Center of the American Experiment
Minnesota's Think Tank

Energy Policy in Minnesota: The High Cost of Failure

STEVEN F. HAYWARD AND PETER J. NELSON

Steven F. Hayward is the senior resident scholar, Institute of Governmental Studies, University of California at Berkeley and author of the *2011 Almanac of Environmental Trends*. Peter J. Nelson is a vice president and senior policy fellow at Center of the American Experiment

Center of the American Experiment's mission is to build a culture of prosperity for Minnesota and the nation. Our daily pursuit is a free and thriving Minnesota whose cultural and intellectual center of gravity is grounded in free enterprise, limited government, individual freedom, and other time-tested American virtues. As a 501(c)(3) educational organization, contributions to American Experiment are tax deductible.

Bulk orders of this publication are available by contacting Peter Zeller at Peter.Zeller@AmericanExperiment.org or 612-338-3605.

8421 Wayzata Boulevard ★ Suite 110 ★ Golden Valley, MN 55426

Center of the American Experiment
Minnesota's Think Tank

OCTOBER 2017

Energy Policy in Minnesota: The High Cost of Failure

STEVEN F. HAYWARD, PH.D. AND PETER J. NELSON, J.D.

Executive Summary

In recent years, the state of Minnesota has pursued a series of increasingly aggressive renewable energy and "clean energy" policies that cost electricity consumers billions of dollars, without achieving its ambitious environmental protection goals.

Minnesota law sets out ambitious state energy policy goals. The primary goal would have the state reduce greenhouse gas emissions 15 percent below 2005 levels by 2015, 30 percent by 2025, and 80 percent by 2050. State law incorporates a number of additional energy policy goals aimed largely at supporting these greenhouse gas reduction targets. In particular, the state's renewable energy standard requires utilities to generate a substantial portion (25 to 30 percent) of electricity from renewable sources, mostly wind.

Historically, Minnesota enjoyed the advantage of relatively cheap electricity, with rates typically 18 percent less than the national average. However, since spending an estimated $10 billion on building wind farms and billions more on new and upgraded transmission lines, Minnesota has lost this competitive advantage with little to show for it, except higher electric bills. As electricity generation from carbon free wind approaches 20 percent of total generation, Minnesota has not experienced any appreciable reduction in greenhouse gas emissions relative to the U.S. average.

This report evaluates Minnesota's energy policy and reaches five main findings that buttress one conclusion: Minnesota's aspirational energy policy is a grand exercise in virtue signaling that does little to reduce either conventional pollution or greenhouse gas emissions.

Minnesota has lost its advantage on electricity pricing. Between 1990 and 2009, the retail price of electricity in Minnesota was, on average, 18.2 percent lower than the national average. However, in just seven years, this price advantage has completely disappeared. February 2017 marked the first month the average retail price of electricity in Minnesota rose *above* the U.S. price. (Data are available dating back to 1990.) If in the past seven years Minnesota would have maintained its historic price advantage versus the rest of the country, the state's consumers would have paid nearly $4.4 billion less than what the actual cost of electricity turned out to be.

Minnesota's energy policy primarily promotes wind power. Minnesota's energy policy emphasizing renewable energy is mostly an *electricity* policy, which represents only about 40 percent of the state's total energy consumption. Because Minnesota's geography is not suitable for large-scale solar power, it aims, to date, for only modest increases in solar. As such, Minnesota's energy policy is primarily a *wind-energy* policy.

Minnesota's energy policy is failing on its own terms, as it has not achieved a significant reduction in CO2 emissions. While Minnesota was losing its advantage on electricity pricing, it did not see any significant decreases in CO2 emissions. CO2 emissions in Minnesota declined by 6.6 percent from 2005 (the peak year for CO2 emissions in both the U.S. and Minnesota) to 2014 (before starting to rise again). This decline is one-third less than the decline experienced by the nation as a whole, which saw greenhouse gas emissions drop 9.3 percent during the same time period. Looking at just emissions from the electric power sector, emissions in Minnesota dropped by slightly more than the U.S. However, since 2009, the state has made little to no progress on emissions even as electricity generation by wind increased by 92 percent.

To satisfy Minnesota's renewable energy standard, an estimated $10 billion dollars has been spent on building wind farms and billions more on transmission. In the past five years, Minnesota utilities have reported using wind power from wind farms totaling 5,000 megawatts of nameplate capacity to meet the requirements of the state's renewable energy standard. Based on industry cost estimates for building new generating capacity, ratepayers are committed to covering an estimated $10 billion for constructing these wind farms and billions more for the transmission needed to move this new power to market. On top of these upfront costs, ratepayers are on the hook for ongoing wind energy maintenance costs, property taxes, and replacement power needed when the wind doesn't blow.

Introduction

Minnesota has established aggressive energy policy goals, the primary goal being to reduce greenhouse gas emissions 15 percent below 2005 levels by 2015, 30 percent by 2025, and 80 percent by 2050. Data on Minnesota CO2 emissions, however, reveals the state is not even close to meeting these goals.

Minnesota's strategy for meeting these goals largely relies on lowering CO2 emissions by shifting electricity generation from fossil fuels to wind power. Over the years an estimated $10.6 billion has been spent on building wind farms to meet Minnesota's state mandated renewable energy requirement.

Despite this massive investment, the federal government reports that reductions in Minnesota greenhouse gas emissions—just 6.6 percent between 2005 and 2014—failed to keep pace with overall U.S. reductions. At the same time, Minnesota completely lost its long-held advantage on electricity prices. As electricity prices continue to rise faster than the U.S. average and emissions reductions fall short, Minnesota appears poised to push forward with the same failed policies.

Section I: Changing and Contradictory Rationales for the Same Policy Prescriptions

Policies promoting renewable energy are popular with many states, though the rationale is flimsy, in part because it has turned inside out over the last generation. The enthusiasm for renewable energy began in earnest during the misnamed "energy crisis" of the 1970s (misnamed because the energy shortages and price instability were overwhelmingly the failure of government policy and not energy markets, as subsequent deregulation, supported by both political parties, demonstrated).[1] At the time, heavy new investment in renewable energy was embraced because it was thought conventional hydrocarbon fuels—especially oil and natural gas—were going to become increasingly scarce and expensive, and secondarily that the U.S. would be dependent on unreliable foreign sources.[2] The energy policy of the "energy scarcity" era aimed to shield citizens from high or volatile prices and potentially ruinous energy shortages. Ironically the emphasis on renewable energy today may well result in volatile prices and energy shortages in the future.

The one exception to this gloomy outlook was coal. It should be kept in mind that a central aspect of the Carter Administration's ambitious energy policy in the late 1970s was a heavy emphasis on the expanded use of coal, a conventional hydrocarbon the U.S. has in abundance, for new electricity generation needs. Starting in the early 1970s and accelerating into the 1980s, the U.S. built nearly 200 new coal plants (many of them very large), and nearly doubled its coal-fired generating capacity, adding a total of 157 gigawatts of coal generation capacity. By comparison, despite all of the hype about the rapid growth of renewable energy in recent years, the total amount of new wind generation from 1970 through 2016 is only one-quarter as much as new coal capacity added in the 1970s and 1980s.

In fact, some of the loudest voices on behalf of "renewable energy" today were solidly behind expanding coal for a time in the 1970s. For instance, Amory Lovins, founder of the Rocky Mountain Institute which, as we shall see, plays a role in Minnesota's energy policy today, said in the early 1970s that "Coal can fill the real gaps in our fuel economy with only a temporary and modest (less than twofold at peak) expansion of mining." Ralph Nader, then at the beginning of his crusade against nuclear power, agreed: "We do not need nuclear power. . . We have far greater amounts of fossil fuels in this country than we're owning up to. . . The tar sands. . . oil out of shale, methane in coal beds."[3] This enthusiasm for expanded domestic fossil fuel production proved short lived, and by the end of the 1970s Lovins and Nader had joined the dominant narrative that the impending scarcity of fossil fuels required the deployment of renewables.

Today it is clear that the conventional wisdom about the scarcity of oil and natural gas was wrong. New technology has expanded global and national oil and natural gas reserves even as global consumption of these primary fuels has more than doubled. The real, inflation-adjusted price of oil and gas is lower today than it was at the outset of the so-called "energy crisis" of the 1970s. The market price of natural gas has fallen so far that it now outcompetes coal as the cheapest source of new baseload electricity generation in the U.S., and natural gas-fired electricity generation is the fastest growing source when measured by actual output. Far from being dependent on foreign oil and gas, the United States is now the world's leading producer of oil and natural gas and has even started exporting oil and natural gas in significant amounts.

Hence the rationale for Minnesota's renewable energy mandate has been turned on its head. Now we are told that Minnesota and the nation as a whole need to invest heavily in renewable energy because oil and natural gas *aren't* running out, but will choke the atmosphere with greenhouse gas emissions if we keep using them. In other words, the premise of energy policy has shifted from scarcity to abundance, *while the remedy remains identical*. And national policy has made an abrupt 180-degree turn with regard to coal, with policy emphasis on shutting down coal-based generating capacity. The point in reviewing this history is to illustrate the capriciousness of politically-driven energy policy.

The shifting basis for a policy that emphasizes renewables raises the question of whether the policy is well-founded, or is the self-interested goal of special interests—in this case environmental advocates and energy producers who seek to capture larger profits through state mandates and taxpayer subsidies rather than from a consumer-driven marketplace. This study explores the costs of Minnesota's energy policy to its consumers, and whether it delivers the benefits it promises.

Finally, beyond the changing rationales for a largely unchanging policy objective, Minnesota's energy policy offers an excellent case study in the cumbersome, wasteful, and self-serving special-interest nature all too typical of administrative policymaking today. Minnesota's policy appears aimed chiefly at satisfying the profit-seeking of wind and solar power providers—both heavily dependent on generous federal subsidies and tax credits for profitability—rather than meeting the real energy needs of its citizens.

Section II: Minnesota's Energy Policy Goals

Minnesota's present energy policy goals were largely established through the Next Generation Energy Act of 2007 (NGEA). A good way to delve into Minnesota's energy policy is to review the state's most recent synopsis of its energy policy goals and implementation process, Minnesota's 2025 Energy Action Plan (MEAP for short), which was published in August 2016.[4] Although sponsored by the Minnesota Department of Commerce and the Minnesota Legislative Energy Commission, the report itself was outsourced to the Rocky Mountain Institute, long known for its ideological hostility to traditional hydrocarbon and nuclear energy.

The MEAP divides Minnesota's various energy policy goals into three categories: total energy consumption and greenhouse gas emissions; renewable electricity; and biofuel content.[5] Goals tied to total energy consumption and greenhouse gas emissions were all established through the NGEA. The primary renewable electricity goals were also established through the NGEA, though the legislature added new solar goals in 2013.

These three broad goals have several subparts and discrete targets. The report lists nine separate policy goals—some aspirational and some mandatory—under these three categories. These goals are outlined in Table 1 below.

The nine goals overlap in such a way as to reduce to two main objectives: 1) use less energy (especially traditional hydrocarbon energy) and 2) reduce greenhouse gas emissions. If there is one overarching goal among the nine, it is to reduce state greenhouse gas emissions by 15 percent below 2005 levels by the year 2015, 30 percent by 2025, and 80 percent by 2050.

