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March 6, 2018

MEMORANDUM

TO: Council Members

FROM: John Ollis, Power System Analyst

SUBJECT: Marginal Carbon Emissions Rate Study

BACKGROUND:

Presenter: John Ollis

Summary: This presentation will update the Power Committee on the stakeholder response to the revised results of the Marginal Carbon Emissions Rate Study and status of finalizing study. Staff will be seeking release of the final study in a following Council presentation.

Relevance: The study of avoided carbon dioxide production rates of the northwest power system will evaluate what the implied avoided emissions rate is in the WECC by reducing 100 MW of Pacific Northwest load in every hour of four test years (2016, 2021, 2026 and 2031), and the implications for regional conservation replacing the need for that production. The results will summarize the findings into an annual avoided carbon dioxide emissions rate (pounds per megawatt-hour) for the years of the study for two scenarios analyzed in the 7th Power Plan: Existing Policy and Average Social Cost of Carbon.

Workplan: N/A

Background: The cost of future carbon dioxide regulation has been a significant factor in resource planning in the Pacific Northwest. To avoid making higher cost

resource choices, a direct evaluation of this risk requires an estimate of the carbon dioxide emissions avoided by purchasing conservation or another resource. The Council has periodically produced this study using the AURORA model to help inform Council staff and regional stakeholder analysis.

Per the discussion in the January and February 2017 Power Committee, and April Council Meeting, AURORA has been used as the Council's wholesale market electricity price forecasting model. The first draft of the study was released for public comment in April 2017. In response to that public comment, staff developed, in conjunction with the System Analysis Advisory Committee, a slightly different methodology for calculating the best estimate for an avoided carbon dioxide emissions rate. This updated draft reflects the new methodology and results. This second draft was released in the January 2018 Council Meeting for stakeholder comment. The updated final draft of the paper contains edits and observations from that stakeholder feedback.

More Info: The second 2017 Marginal Carbon Emissions Study Draft will be available for preview before the meeting.

For second draft of paper, see
<https://www.nwcouncil.org/energy/2018-01-avoided-carbon-report/>

For SAAC discussion of study, see
https://www.nwcouncil.org/energy/saac/meetings/2017_10_06-webinar/

For initial paper, see
<https://www.nwcouncil.org/energy/2017-04-marginal-carbon-draft/>

For initial paper, see
[Marginal Carbon Emissions Study initial scope](#)

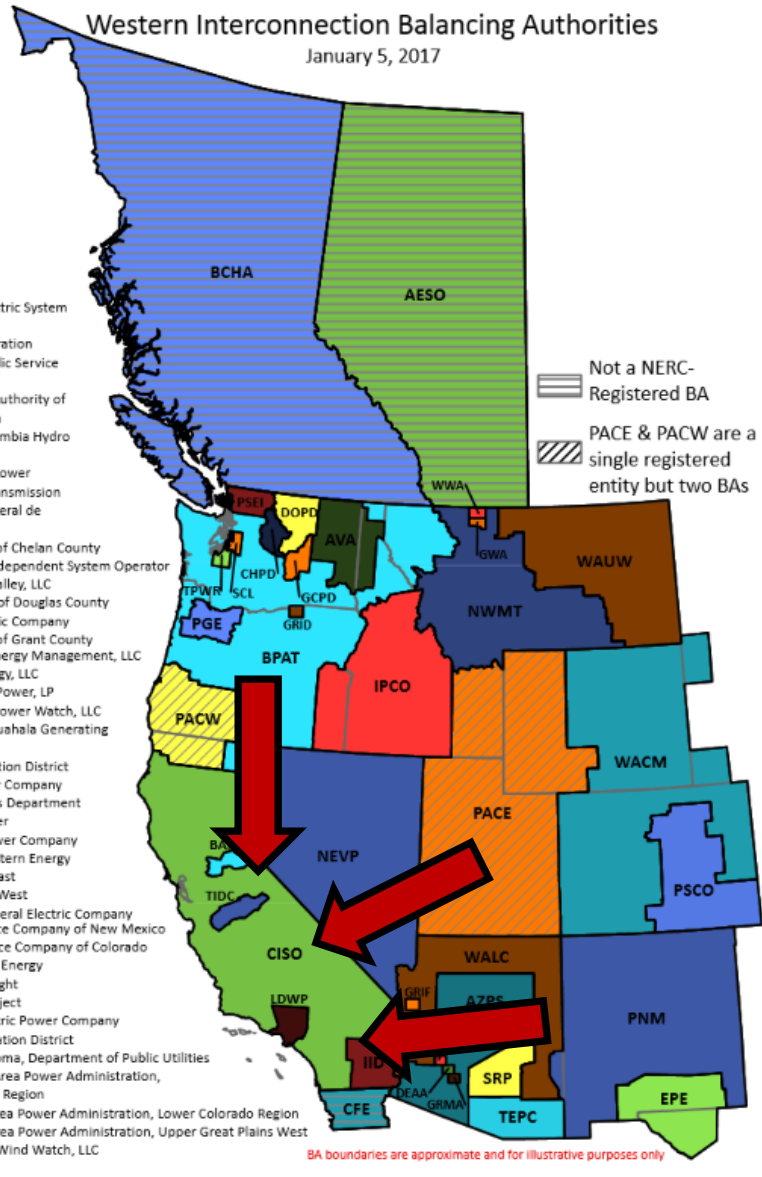
2008 Marginal Carbon Emissions Study:
https://www.nwcouncil.org/media/29611/2008_08.pdf

For more information please contact John Ollis.

Western Interconnection Balancing Authorities

January 5, 2017

- AESO - Alberta Electric System Operator
- AVA - Avista Corporation
- AZPS - Arizona Public Service Company
- BANC - Balancing Authority of Northern California
- BCHA - British Columbia Hydro Authority
- BPAT - Bonneville Power Administration-Transmission
- CFE - Comision Federal de Electricidad
- CHPD - PUD No. 1 of Chelan County
- CISO - California Independent System Operator
- DEAA - Arlington Valley, LLC
- DOPD - PUD No. 1 of Douglas County
- EPE - El Paso Electric Company
- GCPD - PUD No. 2 of Grant County
- GRID - Gridforce Energy Management, LLC
- GRIF - Griffith Energy, LLC
- GRMA - Gila River Power, LP
- GWA - NaturEner Power Watch, LLC
- HGMA - New Harquahala Generating Company, LLC
- IID - Imperial Irrigation District
- IPCO - Idaho Power Company
- LDWP - Los Angeles Department of Water and Power
- NEVP - Nevada Power Company
- NWMT - NorthWestern Energy
- PACE - PacifiCorp East
- PACW - PacifiCorp West
- PGE - Portland General Electric Company
- PNM - Public Service Company of New Mexico
- PSCO - Public Service Company of Colorado
- PSEI - Puget Sound Energy
- SCL - Seattle City Light
- SRP - Salt River Project
- TEPC - Tucson Electric Power Company
- TIDC - Turlock Irrigation District
- TPWR - City of Tacoma, Department of Public Utilities
- WACM - Western Area Power Administration, Colorado-Missouri Region
- WALC - Western Area Power Administration, Lower Colorado Region
- WAUW - Wester Area Power Administration, Upper Great Plains West
- WWA - NaturEner Wind Watch, LLC



Marginal Carbon Dioxide Production Rate Report: Study Release

Power Committee
John Ollis
March 13th, 2018

Why are we Having this Discussion Again?

1. Stakeholder response to first draft asked for more involvement and input on methodology.
2. Multiple meetings with SAAC on methodology.
3. Similar average results, but larger ranges and different reasoning.
4. Approval to release second draft of study.
5. Second draft of study released in January 2018 for stakeholder feedback.
6. **Report on stakeholder feedback and release final study in March 2018.**

Context for Results

- Recall:
 1. Contemporary natural gas-fired combined cycle unit emits roughly 0.8 to 0.9 pounds (lbs.) of CO₂ per kilowatt-hour.
 2. A typical conventional coal-fired steam unit emits roughly 2.1 to 2.4 lbs. of CO₂ per kilowatt-hour.
 3. Peaker gas units have a larger range of emissions rates 1.1 to 1.7 lbs. of CO₂ per kilowatt-hour.

Annual Avoided Emissions Rate (lbs. of CO₂ per kWh) by Scenario

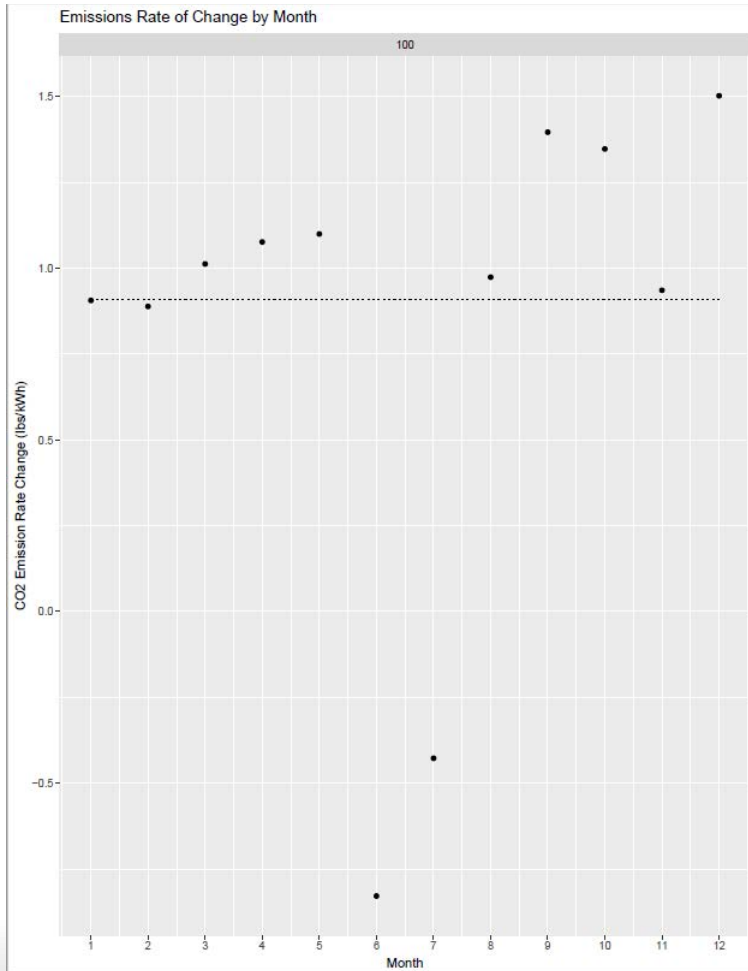
Scenario	Existing Policy	Social Cost of Carbon
2016	1.83	1.40
2021	0.91	0.58
2026	0.93	0.70
2031	0.97	0.55

