South to North Flows In the WECC

By: Ben Hutchins, WPP

Co-Author: Zach Zornes, CHPD

For: WECC SRS, April 11th, 2024

Today's Focus

Heavy Winters

Repeated Comments from Our Members

COI & PDCI: What about **South to North flows**?

We're seeing it in Operations during **Heavy Winters**, what do we do?

Is this an "**unstudied scenario**"?

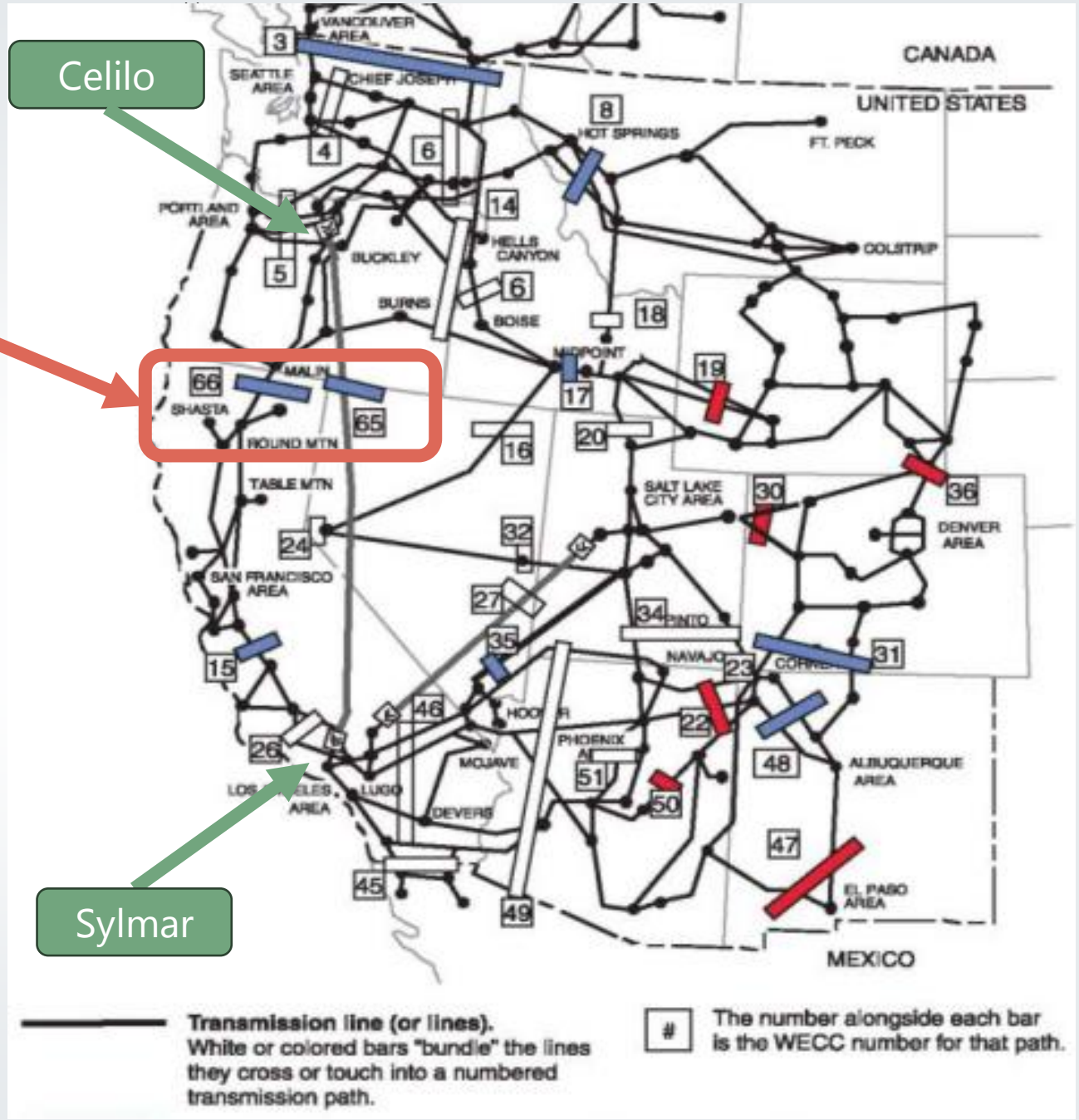
PDCI?
COI?

For the uninitiated…

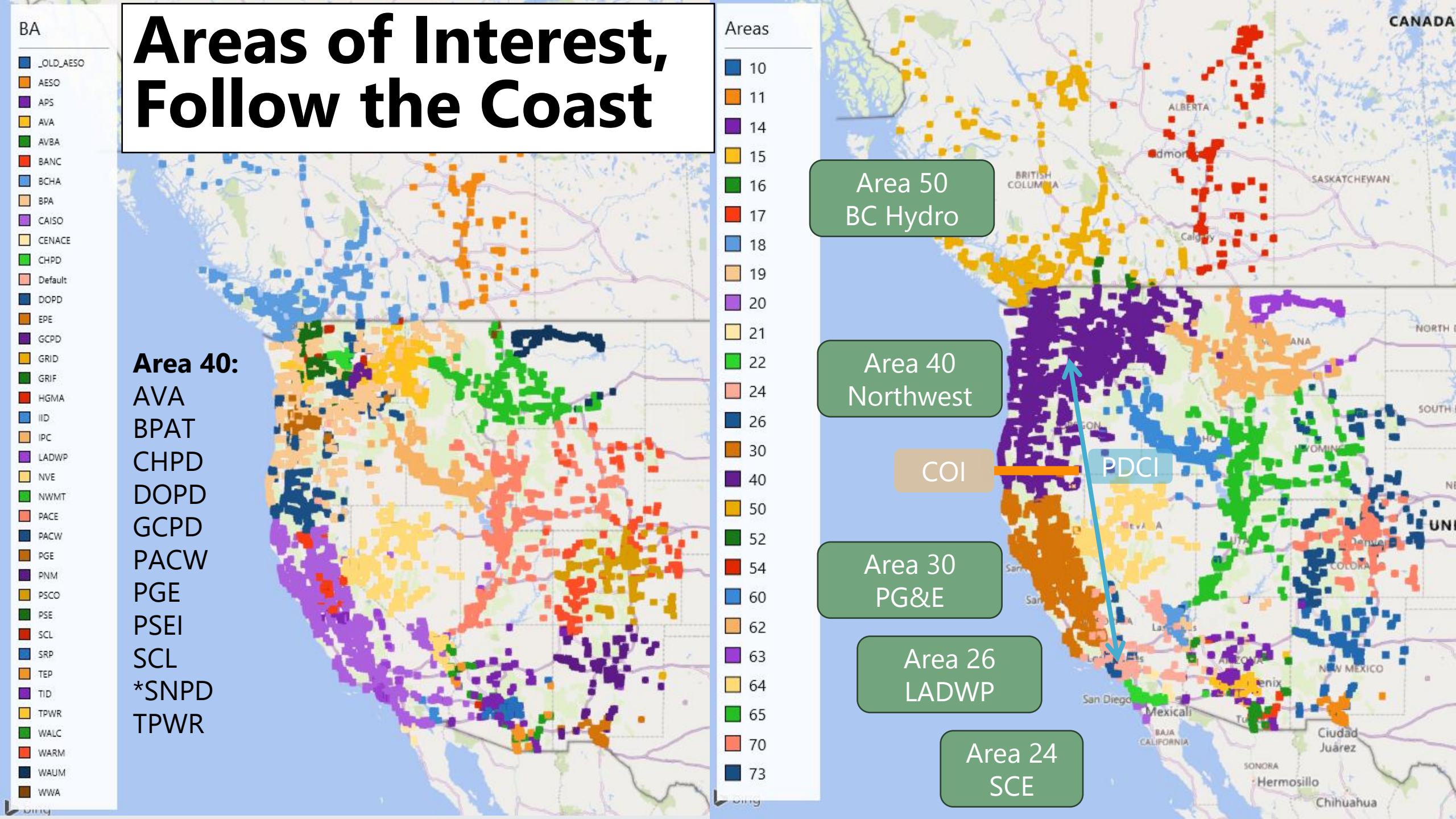
PDCI, Path 65, the “DC” part
- Pacific DC Intertie
- Celilo to Sylmar 500kV DC, Bi-Pole
- Schedules NW (Area 40) to LADWP (Area 26)

COI, Path 66, the “AC” part
- California – Oregon Intertie
- Malin – Round Mountain 525kV #1 & #2
- Captain Jack – Olinda 525kV
- Schedules NW (Area 40) to PG&E (Area 30)

Both paths generally serve transfers between
- North-West (WA/OR)
- South-West (CA)



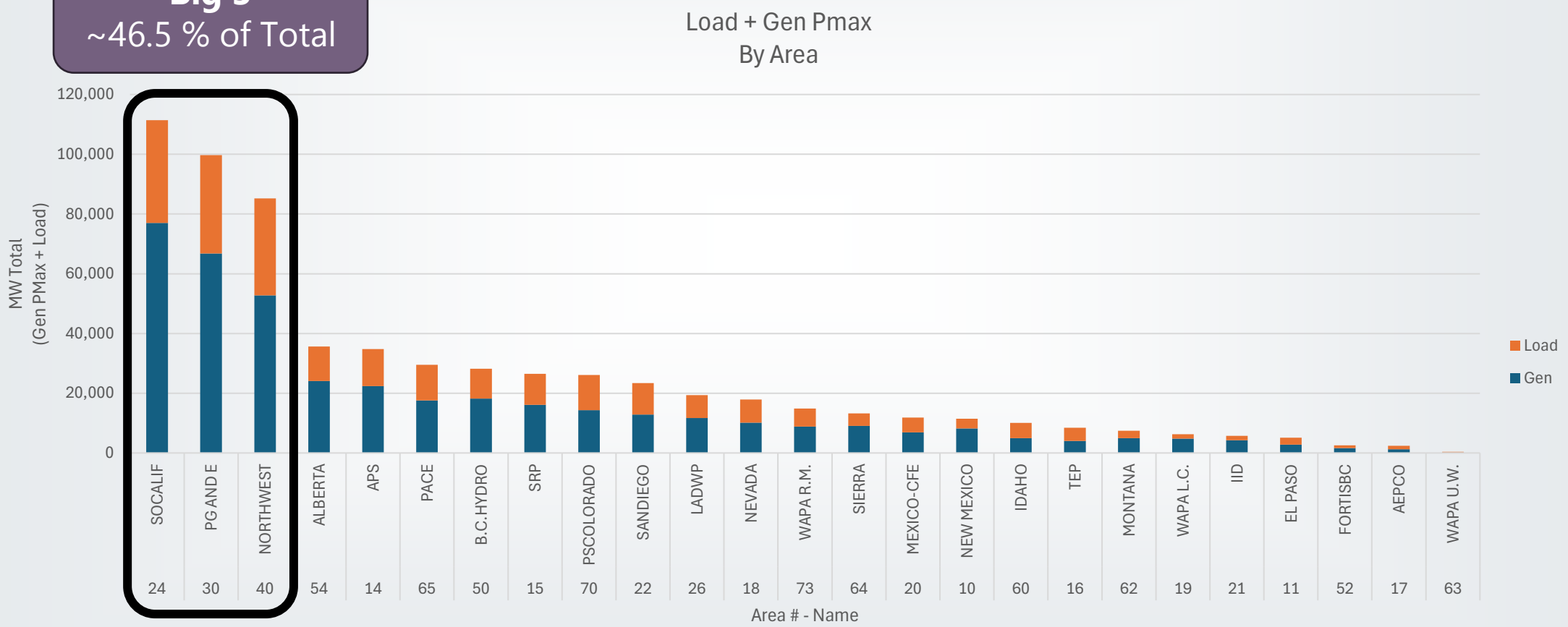
Areas of Interest, Follow the Coast



Area 40:
AVA
BPAT
CHPD
DOPD
GCPD
PACW
PGE
PSEI
SCL
*SNPD
TPWR

Perspective on Areas – 34HS1

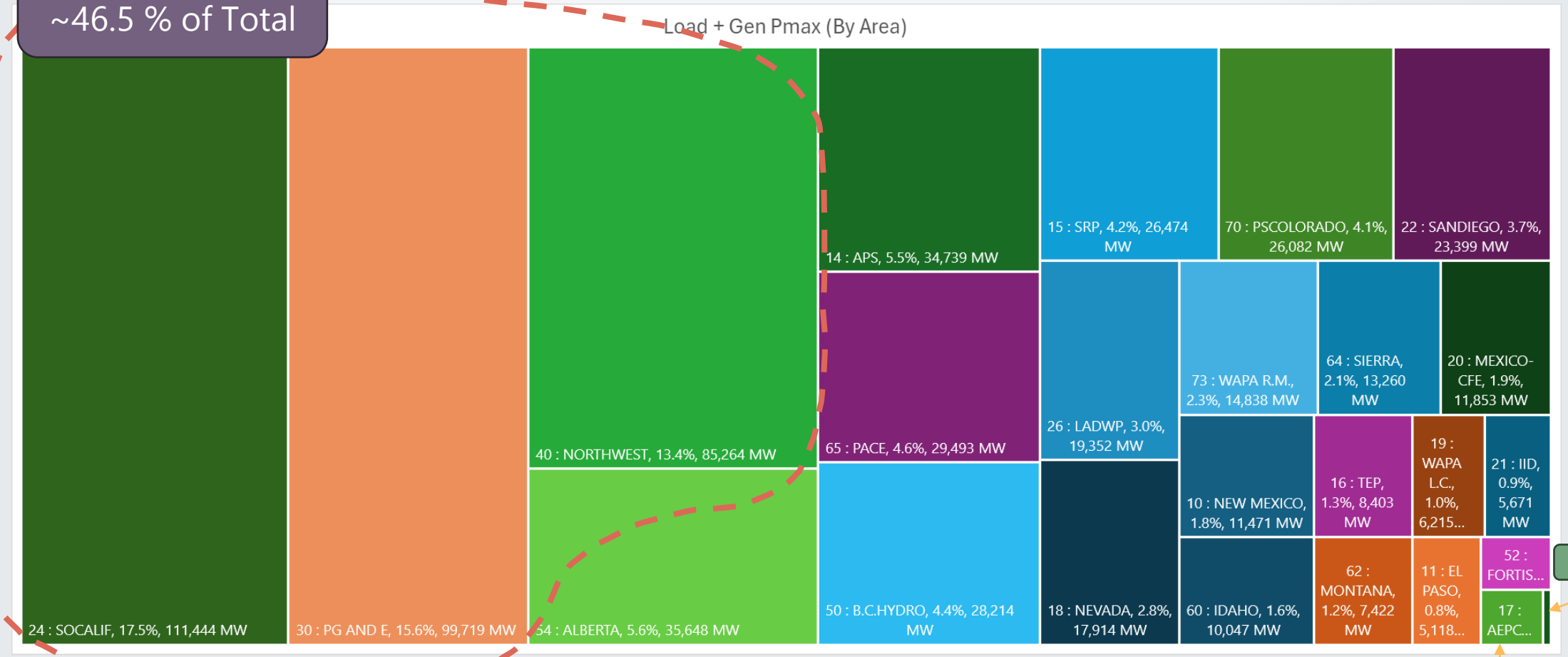
"Big 3"
~46.5 % of Total



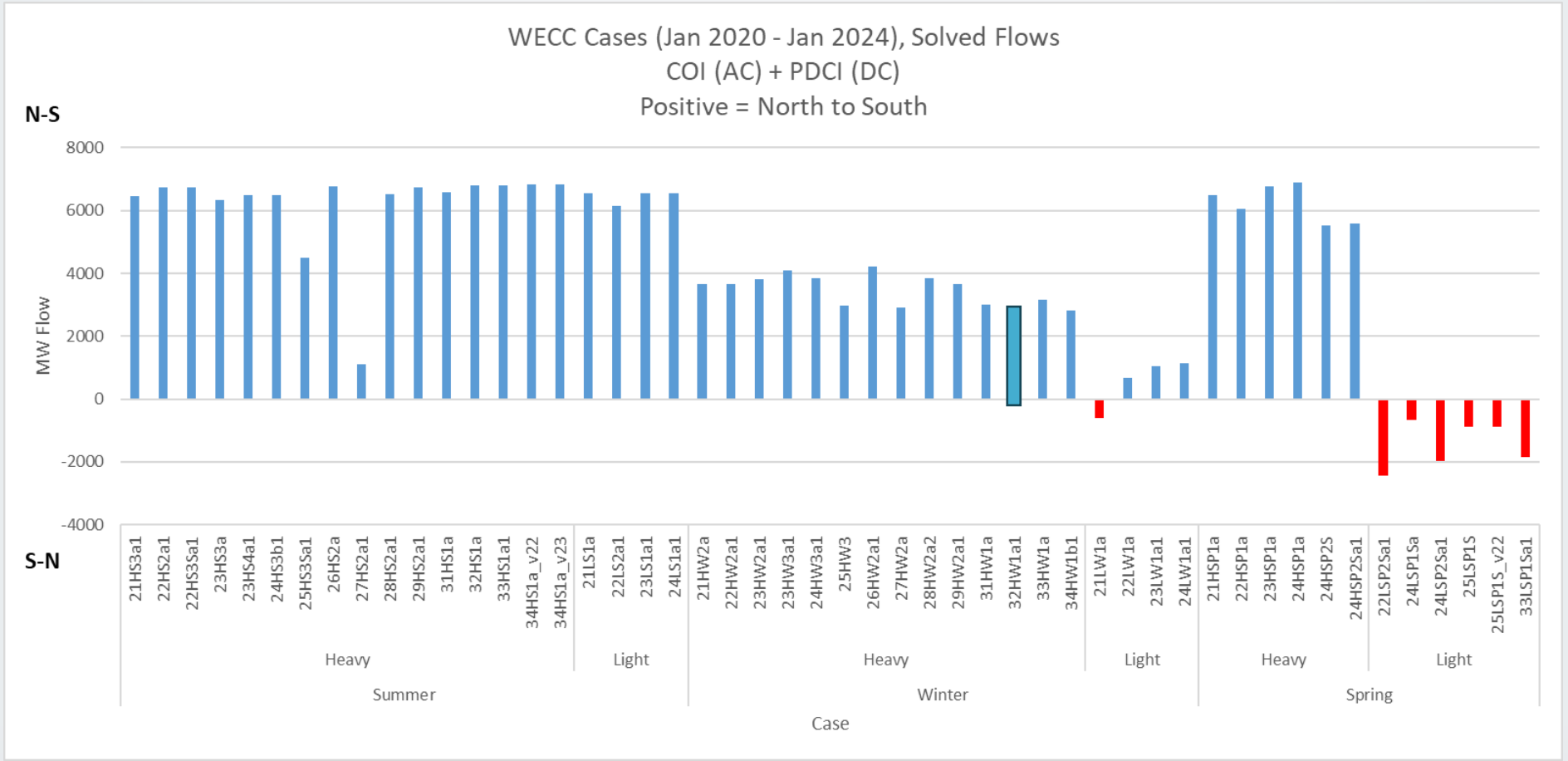
WPP

Perspective on Areas – 34HS1

"Big 3"
~46.5 % of Total



Last 4 Years of WECC Models (Blue = North to South)



Note: Minor Correction: 32HW Path 65 Measurement Direction got flipped

Last 4 Years of WECC Models

North to South:

- Summer
- Winter
- Heavy Spring

South to North

- Light Spring

<Public>

What have we historically studied?

- Schedules typically dictated by the BCCS

- Example:

  2024-25 HW Purpose:

  "Represent … heavy flows from Northwest to California"

4.4 GW N-S Schedule

2024 Base Case Compilation Schedule

CASE DESCRIPTION	2024-25 HEAVY WINTER—25HW3-OP	
CASE DUE DATES:	To Area Coordinator: November 10, 2023 To WECC Staff: December 8, 2023	
PURPOSE: *Operating Case*—To represent anticipated operating conditions with heavy flows from Northwest to California.		
ITEMS TO BE PREPARED:	From Case Stability Data Significant Changes	2023-24 HW3 OP Master Dynamics File From Existing System

INTERCHANGE	CONDITION	TARGET	% RATING
Northwest to British Columbia (Path 3)	Moderate	1500[1]	50%
Northwest to California/Nevada–COI (Path 66)	Moderate	2000	42%
PDCI (Path 65)	Heavy	2400	75%

What are planners saying?

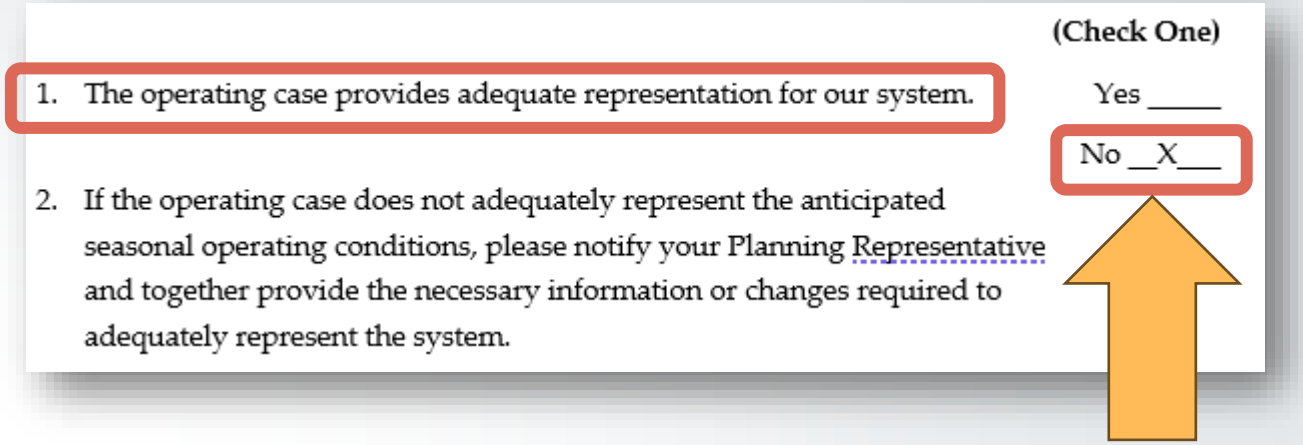
When building this case, LADWP couldn't accept 2,400 MW, because it would require turning on LA's storage pumps!

WPP

<Public>

What are our operators saying?

» 2024-25 HW Sign Off Sheet for one of our operators:



	(Check One)
1. The operating case provides adequate representation for our system.	Yes _____
	No __X___
2. If the operating case does not adequately represent the anticipated seasonal operating conditions, please notify your Planning Representative and together provide the necessary information or changes required to adequately represent the system.	

*"…. flows on **Path 66** (Pacific AC Intertie) have been flowing **northbound** more often than southbound **during heavy load hours** …"*

WPP

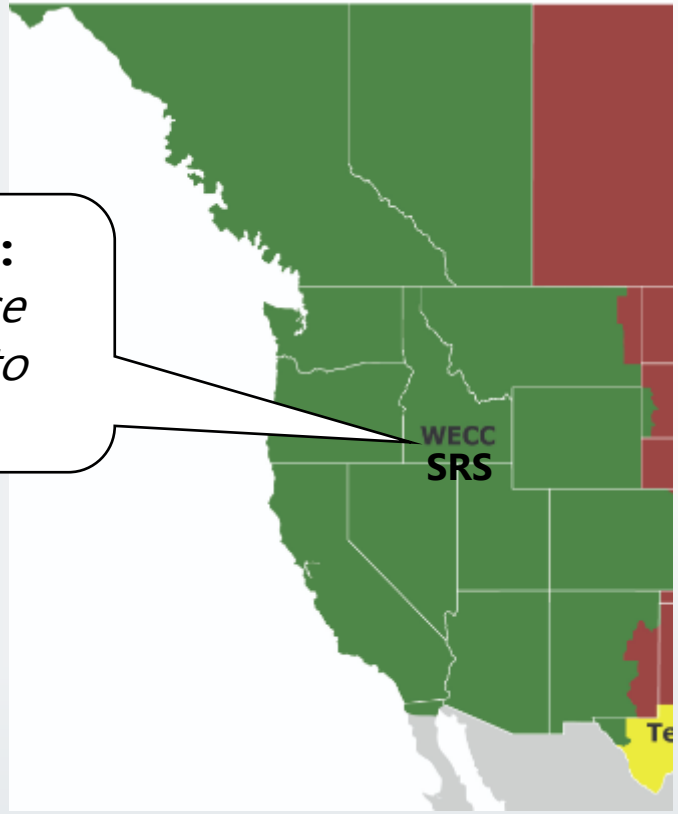
<Public>

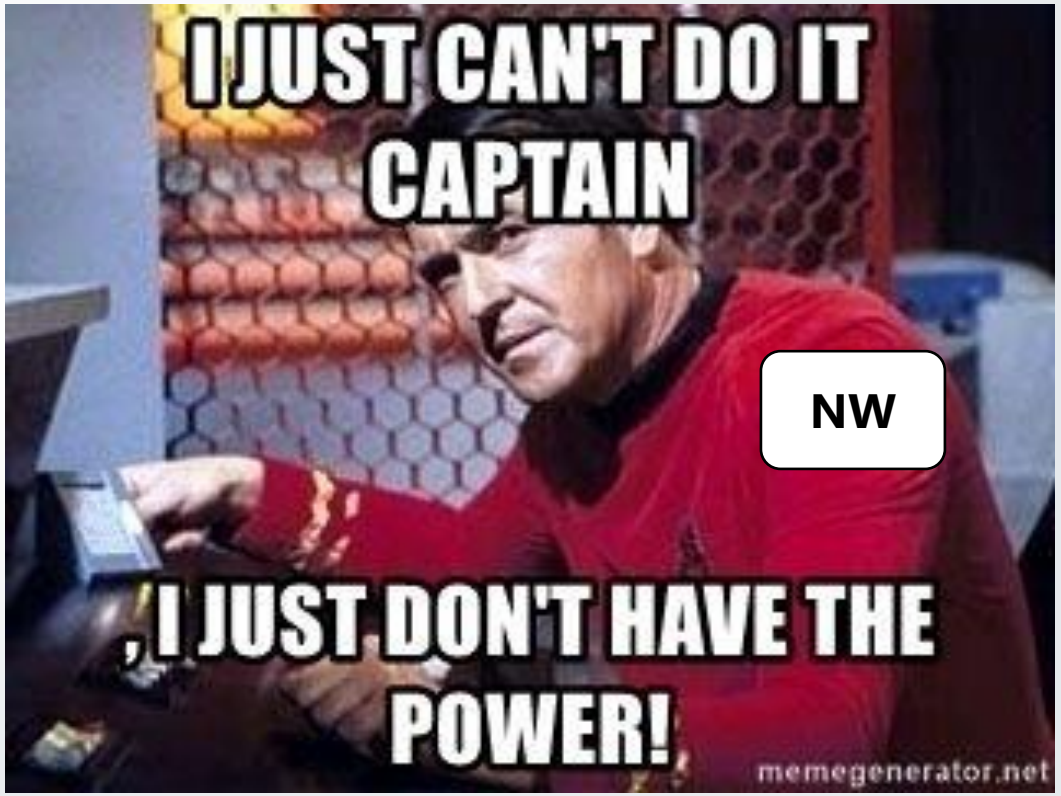
How does our dispatch look in HW Case Builds?

WPP adjusted the 33-34 HW to a 34-35HW for TPL-purposes.

Hydro: **99% Pmax**
Thermal: **87%**
Wind: **55%**
Solar: **29%**

WECC SRS BCCS:
"Northwest, Please Send More GWs to California"





WPP

Copy-Paste?

- Weren't these cases perfectly fine before?
- Can't we keep copy-pasting each year?
- Why are we rejecting cases now?

5 Years of Significant Northwest Change

- Thermal Retirements 2020-2025:
  - Centralia ~1400 MW
  - Boardman ~600 MW
  - Colstrip 1 & 2 ~660 MW

  ~2,660 MW
- Hydro Retirements 2023-25:
  - Copco #1 ~40 MW
  - Copco #2 ~27 MW
  - J.C. Boyle ~60 MW
  - Iron Gate ~16 MW

  ~143 MW

- Large Load Additions:
  - MidC, WA
  - Boardman/Umatilla, OR
  - Prineville, OR
  - The Dalles, OR
  - Portland, OR

  ~2,000+ MW, and growing

Result:
~4800 MW reduction in A40 Exports in Last 5 Years

…Future?

WPP

Look Deeper.

Historical Flows and Trends.

Question

- Does recorded data support what operators have reported in the sign-off sheet?
- I.e. does Heavy Winter flow South to North?

Public Data Sources

EIA - BA Load, Interchange, Generation (By Type)

- https://www.eia.gov/electricity/gridmonitor/

BPA – Path Flows

- https://transmission.bpa.gov/Business/Operations/Paths/

NOAA – Temperature, Wind, etc

- https://www.ncei.noaa.gov/cdo-web/datatools/lcd

US Army Corps of Engineers – Hydro Output

- CENWD-WM System Map (army.mil)

EPA CAMPD – Carbon Generator MW & Emissions

- https://campd.epa.gov/data/custom-data-download

OpenInfraMap – Lines and Substations on a Map

- https://openinframap.org/#16.41/47.954764/-118.998349

Public Data Sources

Want to download our work? It's all public data.

Get a copy of it here:

- 2024-03-01 Public EIA BPA NOAA Data for S-N Discussion

WRAP Report

https://www.westernpowerpool.org/private-media/documents/WPP_Assessment_of_January_2024_Cold_Weather_Event_Final.pdf

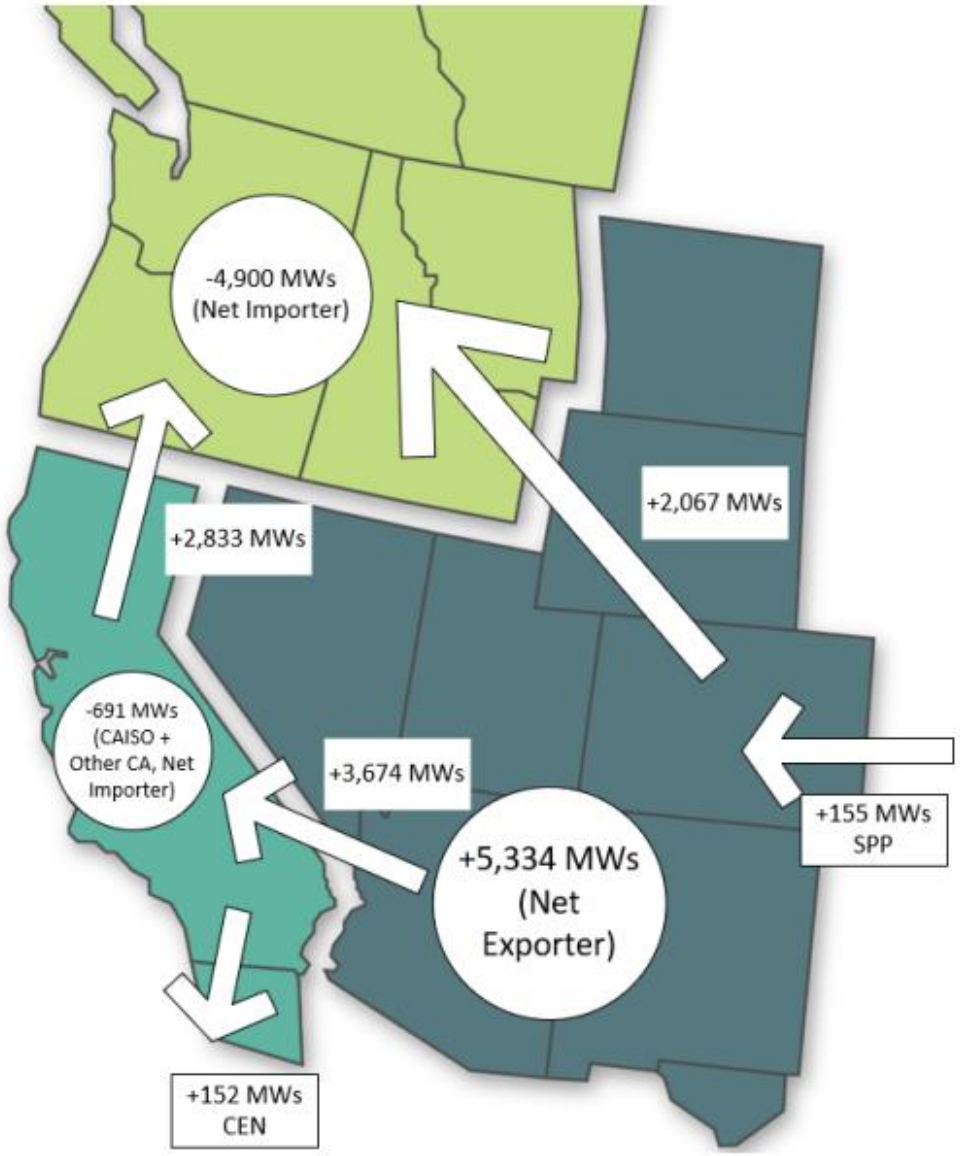
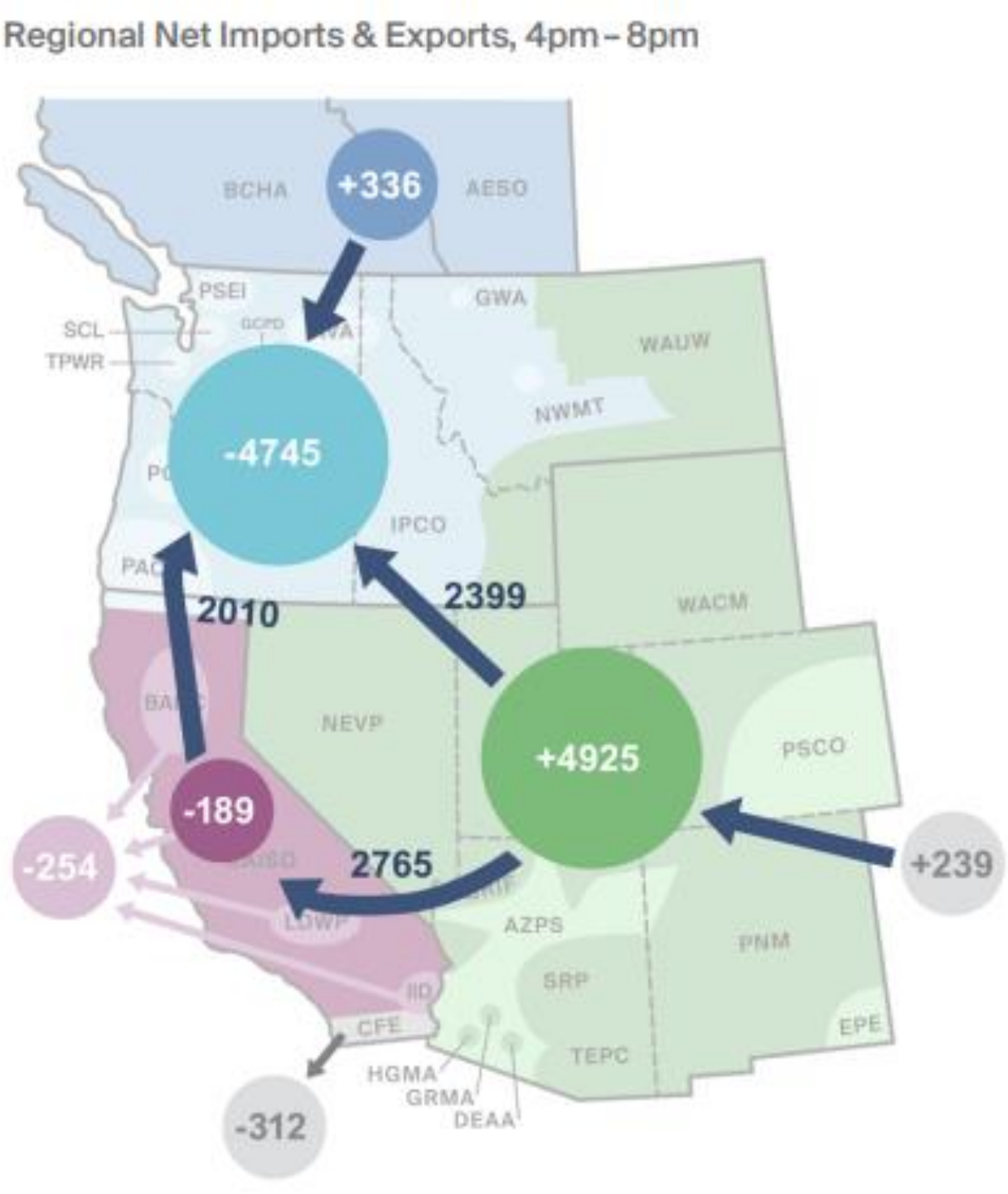


Figure 1 - Average net regional imports into the Northwest during January 12 through January 16, 2024.