The MEAP reports that a number of these goals are on track to be reached, including the energy savings, per capita fossil fuel use, and 10 percent biofuel content goals. Minnesota's Renewable Electricity Standard is also well on its way to being reached on account of heavy federal subsidies and policy favoritism, especially for wind power. (The U.S. Department of Energy estimates that in the absence of subsidies and state renewable portfolio standard mandates, renewable electricity growth would be about 60 percent lower over the last 15 years.[6])

Despite its cheerleading for Minnesota's energy policy, the MEAP concludes: "If Minnesota continues on its current trajectory, the state will fall short of its greenhouse gas reduction goals and overall renewable energy goals."[7] This conclusion is correct, but MEAP offers little analysis or understanding as to why this is the case. If reducing greenhouse gas emissions is now the primary goal of Minnesota's energy policy, a closer look at the actual performance will show that it is failing badly, and at an unreasonable cost.

Table 1: Minnesota Energy Policy Goals	
Total Energy Consumption and GHG Emissions	Electric utilities shall have an annual energy savings goal of 1.5 percent of gross annual retail energy sales. (Minn. Stat. 216B.241)
	Reduce per capita fossil fuel use by 15 percent by 2015. (Minn. Stat. 216C.05)
	Generate 25 percent of electricity from renewable energy sources by 2025. (Minn. Stat. 216C.05)
	Reduce statewide greehhouse gas emissions across all sectors producing emissions by 15 percent below 2005 levels by 2015, 30 percent by 2025, and 80 percent by 2050. (Minn. Stat. 216H.02)
Renewable Electricity	Electric utilities shall generate at least 25 percent of electricity from renewable sources by 2025. (Minn. Stat. 216B.1691)
	Electric utilities shall generate at least 1.5 percent of electricity from solar energy by 2020 and set a goal to generate at least 10 percent of electricity from solar energy by 2030. (Minn. Stat. 216B.1691)
Biofuel Content	Gasoline sold in Minnesota contains at least 30 percent biofuels by 2025. (Minn. Stat. 239.7911)
	Gasoline sold in Minnesota must contain at least 10 percent biofuel. (Minn. Stat. 239.791)
	All diesel fuel sold in Minnesota must contain at least 20 percent biodiesel by 2018. (Minn. Stat. 239.77)

Energy policy ignores gains from trade; follows 18th-century mercantilist economics

One early passage from Minnesota's 2025 Energy Action Plan (MEAP) aptly illustrates the antiquated mercantilist economic theory relied on to justify government mandates over the state's energy mix:

> In 2014, Minnesotans spent $11 billion on transportation fuels, ***the majority of which were imported from out of state***. The opportunity to keep transportation fuel dollars in the state and increase the sector's clean energy footprint is significant. Stakeholders' recommendations for the transportation sector fall into two key categories: electric vehicles and alternative fuel vehicles.[8] [Emphasis added.]

It is correct that Minnesota has few hydrocarbon resources (coal, oil, or natural gas) and imports these commodities from other states, but the neo-mercantilist idea that Minnesota would be better off keeping its energy dollars in-state through subsidies for electric and alternative fuel vehicle cars elides an obvious irony: electric cars and windmills today (and likely tomorrow) are made entirely out of state, in some cases with raw materials (especially iron) produced in Minnesota. We would laugh if someone at Tesla said, "We ought to take advantage of the opportunity to get our iron and steel resources from California instead of Minnesota."

It should be added that many of the enthusiasts for electric cars and wind and solar power are presently opposed to the development of new mining projects in Minnesota to produce the raw materials for these and other energy sources, especially materials-intensive wind mills and solar arrays. (This will be the subject of a separate Center of the American Experiment report.)

It is as though the authors of MEAP skipped the day the lesson of "gains from trade" was taught in Econ 101. (It should be added that while Minnesota produces virtually no oil, its two oil refineries in the state export refined products to other states, representing a value-added segment of the fossil fuel energy supply chain. In fact, the Pine Bend refinery is the nation's second-largest refinery in a non-oil-producing state. Using MEAP's logic, Minnesota should want to close it down.)

Section III: Background on Energy Use, Energy Objectives, and Minnesota's Energy Goals

Before proceeding to a more detailed evaluation of Minnesota's energy goals and performance, it is helpful to review some basics about energy use (including several misconceptions and half-truths), some common objects of sensible energy policy, and Minnesota's energy profile. All of this information helps set a framework for understanding the state's energy goals.

A. Important Differences in the Forms and End Uses of Energy

"Energy" is often discussed as a singular, undifferentiated mass. In fact, the end use of energy comes chiefly in three forms that are largely separate from one another, including: 1) liquid fossil fuels for transportation; 2) fossil fuels for home heating (principally natural gas in Minnesota); and 3) electricity to power industrial and household appliances and other equipment. Liquid fuels—chiefly gasoline and diesel, but also some compressed natural gas in specialized vehicles—can be stored in large quantities and used by consumers on demand. Electricity, in stark contrast, has to be generated at the instant it is consumed and cannot be stored on any large scale for later use. While some fuels—especially diesel and natural gas—are used for both transportation and electricity generation, it is important to keep these separate energy use categories in mind.

While end-use electricity cannot be stored in any substantial way, there is a wide menu of options to produce electricity: nuclear, coal, natural gas, solar, wind, hydro, and so forth. There is much less flexibility in energy for transportation: while battery-powered cars are showing some progress, energy for transportation is almost completely based on oil derivatives (gasoline, diesel, jet fuel), with biofuels severely limited by land scarcity and other technical constraints.

This key distinction in the forms of energy used today—liquid fuels versus electricity—is important for sorting out why the general goal of obtaining 30 reductions in greenhouse gas emissions below 2005 levels by 2025 is not going to be achieved. As detailed in Section IV, a strategy focused on reducing emissions from electricity generation will never successfully meet the state's greenhouse gas reduction goals.

B. Sensible Energy Objectives

Any successful energy policy has to keep two lodestars in mind: energy sources need to be *affordable* and *scalable*. These requirements will tend to favor *high density* energy sources, that is, sources that deliver large amounts of energy from a relatively small amount of matter, and that can be sited close to demand (i.e. metropolitan areas and major commercial and manufacturing centers). This practical necessity explains why traditional hydrocarbons (oil, gas, and coal) and nuclear power dominate America's energy portfolio, and the energy portfolio of every other advanced industrial nation. Wind power especially has to be sited at a distance from electricity end users, and requires substantial new transmission capacity to be integrated into the grid.

The imperative of energy density applies even to the largest source of "renewable" electricity: hydropower. Dams and the water resources they contain use comparatively much less land area than solar and wind power. However, Minnesota excludes large hydropower as an acceptable renewable power source in its renewable energy standard.

The best energy strategy is to pursue *energy resilience* through a diversified energy portfolio that emphasizes abundance, affordability, and reliability. The best policy for achieving energy resilience is an open, adaptable marketplace for competing energy supplies and technologies, rather than mandates and patchwork subsidies that introduce artificial distortions and constraints into energy markets.

C. Some Facts About Minnesota Energy

Minnesota is nearly the median state in energy use. In 2014 it ranked 18th in per capita energy consumption, and 22nd in per capita spending for energy; 24th in carbon dioxide emissions, and 27th in energy use per dollar of economic activity. Its 2016 average all-sector electricity price of 10.02 cents per kilowatt hour (kWh) ranks 19th in the country (12.73 cents for residential customers), and near the middle range of residential electricity cost for the nation as a whole. (Thirty-four of the 50 states have residential electricity rates between 10 and 15 cents per kWh.)

1. Minnesota has lost its advantage on electricity pricing

Since 2010, Minnesota has lost its long-held electricity pricing advantage over the national average. Between 1990 and 2009, the retail price of electricity in Minnesota was, on average, 18.2 percent lower than the national average. This price advantage was remarkably consistent year-to-year with only a small narrowing of the advantage between 1998 and 2000. However, as shown in Figure 1, Minnesota's price advantage began slipping in 2010. (All figures in this report are based on data from the U.S. Energy Information Administration.) Over the next seven years, Minnesota prices increased faster than the nation—a 3.0 percent average annual increase compared to 0.7 percent nationally. By 2016, Minnesota's historic price advantage was just 2.5 percent lower than the national average.

Monthly prices that have so far been reported for 2017 suggest that Minnesota's pricing advantage is now gone. February 2017, marked the first month the average retail price of electricity in Minnesota rose above the U.S. price in data available from the federal

FIGURE 1: AVERAGE RETAIL PRICE OF ELECTRICITY (CENTS/KWH)

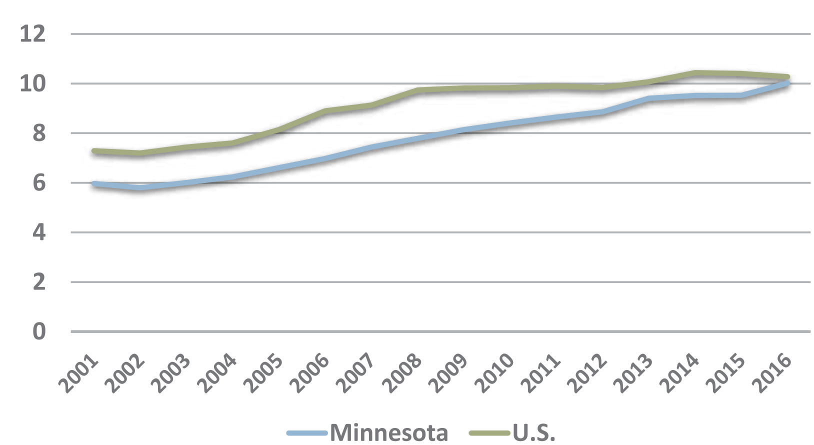
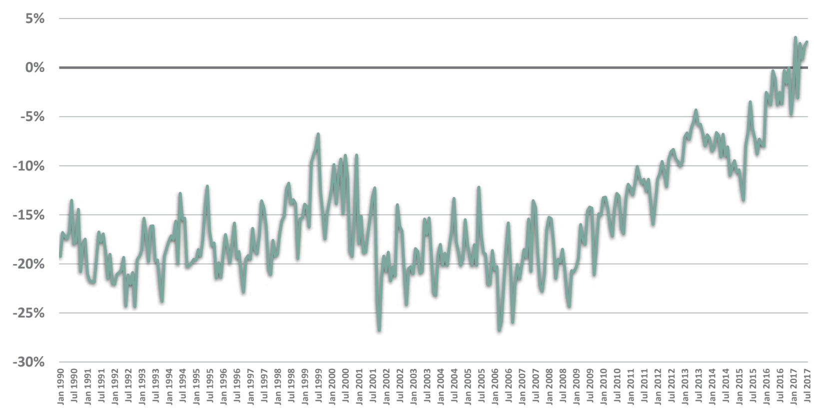


FIGURE 2: MINNESOTA'S ELECTRICITY PRICE ADVANTAGE AGAINST THE U.S. BY MONTH, JANUARY 1990 TO JULY 2017



government that dates back to 1990. So far this year, Minnesota's average monthly retail price of electricity has been higher than the U.S. in five of the seven months reported. Figure 2 plots this recent decline in Minnesota's price advantage by charting the closure of the gap seen in Figure 1. If this trend continues, Minnesota will soon struggle with substantially higher prices than the national average.

