Advanced Modeling of New Energy Systems & New Flexible Resources

Prepared By:

Vibrant Clean Energy, LLC
Dr Christopher T M Clack

Prepared For:

Fall 2018 Joint CREPC-WIRAB Meeting
October 25th, 2018

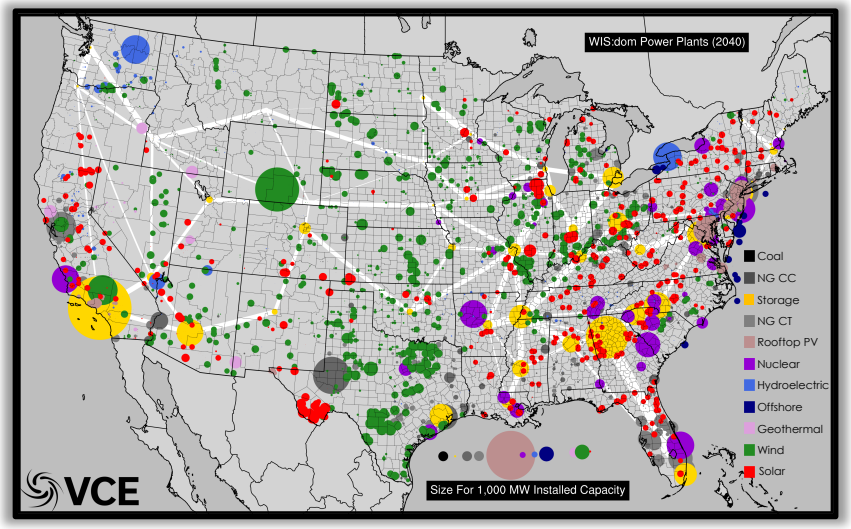
Disclaimer:

This presentation has been prepared in good faith on the basis of information available at the date of publication. The analysis was produced by Vibrant Clean Energy, LLC. No guarantee or warranty of the analysis is applicable. Vibrant Clean Energy, LLC will not be held liable for any loss, damage, or cost incurred by using or relying on the information in this presentation.

info@vibrantcleanenergy.com

VCE

Who Are We: Vibrant Clean Energy



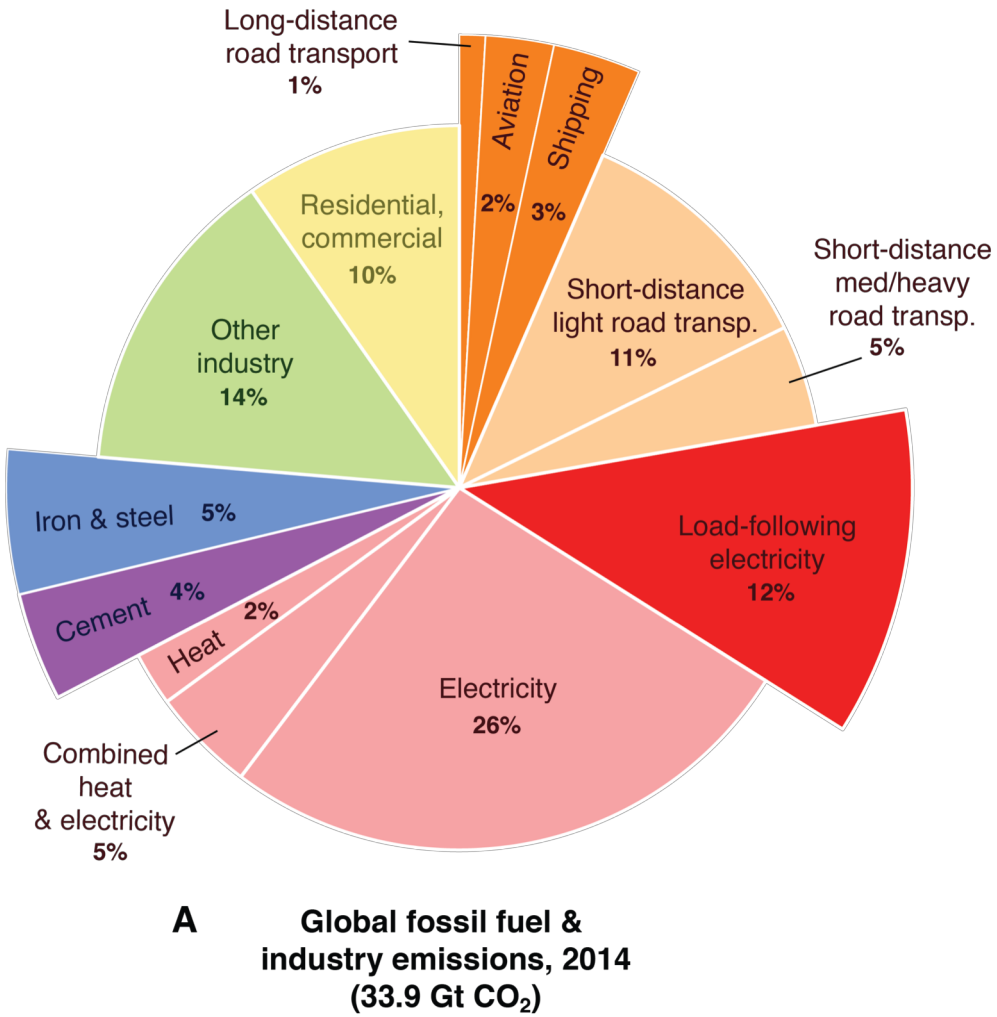
Purpose of Vibrant Clean Energy, LLC:

- 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.