- *Modern natural gas-fired combined cycle unit emits 0.8 to 0.9 lbs. of CO₂ per kWh.*
- *Conventional coal-fired steam unit emits roughly 2.1 to 2.4 lbs. of CO₂ per kWh.*
- *Peaker gas units have a larger range of emissions rates 1.1 to 1.7 lbs. of CO₂ per kWh.*

Stakeholder Discussion

- The last draft was open for comment until February 16, 2018.
- Comments and observations were incorporated into final draft and sent to SAAC participants for a final check.
- Main comments/questions
 1. Appropriate usage
 - a. Depth of net load reduction
 - b. Shape of net load reduction
 2. Methodology

WECC Avoided Carbon Emissions Rate Methodology



The *average avoided emissions rate* over the output changed in the WECC from the flat drop of 100 MW in 2021 is

$$\frac{Emissions_{100} - Emissions_0}{Output_{100} - Output_0} = .91 \text{ lbs/kWh}$$

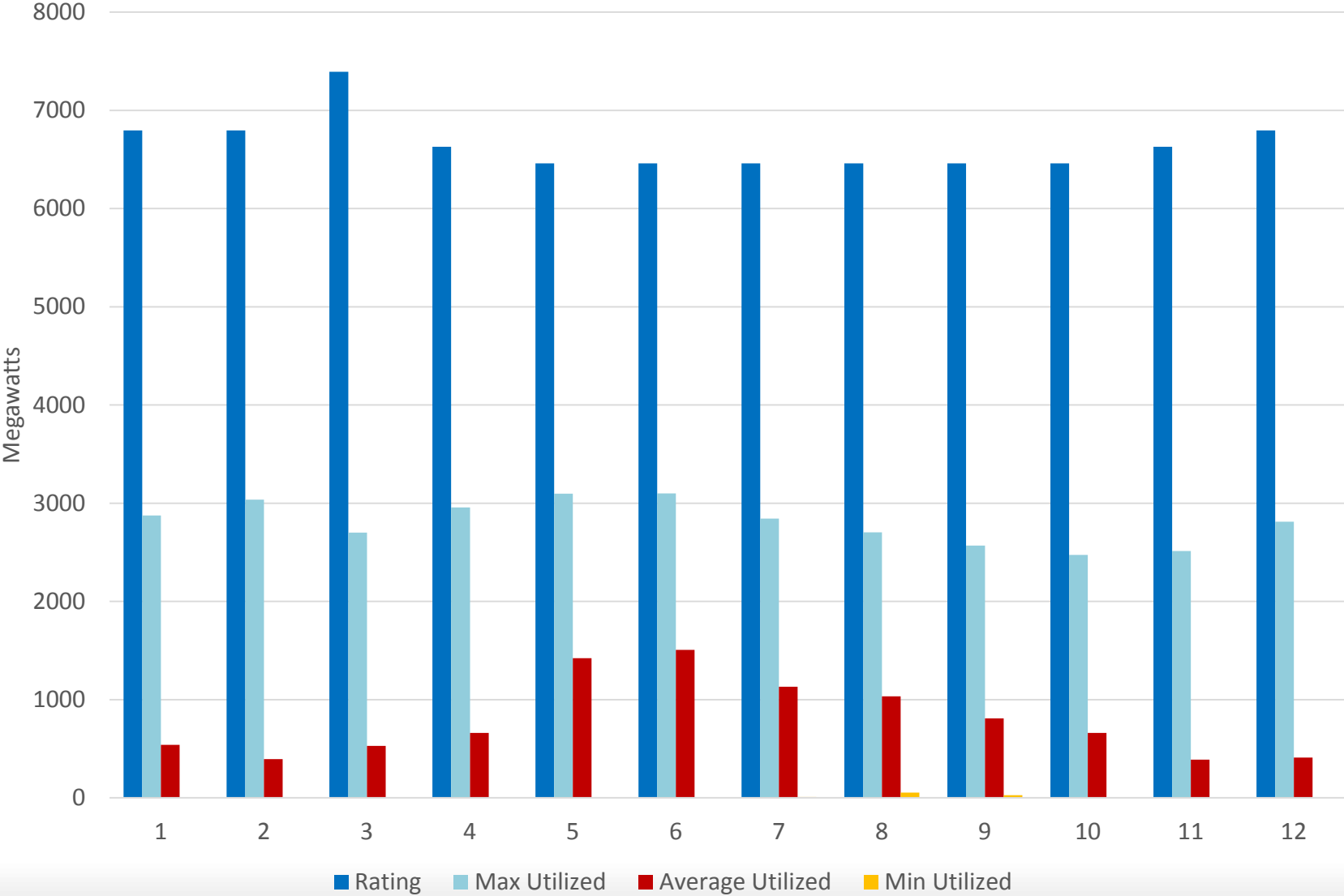
Variable Definition:

1. $Emissions_{100}$ is the emissions in the WECC with 100 MW less load run
2. $Emissions_0$ is the emissions in the WECC in the base run
3. $Output_{100}$ is the output in the WECC with 100 MW less load run
4. $Output_0$ is the emissions in the WECC in the base run

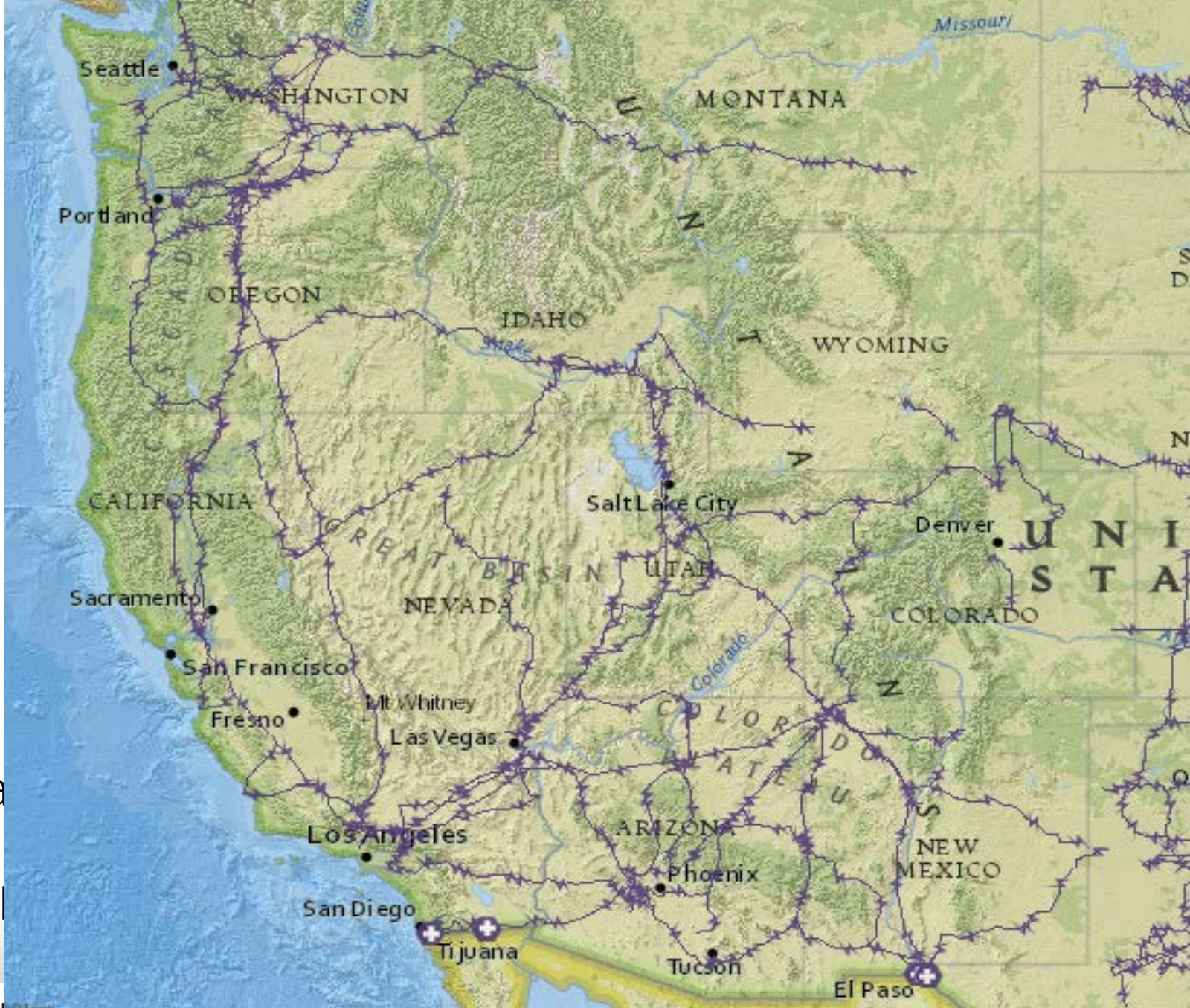
Main Drivers of Emissions Rate Changes

- **NW export levels (hydro variability)**
 - If CA does not get power from us, they get it from coal and gas plants in Desert Southwest or Mountain West.
- **Amount of coal in middle WECC resource stack.**
 - Most not in NW
 - Over 11,000 MW of scheduled coal retirements in WECC between 2016 and 2031