2. **Consumers would save $1 billion annually if Minnesota retained its historic pricing advantage**

Consumers would already have saved billions of dollars if Minnesota had been able to retain its historic electricity pricing advantage over the past seven years. Table 2 shows the difference between Minnesota and U.S. average annual electricity prices. It was 2010 when Minnesota's price advantage began to slip. At that time, consumers would have spent about $250 million less on electricity if prices had not risen faster. In 2016, Minnesota consumers would have saved over $1 billion if the state had retained its price advantage. Altogether, in the seven years since Minnesota's price advantage began slipping, consumers would have saved nearly $4.4 billion if Minnesota electricity prices had held steady against the U.S. average.

3. **Price increases moderated by tax credits and low natural gas prices**

Though Minnesota prices have been rising faster than the nation's and inflation, recent increases have been moderated by two factors. First, wind power enjoys a substantial federal subsidy, enabling wind power providers to underbid other conventional providers on the wholesale market. In well-supplied wholesale electricity markets, wind power providers can sometimes bid *negative* prices (essentially paying utilities to take their electricity), and still make a profit because of the direct federal Production Tax Credit (PTC) of 2.3 cents per kWh. This is especially the case in off-peak hours. As the Department of Energy commented recently, "The production tax credit has created an incentive for renewable resources to bid negative prices as they must run in order to receive their payment from the federal treasury."[9] The PTC tilts the playing field heavily against conventional sources. For example, if the market-clearing wholesale price from conventional sources would be 10 cents per kWh, a wind power facility can bid 9 cents at the auction, but clear 11.3 cents per kWh. It is likely the subsidies and mandates for renewable power sources are *reducing* investment in conventional generation sources. The direct tax credits for wind power lower the cash flow to conventional sources, hence reducing investment in increased efficiency.[10]

Second, the relative stability of electricity prices

Table 2: Cost of Losing Minnesota's Electricity Pricing Advantage

	Difference between MN and U.S. electricity prices	Savings to MN Consumers if Minnesota had retained historic price advantage
2007	-18.5%	NA
2008	-20.0%	NA
2009	-17.1%	NA
2010	-14.4%	$247,508,402
2011	-12.6%	$375,401,427
2012	-10.0%	$548,581,915
2013	-6.6%	$802,202,802
2014	-8.8%	$670,584,125
2015	-8.5%	$672,704,666
2016	-2.5%	$1,038,555,107

FIGURE 3: **ANNUAL ELECTRICITY SALES (MEGAWATT HOURS), MINNESOTA**

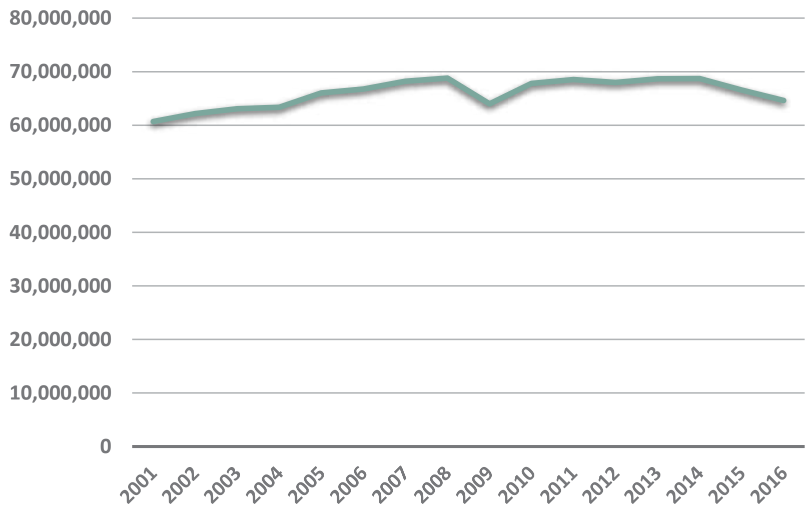


FIGURE 4: **MINNESOTA ELECTRICITY MIX, 1990**

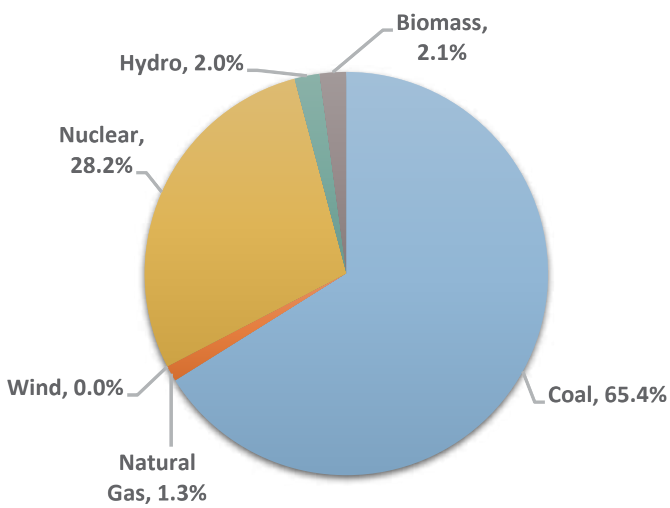
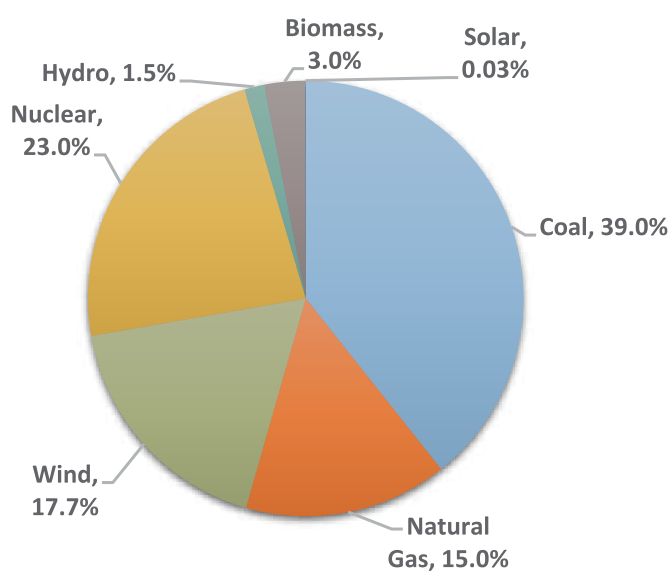


FIGURE 5: **MINNESOTA ELECTRICITY MIX, 2016**



throughout the U.S. owes much to the dramatically falling price of natural gas and gas-fired power plants—a fortuitous development that no one predicted even as recently as 10 years ago. The 80 percent reduction in the price of natural gas from its peak price over the last decade is due to dramatic technological innovations in directional drilling and hydraulic fracturing, which represent the real energy revolution of our time, and the primary cause for the nation's reductions in CO2 emissions over the last decade. It is not news to note that many environmentalists remain fiercely opposed to hydraulic fracturing, despite numerous scientific studies affirming its general safely.

4. Growth in electricity consumption remains flat

Electricity consumption in Minnesota has been relatively stable. Figure 3 shows electricity sales increased by 13.4 percent between 2001 and 2008, but took a dramatic drop in 2009 when the great recession struck. Sales in 2016 remain about the same as in 2009. Looking forward, Minnesota utilities project electricity consumption to remain flat as well. Xcel energy—representing nearly half of Minnesota's eelectricity consumption—forecasts only 2.1 percent growth in electricity consumption for its Minnesota customers over the next 15 years.[11]

This means that the emphasis on installing new renewables is not necessary to meet increased demand, but is replacing—in some cases duplicating—existing electric generators that may not have reached the end of their useful lifespan. *However, it is possible future electricity demand in Minnesota could rise significantly if there occurs a substantial penetration of electric vehicles in surface transportation, and/or if there is a major transition to electrified energy use*

The impossibility of 100 percent renewables

Some observers suggest that the United States can source 100 percent of its electricity from renewable sources by the year 2050, and can easily replace not only coal but also nuclear power plants and even natural gas plants with renewable energy alone. The most frequently cited analysis in support of this proposition comes from Stanford University's Mark Jacobson, who has published a series of papers that purport to establish the feasibility of 100 percent renewable power.[12] This is the kind of work that generates enthusiastic headlines and news stories, and becomes a rote talking point for environmental advocacy and special interest lobbies. A closer look shows the superficiality of this claim. Twenty-one prominent academic energy experts, all of whom generally support renewable energy, recently published a harsh critique of Jacobson's influential work in the *Proceedings of the National Academy of Sciences*, concluding that:

> [Jacobson's] work used invalid modeling tools, contained modeling errors, and made implausible and inadequately supported assumptions. Policy makers should treat with caution any visions of a rapid, reliable, and low-cost transition to entire energy systems that relies almost exclusively on wind, solar, and hydroelectric power... If one reaches a new conclusion by not addressing factors considered by others, making a large set of unsupported assumptions, using simpler models that do not consider important features, and then performing an analysis that contains critical mistakes, the anomalous conclusion cannot be heralded as a new discovery. The conclusions reached by the study about the performance and cost of a system of "100% penetration of intermittent wind, water and solar for all purposes" are not supported by adequate and realistic analysis and do not provide a reliable guide to whether and at what cost such a transition might be achieved... A policy prescription that overpromises on the benefits of relying on a narrower portfolio of technologies options could be counterproductive.[13]

How much more expensive and counterproductive? A recent study in *The Electricity Journal* of decarbonization through reliance on renewables in Germany, California, and Wisconsin (a state closely analogous to Minnesota in many ways) would require an investment in wind and solar power much larger than in conventional energy supplies, chiefly because the intermittency of the wind and solar power (to be discussed further in Section IV below) would require massive amounts of surplus capacity.[14] A power mix in Wisconsin that retained nuclear and natural gas electricity would achieve a 15 percent greater reduction in greenhouse gas emissions than a system with 80 percent wind and solar power, and at less than half the cost. As Brick and Thernstrom note:

> [T]he intermittency of wind and solar PV [photovoltaics] means that systems that are heavily reliant on them must be significantly larger than conventional systems; this increases their cost and capital requirements dramatically... Efforts to promote an all- (or nearly all-) renewables future are, in effect, a commitment to building the largest electric power system possible. It might be better to start from the presumption that the smallest power system that meets our needs is likely to be the most efficient, and have the least social and environmental impact.

