Northwest **Power** and **Conservation** Council

July 5, 2018

MEMORANDUM

TO: **Power Committee**

FROM: **John Ollis, Power System Analyst**

SUBJECT: **Wholesale Electricity Price Forecast**

BACKGROUND:

Presenter: John Ollis

Summary: This presentation will update the Power Committee on the results of the 2018 Wholesale Electricity Price Forecast and response from the System Analysis Advisory Committee. This forecast and associated analysis support the drafting of the Seventh Power Plan's Mid-Term Assessment. While this will not be the only chance for members to offer comment on the price forecast, this meeting will provide an opportunity for discussion and to ask staff questions.

Relevance: The Council periodically updates a 20-year forecast of electric power prices. The AURORA model dispatches all resources in the WECC generating a fundamentals based wholesale electricity price forecast.

Workplan: Power Division workplan, Section A6.1: "The power division will prepare a draft mid-term assessment of the Seventh Power Plan in coordination with the Power Committee for approval for release by the Council."

Background: The Council's wholesale electricity price forecast is a fundamentals-based, forecast that reflects actual power system operation, relationships of supply and demand for, and transmission of electricity. In addition,

underlying a wholesale electricity price forecast in this region would be an understanding of the operating characteristics of future and existing supply and demand-side resources, as well as unit commitment, ancillary services, fuel prices, hydro, wind and solar conditions. The AURORA software captures many of these characteristics of the power system well and has a periodically updated WECC database, and thus, AURORA has been the Council's wholesale market electricity price forecasting model.

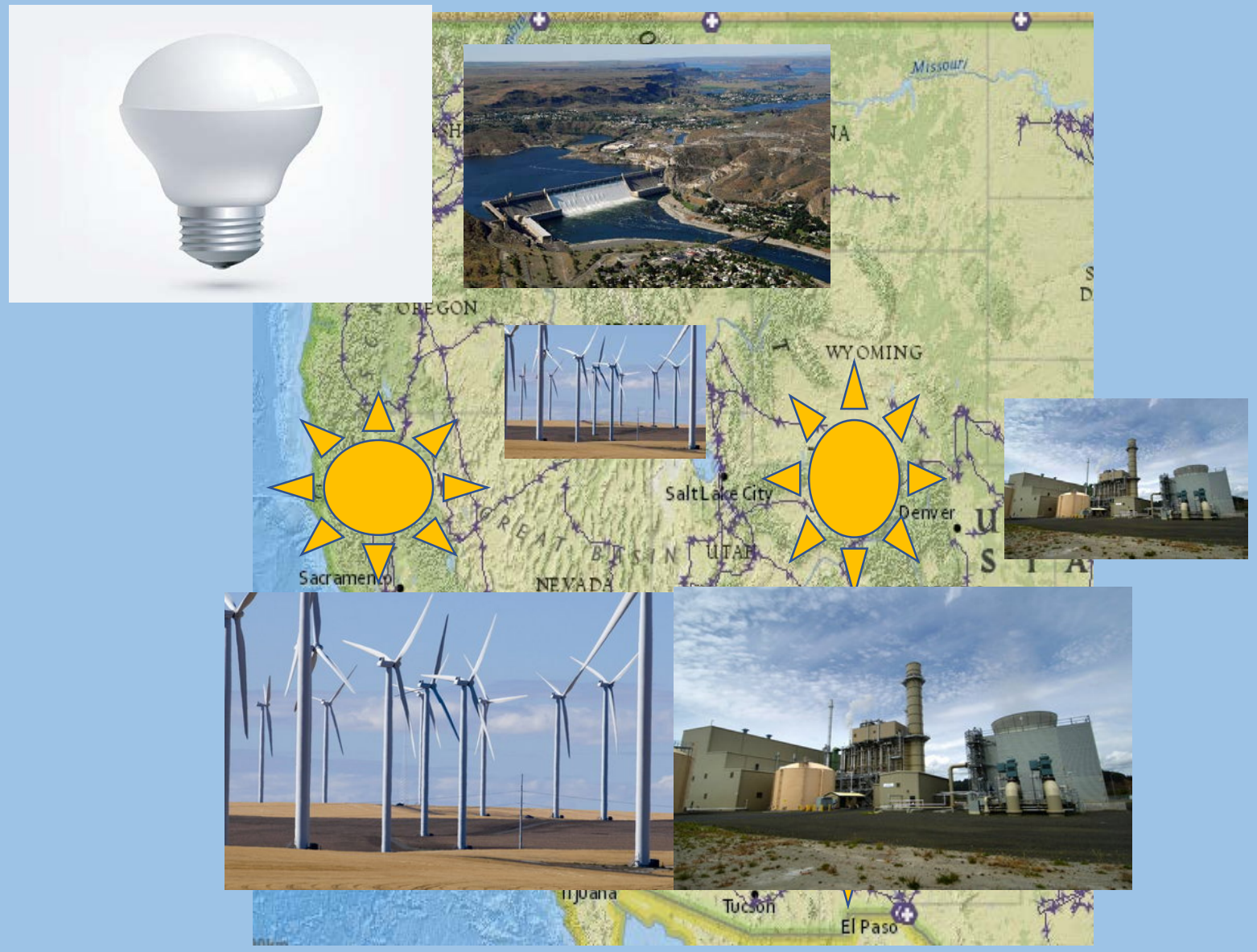
More Info: The methodology and draft results presented to the System Analysis Advisory Committee on June 27, 2018 is available at the following link: https://www.nwcouncil.org/meeting/system-analysis-advisory-committee-june-27-2018

The initial scope of the study and methodology overview.

Most recent forecast (2015/2016)
https://www.nwcouncil.org/media/7149916/7thplanfinal_appdixb_wholesaleretailpricefcast.pdf

Most recent stand-alone study (February 2013)
https://www.nwcouncil.org/media/6829307/wholesaleelectricity.pdf

For more information please contact John Ollis.



Wholesale Electricity Price Forecast – Results

Power Committee

John Ollis

July 10, 2018

Today's Goal: Present Results, Answer Questions

- Review methodology and discuss results from Wholesale Electricity Price study for the upcoming Midterm Assessment
- Prices reflect the following input updates from the Avoided Carbon Emissions Rate Study:
  1. Fuel prices (Q2 2018)
  2. Loads (Q2 2018)
  3. Generating resource fixed costs (Q2 2018)
  4. Updated GENESYS hydro generation information
  5. SAAC suggested input changes
     - CA carbon pricing, transmission availability between PNW and CA, and deeper negative pricing for renewables.
- Prices reflect revised methodology per discussions between SAAC and staff.
  - RPS resource acquisition methodology and price reporting

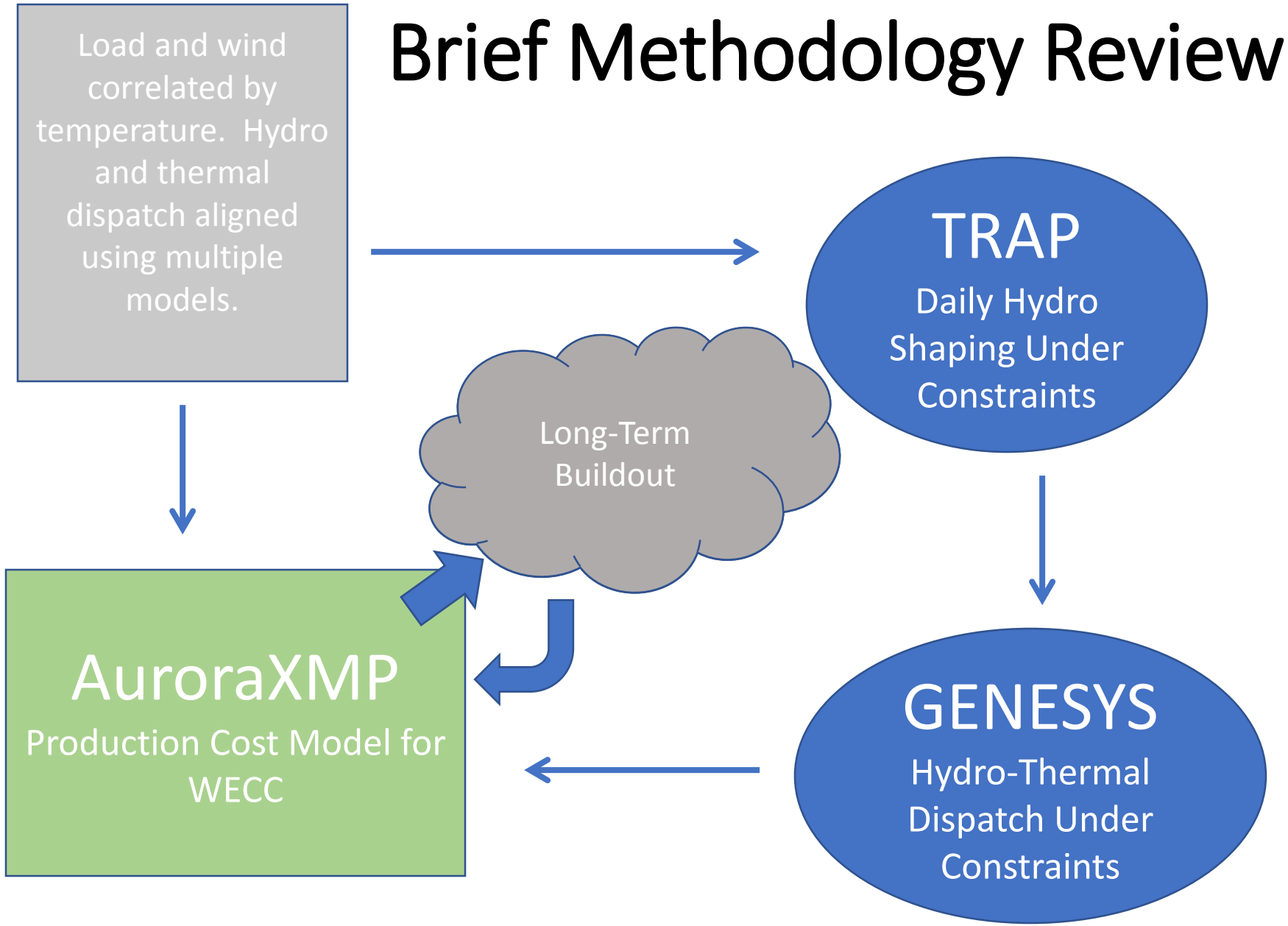
Purposes for Council's Price Forecast

- Used in ProCost model by the Regional Technical Forum to assess the cost-effectiveness of conservation measures.