Regional Exports to California



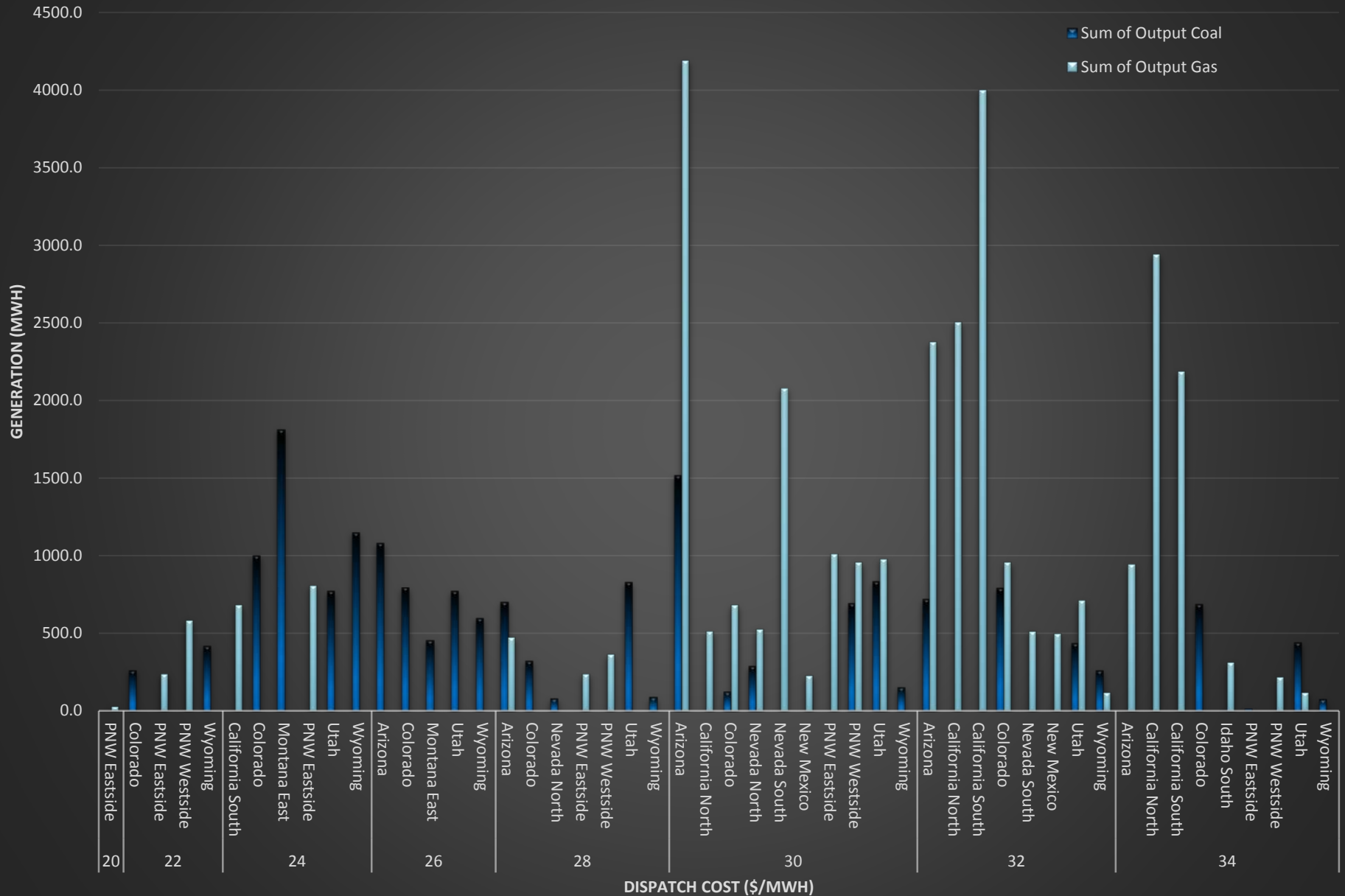
Tra
To
AU



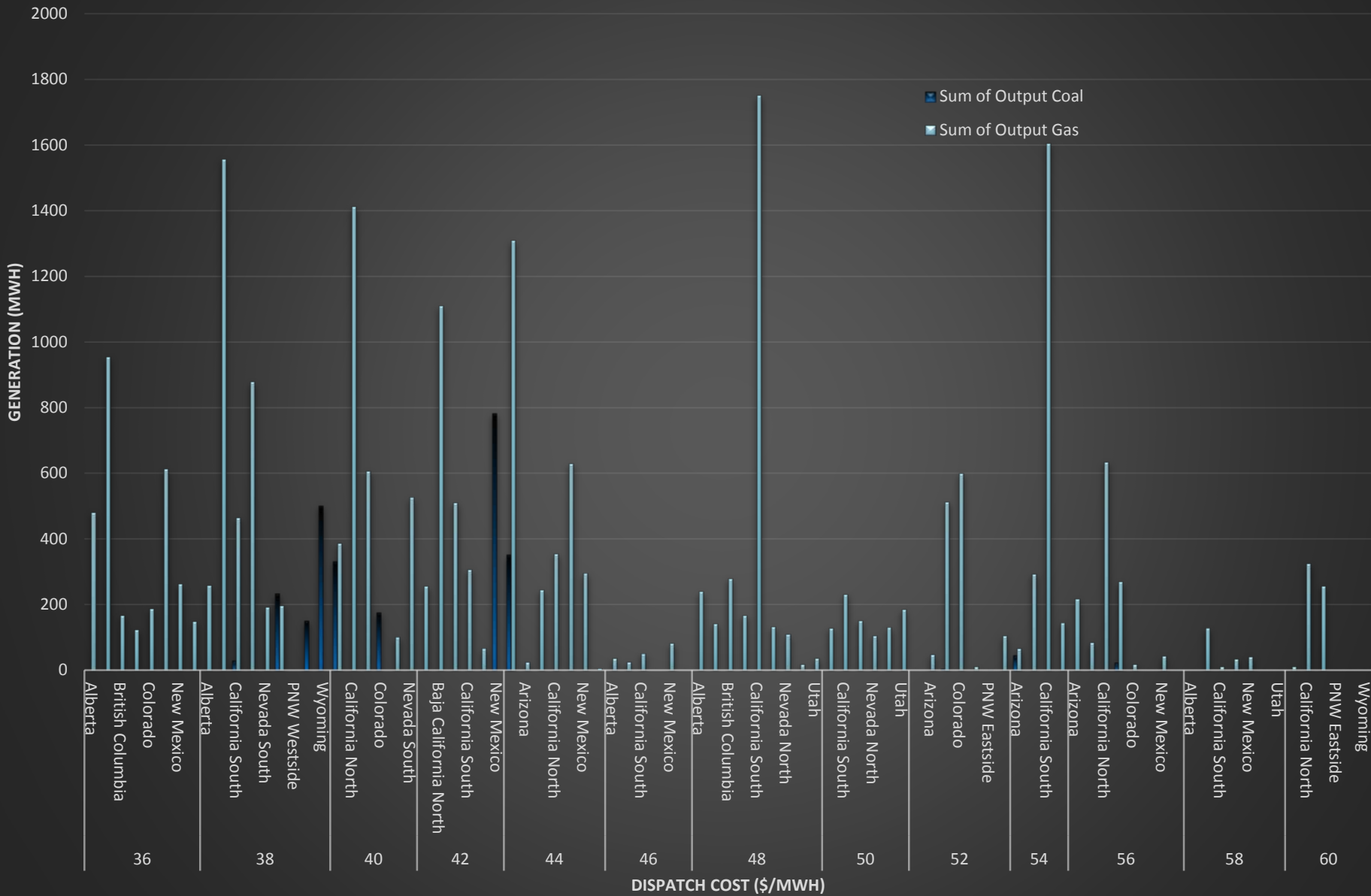
What are we optimizing?

- The optimization in AURORA is focusing on meeting load at the **lowest cost**.
- Optimizing for the **lowest CO2 emissions** would be a different objective.
- Varied fuel types lead to big emissions rate swings from
 - Hour to hour, and
 - Hydro condition to hydro condition, but
 - On an expected basis similar to rate of CCCT

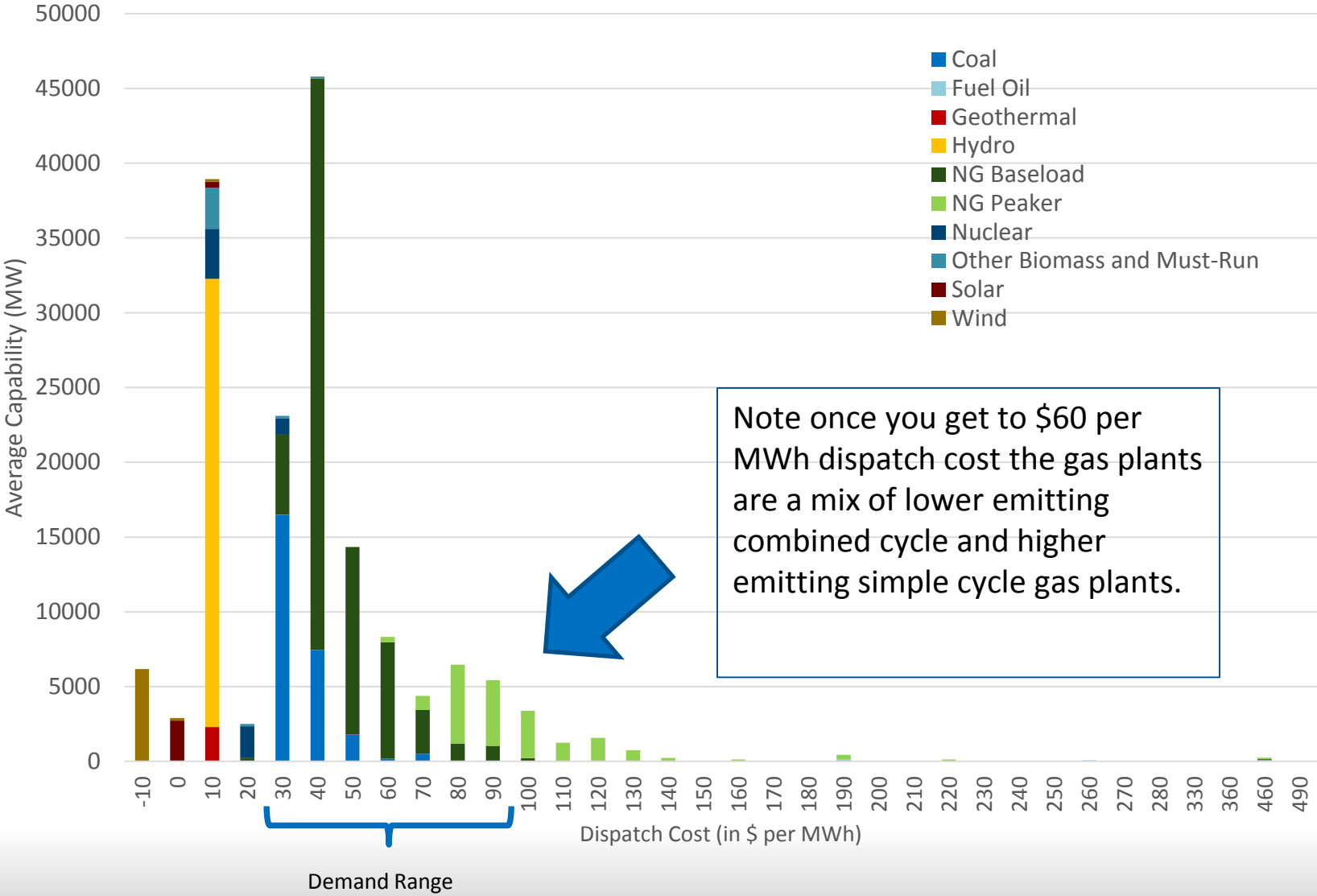
Simulation of WECC Dispatch July 9th, 2021 at 7 PM 2001 Hydro Conditions