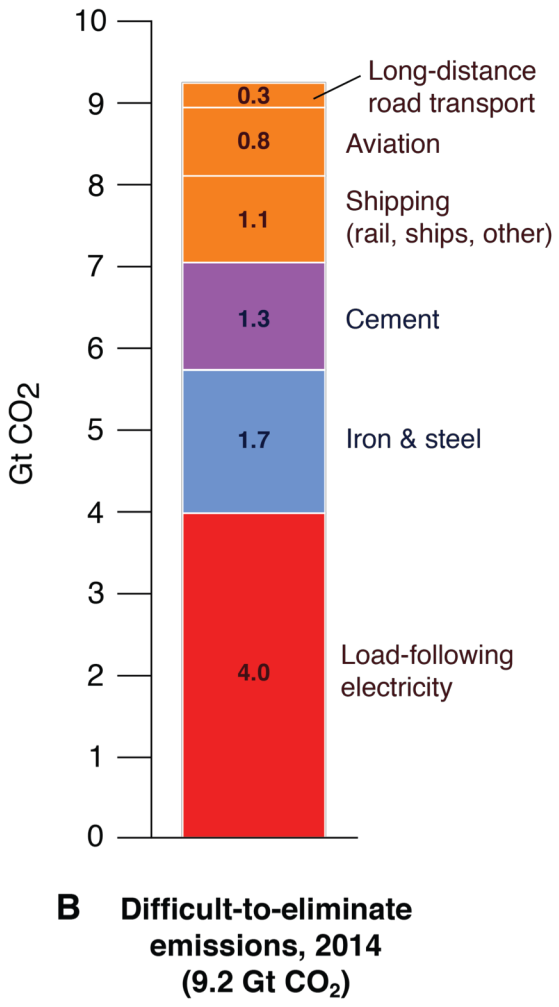
info@vibrantcleanenergy.com

VCE
VIBRANT CLEAN ENERGY

Electricity Is Not All Energy



A **Global fossil fuel & industry emissions, 2014 (33.9 Gt CO_2)**

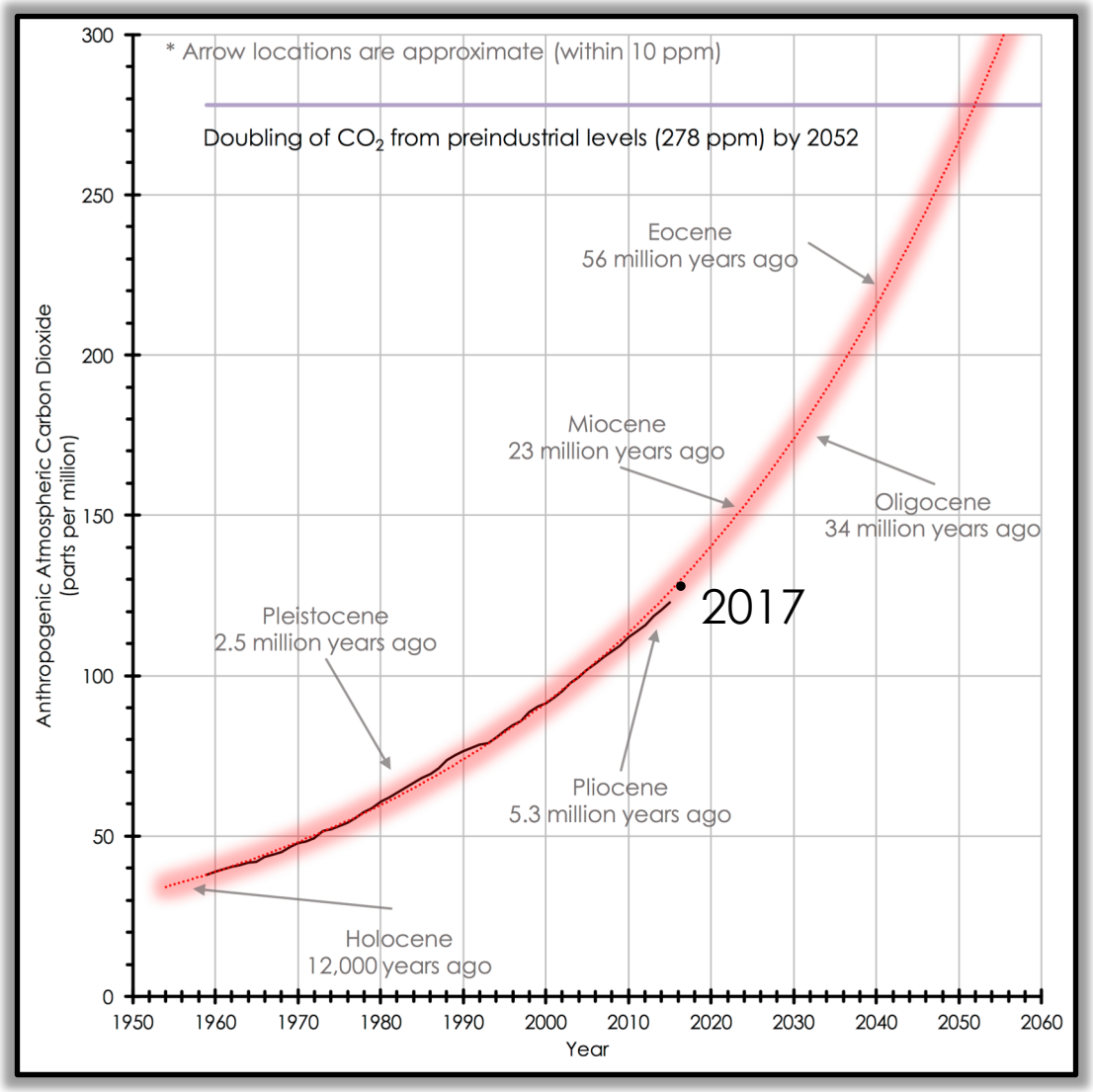


B **Difficult-to-eliminate emissions, 2014 (9.2 Gt CO_2)**

Davis et al. *Science*, 2018

VCE VIBRANT CLEAN ENERGY

Why Consider Electrification & Decarbonization?



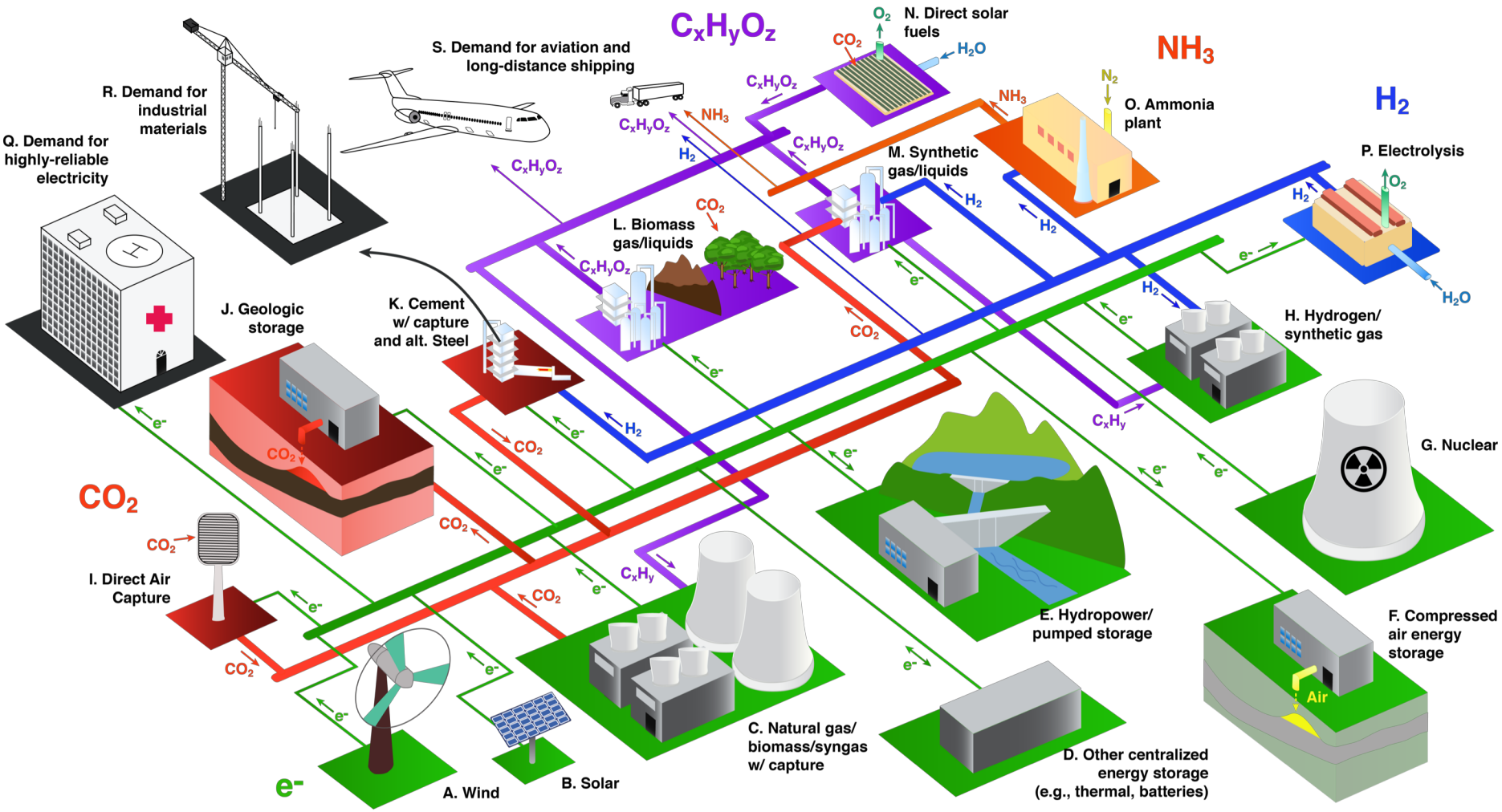
Emissions keep rising faster and faster…

Based on concept by David Hofmann:
https://www.esrl.noaa.gov/gmd/publications/annual_meetings/2008/slides/3-Hofmann.ppt.pdf

info@vibrantcleanenergy.com

VCE
VIBRANT CLEAN ENERGY

The Whole Economy Needs Energy

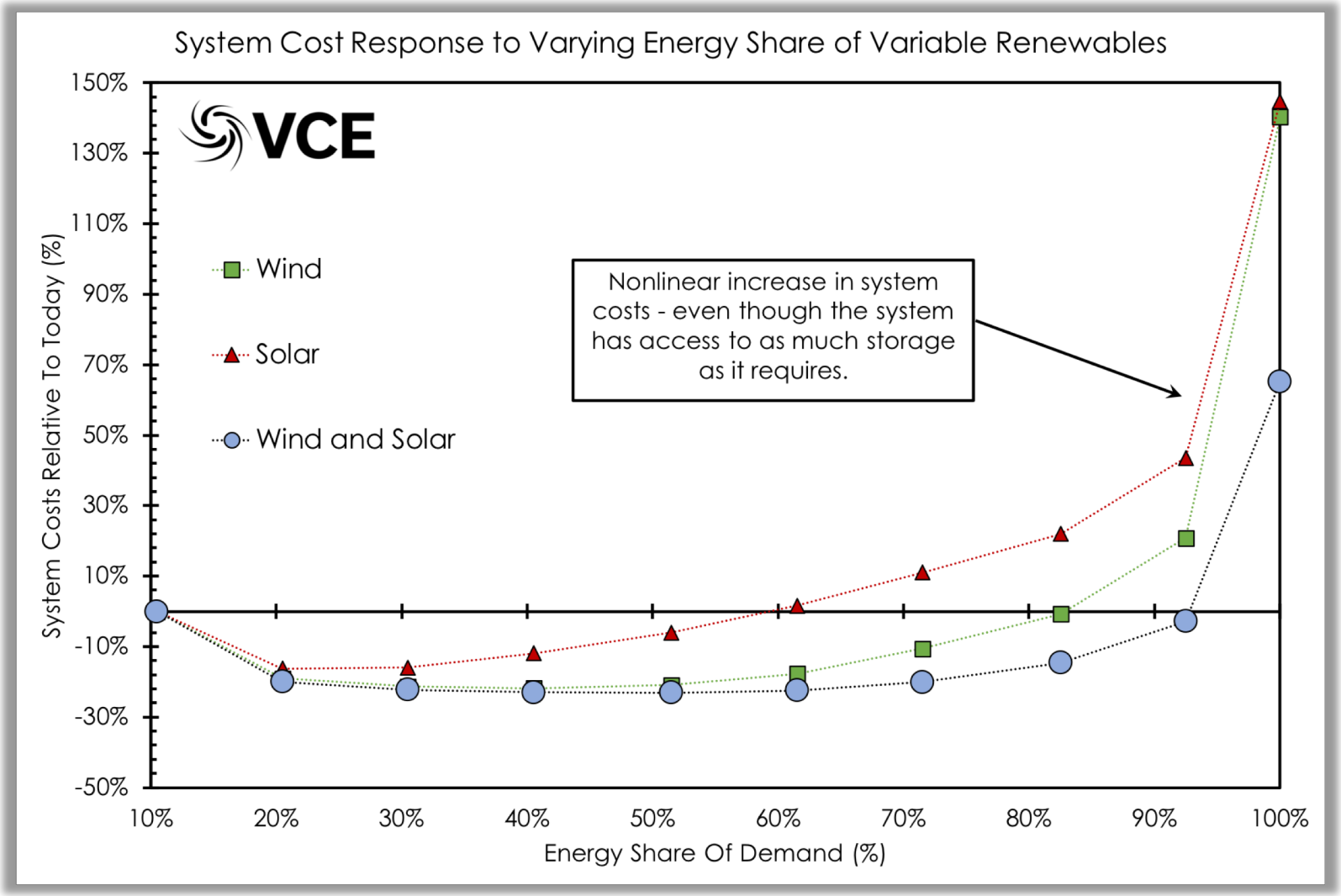


Davis et al. *Science*, 2018

info@vibrantcleanenergy.com

VCE
VIBRANT CLEAN ENERGY

Electrification Is The Opportunity To Avoid Dramatically Increased Costs At High RE Levels