- Used in Regional Portfolio Model
  - Although will be updated before next Power Plan

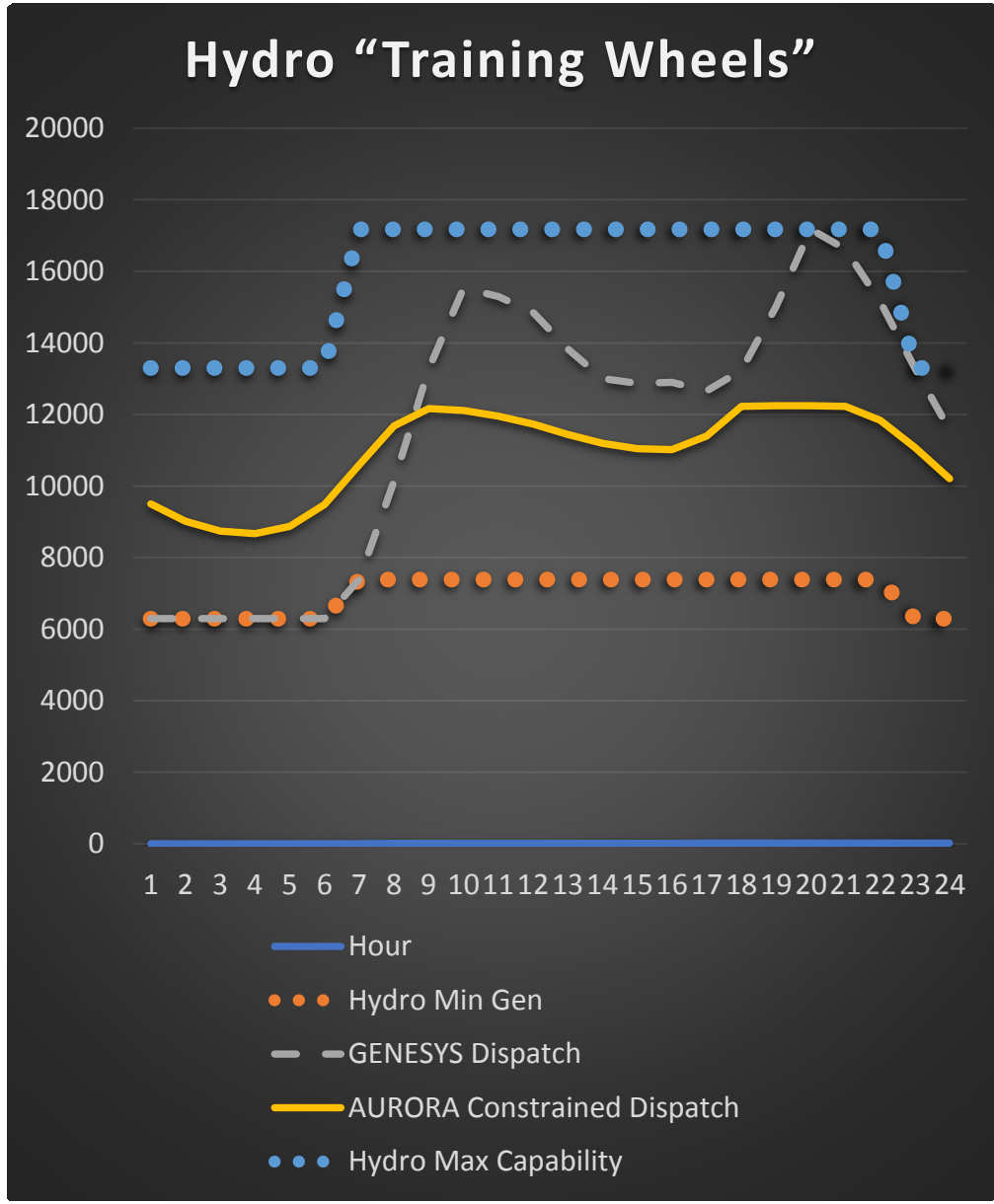
- Other organizations use the Council's price forecast for assessing resource cost-effectiveness, developing resource plans and for other purposes.

Brief Methodology Review



12 sets of 80 year GENESYS Simulations

Sensitivity	2019	2023	2028	2032
Reason		Post Colstrip 1, 2, Valmy 1, Centralia 1 and Boardman retirement (over 2500 MW)	Post Centralia 2, Valmy 2 and Jim Bridger 1 retirement (over 1570 MW retired)	Post Jim Bridger 2 (578 MW retired)
Existing Policy	1	2	3	4
Existing Policy – High Demand	5	6	7	8
Existing Policy – Low Demand	9	10	11	12



Caveats on Long-Term Buildout

- Long-term buildout does not have the benefit of the 80 hydro year data, nor the full array of risks represented in the Regional Portfolio Model to inform resource choices.

- Planning reserve margin and RPS constraints likely a good enough proxy for now, and study actually finished before universe ends.
  - Attempted to use all 80 hydro conditions and study ran for 2 weeks without being close to solving. Estimated time of solution was at the end of July!

Represent Similar Information with Less Simulations

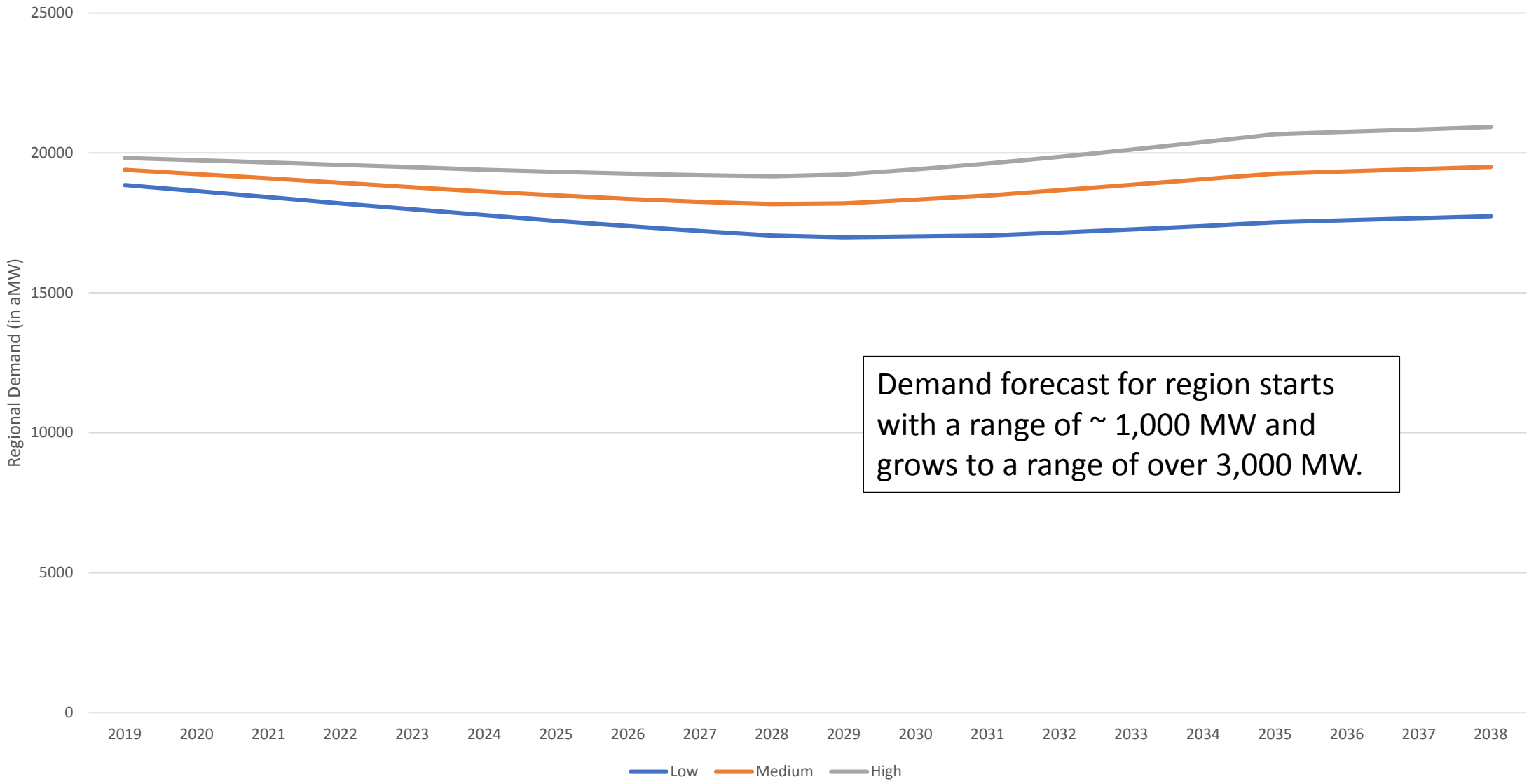
- After some testing it was determined that we did not have enough disk space (~3.2 TB for each sensitivity) to store the data for 80 hydro condition, 20 year long, hourly runs with all the data requested by interested stakeholders.
- Rather than buying about 30 TB more space, decided to run 80 hydro years for each year from 2019 to 2038 on one scenario (fuel mid-level, demand mid-level) to test ALL hydro conditions.
  - SAAC did not object to this simplification
- All the rest of the sensitivities were tested over 9 representative hydro conditions.
  - Social Cost of Carbon sensitivity has a separate buildout

Inputs: Demand Forecast and Natural Gas Price Inputs

Wholesale Electric Price Forecast

Long-Term PNW Weather Normalized Demand Forecast

Growth assumptions similar to 7th Plan



Demand forecast for region starts with a range of ~ 1,000 MW and grows to a range of over 3,000 MW.