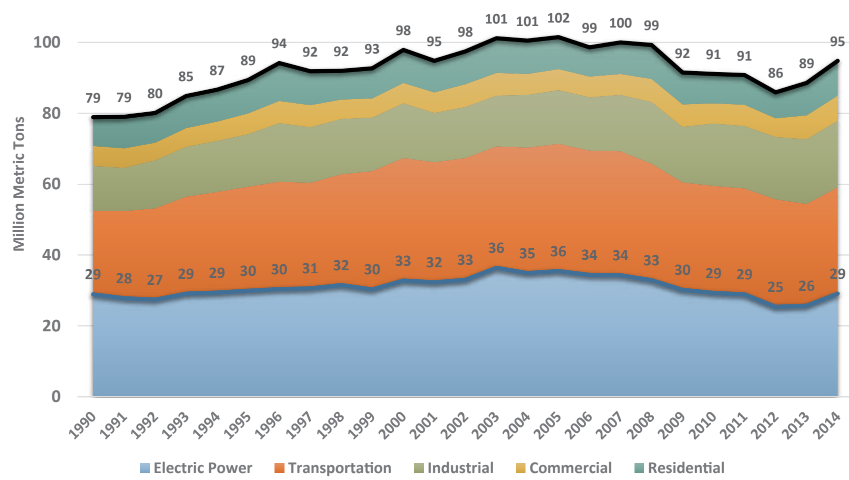
The study does not attempt to estimate the land area requirements for such an extensive renewable energy system, but given the examples contained in Figure 14, they are likely to be substantial. Minnesota's government ought to do a credible estimate of future land area needs for its renewable targets.

such as winter home heating. It is impossible to make confident projections of these potential changes.

5. Coal remains the largest, but declining, source of electricity

Coal is still the leading source of electricity in Minnesota, supplying about 39 percent of the state's electricity in 2016—down from 65 percent in 1990. Coal and nuclear power provide 65 percent of Minnesota's electricity. Coal, nuclear, and natural gas combine for 77 percent of total electricity production. The change in the sourcing of Minnesota's electricity can be seen in Figures 4 and 5. From these two figures it is evident that wind and natural gas are the two sources of energy that expanded the most over this time period.

FIGURE 6: MINNESOTA CO2 EMISSIONS BY SECTOR



course in the last three years. Figure 6 shows CO2 emissions trends dating back to 1990. After falling 15 percent from the peak in 2005, total CO2 emissions rose 10.4 percent between 2012 and 2014. Overall, CO2 emissions dropped 6.6 percent from 2005 levels. By this 2014 measure, there is no way Minnesota came close to meeting its 15 percent by 2015 greenhouse gas emissions reduction goal. State agencies, accounting for all greenhouse gas emissions, report even less progress—only a 4 percent reduction in 2014 compared to 2005.

Section IV: Minnesota's Energy Policy Fails by its Own Measure

As explained in Section II, Minnesota's primary energy policy goal is to reduce greenhouse gas emissions by 15 percent by 2015, 30 percent by 2025, and 80 percent by 2050. To date, Minnesota has not come close to meeting these goals. In the latest biennial report to the legislature on greenhouse gas emissions, state agencies found that greenhouse gas emissions "decreased slightly, about 4%, from 2005 to 2014." That is far short of the 15 percent by 2015 goal.[15] To reach greenhouse gas emission reduction goals, Minnesota might pay lip service to a broad-based strategy, but, in reality, the strategy focuses almost entirely on reducing emissions from electricity generation. This strategy is failing and will continue to fail.

A. Wind and Solar Power are Not Driving Down Emissions

The most glaring failure of Minnesota's energy policy is this: ***Increases in renewable energy such as wind and solar power are not driving down carbon dioxide emissions***.

Minnesota's carbon dioxide emissions have fallen only slightly during the same time period it has vastly expanded its renewable energy, and progress in decarbonizing its electricity supply has actually reversed

The failure of wind power to reduce CO2 emissions is made especially evident in Figure 7 below, which shows that carbon dioxide emissions from the electricity sector in 2014 were the same as they were in 1990 when there was virtually *no* wind power in the state. While electric power carbon emissions are lower today than in 2005, the state has made little to no progress since 2009, even as electricity generated by wind increased by 92 percent. Note that the dip in emissions in 2012 and 2013 is directly related to a catastrophic failure that took down Minnesota's largest coal-fired power plant for 22 months, beginning in November 2011.

Wind power's failure to meaningfully reduce CO2 emissions in Minnesota is also revealed by comparing Minnesota wind generation and emissions trends to

FIGURE 7: ELECTRIC POWER SECTOR CO2 EMISSIONS AND WIND POWER CAPACITY

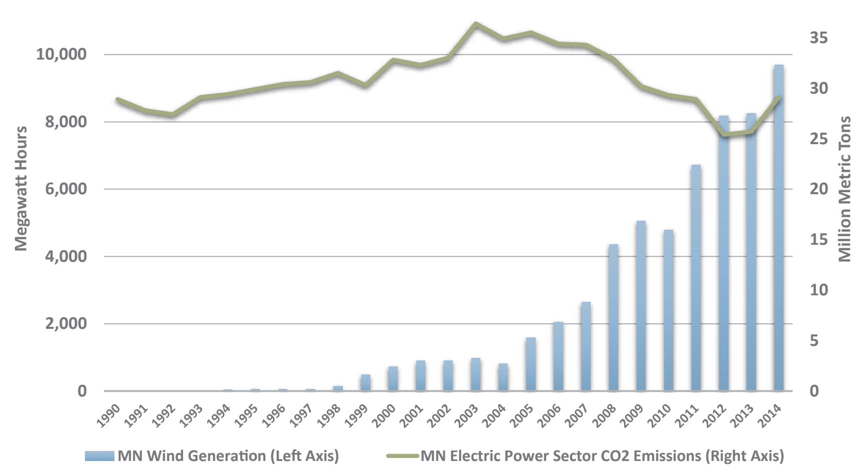
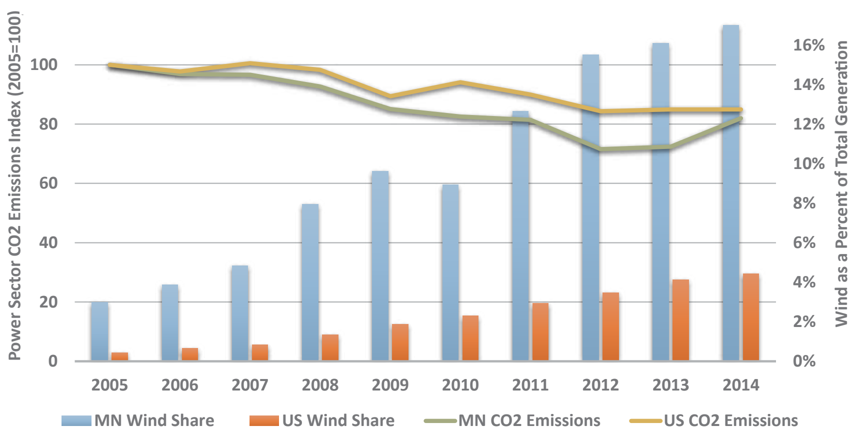


FIGURE 8: POWER SECTOR CO2 EMISSIONS AND THE SHARE OF WIND GENERATION FOR MN AND THE U.S.



the U.S. as a whole. If wind works well to reduce carbon emissions, then Minnesota's electric power sector should be experiencing far greater emissions reductions than the U.S. However, Figure 8 reveals that CO2 emissions in Minnesota's electric power sector dropped by about the same level as the U.S between the 2005 baseline and 2014. Despite wind generating 17 percent of Minnesota's electricity—substantially higher than the 4.4 percent wind generation across the U.S.—electric power sector emissions dropped by 18 percent in Minnesota and 15 percent in the U.S. Again, the apparent drop in 2012 and 2013 in Minnesota is entirely due to the catastrophic failure of Minnesota's largest coal-fired power plant.

The U.S. does better than Minnesota when comparing total greenhouse gas emissions. Between 2005 and 2014, greenhouse gas emissions dropped by 9.3 percent across the U.S. compared to a 6.6 percent drop in Minnesota.

B. **Why Renewables Fail and Will Continue to Fail**

1. **Intermittency**

Understanding why renewables fail begins with the inherent *intermittency* of wind and solar power, which requires backup generation from conventional sources of electricity to assure grid stability during periods of peak demand. The U.S. Department of Energy classifies wind and solar power as *non-dispatchable* technology—that is, wind and solar are not "on demand" sources of electricity because they depend on optimal wind conditions and sunshine. Solar power obviously produces no power at night (or in the winter when panels may be covered with snow or ice), and wind power falls if the wind stops blowing or blows too hard.

Dispatchable electricity sources include coal, natural gas, and nuclear. The Department of Energy estimates what it calls the *capacity factor* of different sources of electricity—that is, how much of the time the source can be relied upon to produce power. Coal, natural gas and nuclear power can all produce power 85 to 90 percent of the time, any time of day or night, under any weather conditions. Importantly, down time for these power sources is generally predictable and easily planned around. By contrast, despite improvements in wind and solar technology, the Department of Energy estimates that onshore wind power has a capacity factor of only 41 percent (up from 35 percent in 2014), while solar power has a capacity factor of just 25 percent. Southwestern Minnesota has a higher capacity factor than the national average (approximately 50 percent) because of more favorable prevailing wind conditions, but the bulk of Minnesota's electricity usage is in the eastern half of the state, requiring extra expense for transmission lines from most wind power facilities. Conventional electricity generation facilities can be sited close to existing grid resources and end-users.

The most important factor in thinking about the resource mix of electricity generation is that electricity has to be available at constant and predictable amounts 24/7. Here is how the Department of Energy describes it: "Since load must be balanced on a continuous basis, units whose output can be varied to follow demand (dispatchable technologies) generally have more value to a system than less flexible units (non-dispatchable technologies), or those whose operation is tied to the availability of an intermittent resource."[16]

Electricity demand in Minnesota varies by time of day and by as much as 40 percent by season, from its lowest points in the spring and fall (when the weather is mildest) to its highest points in the middle of the summer and around the holidays. The data show that wind power produces the least amount of power in the hot summer months when annual power demand peaks. Wind power performs moderately well in the winter months, but falls precipitously—as much as 50 percent—in the summer months when demand is highest. (See Figures 9 through 12.) When wind power in 2016 slumped by 60 percent in August, the gap was mostly filled by coal-fired and gas-fired power. Coal power increased output 82 percent between April and August in 2016. (See Figure 11.)

This point bears restating in stronger terms. A closer look at the actual power output data reveals facts contrary to the narrative of the claimed benefits of greater renewable capacity. Coal accounts for more than 90 percent of total CO2 emissions from the electric power sector, and the fact that total coal-fired electricity production has fallen by much less than the amount of new wind capacity accounts for the lack of progress in reducing CO2 emissions. This is because coal—much more than natural gas—*is the swing producer*, i.e., ***coal is the primary backstop when wind production falls***.

The inverse relationship between coal and wind output can be seen vividly in Figure 12, which displays the relationship between coal and wind output from January 2014 through February of 2017. Notice especially that coal power increases sharply in the summer months when wind power declines because of slack prevailing winds. Wind power performs best in the winter months, when power demand experiences its second peak period of the year, but here again Figure 12 shows that coal-fired power is the swing producer in meeting the higher demand.

2. Natural gas

If the primary object of Minnesota's energy policy is decarbonization, it should allow undistorted market forces to determine the mix of sources to displace coal. This may mean wind in some cases, but will probably mean more natural gas. Numerous studies show the most effective emission reduction strategies rely primarily on natural gas, not wind.[17] Natural gas emits far lower emissions than coal without any of the severe intermittency problems posed by renewables.