info@vibrantcleanenergy.com

VCE
VIBRANT CLEAN ENERGY

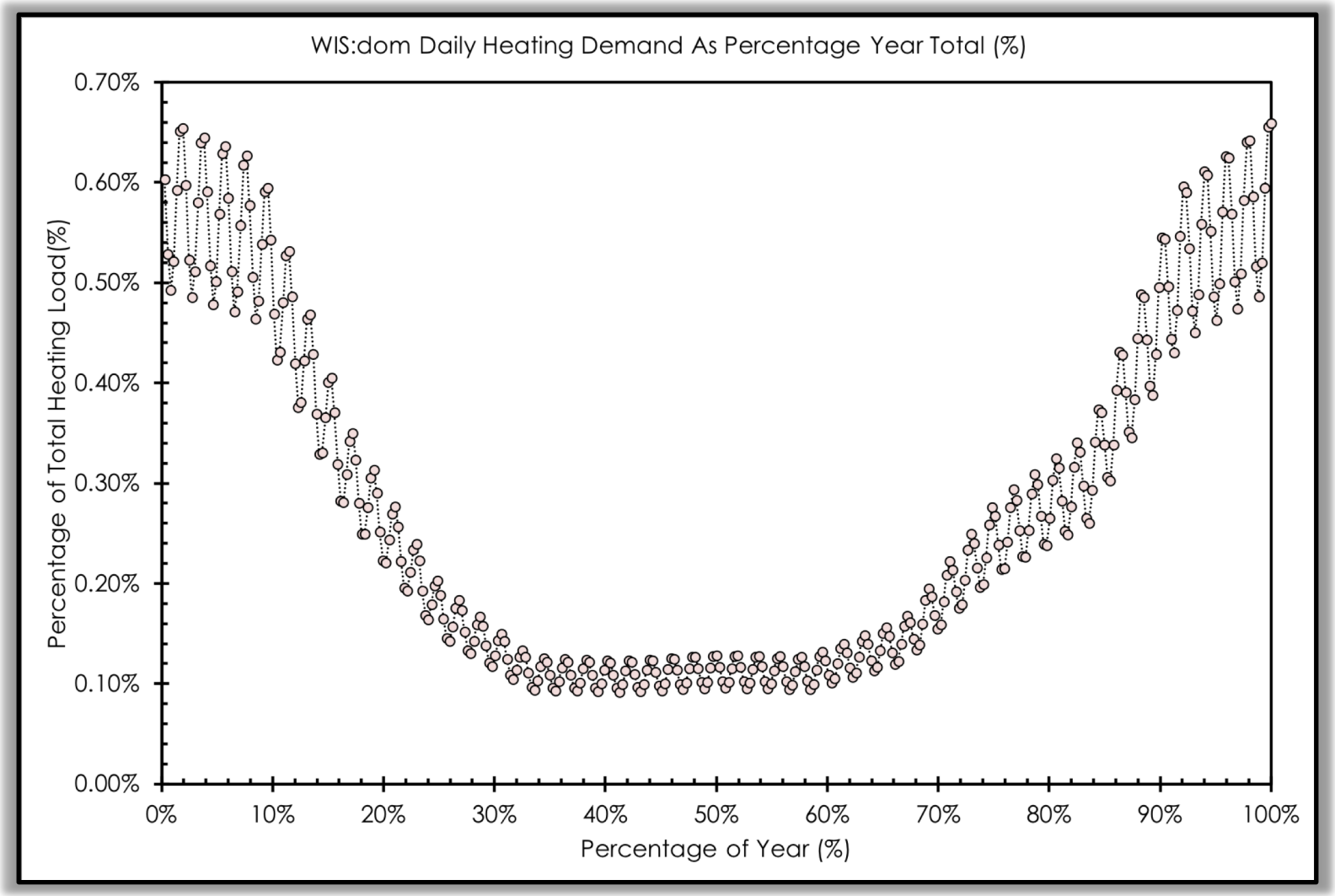
Electrification That WIS:dom Considers

The WIS:dom optimization model considers

electrification through:

1. Light Duty Vehicles,
2. Heat pump Water Heaters (residential and commercial),
3. Heat pump space heating (residential and commercial),
4. Light Duty Trucks,
5. H2 production for:
   - *Medium / Heavy Duty Trucking,*
   - *Industrial Demands,*
   - *Space heating (residential and commercial),*
   - *Other transportation (Sabitier to Fischer-Tropsch Processes).*

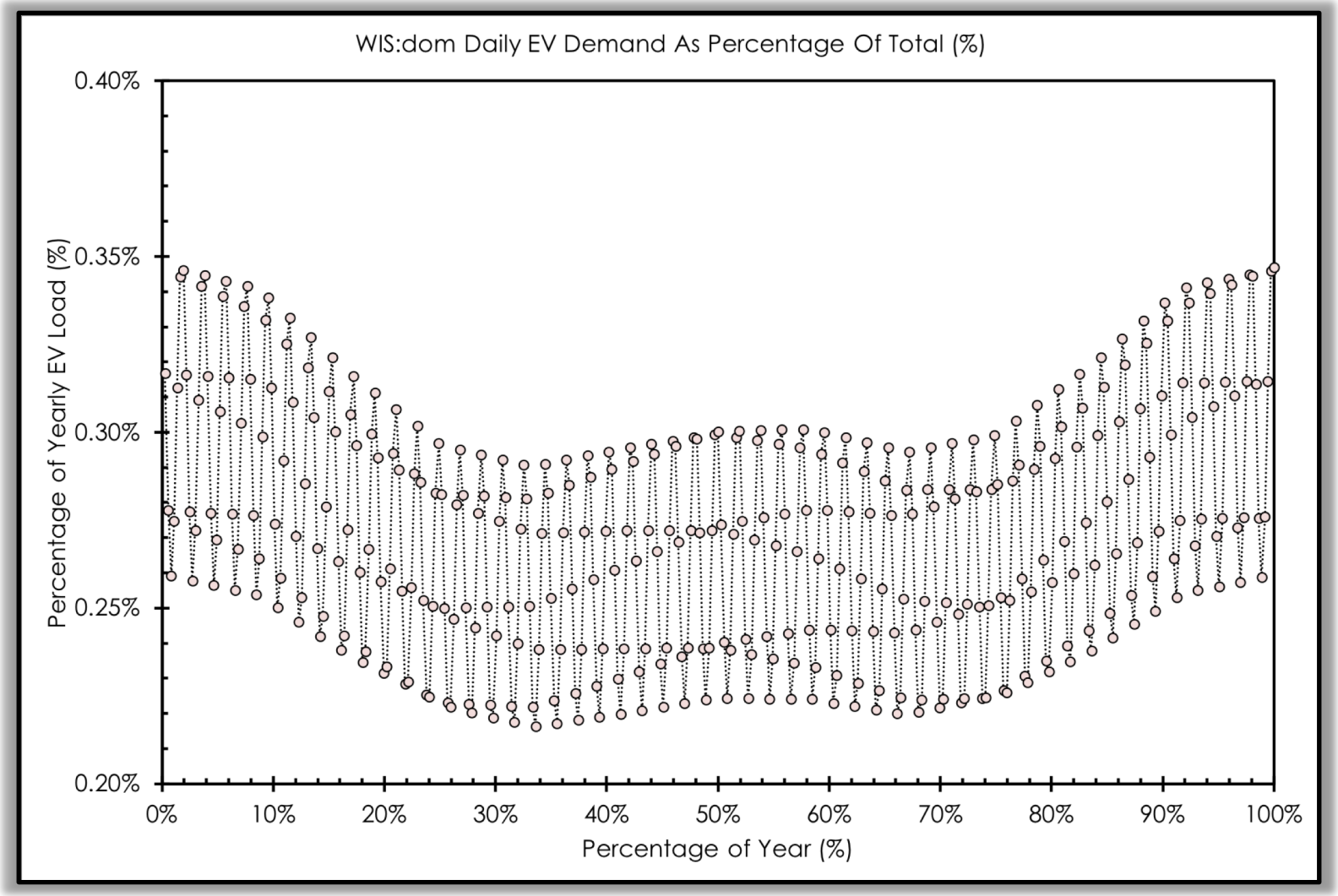
Addition Heating Demands (Daily)