PowerEx Report

https://powerex.com/sites/default/files/2024-03/Analysis%20of%20the%20January%202024%20Winter%20Weather%20Event.pdf

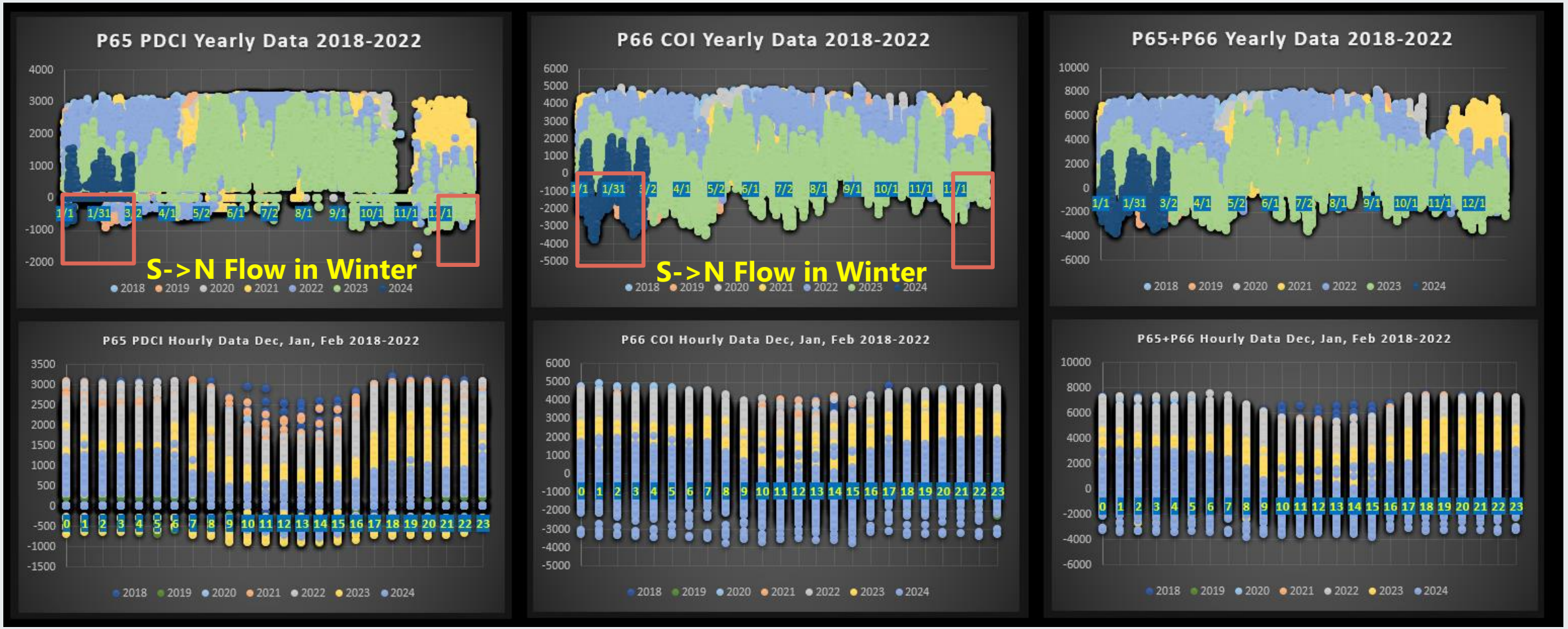
Peak demand generally occurred between 4 p.m.–8 p.m. PT each day during the January 2024 Event. Data on delivery schedules published by transmission service providers, together with data from the U.S. Energy Information Administration, shows that the U.S. Northwest region imported an average of 4,745 MW during these peak demand hours. The most significant supply during these hours came from the Southwest and Rockies region, which had average hourly net exports of nearly 5,000 MW. Canada also supplied an average of 336 MW to the U.S. Northwest region. In contrast, the California ISO, and other California utilities that are not part of the California ISO, were net importers on average of approximately 443 MW (189 MW and 254 MW respectively) during these peak demand hours. Further details are provided in the map below, which shows whether each sub-region was a net exporter or net importer in the peak hours, and the respective magnitude of such transfers.



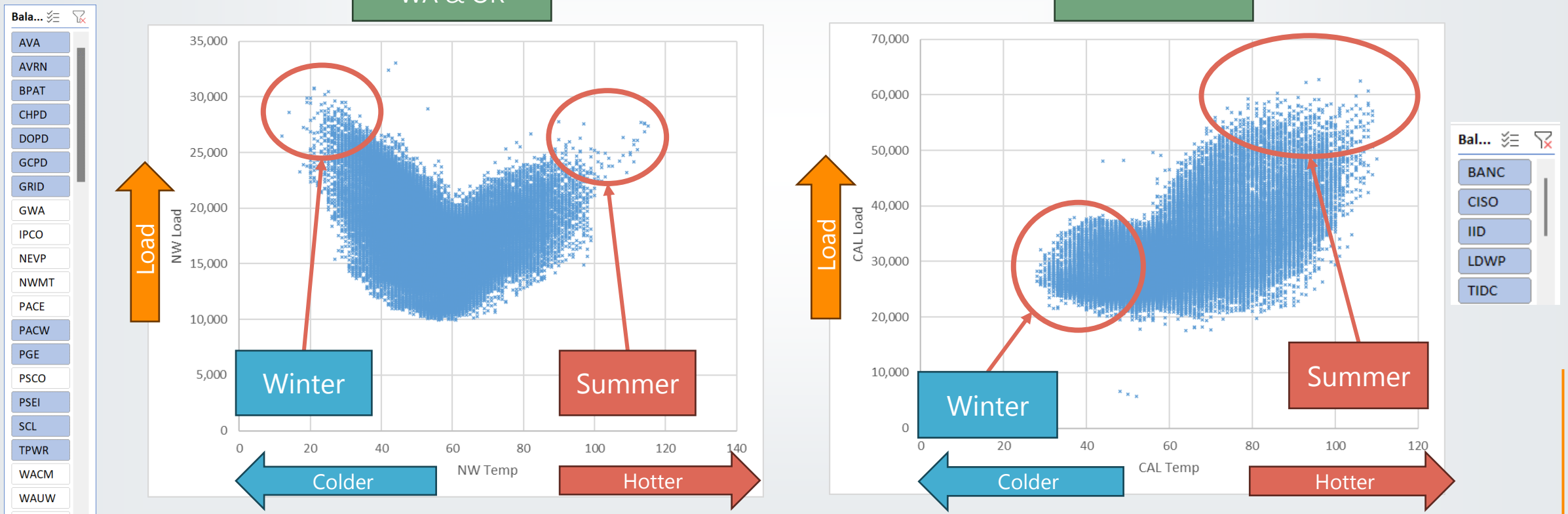
WPP

Historical Path Flows

We see S->N Flows in Winter.
What can explain this?
Let's look at Loads & Generation.



Hourly Temperature (f) vs Load (MW)

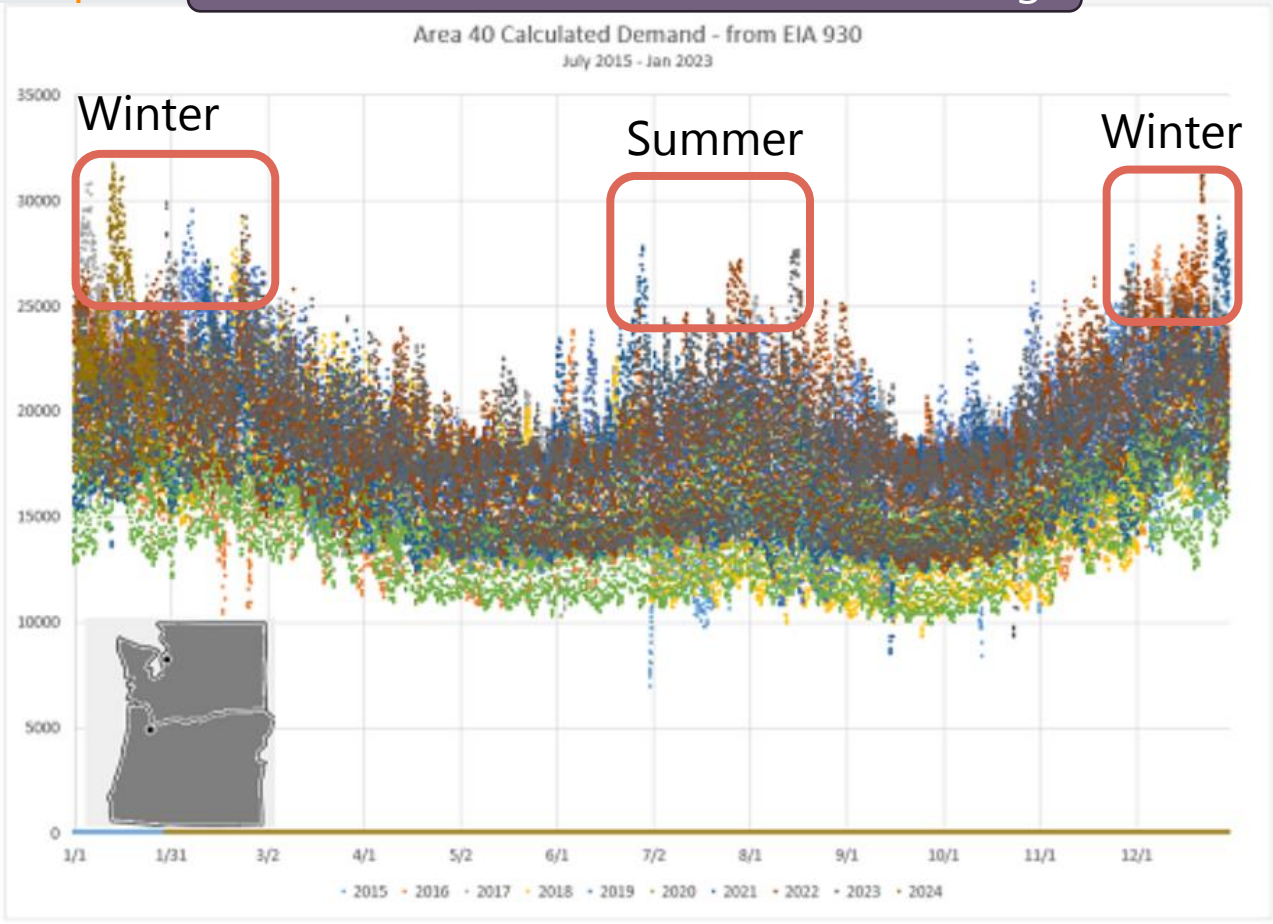


PORTLAND INTERNATIONAL AIRPORT, OR US

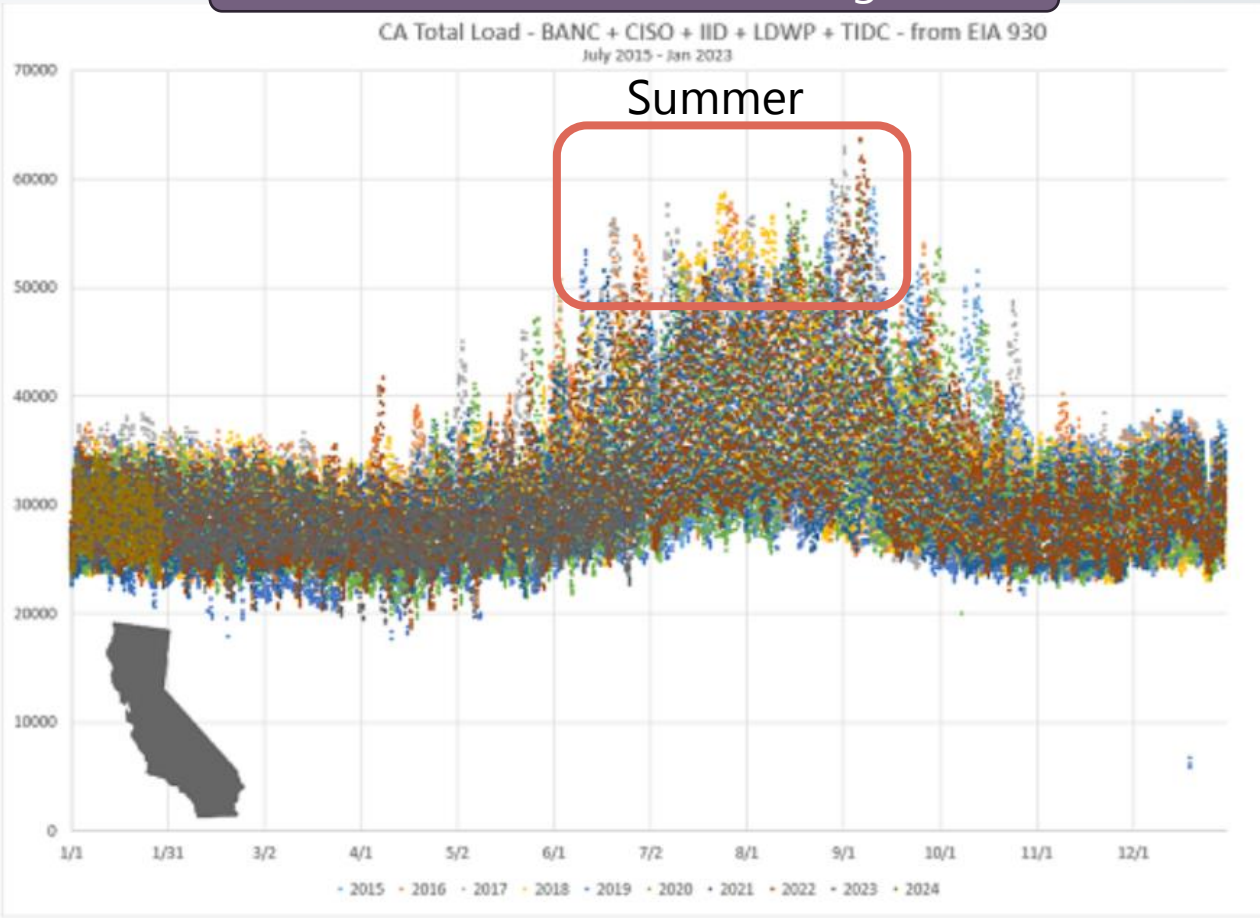
SACRAMENTO AIRPORT ASOS, CA US

Loads Over Time

WA & OR – Winter & Summer Peaking



CAL – Summer Peaking

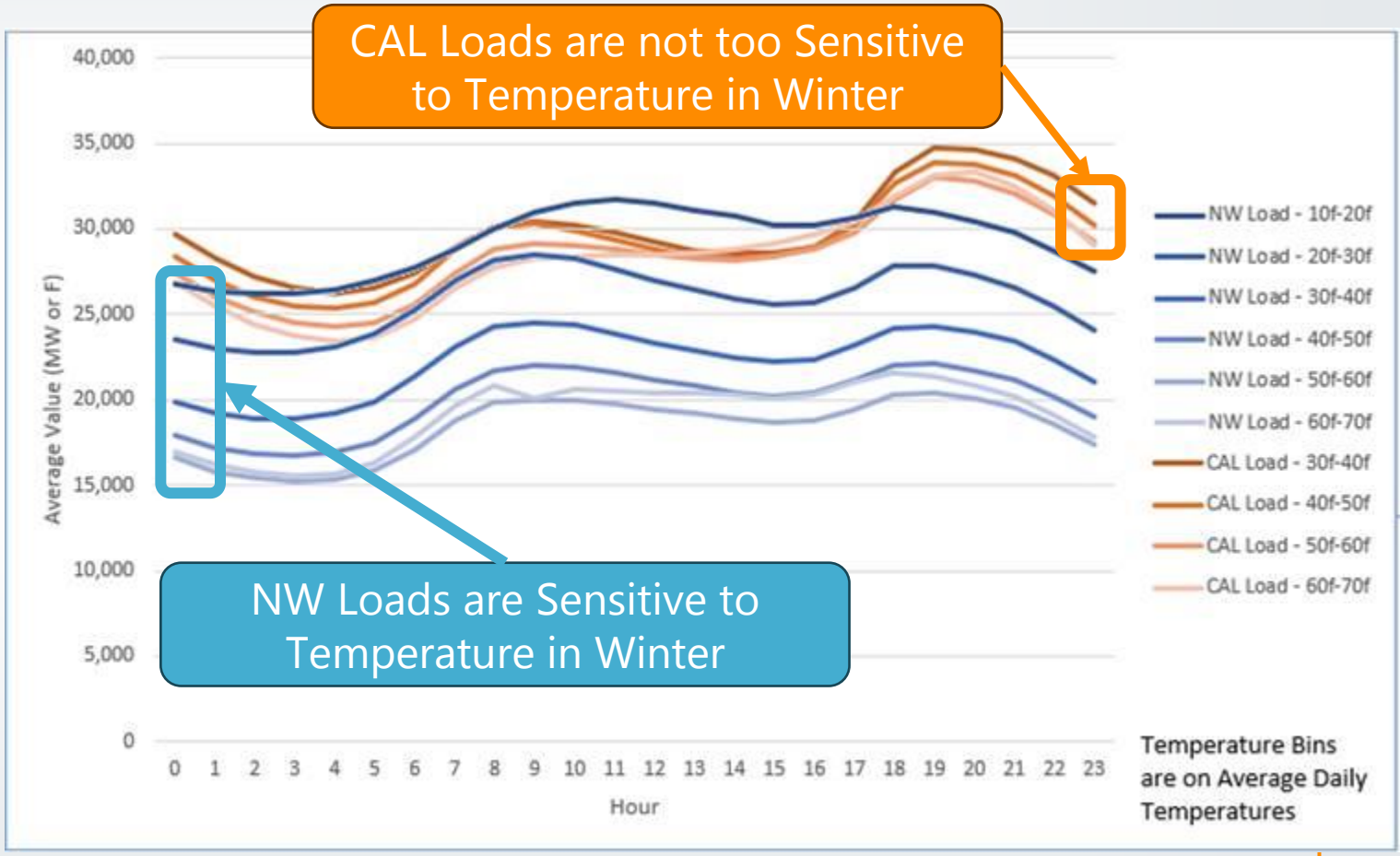


Load Coincidence (Winters, 2015-2024)

- Winter on average…
- NW Peak: 6:00 PM, PST
- CAL Peak: 7:00 PM, PST

NW Morning & Evening Peaks are often similar

CAL Evening Peaks are bigger than CAL Morning Peaks



2022-23 Winter

CAL & NW Peak Winters did not occur at the same time.

Peak CAL Hours

DateTimeLocal	ACDC	CAL Demand (MW) (Adjusted)	NWDemand (MW) (Adjusted)
12/12/2022 20:00	2031	36149	23916
12/14/2022 20:00	3721	35936	24991
12/12/2022 19:00	1983	35883	24272
12/14/2022 19:00	3210	35880	25265
12/13/2022 20:00	1656	35835	24741
12/14/2022 21:00	3849	35806	24561
12/13/2022 19:00	1636	35698	25211
12/12/2022 21:00	1945	35662	23375
12/13/2022 21:00	2159	35592	24120
12/19/2022 19:00	309	35539	27187
12/15/2022 19:00	2025	35505	25942
12/19/2022 20:00	718	35500	26686
12/15/2022 20:00	2184	35369	25695
2/27/2023 20:00	911	35301	24415
12/15/2022 21:00	2140	35201	25300
12/19/2022 21:00	799	35188	26000
12/14/2022 22:00	3425	35158	23540
12/1/2022 19:00	1230	35073	26094
12/13/2022 9:00	-518	35057	25754
1/19/2023 20:00	3322	35042	23613

N-S

Most peak hours:
Evening
12/12-12/15

Peak NW Hours

DateTimeLocal	ACDC	CAL Demand (MW) (Adjusted)	NWDemand (MW) (Adjusted)
12/22/2022 18:00	-1410	32112	31196
12/22/2022 10:00	-1015	32077	31188
12/22/2022 9:00	-1277	31763	31075
12/22/2022 11:00	-1460	32155	31005
12/22/2022 17:00	-1838	30575	30837
12/22/2022 19:00	-1275	34078	30730
12/22/2022 12:00	-1303	32270	30651
12/22/2022 8:00	-1004	30696	30485
12/22/2022 13:00	-1595	31779	30246
12/22/2022 16:00	-1684	30094	30048
12/22/2022 20:00	-1026	33680	30037
12/22/2022 14:00	-1752	30816	29958
12/22/2022 15:00	-1789	30139	29881
1/30/2023 8:00	102	30767	29845
1/30/2023 9:00	-441	32405	29629
12/22/2022 21:00	-537	33055	29225
12/21/2022 18:00	-837	32790	29220
12/21/2022 19:00	-588	35022	29180
2/24/2023 8:00	-1393	31554	29153
12/22/2022 7:00	-672	28850	29097

S-N!

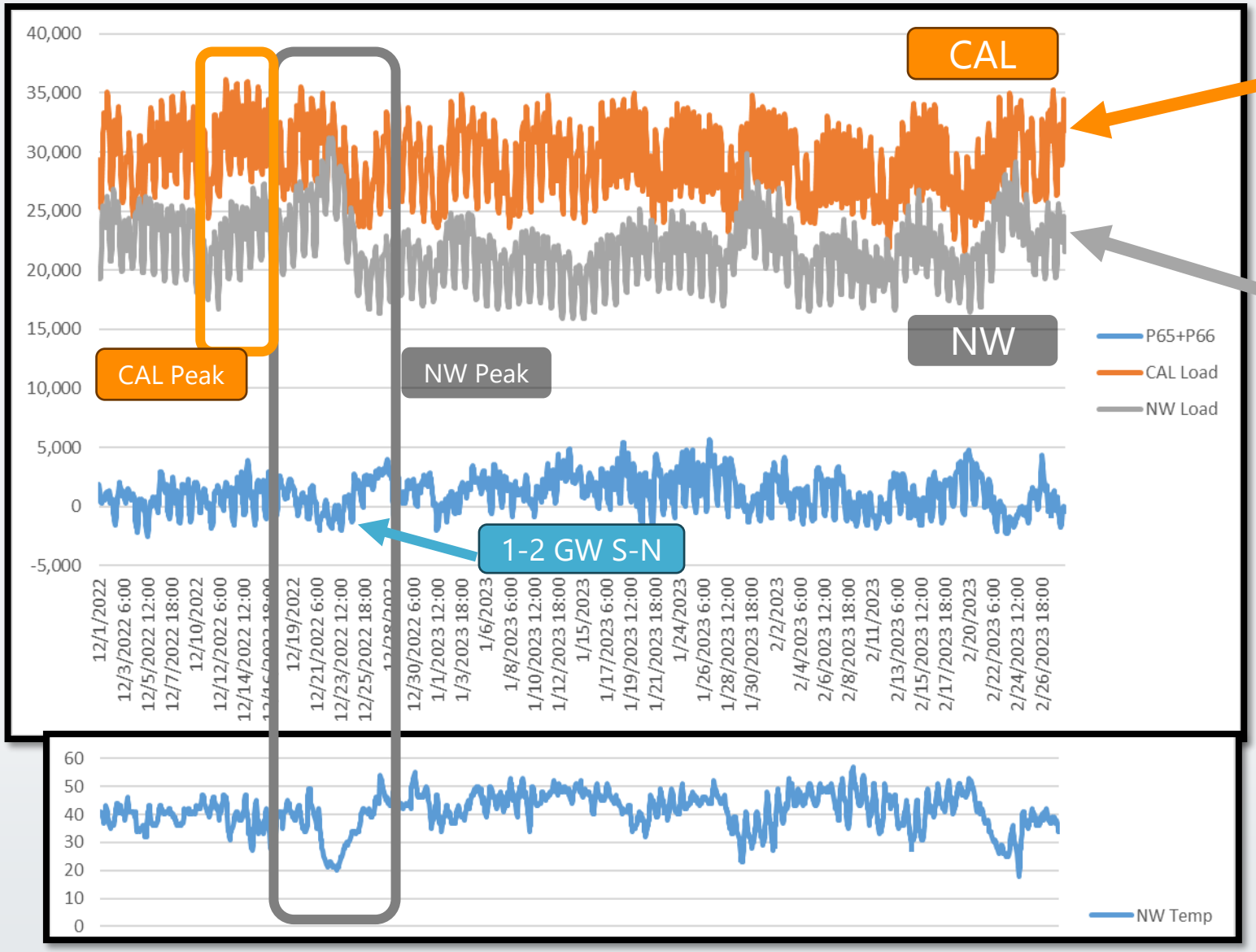
Most peak hours:
Morning & Evening
12/21 - 12/22

WPP

2022-23 Winter – CAL vs NW Load

Very Cold

High NW Load & South to North



Similar peaks almost every weekday

Significant Temperature-Driven Peaks

2022-23 Winter

- May 2022: BPA joined the Energy Imbalance Market (EIM)
- 2022-23 and 2023-24 Winters were particularly cold for the NW
- Gas constraints and spikes in pricing:
  - https://www.caiso.com/Documents/Gas-Conditions-and-CAISO-Markets-Report-for-Dec2022-Jan2023.pdf
  - https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2022/12_22/
  - *"Several events occurring simultaneously at this point in the season contributed to prices rising to these levels:*
    - *Widespread, below-normal temperatures*
    - *High natural gas consumption*
    - *Reduced natural gas flows*
    - *Pipeline constraints, including maintenance in West Texas*
    - *Low natural gas storage levels in the Pacific region"*

2023-24 Winter – CAL vs NW Load

CAL & NW Peak Winters did not occur at the same time.

CAL Peaks

DateTime	CAL Load	NW Load	P65+P66
1/8/2024 20:00	34727	23893	-265
12/13/2023 19:00	34631	23290	1554
12/20/2023 19:00	34603	22320	1296
12/14/2023 19:00	34503	22702	1100
12/13/2023 20:00	34452	22895	1462
1/10/2024 20:00	34437	24859	-836
12/12/2023 19:00	34422	23415	1047
12/11/2023 19:00	34416	22679	-111
1/8/2024 19:00	34360	24625	-700
12/12/2023 20:00	34318	22997	1039
12/18/2023 19:00	34310	23421	519
1/10/2024 19:00	34309	25207	-1016
12/14/2023 20:00	34279	22333	1162
12/11/2023 20:00	34262	22281	-149
1/8/2024 21:00	34235	23131	-463
12/13/2023 21:00	34161	22339	1490
12/20/2023 20:00	34141	21767	1125
12/18/2023 20:00	34137	22821	832
12/19/2023 19:00	34088	22172	1048
12/12/2023 21:00	33987	22537	746

Mild Flows

Most peak hours:
Evening
19:00 – 21:00

1/8
1/10
12/11
12/12
12/13
12/20
12/14

NW Peaks

DateTime	CAL Load	NW Load	P65+P66
1/13/2024 11:00	29438	31689	-3561
1/13/2024 10:00	29866	31533	-3330
1/13/2024 12:00	29594	31510	-3042
1/13/2024 18:00	29119	31290	-3160
1/13/2024 13:00	29390	31125	-3055
1/16/2024 9:00	32035	31078	-2595
1/13/2024 19:00	31313	30939	-3276
1/13/2024 9:00	28482	30936	-3087
1/16/2024 8:00	30185	30913	-3072
1/13/2024 14:00	28565	30707	-2894
1/13/2024 17:00	27906	30676	-3085
1/12/2024 18:00	31543	30662	-3303
1/16/2024 10:00	32480	30589	-2645
1/15/2024 9:00	29361	30563	-3345
1/12/2024 19:00	33381	30515	-3232
1/13/2024 20:00	31793	30423	-3255
1/15/2024 10:00	30409	30382	-3691
1/13/2024 16:00	27685	30202	-3023
1/13/2024 15:00	27892	30175	-3286
1/12/2024 20:00	33321	30043	-3158

S-N!

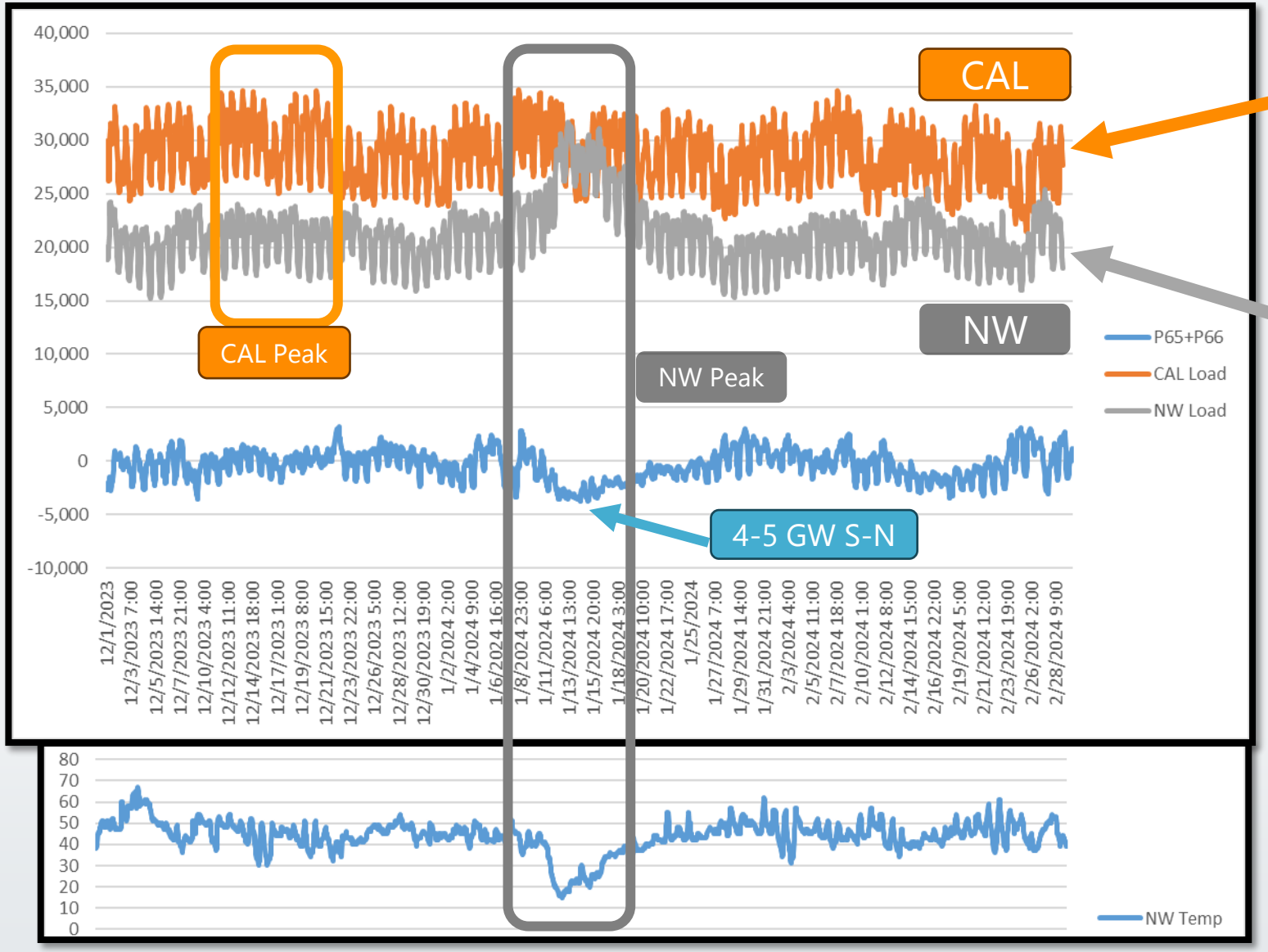
3-4 GW S-N!

Most peak hours:
Morning & Evening
1/13 – 1/16

2023-24 Winter – CAL vs NW Load

Very Cold

High NW Load & South to North



Similar peaks almost every weekday

Significant Temperature-Driven Peaks

2023-24 Winter

- NW Gas Storage Facility Outage
  - https://bnnbreaking.com/world/us/energy-crisis-in-the-pacific-northwest-major-gas-storage-facility-outage/

- Jackson Prairie (near Centralia, SW Washington)– January 13-14 – request to conserve
  - https://www.kuow.org/stories/why-pse-urged-people-to-conserve-energy-amid-severe-cold
  - https://www.opb.org/article/2024/01/14/nw-natural-lifts-request-for-customers-to-reduce-gas-use/

Summary

- S-N Winters?
  - Not studied at WECC.

- California and Northwest might not peak together.
- Northwest Winter loads vary heavily on temperature. Very distinguished peak loads.
- California Winter loads are a bit repetitive. Many peaks of almost the same magnitude, all winter.

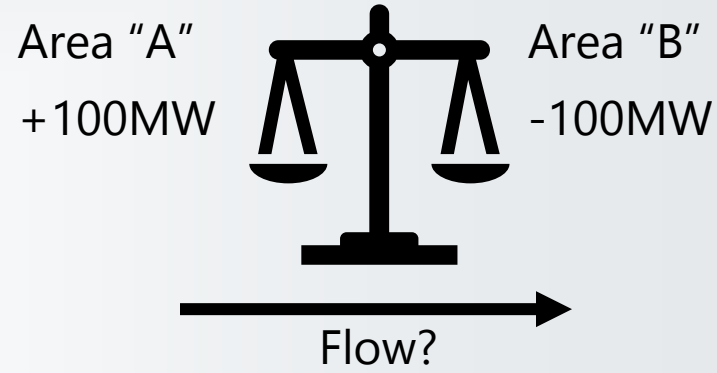
- We experienced heavy S-N flows during NW peaks in the last two winters (2022-23, and 2023-24).

- Questions:
  - Is this the new normal, or an abnormal condition?
  - Should we study HW cases with S-N COI/PDCI flows?

Look Deeper.

Model: Dispatch & Schedules

Schedules <-> Dispatch <-> Flow

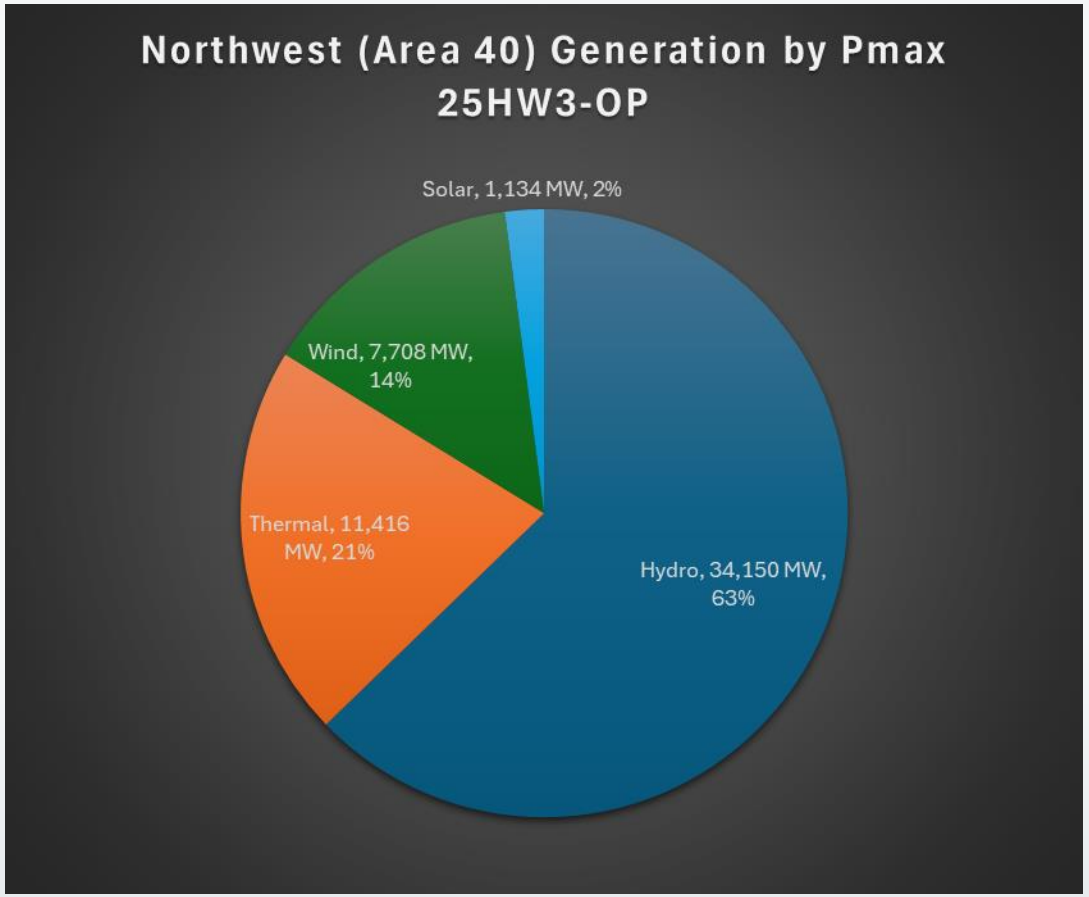


» Note before proceeding:
  » When talking about Path Flows and Schedules…

» Schedules are an “Intermediate Step”.
  » They mean nothing, unless *actioned* upon to change *generation dispatch*.
    » Schedules change Area-Interchange control setpoints.
    » Area-Interchange control setpoints change generation in each area.
    » Generation changes Flows (via Physics, R/X, Voltage Angles, etc).
    » (Ask your Newton-Raphson solution engine).

» “Schedules” will not match “Flows”, but they do have a relationship.