FIGURE 9: TOTAL MINNESOTA ELECTRICITY DEMAND/OUTPUT BY MONTH, 2015-2016

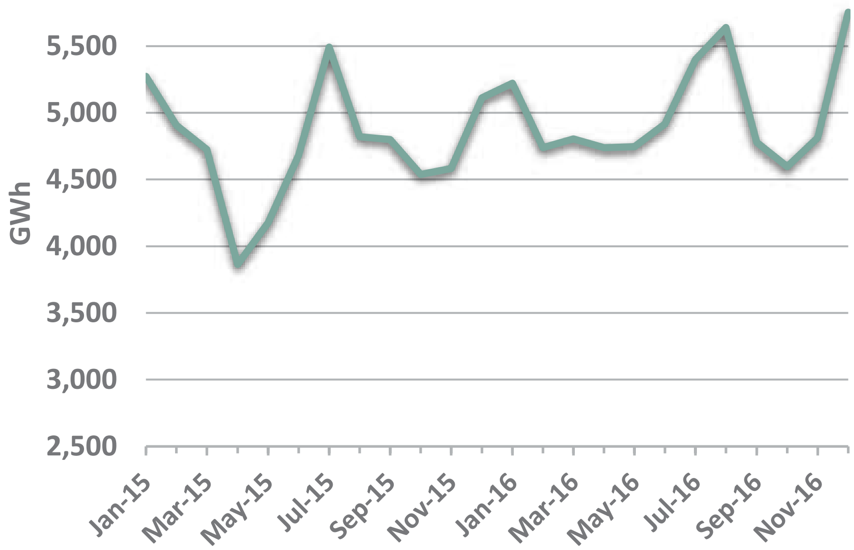
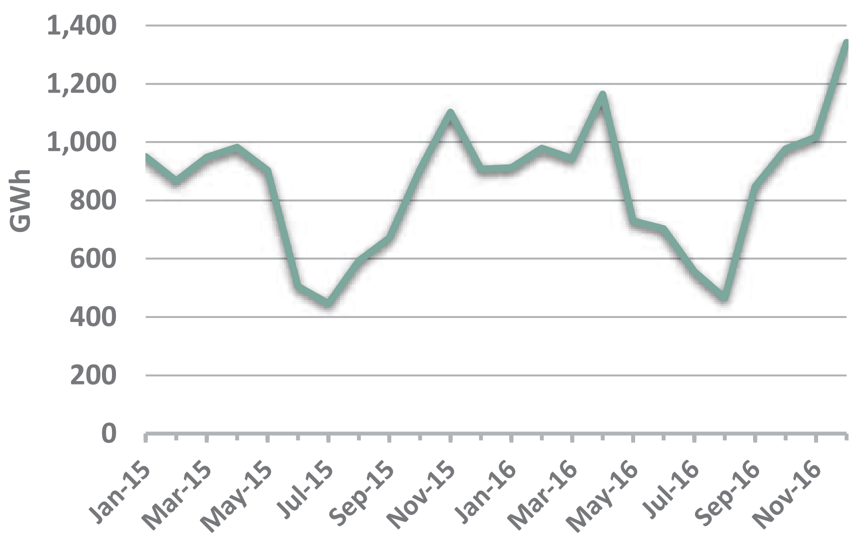


FIGURE 10: MINNESOTA WIND POWER OUTPUT BY MONTH, 2015-2016



Minnesota's experience compared to the U.S. strongly suggests the state is making a serious mistake by focusing too much on wind and solar. While Minnesota has been ramping up wind, most of the rest of the country has been shifting to natural gas. Minnesota is also relying more on natural gas, but not nearly as much as other states. Between 2005 and 2015, natural gas generation grew from a 5.1 percent share to a 13.0 percent share of Minnesota's electricity generation. By contrast, natural gas grew from an 18.8 percent share to a 32.7 percent share across the U.S. These data suggest the rest of the country, by relying on natural gas, achieved the same, but still limited level of emissions reduction as Minnesota, but at a lower price. Recall that it was during this same time-period that Minnesota lost its historic electricity pricing advantage.

3. Emphasis on electricity generation addresses only a fraction of energy use

Even if Minnesota were to devise a better strategy to reduce emissions from the electric power sector, the impact on total greenhouse gas emissions would still be very limited. Electricity, as shown in Figure 13, only accounts for about 40 percent of final energy use in the state. More important, 70 percent of fossil fuel consumption in Minnesota is used for purposes other than generating electricity, such as transportation and home heating, which is predominantly supplied by natural gas. This means that the principal emphasis of Minnesota's energy policy is aimed at a fraction of overall energy use. Generating 25 percent of Minnesota's *electricity* from renewable sources would mean that it would only be generating about 15 to 20 percent of *total* energy from renewable sources at best.

FIGURE 11: TOTAL MINNESOTA OUTPUT FROM MAJOR SOURCES

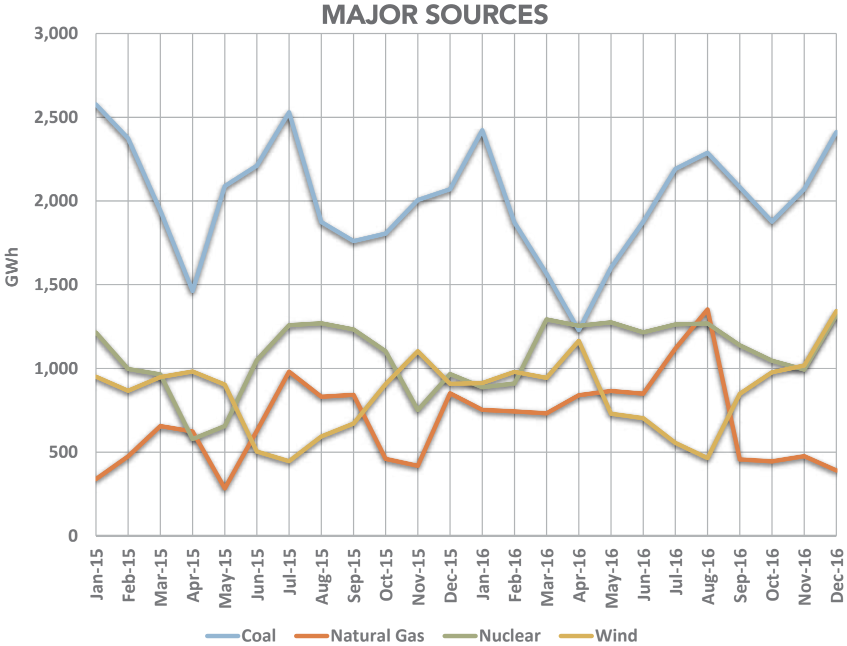
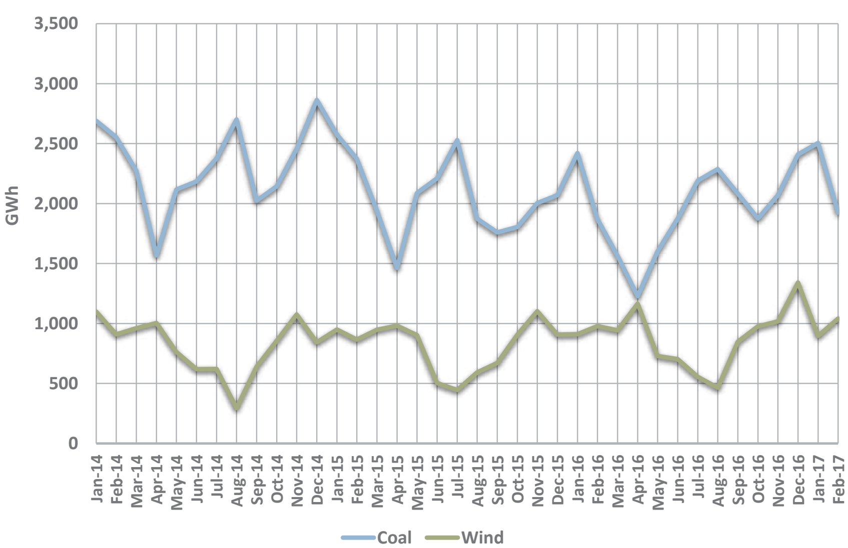


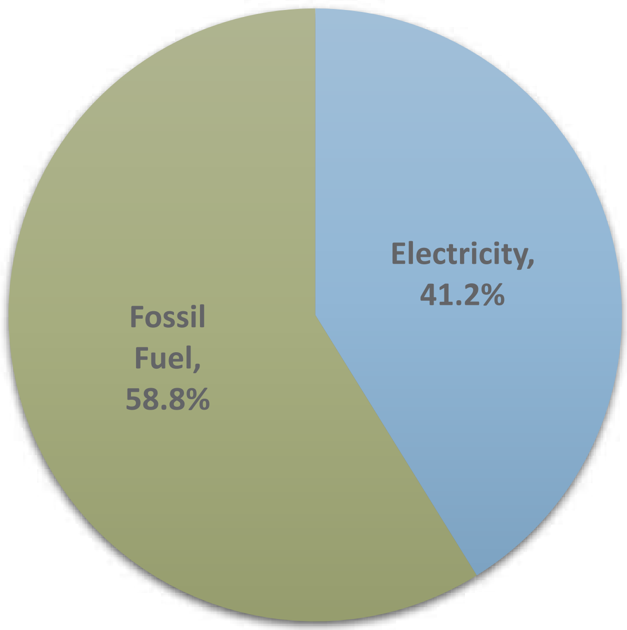
FIGURE 12: ELECTRICITY OUTPUT FROM MINNESOTA COAL AND WIND, JANUARY 2014 TO FEBRUARY 2017



C. Biofuels Production May Be Reaching its Limit

Efforts to address emissions in the largest fraction of energy use—liquid fuels—emphasize biofuels, especially ethanol blended with gasoline. This is another policy that piggybacks on national mandates and subsidies, though it is far from clear that ethanol is environmentally preferable to conventional gasoline.[18] In any case, the U.S. Environmental Protection Agency has recently *reduced* the mandated level of ethanol blending in the nation's gasoline supply, and hints at further

FIGURE 13: MINNESOTA ENERGY USE, 2015



reductions in the years ahead, far short of the original ambitious target contemplated by the Bush Administration in 2005. In other words, the U.S. appears to be close to the limit for the production and use of corn-based ethanol.

Minnesota also appears to be reaching its biofuel production limits. As the MEAP notes, Minnesota is far off track from reaching its biodiesel content mandate of 20 percent biodiesel by 2018. Presently, Minnesota can only deliver 55 percent of the biodiesel capacity to meet this mandate.

The historic reliability and robustness of American energy systems has led Americans to take energy for granted. With a few extraordinary exceptions, transportation fuel is always in abundance, and the lights come on whenever we flip the switch. In fact, our energy systems are highly complex. Simplistic mandates will stress complex energy systems—especially the electricity grid—as they scale up.