Simulation of WECC Dispatch July 9th, 2021 7 PM 2001 Hydro Conditions



2021 WECC Resource Portfolio - Good Hydro Conditions



Annual Avoided Emissions Rate (lbs. of CO₂ per kWh)

Scenario	Existing Policy	Social Cost of Carbon
2016	1.83	1.40
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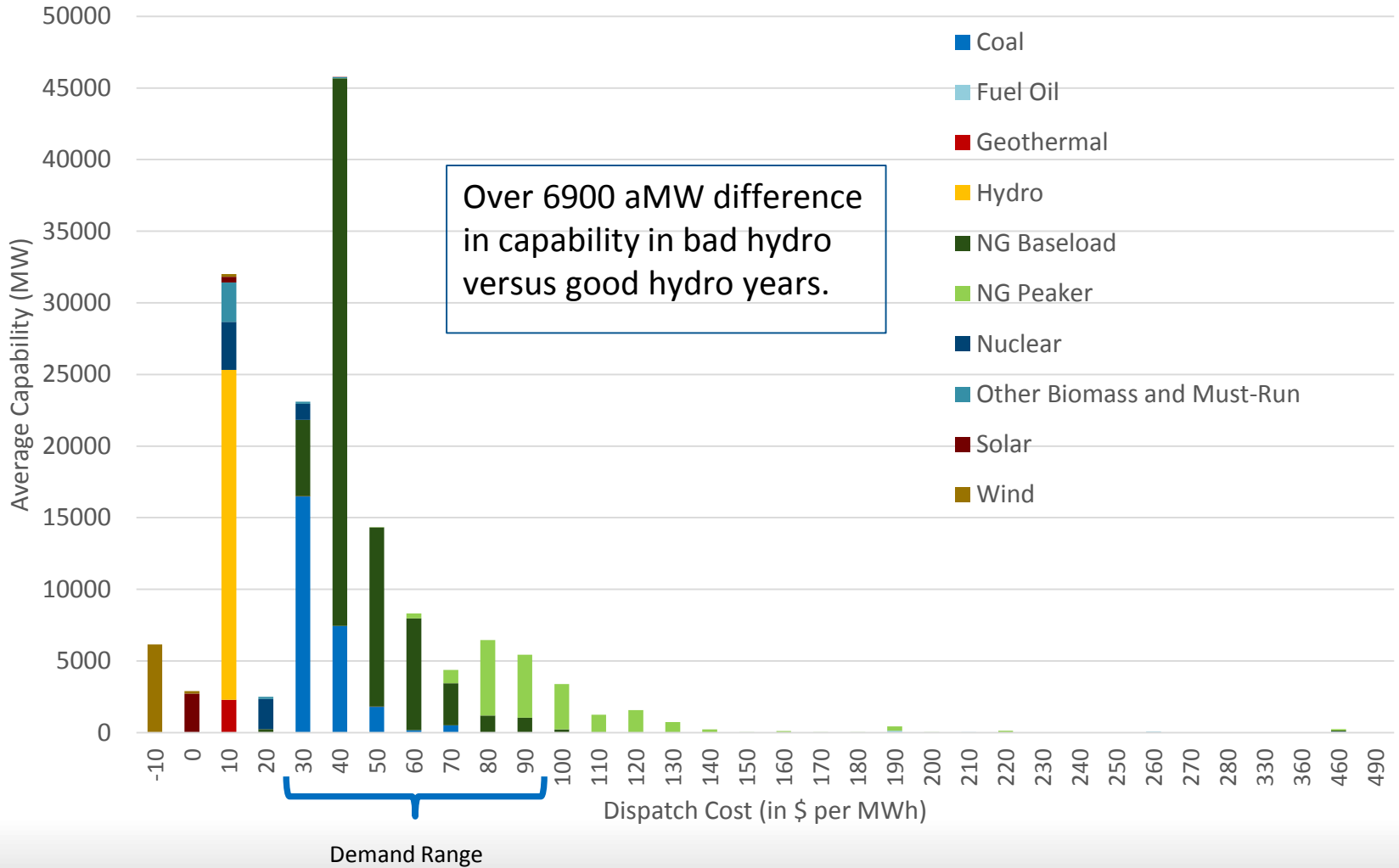
- *Modern natural gas-fired combined cycle unit emits 0.8 to 0.9 lbs. of CO₂ per kWh.*
- *Conventional coal-fired steam unit emits roughly 2.1 to 2.4 lbs. of CO₂ per kWh.*
- *Peaker gas units have a larger range of emissions rates 1.1 to 1.7 lbs. of CO₂ per kWh.*

Approval to Release Study

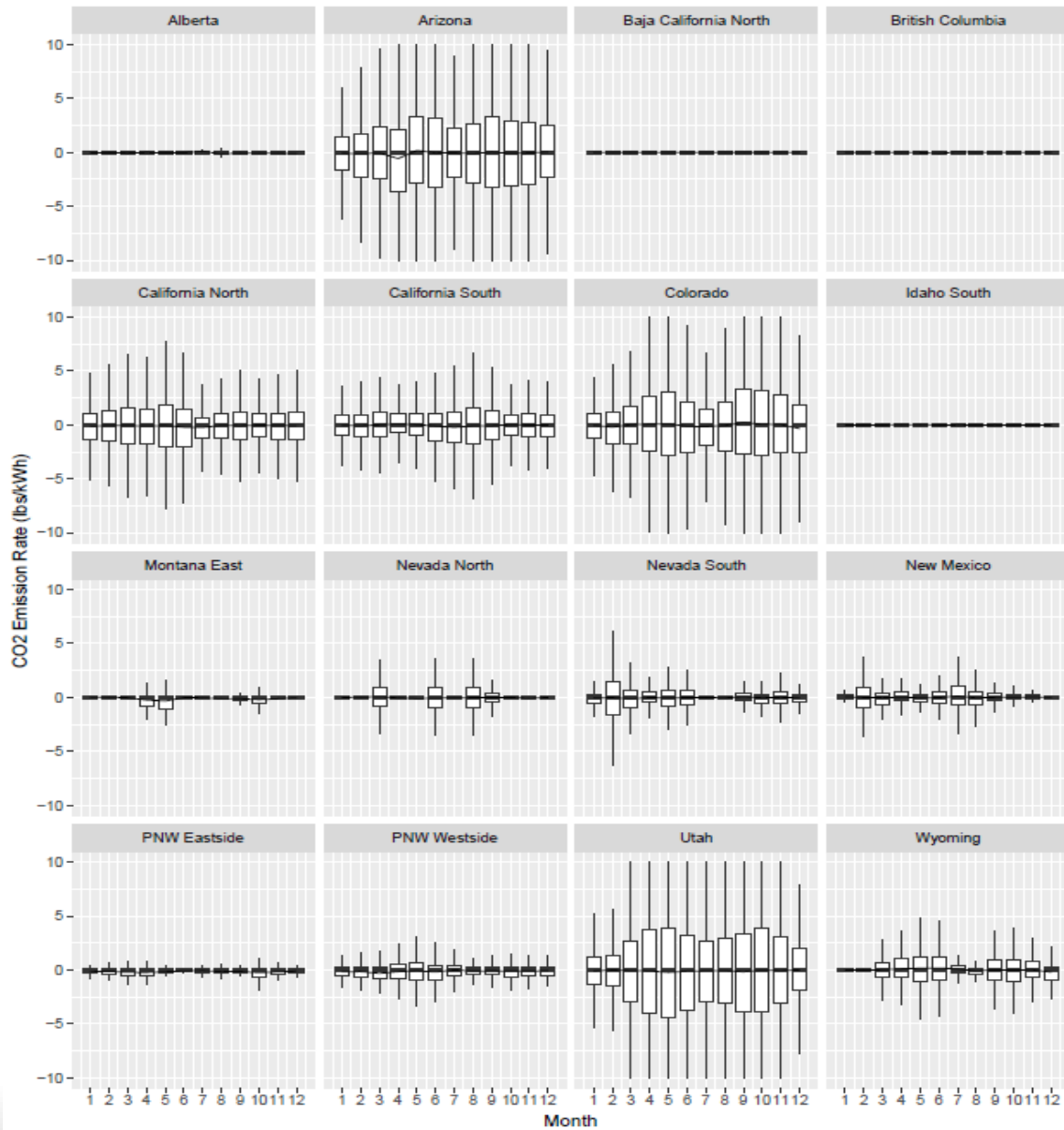
- Questions?

Additional Content for Reference

2021 WECC Resource Portfolio - Poor Hydro Conditions



Emissions Rate By Month



WECC Emissions Rate Changes by Zone

Notice the spreads are large but the net effect may still be small depending on how much output is increased or decreased at that emissions rate

WECC-wide data

- **Change in fuel usage at plants**
 - What types of plants are driving the emissions rate?
- **Change in delta emissions and output**
 - Where are plants changing output?
 - What is driving the large emissions changes?
 - Is this driven by hydro exports?

Box Plot Review

Since we need to look at distributions of results...