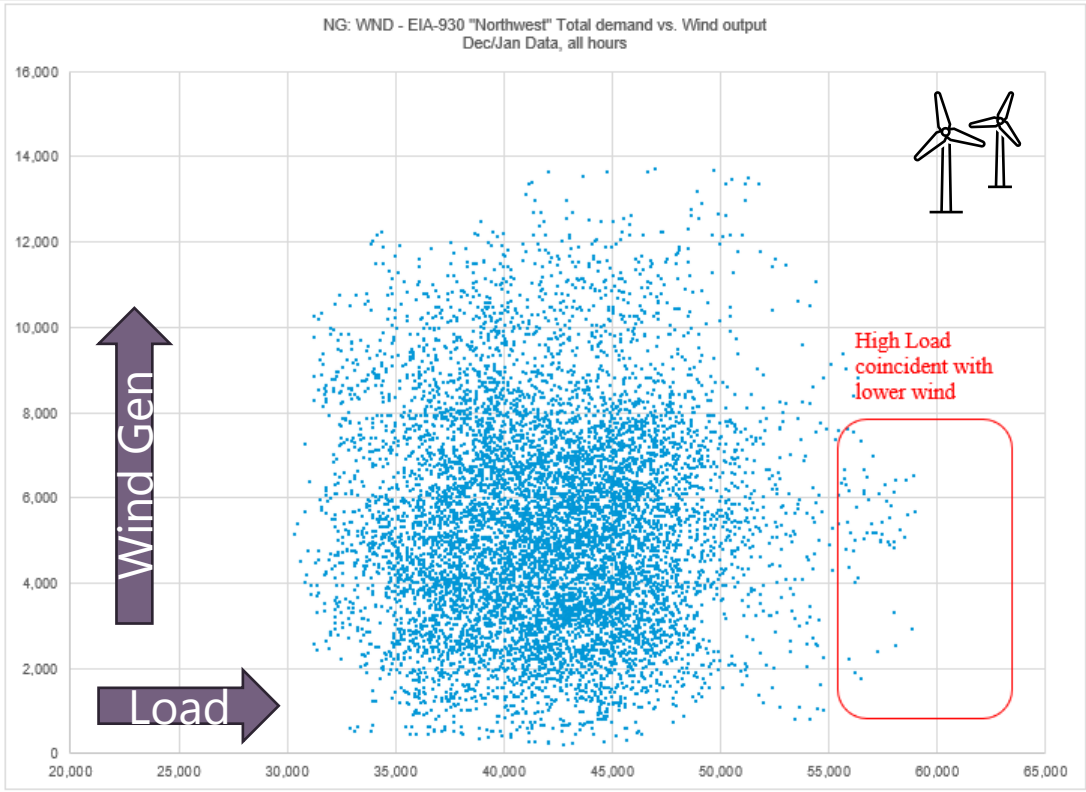
NW Generation



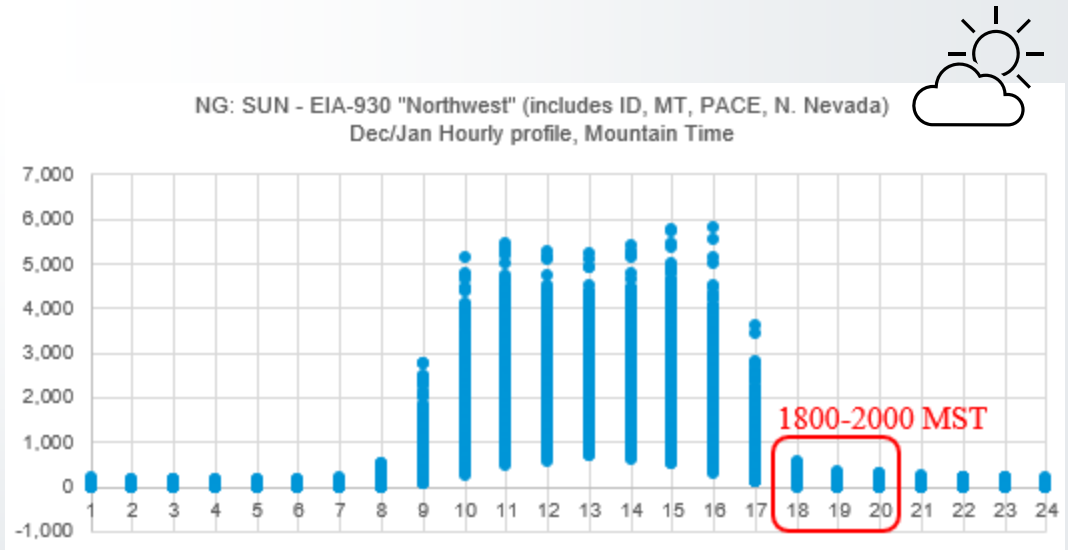
NW Wind & Solar Historically…

Northwest operational experience:

- Wind tends not to blow at extreme temperatures (15%-60% of max)
- Solar effect diminished in winter mornings/evenings (~10% of max)

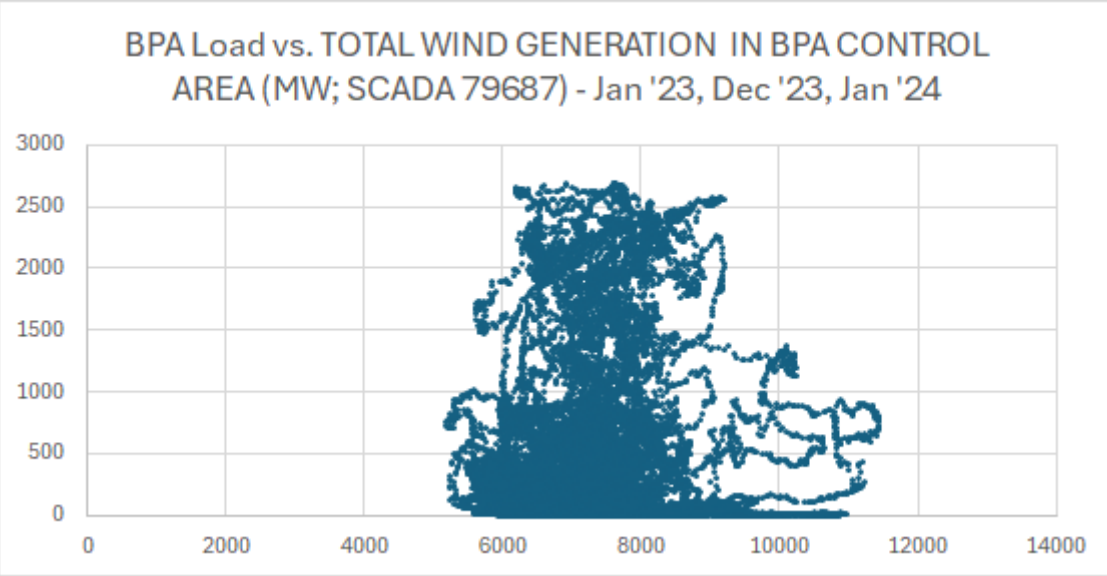


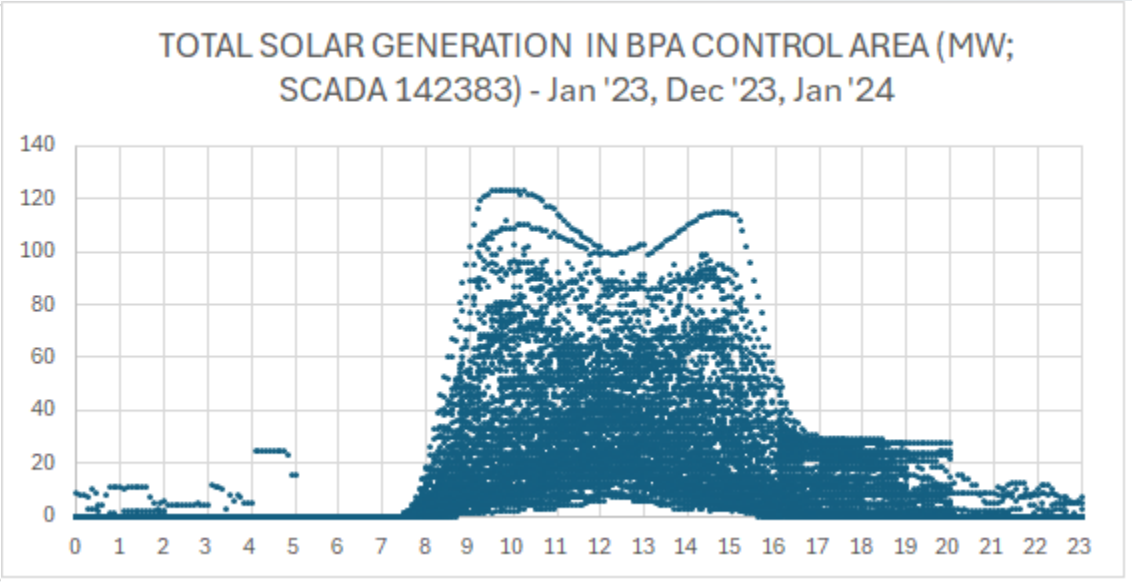
A40 Wind ~7.7 GW nameplate @ 15-60% = ~1.2 - 4.6 GW



A40 Solar ~1.1 GW nameplate @ 10% = 110 MW

NW Wind & Solar More Granularly…



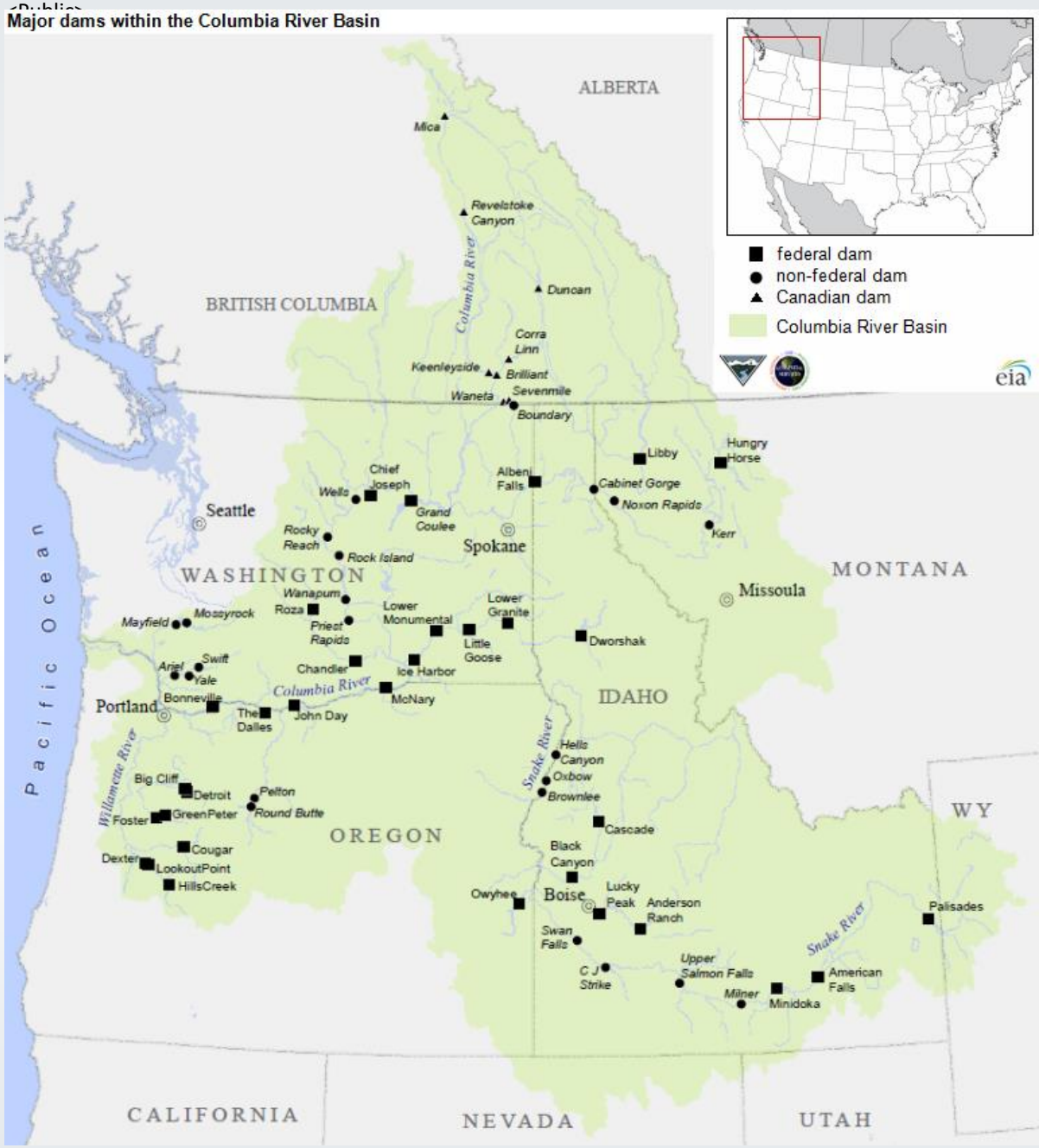


NW Hydro

» Renewable, and reasonably dispatchable!

» However, is dependent on:
  » water shed filling the river,
  » water management along the river

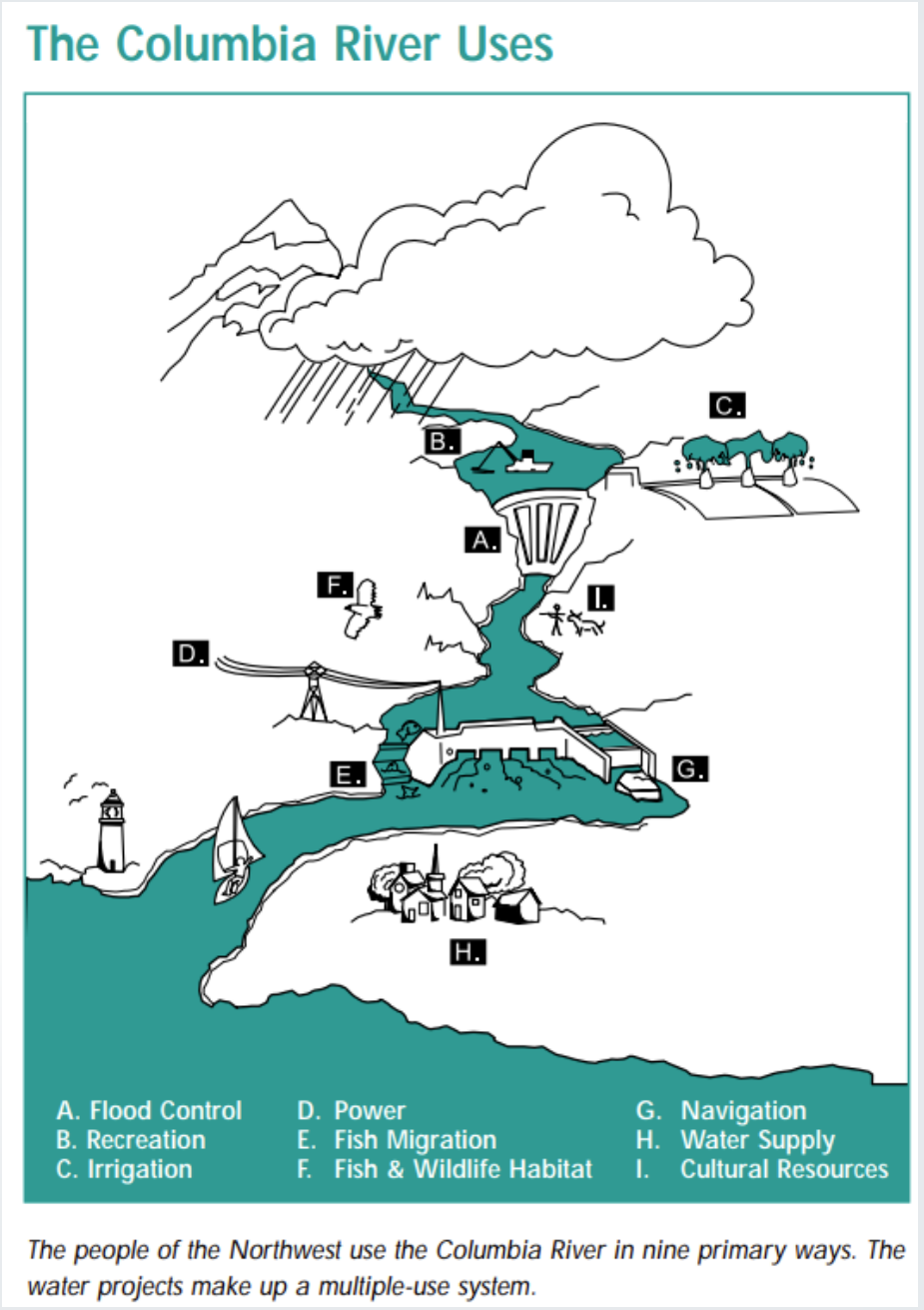
» … The river is not *only* used for power!



NW Hydro

- The water has many uses.
  - Fishing!
  - Kayaking!
  - Irrigation!
  - Salmon Migration & Survival!
  - Locks to raise/lower ships!

- Learn More:
  - BPA: Columbia River – Inside Story
  - BPA: River of Power



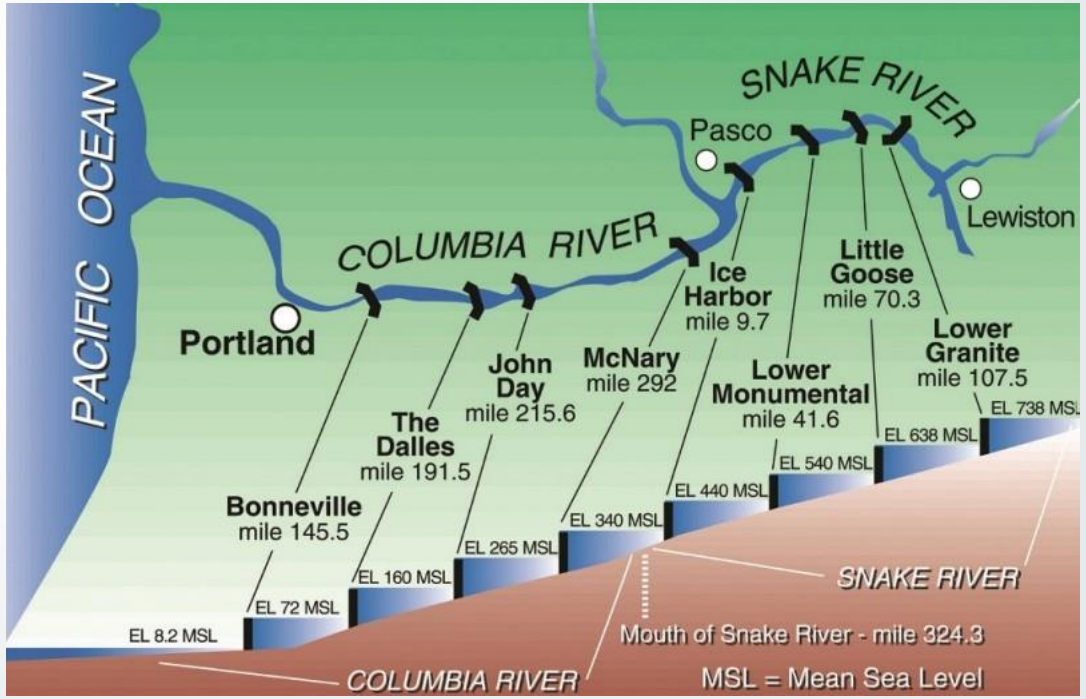
The people of the Northwest use the Columbia River in nine primary ways. The water projects make up a multiple-use system.

<Public>

NW Hydro

» *"Ten million tons of commercial cargo, valued between $1.5 to $2 billion, is transported through the system each year, according to navigation industry data."*

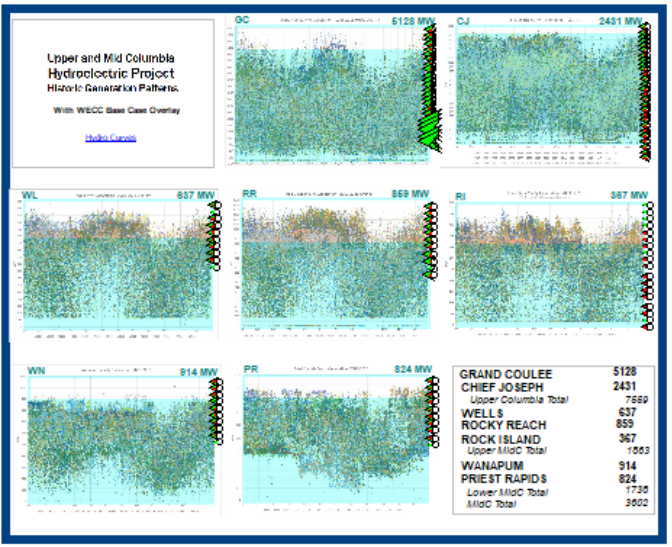
Oh, the Locks You'll Find!

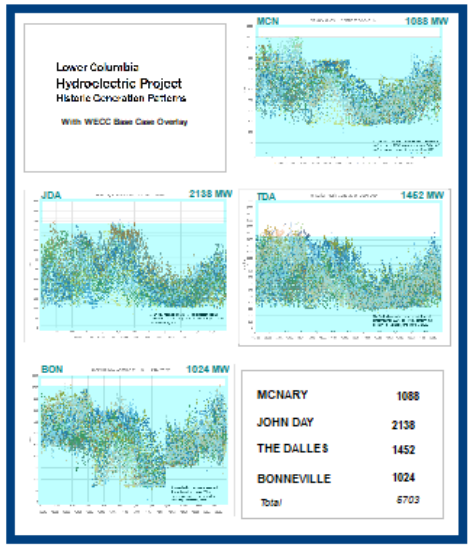


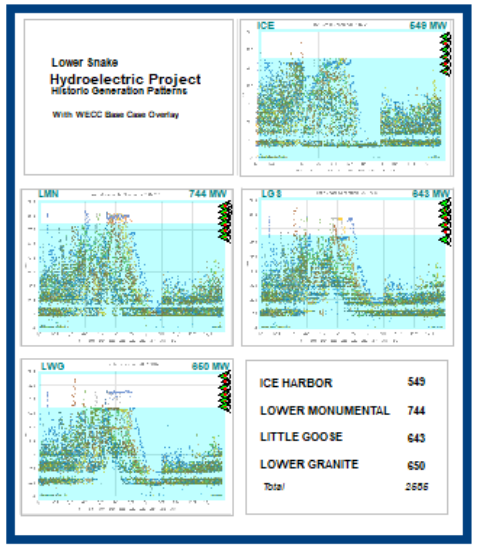
<Public>

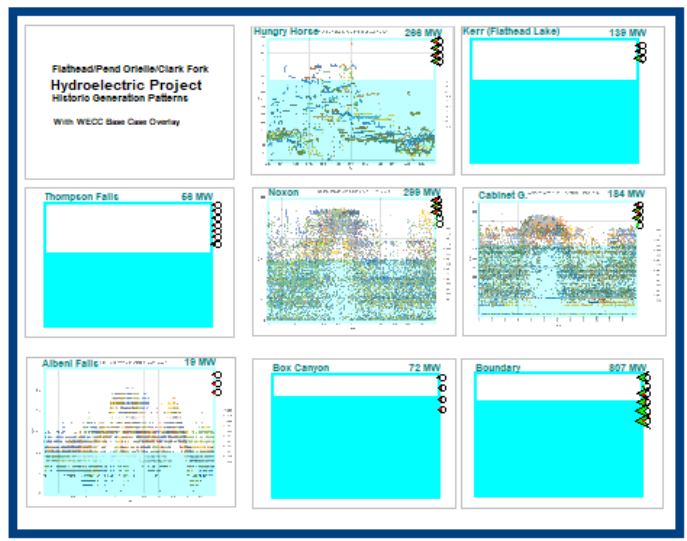
NW Hydro Historically…

» We try to land somewhere in the middle of what has been previously operated for that season, per sections of the river.





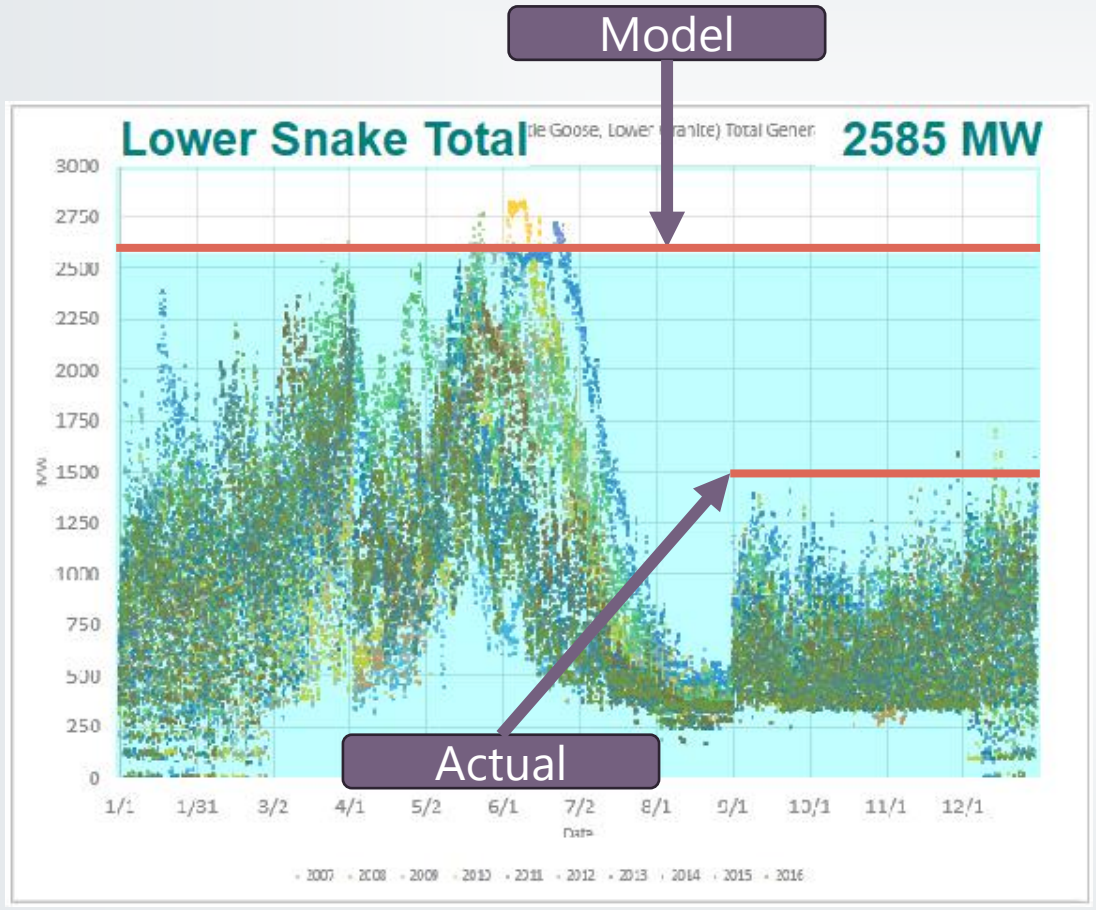




Summary
NW: What is Reasonable HW Dispatch?

Hydro	• Historical Recordings (Per Plant)
Wind	• 15% of Pmax • It's typically not windy during heavy winter loads
Solar	• 10% of Pmax (or turned off)
Thermal	• High output is OK, to support load

2025 HW3-OP – How is it dispatched?



Lower Snake Hydro: 1 GW too high

25HW3-OP - Area 40 (NorthWest)				
Type	Pgen	Pmax	Pgen / Pmax	Reasonable Level?
Hydro	25393	34150	74%	Reduce Grand Coulee by 0.5 GW. Reduce Lower Columbia by 1 GW. Reduce Lower Snake by 1 GW.
Wind	3817	7708	50%	15%-60% is possible, but likely lower. 15% is about 2.5 GW less.
Solar	151	1134	13%	< 10% is more likely.
Thermal	9984	11416	87%	Already fairly high.

- One take:
  - **Over-Dispatched by ~5 GW.**

WPP

<Public>

2025 HW3-OP – How is it Scheduled?

* Positive (+) is out of NW (Area 40)

Interchange Schedules

To	Area Name	Path	* Schedul
30	PG AND E	Path 66 (COI)	2000
50	B.C.HYDRO	Path 3W	1500
26	LADWP	Path 65 (PDCI)	1500
64	SIERRA	N/A	115
52	FORTISBC	Path3E	0
60	IDAHO	Path 14	-474
62	MONTANA	Path 8	-493.2
Total			4147.8

2024 Base Case Compilation Schedule

CASE DESCRIPTION	2024-25 HEAVY WINTER—25HW3-OP	
CASE DUE DATES:	To Area Coordinator: November 10, 2023 To WECC Staff: December 8, 2023	
PURPOSE: *Operating Case*—To represent anticipated operating conditions with heavy flows from Northwest to California.		
ITEMS TO BE PREPARED:	From Case	2023-24 HW3 OP
	Stability Data	Master Dynamics File
	Significant Changes	From Existing System

INTERCHANGE	CONDITION	TARGET	% RATING
Northwest to British Columbia (Path 3)	Moderate	1500[1]	50%
Northwest to California/Nevada–COI (Path 66)	Moderate	2000	42%
PDCI (Path 65)	Heavy	2400	75%

*Note: LADWP wasn't able to accept so much power. It would have required LA to turn on storage pumps during winter, so schedules were reduced.

WPP

2025 HW3-OP

» Is there room in other areas?

» Is 15% of Pmax… "High" Thermal?

» Thermal EPC-types:

```
// Thermal-------------------------------------------------------------------------
//    1  steam turbine (except steam of combined cycle)
//    2  combined cycle steam part
//    3  steam cross-compound
//    4  combined cycle total unit (planned gens and details for separate model not available)
//    6  Internal Combustion Engine (diesel, piston, reciprocating)
//    7  diesel turbo charged
//    11 GT (single shaft, does not include turbine part)
//    12 aero derivative GT
//    13 single-shaft combined cycle
//    29 combined cycle combustion turbine part
//    19 Turbines used in a Binary Cycle (including geothermal)
```

CASE DESCRIPTION	2024-25 HEAVY WINTER—25HW3-OP	
CASE DUE DATES:	To Area Coordinator: November 10, 2023 To WECC Staff: December 8, 2023	
PURPOSE: *Operating Case*—To represent anticipated operating conditions with heavy flows from Northwest to California.		
ITEMS TO BE PREPARED:	From Case	2023-24 HW3 OP
	Stability Data	Master Dynamics File
	Significant Changes	From Existing System
LOADS:	Expected peak load for the months of December through February	
TIME:	1800–2000 hours MST	
RATINGS:	As appropriate for temperatures associated with the conditions modeled.	

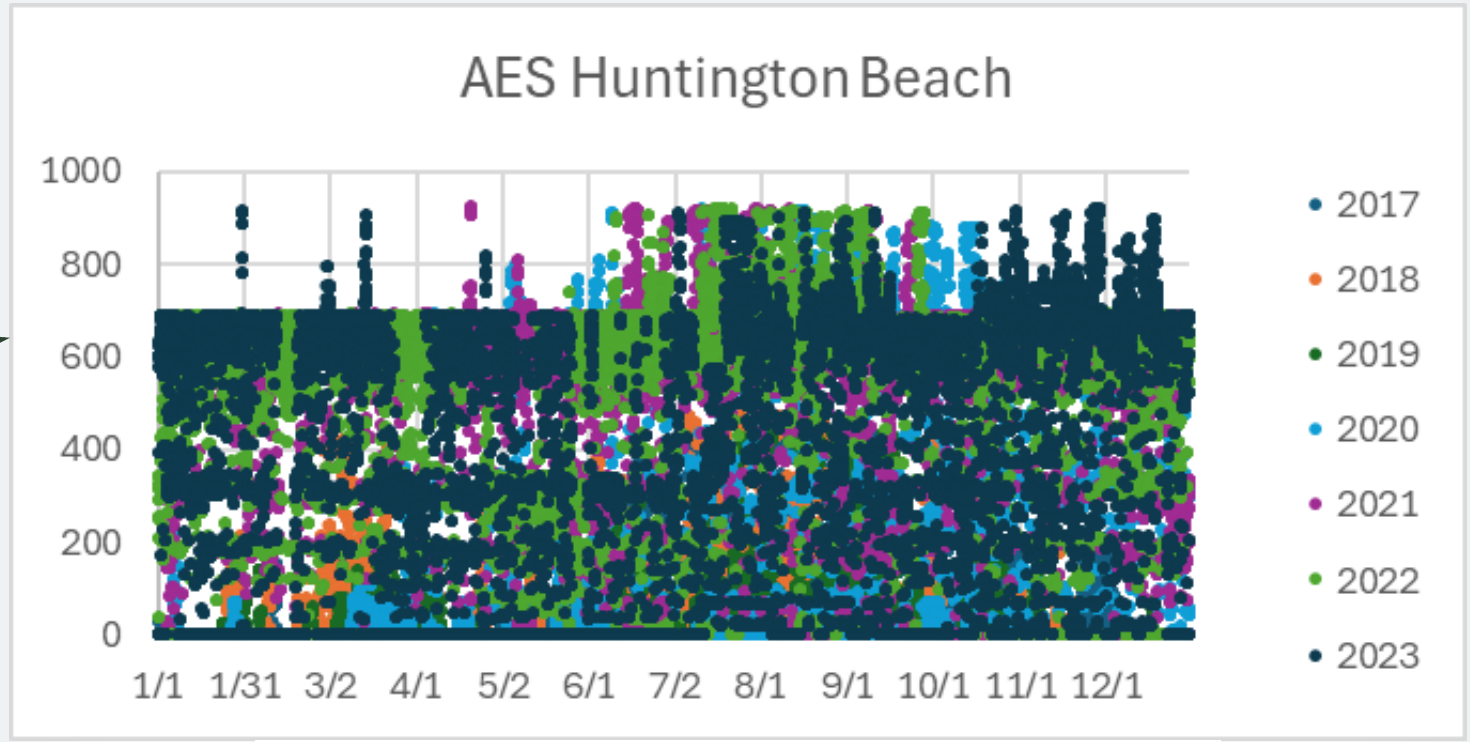
GENERATION:	HYDRO	THERMAL	RENEWABLE
Canada	High/Median	--	--
Northwest	High/Median	High	--
Idaho/Montana	Median	High	--
Colorado/Wyoming	Low	High	--
Northern California Hydro	Median	--	--
Northern California	Low	High	--
Southern California	Low	High	--
Arizona/New Mexico/Southern Nevada	Low	High	--

Name	Total MW Injection	Gen Max MW Total	Pmax-Pgen	Pgen/Pmax
_A24_Gen_Thermal	3,390 MW	21,935 MW	18,545 MW	15%
_A24_Gen_Storage	398 MW	10,720 MW	10,322 MW	4%
_A30_Gen_Thermal	16,595 MW	21,375 MW	4,779 MW	78%
_A26_Gen_Thermal	3,136 MW	6,745 MW	3,609 MW	46%
_A30_Gen_Storage	857 MW	3,772 MW	2,915 MW	23%
_A64_Gen_Thermal	1,858 MW	3,032 MW	1,175 MW	61%

