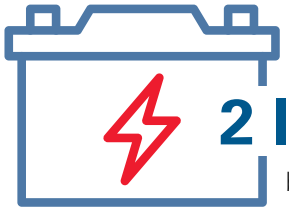
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Leading the Clean Energy Brief

Renewable Energy Brief

Product and Service Innovation Brief

Public Policy Brief



2 large-scale
battery demonstrations planned

2 hydrogen
demonstrations underway and 2 hydrogen hub applications submitted to DOE

8 Venture Funds
supported to advance technology, strategy and innovation



6 Rapid Innovation
technology tests

NOTEWORTHY

Form Energy Partnership

Long-duration storage will play a critical role in building the reliable grid needed to underpin our clean energy future. Our partnership with Form Energy will build two 10-megawatt, 100-hour battery arrays near retiring coal plants in Becker, Minnesota, and Pueblo, Colorado. They're expected to go online as early as 2025, pending regulatory approval.

The pilot battery arrays — each the size of a football field — will feature iron-air technology that is cost-competitive with electricity from conventional power plants. The multi-day storage systems will strengthen the grid against the day-to-day variability of wind and solar as well as extreme weather events.

While most existing battery technologies provide less than eight hours of energy storage, Form Energy's iron-air batteries could deliver enough to power 2,000 homes for up to five days. The reversible rusting technology uses electrochemical reactions between abundant, inexpensive materials — water, air and iron — to charge and discharge. A clear advantage is that the technology doesn't rely on elements such as lithium, cobalt or nickel where sourcing is an issue.

In May 2023, Breakthrough Energy Catalyst agreed to commit $20 million in grant funding to accelerate the projects at the Sherco and Comanche generating plants. They will tap into existing transmission on-site, further speeding the process and keeping costs low.

Clean Fuels

Clean fuels not only help achieve our environmental goals but present growth opportunities for Xcel Energy. We're exploring using hydrogen and other clean fuels to provide an alternative to natural gas and produce electricity, supporting grid reliability as we add renewable energy sources.

Carbon-free Hydrogen Production Demonstration

Our innovative proof-of-concept pilot will show how hydrogen can be produced using carbon-free energy at the Prairie Island Nuclear Plant, beginning in early 2024. The U.S. Department of Energy awarded Xcel Energy and its partners, Bloom Energy and Idaho National Laboratory, approximately $10 million for the $12 million project, which will use electricity and steam from the plant to produce hydrogen from water.

Hydrogen and oxygen molecules in water will be separated using a semi-trailer-sized high-temperature steam electrolysis system developed by Bloom Energy. At full capacity, the pilot will be able to produce about 90 kilograms of hydrogen per day. Scaled up, this carbon-free hydrogen could potentially be used in other industries that would benefit from efficient, local hydrogen production sources.

Hydrogen Hub Applications

Working with our states and other partners, Xcel Energy is participating in two hydrogen hub applications competing for $8 billion in U.S. Department of Energy funding. A hub is a network of strategically located hydrogen producers — near both infrastructure for storage and transportation and demand from industry, generating plants and other uses. When strategically sited, hubs can significantly improve the cost-effectiveness and environmental benefits of producing and using hydrogen. DOE expects to announce awards in 2023.

- **Western Interstate Hydrogen Hub:** Xcel Energy proposed to build a green hydrogen hub on the eastern plains of Colorado as part of this multi-state hydrogen network that includes partners with projects in New Mexico, Utah and Wyoming. Xcel Energy's project offers a strategic location near existing and future wind and solar energy, power plant infrastructure and favorable geography for underground hydrogen storage.

- **Heartland Hydrogen Hub:** The University of North Dakota's Energy & Environmental Research Center and Xcel Energy are partnering on the Heartland application, which includes three primary projects across Minnesota, Montana, North Dakota, South Dakota and Wisconsin. Xcel Energy's projects would produce hydrogen using nuclear and renewable energy for use by power generation, industrial and agricultural customers.

Hydrogen Blending Studies

Xcel Energy has participated in the National Renewable Energy Laboratory's HyBlend Project, which seeks to address technical barriers associated with blending hydrogen in natural gas infrastructure. With Worley Ltd., a global provider of professional project and asset services, we're studying the feasibility of injecting and blending hydrogen into our existing natural gas system companywide. Results, expected in 2023, will help identify the current system's capabilities and pinpoint areas where enhancements are needed.

Renewable Natural Gas

These projects support the carbon reduction goals of our customers and help build the market for RNG, which is an important step toward greening our natural gas supply.

In fall 2022, Xcel Energy began transporting renewable natural gas from the first landfill RNG production facility in Minnesota. Developed by OPAL Fuels and NextEra Energy Resources, the Pine Bend project at a Republic Services, Inc., landfill is expected to produce 6.3 million gasoline gallon equivalents per year of low-carbon RNG.