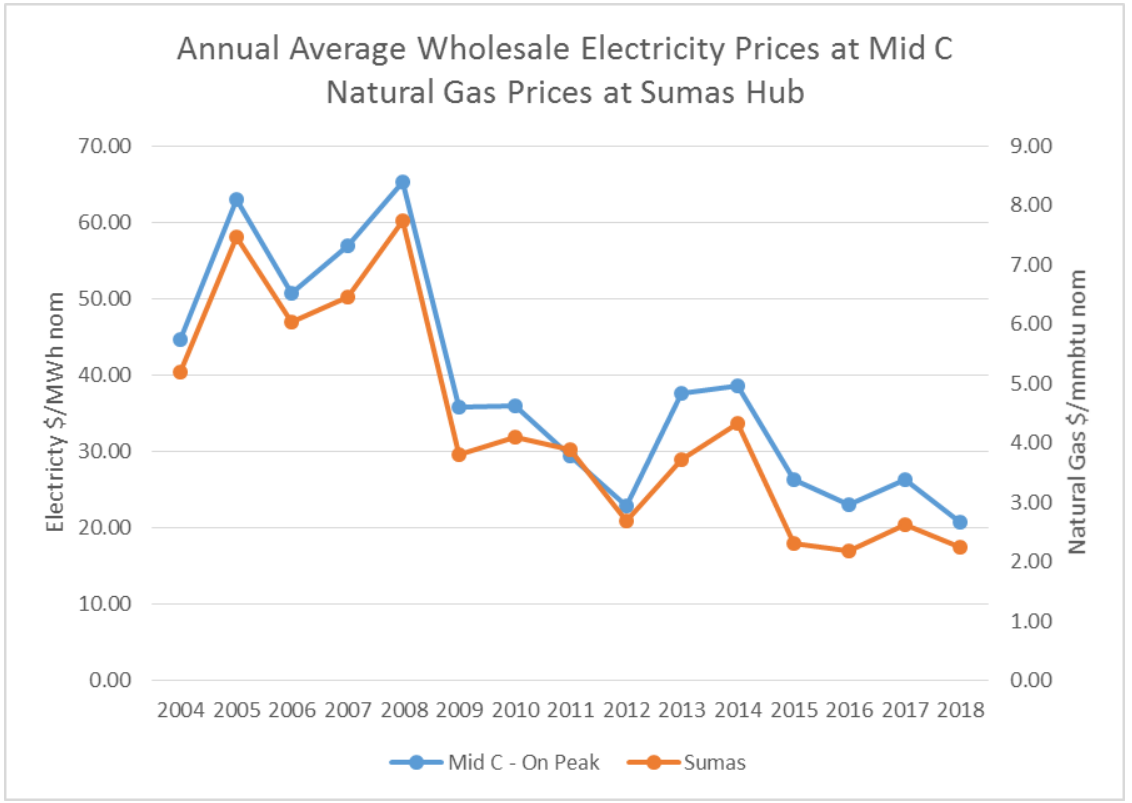
Natural Gas Price Inputs

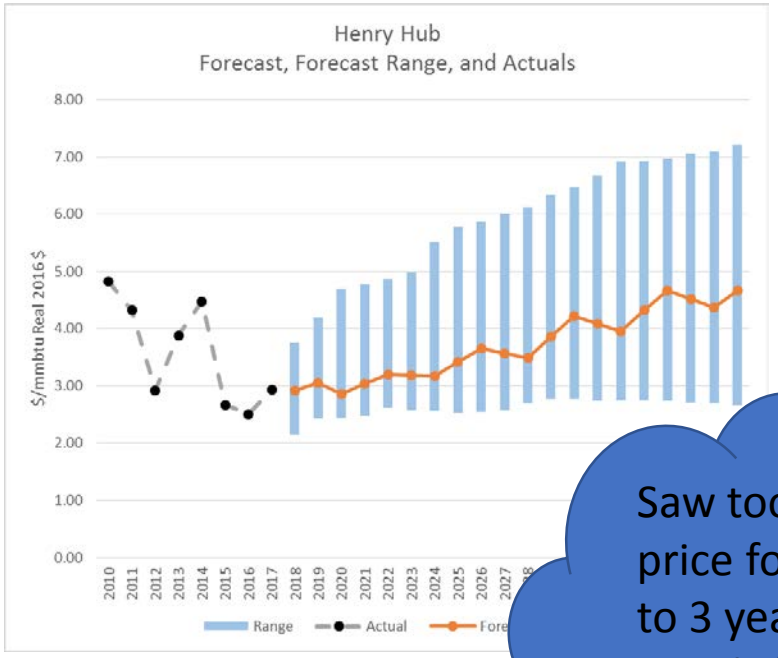
1. Sourced from the Council's 2017 Natural Gas Price Forecast, updated with actuals thru March 2018
2. Long range forecast
   a) Key natural gas pricing hubs
   b) Annual and Monthly level
   c) Medium, High and Low outlooks
3. Enhanced to provide prices for the Western hubs modeled in Aurora
4. The 2017 medium forecast runs between the low and medium price cases of the 7th Plan.

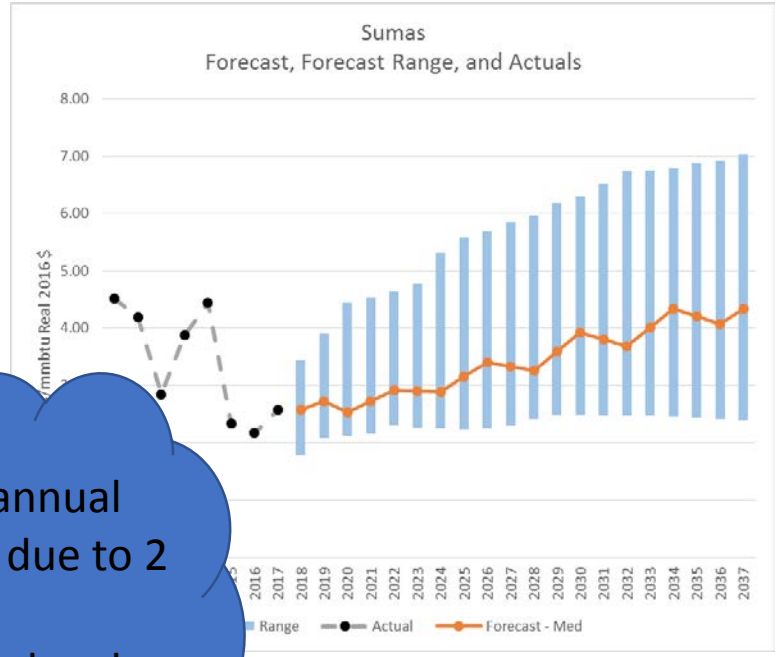
Natural Gas Price Inputs

Historic Electricity and Natural Gas Prices in the Northwest

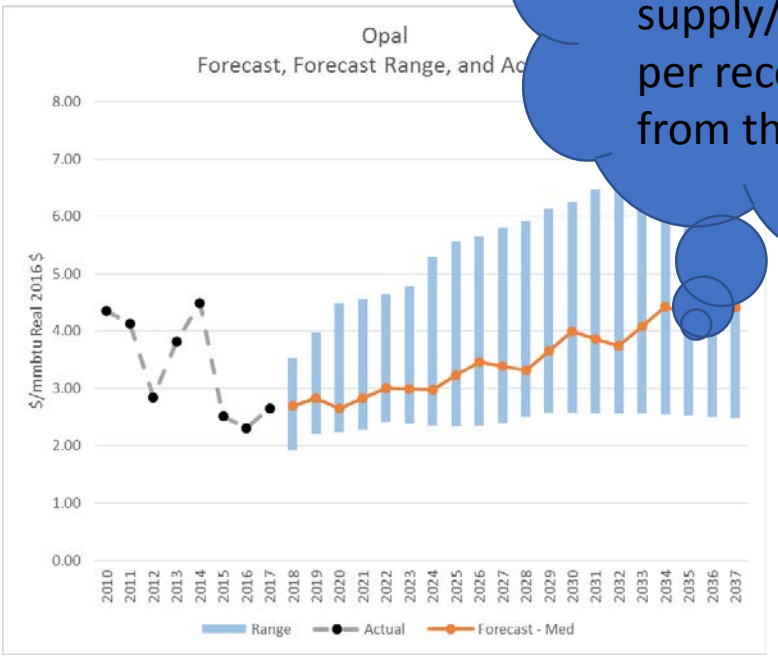
Strong correlation between historical On-Peak Mid-C prices and Sumas natural gas prices.