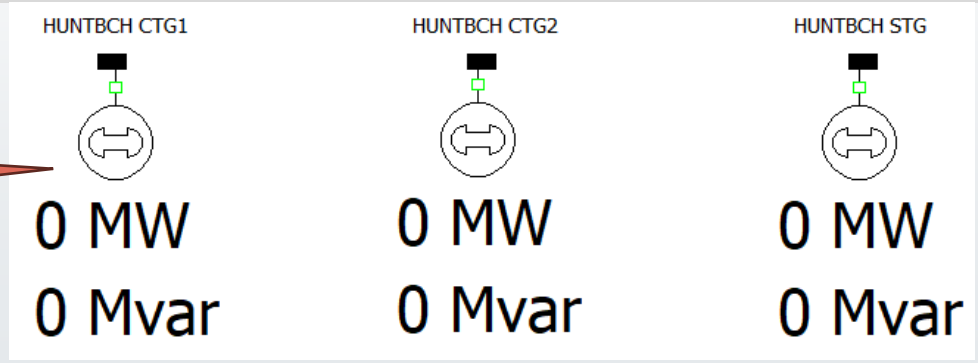
WPP

2025 HW3-OP : Area 24 Thermal

Historically "on" in Winter



Turned "off" in 2025 HW3-OP

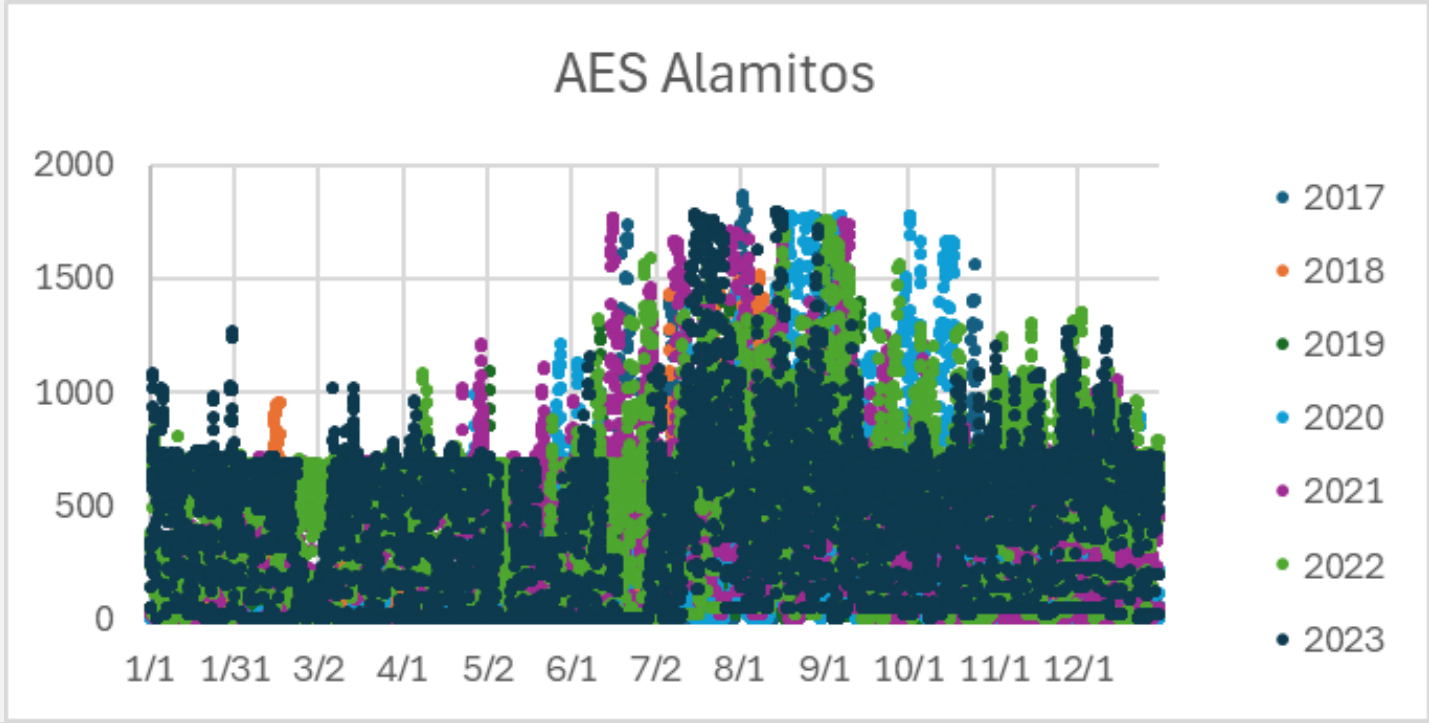


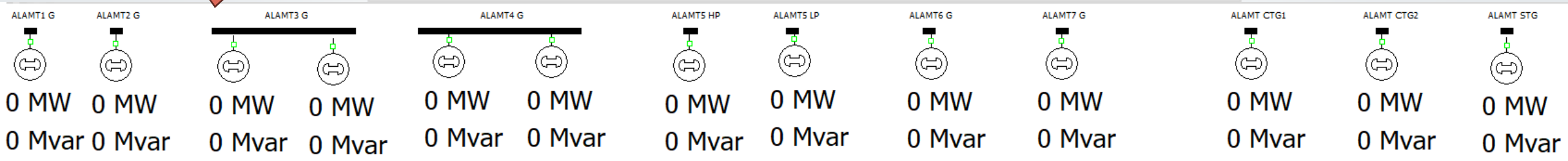
WPP

2025 HW3-OP : Area 24 Thermal

Historically "on" in Winter

Turned "off" in 2025 HW3-OP

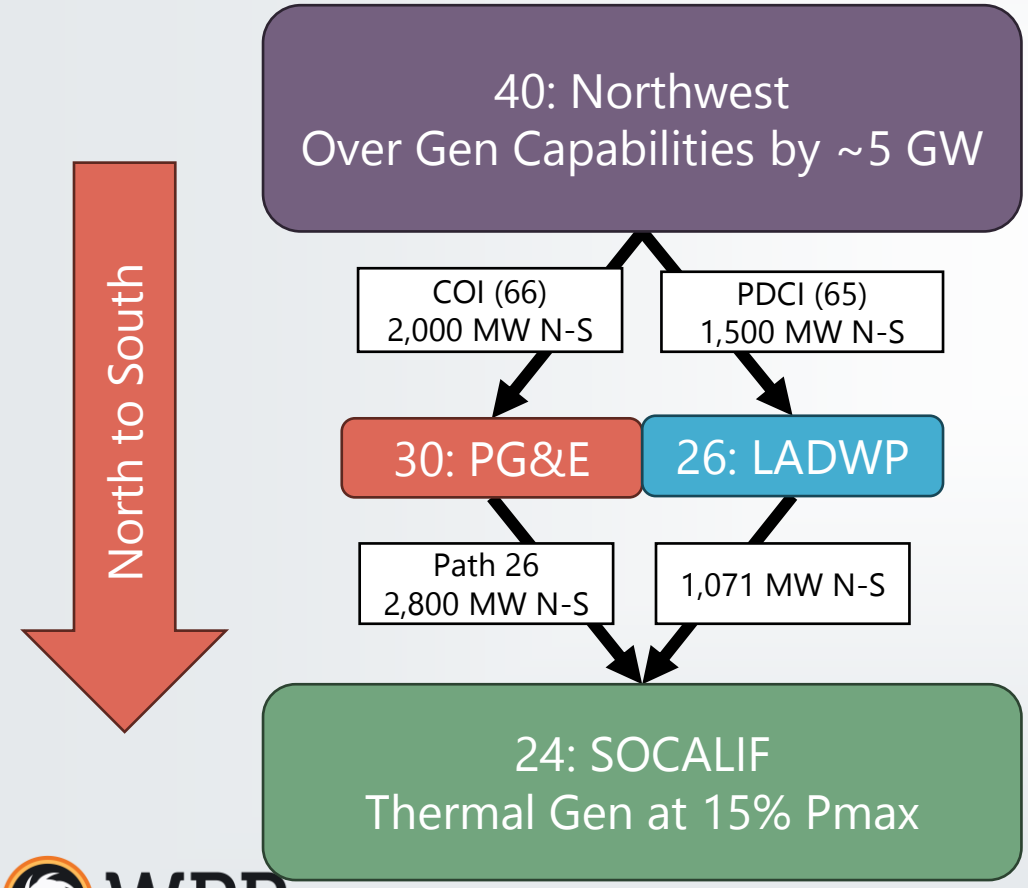




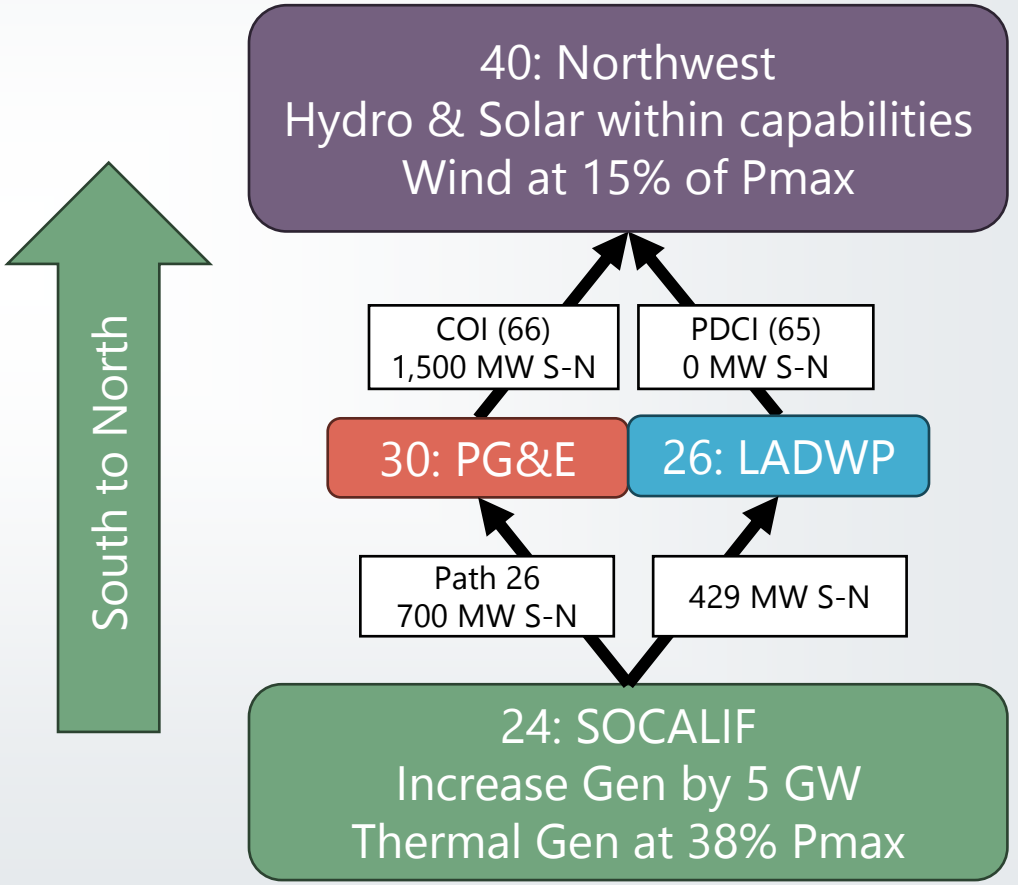
<Public>

1-2 Year HW OP

Existing
(2025 HW3-OP)



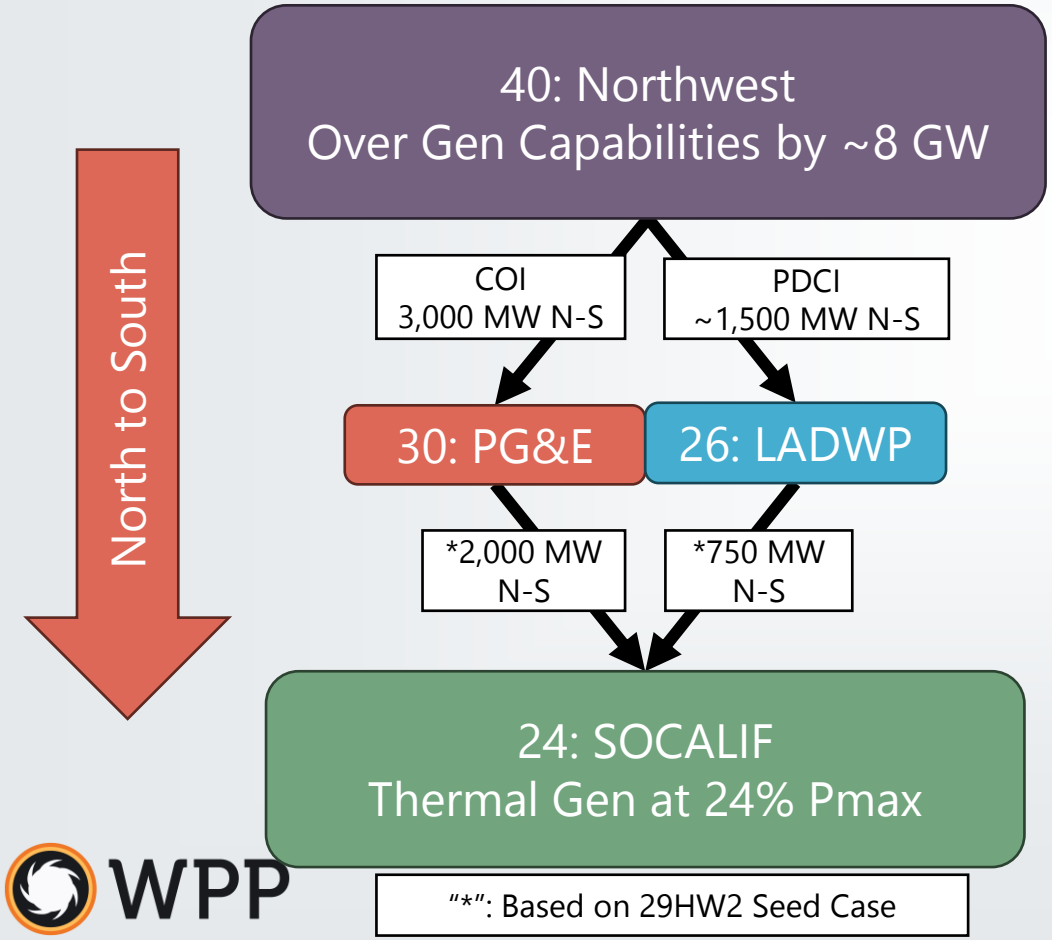
Proposed
(26HW3-OP, next BCCS)



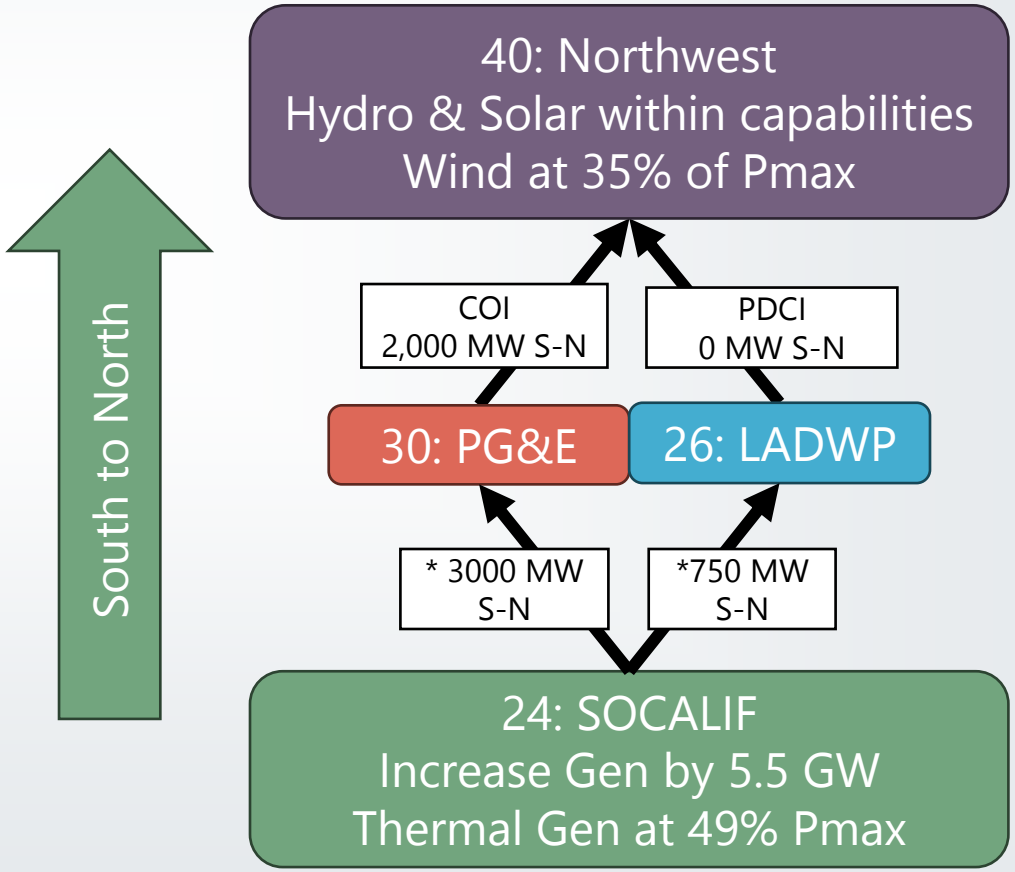
WPP

5-Year HW

Existing
(2030 HW2)

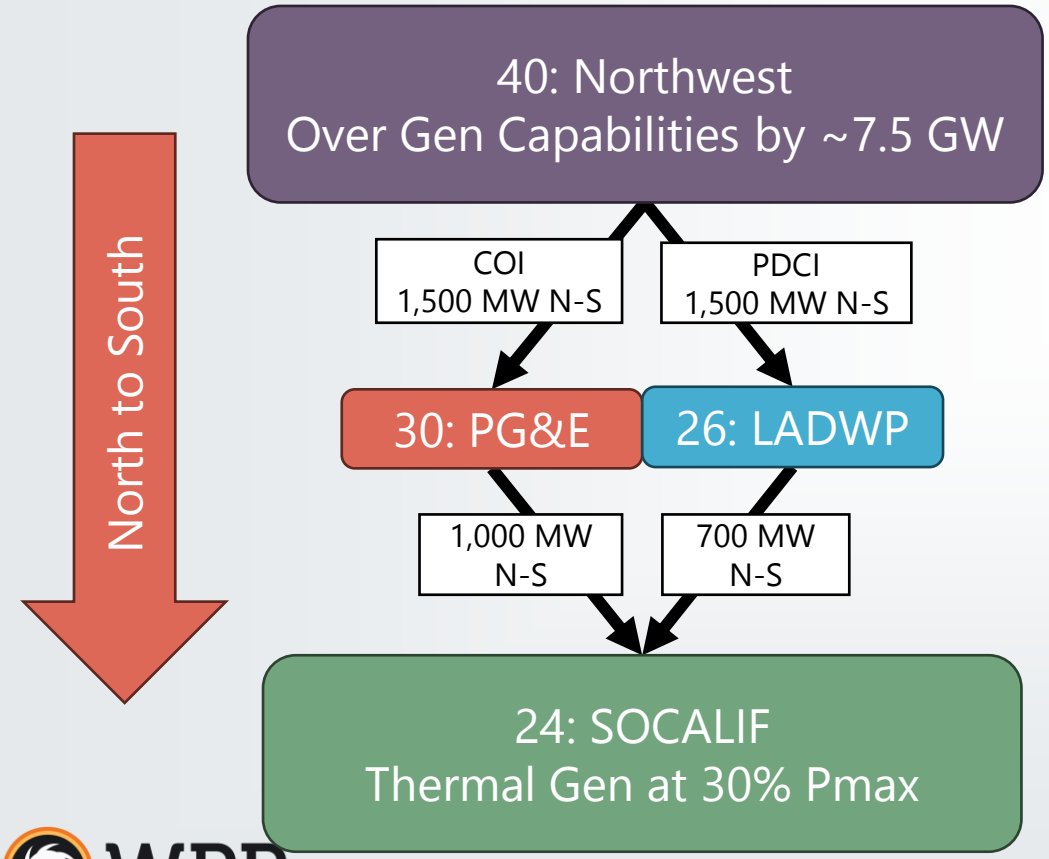


Proposed
(2031 HW2, next BCCS)

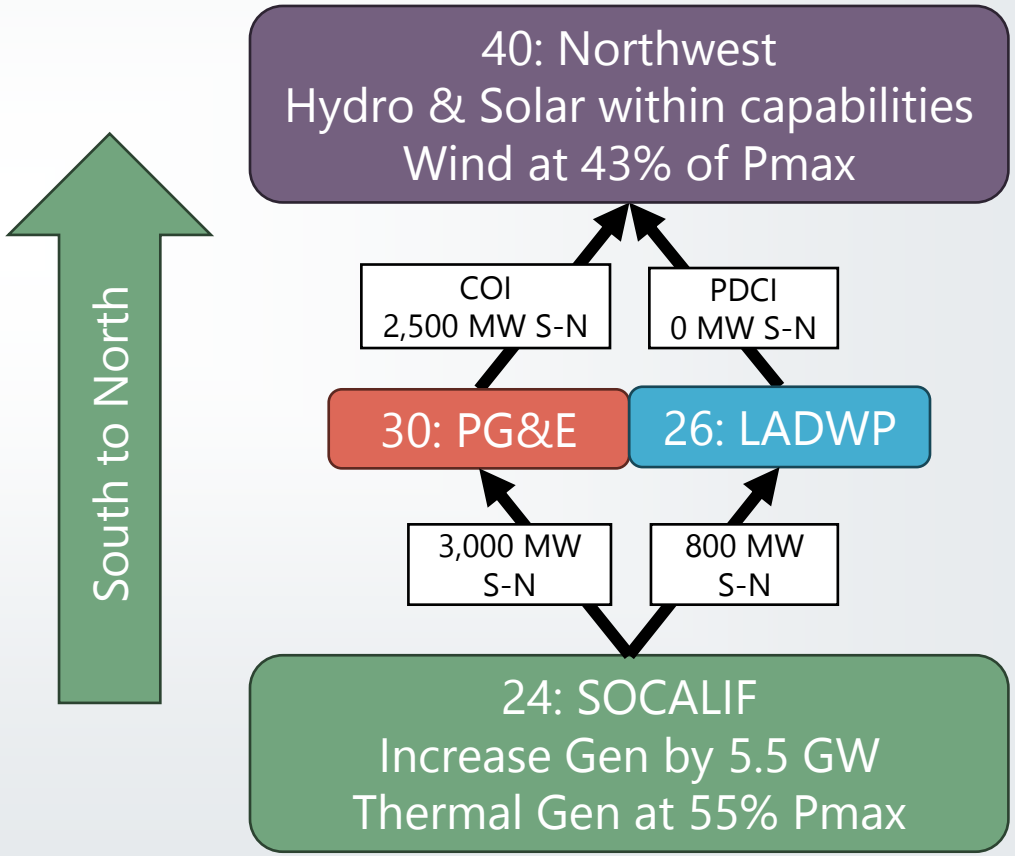


10-Year HW

Existing
(2034 HW1)



Proposed
(2036 HW1, next BCCS)



<Public>

Proposal

- HW BCCS Schedules:
  - 1-2 Year: 1.5 GW S-N
  - 5 Year: 2 GW S-N
  - 10 Year: 2.5 GW S-N

65. Pacific DC Intertie (PDCI) [*Revised* February 2018]

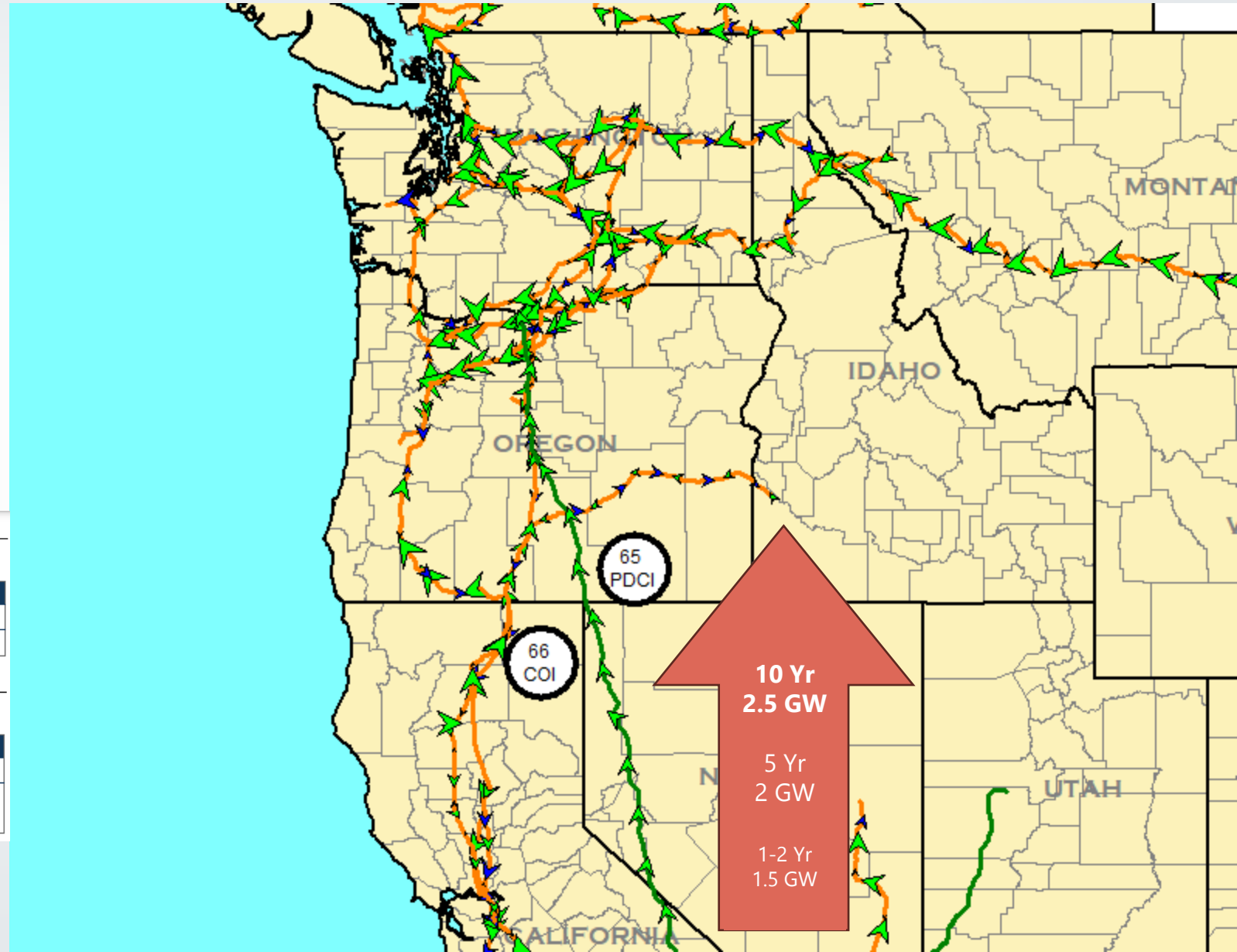
Existing Rating

Definitions	Transfer Limits	
Celilo to Sylmar 500 kV DC line	North to South	South to North
	3,220 MW	3,100 MW

66. California–Oregon Intertie (COI)

Existing Rating

Definitions	Transfer Limits	
Malin to Round Mt. 500 kV	North to South	South to North
(2 lines) (Pacific AC Intertie)	4,800 MW	3,675 MW
Captain Jack–Olinda 500 kV line (COTP)		



WPP

Proposal

- Targets for the 2025 BCCS
  - 1-2 Year Case, 26HW3-OP:
    - Purpose: Operating Case—To represent anticipated operating conditions at winter peak loads.
    - COI: S-N 1,500 MW
    - PDCI: 0 MW
    - Path 26: S-N 700 MW
  - 5 Year Case, 31HW2:
    - COI: S-N 2,000 MW
    - PDCI: 0 MW
    - Path 26: S-N 3,000 MW
  - 10 Year Case, 36HW1:
    - COI: S-N 2,500 MW
    - PDCI: 0 MW
    - Path 26: S-N 3,000 MW

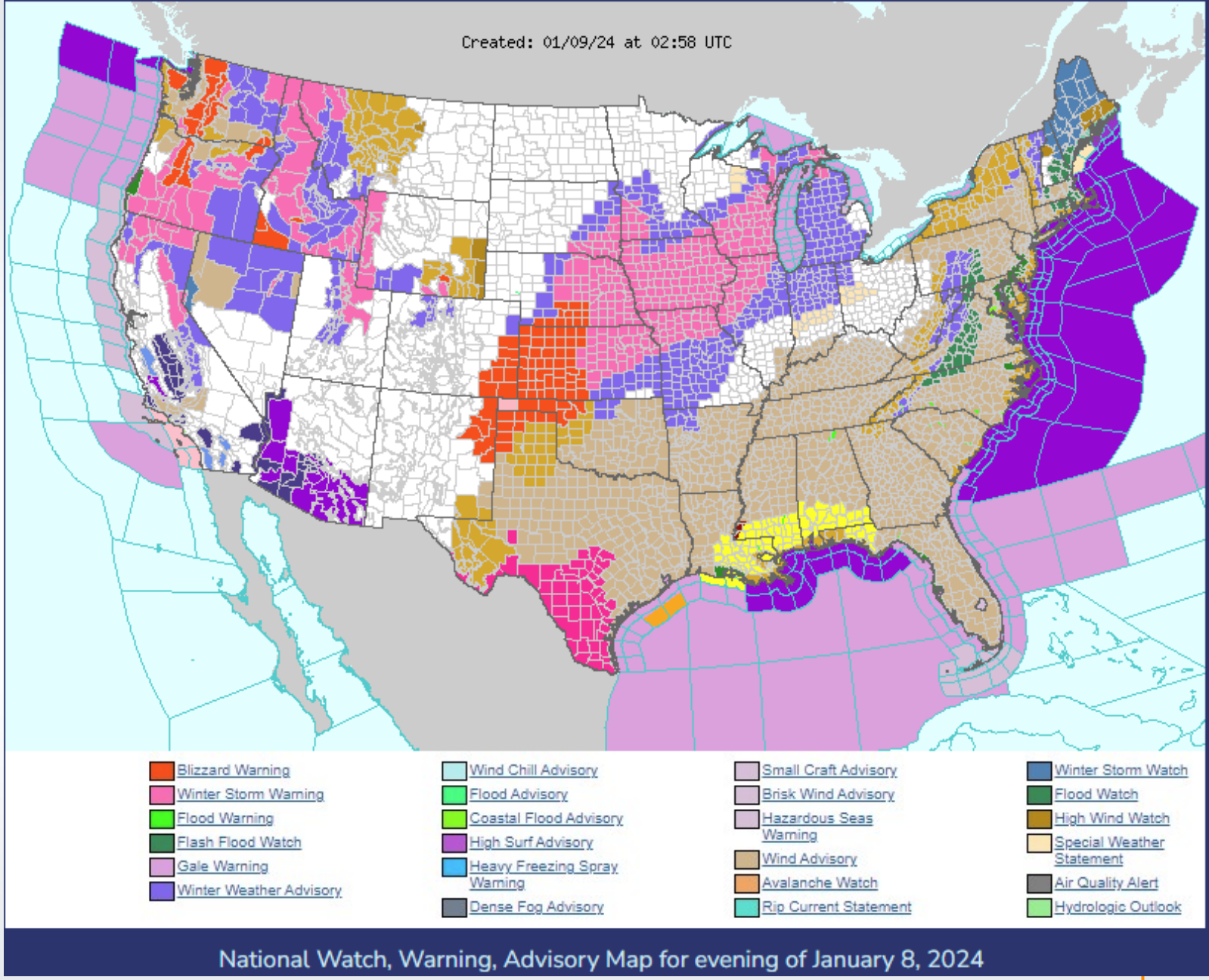

Questions?

Other Good CAISO Resources

- California ISO - Transmission planning (caiso.com)
- Appendix-A-Board-Approved-2022-2023-Transmission-Plan.pdf (caiso.com)
- http://www.caiso.com/Documents/AnnouncedRetirementAndMothballList.xlsx

January 2024 Weather

https://storymaps.arcgis.com/stories/d384af86050144a391a00a551c07a7f9



National Watch, Warning, Advisory Map for evening of January 8, 2024

<Public>

California Natural Gas Units – EIA Data

» California natural gas tends to be dispatched around 50% to 60% during heavy winter hours. (As compared to California's peak recorded Natural Gas output in Summer)

2023-24 HW Hours

DateTime	CAL Load	% Nat Gas
2024-01-08 20:00	34727	63%
2023-12-13 19:00	34631	60%
2024-02-07 20:00	34610	46%
2023-12-20 19:00	34603	56%
2023-12-14 19:00	34503	62%
2023-12-13 20:00	34452	61%
2024-01-10 20:00	34437	58%
2023-12-12 19:00	34422	63%
2023-12-11 19:00	34416	63%
2024-01-08 19:00	34360	63%

2022-23 HW Hours

DateTime	CAL Load	% Nat Gas
2022-12-12 20:00	36149	55%
2022-12-14 20:00	35936	58%
2022-12-12 19:00	35883	56%
2022-12-14 19:00	35880	59%
2022-12-13 20:00	35835	63%
2022-12-14 21:00	35806	57%
2022-12-13 19:00	35698	63%
2022-12-12 21:00	35662	54%
2022-12-13 21:00	35592	63%
2022-12-19 19:00	35539	59%

2021-22 HW Hours

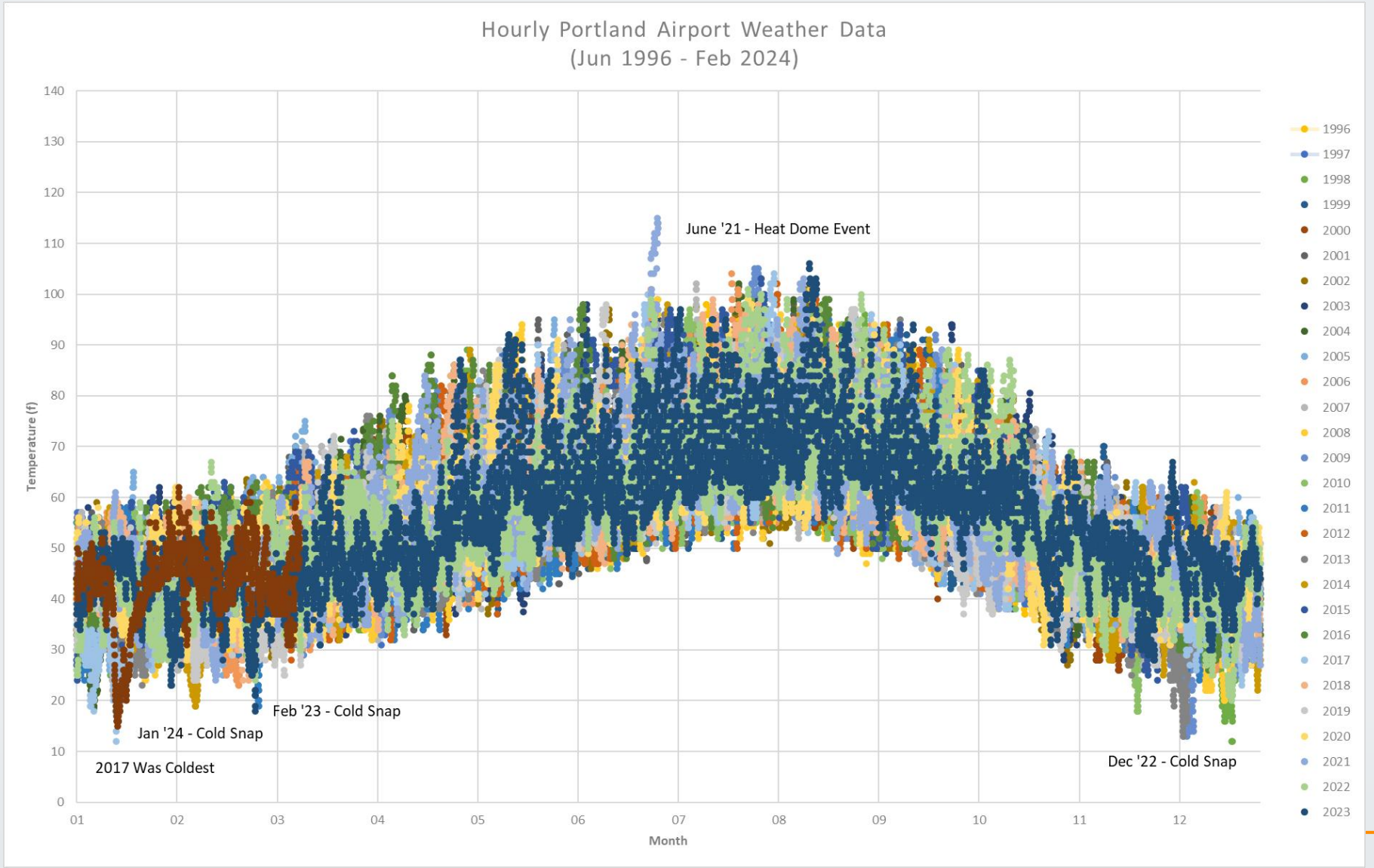
DateTime	CAL Load	% Nat Gas
2021-12-09 20:00	38561	40%
2021-12-14 19:00	37955	49%
2021-12-15 19:00	37893	54%
2021-12-14 18:00	37890	49%
2021-12-15 18:00	37861	56%
2021-12-14 20:00	37542	48%
2021-12-15 20:00	37491	53%
2021-12-13 18:00	37305	52%
2021-12-16 19:00	37218	46%
2021-12-16 18:00	37190	48%

