An Alternative Energy Model for Minneapolis

Building a cleaner grid at a comparable cost

VERSION 1.0

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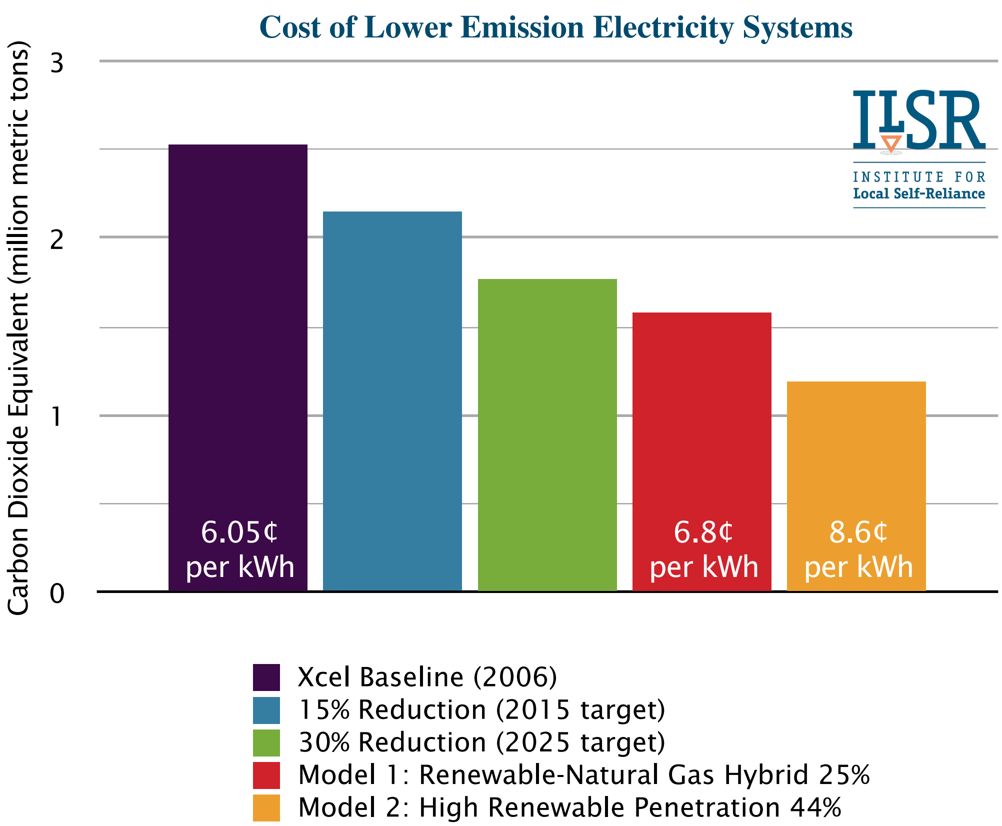
Executive Summary

An advanced technical and economic model of the electric grid in Minneapolis shows that the electric consumers in the city could receive cleaner energy that would substantially reduce greenhouse gas emissions (and increase renewable energy) at a comparable cost to existing electricity service.

The conservative model, not accounting for opportunities to buy and sell power with the larger electrical grid, suggests that the City of Minneapolis and its electric utility have substantial opportunities to meet and exceed the Minneapolis Climate Action Plan with changes in the electricity supply used to meet the needs of consumers citywide.



Acknowledgments

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Table of Contents

Why Model?

Over the next decade in Minneapolis we face a critical decision about how we will confront the risks posed by climate change while promoting security and well being. In 2013, the city of Minneapolis commissioned its Climate Action Plan. The city has set a goal of a 15% reduction of its greenhouse gas emissions by 2015 and a 30% reduction by 2025. In addition to its overall goal the city has set out specific goals of a 17% reduction in energy use and doubling the amount of local renewables by 2025.