info@vibrantcleanenergy.com

VCE
VIBRANT CLEAN ENERGY

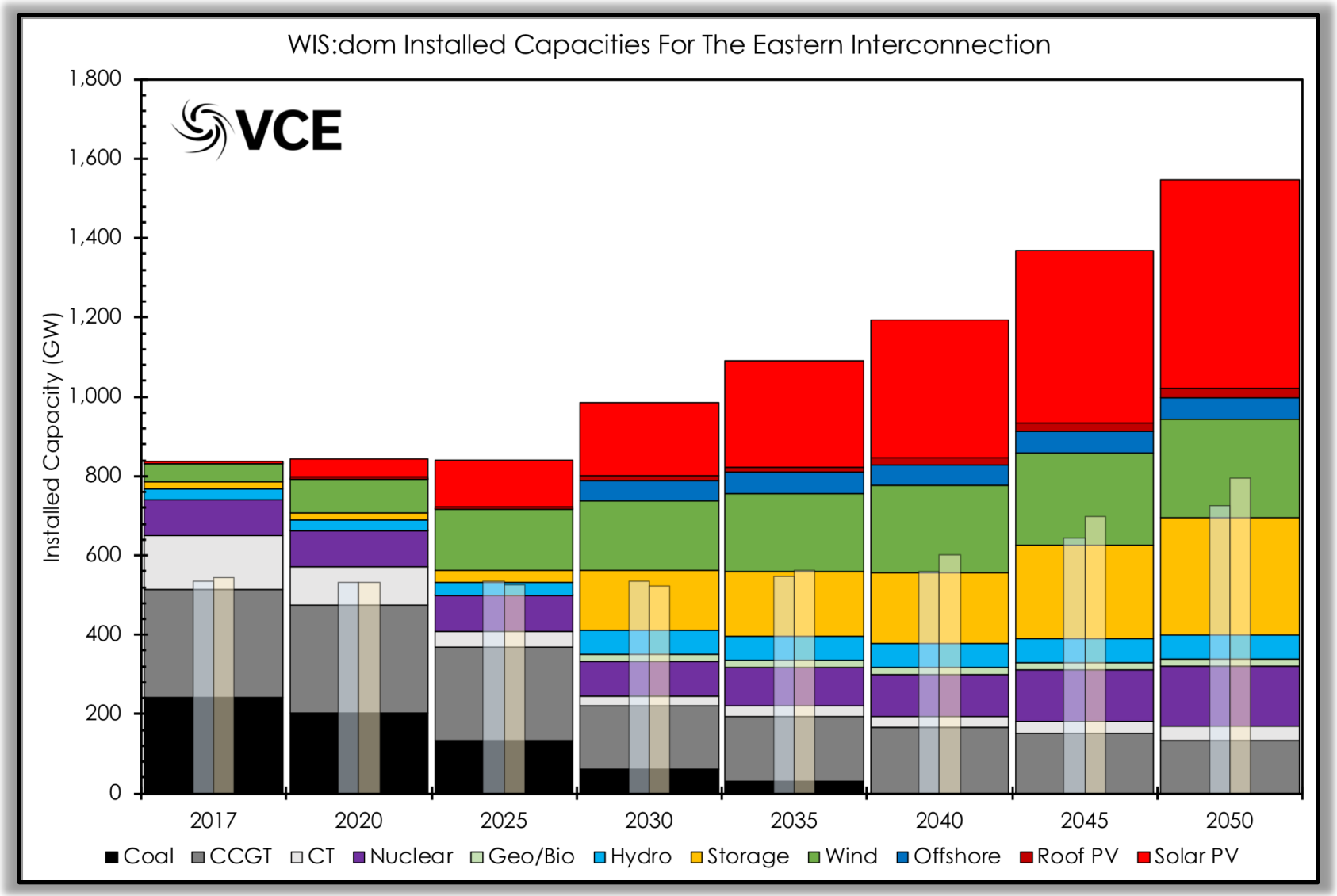
Addition Transportation Demands (Daily)



VCE
VIBRANT CLEAN ENERGY

Eastern Interconnect Low-Carbon Grid

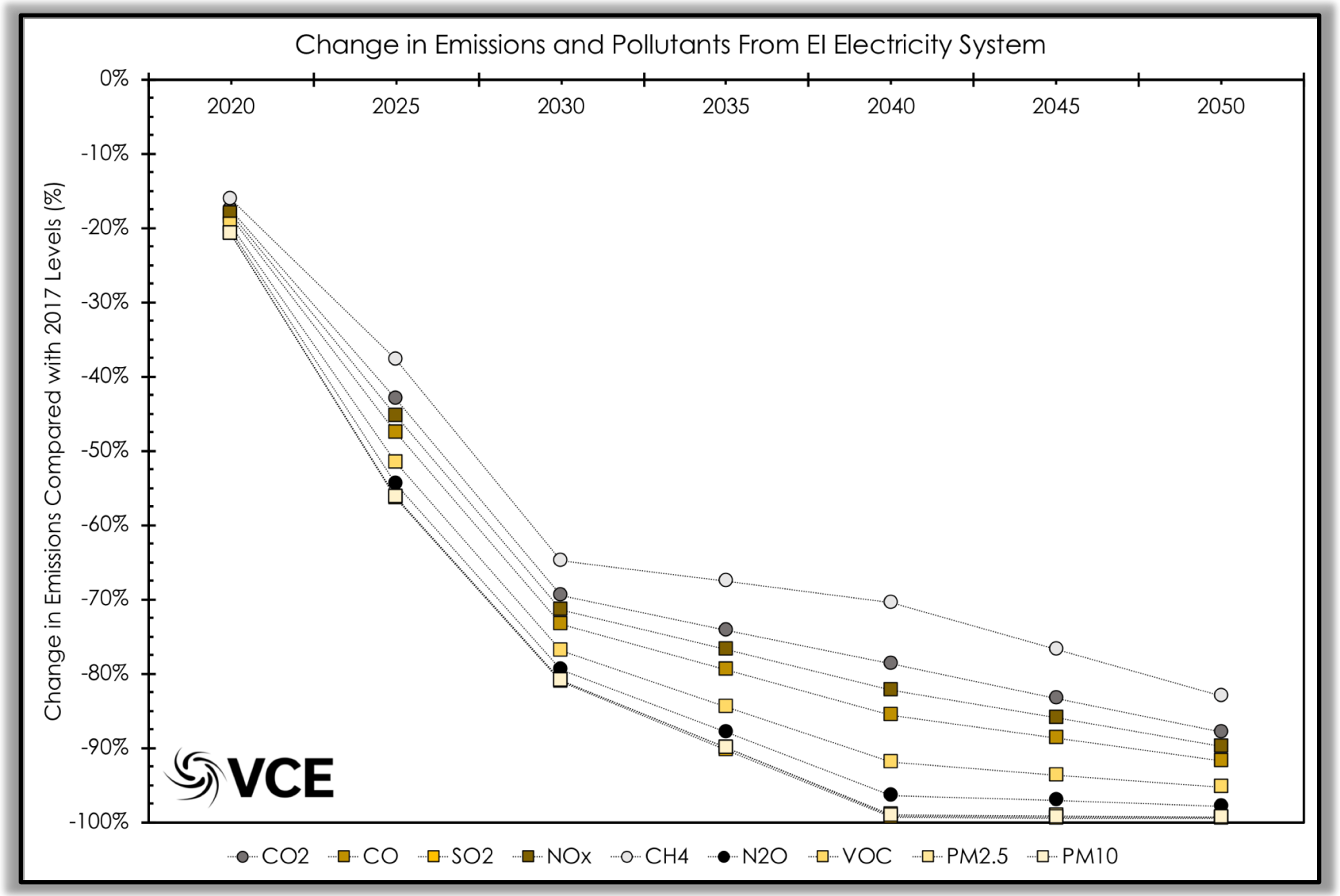
Eastern Interconnection Installed Capacity



info@vibrantcleanenergy.com

VCE
VIBRANT CLEAN ENERGY

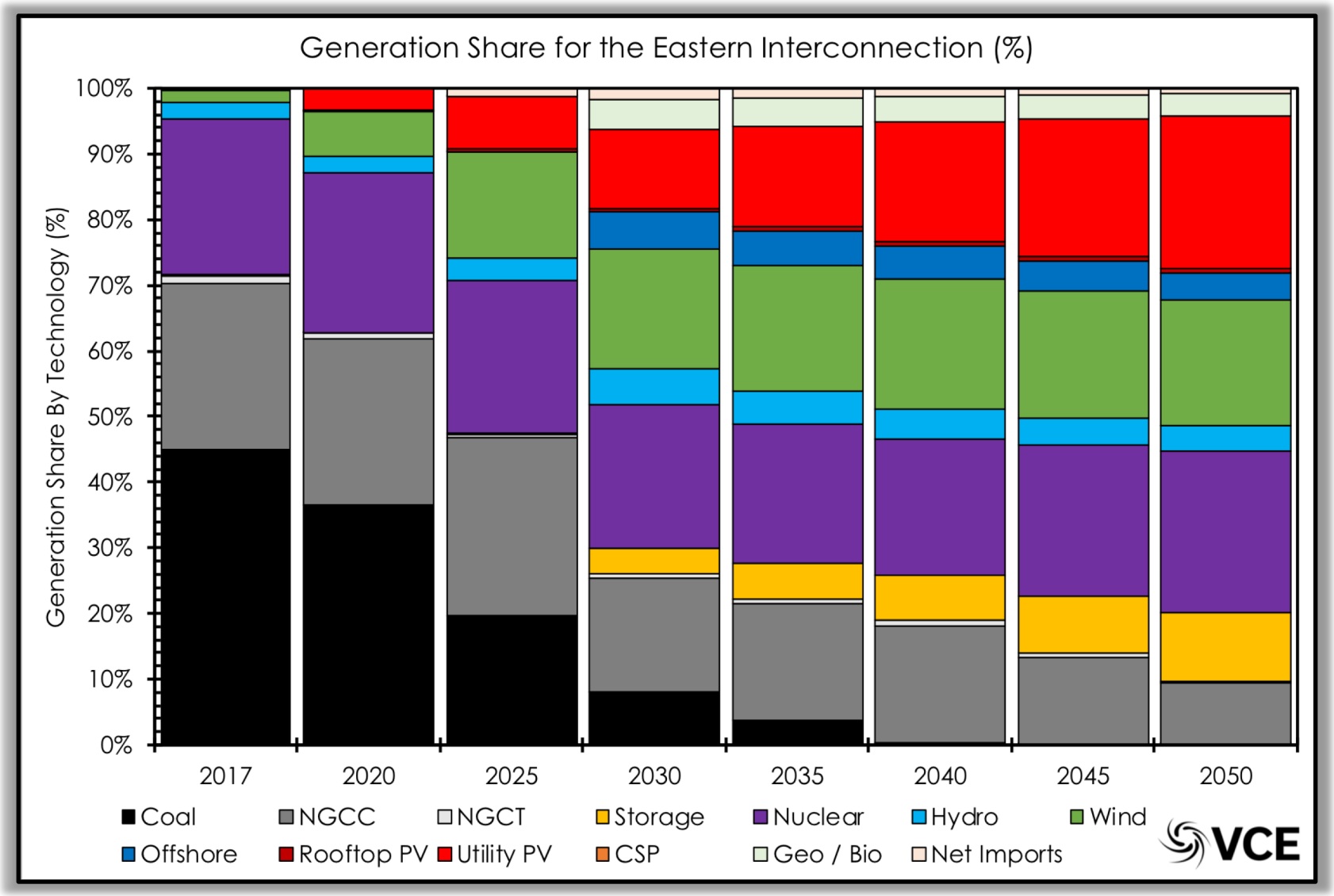
Eastern Interconnection Emissions Change