2020-21 HW Hours

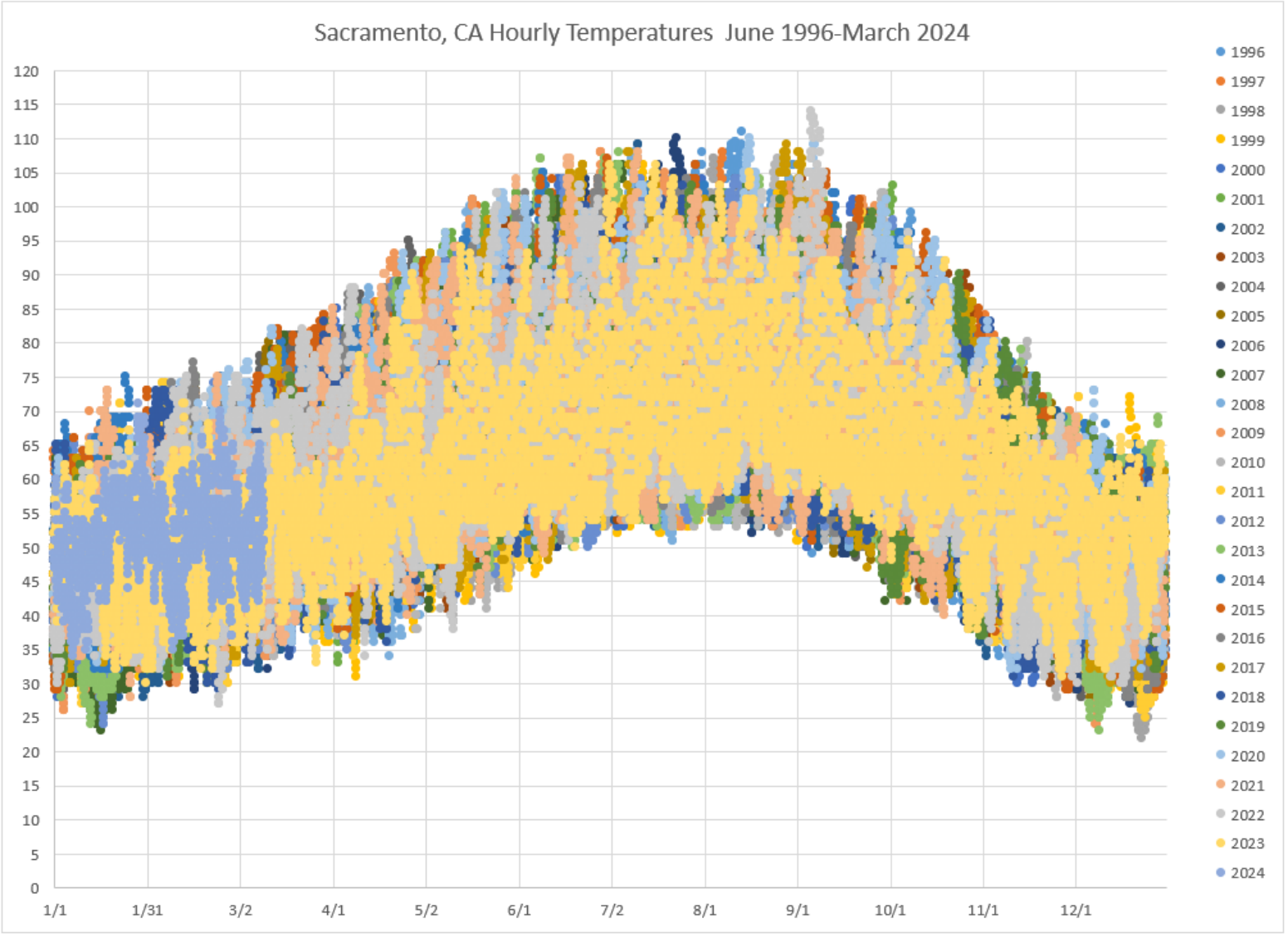
DateTime	CAL Load	% Nat Gas
2020-12-15 19:00	35837	56%
2020-12-14 19:00	35677	52%
2020-12-16 19:00	35597	58%
2021-01-26 19:00	35514	46%
2020-12-15 18:00	35476	58%
2020-12-17 19:00	35444	41%
2020-12-14 18:00	35405	55%
2020-12-16 18:00	35368	60%
2020-12-11 18:00	35366	50%
2020-12-07 18:00	35351	54%

WPP

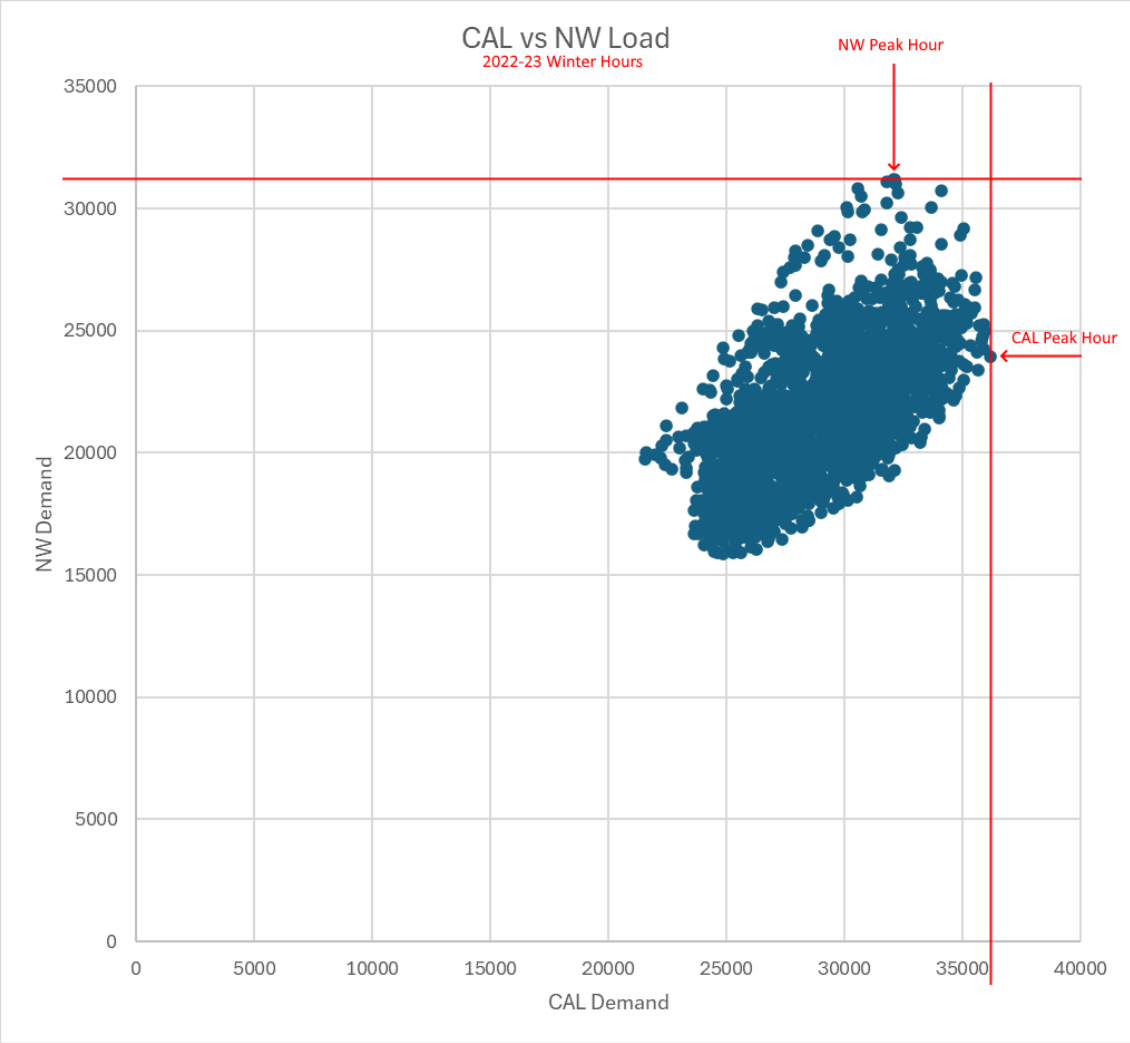
NW Temperatures



CAL Temperatures

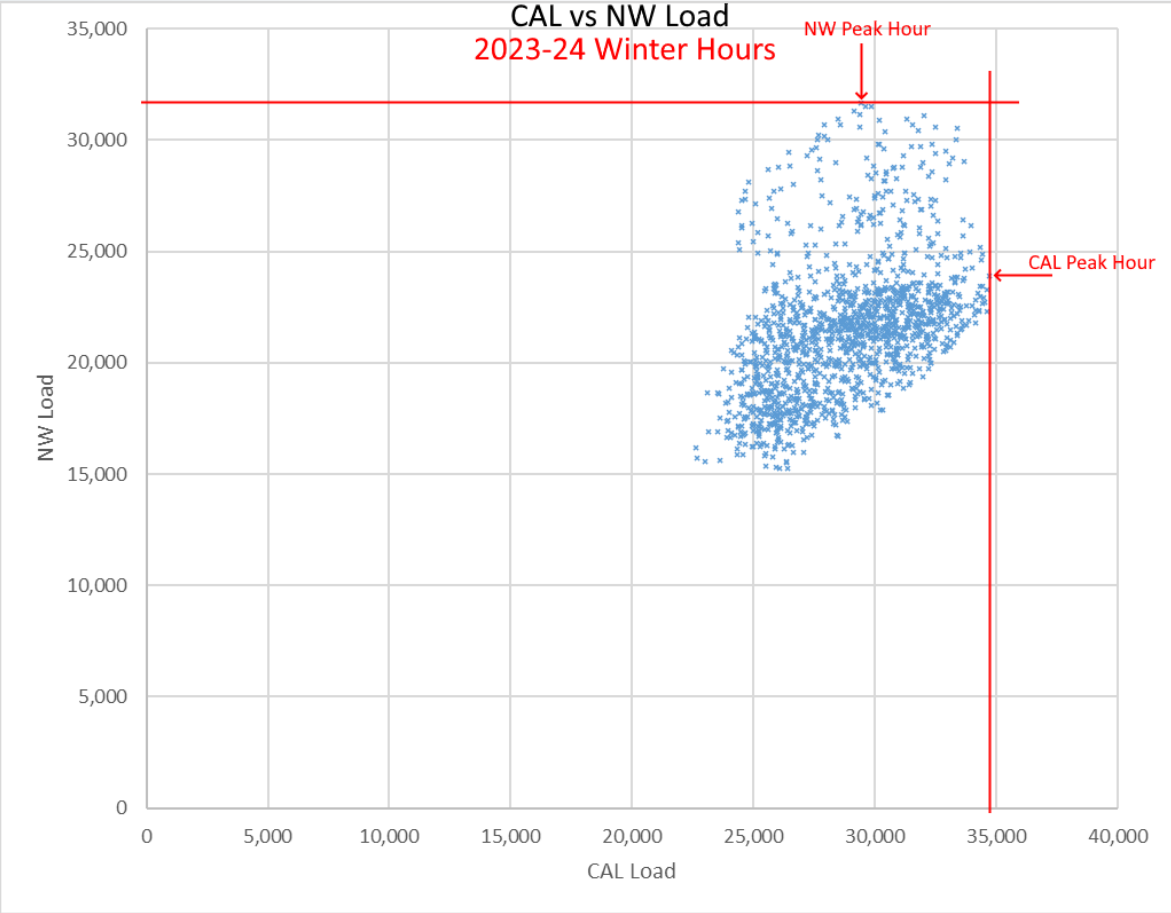


2022-23 Winter – CAL vs NW Load



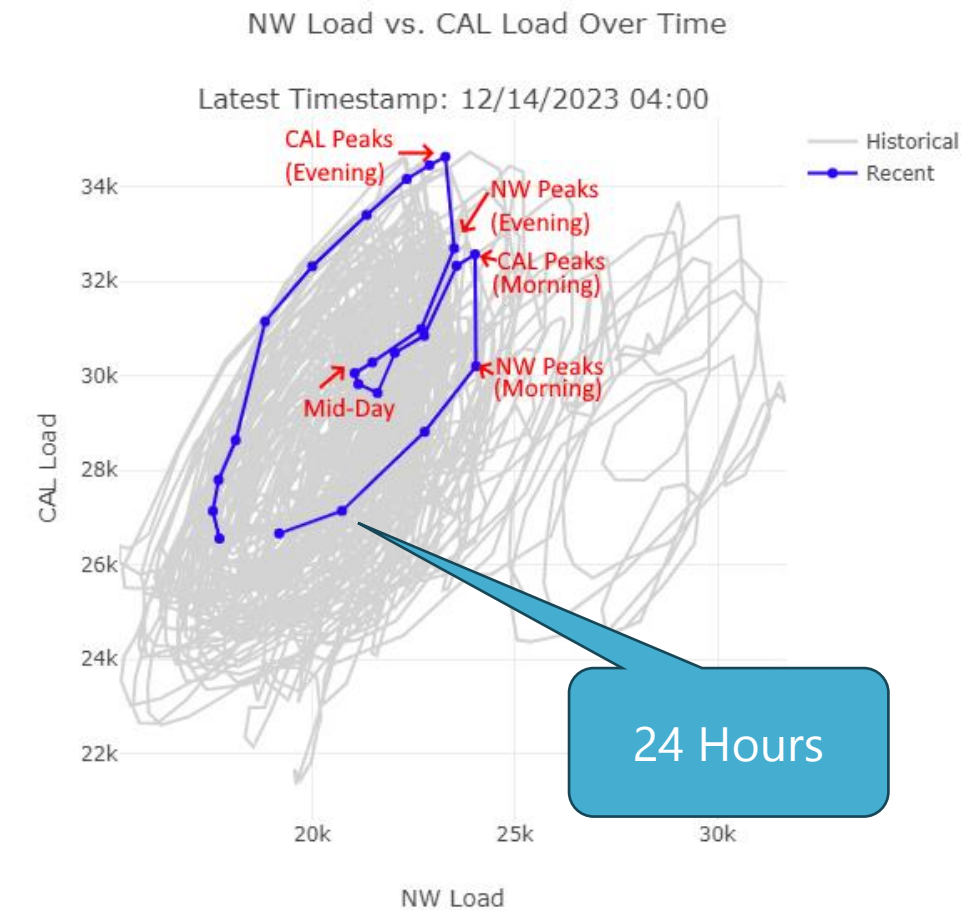
CAL & NW Peak Winters did not occur at the same time.

2023-24 Winter – CAL vs NW Load



CAL & NW Peak Winters did not occur at the same time.

2023-24 Winter – CAL vs NW Load



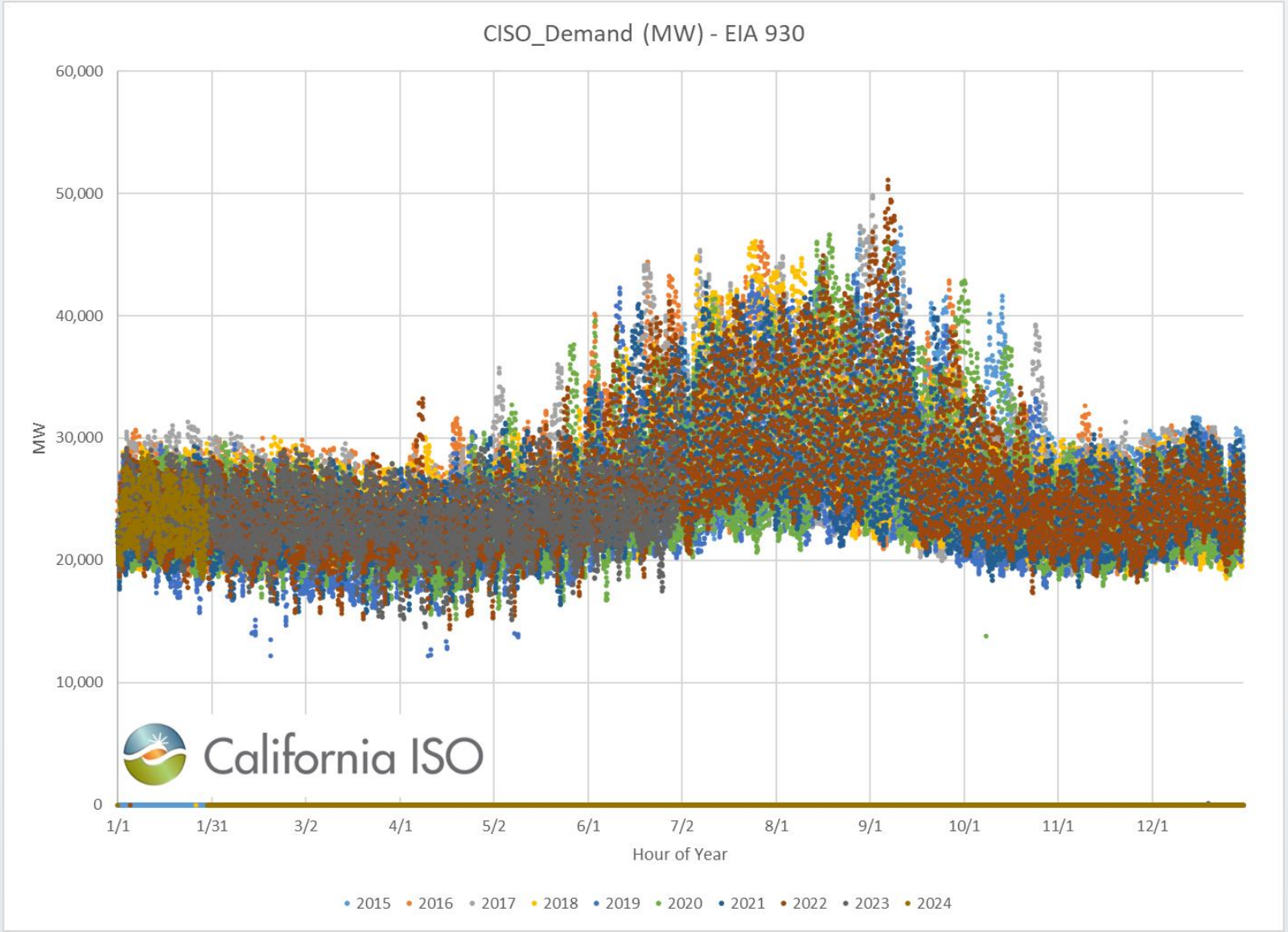
CAL & NW Peak Winters did not occur at the same time.

If you follow the graph along a "Day Path", it often follows a double-oval.

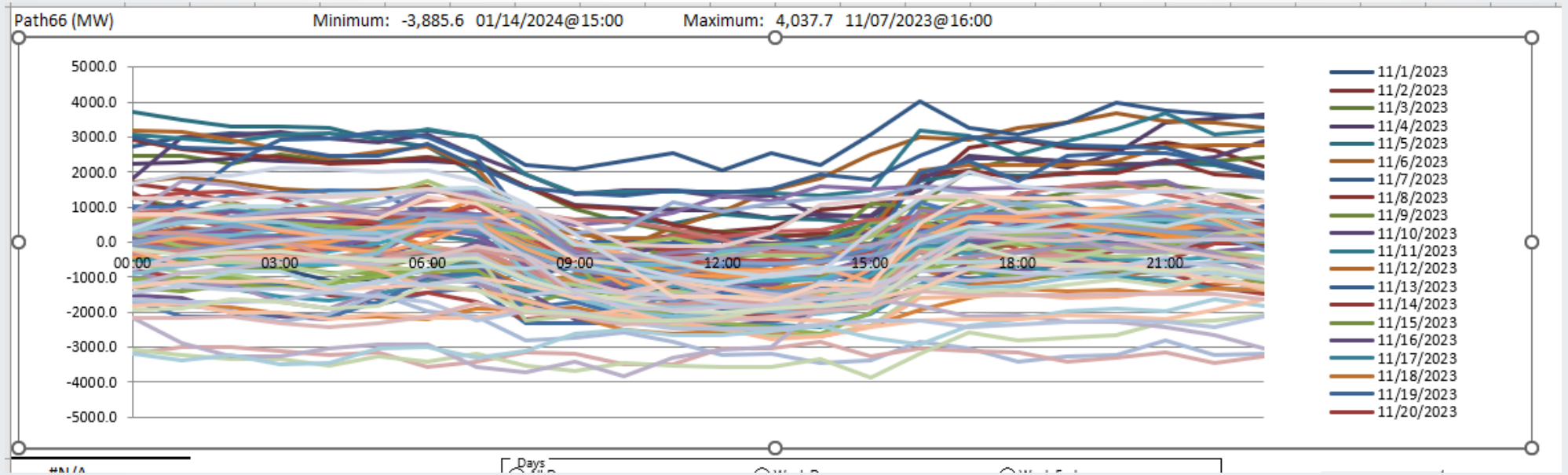
NW Morning Peak
CAL Morning Peak
NW Evening Peak
CAL Evening Peak
Low at night… Repeat