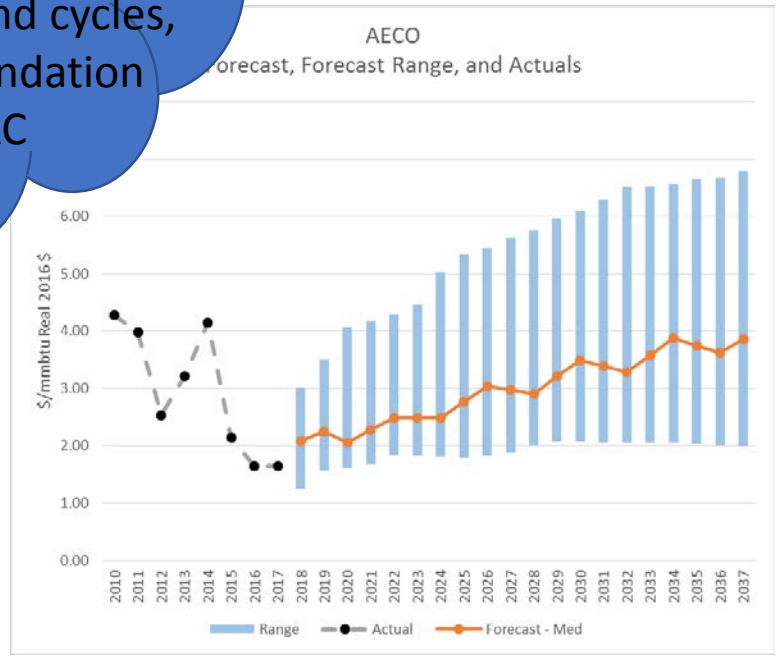


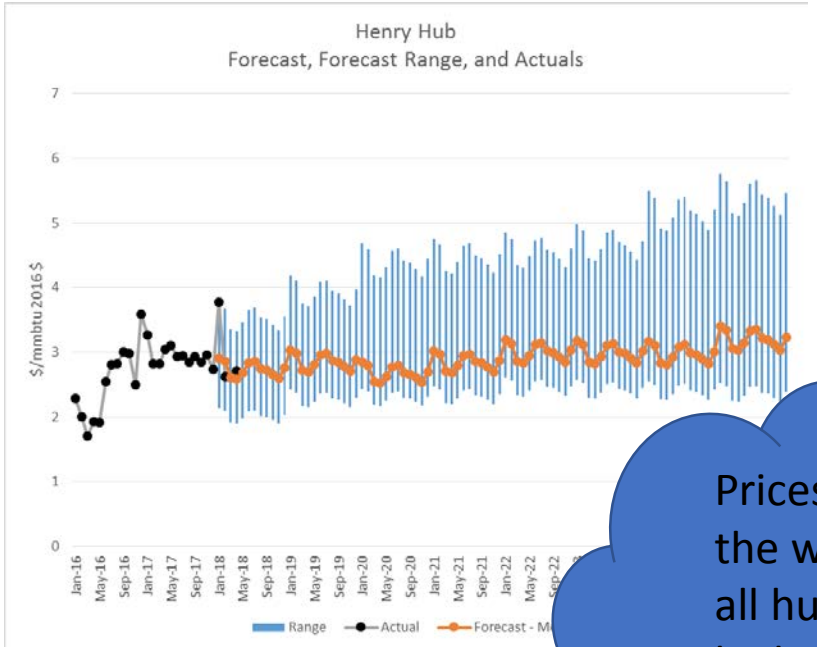


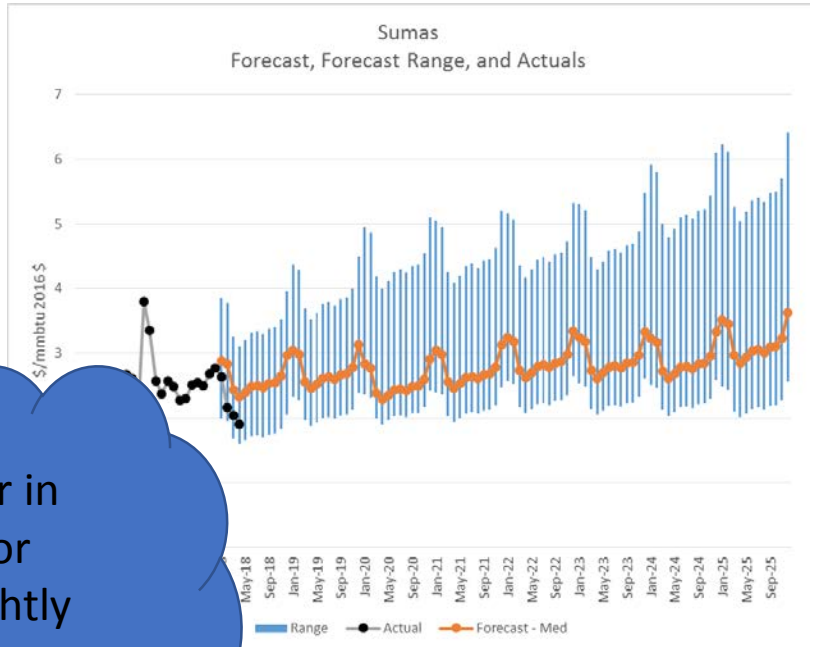


Saw toothed annual price forecast due to 2 to 3 year supply/demand cycles, per recommendation from the NGAC