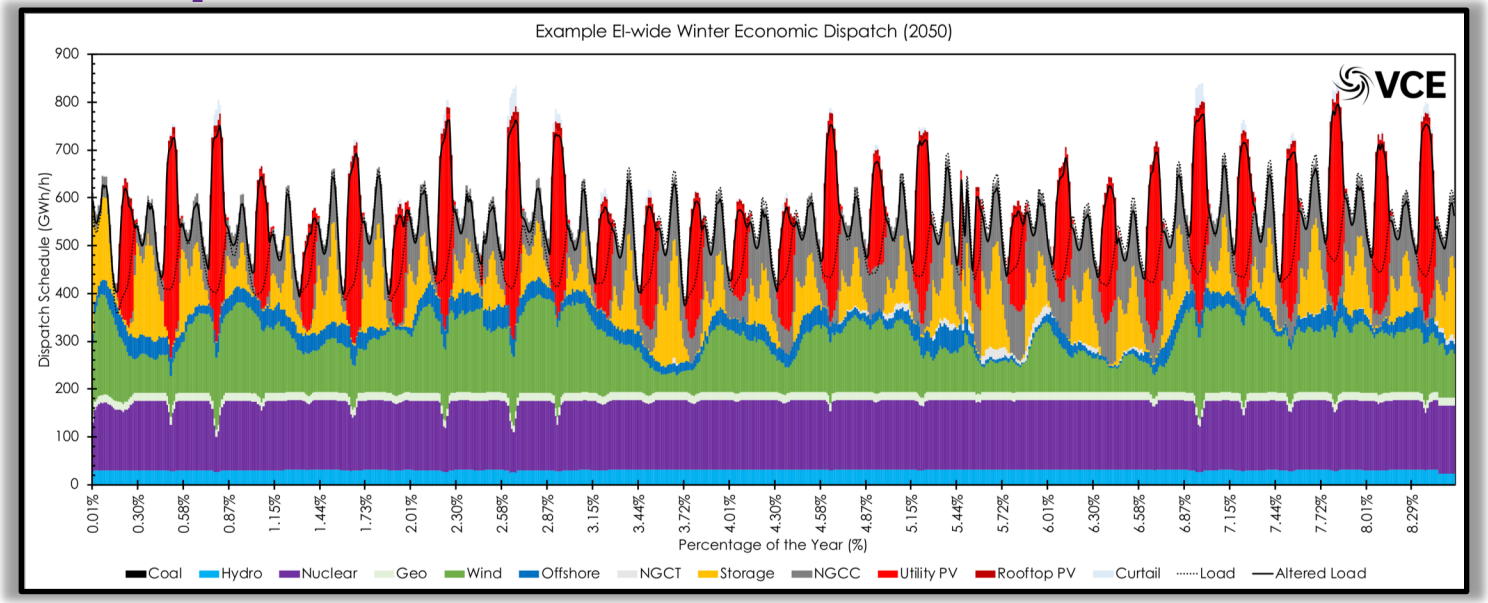
info@vibrantcleanenergy.com

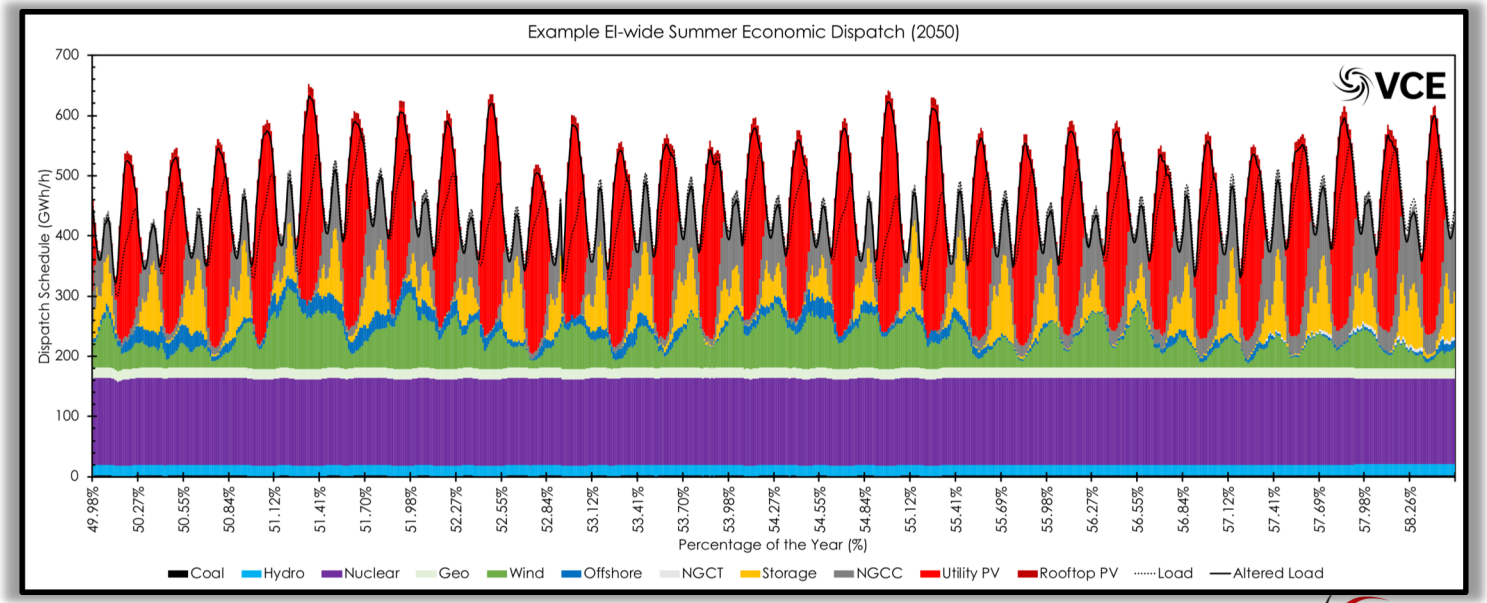
VCE
VIBRANT CLEAN ENERGY

Generation Share For Eastern Interconnection



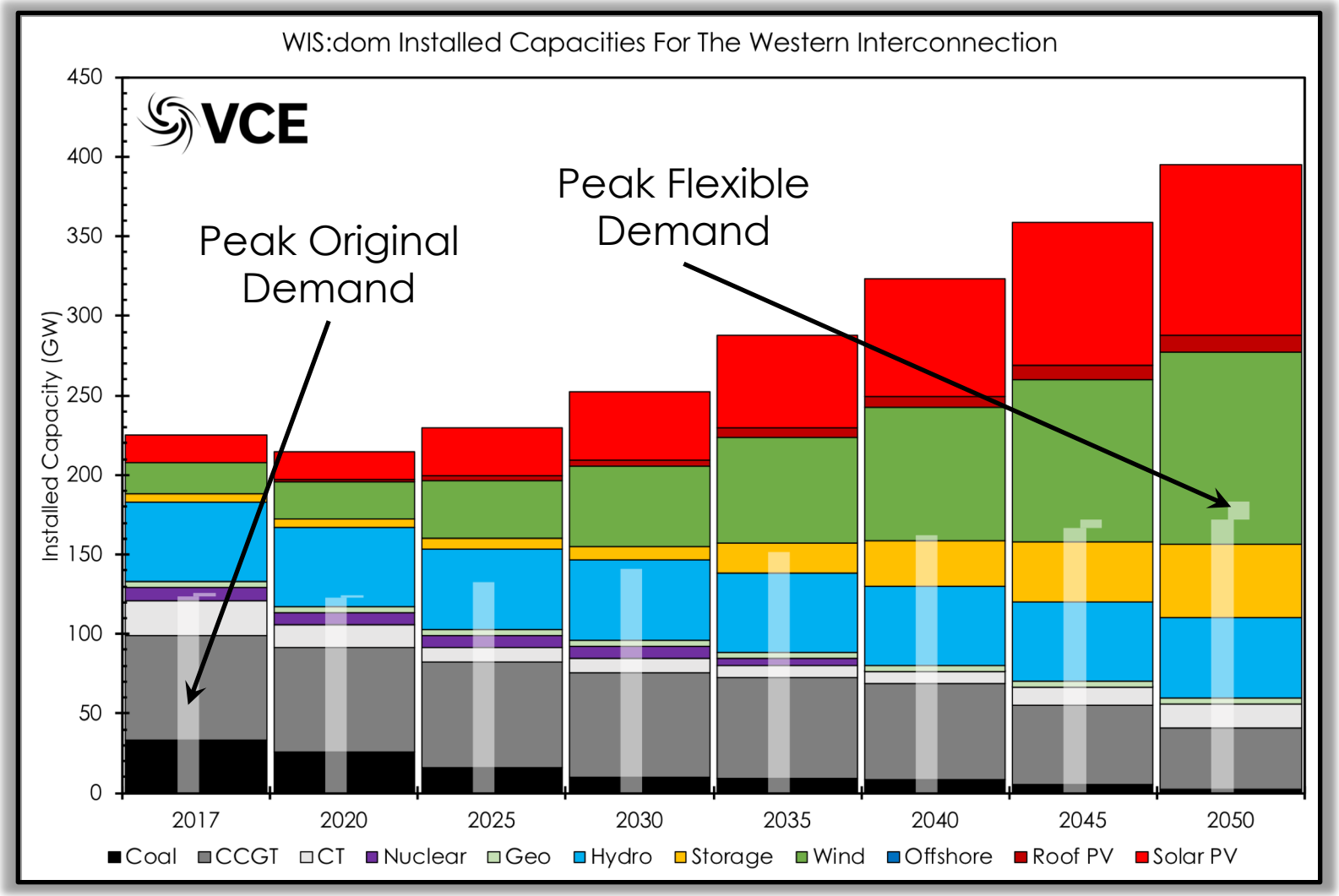
Dispatch For Eastern Interconnection





Western Interconnect Low-Carbon Grid

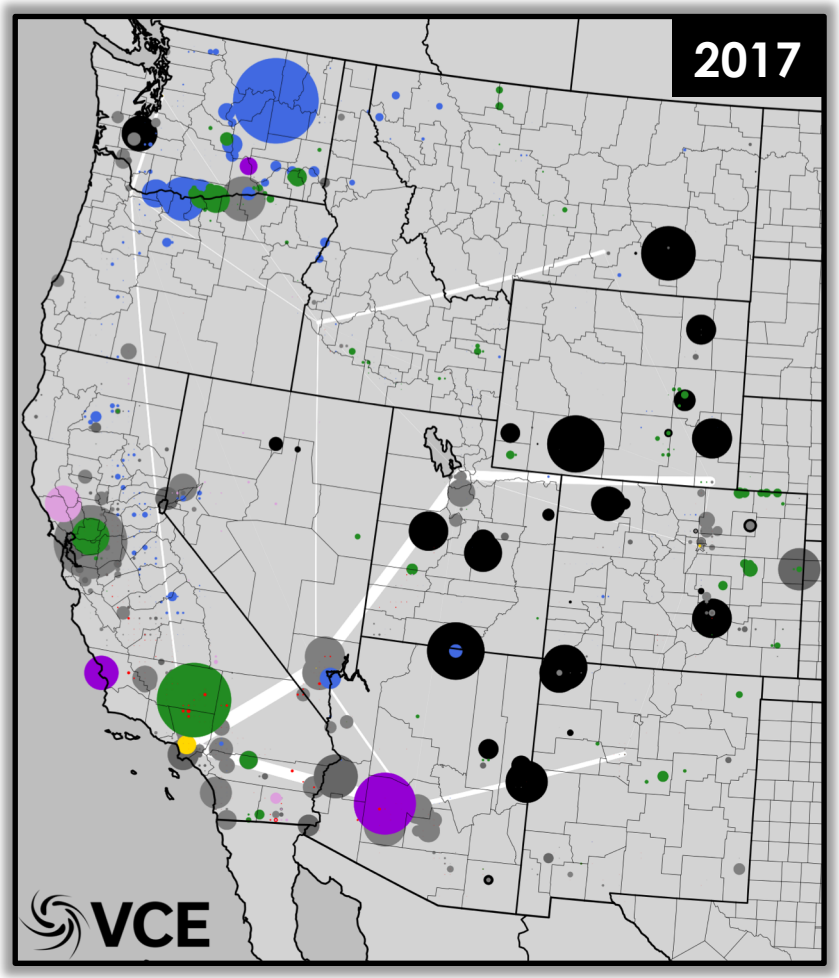
Western Interconnection Installed Capacity

