

GridLAB

MINNESOTA'S SMARTER GRID

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

Expertise to enable grid transformation



ENERGY FOUNDATION

building a new energy future

Purpose of the Report

- *Investigate the pathways to Minnesota's carbon goals of 80% reduction by 2050, with an emphasis on the electricity sector.*
- **Synapse** modeled that the electricity sector would need to meet 91% decarbonization, as some sectors will struggle to meet the 80% target (industrial, agriculture) based on a **Rhodium group** national decarbonization study.
- **Synapse** provided energy efficiency and electrification projections.
- **Vibrant Clean Energy** executed the modeling and the report.
- **GridLab** managed the overall project.
- **McKnight foundation** provided the genesis and funding

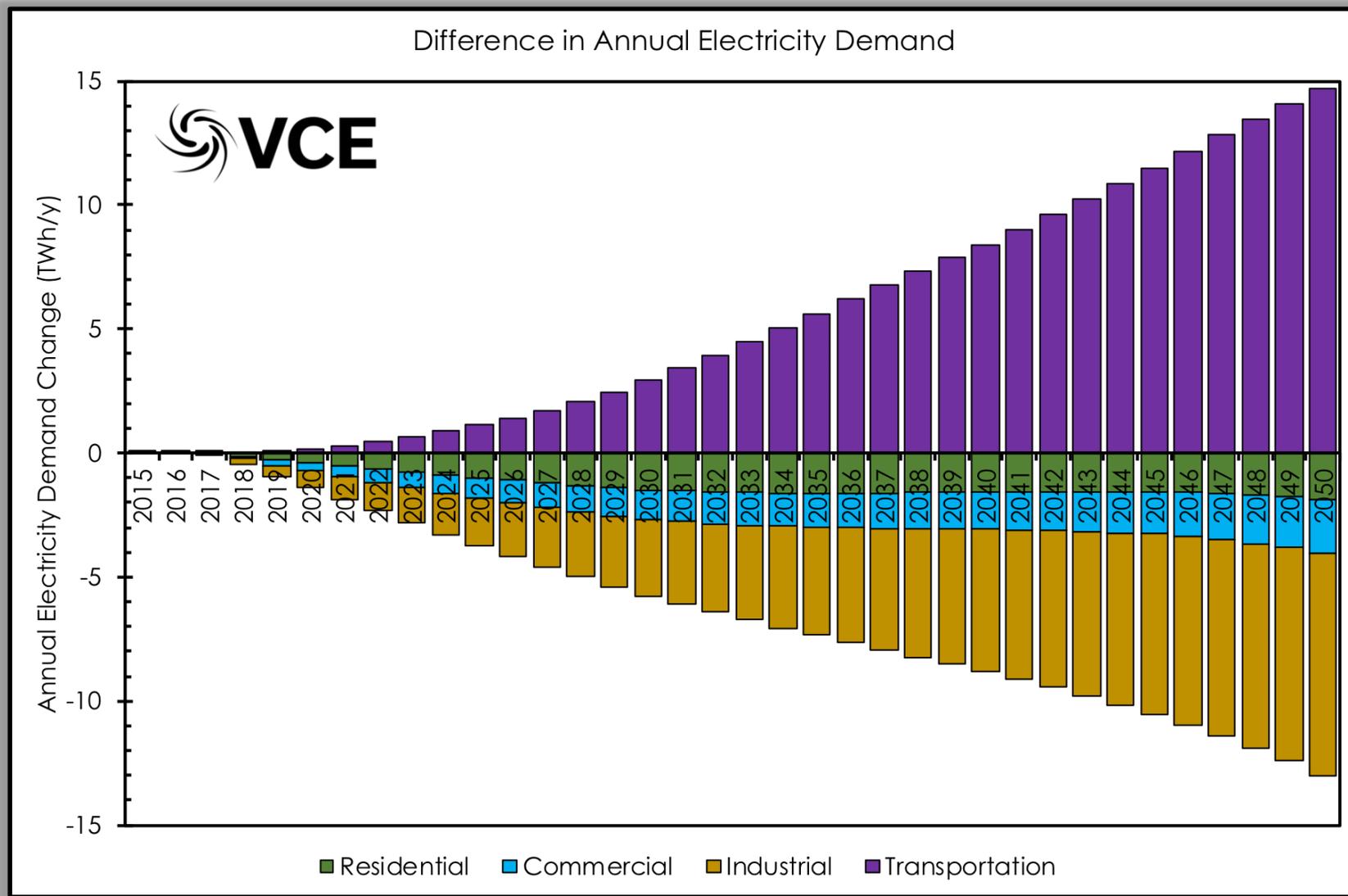
Issues to address

- What technologies will we need to deploy?
- How much will it all cost?
- How much more transmission expansion is needed?
- What is the role of customer sited energy resources in decarbonization?
- How will electrification help or hinder?
- What are the potential benefits in terms of GDP and Jobs?