- Lower boundary on box: 25% quantile
- Middle line: 50% quantile
- Upper boundary on box: 75% quantile
- Min and max whiskers:

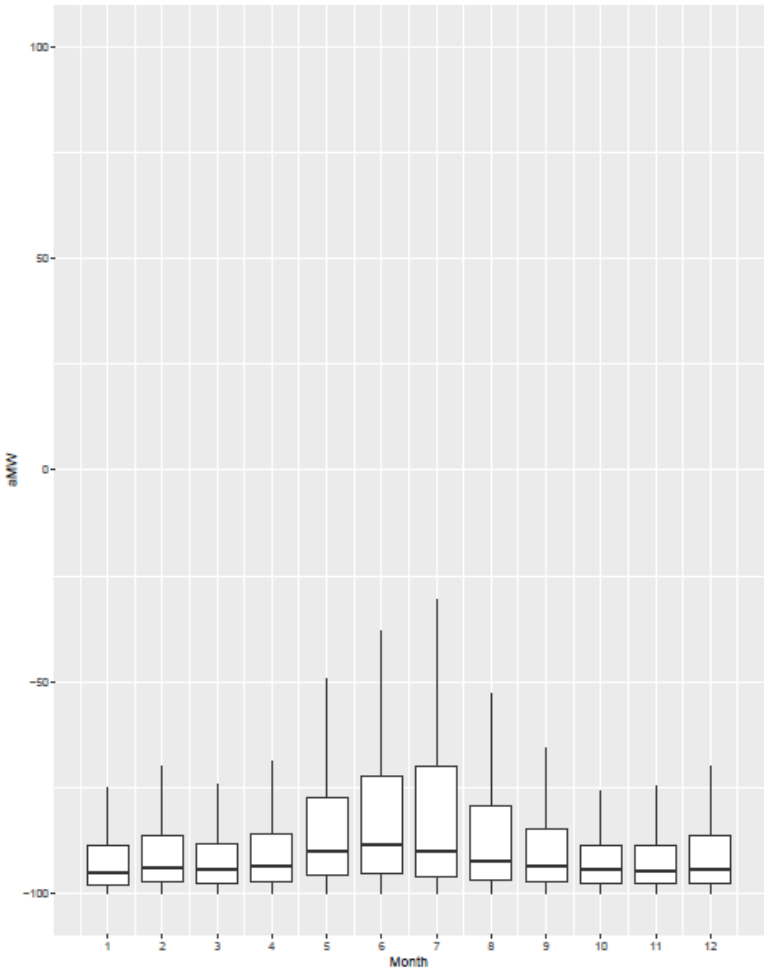
(Min Observation-1.5*IQR, Max Observation+1.5*IQR)

- IQR is Interquartile range

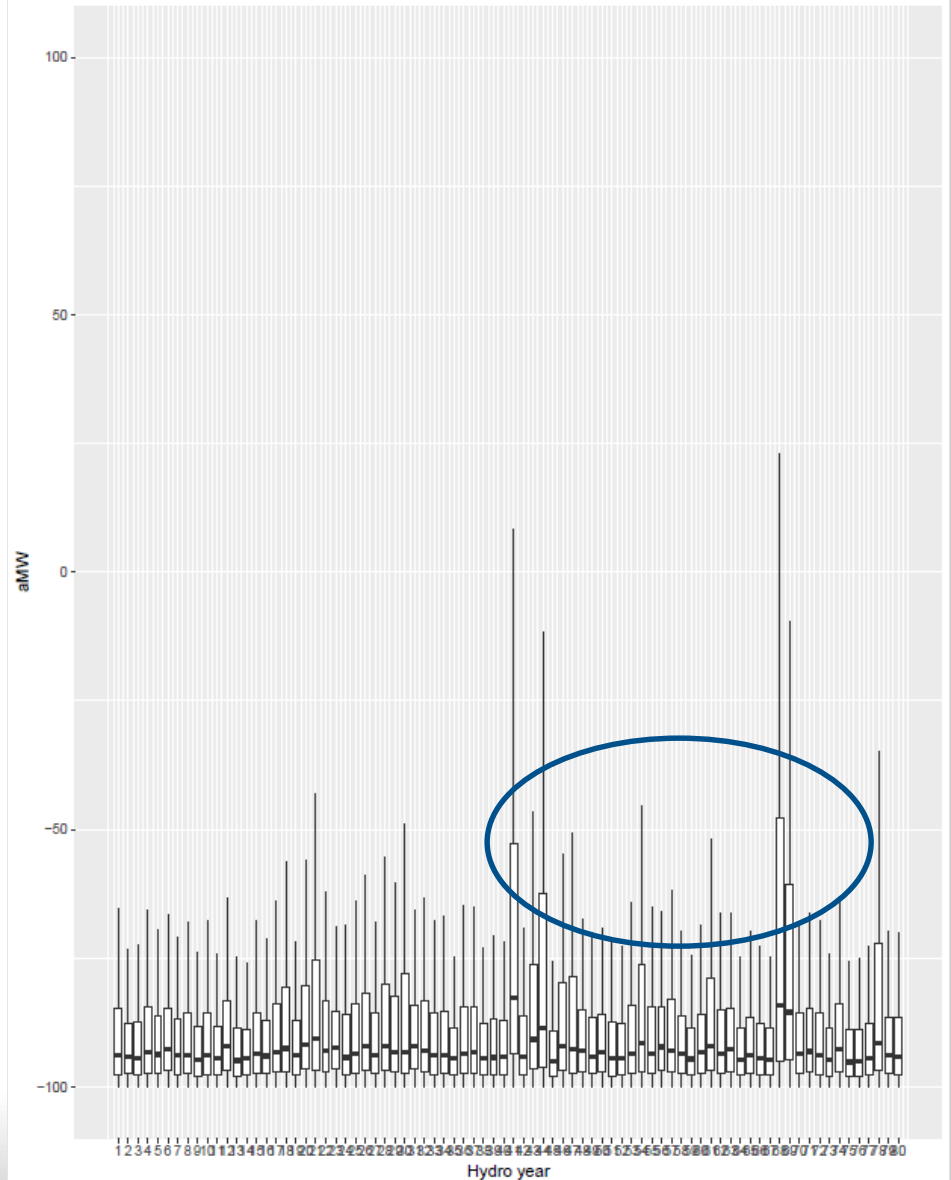
WECC Output Change

As expected, this is close to 100 MW less output in the WECC corresponding to the flat load drop of 100 MW in the PNW Westside.