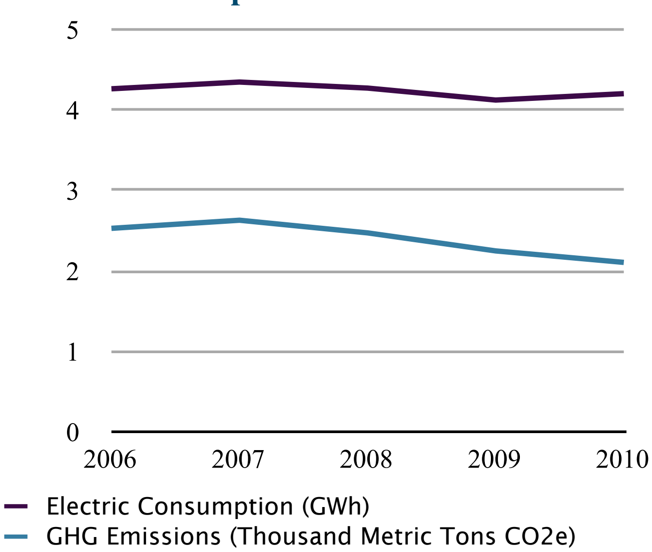
Since electricity use represents a primary driver of emissions, if the city is going to meet its overall greenhouse gas reduction goals it likely needs to meet or exceed the reduction targets in the electricity sector.

These two alternative energy models identify two technically sound and economically affordable ways to substantially reduce greenhouse gas emissions and provide opportunity for community development through local renewable generation. They represent conservative alternatives to the power supply options offered by the city's incumbent utility, Xcel Energy.

Background

Every 20 years, the City of Minneapolis has renewed a "franchise" contract with Xcel Energy, explaining how the utility will respect and use public property to deliver energy services. In anticipation of the 2014 renewal of this contract, the city began exploring the limits of its authority to control its energy future – inspired by the groundswell of public support from the Minneapolis Energy Options campaign. In addition to contemplating forming a city-owned electric and gas utility, the city commissioned the Energy Pathway Study. Completed in 2014, the study highlights the legal power and options the city may exercise to meet its electricity based emission goals.

Fig 1. Minneapolis Electricity Consumption and GHG Emissions



These technical and economic energy models complement the city's analysis of the environmental impact and its legal authority over its energy system.[1]

Assumptions

This model uses 2013 dollars, and supposes that the city build its own electric generating capacity that operates independently of the larger electrical grid. It assumes that the city begins the process of permitting and building these electrical plants within the next year or two.

The model is also isolated from the rest of the electrical grid, showing how the combination of natural gas and renewable generation selected is adequate to match the cities hour-by-hour load throughout the entire year, without resorting to power exports or imports.

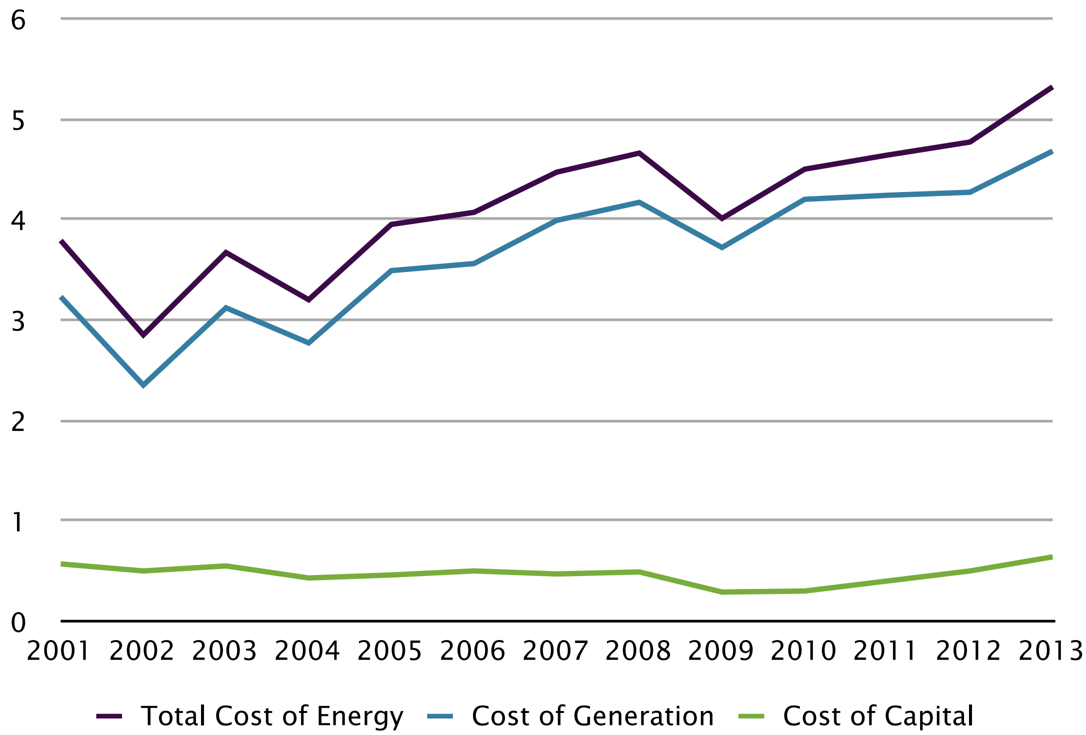
Finally, the model assumes that all the wind and solar power is built in the same place, maximizing fluctuations in power output due to variable wind and sun.