https://codepen.io/BenHutchinsWPP/pen/LYvGJRL

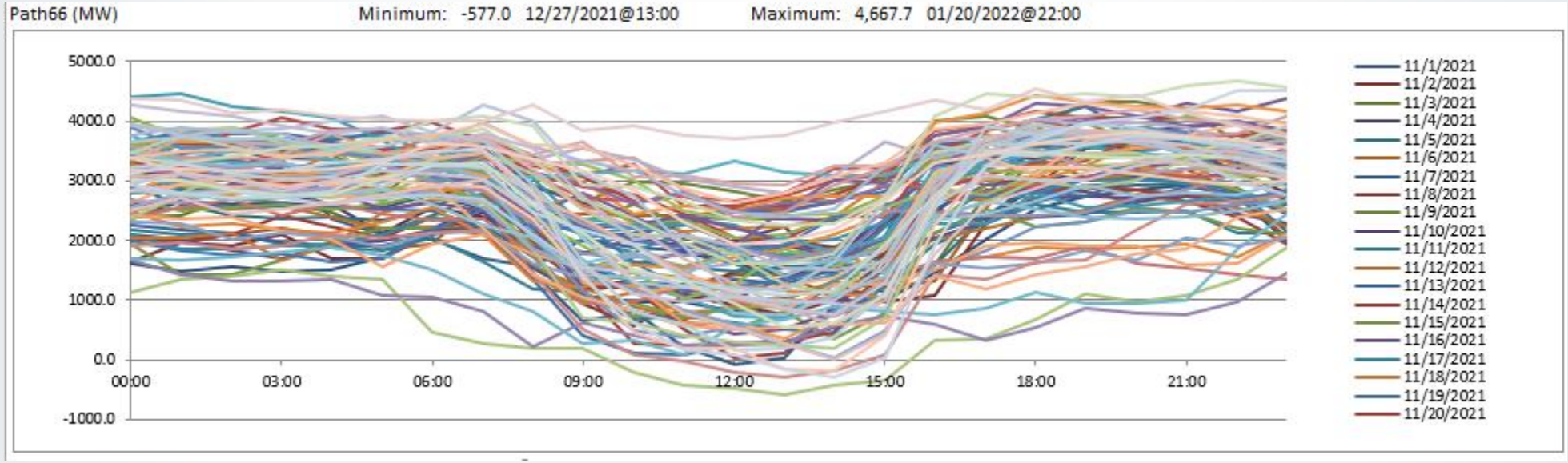
California Loads



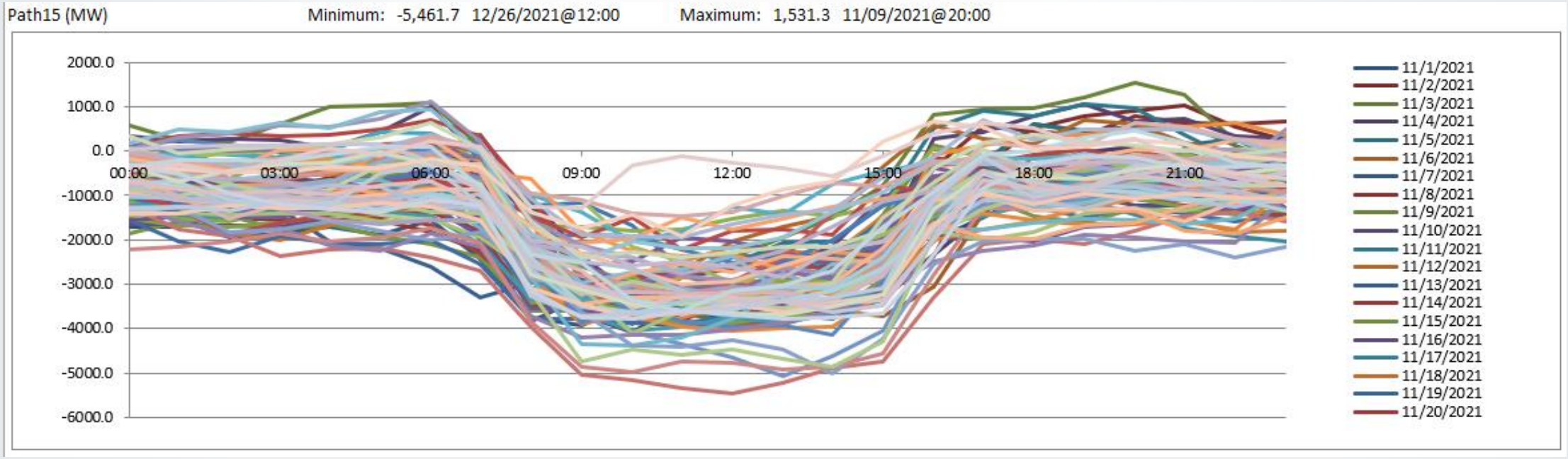
Path 66, 2023-24 Winter



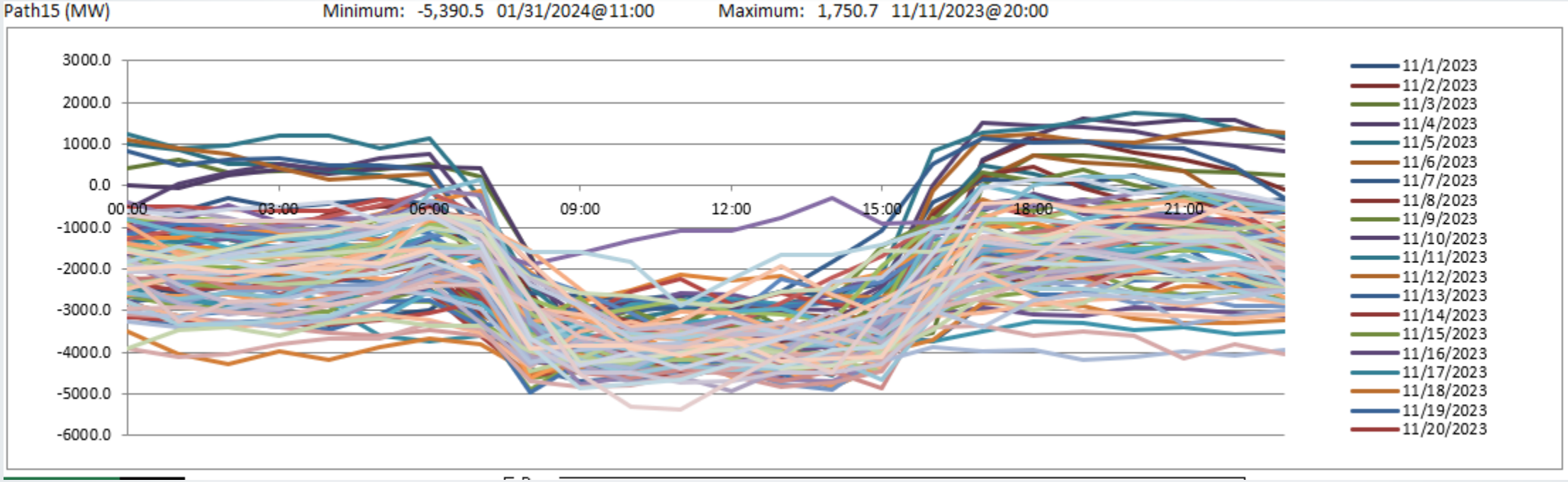
Path 66, 2021-22 Winter



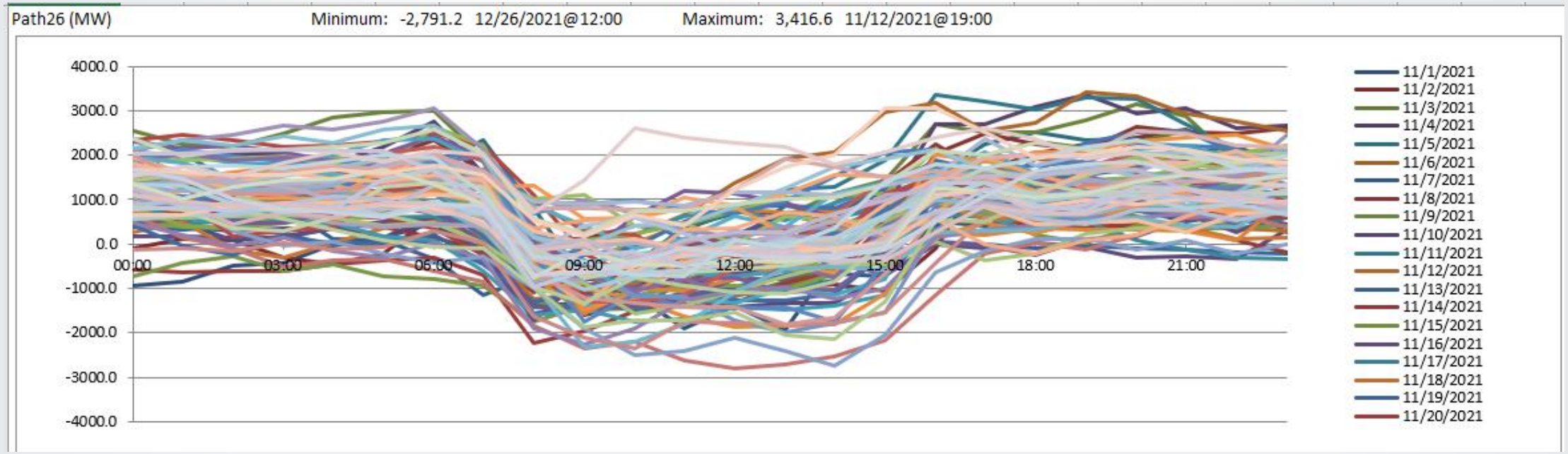
Path 15, 2021-22 Winter



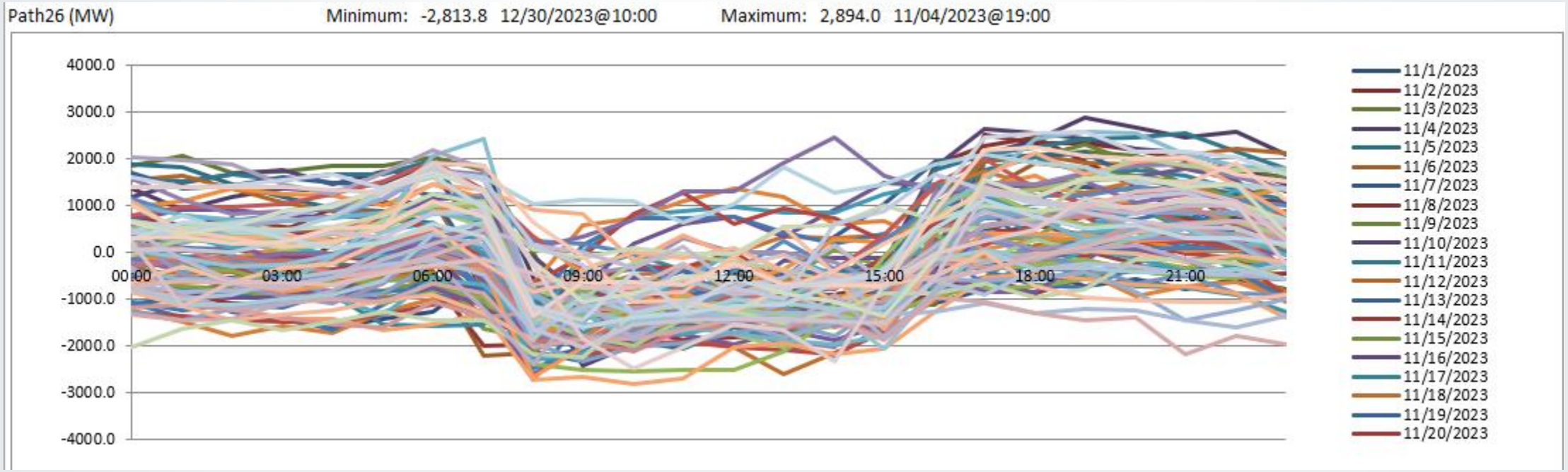
Path 15, 2023-24 Winter



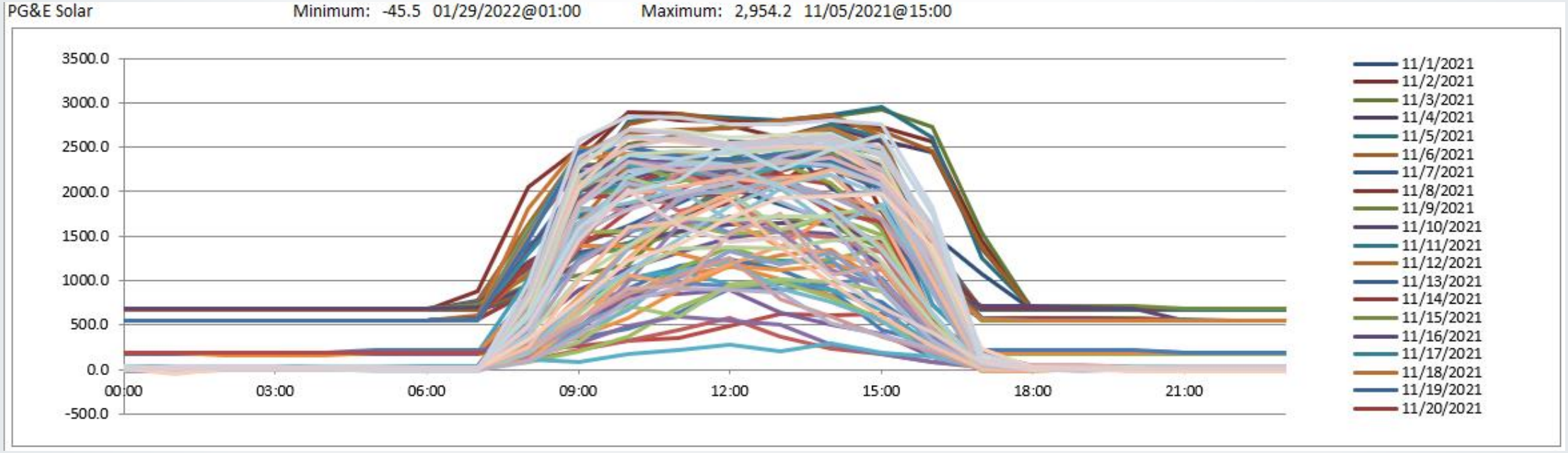
Path 26, 2021-22 Winter



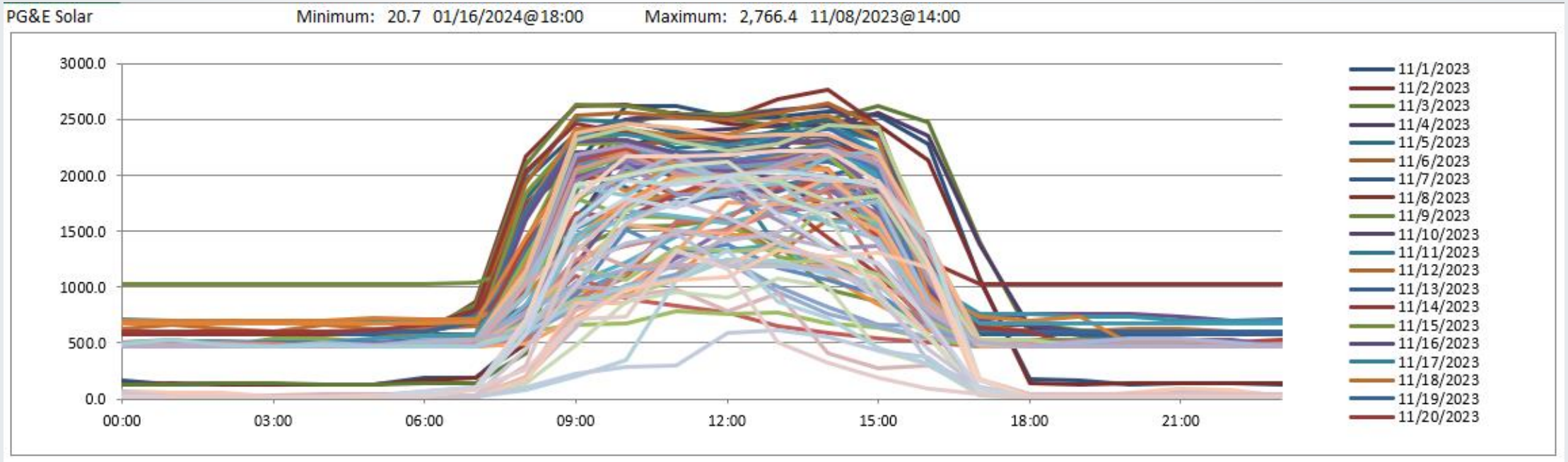
Path 26, 2023-24 Winter



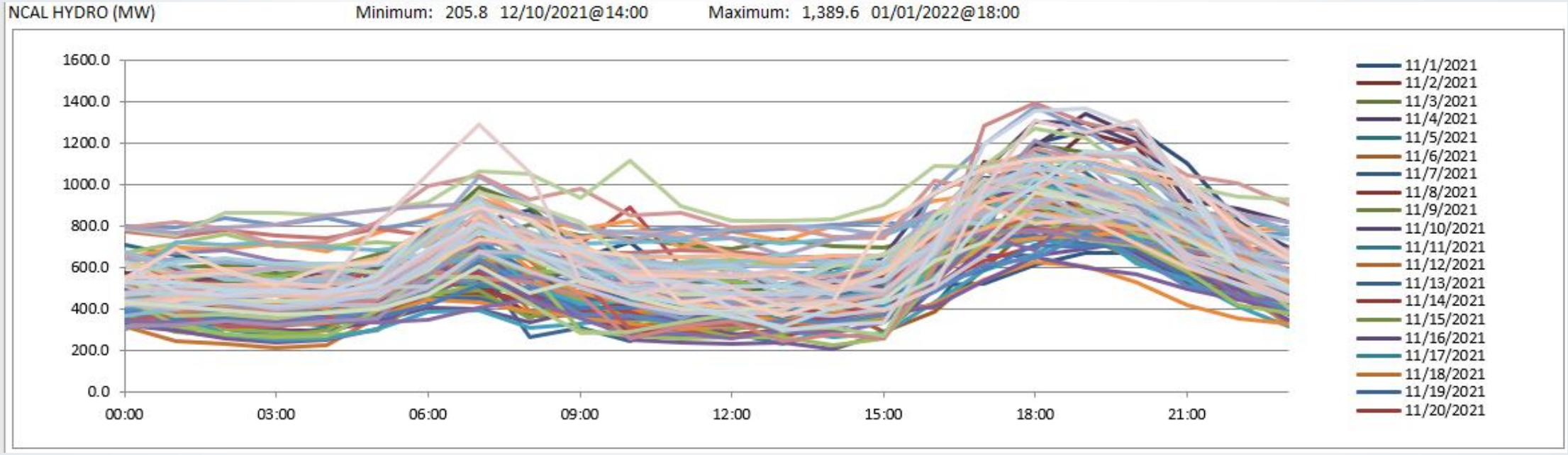
PG&E Solar 2021-22 Winter



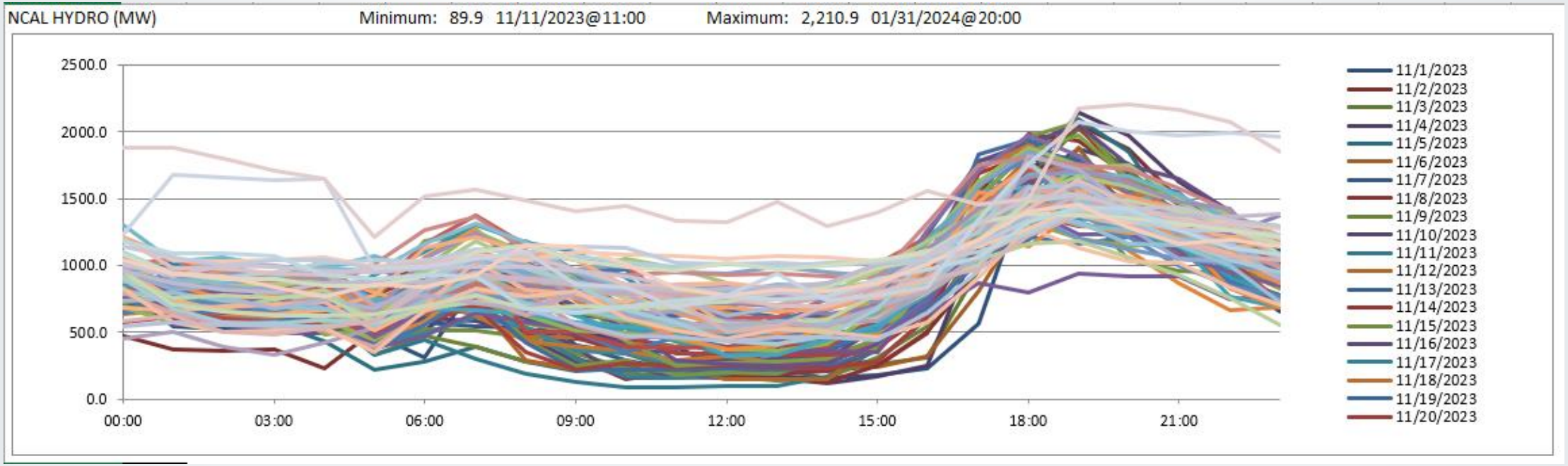
PG&E Solar 2023-24 Winter



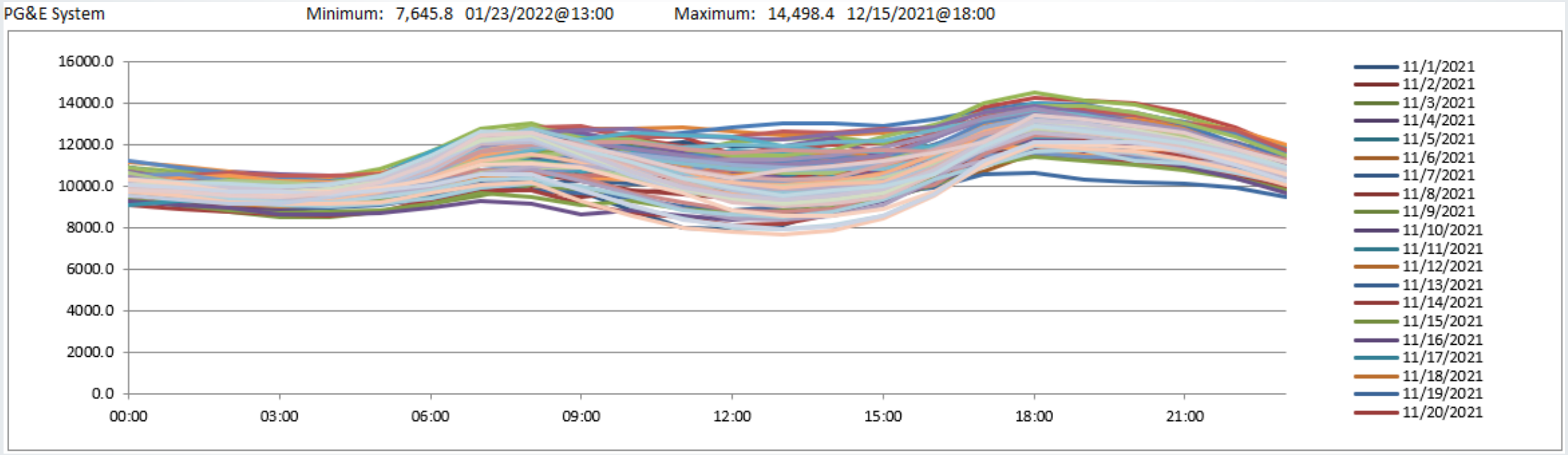
NCAL Hydro


NCAL HYDRO (MW)
Minimum: 205.8 12/10/2021@14:00
Maximum: 1,389.6 01/01/2022@18:00
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
11/1/2021
11/2/2021
11/3/2021
11/4/2021
11/5/2021
11/6/2021
11/7/2021
11/8/2021
11/9/2021
11/10/2021
11/11/2021
11/12/2021
11/13/2021
11/14/2021
11/15/2021
11/16/2021
11/17/2021
11/18/2021
11/19/2021
11/20/2021

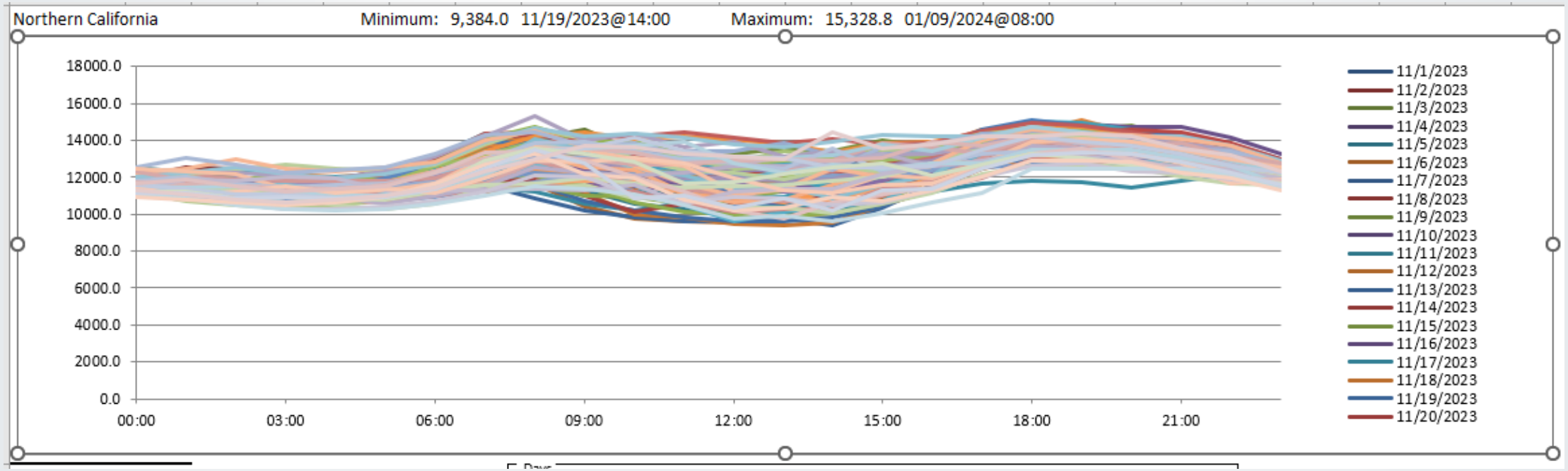
NCAL Hydro


NCAL HYDRO (MW)
Minimum: 89.9 11/11/2023@11:00
Maximum: 2,210.9 01/31/2024@20:00
2500.0
2000.0
1500.0
1000.0
500.0
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
11/1/2023
11/2/2023
11/3/2023
11/4/2023
11/5/2023
11/6/2023
11/7/2023
11/8/2023
11/9/2023
11/10/2023
11/11/2023
11/12/2023
11/13/2023
11/14/2023
11/15/2023
11/16/2023
11/17/2023
11/18/2023
11/19/2023
11/20/2023

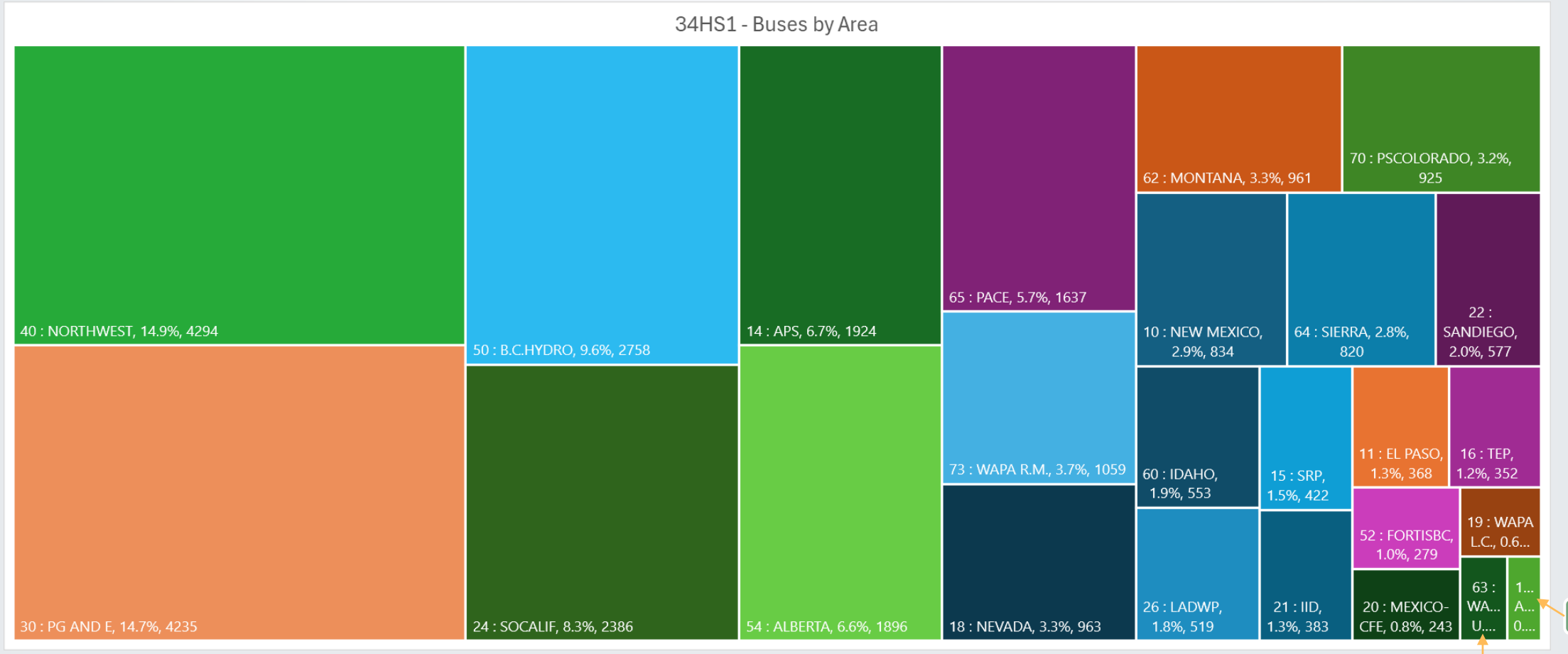
PG&E System Load



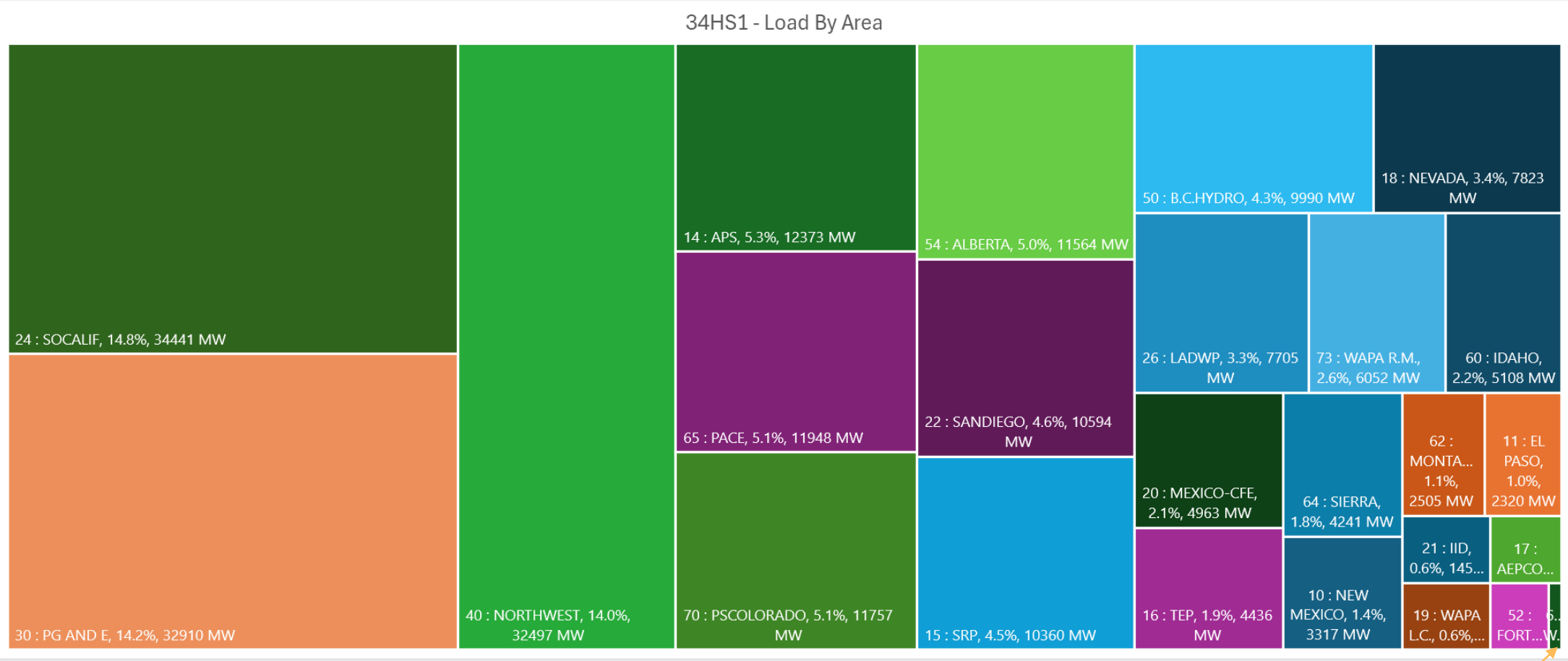
NCAL System Load



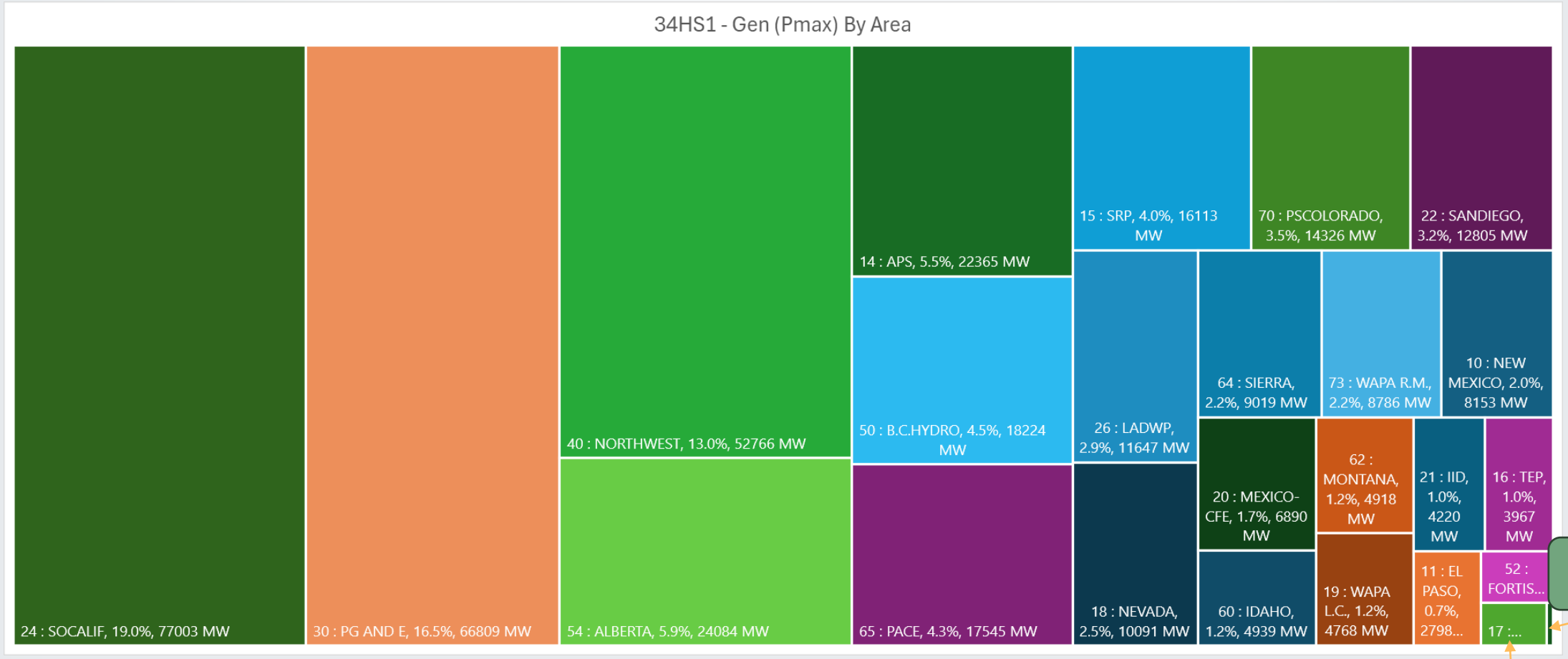
Perspective on Areas - Buses



Perspective on Areas - Load



Perspective on Areas - Generation



<Public>

NW Temperatures

Last couple years have seen particularly cold NW Winters

Attribute	Season	Year-Season	Min of Value	Average of Value	Max of Value
NW Temp	Spring	2015 Spring	31	55	84
		2016 Spring	34	56	88
		2017 Spring	34	52	90
		2018 Spring	31	54	89
		2019 Spring	25	54	89
		2020 Spring	32	53	91
		2021 Spring	31	54	87
		2022 Spring	30	52	77
		2023 Spring	31	53	92

Spring

Attribute	Season	Year-Season	Min of Value	Average of Value	Max of Value
NW Temp	Summer	2015 Summer	51	71	103
		2016 Summer	48	68	99
		2017 Summer	49	68	104
		2018 Summer	47	69	99
		2019 Summer	50	68	98
		2020 Summer	49	67	99
		2021 Summer	49	71	115
		2022 Summer	50	70	101
		2023 Summer	47	71	106

Summer

Hot Summer

Attribute	Season	Year-Season	Min of Value	Average of Value	Max of Value
NW Temp	Fall	2015 Fall	24	56	94
		2016 Fall	39	57	88
		2017 Fall	36	55	96
		2018 Fall	32	56	90
		2019 Fall	27	54	88
		2020 Fall	31	56	94
		2021 Fall	34	57	89
		2022 Fall	30	58	93
		2023 Fall	28	57	94

Fall

Attribute	Season	Year-Season	Min of Value	Average of Value	Max of Value
NW Temp	Winter	2014-2015 Winter	24	46	63
		2015-2016 Winter	28	45	63
		2016-2017 Winter	12	37	59
		2017-2018 Winter	23	43	60
		2018-2019 Winter	24	42	58
		2019-2020 Winter	28	44	62
		2020-2021 Winter	24	43	61
		2021-2022 Winter	24	42	67
		2022-2023 Winter	18	41	57
		2023-2024 Winter	15	44	67

Particularly cold winters

Winter

WPP

NW Interchanges

Last couple years, less exports from NW

Season	Spring			
Attribute	**Year-Season**	**Min of Value**	**Average of Value**	**Max of Value**
NW Int	2016 Spring	-2698	6298	10150
	2017 Spring	-3658	7544	12592
	2018 Spring	-1450	8213	12368
	2019 Spring	-2574	5519	10776
	2020 Spring	-1791	7640	13222
	2021 Spring	-2082	5080	10859
	2022 Spring	-694	5836	11758
	2023 Spring	-4081	3456	11095

Spring

Season	Summer			
Attribute	**Year-Season**	**Min of Value**	**Average of Value**	**Max of Value**
NW Int	2015 Summer	609	4203	8487
	2016 Summer	-1803	3782	7718
	2017 Summer	-1300	7054	11923
	2018 Summer	1701	9316	14137
	2019 Summer	2292	6694	12766
	2020 Summer	4169	9273	13519
	2021 Summer	801	6825	12097
	2022 Summer	-271	7796	12991
	2023 Summer	-621	4854	11973

Summer

Season	Fall			
Attribute	**Year-Season**	**Min of Value**	**Average of Value**	**Max of Value**
NW Int	2015 Fall	-2690	2699	6110
	2016 Fall	-3316	3528	13178
	2017 Fall	61	5042	9479
	2018 Fall	867	5319	13263
	2019 Fall	-2423	4004	9183
	2020 Fall	986	7654	14735
	2021 Fall	-3992	4156	12739
	2022 Fall	-2908	3502	10312
	2023 Fall	-4244	2947	10208

Fall

Season	Winter			
Attribute	**Year-Season**	**Min of Value**	**Average of Value**	**Max of Value**
NW Int	2015-2016 Winter	-2364	2911	8188
	2016-2017 Winter	-2296	4892	8534
	2017-2018 Winter	3085	7456	12160
	2018-2019 Winter	-3788	3248	8465
	2019-2020 Winter	470	7304	14676
	2020-2021 Winter	1379	7440	13570
	2021-2022 Winter	-3582	6002	11475
	2022-2023 Winter	-3738	2172	9984
	2023-2024 Winter	-4918	1521	8602

Winter

CAL Interchanges

Last couple years,
Lower average imports,
And look at those heavy exports!!!

Attribute	Season	Year-Season	Min of Value	Average of Value	Max of Value
CAL Int	Spring	2016 Spring	-11926	-8445	-3839
		2017 Spring	-11595	-7382	-451
		2018 Spring	-12355	-7319	-529
		2019 Spring	-11301	-5367	1403
		2020 Spring	-12254	-6737	-64
		2021 Spring	-11603	-6132	1123
		2022 Spring	-12413	-6336	2103
		2023 Spring	-11144	-3719	4395

Spring

Attribute	Season	Year-Season	Min of Value	Average of Value	Max of Value
CAL Int	Summer	2015 Summer	-11969	-8622	-1051
		2016 Summer	-12780	-8806	-4055
		2017 Summer	-13074	-8242	-568
		2018 Summer	-12682	-8476	-414
		2019 Summer	-12356	-7322	-1755
		2020 Summer	-11910	-7710	-325
		2021 Summer	-11382	-6596	774
		2022 Summer	-12509	-7299	-702
		2023 Summer	-10184	-3206	5444

Summer

Attribute	Season	Year-Season	Min of Value	Average of Value	Max of Value
CAL Int	Fall	2015 Fall	-15289	-8735	-4229
		2016 Fall	-12169	-7627	-60
		2017 Fall	-13350	-7807	-369
		2018 Fall	-15318	-7215	-2247
		2019 Fall	-12811	-7313	-1316
		2020 Fall	-14708	-8113	-2428
		2021 Fall	-13598	-7037	-1473
		2022 Fall	-13649	-6349	-297
		2023 Fall	-13481	-4251	3725

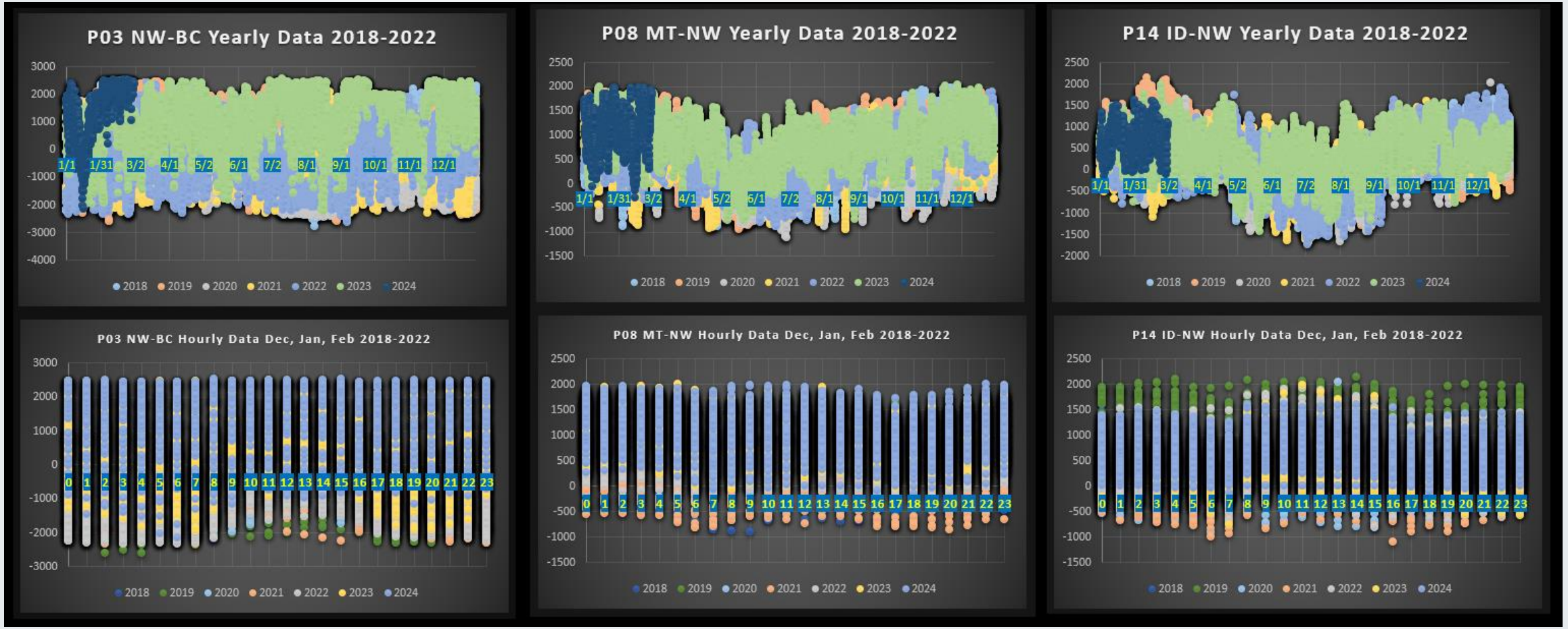
Fall

Attribute	Season	Year-Season	Min of Value	Average of Value	Max of Value
CAL Int	Winter	2015-2016 Winter	-11845	-7624	-3171
		2016-2017 Winter	-10991	-7277	-2123
		2017-2018 Winter	-12833	-8938	-1106
		2018-2019 Winter	-11860	-7149	-782
		2019-2020 Winter	-12545	-8115	-2650
		2020-2021 Winter	-12597	-8383	142
		2021-2022 Winter	-13103	-8808	-1730
		2022-2023 Winter	-10944	-5313	-122
		2023-2024 Winter	-7931	-3120	2086

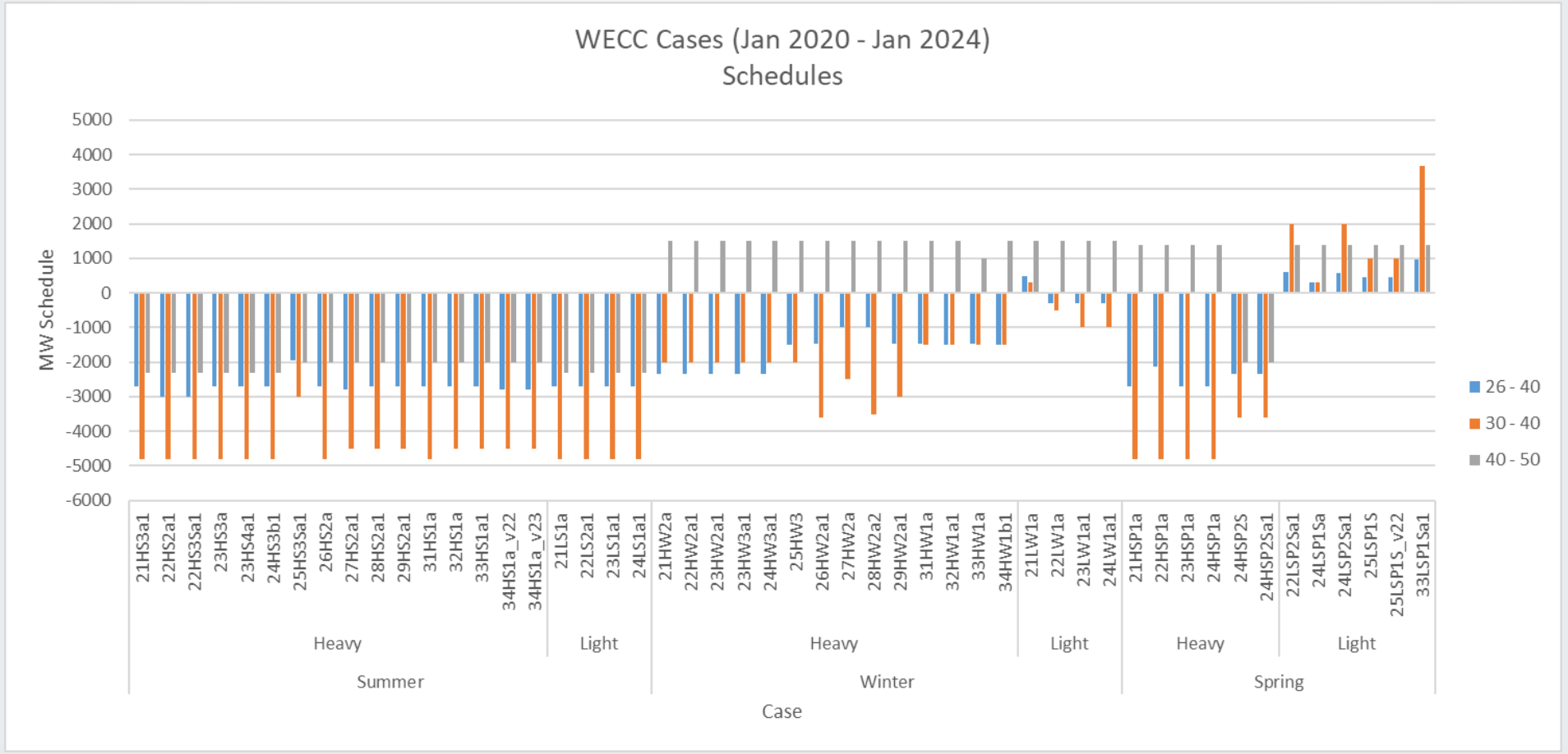
Winter

<Public>

Historical Path Flows

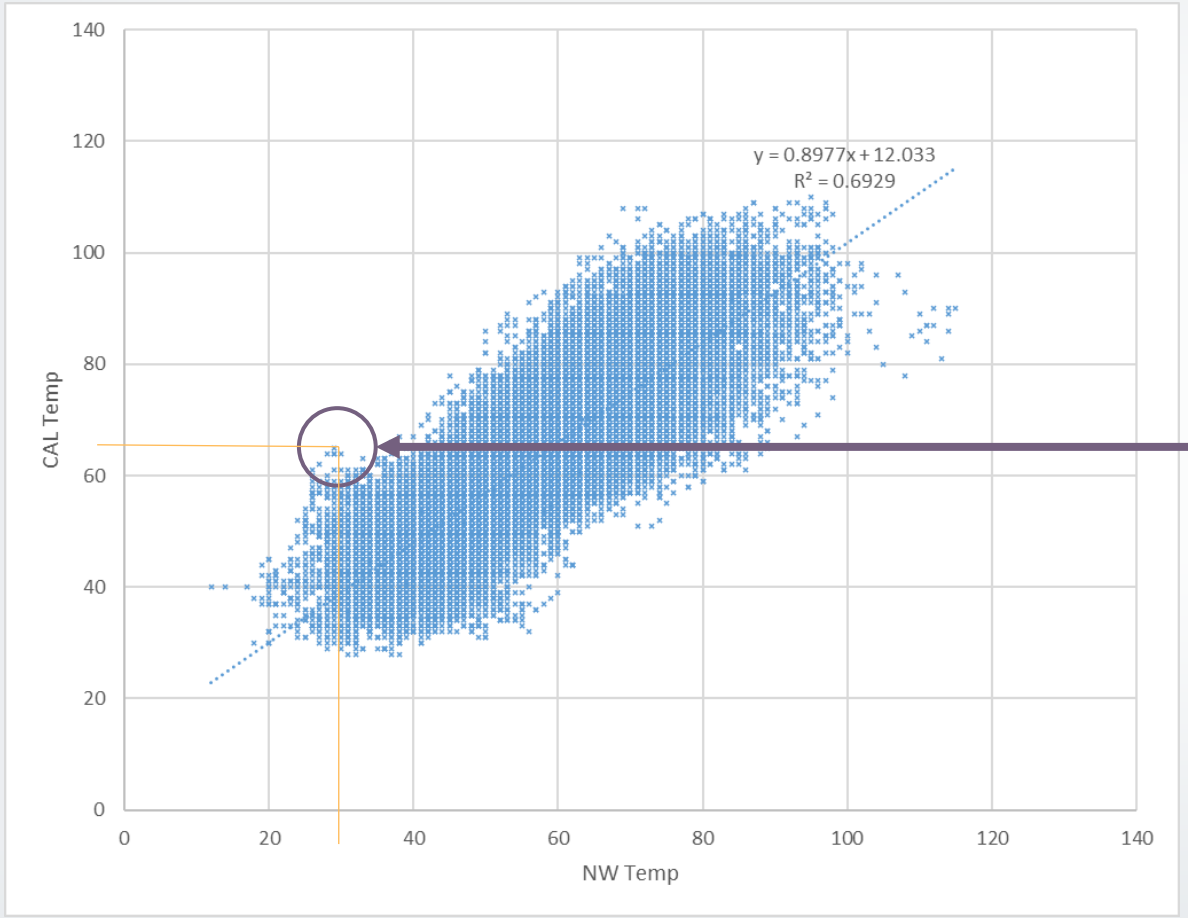


What have we historically studied?