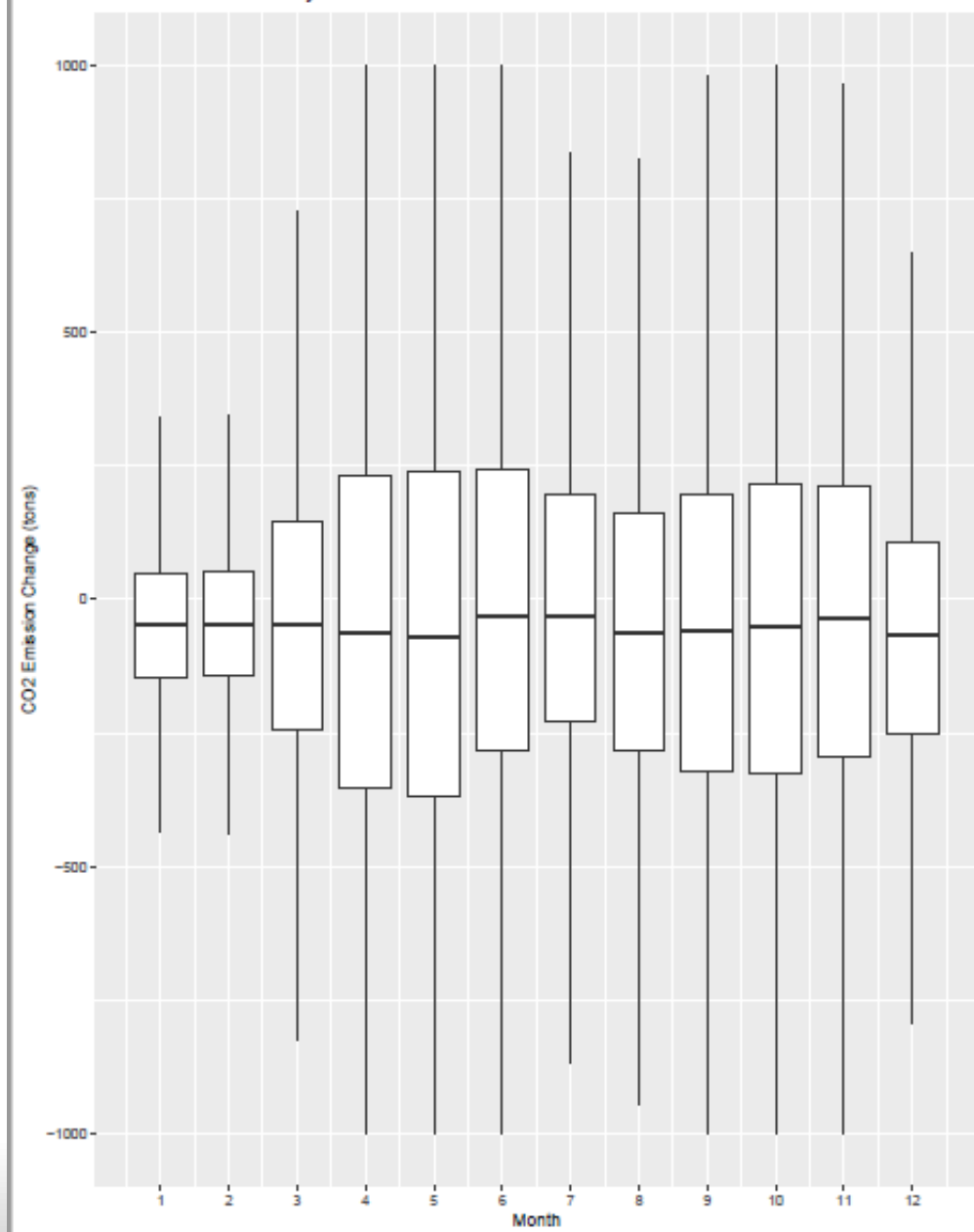
Output Variations By Month



Output Variations By Hydro Year



Emissions Variations By Month

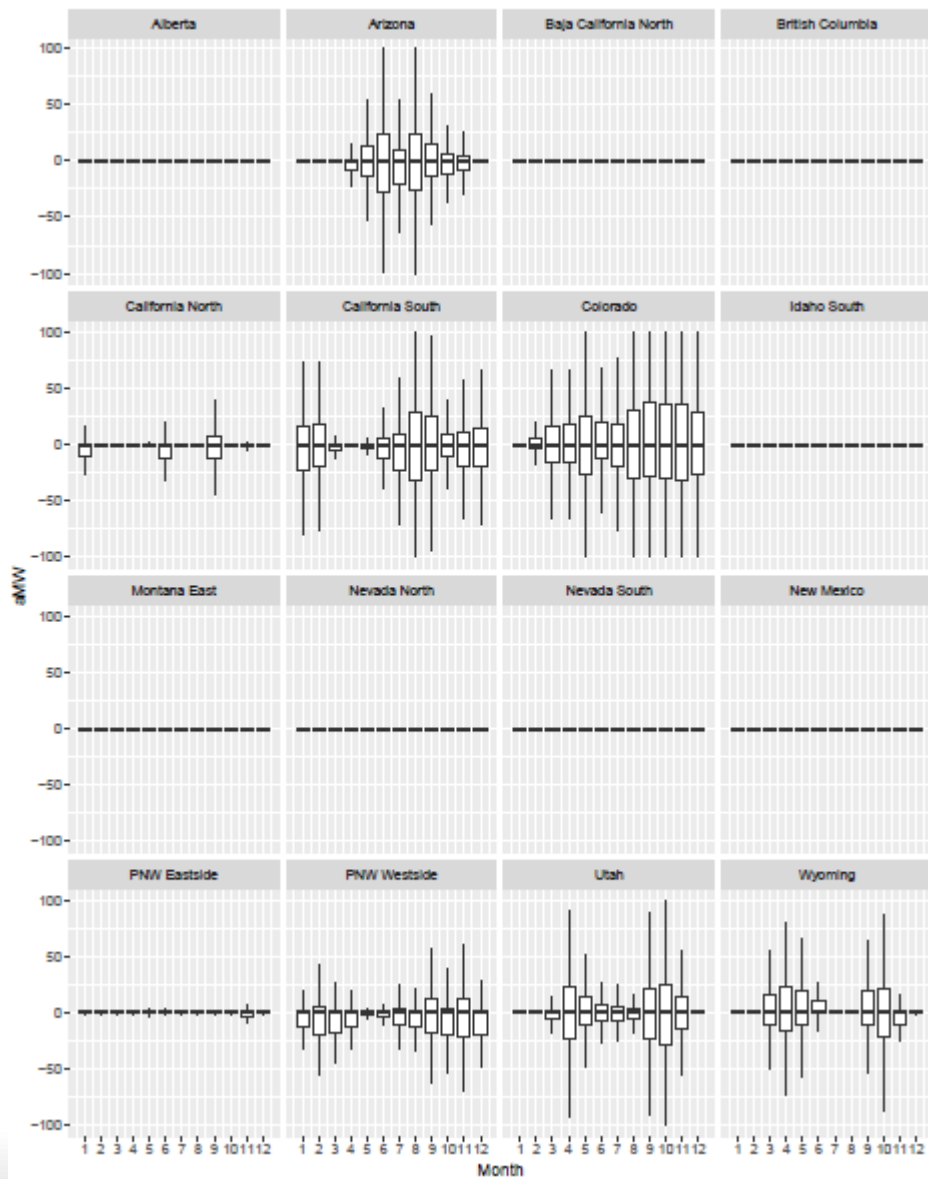


WECC Emissions Change

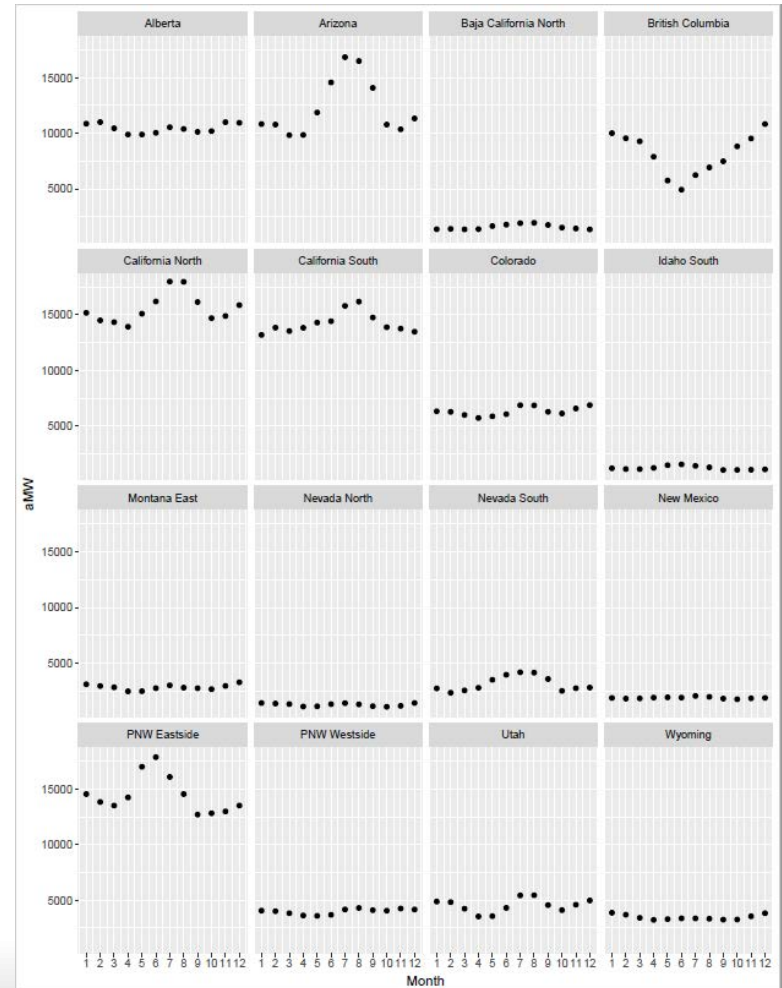
For context, all the changes in emissions are very small ($\ll 1\%$) in comparison to the total amount of WECC Emissions in a month.

	Report_Month [△]	Amount [△]
1	1	61319815
2	2	54787489
3	3	55211064
4	4	47719302
5	5	52770715
6	6	56887022
7	7	67330810
8	8	67567049
9	9	58443896
10	10	54794026
11	11	56928405
12	12	62391053