This model is much more conservative than a real-world city-owned utility scenario. All actual distribution utilities use the greater electric grid to balance short-term supply and demand and to purchase at least some power from a wholesale provider such as a municipal power agency, generation and transmission cooperative, Xcel Energy or on the open wholesale market. Additionally, the a city-run energy system would acquire its wind and solar power from a variety of geographic locations within and outside of the city boundaries, resulting in much lower variability[2] and reduced demand for natural gas generation.

Baseline Metrics

Xcel Energy serves the City of Minneapolis as part of its integrated Northern States Power system. In order to make a valid comparison between energy costs associated with existing services and our model it is important to have some baseline metrics. As the city looks towards a more sustainable energy future it must consider both the long term price of electricity and as well as the associated emissions.

Fig. 2 The Cost Xcel Energy Incurs to Generate Electricity (¢/kWh)



Cost of Generation reflects the cost of operations, ongoing maintenance and fuel. Cost of Capital is the amortized cost of building power plants.

Costs

Our baseline cost calculations are derived from a number of sources including Xcel Energy's Integrated Resource Plan and FERC-1 regulatory filing, the Minneapolis Energy Pathways Study and Climate Action Plan. It is important for comparison that we only account for the costs related to the production of electricity and exclude any costs related to transmission, distribution, billing or any other expenses Xcel incurs. We determined two methods for isolating the relevant production costs: one based on Northern States Power Minnesota's FERC-1 regulatory filing,[3] and another based on an Xcel billing insert explaining what percentage of your bill is attributable to production, transmission and distribution.[4] Both estimates represent the "levelized cost of energy," which is the total cost of a power plant divided by its expected lifetime energy production.[5]

Greenhouse Gas Emissions

Our baseline greenhouse gas emissions are from the City of Minneapolis' Climate Action Plan, which uses the calendar year 2006. We elected to compare our model's emissions to the Climate action baseline as well as a 15% and 30% reduction in greenhouse gas emissions that represent the city's overall target in 2015 and 2025 respectively.

These estimates represent the average cost of energy for Xcel Energy generated on behalf of its Minneapolis customers as well as the city's annual carbon dioxide emissions attributable to their electricity consumption. By comparing these values to our model's output we are able to show the impact a shift in electric generation supply would have in terms of electricity price and greenhouse gas emissions.

Modeling with Homer Energy

Could the City of Minneapolis effectively use renewable resources to provide clean and reliable energy at a comparable cost?

In order to answer this question we turned to Homer Energy, a microgrid[6] modeling software first developed by the National Renewable Energy Laboratory. Given a set of different electric generator types and sizes to choose from, Homer will test each possible combination to see if it is capable of meeting demand and reserve requirements. Homer has the ability to match generation with load in order to select the cheapest available energy, in a process called economic dispatch.

In general, we modeled a grid with the maximum amount of cost-effective wind and solar energy paired with natural gas power plants that could ramp production up and down to accommodate shifts in the wind and sun.

By modeling with Homer we are able to show that our mix of variable renewables and dispatchable natural gas plants are capable of meeting electricity demand every hour throughout the year, and determine the associated levelized cost of energy.