In Colorado, we've worked with South Platte Water Renewal Partners and the City of Boulder Water Resource Recovery Facility to interconnect RNG from wastewater treatment plants. We purchase the gas from South Platte as part of our supply and transport the gas for the City of Boulder.

Hayden Biomass

A biomass power plant that makes electricity from trees cleared to reduce wildfire risk is one of the ideas for reuse of the Hayden Generating Station property in northwest Colorado.

The proposed 20-megawatt Hayden Biomass Project would generate electricity on land near two coal-fueled units due to retire by 2028. Its feedstock would include timber from beetle-killed pine and other forest reduction and restoration efforts to mitigate the risk of destructive wildfires. Other sources include residuals from logging and clean wood from sawmills, construction, demolition and tree trimming.

All fuels would be sourced within a 100-mile radius of the Hayden plant. The proposed biomass plant forecasts demand for 160,000 tons of feedstock a year, well within the area's forecast supply.

If approved, the biomass plant could be in service by the end of 2028. It was submitted to Xcel Energy's all-source solicitation for electric resources in the Colorado Clean Energy Plan. A decision on the portfolio by the Colorado Public Utilities Commission is expected in November 2023.

Venture Capital

Through strategic support for venture capitalists, Xcel Energy stays abreast of promising technologies and business applications.

Energy Impact Partners

EIP provides capital primarily to clean-tech companies that seek to enhance energy management, increase operational efficiency and improve sustainable energy generation. Investments have included distributed energy resources, storage, electric vehicles, advanced data analytics, cybersecurity and microgrid applications.

Xcel Energy first joined EIP's Fund I in 2015 as a founding participant, then recommitted and joined Fund II. Since then, we've invested in other EIP funds, including:

- **Frontier Fund (co-chair):** Targets investment into companies focused on eliminating carbon emissions from the power sector, including zero-carbon energy generation, clean hydrogen, energy storage, transportation electrification and carbon capture.

- **Elevate Fund (co-chair):** Invests in clean-tech companies founded or run by diverse leaders in targeted sectors, such as digital infrastructure, smart buildings or cities, customer engagement, mobility and electrification, supply chain, distributed energy and cybersecurity.

- **Energy Impact Credit Fund:** Invests in small U.S. businesses in the emerging energy sector.

By joining with peer companies, we gain greater visibility into the business models and technologies of promising companies and can influence emerging ideas. We share diverse, global perspectives, positioning Xcel Energy to successfully manage policy changes in the states we serve. We are gaining insights that inform our decisions from energy supply to distribution, customer solutions and cybersecurity.

Other Investments

In 2022, Xcel Energy committed to Buoyant Ventures' debut fund, which focuses on early-stage companies in the digital space that address climate change. Headquartered in Chicago with leadership presence in Denver, the women-owned venture fund already has a robust portfolio of high-impact investments that can be rapidly scaled and deployed, from optimization software for utility-scale solar to demand response software for residential energy load.

Xcel Energy officially committed to join MSP Equity Fund in early 2023. This first-of-its-kind fund aims to attract venture capital expertise and investment to support Minnesota-based startups led by women and people of color.

In 2021, we committed to Energize Ventures, a global investment manager accelerating digital innovation in energy and sustainability. Energize actively partners with entrepreneurs to drive impact across four key software themes: accelerating renewable deployment, advancing electrification, enabling infrastructure resilience and powering sustainable business.

NOTEWORTHY

Rapid Innovation

Xcel Energy's partnerships in venture capital, the Electric Power Research Institute's Incubatenergy Labs and other programs give us the visibility and opportunity to demonstrate leading-edge technology and concepts that support our strategic priorities. Rapid Innovation is our 16-week limited-scope framework that enables business areas to quickly prove the value of new services, hardware and software. Vendors are selected for the demonstration only. Some examples:

- **Singularity Energy:** Both an Energy Impact Partners investment and a 2022 Incubatenergy finalist, this demonstration provided large commercial customers visualizations of their current carbon activity and reductions and forecasted how they might shorten their carbon-free trajectory by implementing new efficiency programs.

- **KrakenFlex:** Another 2022 Incubatenergy finalist, UK-based KrakenFlex demonstrated the ability to securely connect and operate a distributed energy resource through the Internet. This is a crucial capability as the number of non-Xcel Energy-owned batteries, solar and other smaller dispatchable resources increase on the grid.

- **Accure Battery Intelligence*:** Grid energy storage can play an important role to "firm" renewables when the sun isn't shining or the wind isn't blowing. Accure's analytics and artificial intelligence provide in-depth battery health and behavior data beyond the battery's factory-installed system to improve safety, reduce maintenance and optimize operation. In 2023, Xcel Energy will demonstrate Accure's capabilities using data from the Peña Station Panasonic battery array in Colorado.

- **Noteworthy.AI*:** Analogous to Xcel Energy's use of drone-captured imagery and AI to inspect transmission lines, in 2023 Distribution Operations will demonstrate Noteworthy's ability to identify and prioritize defects found on poles, pole-mounted assets and conductors by applying AI to images captured by vehicle-mounted high-resolution cameras.