Temperature Dependence

SACRAMENTO AIRPORT ASOS, CA US



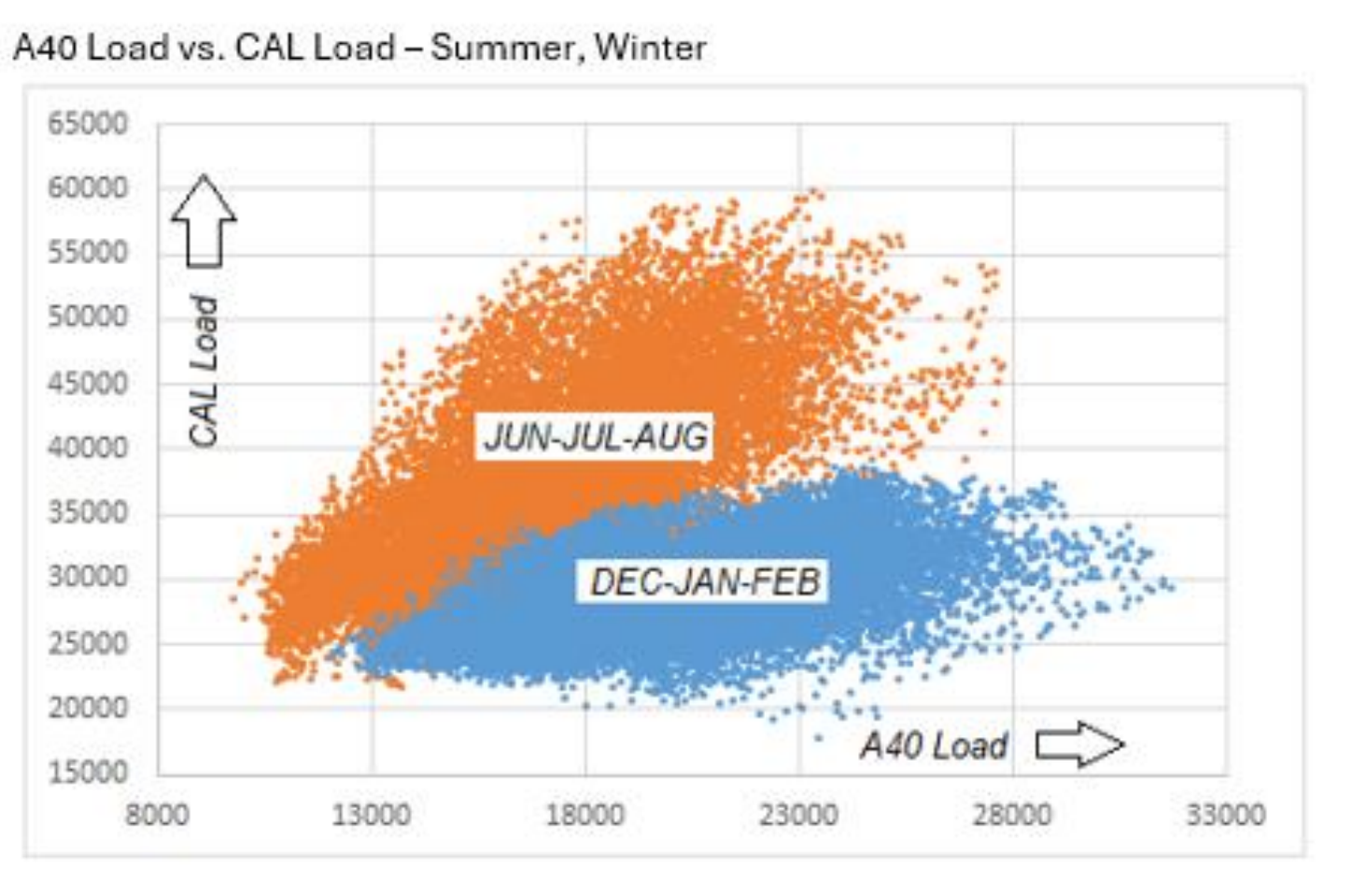
PORTLAND INTERNATIONAL AIRPORT, OR US

Do NW and CAL temperatures correlate?

Yes, to some degree!

But Sometimes, it's simultaneously:
- Room-temperature in California, and
- Below freezing in NW!

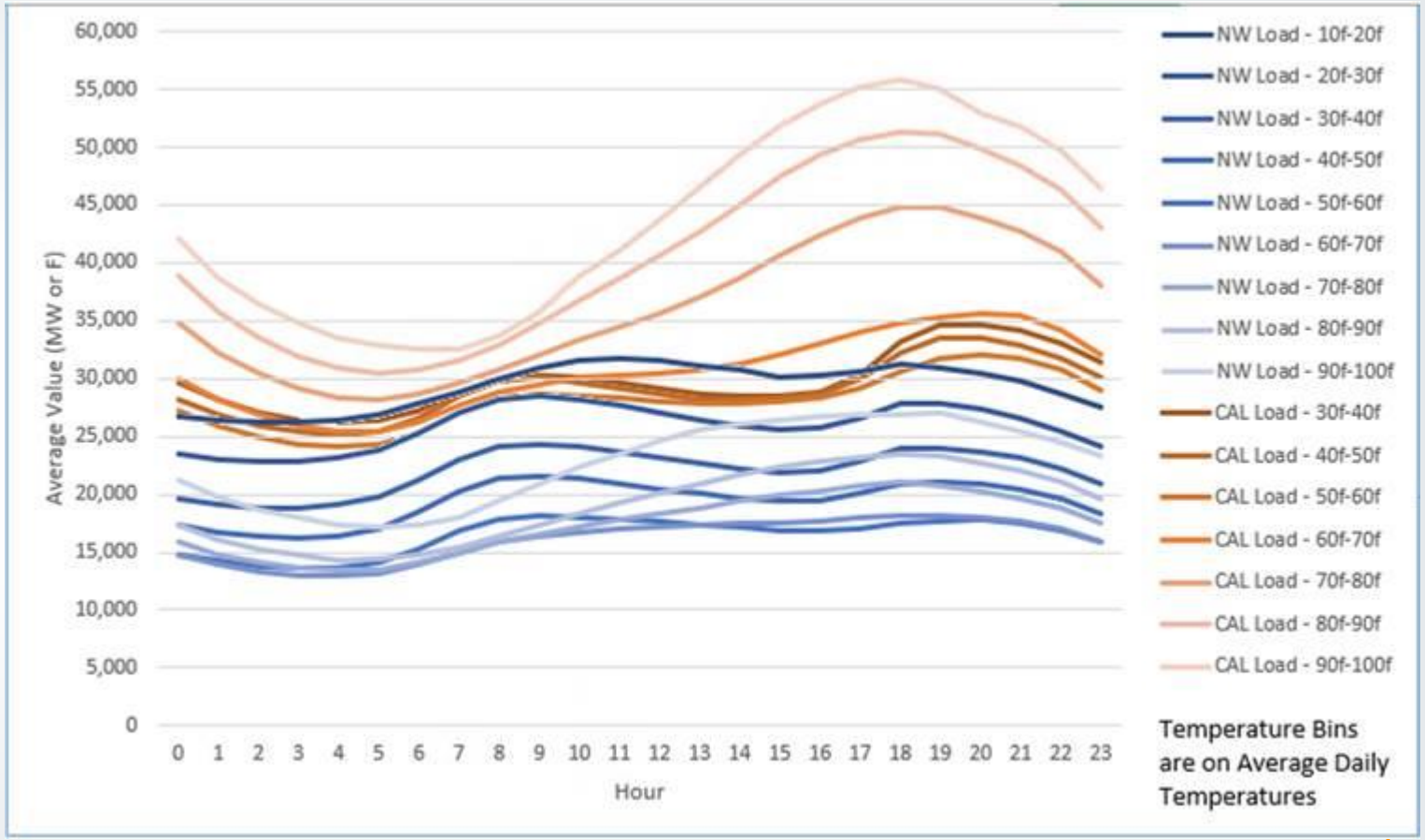
Load Dependence



Load Coincidence (Jul 2015 - Feb 2024)

- Hourly Averages
- CAL: Summer peaking
- NW: Winter peaking

- Summer:
  - Single peak (Evening)
- Winter:
  - Double peak (Morning & Evening)



Other Winter's NW Peaks

2019-20 Winter

DateTime	P65+P66	CAL Load	NW Load
12/17/2019 8:00	3,957	33,833	25,522
12/17/2019 9:00	3,523	33,162	25,261
12/18/2019 8:00	3,333	33,731	25,090
12/16/2019 8:00	3,340	33,407	25,012
12/18/2019 18:00	4,519	36,685	24,909
12/17/2019 18:00	4,038	36,523	24,873
12/18/2019 9:00	3,315	33,712	24,849
12/17/2019 10:00	3,256	32,296	24,824
12/17/2019 19:00	4,255	36,954	24,811
12/16/2019 9:00	2,354	32,248	24,771
12/18/2019 19:00	4,316	36,979	24,758
12/2/2019 8:00	1,277	31,353	24,741
12/16/2019 19:00	4,038	37,027	24,726
12/16/2019 18:00	3,996	36,580	24,707
12/26/2019 18:00	3,199	35,461	24,573
12/2/2019 9:00	1,106	30,987	24,473
12/26/2019 10:00	2,363	30,908	24,467
12/16/2019 20:00	4,211	36,661	24,463
12/26/2019 19:00	3,657	35,796	24,390
12/18/2019 10:00	2,888	33,389	24,388

N-S

2020-21 Winter

DateTime	P65+P66	CAL Load	NW Load
2/12/2021 10:00	191	28,241	27,157
2/12/2021 9:00	985	28,972	27,037
2/12/2021 11:00	383	26,968	27,026
2/11/2021 19:00	2,941	33,204	26,814
2/12/2021 19:00	2,361	31,727	26,758
2/11/2021 18:00	2,704	32,321	26,712
2/12/2021 18:00	2,234	30,091	26,684
2/12/2021 12:00	262	26,126	26,613
2/12/2021 8:00	1,315	29,107	26,469
2/12/2021 13:00	-637	25,517	26,197
2/11/2021 20:00	3,261	32,398	26,179
2/12/2021 20:00	2,626	31,094	26,112
2/10/2021 9:00	934	29,304	25,991
2/12/2021 17:00	1,700	27,469	25,875
2/10/2021 8:00	1,704	29,722	25,863
2/12/2021 14:00	-823	25,774	25,819
2/11/2021 17:00	3,082	30,573	25,769
2/11/2021 10:00	1,343	28,879	25,637
2/11/2021 9:00	1,241	29,561	25,573
2/12/2021 16:00	-555	26,004	25,467

N-S

2021-22 Winter

DateTime	P65+P66	CAL Load	NW Load
2/23/2022 8:00	-305	32,497	29,227
12/27/2021 18:00	1,072	35,658	29,130
12/27/2021 19:00	1,494	35,579	28,681
12/29/2021 18:00	2,468	36,367	28,491
12/28/2021 18:00	1,014	35,855	28,405
2/23/2022 9:00	-330	31,546	28,395
12/27/2021 17:00	921	33,399	28,320
2/25/2022 8:00	1,747	33,087	28,304
12/29/2021 19:00	2,521	36,174	28,207
12/29/2021 10:00	580	31,712	28,156
12/27/2021 10:00	186	30,527	28,100
2/23/2022 7:00	553	31,691	28,071
12/29/2021 9:00	1,052	31,459	28,036
12/28/2021 10:00	27	31,119	28,019
12/27/2021 20:00	1,454	34,982	27,990
12/28/2021 19:00	1,417	35,942	27,937
12/27/2021 9:00	546	30,725	27,878
12/27/2021 11:00	156	30,149	27,877
12/28/2021 11:00	-110	30,964	27,813
12/28/2021 9:00	585	31,415	27,791

N-S

Other Winter's NW Peaks

2016-17 Winter

DateTime	P65+P66	CAL Load	NW Load
1/6/2017 8:00	1,624	32,786	30,778
1/5/2017 8:00	397	31,622	30,736
1/5/2017 9:00	405	32,256	30,445
1/6/2017 9:00	1,510	32,899	30,237
1/13/2017 9:00	1,510	33,811	29,904
1/13/2017 8:00	1,838	33,799	29,894
1/6/2017 10:00	1,874	32,378	29,640
1/5/2017 10:00	535	32,385	29,541
1/4/2017 8:00	2,656	31,608	29,509
1/5/2017 7:00	429	29,738	29,484
1/6/2017 7:00	2,161	31,268	29,457
1/13/2017 10:00	1,294	33,457	29,454
1/12/2017 8:00	910	32,885	29,287
1/12/2017 9:00	650	33,316	29,177
1/4/2017 9:00	2,457	32,121	29,132
1/5/2017 19:00	1,266	36,232	28,947
1/3/2017 19:00	1,890	37,279	28,943
1/4/2017 19:00	2,674	36,282	28,829
1/3/2017 18:00	1,947	36,953	28,761
1/5/2017 20:00	1,214	35,788	28,758

N-S

2017-18 Winter

DateTime	P65+P66	CAL Load	NW Load
2/23/2018 8:00	4,956	33,446	28,929
2/23/2018 9:00	4,074	32,854	28,059
2/23/2018 7:00	5,627	32,424	27,853
2/21/2018 8:00	4,034	33,535	27,638
2/20/2018 8:00	3,250	34,285	27,419
2/21/2018 9:00	3,625	32,841	27,281
2/23/2018 10:00	3,818	32,055	27,095
2/22/2018 8:00	4,243	33,741	26,973
2/20/2018 9:00	2,895	33,266	26,970
2/13/2018 8:00	4,813	31,820	26,865
12/11/2017 8:00	4,944	32,723	26,663
2/22/2018 9:00	3,340	32,755	26,617
2/21/2018 7:00	4,560	32,714	26,544
2/20/2018 19:00	5,544	36,573	26,530
2/21/2018 10:00	3,467	31,964	26,465
12/11/2017 9:00	4,916	32,745	26,397
2/21/2018 19:00	5,337	35,478	26,393
2/23/2018 11:00	3,858	31,298	26,373
2/20/2018 7:00	3,844	33,267	26,352
12/21/2017 9:00	2,836	33,266	26,350

N-S

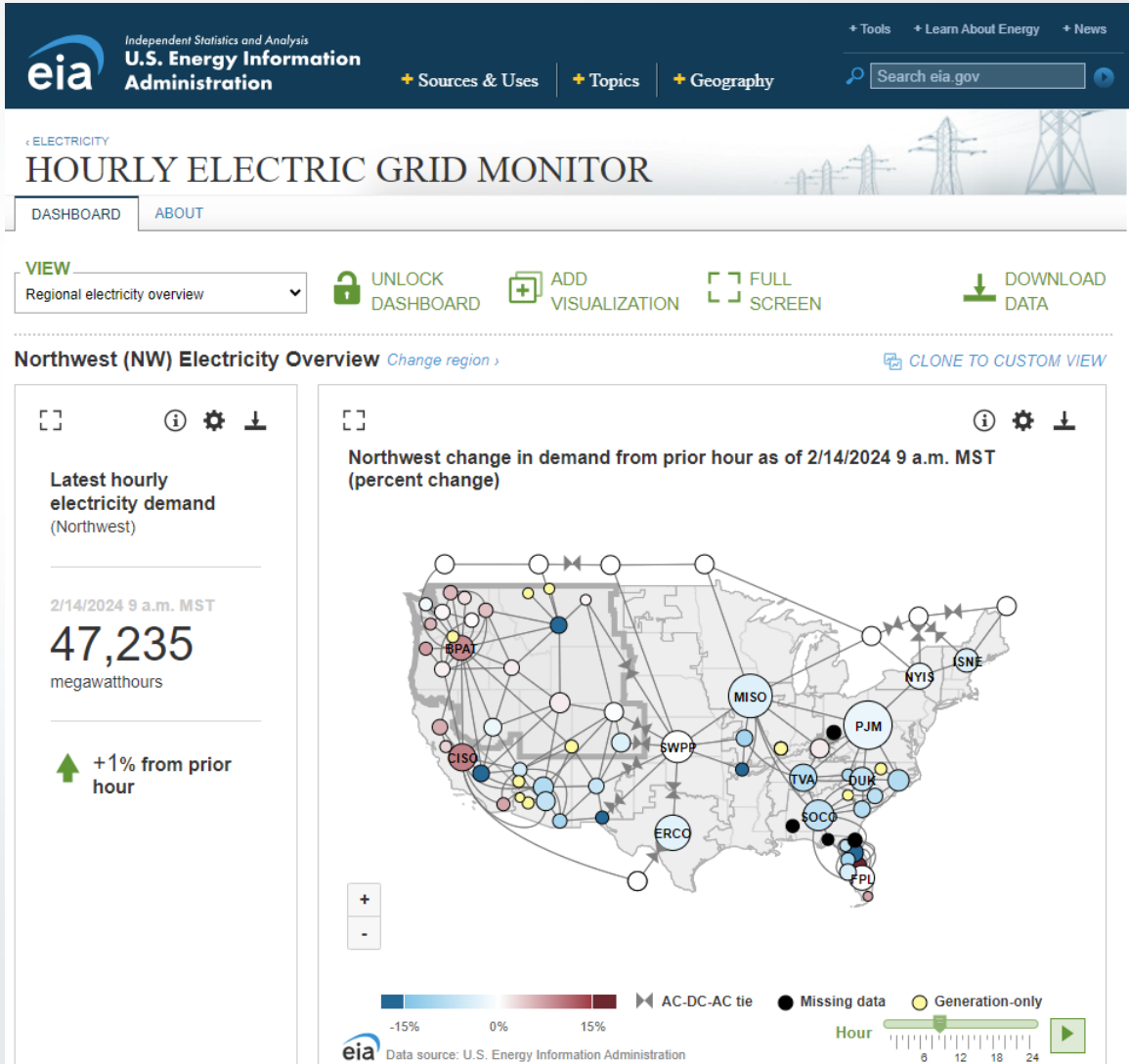
2018-19 Winter

DateTime	P65+P66	CAL Load	NW Load
2/7/2019 8:00	20	28,207	29,500
2/7/2019 9:00	-1,046	26,559	28,907
2/6/2019 8:00	-2,105	32,535	28,759
2/6/2019 9:00	-2,586	30,248	28,489
2/7/2019 7:00	1,023	25,702	28,178
2/5/2019 9:00	-2,617	30,422	27,960
2/5/2019 8:00	-2,129	31,520	27,890
2/7/2019 10:00	-1,322	26,350	27,767
2/4/2019 19:00	1,007	34,693	27,538
2/6/2019 10:00	-2,478	28,833	27,463
2/5/2019 10:00	-3,055	29,818	27,440
2/6/2019 7:00	-965	32,260	27,403
2/8/2019 8:00	632	32,385	27,398
2/4/2019 18:00	680	33,912	27,190
2/8/2019 9:00	-59	30,378	27,101
2/4/2019 20:00	1,541	34,393	27,036
2/10/2019 19:00	245	31,133	26,949
2/21/2019 8:00	4,172	32,406	26,837
2/28/2019 8:00	-1,369	24,875	26,809
2/27/2019 8:00	-1,263	25,984	26,739

S-N

EIA Data

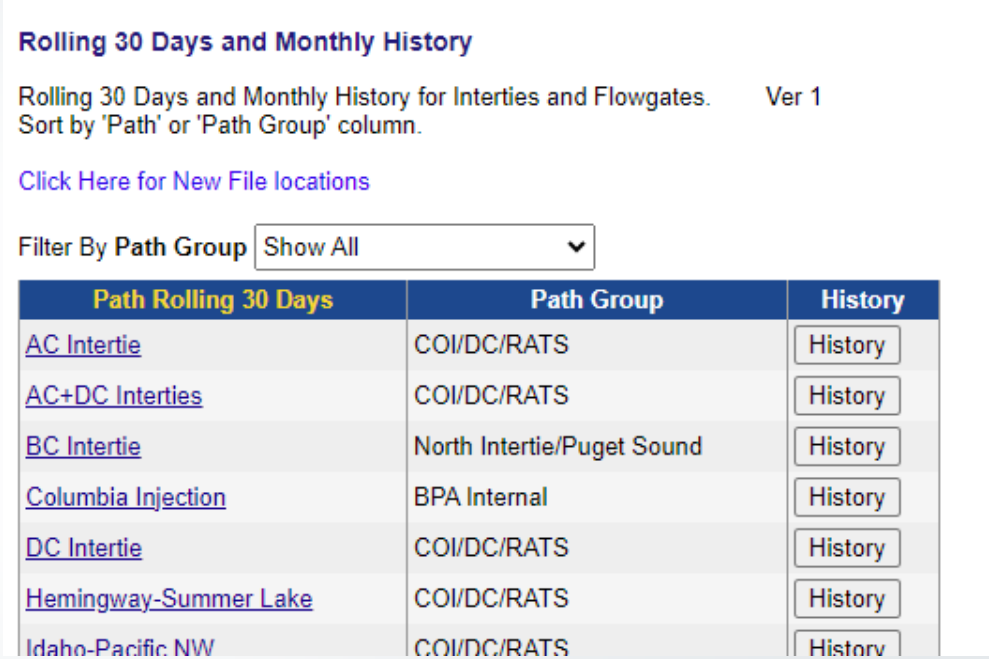
- EIA Hourly Electric Grid Monitor
  - Download Data -> 6-Month Files
  - "Balance" Files, by BA, Hourly:
    - Jan 2016 to Today:
      Load, Generation, Interchange
    - July 2018 to Today:
      Generation by Type
      Petrol, Coal, Nat Gas, Hydro, Nuclear, Solar, Wind
- https://www.eia.gov/electricity/gridmonitor/dashboard/electric_overview/regional/REG-NW



WPP

BPA Operations Page

- BPA Operations Info page
  - https://transmission.bpa.gov/Business/Operations/Paths/
- Hourly Path Flows



Rolling 30 Days and Monthly History

Rolling 30 Days and Monthly History for Interties and Flowgates. Ver 1
Sort by 'Path' or 'Path Group' column.

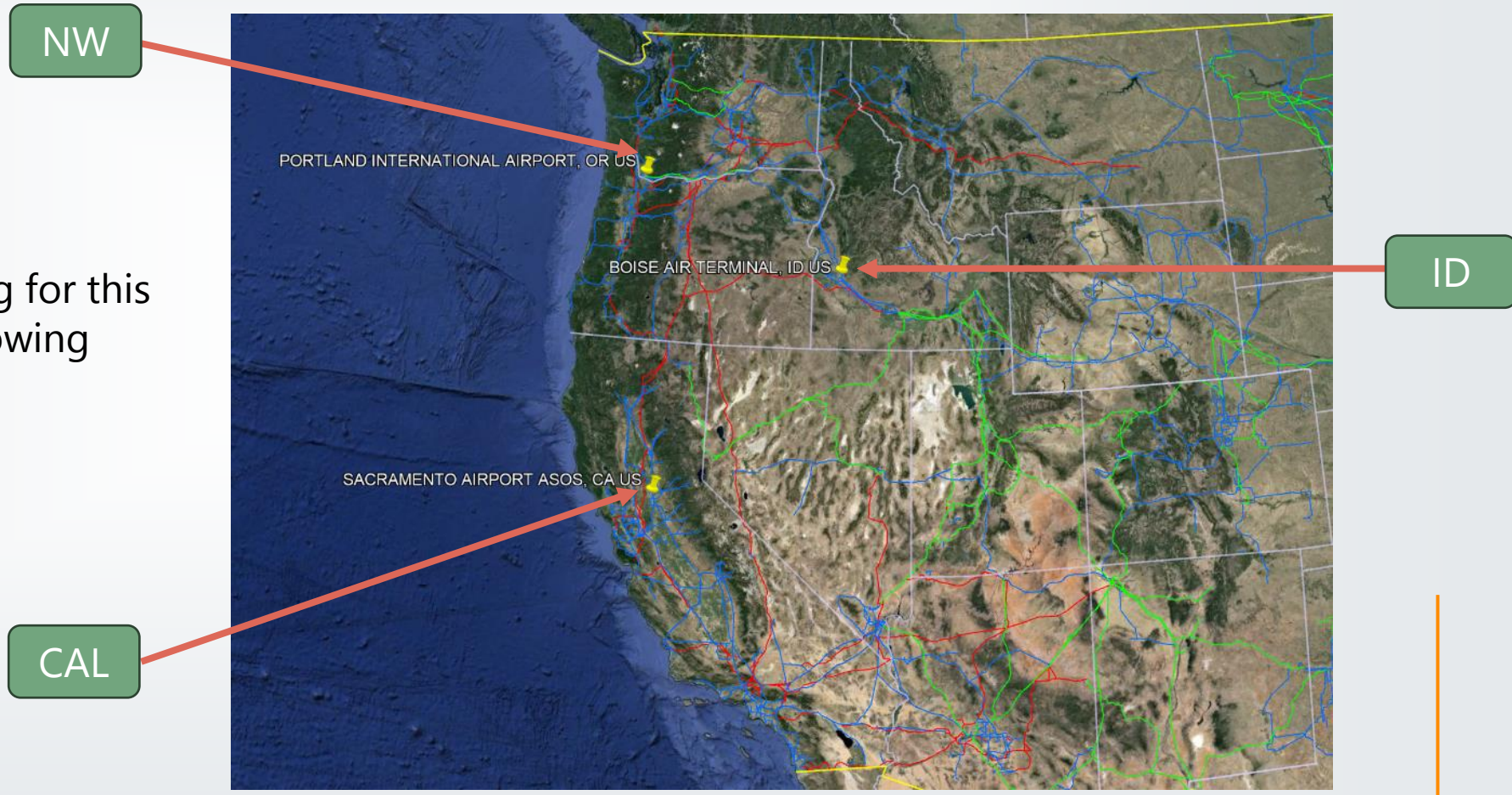
Click Here for New File locations

Filter By **Path Group** Show All

Path Rolling 30 Days	Path Group	History
AC Intertie	COI/DC/RATS	History
AC+DC Interties	COI/DC/RATS	History
BC Intertie	North Intertie/Puget Sound	History
Columbia Injection	BPA Internal	History
DC Intertie	COI/DC/RATS	History
Hemingway-Summer Lake	COI/DC/RATS	History
Idaho-Pacific NW	COI/DC/RATS	History

NOAA Climate Data Online

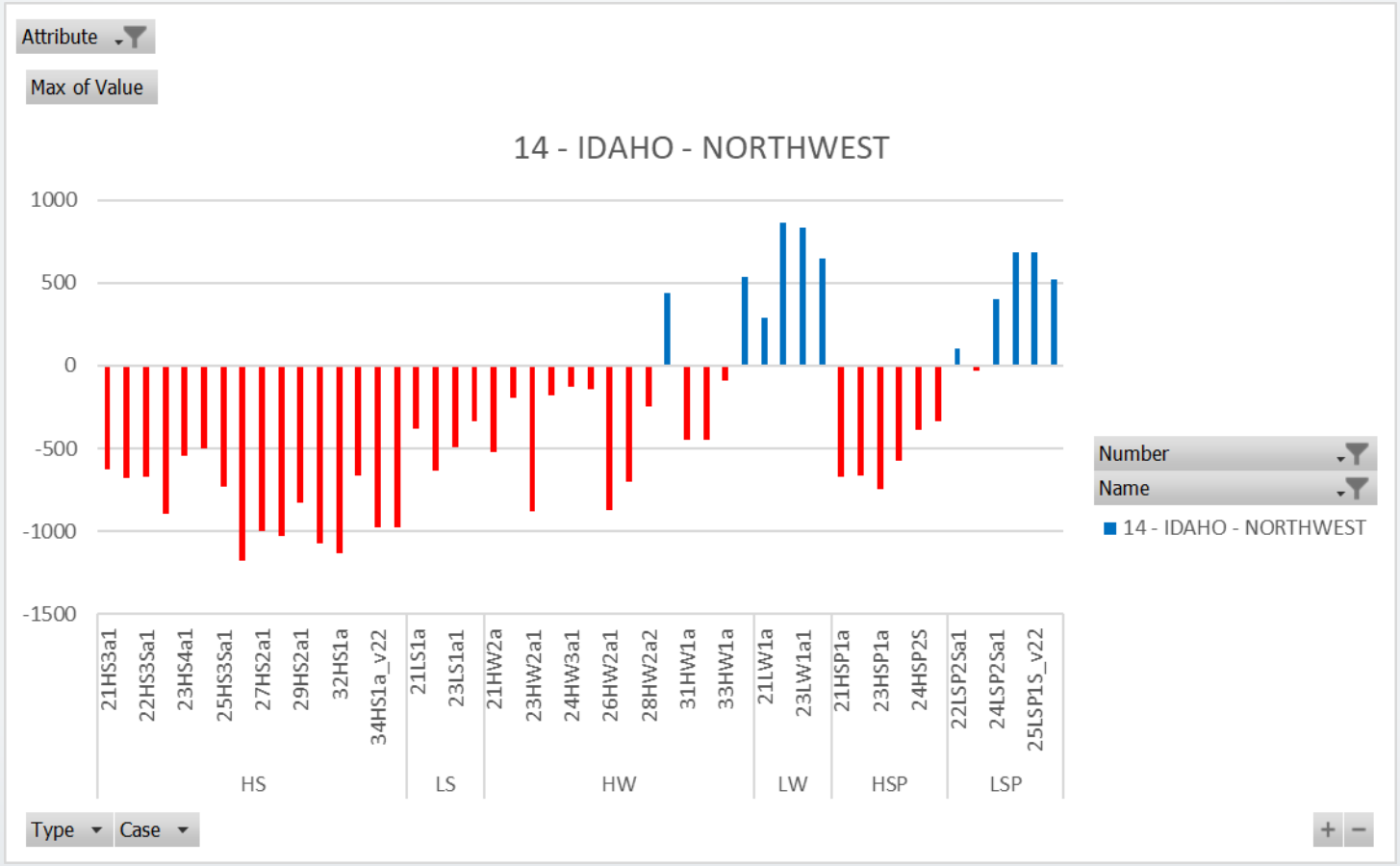
The temperature data we're using for this presentation come from the following weather stations.



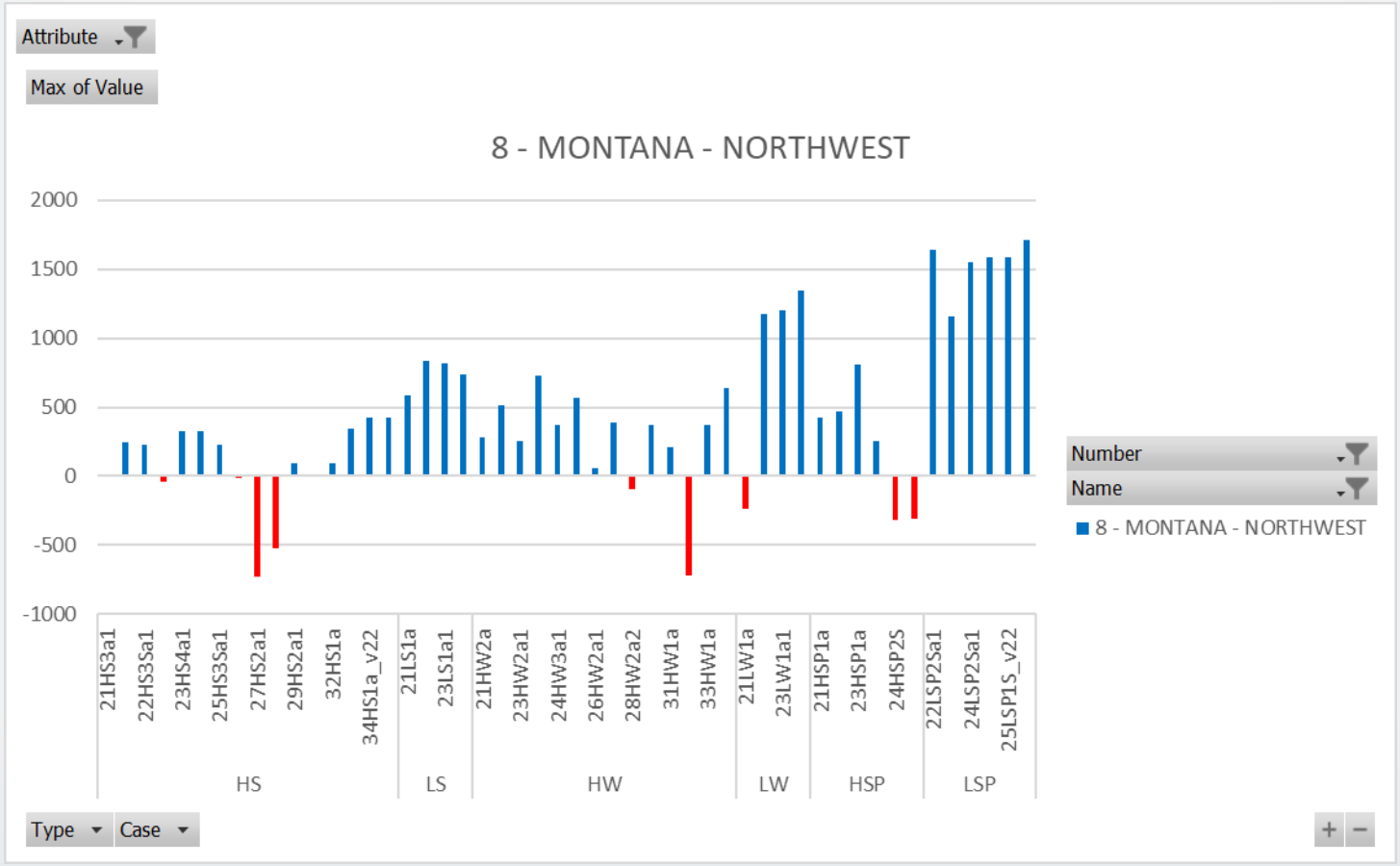
NOAA Climate Data Online

- Near Idaho Power Corporate Office
  - BOISE AIR TERMINAL, ID US
  - https://www.ncei.noaa.gov/cdo-web/datasets/LCD/stations/WBAN:24131/detail
- Near Western Power Pool Corporate Offices
  - PORTLAND INTERNATIONAL AIRPORT, OR US
  - https://www.ncei.noaa.gov/cdo-web/datasets/LCD/stations/WBAN:24229/detail
- Near CAISO Corporate Office
  - SACRAMENTO AIRPORT ASOS, CA US
  - https://www.ncei.noaa.gov/cdo-web/datasets/LCD/stations/WBAN:23232/detail

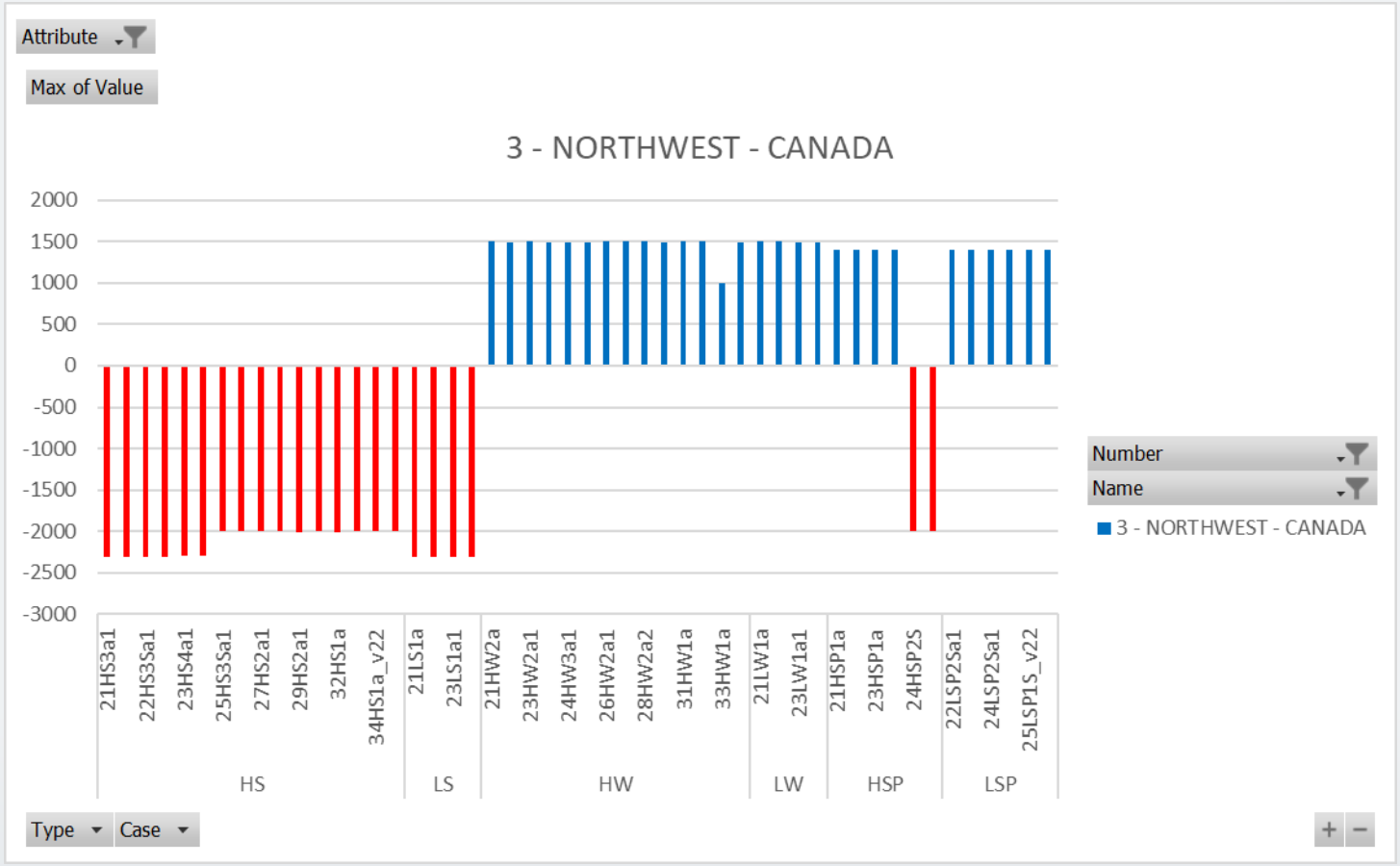
What have we historically studied?