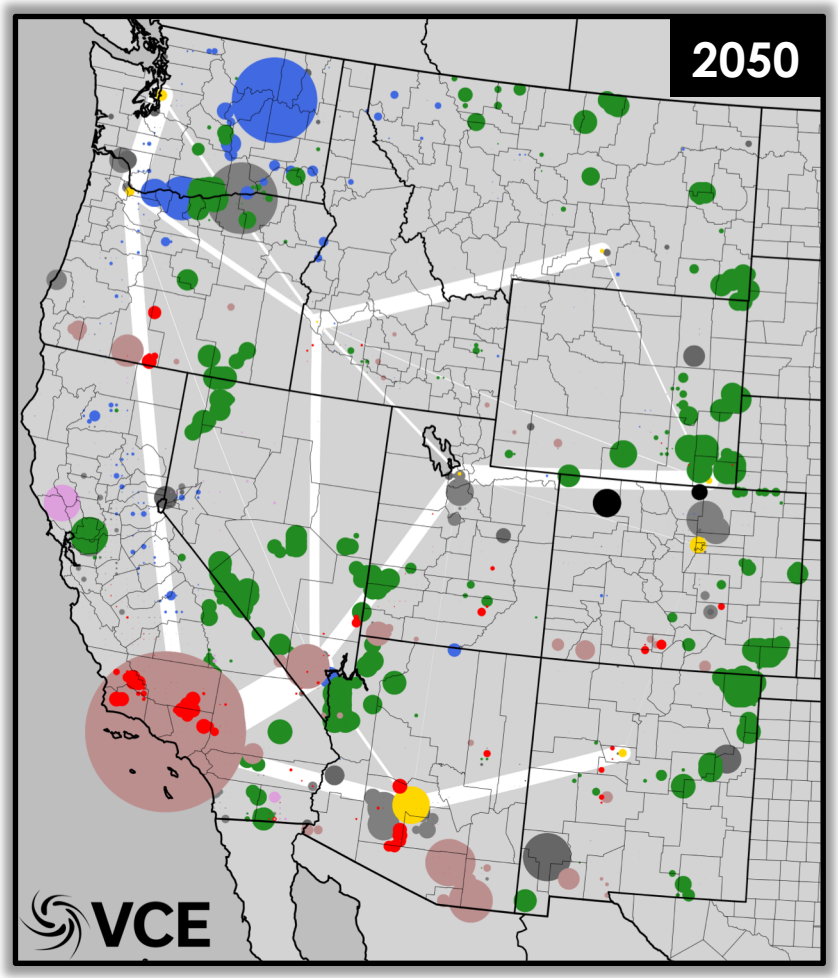


info@vibrantcleanenergy.com

VCE
VIBRANT CLEAN ENERGY

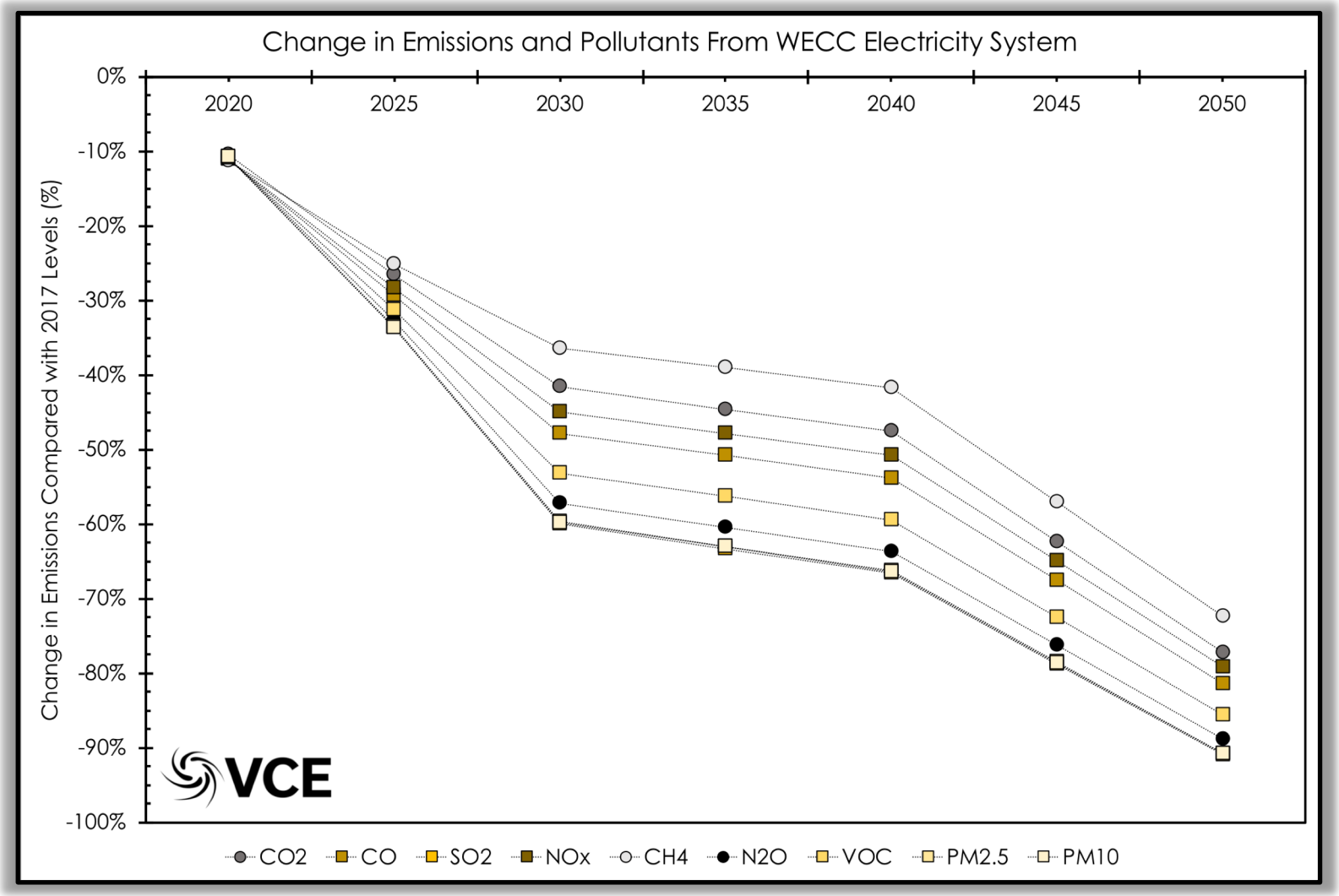
Installed Capacities



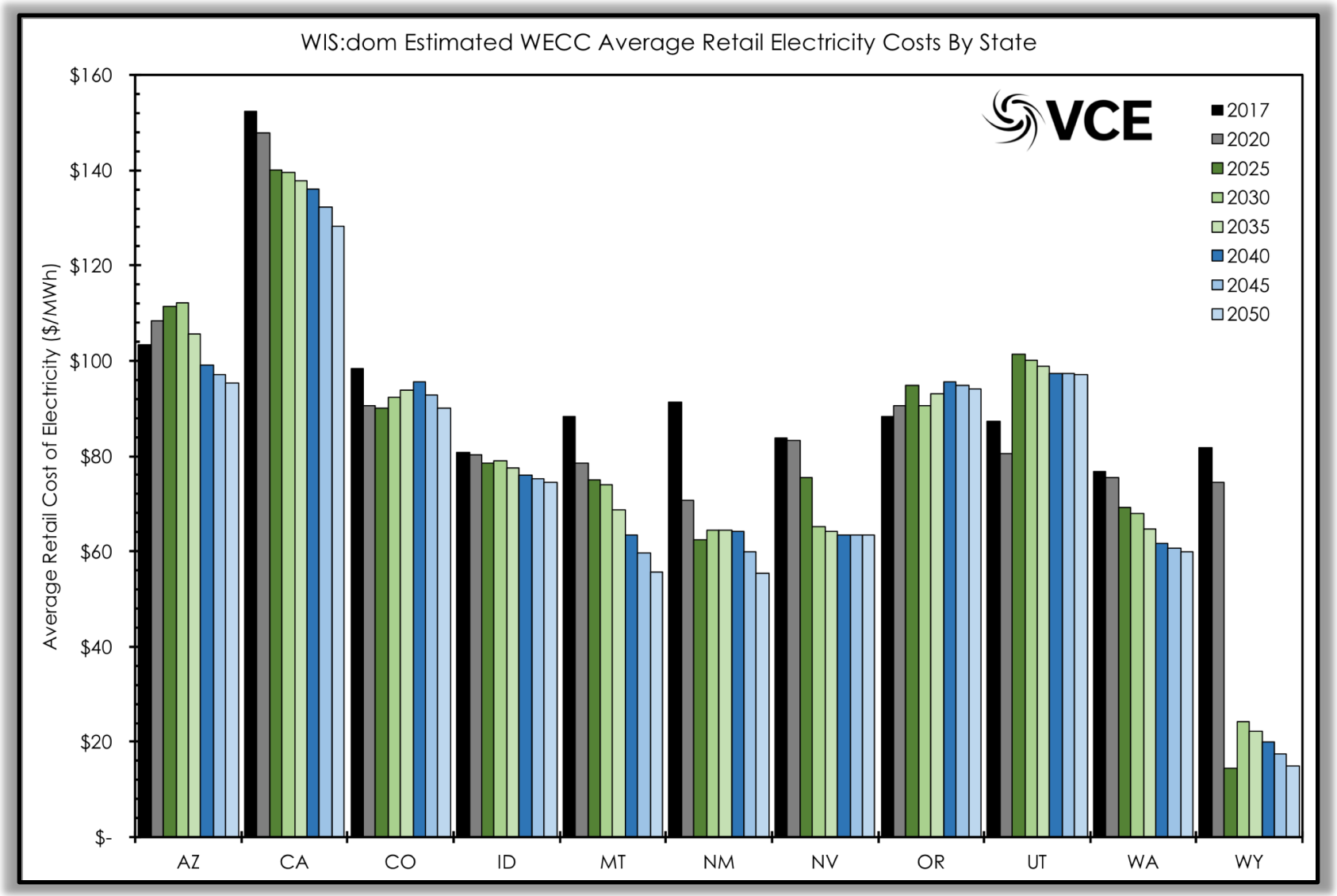


- Interstate transmission capacity is shown in white. Black