MINNESOTA'S SMARTER GRID

Pathways Toward a Clean, Reliable and Affordable Transportation and Energy System

Minnesota Gov. Tim Pawlenty signed the Next Generation Energy Act in 2007, bipartisan legislation designed to spur renewable energy deployment with the goal of decarbonizing the Minnesota economy 80% from 2005 levels by 2050. The *Minnesota's Smarter Grid* study modeled electric sector scenarios to determine optimal pathways that significantly decarbonize Minnesota's economy, in alignment with the Act's goals. The study was funded by the McKnight Foundation, managed by GridLab, and executed by Vibrant Clean Energy.

Vibrant Clean Energy used its WIS:dom energy model to project a future electric system of the entire Eastern United States grid out to 2050, with a focus on Minnesota. Initial economy-wide modeling suggests that in order to decarbonize 80% of the entire Minnesota economy by 2050, the electricity sector will need to decarbonize at 91% from 2005 levels, as it will be costly and difficult for other sectors to meet their 80% goals alone. The modeling includes significant electrification of heating and transportation, which allows for decarbonizing these sectors of the economy.

"This report shows that **Minnesota can achieve our 2050 greenhouse gas reduction goals** across the buildings, energy, and transportation sectors while providing reliable energy at affordable prices. Continuing our state's progress on **clean energy will not only allow us to tackle climate change**, but will significantly **reduce air pollution, increase human health, and boost our economy** by **tripling the number of energy sector jobs** by 2050."

- KATE WOLFORD
President of the McKnight Foundation

KEY TAKEAWAYS

- Minnesota can have dramatically cleaner, more affordable, and more reliable electricity by significantly increasing renewable energy and clean transportation deployments. The state already benefits from home-grown clean energy production, and the scenarios detailed here will increase jobs, drive economic growth, reduce resident's electric bills, and deliver drastically improved air quality.
- To decarbonize the MN economy 80% by 2050 compared with 2005 levels, the electricity sector must decarbonize by 91% and serve new heating and transportation demands as those sectors electrify. Electrification includes a large expansion of residential and commercial water and space heat pumps, along with aggressive energy efficiency investments. We assume that by 2050, 89% of light-duty transport is electric vehicles.
- This deep decarbonized energy system will triple the number of jobs for Minnesota in the energy sector, creating an estimated 14,000 jobs in wind and 36,000 jobs in solar by 2050.
- Every major local and global air pollutant is reduced substantially.
- Residential electricity rates will remain stable or even fall.
- The cost of energy is reduced in all electrification and decarbonization scenarios. Households will save between $600 and $1200 a year on energy spending, amounting to cumulative economy-wide energy savings of up to $50 billion by 2050.
- In a business as usual scenario, natural gas is the dominant fuel, and emissions reductions cease by 2030. This natural gas future also exposes Minnesota to fuel price risk. In a decarbonized future, natural gas will play an important, but diminishing role in the reliable operation of Minnesota's grid. Flexible loads, interconnection to the wider MISO grid, and limited deployments of storage are a more cost-effective solution to address the variability of renewable generation.
- Minnesota can decarbonize without extending the current licenses of its two nuclear plants or building new nuclear. If the Eastern US decarbonizes along with Minnesota, new nuclear may be deployed to provide carbon-free generation.
- While Minnesota can meet its decarbonization goals without expanding transmission, limiting new transmission investment will raise the overall cost of decarbonization. In addition, Minnesota could meet its goals with heavy reliance on distributed resources such as rooftop solar, but this pathway would require much more energy efficiency and additional costs.