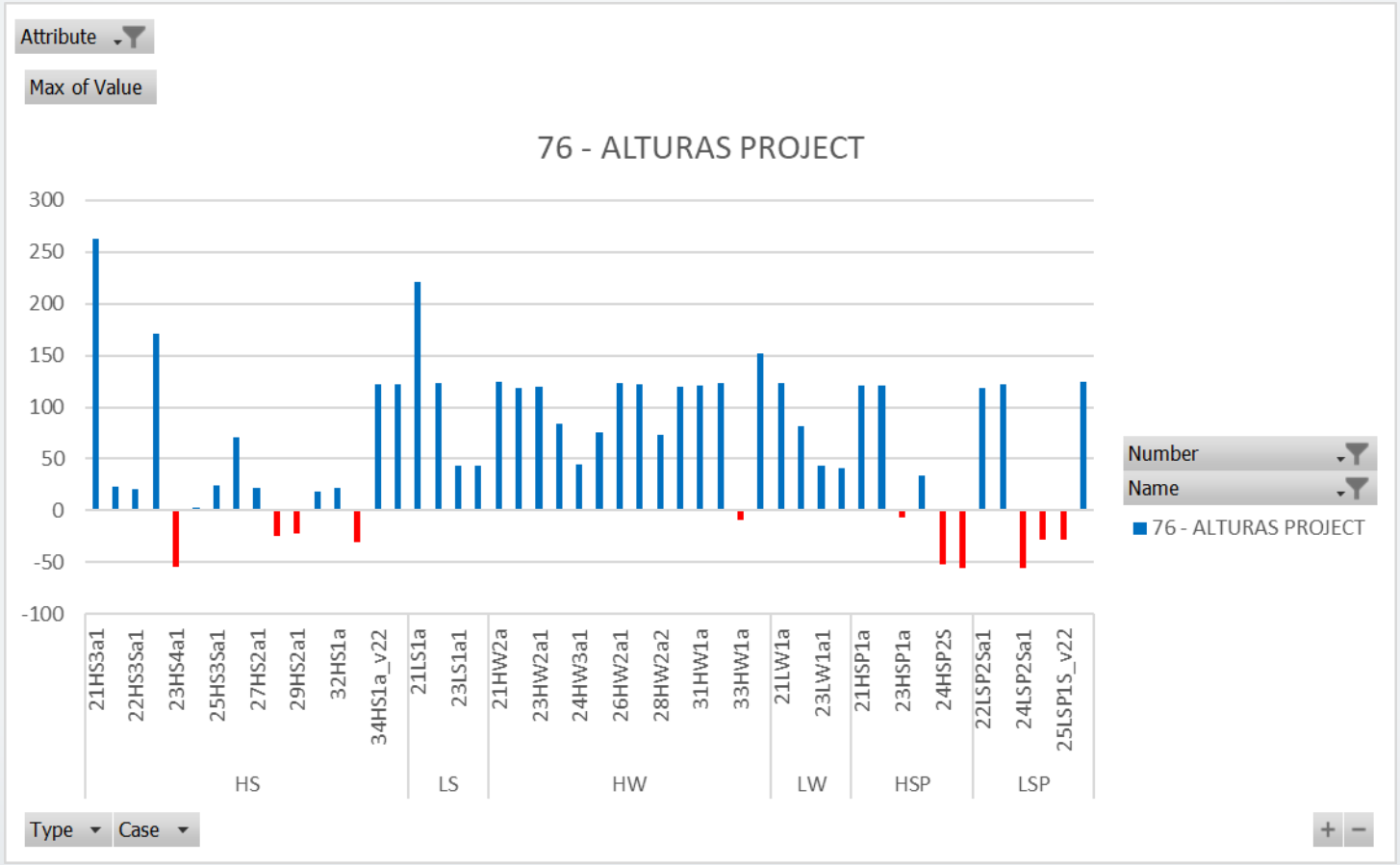
What have we historically studied?



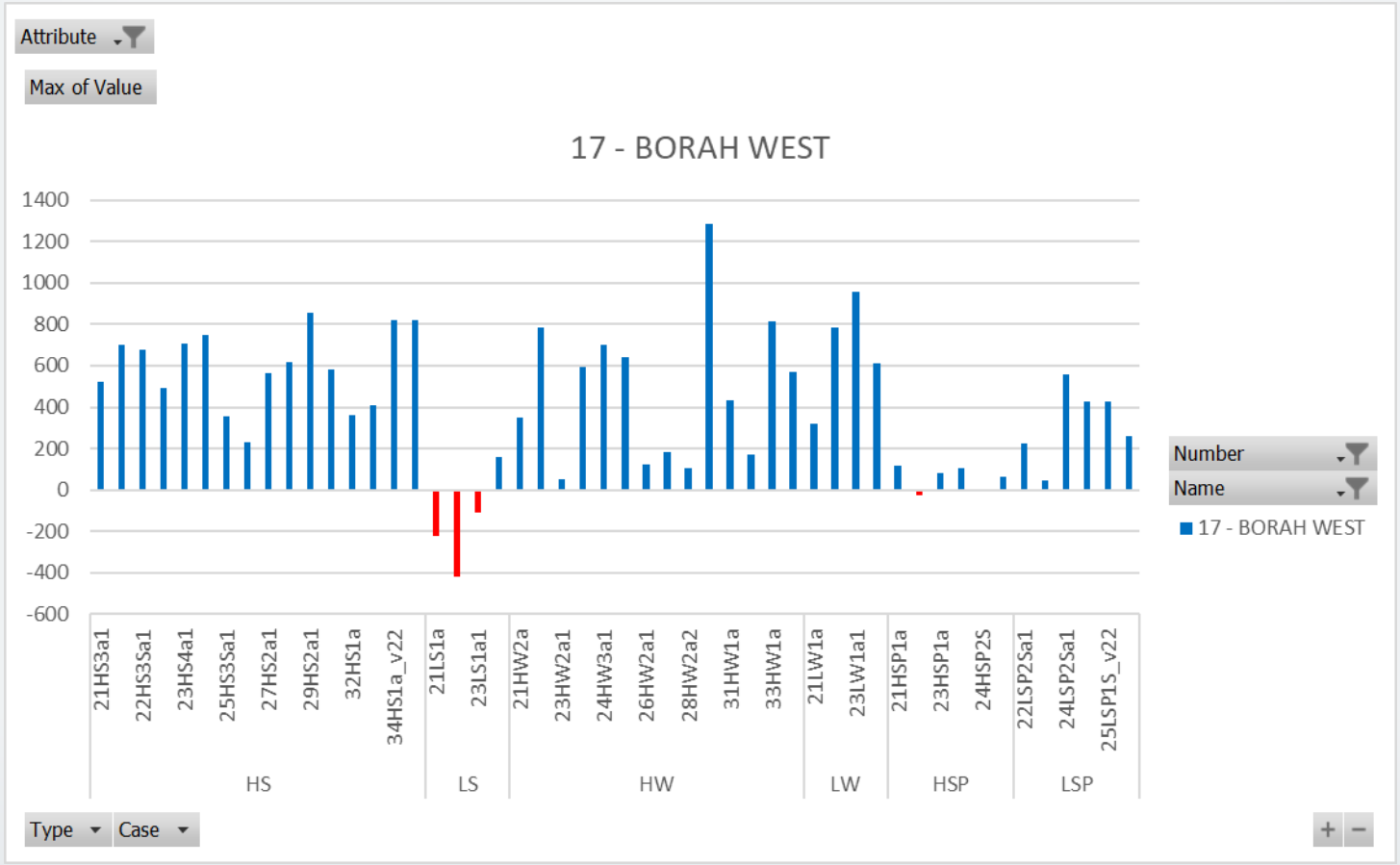
What have we historically studied?



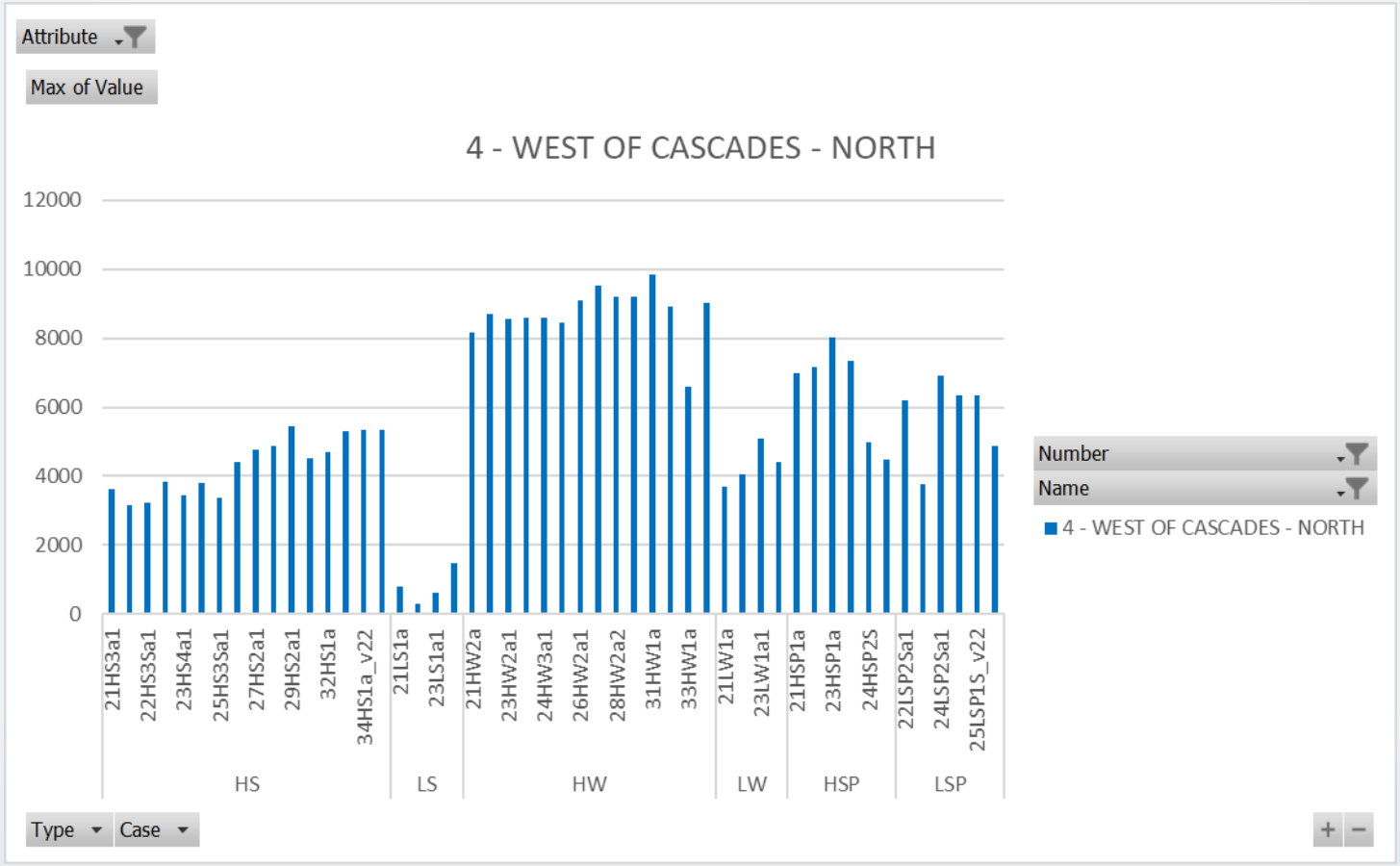
What have we historically studied?



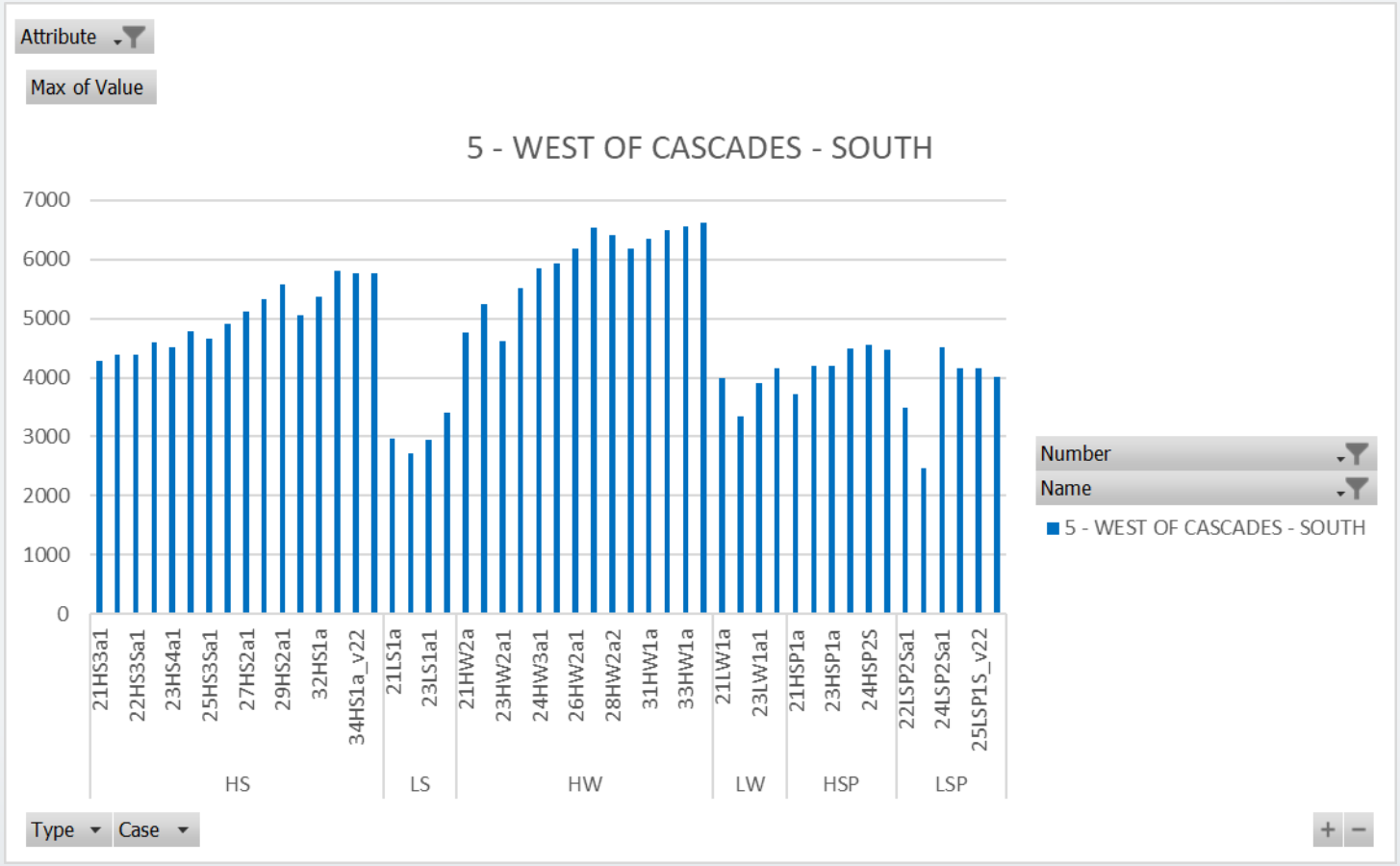
What have we historically studied?



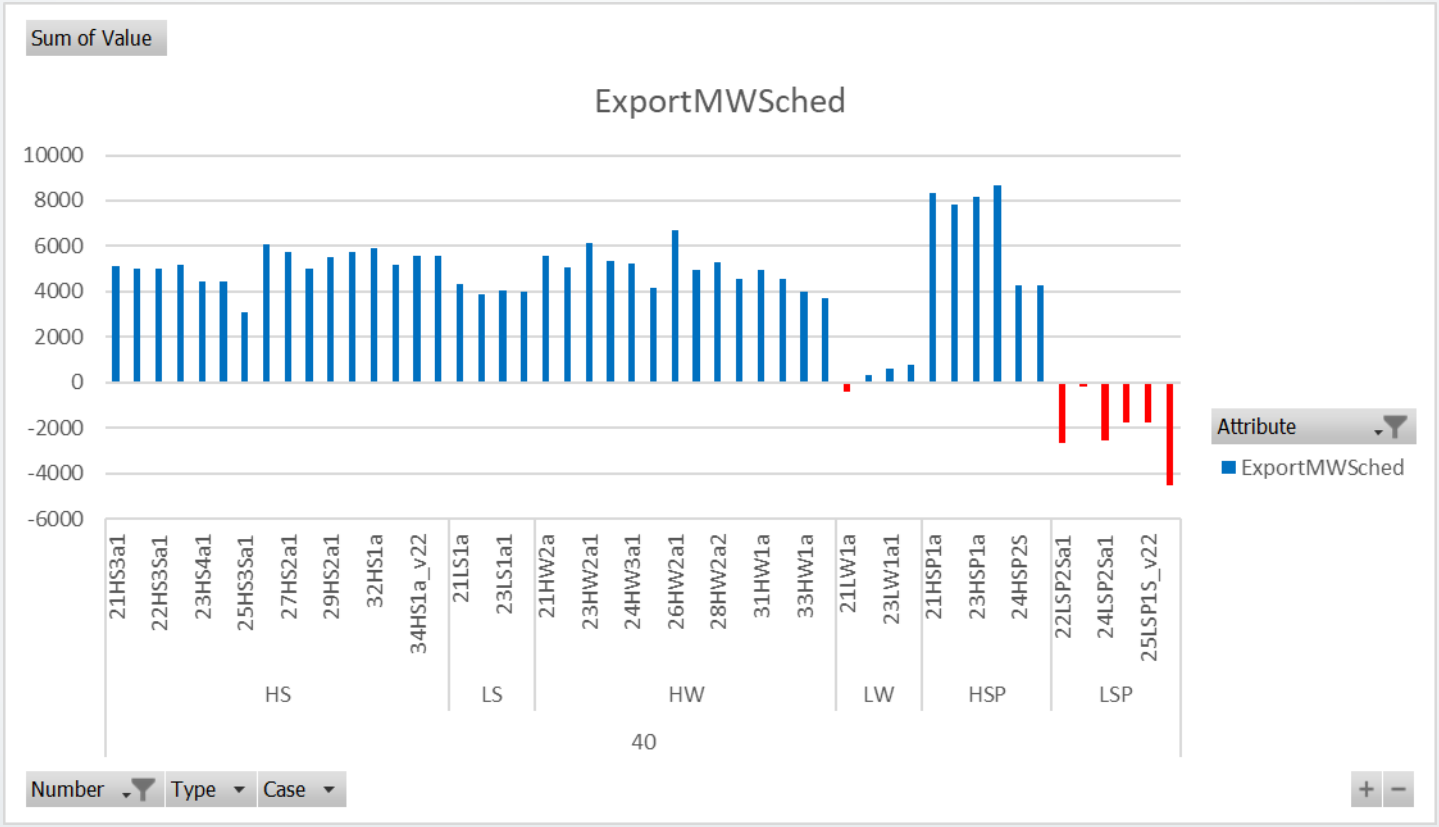
What have we historically studied?



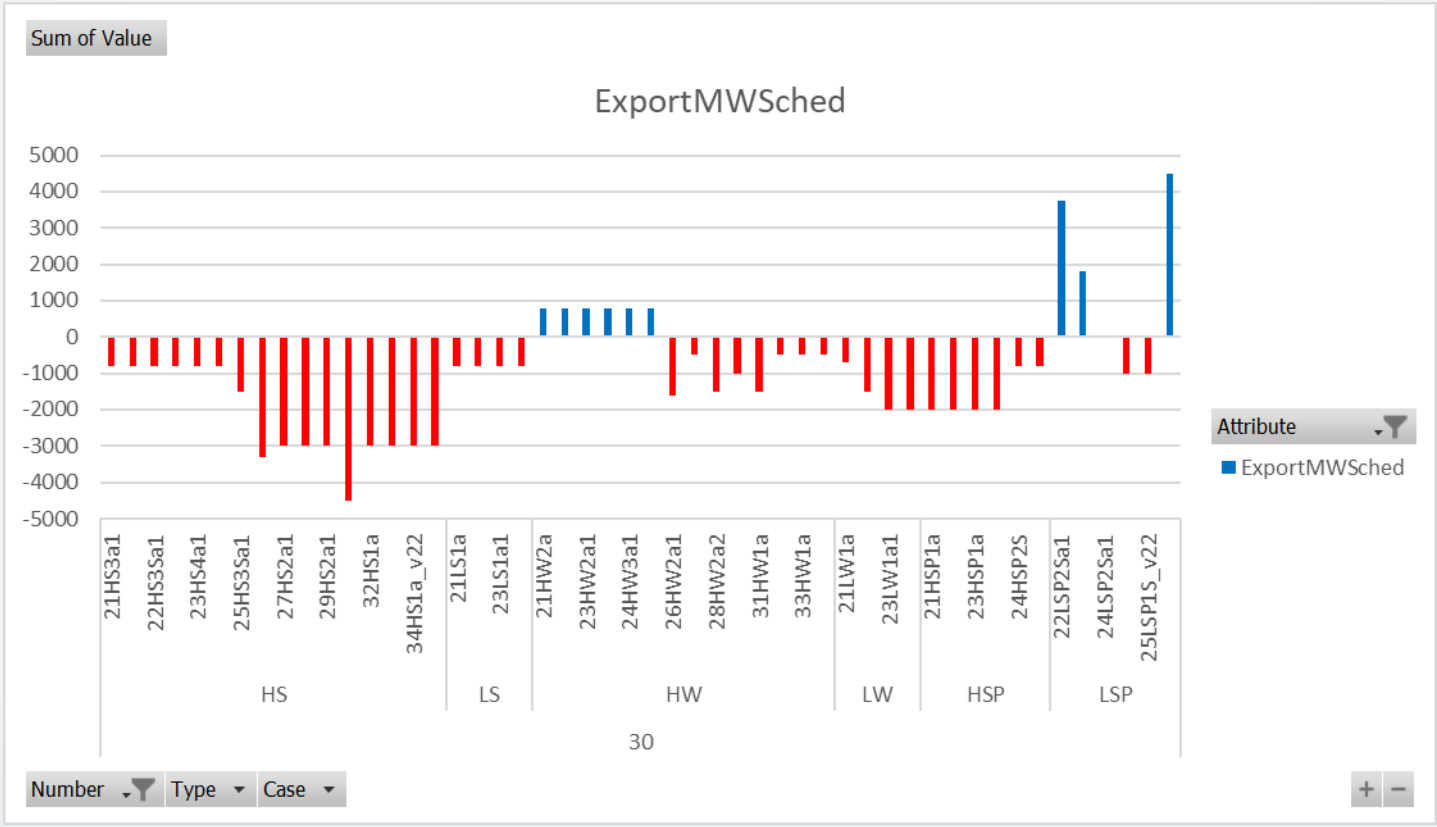
What have we historically studied?



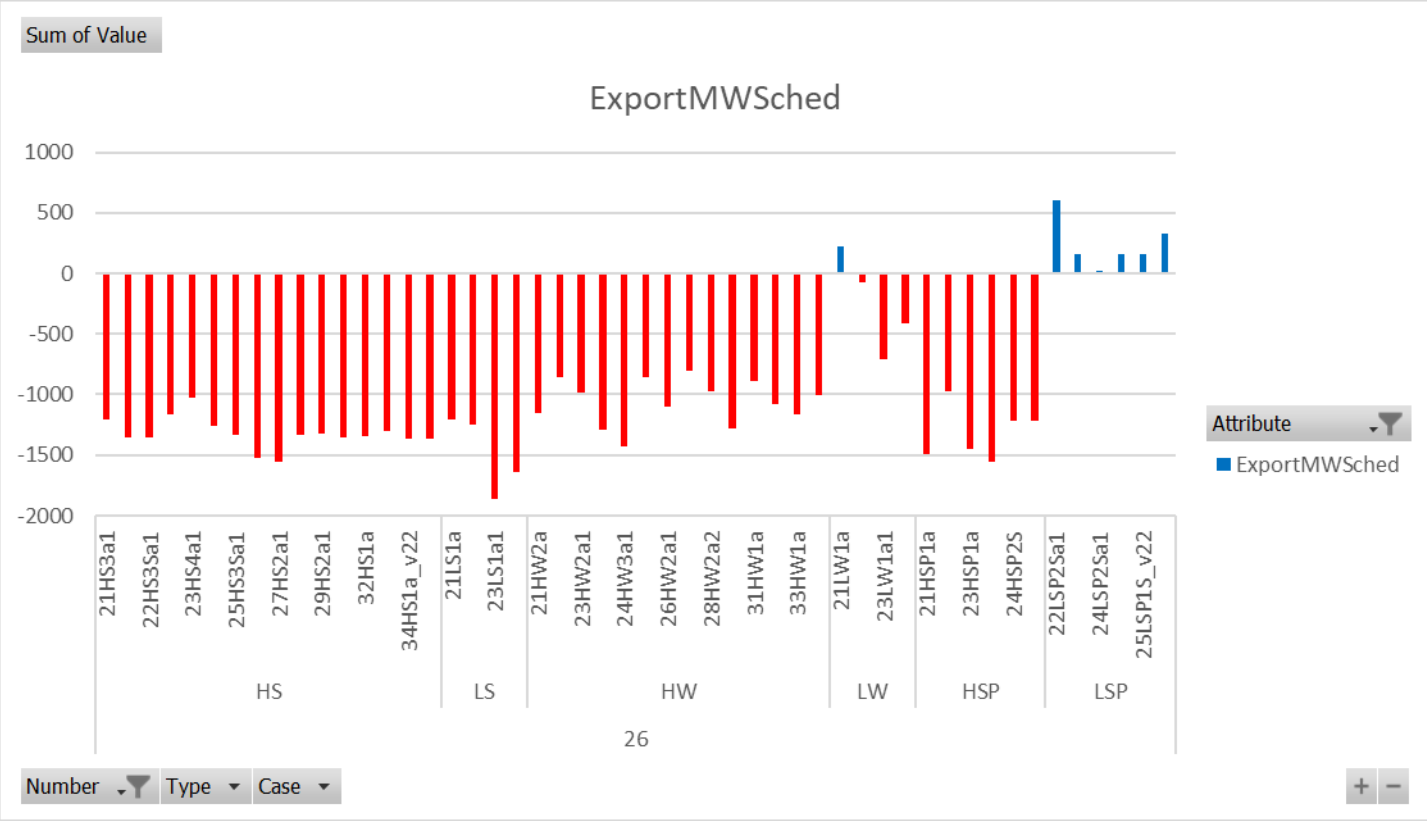
What have we historically studied?



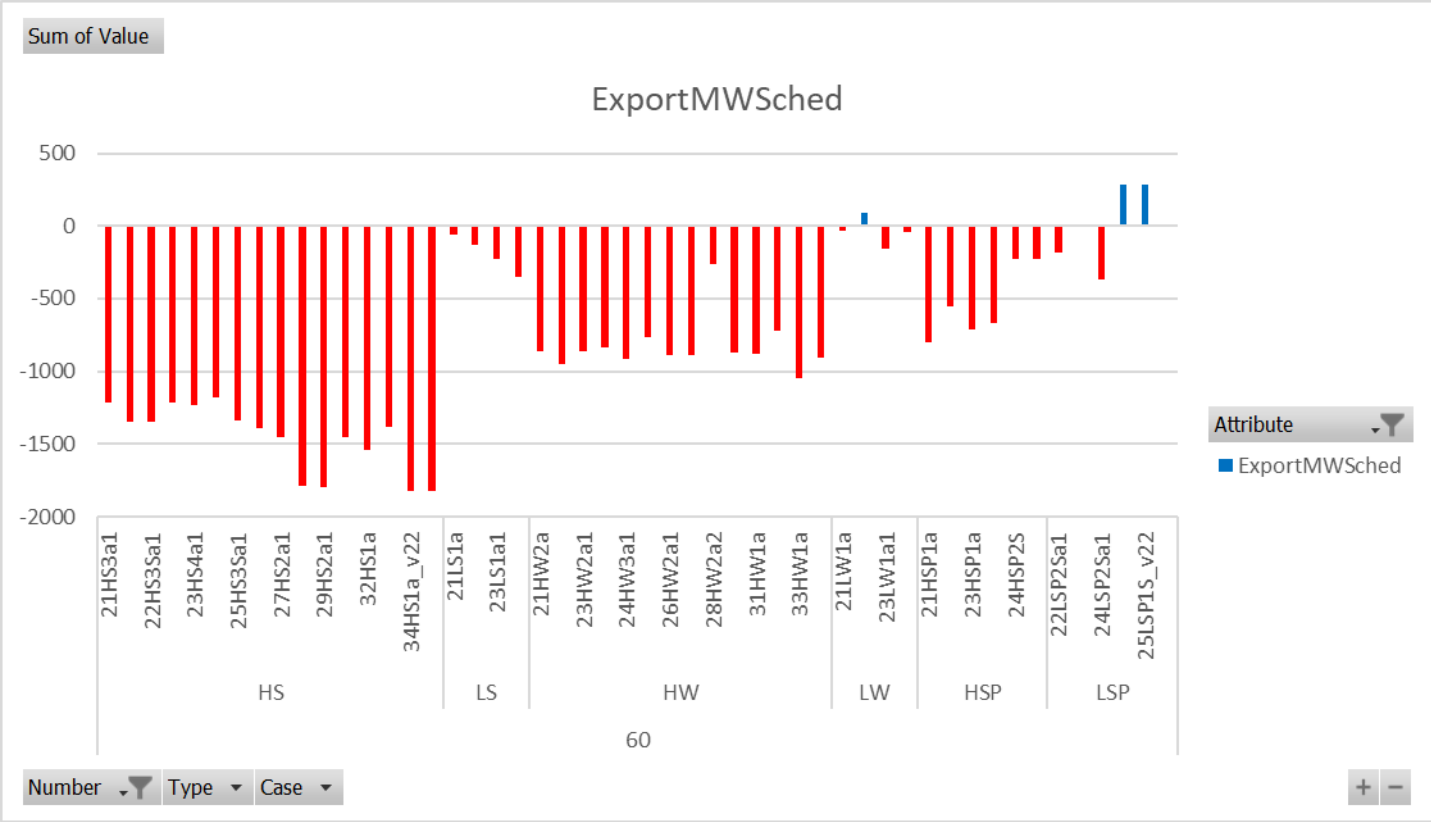
What have we historically studied?



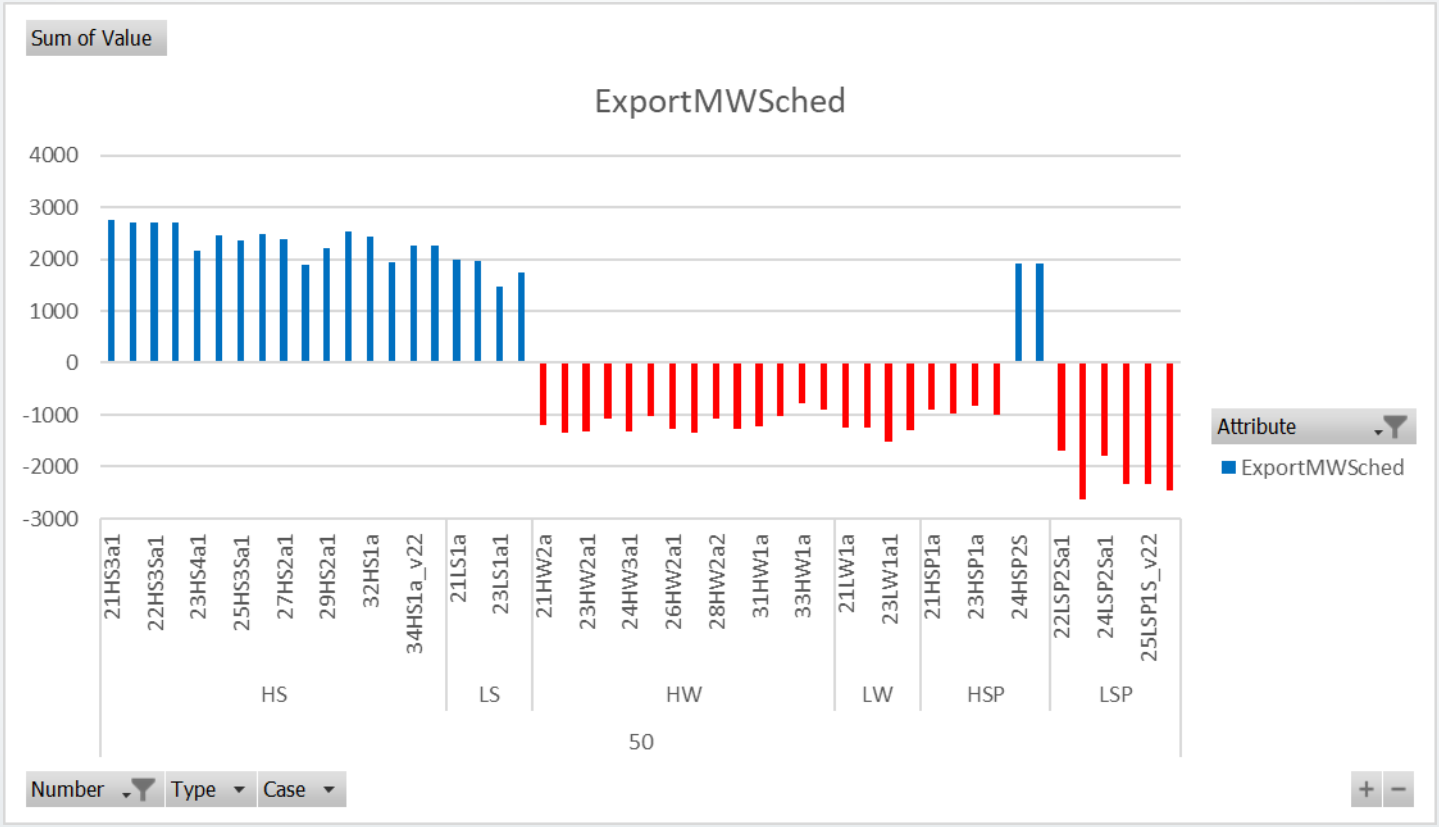
What have we historically studied?



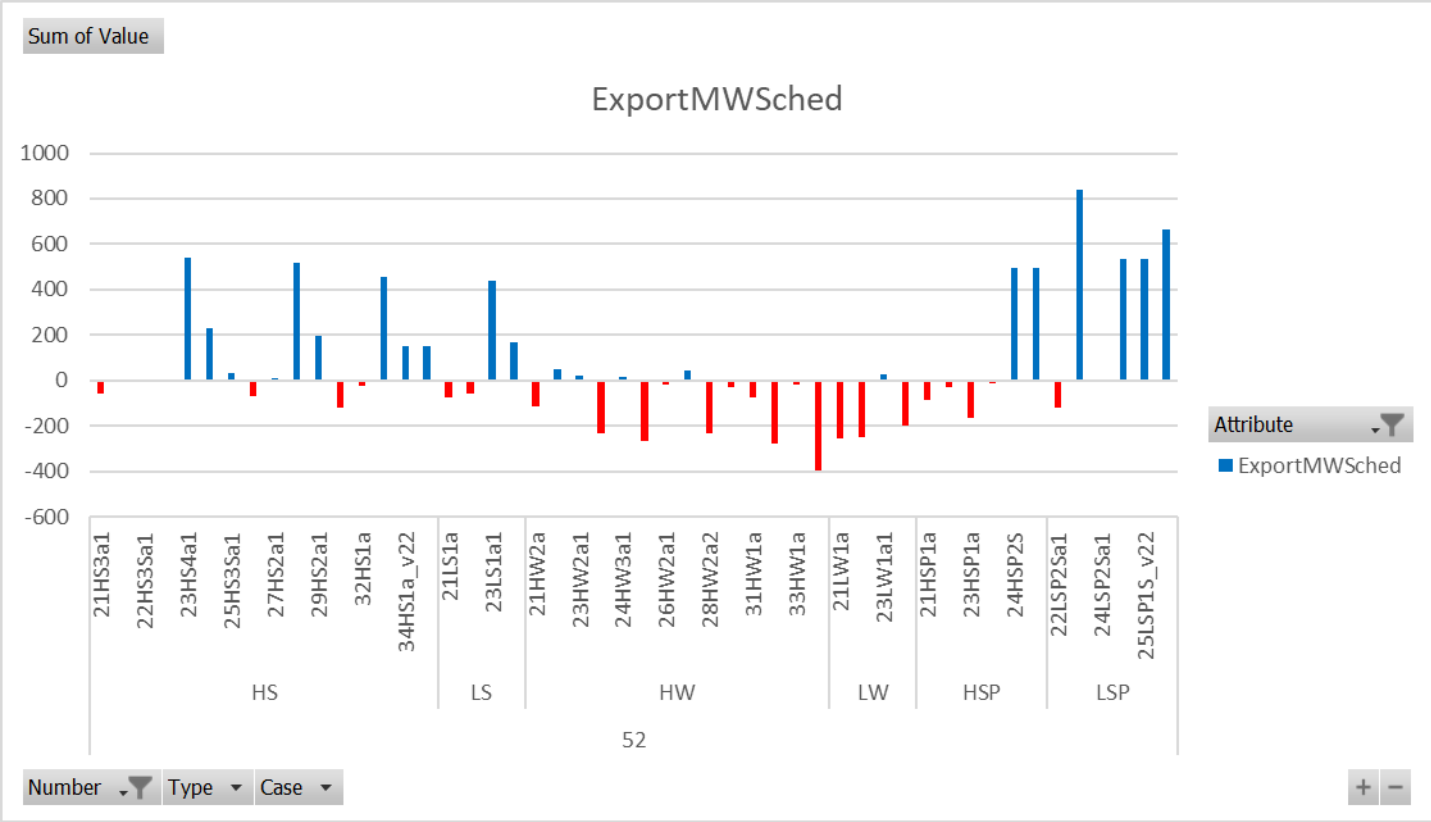
What have we historically studied?



What have we historically studied?



What have we historically studied?



What have we historically studied?