- **Solid State Power*:** Xcel Energy and six peer utilities selected this 2023 Incubatenergy finalist's solid-state transformer to demonstrate at EPRI's Massachusetts lab. In addition to stepping AC voltage up and down, solid-state transformers offer improved power flow control, voltage regulation, power quality and the potential of a direct DC output.

*Demonstration project development in progress.



Electric Power Research Institute

Through our long-time membership with EPRI, we gain insights into the challenges and opportunities associated with advanced clean energy and emission-reduction technologies. This includes:

- Electric system resiliency, climate scenario analysis and greenhouse gas reduction goals.
- Renewable integration, electric vehicles, combined heat and power, customer demand response and energy efficiency.
- Informing regulators and customers on the technical and economic opportunities and challenges of new grid technologies, such as energy storage and distributed generation.

In this collaborative research environment, we engage with other organizations that are developing and evaluating new products to optimize and analyze distributed energy resources on the power grid. Xcel Energy participates in the Low-Carbon Resources Initiative led by EPRI and GTI Energy. It's a five-year research and development commitment to advance low-carbon technologies for large-scale deployment. The goal is to create risk-informed understanding of options and technologies for 2030 and beyond, through global partnerships and demonstrations, applied engineering developments, and technology acceleration of the most promising options.

Ambri Project at SolarTAC

Xcel Energy will test Ambri's Liquid Metal™ energy storage technology at Solar Technology Acceleration Center in Aurora, Colorado. SolarTAC is a 74-acre facility for demonstrating and validating energy technologies in a real-world, grid-connected environment.

Ambri's advanced long-duration storage is built for daily cycling, even in extreme environments, with a 20-year lifespan. They report minimal fade and no gas emissions or thermal runaway, capabilities that could provide greater resiliency and reliability as more renewables and higher loads are added to the power grid. Xcel Energy was a founding member of SolarTAC in 2011 and has used the site to test storage, solar and microgrid systems. Also on site is GridNXT, a plug-and-play microgrid where integrated distributed generation and storage ideas can be demonstrated.

NuScale Power

NuScale Power is developing advanced small modular nuclear reactors, and Xcel Energy is recognized for our expertise and insights in nuclear operations. These synergies led to a memorandum of understanding with NuScale in 2021 to explore the feasibility of becoming a plant operator at future plants.

The agreement has expanded into support for the Carbon Free Power Project, which is the legal entity created to build the nation's first small modular reactor on the Idaho National Lab site. Utah Associated Municipal Power Systems, a nonprofit wholesale electric provider for 50 community-owned power systems in seven Western states, created CFPP to secure long-term, firm, dispatchable carbon-free power for its members.

In 2022, Xcel Energy partnered with CFPP and NuScale to provide operational expertise and insight on our operating model for the CFPP reactor. We created a new, non-regulated legal entity to perform work for CFPP and support the effort.

This work provides Xcel Energy with valuable insight into the regulatory process and advanced reactor landscape and promotes our leadership on the topic of advanced small modular reactors.

Beneficial Electrification and Clean Heat

Xcel Energy operates in challenging climates — with cold winters, hot summers or both — that provide ideal conditions to demonstrate how heat-pump technology performs in our customers' homes. We participate in several federal programs to assess the potential of heat pumps.

NREL Cold Climate Heat Pump Study: Xcel Energy is partnering with the National Renewable Energy Laboratory to study the real-world effectiveness of cold climate heat pumps at high altitude. Colorado customers can receive incentives if they install heat pumps and agree to data monitoring and collection for 16 to 18 months. NREL is also performing lab simulations on a second system, in which a pair of test trailers will be set up to simulate single-family homes and sited at high altitude. This near-real-world impact study will thoroughly test heat pump operation in Xcel Energy's harshest climate conditions.

Department of Energy Collaborations:

- We are on the advisory board for a DOE-funded study on advanced controls for cold-climate heat pumps in dual fuel applications. Conducted by Newport Partners in upstate New York, the 2023 study includes simulation, monitoring and analysis of a control methodology with a single field installation. The study aims to develop and validate controls that also provide energy-efficiency and grid benefits for hybrid heat pumps and furnace systems in cold-climate homes. Results will be shared in an advanced, interactive workforce training program.

- DOE has asked Xcel Energy to support a new DOE Cold-Climate Heat Pump Challenge to manufacturers. It seeks to extend the capability of heat pumps by addressing changes in refrigerant requirements and establishing lower operating cutoff temperatures in two segments, below 5 degrees F and below minus 15 F. The colder cutoff range is of interest to future efforts in electrification. Company support will include offering a higher rebate tier within our current cold-climate heat pump measures and recruiting customers for the field study.

- We are also on the advisory committee for a study of hybrid heat pump controls. The DOE-funded research project is testing and monitoring advanced control strategies to optimize dual-fuel heat pump controls and validate efficiency, demand reduction and emission reduction benefits.

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