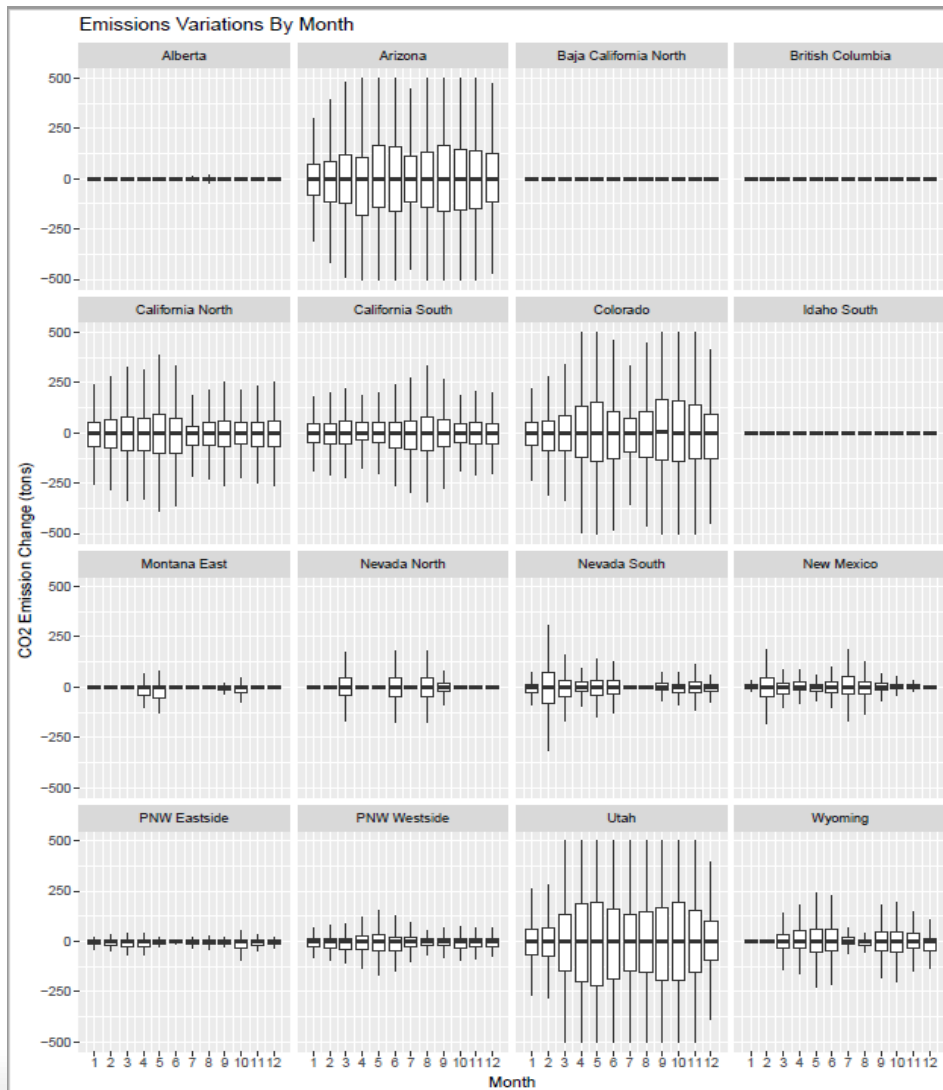
Output Variations By Month



WECC Output by Zone

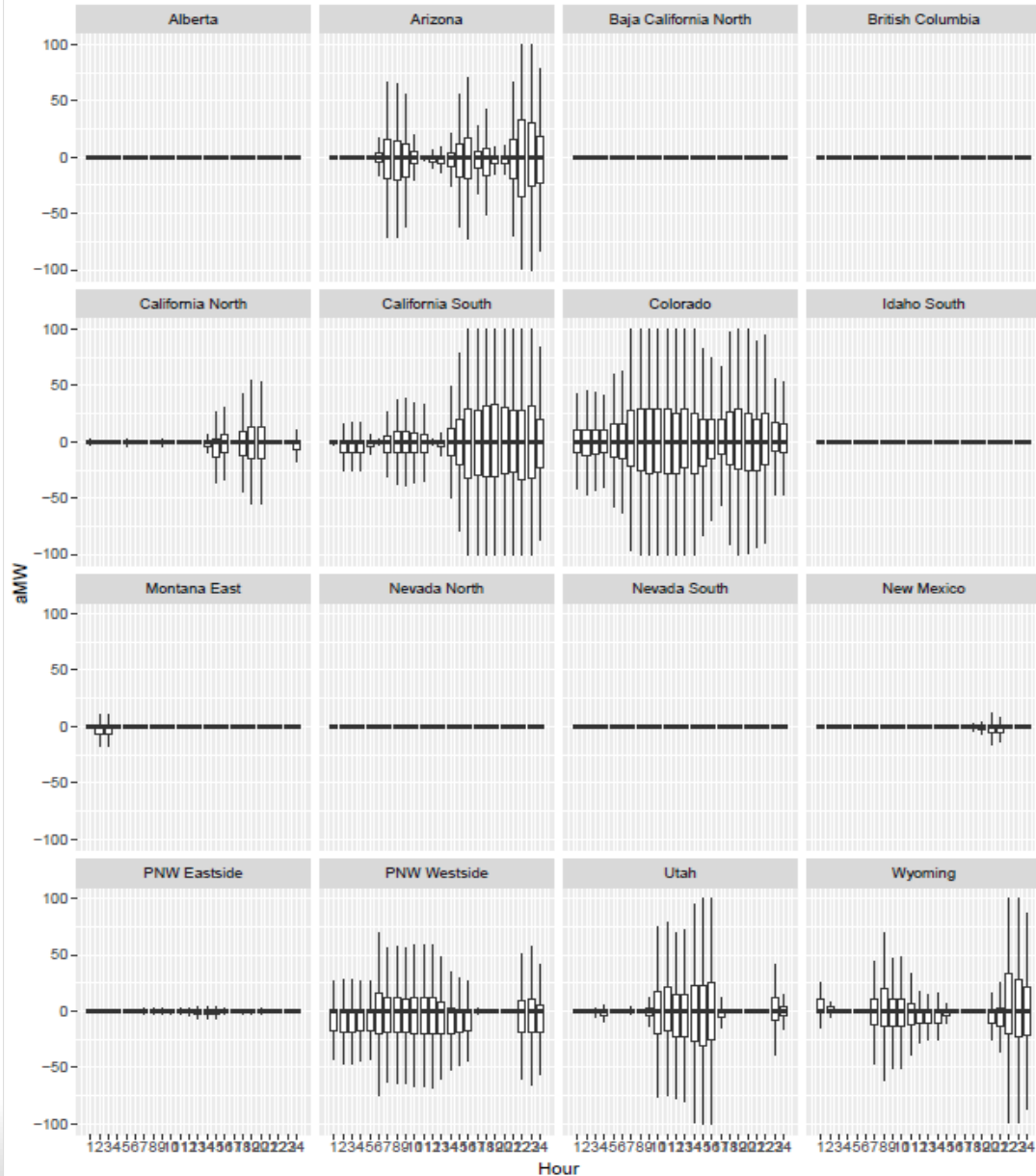


WECC Emissions Change by Zone



Notice that most of the emissions change happens in a few zones and not much in the NW

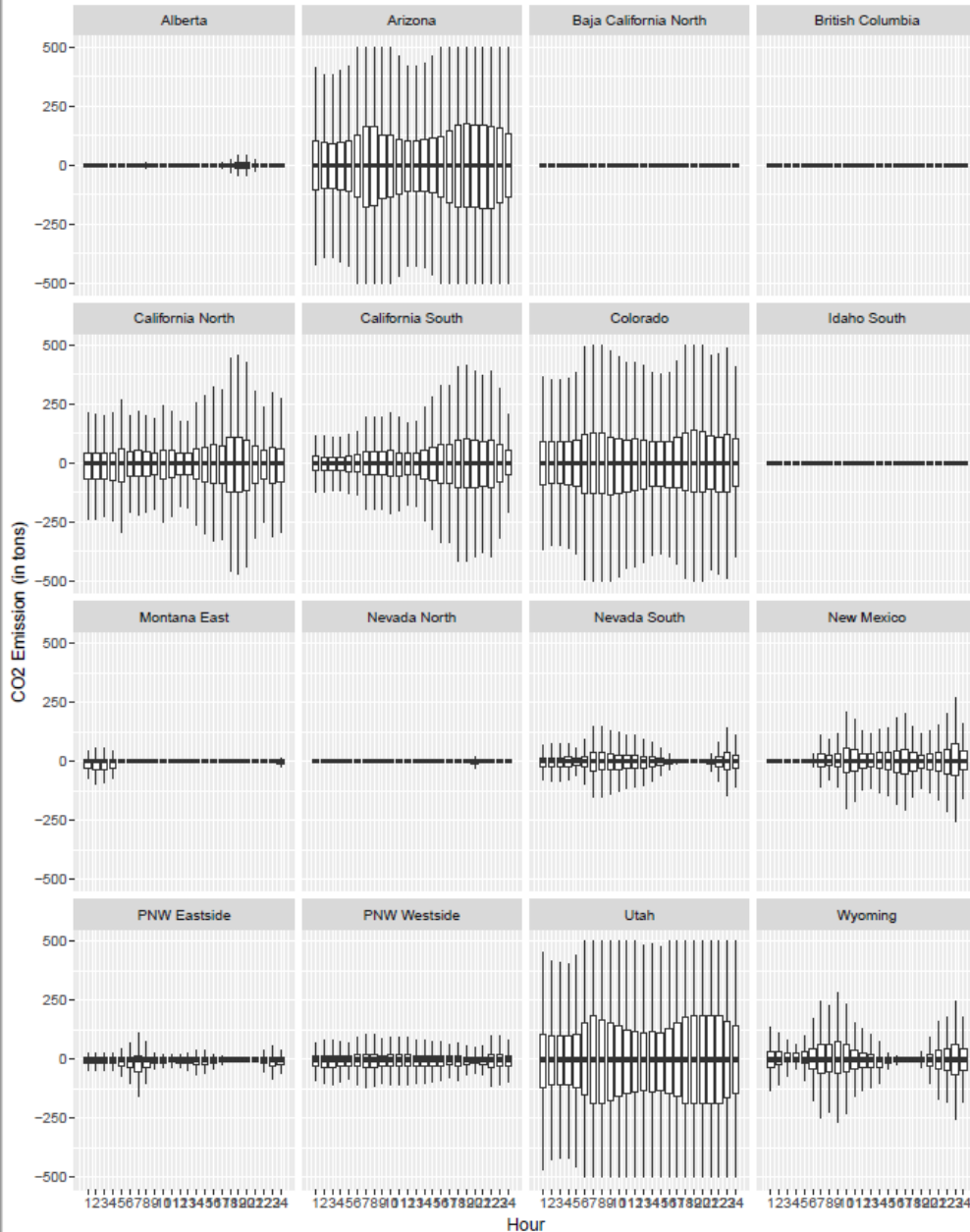
Output Variations By Hour



Output Change By Hour

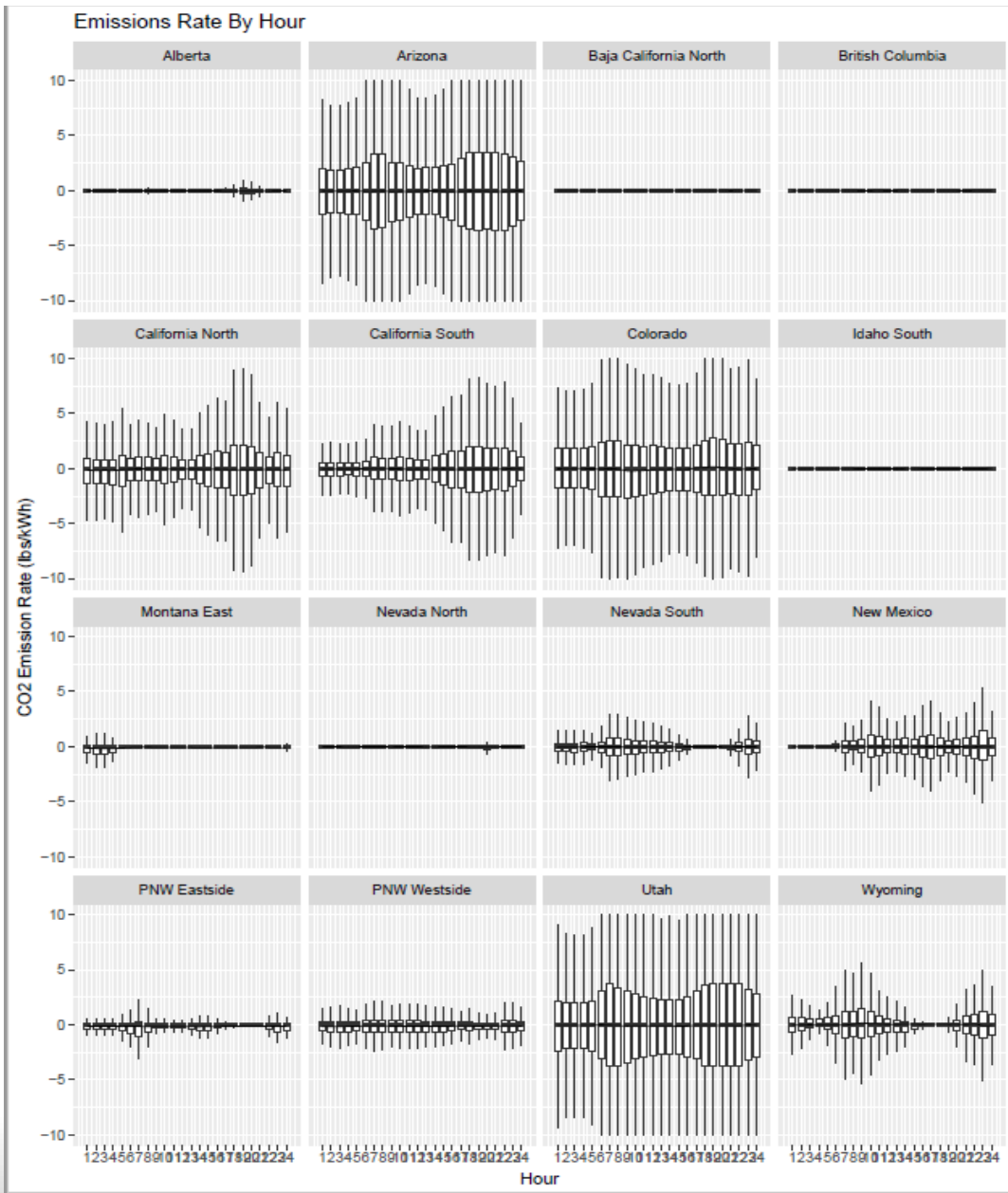
There are some patterns here, like more variation around the daily load shape in certain zones.