Alternative Energy Scenarios

Renewable-Natural Gas Hybrid: 25% Renewable

This system is a natural gas, wind, solar and hydro system. This system shows that the city could drastically reduce its carbon dioxide emissions simply by eliminating coal from its resource mix.

Most of the renewable energy in this scenario comes from wind, with a small fraction from solar and hydro power. The remaining power is from two types of natural gas power plants: gas combustion turbine and combined cycle gas turbine.[7]

The modeled cost of energy from this system is 6.8¢ per kilowatt-hour (kWh), compared to the estimated current cost of 5.3¢ to 6.8¢ per kWh.

High Penetration Renewable: 44% Renewable

In the High Penetration scenario, we double the energy production from wind turbines and solar panels. The additional wind power in this scenario offsets a significant amount of the production from the natural gas plant.

However, due to fluctuations in wind power output, Homer requires building the same amount of natural gas capacity as in our first model in order to maintain adequate reserve margins. As such, this system has the same four natural gas power plants as the Renewable-Natural Gas Hybrid system. Due to this fact, the costs of energy for the system is substantially higher at 8.6¢ per kWh.

Fig. 3 Electricity Production by Generator Type

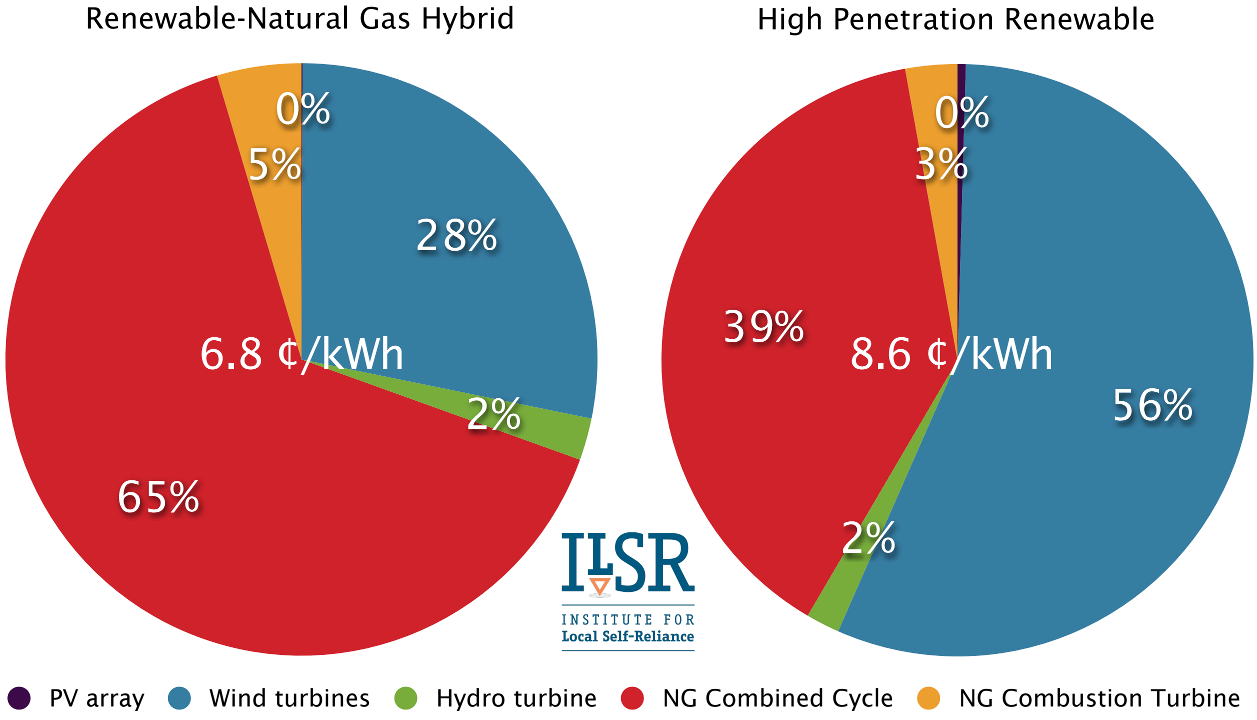
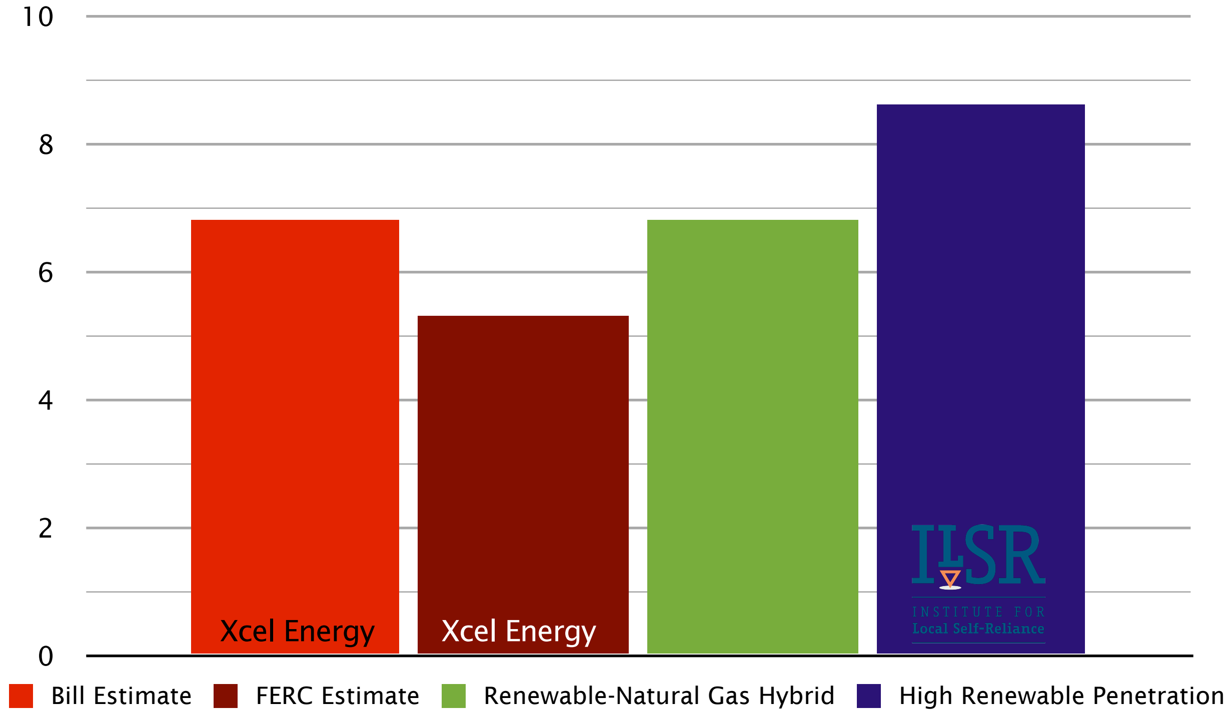