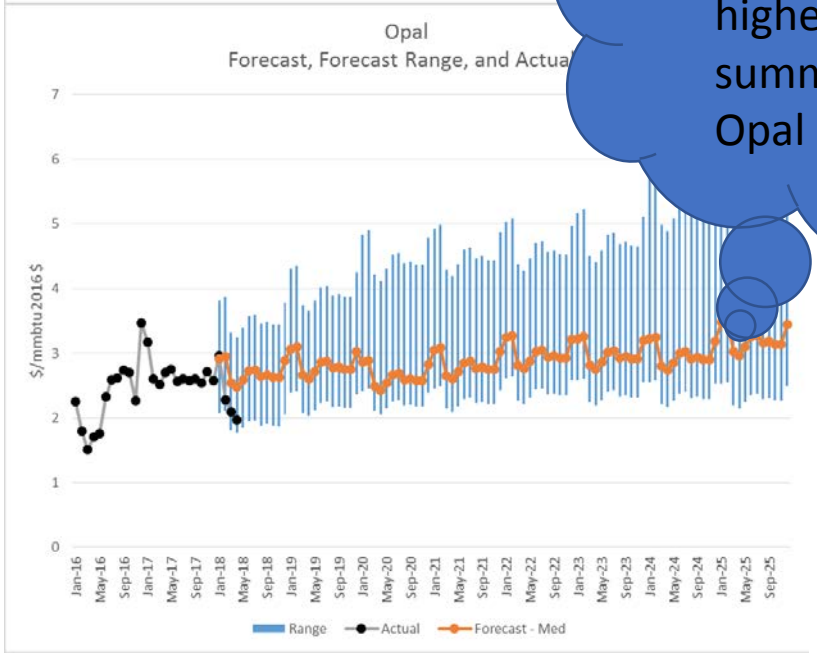


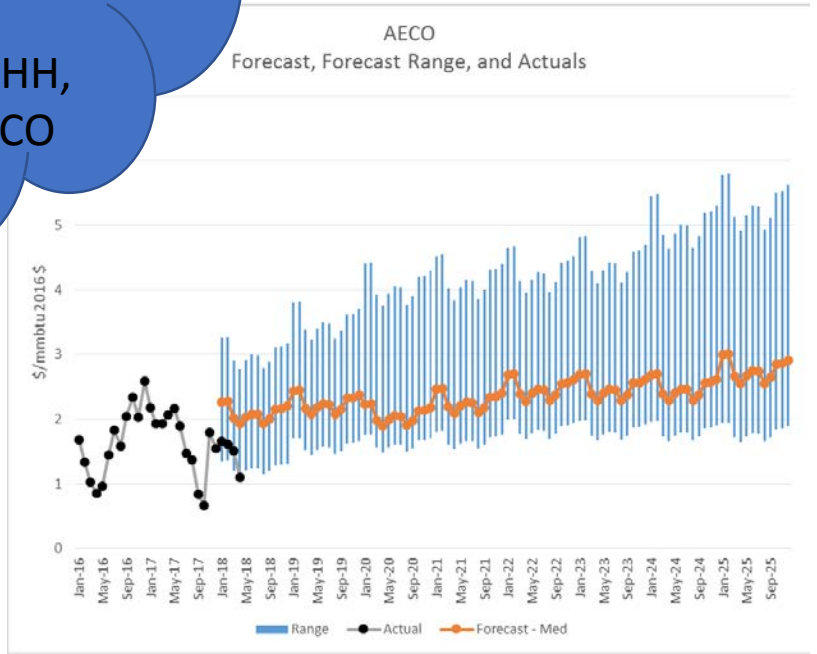




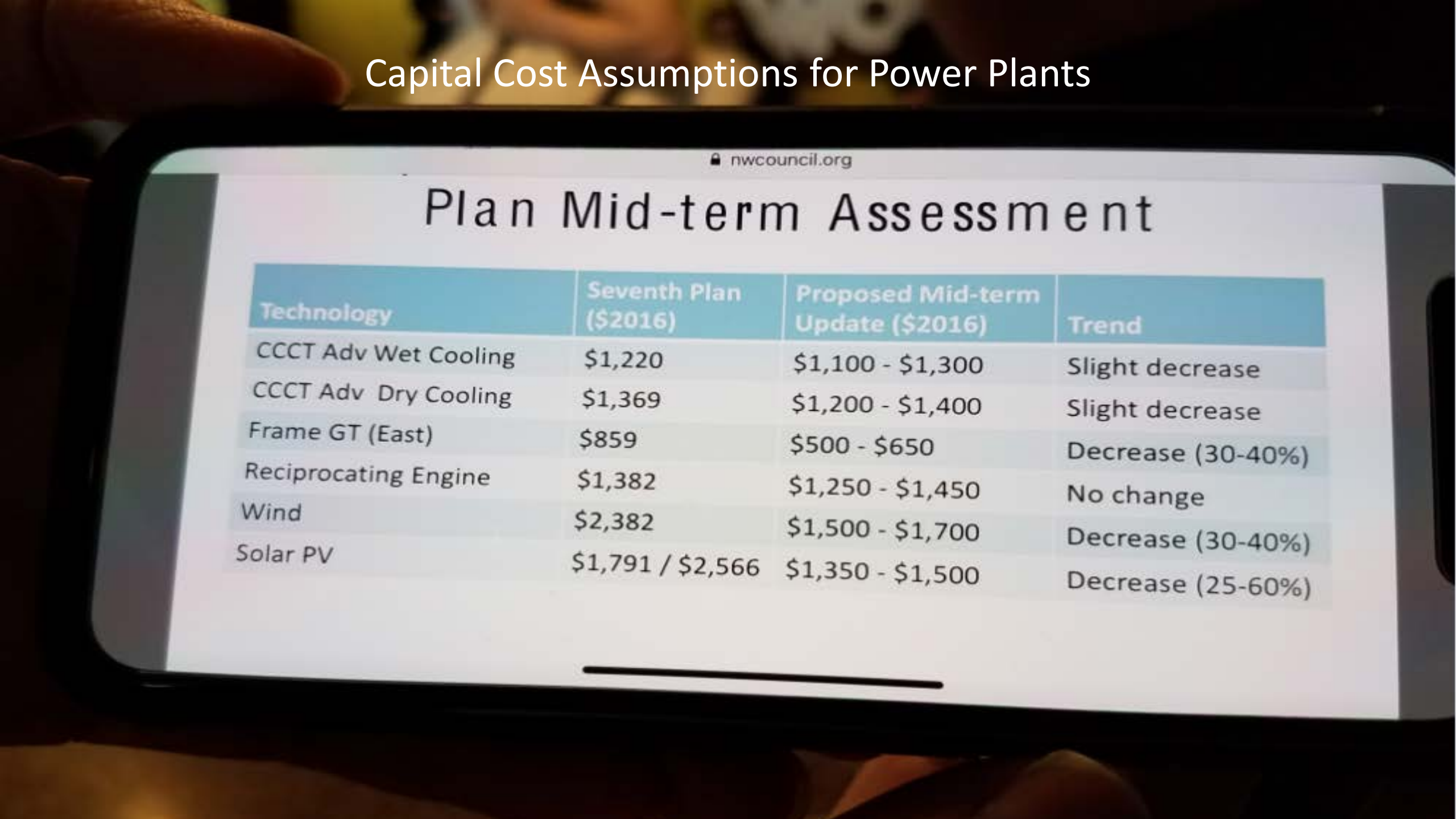


Prices higher in the winter for all hubs, slightly higher in summer for HH, Opal and AECO





Capital Cost Assumptions for Power Plants



Technology	Seventh Plan ($2016)	Proposed Mid-term Update ($2016)	Trend
CCCT Adv Wet Cooling	$1,220	$1,100 - $1,300	Slight decrease
CCCT Adv Dry Cooling	$1,369	$1,200 - $1,400	Slight decrease
Frame GT (East)	$859	$500 - $650	Decrease (30-40%)
Reciprocating Engine	$1,382	$1,250 - $1,450	No change
Wind	$2,382	$1,500 - $1,700	Decrease (30-40%)
Solar PV	$1,791 / $2,566	$1,350 - $1,500	Decrease (25-60%)

Wholesale Price Results

All results shown are in nominal dollars per megawatt-hour

High Level Study Narratives

1. Wholesale prices in the PNW depend on PNW demand, more so on gas prices.

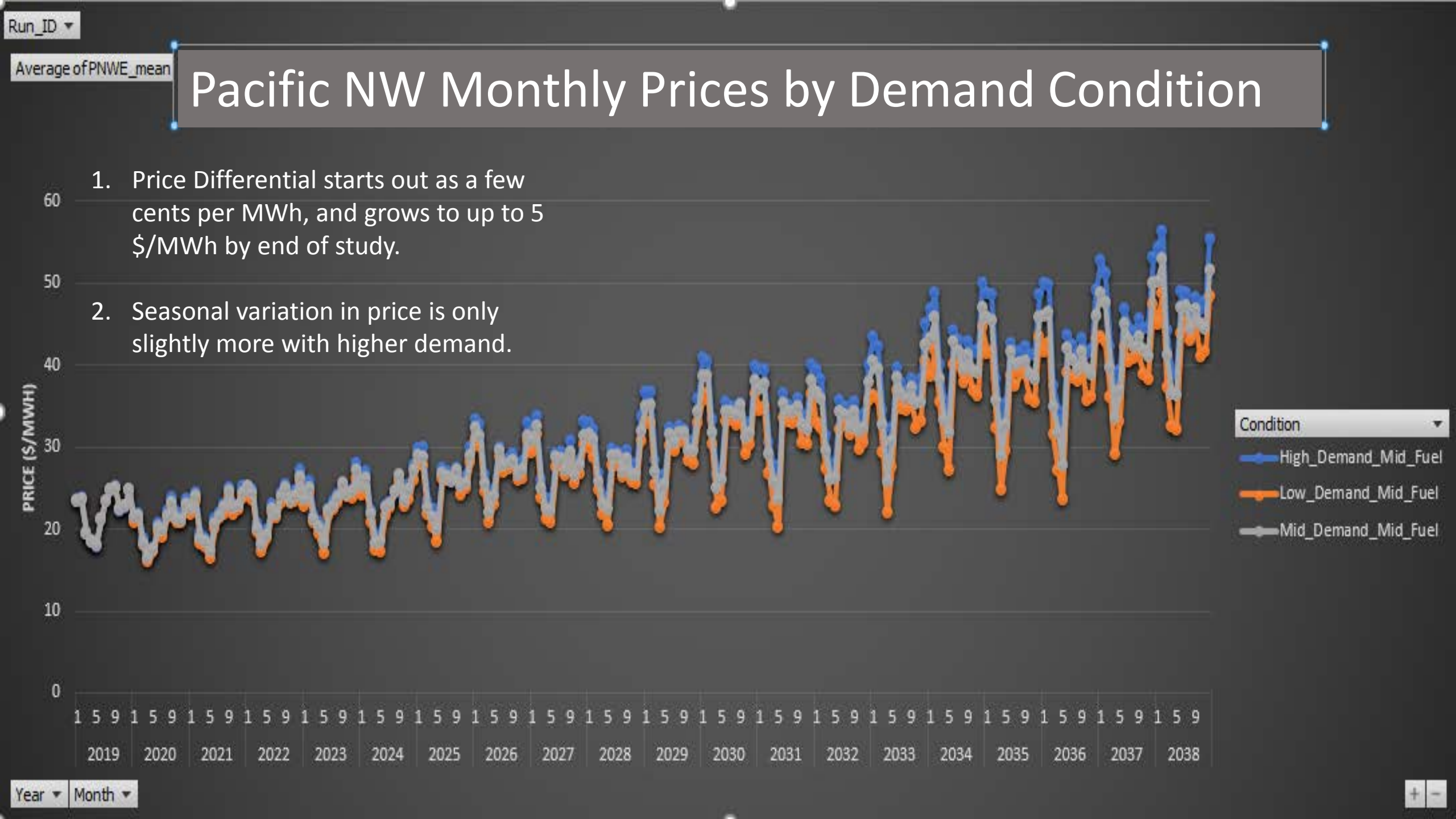
2. Renewable resources buildout external to region makes hourly prices more volatile, and influences daily price shape in PNW.