Emissions Change By Hour



Emissions Change By Hour

There are some similar patterns here, like more variation around the daily load shape in certain zones.



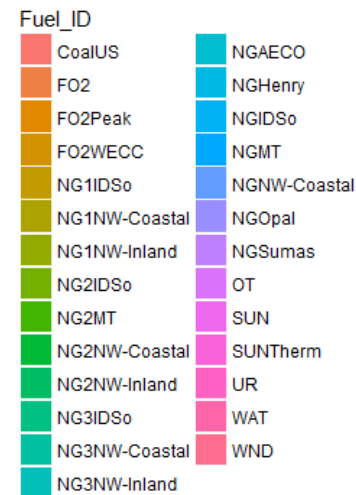
Emissions Rate Change By Hour

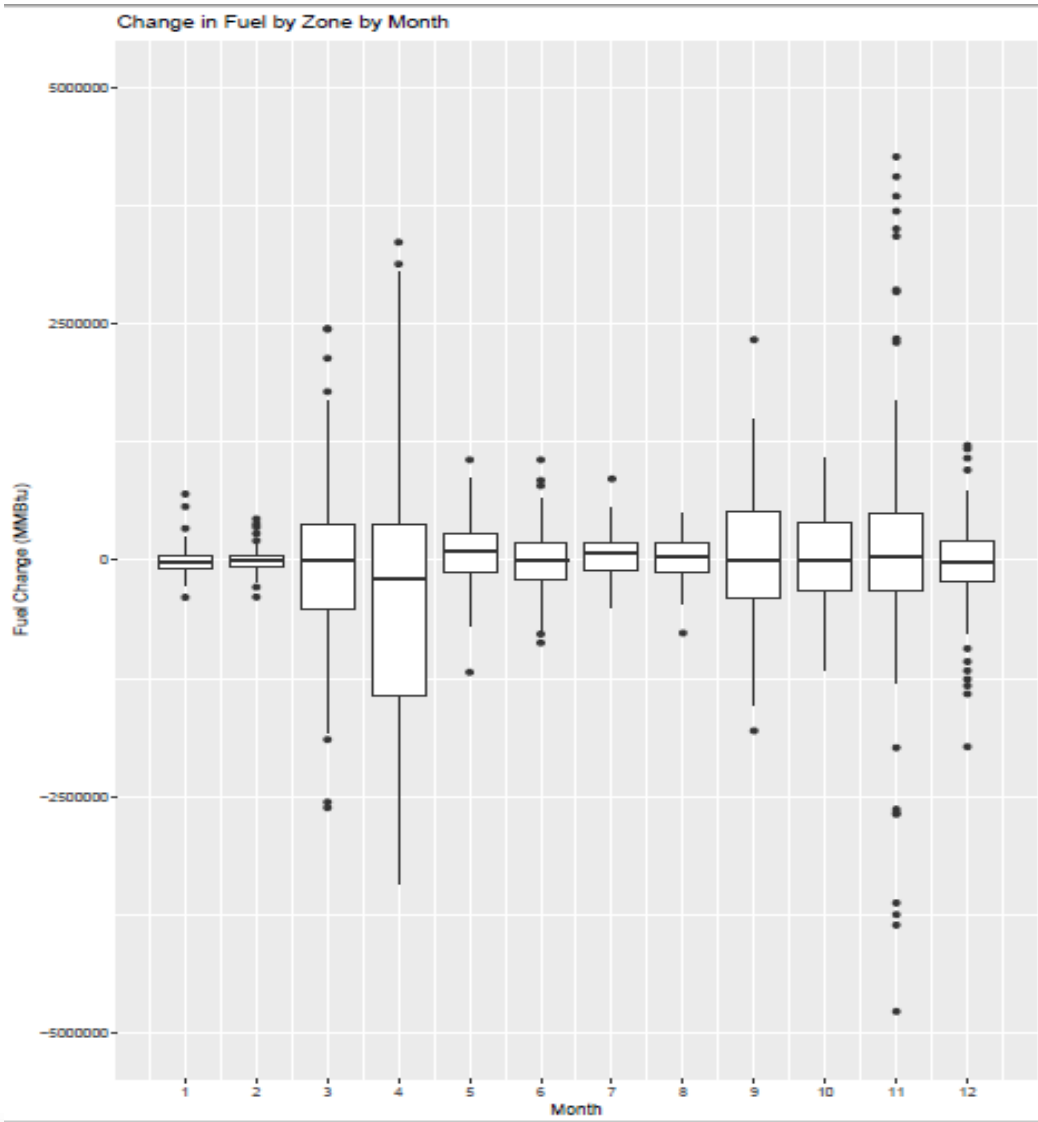
There are some similar patterns here, like more variation around the daily load shape in certain zones.

Change in Fuel by Zone by Month

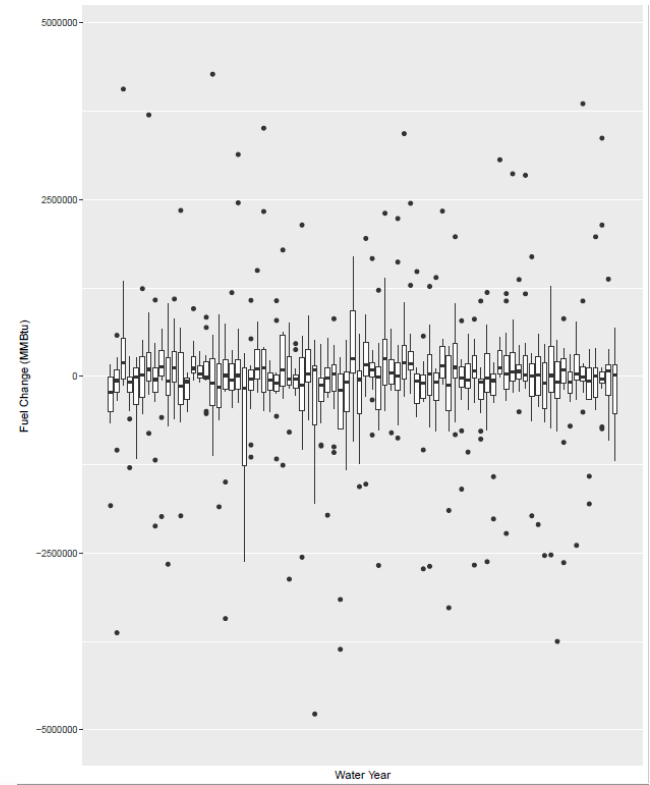


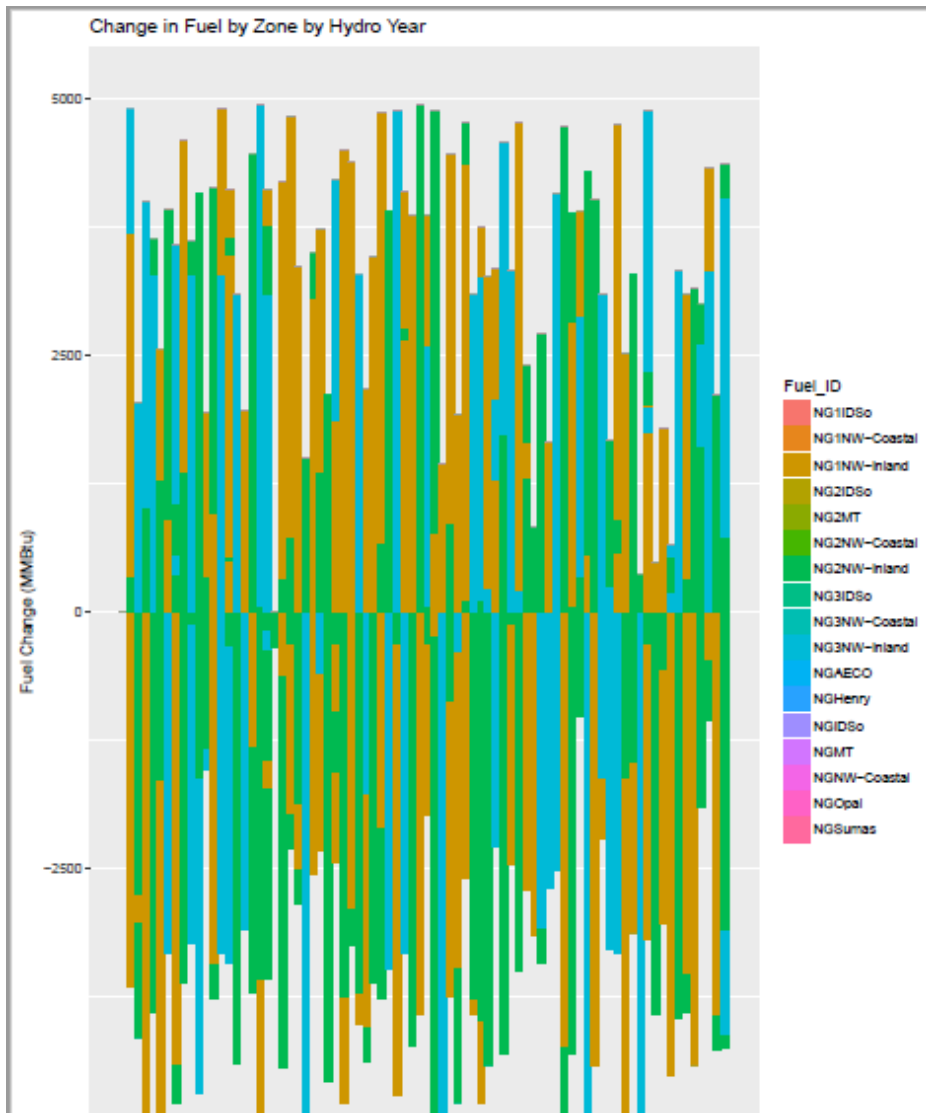
Coal plant fuel usage in Arizona changes the more than any fuel by month, but why?





- Coal usage drives WECC emissions change
- Coal usage in Arizona fluctuates by month and by water condition





In the east side of the region, gas usage changes, but not often and not much.