is coal plants, grey is natural gas, green is wind, red is solar, purple is nuclear, blue is hydroelectric and purple is nuclear.

Western Interconnection Emissions Change



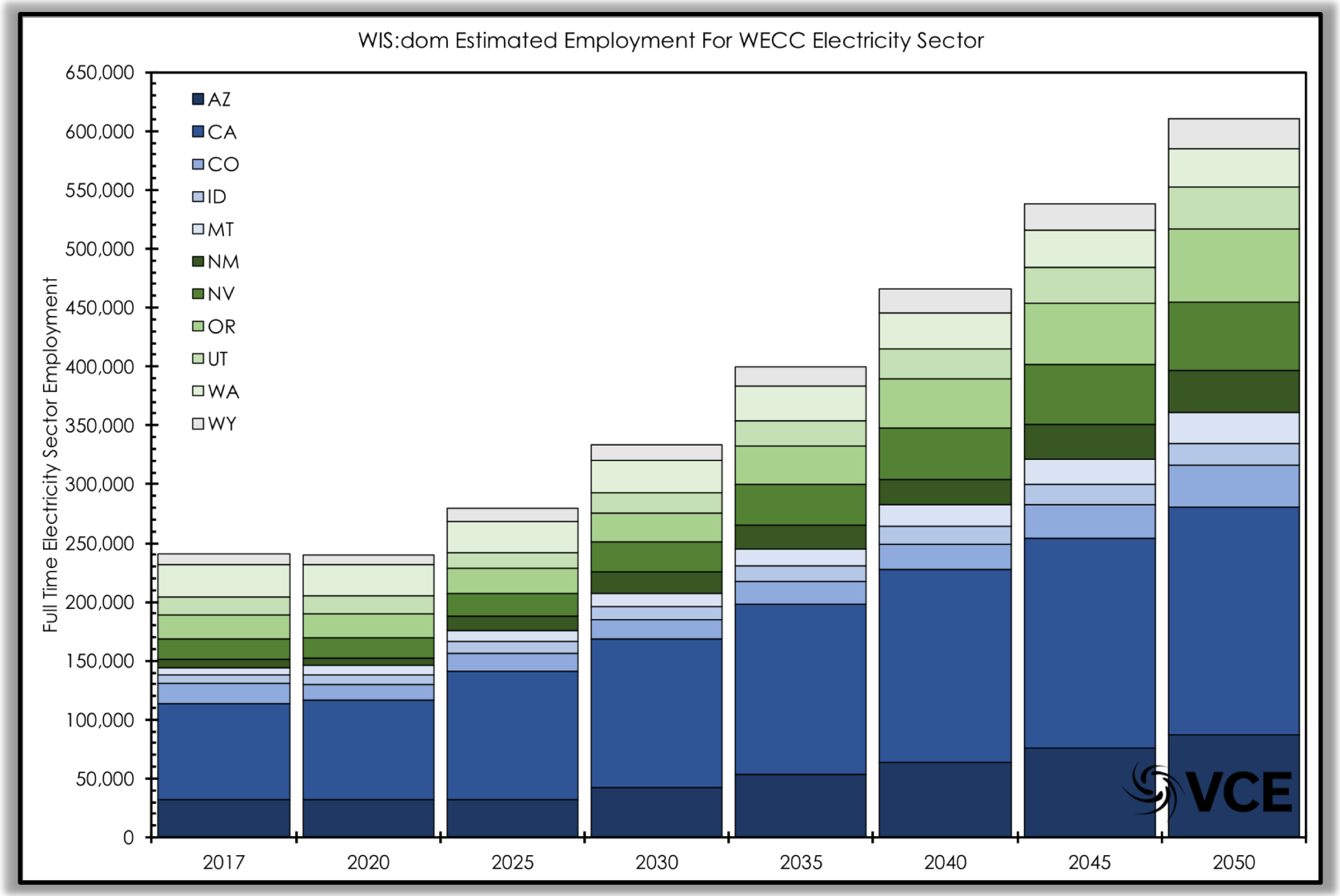
WECC-wide Average Retail Electricity Costs