Key Assumptions

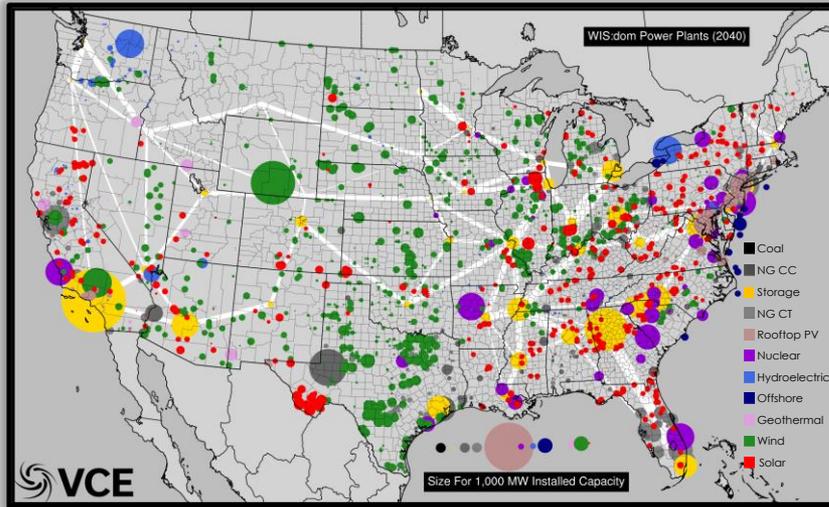
- Aggressive but realistic **energy efficiency**
- Continued improvement in wind, solar and storage costs, using **NREL Advanced Technology Baseline**.
- Federal tax credits for wind and solar at current policy.
- **Light duty vehicles** would be 89% electrified by 2050 (VMT)
 - 22% for Medium/Heavy duty vehicles
- **Residential**: Roughly 3/4 of buildings heated with electric heat pumps and electric heat pump water heaters
- **Commercial**: 2/3 of buildings have electric heat pumps and electric heat pump water heaters.

Electricity Demand Change For Decarbonization



Data provided by **Synapse**

Vibrant Clean Energy



Purpose of Vibrant Clean Energy, LLC:

- Reduce the cost of electricity and help evolve economies to near zero emissions;
- Co-optimize transmission, generation, storage, and distributed resources;
- Increase the understanding of how Variable Generation impacts and alters the electricity grid and model it more accurately;
- Agnostically determine the least-cost portfolio of generation that will remove emissions from the economy;
- Determine the optimal mix of VG and other resources for efficient energy sectors;
- Help direct the transition of heating and transportation to electrification;
- License WIS:dom optimization model and/or perform studies using the model;
- Ensure profits for energy companies with a modernized grid;
- Assist clients unlock and understand the potential of high VRE scenarios, as well as zero emission pathways.