Section V: The Cost and Collateral Damage of Minnesota's Energy Policy

The little progress Minnesota has made in reducing emissions since 2005 has come at a great cost. There is of course the cost of building out wind and solar generation capacity. On top of this financial cost, the build-out of renewables also puts the stability of the electric grid at risk and removes substantial acreage of land from productive use.

A. The Difficulty of Estimating the Cost of Minnesota Renewable Energy Mandate

It is difficult to estimate with any precision the cost of Minnesota's rapid expansion into renewable electricity generation. However, make no mistake, government mandates come at a cost. There are a number of costs involved with mandating renewable energy.

- ***Stranded costs:*** Adding new renewable generation when new generation is not needed results in stranded costs related to the loss of value in retiring the existing generation before it has reached the end of its useful life.
- ***Transmission costs:*** The geographic dispersion of renewables requires substantially higher investments in transmission to connect to the people who will use it.
- ***Backup costs:*** Renewables' intermittency—the fact that they produce zero electricity when the wind does not blow or the sun does not shine—requires extra generation to always be online as a backup.
- ***Baseload cycling costs:*** Ramping this extra backup baseload generation up and down to accommodate intermittency also comes at a cost to both efficiency and wear and tear.
- ***Curtailment costs:*** When the renewables produce too much electricity at low demand times, power producers must, at times, shut them down. Under certain contracts, a utility must still pay for the power not produced.
- ***Profile costs:*** Maybe the largest cost—the profile cost—results from the fact that wind provides electricity at low demand times (the spring, the fall, and the middle of the night) when prices are very low.

Accounting for all of these factors is incredibly challenging. Adding to the challenge, Minnesota's major investor-owned utility (IOU), Xcel Energy, has little to no incentive to accurately account for the cost. As an IOU, Xcel receives a guaranteed rate of return on all approved capital expenditures. Thus, so long as spending on renewables is approved, it is guaranteed a higher return. The only thing moderating Xcel's move to renewables is the possibility of losing price sensitive industrial customers. However, many of these customers, especially in the mining industry, are outside of their service territory.

B. Building Wind Farms to Meet Minnesota's Mandate Has Cost an Estimated $10.6 Billion to Date

While it may be difficult to precisely estimate the full cost of Minnesota's renewable energy mandate, the cost to build out the wind farms currently serving the state's mandate amounts to around $10.6 billion. Every year utilities report on the renewable energy credits (RECs) they use to satisfy the state's RES. These RECs are linked to the specific renewable electricity generating facilities responsible for the credit, including both utility-owned and independently-owned facilities. Based on these reports, Minnesota utilities depend on wind farms with about 5,000 megawatts of nameplate capacity to meet the state mandate. The cost of building out these windfarms can be estimated by matching the year a windfarm is built with the capacity-weighted average cost of installing wind for that year, as reported by Berkeley Lab. Add it all up and the wind mills currently meeting Minnesota's RES cost around $10.6 billion to build.[19]

These investments are largely in addition to the regular capital investments necessary to maintain the existing system. Though Xcel Energy might issue press releases claiming renewables are "cost-effective" and at times even claim they are the lowest-cost choice, even Xcel must be forthright in legal filings before the Minnesota Public Utilities Commission (MPUC).[20] In Xcel's latest request for a rate increase they were asked to explain recent capital investments. Here is their response:

> For at least the last five-years, we have focused on investing in carbon free generation—specifically our nuclear generating units and new wind generation resources—and the transmission system needed to deliver this generation to load. These investments were ***in addition*** to the capital investments we always need to make in our distribution, transmission, and generation assets to help ensure we can safely and reliably serve our customers.[21] [Emphasis added]

Why did they make these *additional* investments in carbon-free generation? As they explain, state and federal policies required them.

> The State of Minnesota and the federal government have set forth environmental and policy goals that we are obligated to meet. We are also obligated to meet North American Electricity Reliability Corporation (NERC) system reliability standards, and we take seriously our obligations to provide quality customer service and a safe working and operating environment. These needs exist at all times.[22]

Looking through other filings for rate increases reveals that most utilities at least in part blame Minnesota's RES for the need for higher rates.[23]

C. Transmission Costs

As Xcel acknowledges in its rate increase request, a portion of its capital investment in recent years went to fund transmission upgrades needed to deliver the new load from new wind facilities. This represents a substantial and often overlooked component of the cost of mandating renewable energy. According to Xcel's most recent Renewable Energy Rate Impact Report, transmission project costs attributable to Minnesota's RES equal $1.8 billion.[24] This is no doubt a conservative estimate. Assuming a similar cost to the rest of Minnesota's utilities, installing new transmission to meet the RES costs roughly $4 billion statewide.

D. Profile Costs

Wind is a very low "value" energy source. That's because the wind blows the strongest and, therefore, produces the most electricity when demand for electricity is the lowest. This is true on both a seasonal and a daily basis. Wind blows strongest in the spring and the fall and at night when electricity usage is the lowest. As a result, wind on average sells at a lower price than other sources of electricity. The lower sale price imposes a cost, which is referred to as a "profile cost." At many times during the year, the demand for power when the wind is blowing is so low that the price of wind goes negative, meaning utilities must literally pay someone to take their wind power.

This profile cost is hard to quantify because wind production data is usually considered proprietary and nonpublic. However, one wind farm in Minnesota—the Wapsipinicon wind farm—has published this data. A review of this data confirms that the contract for this wind farm has cost the Southern Minnesota Municipal Power Agency (SMMPA) millions of dollars.[25] SMMPA contracted to buy wind at 6.2 cents per kWh in 2012 and 6.3 cents per kWh in 2013. Yet the wind on average only sold for 1.8 cents per kWh in 2012 and 2.4 cents per kWh in 2013. That resulted in a loss of $14.6 million in 2012 and $12.7 million in 2013, compared to what SMMPA could have paid buying electricity on the wholesale market.

E. **Less Grid Stability**

On top of these quantifiable costs, a basic threshold question about wind is rarely asked or answered: Can wind power guarantee reliable, on-demand electricity? Until there is a substantial breakthrough in mass electricity storage technology, the answer is going to be *No*. This is not acceptable for major metropolitan areas or any substantial commercial enterprise, especially a wireless communications or data server facility. (For example, there is not a single metals smelter anywhere in the world powered exclusively by wind or solar power.)

The increased emphasis on renewable energy sources is represented as an increase in the diversity of the generation portfolio, but the irony is that it might lead to *less* system stability and reliability, and not just because of the intermittency of wind power. The Department of Energy's recent report on grid stability warns:

> In regions with high penetration of VRE [variable renewable energy], sharper fluctuations in net load require increased flexibility (ramping up and down) from conventional sources. . . Generator profitability could become a public policy concern if so much generation is financially challenged that the reliability or resilience of the BPS [bulk power systems] becomes threatened. New market structures may be necessary to reflect these market dynamics, particularly in an industry in which suppliers with high fixed capital costs and relatively low marginal costs often struggle to recover their long-run average costs. . . Maintaining short-term reliability has grown more complex in light of higher levels of VRE. . . Simple extrapolation of previous reliability trends is not prudent.[26]

Minnesota's electricity sector is part of MISO—the Midcontinent Independent System Operator—that manages the wholesale electricity market and grid stability for all or part of 13 states stretching all the way down the Mississippi River basin to include Louisiana. (MISO is one of nine regional wholesale electricity markets in the continental U.S.) Electricity systems are required to maintain a minimum 15 percent reserve margin to allow for supply outages and surges in demand. In 2016 MISO maintained an average reserve of 18 percent; however, this was the *lowest* reserve margin of the nine regional wholesale power market systems. (By comparison, the Atlantic regional wholesale market has maintained a reserve margin between 25 and 33 percent over the last five years.) At present Minnesota obtains only a very small amount of its electricity from interstate purchases. The Department of Energy notes that regulatory mandates such as RPS standards are eroding baseload generating capacity and that the risk to grid stability could grow in the future: "Investments required for regulatory compliance have also negatively impacted baseload plant economics, and the peak in baseload plant retirements (2015) correlated with deadlines for power plant regulations as well as strong signals of future regulation. . . States and regions are accepting increased risks that could affect the future reliability and resilience of electricity delivery for consumers in their regions."[27] While Minnesota's RPS policies alone may not erode the region's overall grid resiliency, they do mean that Minnesota could become more dependent on out-of-state electricity purchases in the future.

Moreover, if the answer to the intermittency or low seasonal output of wind power is to build extra wind capacity for low output periods, the cost competitiveness of wind power will vanish.

FIGURE 14: COMPARISON OF LAND AREA AND ELECTRICITY OUTPUT OF WIND AND NUCLEAR

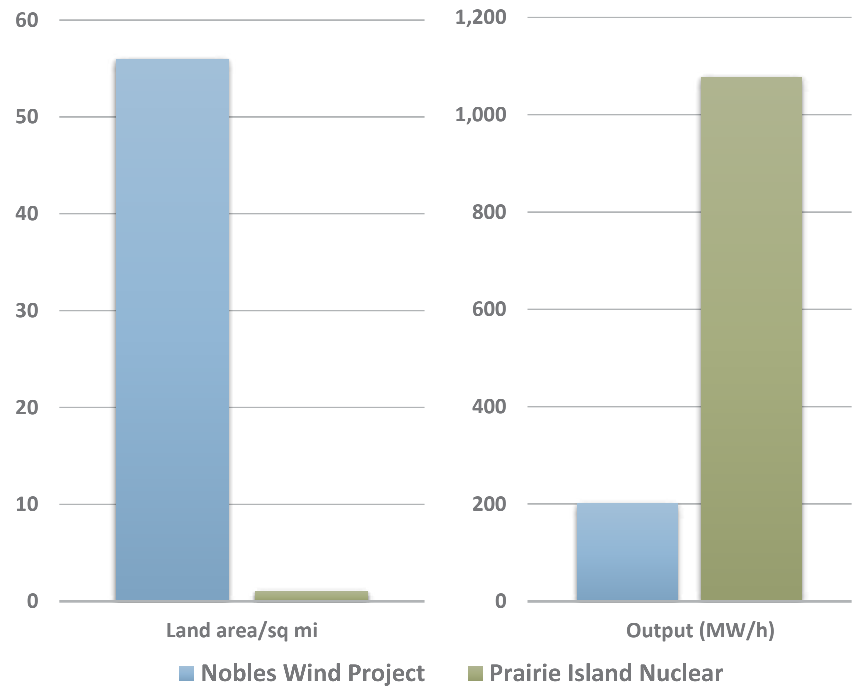
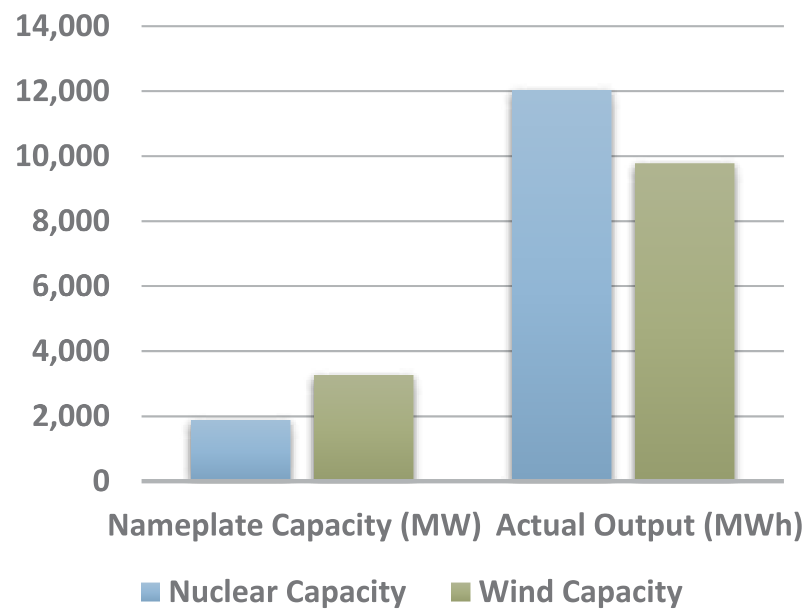


FIGURE 15: ELECTRICITY OUTPUT FROM COAL AND WIND, JANUARY 2014 TO FEBRUARY 2017 (MEGAWATTS)



F. **Resource Tradeoff**

Another source of collateral damage from Minnesota's RES is the resource tradeoffs involved in adding renewables. Traditional electricity generation plants require a much smaller land footprint than wind or solar. According to U.S. Department of Energy data for 2015, Minnesota's Prairie Island nuclear power plant produced ten times as much electricity as the largest wind power "farm" in the state, the Nobles Wind Project that straddles Nobles and Murray Counties (7,375 gigawatt hours from Prairie Island versus 741 gigawatt hours from Nobles Wind Project in 2015).[28] The land and materials footprints of these two sources of power deserve a close comparison.