info@vibrantcleanenergy.com

VCE
VIBRANT CLEAN ENERGY

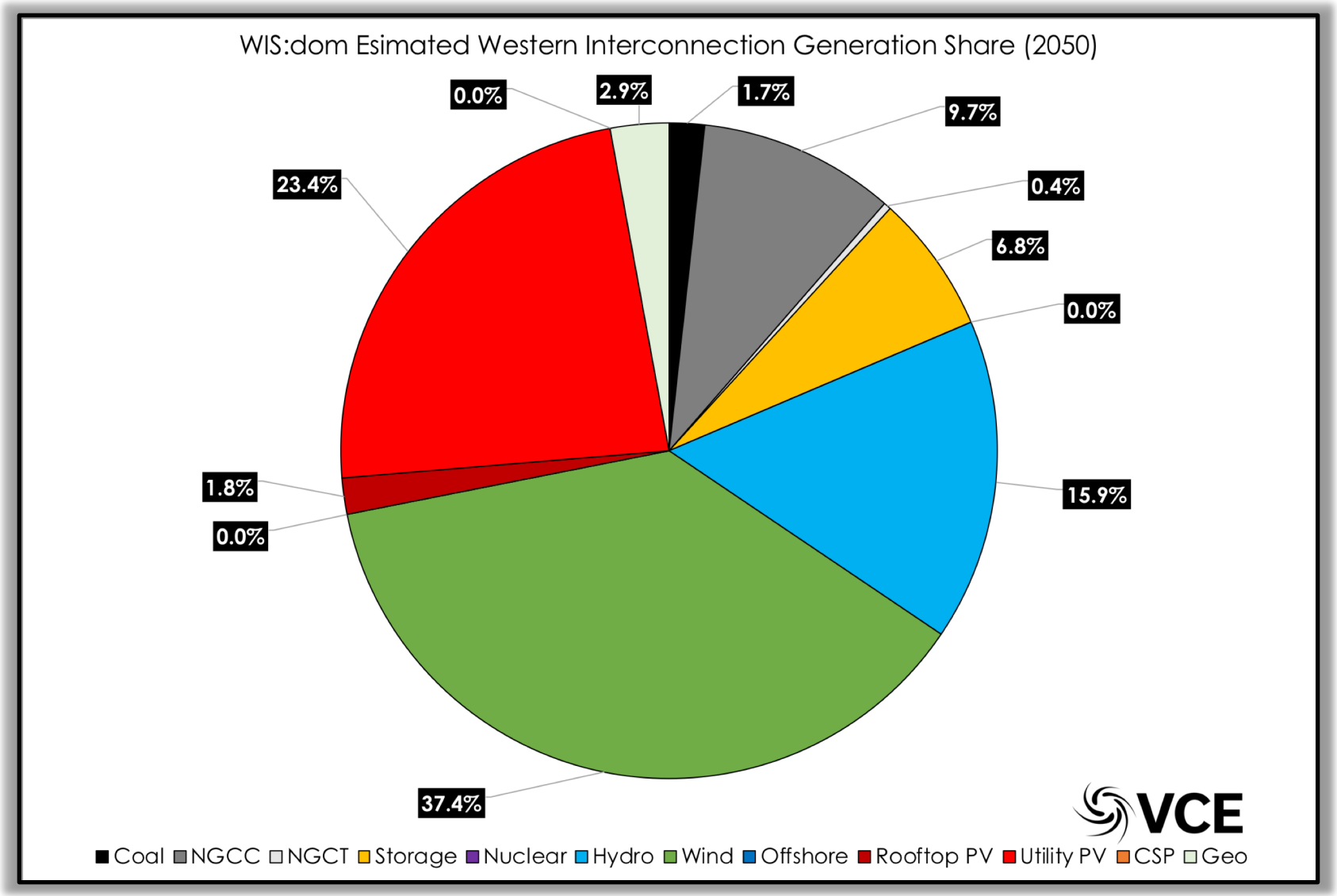
Full-time Jobs In Electricity Over WECC



- Under baseline conditions, there are 61% more full time jobs in the electricity sector compared with 2017 numbers.

VCE
VIBRANT CLEAN ENERGY

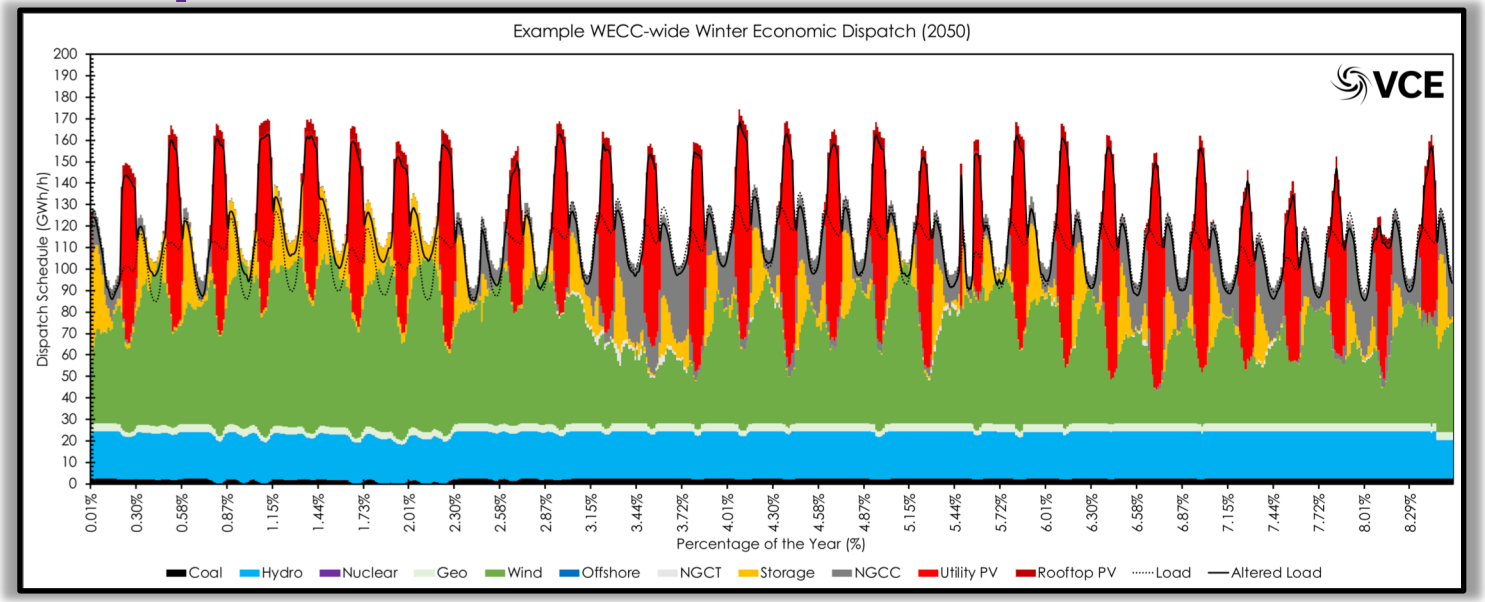
Generation Share For Western Interconnection

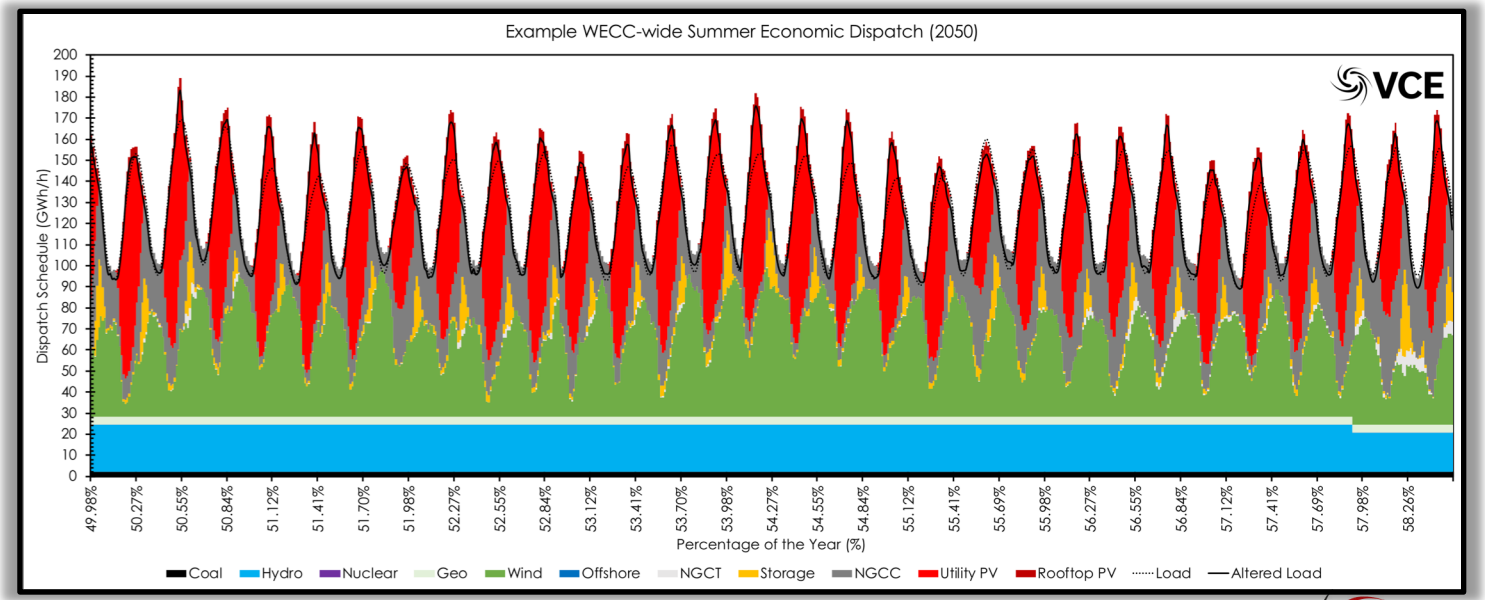


info@vibrantcleanenergy.com

VCE
VIBRANT CLEAN ENERGY

Dispatch For Western Interconnection





info@vibrantcleanenergy.com

VCE
VIBRANT CLEAN ENERGY

Electrification is Key To Low-Cost Decarbonization

- ✓ ***Electrification provides increased electricity demand (helping investment);***
- ✓ Electrification provides a pathway for other sectors to decarbonize cost effectively;
- ✓ ***Electrification provides flexibility to the electricity sector that reduces the impact of resource variability (but does not eliminate it completely);***
- ✓ Electrification reduces the net-peak issue with VREs while reducing the impact of over-generation periods;
- ✓ ***Without electrification, more transmission is required, and decarbonization becomes much more difficult.***

Thank You

Dr Christopher T M Clack
CEO Vibrant Clean Energy, LLC

Telephone: +1-720-668-6873
E-mail: christopher@vibrantcleanenergy.com
Website: VibrantCleanEnergy.com