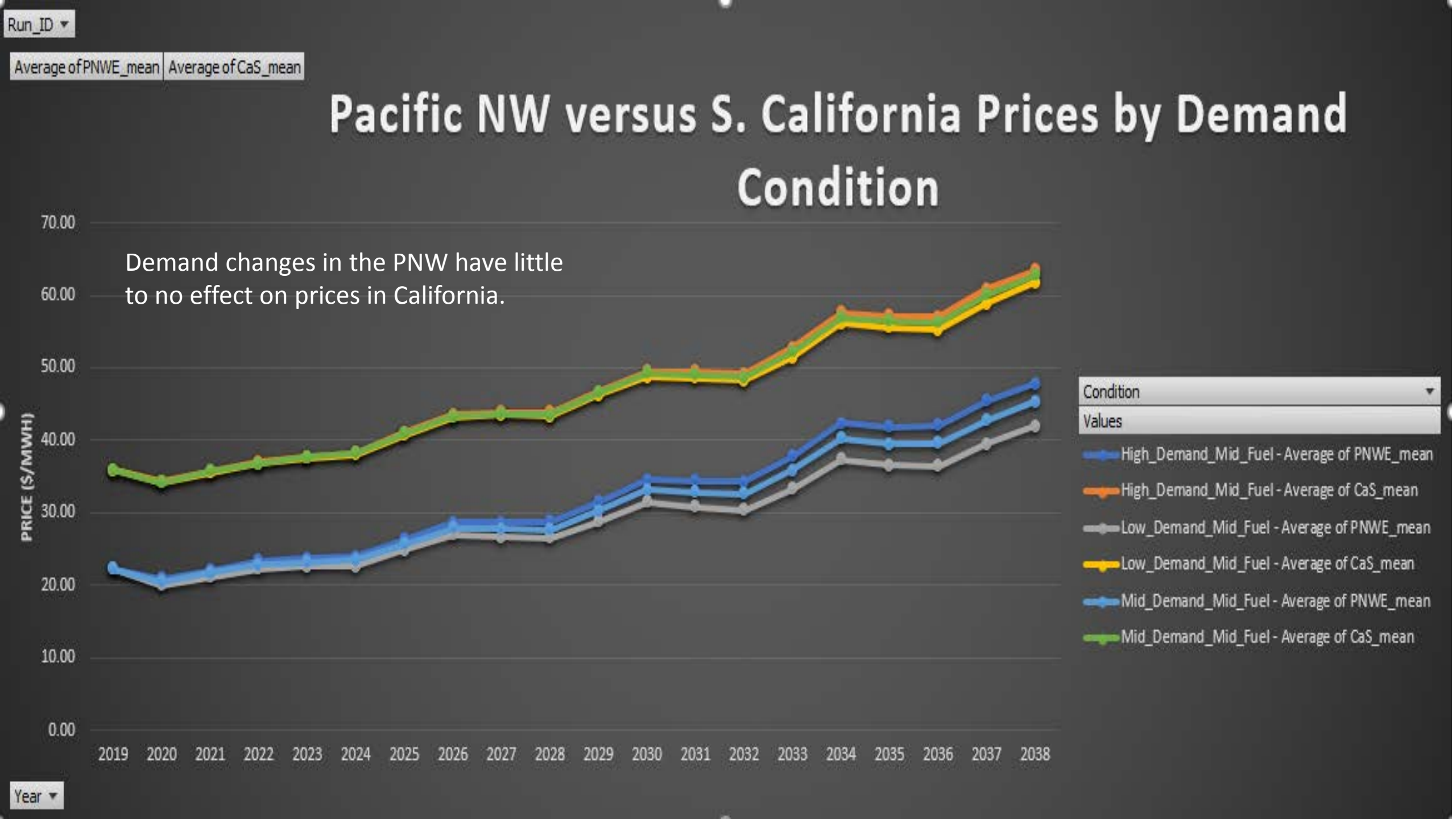
3. Hydro conditions are a big factor in variability in the wholesale electric prices in the PNW.

1. Wholesale prices in the PNW depend on PNW demand, more so on gas prices.

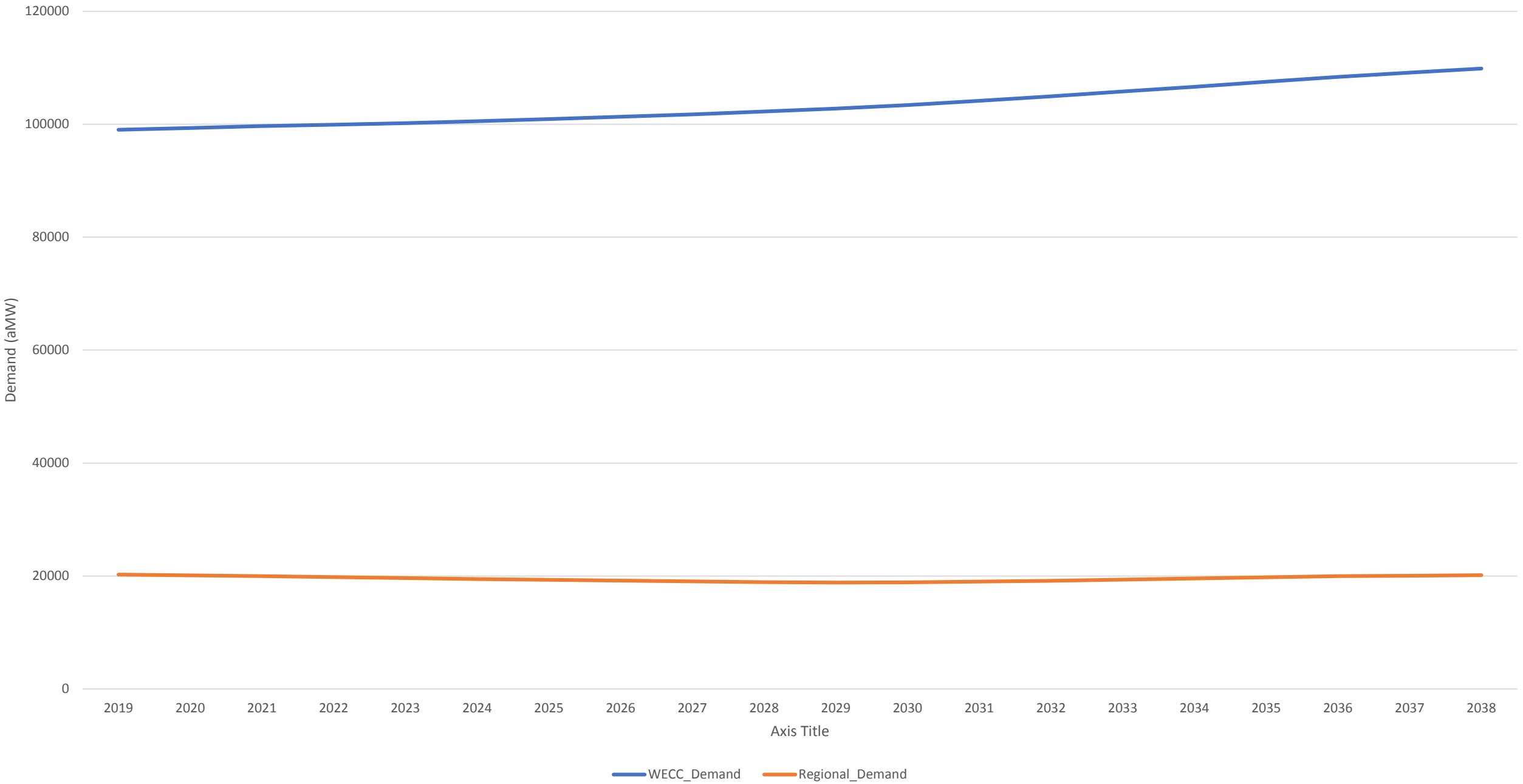
Pacific NW Monthly Prices by Demand Condition

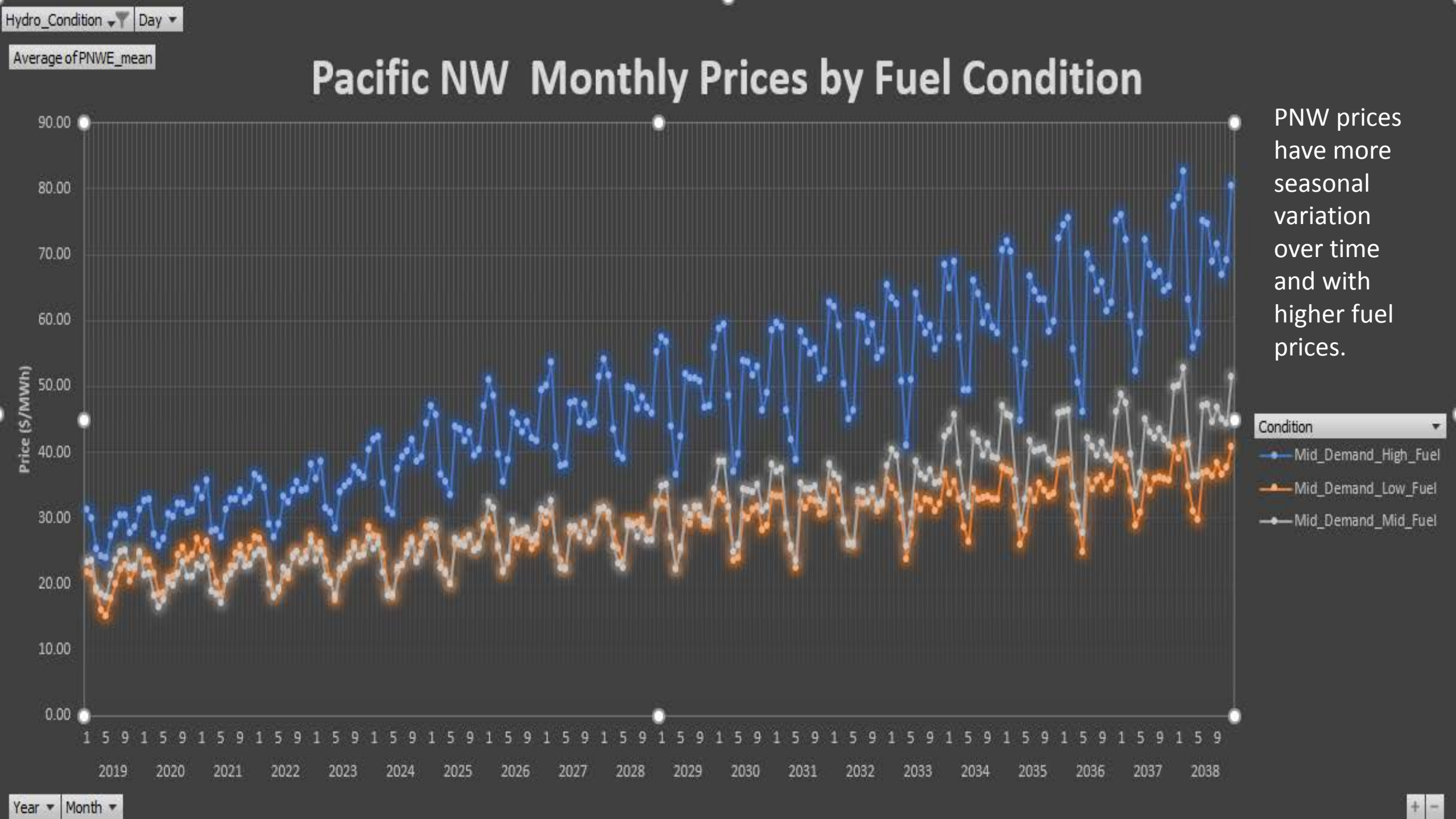
1. Price Differential starts out as a few cents per MWh, and grows to up to 5 $/MWh by end of study.
2. Seasonal variation in price is only slightly more with higher demand.