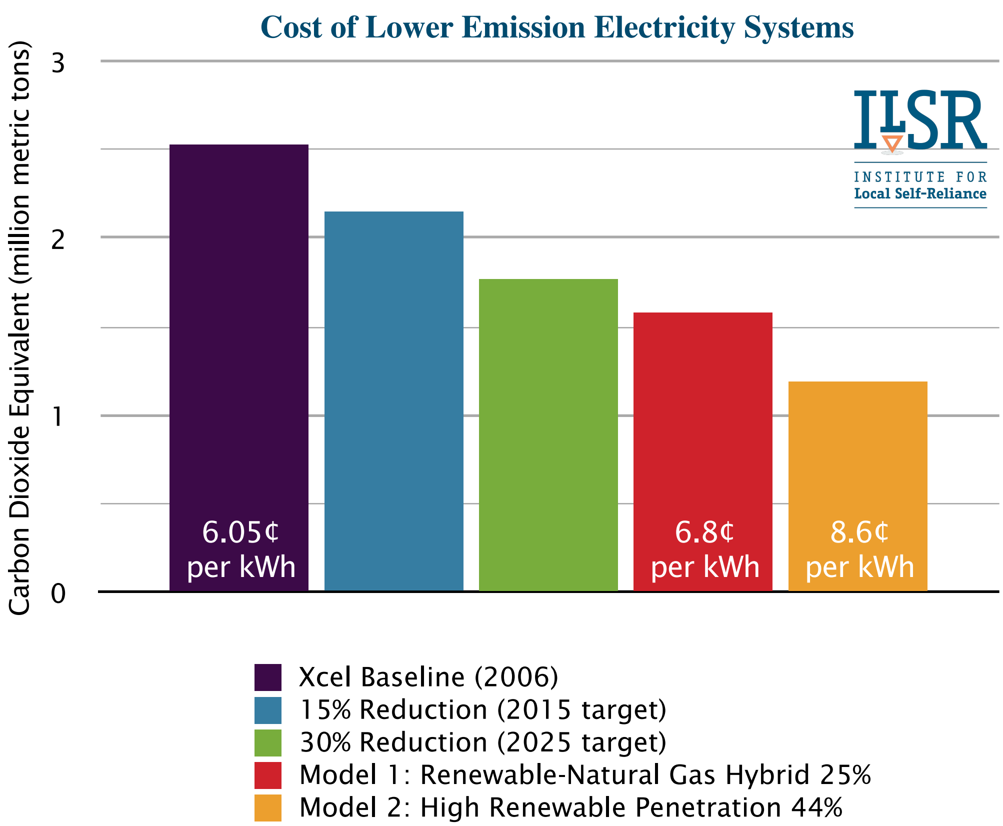
Fig. 4 Comparing Cost of Energy for Existing and Alternative Energy Systems (¢/kWh)