The Nobles Wind Project comprises 134 separate wind turbines spread over 56 square miles, and can produce 201 MW per hour of electricity under optimal wind conditions (compared to over 1 GW per hour by Prairie Island), which is at a wind speed of about 27 mph. The Prairie Island facility has a total land footprint of 578 acres—less than one square mile.[29] (See Figure 14. The land footprint of Prairie Island is so small that it barely shows up on the scale.) A back-of-the-envelope calculation suggests that to replace Prairie Island's capacity with wind power would require a land footprint of about 300 square miles.

Figure 15 illustrates that while wind power *on paper* may be capable of producing more electricity than nuclear power (what is called "Nameplate" capacity in the electricity trade), in practice nuclear power produces more.

Section VI: A Closer Look at Minnesota's Long-Range Greenhouse Gas Emissions Reduction Goal

Although Minnesota's renewable energy targets are not explicitly linked to its greenhouse gas emissions target, it is worth taking a closer look at the long-term target to reduce greenhouse gas emissions by 80 percent from their 2005 level by the year 2050 (call it the "80 by 50" target). Minnesota's state legislature adopted this long-term target without any understanding of what it means in real terms. Specific historical greenhouse gas emissions estimates for Minnesota are not available, but a look at national historical data illustrates how fantastical the "80 by 50" target is.

In 2005, the baseline year, the United States emitted about 5.9 billion tons of CO2 and another billion tons of other greenhouse gases such as methane and nitrous oxide. But CO2, as the byproduct of fossil fuel consumption and the most abundant greenhouse gases other than water vapor, is the principal focus of policy. An 80 percent reduction in CO2 emissions in 2050 would result in total CO2 emissions of about 1.1 billion tons.

The first question is: when were U.S. CO2 emissions from fossil fuel used last at 1.1 billion tons? From Department of Energy historical statistics on energy consumption, it is possible to estimate that the United States last emitted 1.1 billion tons in the year 1910, when the nation's population was only 92 million people, per-capita income (in 2015 dollars) was only $6,500, and total GDP (in 2015 dollars) was about $625 billion—about one-twenty-fifth the size of the U.S. economy today.

By the year 2050, however, the United States is expected to have a population of 420 million, according to Census Bureau projections—more than four times the population of 1910. In order to reach the 80 percent reduction target, per-capita CO2 emissions will have to be no more than 2.4 tons per person—only one-quarter the level of per-capita emissions in 1910.

This suggests a second question: When did the United States last experience per-capita CO2 emissions of only 2.4 tons? From the limited historical data available, it appears that this was about 1875. At that time, 142 years ago, the nation's GDP (in 2015 dollars) was $147 billion, per-capita income (in 2015 dollars) was $3,400, and the population was only 45 million. (It is possible that per-capita CO2 emissions were never this low even before the advent of widespread fossil fuel use, as wood burning by Americans in the nineteenth century may have produced more than 2.4 tons of CO2 per capita.)

To understand how extreme an 80 percent reduction in CO2 emissions for the United States in the year 2050 is, consider the following: Are there any modern industrialized nations whose CO2 emissions come close to the putative target for 2050? The advanced industrialized nations with the lowest current per-capita CO2 emissions are France and Switzerland. France famously generates about 80 percent of its electricity with nuclear power, which is carbon-free, while Switzerland generates most of its electricity with nuclear and hydropower, which are also carbon-free. Both nations are also compact compared to the United States, with much lower energy needs for transportation. Yet France's per-capita CO2 emissions are 6.5 tons, and Switzerland's are 6.1 tons—both more than twice the per-capita level the United States must achieve to reach the 80 percent

FIGURE 16: MINNESOTA CO2 EMISSIONS FROM FOSSIL FUELS, 1980-2014

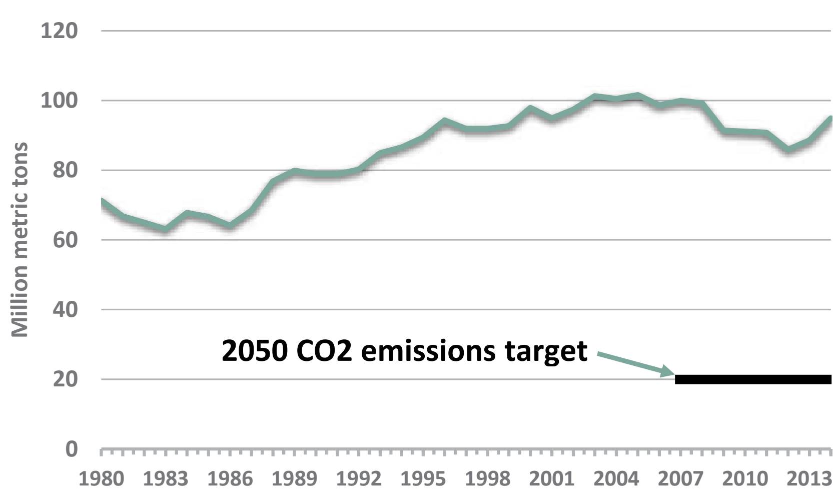
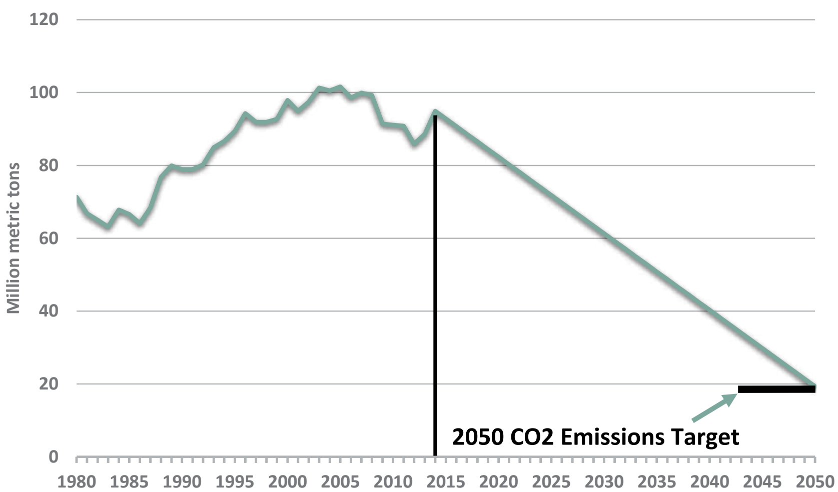


FIGURE 17: NECESSARY CO2 EMISSIONS PATHWAY TO ACHIEVE 2050 TARGET



reduction target.

While historical data for greenhouse gas emissions in Minnesota are not available, we can analyze what the target means in practical terms. Total fossil fuel emissions of CO2 in Minnesota in 2005 were 101 million tons. An 80 percent reduction would require reducing emissions to about 20 million tons in 2050. The target, and Minnesota's greenhouse gas emissions history since 1980, is shown in Figure 16. The emissions reduction pathway necessary to reach the 80 by 50 target in 2050 is shown in Figure 17.

It might appear from the reduction achieved between 2005 and 2014 that this trajectory is plausible, though the reversal of the trend in 2014 and 2015 might suggest that Minnesota has merely achieved the easier reductions. It is more sobering to consider the magnitude of this target by putting it in per capita terms. At the present time Minnesota CO2 emissions are about 17 metric tons per person. Minnesota's current 5.5 million population is expected to grow slowly (and age considerably) to about 6.8 million people in 2050. To achieve the 80 by 50 target, Minnesota's per capita CO2 emissions would need to fall to about 3 metric tons per person—a level, as previously noted, only seen today in very poor developing nations whose absolute energy poverty is the most distinctive factor in their low emissions. Even the total elimination of all coal-fired electricity in Minnesota would only reach about two-fifths of the distance to the 80 by 50 target. Reaching it would require deep reductions of 60 percent or more in consumption of gasoline and natural gas for home use.

The 80 by 50 target has been climate change policy orthodoxy for more than a decade, thoughtlessly adopted in many jurisdictions in the U.S. and around the world. Yet *no U.S. state or country in the world is presently achieving the necessary rate of decarbonization of its energy supply to reach the 80 by 50 target.* At the time this target was adopted a decade ago the International Energy Agency in Paris observed:

> It is uncertain whether the scale of the transformation envisaged is even technically achievable, as the scenario assumes broad deployment of technologies that have not yet been proven. The technology shift, if achievable, would certainly be unprecedented in scale and speed of deployment.[30]

After an outcry from climate change activists, the International Energy Agency (IEA) scrubbed this statement and removed the *2008 World Energy Outlook* where it appeared from their website—a fine example of the politicization of energy policy. There is no reason to conclude, ten years later, that the IEA's judgment is not still correct.

Every independent energy forecasting agency, from the EIA in the U.S. Department of Energy to the IEA in Paris, along with private sector forecasters such as IHS Energy, BP, and Wood Mackenzie, projects that fossil fuels will be the dominant energy source for the world in 2050 and beyond. Indeed, all of the exertions on behalf of renewable energy for the last generation have produced the following change: according to the most recent BP Statistical Review of World Energy, in 1990, 88 percent of the world's total energy came from fossil fuels; in 2015, 86 percent of the world's energy came from fossil fuels.[31]

This is not going to change very much in the future.

The IEA's latest global energy forecast projects that wind and solar power will provide only 2.9 percent of the world's energy by 2040.[32] NASA's former chief climate scientist James Hansen agrees: "Suggesting that renewables will let us phase rapidly off fossil fuels in the U.S., China, India, or the world as a whole is almost the equivalent of believing in the Easter Bunny and Tooth Fairy." In this respect, Minnesota's renewable-heavy energy policy can be regarded more as a vanity project than a serious policy to advance innovation or an energy transition.

