Hydropower Vision

Senior Design Team May 15-08

Clients: Department of Energy

National Renewable Energy Lab.

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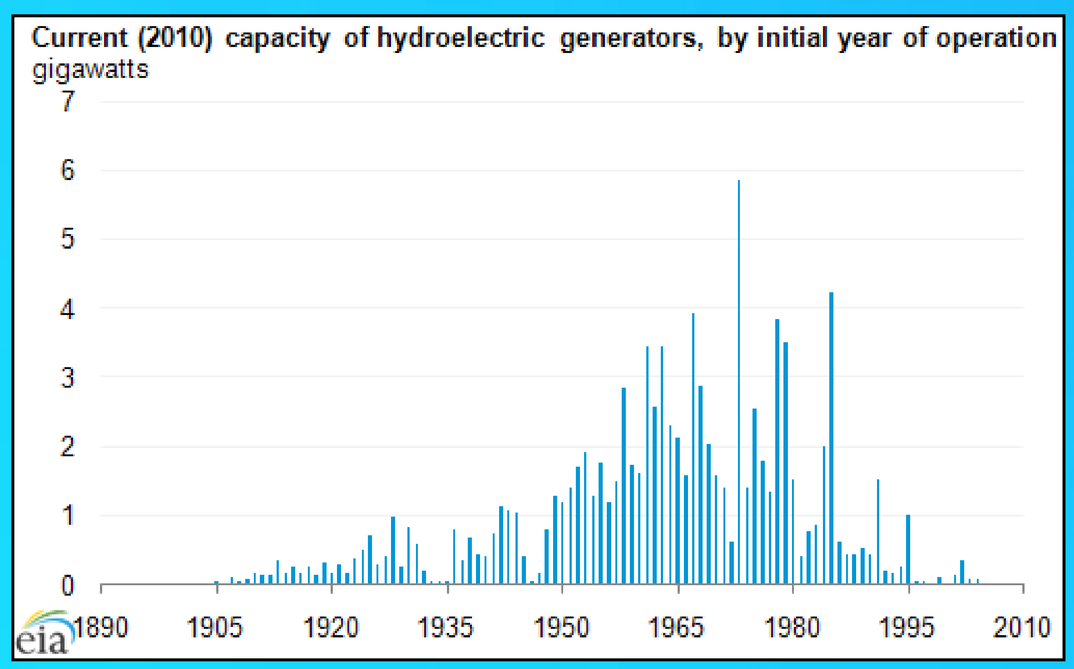
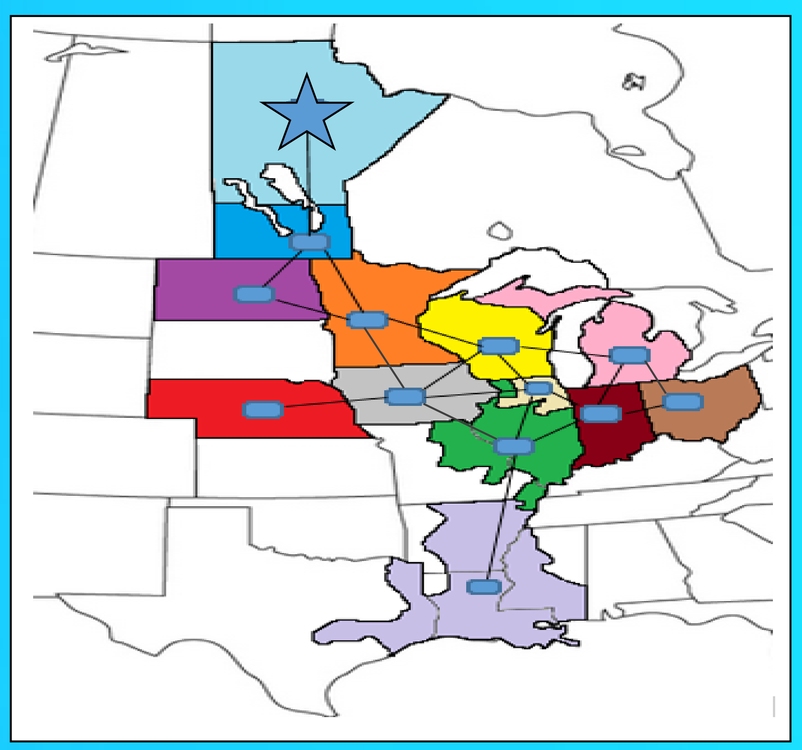
Introduction

With the rising demand for electricity, there is an ever increasing need to reduce greenhouse gas emissions and improve the overall quality of our electric grid. Many of the resources that we are currently using are either non-renewable (e.g. fossil fuels) or cannot consistently guarantee generation (e.g. wind and solar); however, hydropower is renewable, consistent, and allows for greater manipulation of output compared to other renewable generation sources. As seen by Figure 1, hydroelectric power has also not seen large growth in North America in the past few decades, leading to a large untapped potential.