Comparison

ILSR's alternative Minneapolis energy model shows that the city can achieve an energy system that is completely coal and nuclear free, with significantly lower greenhouse gas emissions, and at a comparable cost to existing electricity service.

The Natural Gas-Renewable Hybrid system includes 25% of electrical production from renewable sources and reduces the cities carbon dioxide emissions from electricity by over half. The High renewable scenario goes further, expanding the renewable production to almost fifty percent of electrical demand and reducing carbon dioxide emissions to below fifty percent of the City of Minneapolis' Baseline.



Conclusion

The ILSR energy model shows that given the power to choose its own electricity supply, the City of Minneapolis can obtain substantially cleaner electricity at a comparable cost. This can be achieved using a ready deployable and pre-existing mix of renewable and natural gas generators.

The barriers are not are not technological, but rather are political in nature. Xcel Energy's current fleet of coal and nuclear generators are in large part already paid for and are highly profitable, so Xcel has an economic incentive to keep them running at full capacity. As shown in the Energy Pathways study municipalization of the electrical system comes with risks and includes additional costs: startup costs of purchasing and separating the distribution system from Xcel, paying Xcel for lost revenue, and costs of borrowing.[8]

However, developing renewable capacity enables the city to stem the long term risks posed by rising fossil fuel costs. Additionally, the ability to control investments in its electrical system provides a potent vehicle for local economic growth as the city develops and contracts for renewable energy in and around Minneapolis.

As Minneapolis plans for the future it is important that it considers all options in a fiscally and socially prudent way to ensure it has an electricity system that best meets its citizens' needs.

Model Inputs

Fig A.1 Power Plant Costs

	Capital ($/kW)	Replacement ($/kW)	O&M ($/kW)	Lifetime	Source
PV	3,500	2,000	29/yr	25 yr	Institute for Local Self-Reliance
Wind	1,940	970	36/yr	25 yr	2013 Wind Technologies Market Report, Lawrence Berkeley National Lab. p. 51
Hydro	2,972	-	90/yr	30 yrs	OpenEI Database
1x1 Combined Cycle	1,181	886	0.002/hr	146,000 hr	PSCoC 211 Electric Resource Plan Vol 2. p. 2-221
Combustion Turbine	655	491	0.004/hr	31,536 hr	PSCoC 211 Electric Resource Plan Vol 2. p. 2-221