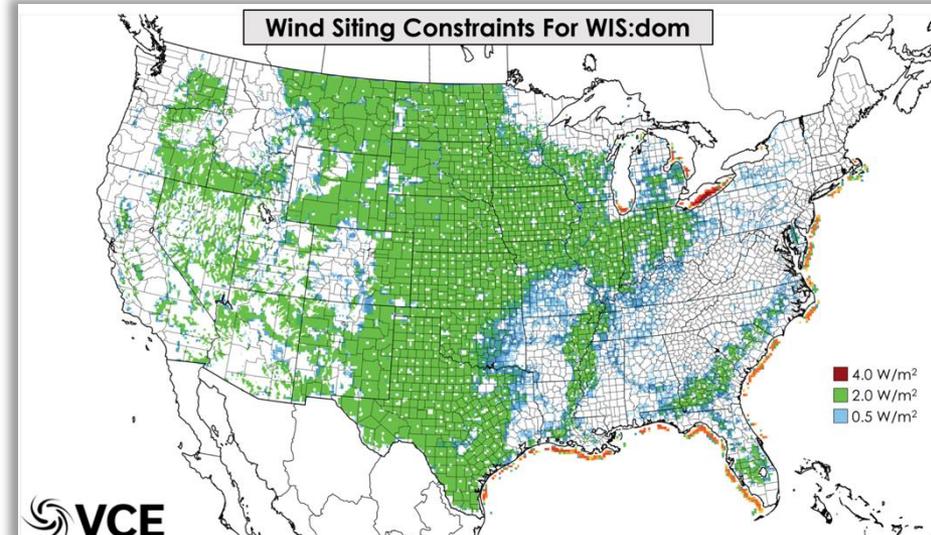
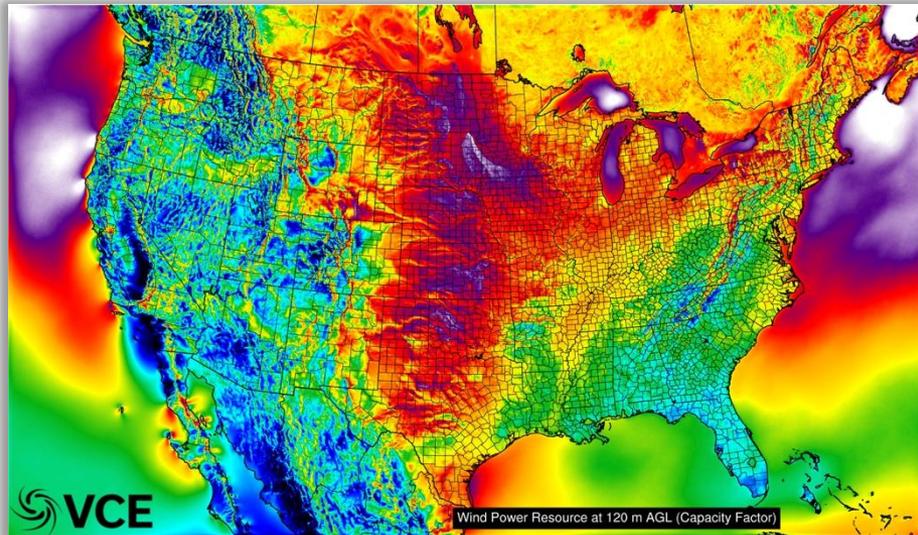
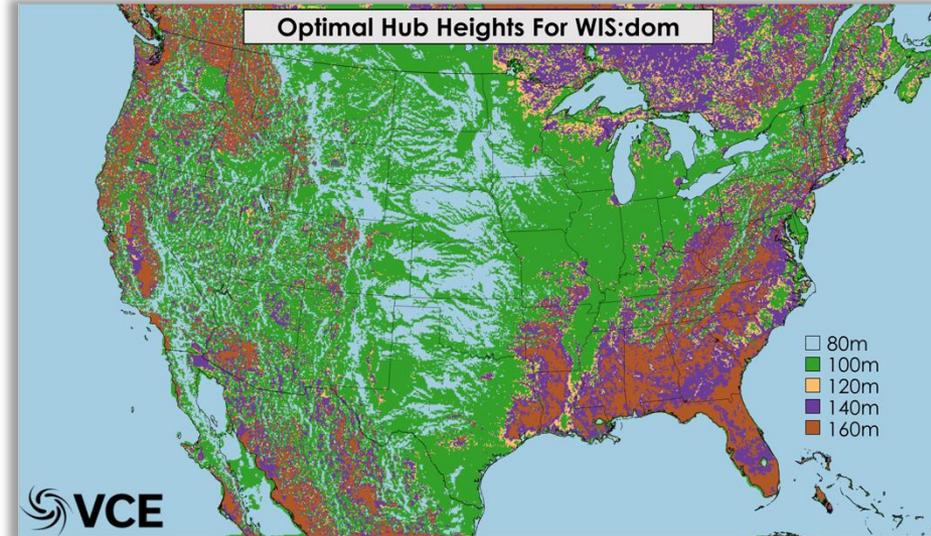
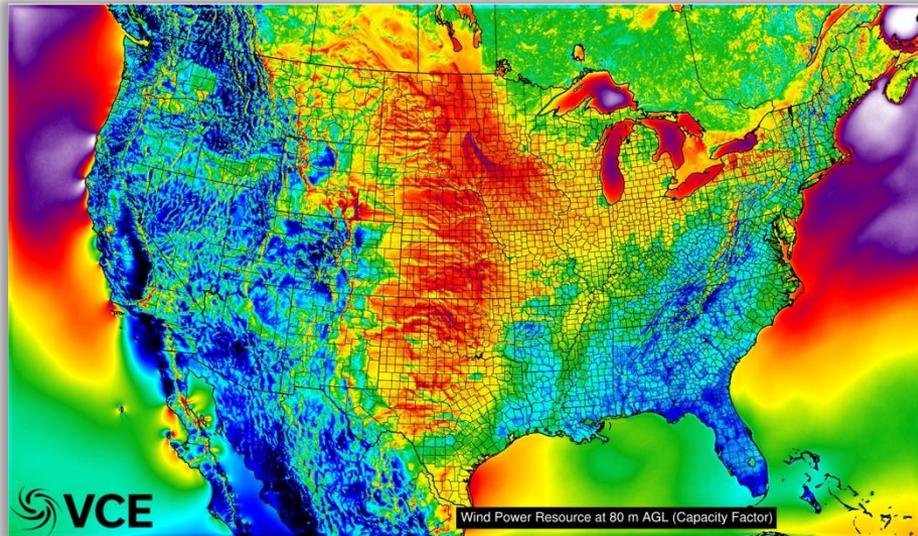


```
Iteration 28 did 2 central corrections 1225 vars  
Refinement - orig 4.66e+00, refined 4.66e+00, target 3.41e+00, 0 iter  
78 -2.97015197e+11 2.5268551e+11 6.16e+07 0.00e+00 3.56e+10 4.85e+03  
2054.51s (216027.49 ticks) for iteration (1932.03s, 314221 Mflops for lin. solve)  
Iteration 29 did 3 central corrections 1462 vars  
Refinement - orig 9.70e+00, refined 9.70e+00, target 3.13e+00, 0 iter  
29 -2.5942768e+11 2.5817608e+11 5.72e+07 0.00e+00 1.51e+10 4.38e+03  
2074.01s (218330.25 ticks) for iteration (1920.56s, 314003 Mflops for lin. solve)  
Iteration 30 did 10 central corrections 1366 vars  
Refinement - orig 1.13e+01, refined 1.13e+01, target 3.03e+00, 0 iter  
30 -3.03267e+11 3.03267e+11 1.22e+08 0.00e+00 1.22e+10 6.10e+03  
10s, 299181 Mflops for lin. solve)
```



```
64e+00, 0 iter  
0 1.00e+10 7.79e+02  
0s, 0 Mflops for lin. solve)  
-----  
Copyright Vibrant Clean Energy, LLC  
Adapted From Original Version November 1st, 2016  
Final Version August 31st, 2017  
Energy-Informed energy Systems: design, operations and markets  
WIS:dom (Planning and Dispatch Modes)  
EDF National Variant  
Item to depict the transition of the US electric sector  
Particular attention is paid to the nuclear plants  
Version 1.4  
Dr Christopher T M Clack
```