Our objective is to coordinate with the US Department of Energy and the National Renewable Energy Laboratory to help develop a long-term "Hydropower Vision". The goal of this vision is to establish an analytic basis for responsible growth in hydropower, and continue as a major source in the renewable energy market





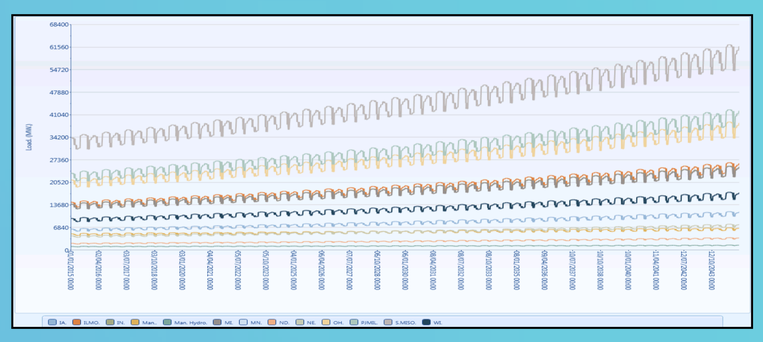
Region Identification

Manitoba, Canada

- Potential to add 8785MW of hydro capacity ✓
- 2230MW currently planned over next 15 years ✓
- Current export capacity of 1850 MW with potential for more ✓
- Low environmental impacts ✓
- 98% of generation from Hydro ✓
- Approved construction of a 500kV transmission line between Manitoba and Minnesota ✓
- Located far from large population centers ✓

Base Model

- 30 year & 13 node model of MISO region
- Load increase of 2% in the U.S
- Load increase of 1% in Manitoba, Canada
- Manually input 10950 loads per nodes with seasonal variance (Highest in summer)



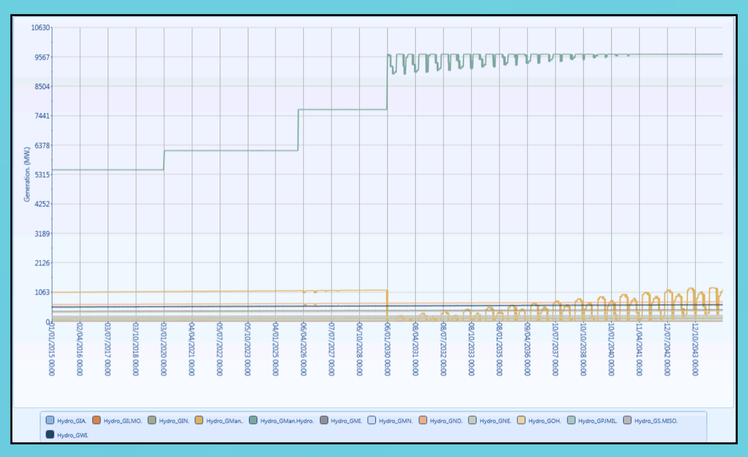
- Generation capacities changed as shown below:

Generation:	2016	2017	2018	2019	2020	2021-2045
Coal	-4.8%	-9.2%	-.8%	-.8%	-.8%	-.8%
Natural Gas	+2%	+2%	+2%	+2%	+2%	+2%
Wind	+.5%	+.5%	+.5%	+.5%	+.5%	+.5%
Nuclear	+.6%	+1.9%	-.9%	-1.1%	-1.7%	+.2%

Note: Added 2000MW of planed Hydro in northern Manitoba

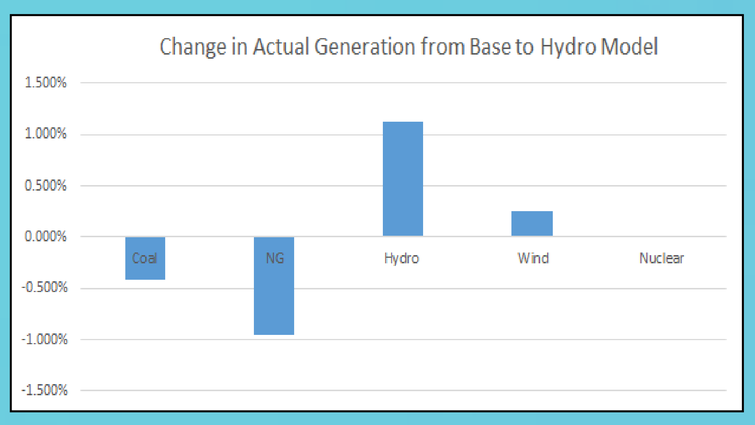
Hydro Expansion Model

- Coal generation capacity dropped from -.8% to -2% a year
- Wind generation capacity is the same as in the Wind Expansion model
- Increased line capacity by 1000MW between Manitoba and Minnesota
- . Added in an additional 2000MW of hydro in Northern Manitoba in 2030 as well as a +.5% capacity a year increase at every other node
- The hydro generation is shown below



2032 Short Term Model

- 1 week model taking place in the year 2032
- Calculations done every five minutes. Gives greater detail in day to day activities
- For both short term models coal generation's max capacity was the same
- Shows how hydro compensates for the variability of wind generation
- The graph below shows the over all difference in generation from our base model compared to our hydro model



Results

Hydro vs Base Model

- Using the modeling software PLEXOS we found that there it was 1.8% cheaper in the hydro model. A large benefit was environmental.
- Hydro vs Base
  12.9% decrease in CO2 emissions

2032 Short Term Models

- We see a greater wind penetration from adding hydropower due to its faster ramp rate abilities. We were able to reduce the need for natural gas to provide ancillary services and reduced coal's market presence in the energy market