80% REDUCTION OF GAS EMISSIONS *by* 2050

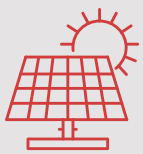
THE NUMBERS

ENERGY SAVINGS PER HOUSEHOLD

$600 - $1200 per year

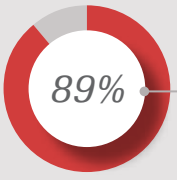
WIND JOBS

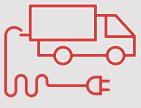
14,000



SOLAR JOBS

36,000





OF LIGHT-DUTY TRANSPORT

will be electric

30% 

DECREASE IN PRICE PER KWH

ENERGY SECTOR

300%

increase in employment

OVERVIEW

The WIS:dom optimization model demonstrates numerous viable pathways to decarbonization through deployment of new in-state wind and solar generation, along with extensive energy efficiency, flexible loads, and electric storage. The model validates that Minnesota can effectively achieve a deep carbonization of the energy sector and meet its 2050 Next Generation Energy Act goals. The model further demonstrates that a high penetration of renewable energy and energy storage deployments *will not* threaten the reliability of the electric grid, while still providing service at prices less than current costs. Finally, these decarbonization pathways would deliver both jobs and increased revenue to Minnesota communities, provide enhanced air quality, and reduce overall greenhouse gas emissions.

GENERATING CAPACITY CHANGES

Currently, roughly a quarter of Minnesota's electricity comes from in-state coal fired generation, a fifth from Minnesota's two nuclear plants, a fifth from in-state wind, a quarter imported from outside Minnesota, and the final 10 percent from in-state natural gas fired generation.

By 2035, the model shows that wind and solar will make up 65% of Minnesota's generation, with the rest composed of imports (mostly renewable) from MISO and the Eastern Interconnection. Three percent of the generation will come from storage, which provides a key role in balancing supply and demand.

Nuclear energy provides low carbon electricity for the initial years, but MN can reach its decarbonization goals even with its two nuclear facilities retiring at the end of their current licenses. A scenario where the nuclear units stay online through 2050 increases electricity costs.

As the entire Minnesota economy electrifies, including the transportation, power, and heating sectors, the need for additional transmission upgrades declines as the load better matches the in-state generation. However, adequate transmission deployment is essential in keeping costs low during the decarbonization period. Minnesota will continue to exchange low-carbon electricity with MISO through decarbonization, but will become a net exporter of electricity by 2050 in the decarbonization scenario.

ELECTRICITY AND DEMAND

Increasing electric load over the next 30 years is due to electrification of heating and transportation, driven primarily by the latter and partially offset by increased energy efficiency. However, the deployment of these flexible loads, such as electric vehicle charging, are critical to economy-wide decarbonization, and result in significantly decreased energy costs over the scenario timelines. Importantly, increased electrification results in a higher nighttime winter load, increasing the value of "winter energy" and thus leading to higher wind deployments.

DECLINING COSTS AND INCREASED JOBS

Minnesotans currently pay an average of 10¢/kWh for electricity. In both the baseline and decarbonization scenarios, electricity costs fall considerably. Under the decarbonization scenario, electric prices are 3¢/kWh cheaper than today (around 7.2¢/kWh total), representing a decrease of approximately 30% by 2050. Employment in the electricity sector also jumps substantially. While coal and natural gas jobs, which currently encompass approximately one-half of the 20,000 jobs in the sector, drop precipitously, employment in the electricity sector overall almost triples, with the vast majority of jobs in wind and solar PV.

FINAL THOUGHTS

In order for the Minnesota economy to achieve an 80% reduction of greenhouse gas emissions by 2050, in line with its legislative goals, the electricity sector must decarbonize by at least 91%. Energy models indicate that a heavily decarbonized electric sector is possible at prices comparable to or lower than current electric costs, with a heavy focus on energy efficiency, along with the electrification of space heating, water heating, and transportation systems. A massive deployment of renewable energy will not disrupt the reliability of the electric grid, although increased transmission upgrades, as well as heavy transmission sharing and grid integration with neighboring states will be important to keep costs down as the sector decarbonizes. As natural gas and nuclear energy play a diminishing role in the states capacity mix, the flexible grid can efficiently support high penetrations of renewable energy as well as electrified heating and transportation systems. This flexible grid has the added bonus of improving air quality across all major human pollutants and reducing greenhouse gas emissions. The decarbonized trajectories will deliver both jobs and increased revenue to the state of Minnesota, with no sacrifice to system reliability or services.

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