Fig A.2 Fuel Natural Gas Characteristics and Emissions

Fuel Characteristics	EPA A-42 Value	Homer Entry
Energy Content	1020 Btu/scf	51 MJ/kg (Lower Heating Value)
Density	.041 lbs/scf	.66 kg/m3
Carbon Content by Mass	75%	75%
Sulfur Content by Mass	-	0.0085%
Emissions	**(lb/Million Btu)**	**(g/m^3)**
Carbon Monoxide	0.015	1.29
Unburned Hydrocarbons	0.009	0.135
Particulate Matter	0.007	0.104
% Fuel sulfur converted to PM	0%	0%
Nitrogen Oxides	0.099	1.55

AP 42, Fifth Edition, Volume I, Chapter 3: Stationary Internal Combustion Sources, Section 1: Stationary Gas Turbines p. 10-11.

Fig A.3 Other Inputs

Input	Value	Source	Notes
Energy Demand	-	Rochester Public Utilities	Scaled to Minneapolis by population
		Renewable Energy Resources	
Solar	Minneapolis, MN	Typical Meteorological Year Version 2, National Renewable Energy Laboratory	
Wind	American Foothills.wnd	Wind Resource Files, Homer Energy	Scaled average wind speed corrected to 7 m/s
Hydro	-	EIA-860 2012, U.S. Energy Information Administration.	Monthly average flow rate calculated so hydroelectric generator output matches the total monthly output of the Hennepin Island and Lower Saint Anthony Falls generating stations
		Fuel: Natural Gas	
Price	.16 $/m^3	U.S. Natural Gas Electric Power Price, U.S. Energy Information Administration.	
		Economics	
Interest Rate	6%	Minneapolis Energy Pathways Study, Minnesota Center for Energy and Environment	Average Interest Rate Considered

Notes and References

[1] In appendix G of the Pathways Study, the cost of municipalization is broken into twelve cost components. In our model, we focus on the Power Supply cost component.

[2] Farrell, John. Solving Solar's Variability with More Solar. (Institute for Local Self-Reliance, 2/17/11). Accessed 8/11/14 at http://bit.ly/VfZ5wS.

Farrell, John. Solving Wind's Variability with More (Dispersed) Wind. (Institute for Local Self-Reliance, 6/3/11). Accessed 8/11/14 at http://bit.ly/VfZ9fU.

[3] The FERC estimate of $0.053 per kWh was derived from NSP-Minnesota's FERC-1 regulatory filing by taking the Cost of Electric Operation including Operations & Maintenance, as well as, the Amortized Plant Capital costs and dividing by the total Energy Generated and net energy Purchased by NSP-Minnesota

[4] The Bill based estimate of $0.068 per kWh was obtained by taking the total Residential Electric Revenues, multiplying it by the Percent of Average Residential Bill that goes towards Electric Generation as stated on Xcel Energy's bill insert and dividing the product by the amount of Energy sold to residential costumers (MWh).

[5] Since the service lifetime, capital and operational costs of generation technologies vary, it is necessary to accurately distribute costs to energy production. Levelized Cost of Energy is a calculation that distributes the capital costs of a electric generator across the entire lifetime of energy production. The capital cost is then added to the ongoing cost of operations and fuel to give a cost per unit of energy (typically kWh). In this way we can compare the costs of a natural gas combustion turbine, which has lower upfront capital but high fuel costs, to technologies like Solar PV, which has high upfront costs but requires little maintenance and zero fuel costs.

[6] A microgrid is an subset of the larger electrical grid that includes both generators and load, and has the ability to "island", meaning it can operate independently of the greater grid.

[7] Combustion turbines are similar to a jet engine. The natural gas fuel and compressed air are injected into the turbine and ignited. The resulting expansion drives the turbine which is connected to the generator shaft. Combustion turbines are typically around 30% efficient. Combined cycle gas turbine use two stages of energy extraction to improve efficiency. The first stage is a combustion turbine, which operates just like a stand alone combustion turbine power plant only the heat from the exhaust is used to generate steam, which is run through a steam turbine creating electricity out of what would otherwise have been waste. The increased output allows the combine cycle gas turbine to reach over 50% efficiency.

[8] The city's Energy Pathways Study also offers community choice aggregation as a potential lower risk and lower cost strategy than municipalization. However, this would require a change to Minnesota state law.