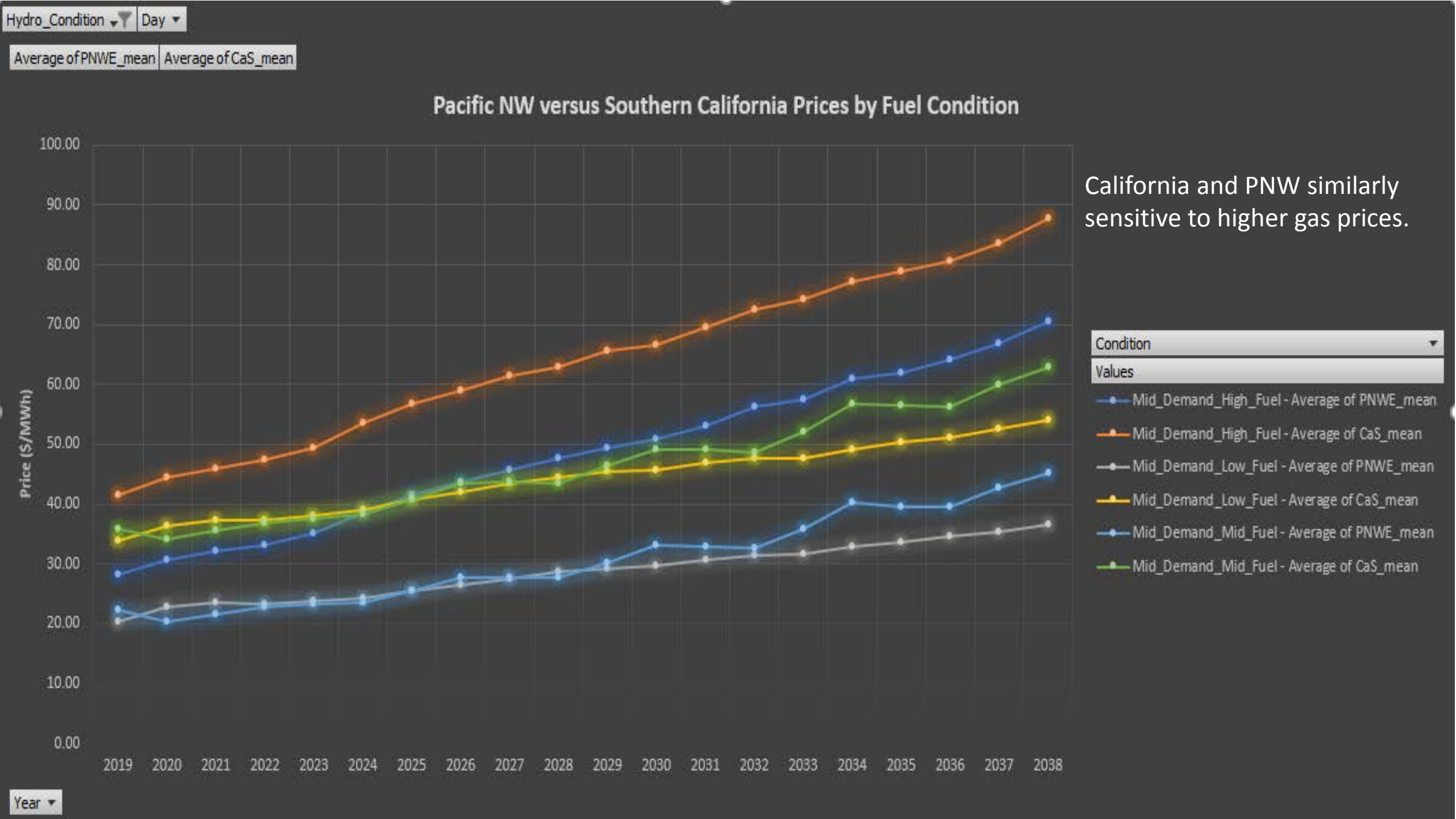

Run_ID
Average of PNWE_mean
Average of CaS_mean
Pacific NW versus S. California Prices by Demand Condition
Demand changes in the PNW have little to no effect on prices in California.
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
PRICE ($/MWH)
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
Year
Condition
Values
High_Demand_Mid_Fuel - Average of PNWE_mean
High_Demand_Mid_Fuel - Average of CaS_mean
Low_Demand_Mid_Fuel - Average of PNWE_mean
Low_Demand_Mid_Fuel - Average of CaS_mean
Mid_Demand_Mid_Fuel - Average of PNWE_mean
Mid_Demand_Mid_Fuel - Average of CaS_mean

Average Annual WECC versus Regional Demand





PNW prices have more seasonal variation over time and with higher fuel prices.



California and PNW similarly sensitive to higher gas prices.

2. Renewable resources buildout external to region makes prices more volatile, and changes daily price shape.

Buildout Observations (Part 1)

- Buildout study from 2019 to 2044.
  - Extra years to minimize end effects and include RPS target years.

- 7th Power Plan EE buildout included the updated demand forecast deferred need for additional capacity in the region.

- Buildout of 1,800 MW of solar and wind in PNW by 2038.
  - 90% of the solar and 100% of the wind is driven by RPS requirements in CA
  - Half of total PNW solar buildout in first 5 years of study, all due to RPS.
  - Under 1,000 MW on non-RPS driven builds in the WECC, and none in the PNW.
  - Over 13,000 MW of solar and 24,800 MW of wind built in WECC

Buildout Observations (Part 2)

- Nearly 25,000 MW of natural gas built consistently
- 73% of builds are CCCTs and 27% are SCCTs.

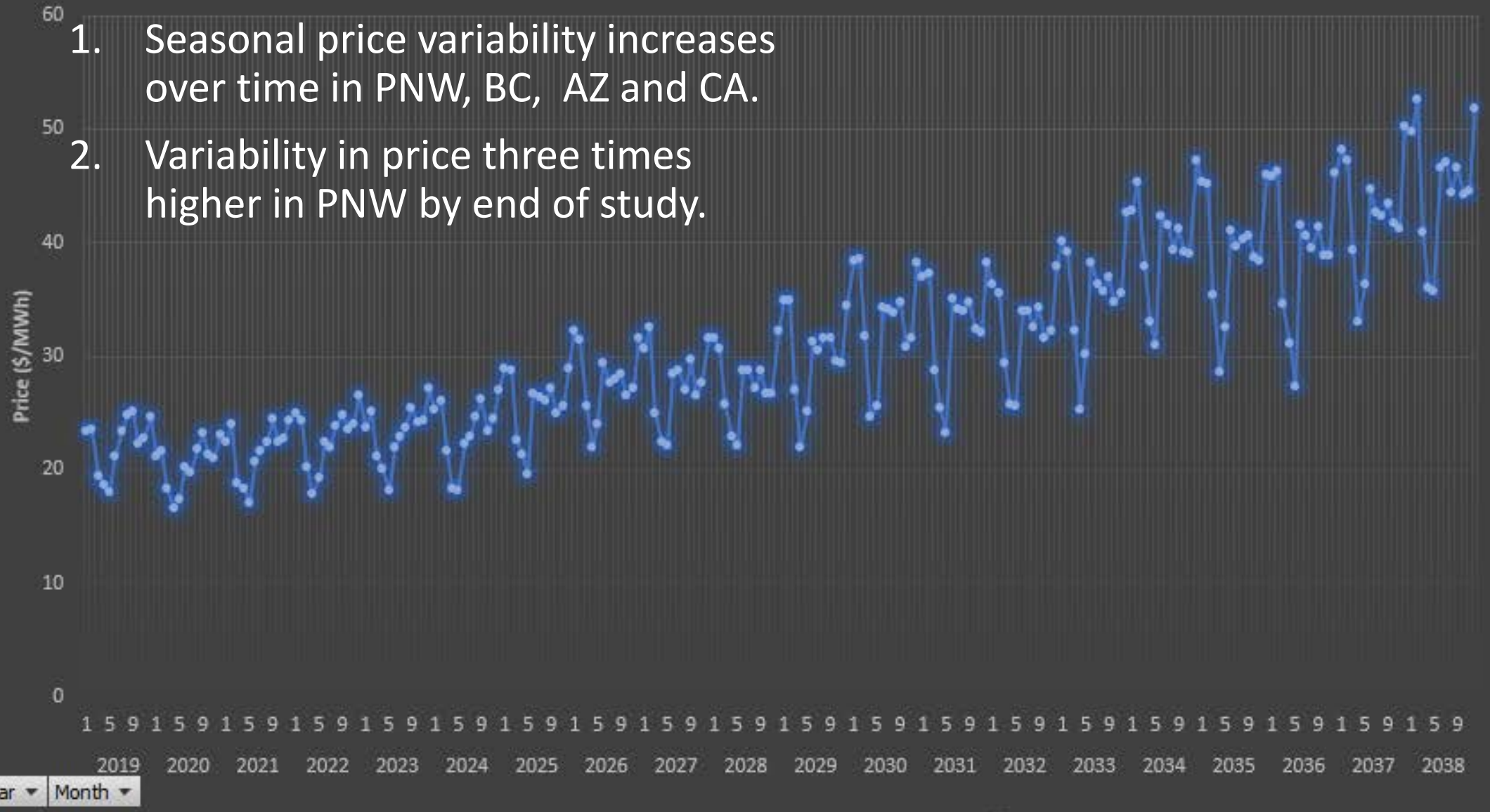
- About 14,800 MW in Desert SW and Baja California.
- About 6,400 MW in Canada (mostly Alberta).
- About 3,300 MW in Mountain West