WIS:dom Contains Detailed Weather and Siting Datasets



Scenarios

- Background (Business as usual)
- MN Deep Decarbonization
- High Natural Gas costs
- Zero Emissions (100%) electricity MN
- Eastern Interconnect decarbonizes with MN
- 50% of energy to come from DER
- Less flexibility available from load and DER
- Nuclear allowed to retire early, or kept on until 2050

80% REDUCTION OF GAS EMISSIONS

by
2050

THE NUMBERS



ENERGY
SAVINGS PER
HOUSEHOLD

\$600 - \$1200
per year



WIND JOBS
14,000



SOLAR JOBS
36,000



89%



OF LIGHT-DUTY
TRANSPORT
will be electric

30%



DECREASE IN
PRICE PER KWH

ENERGY
SECTOR

300%

*increase in
employment*



- An 80% reduction in economy wide emissions for MN is **feasible and cost effective**
- Aggressive building and transportation electrification **complements decarbonization**, providing flexibility that allows for more renewables on the grid

MINNESOTA'S SMARTER GRID

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

GridLAB

Conclusions

- Minnesota has the potential to ***reduce the cost of electricity for customers regardless of decarbonization portfolio.***
- Minnesota can completely decarbonize. Doing so along with the rest of the Eastern Interconnection raises the difficulty; however, Minnesota can still achieve its goals.
- Without action ***emission reductions would cease by 2030.*** Further, the asset choices would keep emissions high, or would be stranded if emission targets were enacted at a later date.
- The jobs within the electricity sector in Minnesota is robust under all scenarios. In particular, ***with decarbonization and electrification jobs in the electricity sector rise dramatically.***
- If natural gas costs rise, and decarbonization is not chosen Minnesotans could face a cumulative ***additional spend on electricity of approximately \$15.6 billion by 2050.***

Thanks!

MINNESOTA'S SMARTER GRID

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

Ric O'Connell – ric@gridlab.org

MINNESOTA'S SMARTER GRID

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

GridLAB