Conclusion

Legislation passed in 2017 reveals the Minnesota legislature understands the problem rising electricity prices pose to the state. Until this year, state energy goals largely ignored the cost involved in achieving them. But the Minnesota legislature recently enshrined one more energy goal into state statute that directs utilities to aim for electricity rates to "be at least five percent below the national average."[33] What this means is that the MPUC must now balance the cost of achieving the state's various green energy goals with the cost.[34]

This report shows how Minnesota fails to come close to meeting near-term greenhouse gas emission reduction goals and how hopelessly unattainable it is to reach the longer-term goals. Considering these future goals are unattainable without great cost and hardship, the new goal to keep Minnesota electricity prices lower than the national average might appear to be in direct conflict.

Though a conflict may now exist among the goals, this rivalry will hopefully lead to a more measured and effective approach to reducing greenhouse gas emissions. Instead of rubberstamping a renewable energy project just because it might advance Minnesota's green energy goals, moving forward the MPUC should now take greater care in evaluating alternatives and whether the project undermines competitive electricity rates.

The change is welcome, but will it be enough? Minnesota electricity rates are now higher than the nation's, but substantial investments in new wind and solar have already been approved by the MPUC, despite no increase in demand. Getting back to a proper balance will almost certainly require further updates to state law. ●

Endnotes

1 For a detailed history and critique of the dysfunction of U.S. energy policy from the 1950s to the present, see Peter Z. Grossman, *U.S. Energy Policy and the Pursuit of Failure* (New York: Cambridge University Press, 2013).

2 The chief finding of the Energy Policy and Conservation Act of 1975 (EPCA) was that "the fundamental reality is that this nation has entered a new era in which energy resources previously abundant will remain in short supply, retarding our economic growth and necessitating an alteration in our life's habits and expectations."

3 Quotes from Sheldon Novick, *The Electric War: The Fight Over Nuclear Power* (Sierra Club Books, 1976), cited by Michael Shellenberger, Address to the American Nuclear Society, June 12, 2017, available at http://www.environmentalprogress.org/big-news/2017/6/12/atomic-humanism-as-radical-innovation-2017-keynote-address-to-the-american-nuclear-society.

4 Minnesota Department of Commerce, "Minnesota's 2025 Energy Action Plan," available at https://mn.gov/commerce/policy-data-reports/energy-data-reports/mn-action-plan.jsp.

5 "Minnesota's 2025 Energy Action Plan," Figure ES1, p. 8.

6 Galen Barbose, *U.S. Renewables Portfolio Standards: 2016 Annual Status Report* (Lawrence Berkeley National Laboratory, April 2016), available at https://emp.lbl.gov/sites/all/files/lbnl-1005057.pdf.

7 "Minnesota's 2025 Energy Action Plan," p. 24.

9 U.S. Department of Energy, *Staff Report on Electricity Markets and Reliability* [SREMR], (August 2017), p. 114, available at https://energy.gov/downloads/download-staff-report-secretary-electricity-markets-and-reliability.

10 Lawrence Makovich (IHS Markit), "State Policies and Wholesale Markets Operated by ISO New England Inc., New York Independent System Operator, Inc., and PJM Interconnection, L.L.C." (written statement submitted to the Federal Energy Regulatory Commission, Technical Conference, May 1–2, 2017).

11 Xcel Energy, Minnesota Electric Utility Information Reporting - Forecast Section, (2016), available at https://mn.gov/commerce/industries/energy/utilities/annual-reporting/.

15 Minnesota Pollution Control Agency and Minnesota Department of Commerce, *Greenhouse Gas Emissions: 1990-2014* (January 2017), available at https://www.pca.state.mn.us/sites/default/files/lraq-2sy17.pdf.

16 U.S. Energy Information Administration, *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2017*, (April 2017): p. 2, available at https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf.

17 *See, e.g.,* Charles R. Frank, Jr., "The Net Benefits of Low and No-Carbon Electricity Technologies," Brookings Institute Global Economy & Development Working Paper 73 (May 2014) ("Assuming that reductions in carbon dioxide emissions are valued at $50 per

metric ton and the price of natural gas is not much greater than $16 per million Btu, the net benefits of new nuclear, hydro, and natural gas combined cycle plants far outweigh the net benefits of new wind or solar plants. Wind and solar power are very costly from a social perspective because of their very high capacity cost, their very low capacity factors, and their lack of reliability.")

18 *See, e.g.,* "Water Implications of Biofuels Production in the United States," National Research Council, National Academies Press, 2008, https://www.nap.edu/catalog/12039/water-implications-of-biofuels-production-in-the-united-states. Among other findings: "If projected future increases in the use of corn for ethanol production do occur, the increase in harm to water quality could be considerable."

19 This calculation is based on the wind farms identified in Minnesota electric utility Reneable Energy Certificate Retirement Reports issued for the 2012 to 2016 reporting periods; M-RETS data on wind farm commencement dates; and annual estimates of construction costs from Berkeley Lab for the U.S. Department of Energy. *Renewable Energy Certificate Retirement Report for Renewable Energy Standards and Green Pricing Programs*, MPUC Docket No. E999/Pr-17-12 (Reporting periods 2012 to 2016); Midwest Renewable Energy Tracking System, *M-RETS Generators* at https://portal2.m-rets.com/myModule/rpt/myrpt.aspx?r=111; and Berkeley Lab, Wind Technologies Market Report, 2016 WTMR Data File, "Figure 41. Installed wind power project costs over time" (August 2017).

20 Xcel Energy, Press Release, "Xcel Energy Announces the Nation's Largest Multi-State Investment in Wind Energy," March 3, 2017, available at http://investors.xcelenergy.com/file/Index?KeyFile=38629529; and Xcel Energy, Press Release, "Xcel Energy achieves wind energy milestone," March 19, 2013, available at https://www.xcelenergy.com/company/media_room/news_releases/xcel_energy_achieves_wind_energy_milestone. *See also*, Peter Nelson, "Why Won't Xcel Come Clean on Cost of "Clean" Energy?", AmericanExperiment.org, October 20, 2016, at https://www.americanexperiment.org/2016/10/wont-xcel-come-clean-cost-clean-energy/

21 Aakash H. Chandarana, "In the Matter of the Application of Northern States Power Company for Authority to Increase Rates for Electric Service in Minnesota," Direct Testimony and Schedules, MPUC Docket No. E002/GR-15-826, November 2, 2015.

22 Id.

23 *See e.g.*, David J. McMillan, Direct Testimony and Schedule, *In the Matter of the Application of Minnesota Power for Authority to Increase Rates for Electric Utility Service in Minnesota*, MPUC Docket No. E015/GR-16-664, November 2, 2016, p. 18; Aakash H. Chandarana, Direct Testimony and Schedules, *In the Matter of the Application of Northern States Power Company for Authority to Increase Rates for Electric Service in Minnesota*, MPUC Docket No. E002/GR-15-826, November 2, 2015, p. 39; David M. Sparby, Direct Testimony and Schedules, *In the Matter of the Application of Northern States Power Company for Authority to Increase Rates for Electric Service in Minnesota*, MPUC Docket No. E002/GR-13-868, November 4, 2013, p. 18; Ian R. Benson, "Transmission Operation & Maintenance Expense and Investments," Direct Testimony and Schedules, *In the Matter of the Application of Northern States Power Company, a Minnesota corporation for Authority to Increase Rates for Electric Service in Minnesota*, MPUC Docket No. E002/GR-10-971, November 3, 2010, pp. 2, 9; Thomas L. Aller, Direct Testimony, *In the Matter of Application of Interstate Power and Light Company for Authority to Increase Rates for Electric Service in Minnesota*, MPUC Docket No. E001/GR-10-276, May 7, 2010, p. 13; David J. McMillan, *In the Matter of the Application of Minnesota Power for Authority to Increase Electric Service Rates in Minnesota*, Docket No. E015/GR-09-1151, November 2, 2009, pp. 7-8; and Jeffrey C. Robinson, "Overall Revenue Requirement Rate Base Income Statement," Direct Testimony and Schedules, *In the Matter of the Application of Northern States Power Company d/b/a Xcel Energy for Authority to Increase Rates for Electric Utility Service in Minnesota*, Docket No. E002/GR-05-1428, November 2, 2005, pg. 13-14.

24 Xcel Energy, "Renewable Energy Standard (RES) Rate Impact Report," January 2015, available at https://www.xcelenergy.com/staticfiles/xe/PDF/Regulatory/09-App-F-NSP-RES-Rate-Impact-Report-January-2015.pdf.

25 Tyler McNeal, "Profile Costs as a Component of Integration Costs in Wind Energy," *Comparative Advantage* (Spring 2016), available at https://economics.stanford.edu/sites/default/files/comparative-advantage-2016.pdf.

26 SREMR, pp. 61, 63, 82, 118.

27 Id., p. 14.

28 U.S. Energy Information Administration, *Minnesota Electricity Profile 2015*, Table 2B, January 17, 2017, available at https://www.eia.gov/electricity/state/minnesota/index.php.

29 Prairie Island Environmental Impact Statement, Nuclear Regulatory Commission, pp. 2-24, available at https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/supplement39/sr1437s39.pdf.

30 International Energy Agency, *World Energy Outlook 2008*, p. 48, available at http://www.worldenergyoutlook.org/media/weowebsite/2008-1994/weo2008.pdf.

31 *BP Statistical Review of World Energy* (June 2017), at http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html. *See also* Barry Saxifrage, "These 'missing charts' may change the way you think about fossil fuel addiction," *National Observer*, July 13, 2017, available at http://www.nationalobserver.com/2017/07/13/analysis/these-missing-charts-may-change-way-you-think-about-fossil-fuel-addiction.

32 International Energy Agency, *World Energy Outlook 2016*, available at http://www.iea.org/Textbase/npsum/WEO2016SUM.pdf.

33 Minn. Stat. § 216C.05.

34 Long before the state established its present green energy goals, state law directed the MPUC "to provide the retail consumers of natural gas and electric service in this state with adequate and reliable services at reasonable rates." Minn. Stat. § 216B.01. That language promoting reasonable rates still exists in state statute, but has been largely ignored and replaced by the more specific green energy goals added over the years.

CENTER OF THE
AMERICAN
EXPERIMENT

Minnesota's Think Tank

8421 Wayzata Boulevard ★ Suite 110
Golden Valley, MN 55426

AmericanExperiment.org

NON-PROFIT ORG
U.S. POSTAGE
PAID
TWIN CITIES, MN
PERMIT NO. 4546

To obtain copies of American Experiment's recent reports—Mitch Pearlstein's "Specifically, What Must We Do to Repair Our Culture of Massive Family Fragmentation?", Peter Nelson's "Minnesotans on the Move to Lower Tax States 2016," and Dr. Joseph Kennedy's "Minnesota's Economy: Mediocre Performance Threatens the State's Future," or to subscribe to the Center's free quarterly magazine, *Thinking Minnesota*, email Peter Zeller at Peter.Zeller@AmericanExperiment.org, or call (612) 338-3605.