Mean Annual Prices By Zone

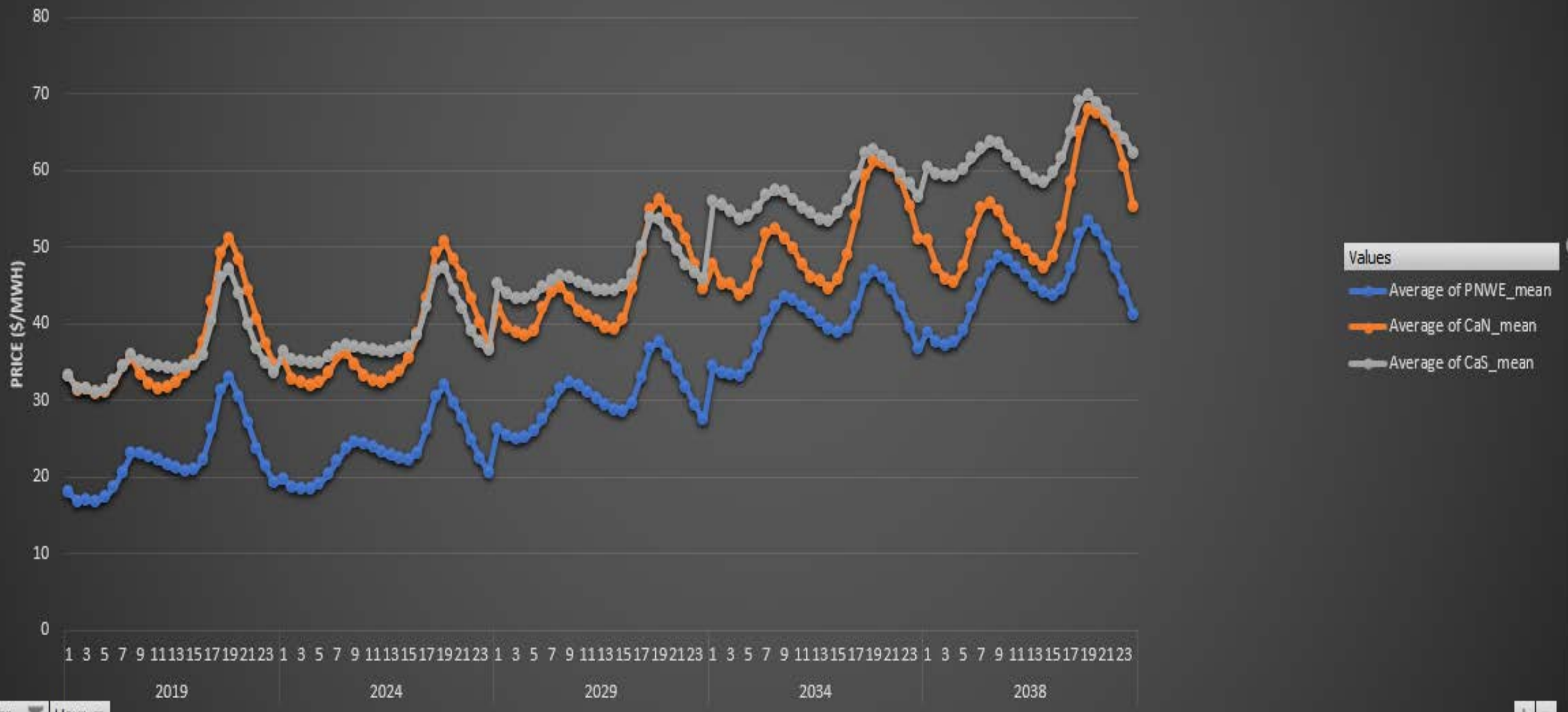
Price increases over time in all zones, PNW has consistently low annual prices in comparison.

Mean Monthly Prices By Zone

1. Seasonal price variability increases over time in PNW, BC, AZ and CA.
2. Variability in price three times higher in PNW by end of study.



Average Daily Prices By Zone

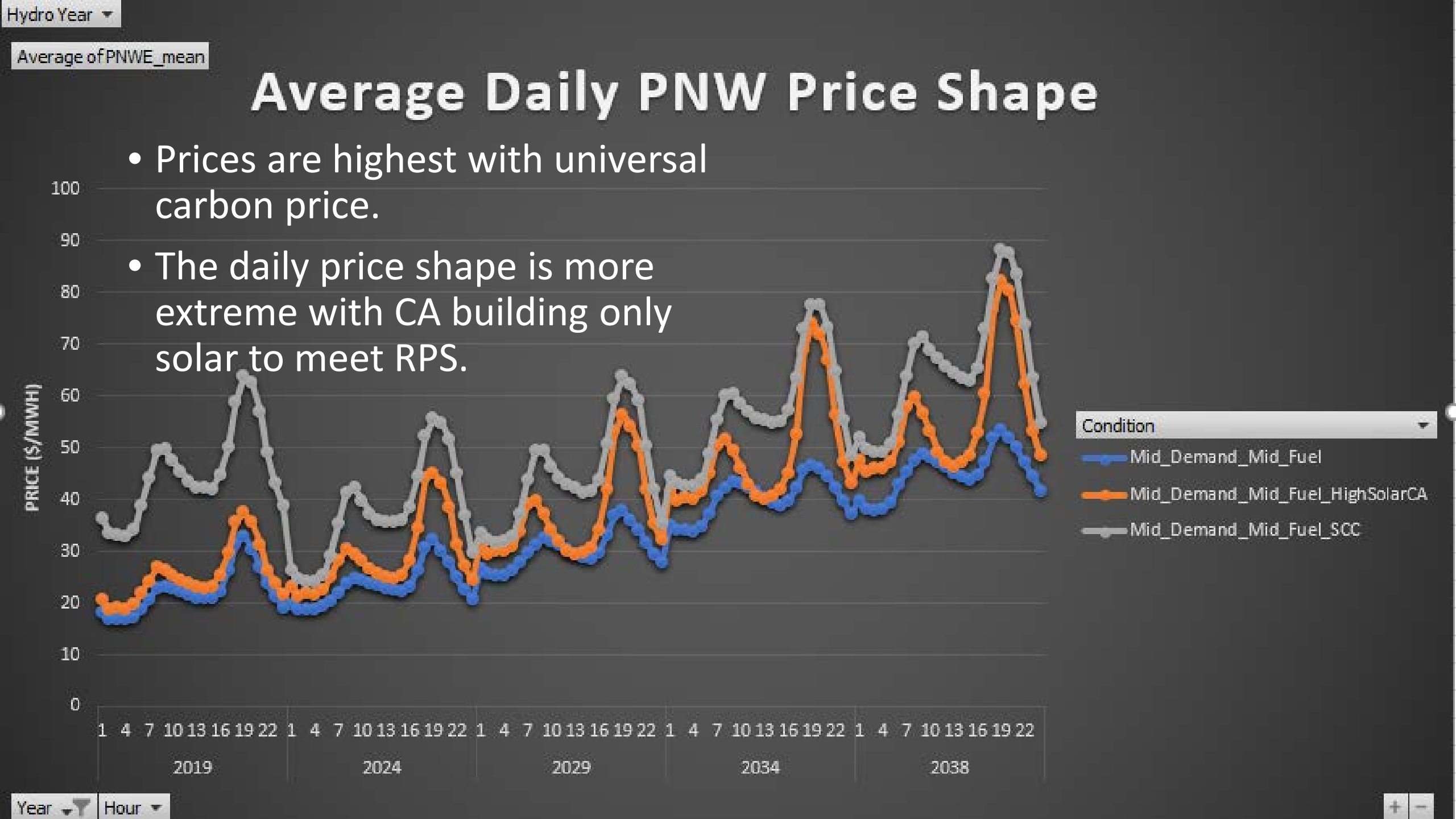


Buildout Observations (Part 3)

1. Some folks in the SAAC were concerned about the amount of wind built in CA.
   - 80% of future RPS need met by in-state wind and 20% solar
   - Ran a sensitivity with 80% of need forced to be met by solar, and the CA buildout ended up being all solar.
   - 1,500 MW more renewables required, but 1,500 MW less gas built.
   - Prices are higher in general, and evening ramp is more extreme.
2. California carbon pricing drives many of the gas builds in Desert SW, but universal carbon pricing drives gas builds everywhere.
   - Ran a sensitivity with Social Cost of Carbon (SCC) applied to all zones in AURORA.
   - SCC run had 5,000 MW more renewables built and nearly double the new gas plants (including 11,000 MW in the region)

Average Daily PNW Price Shape

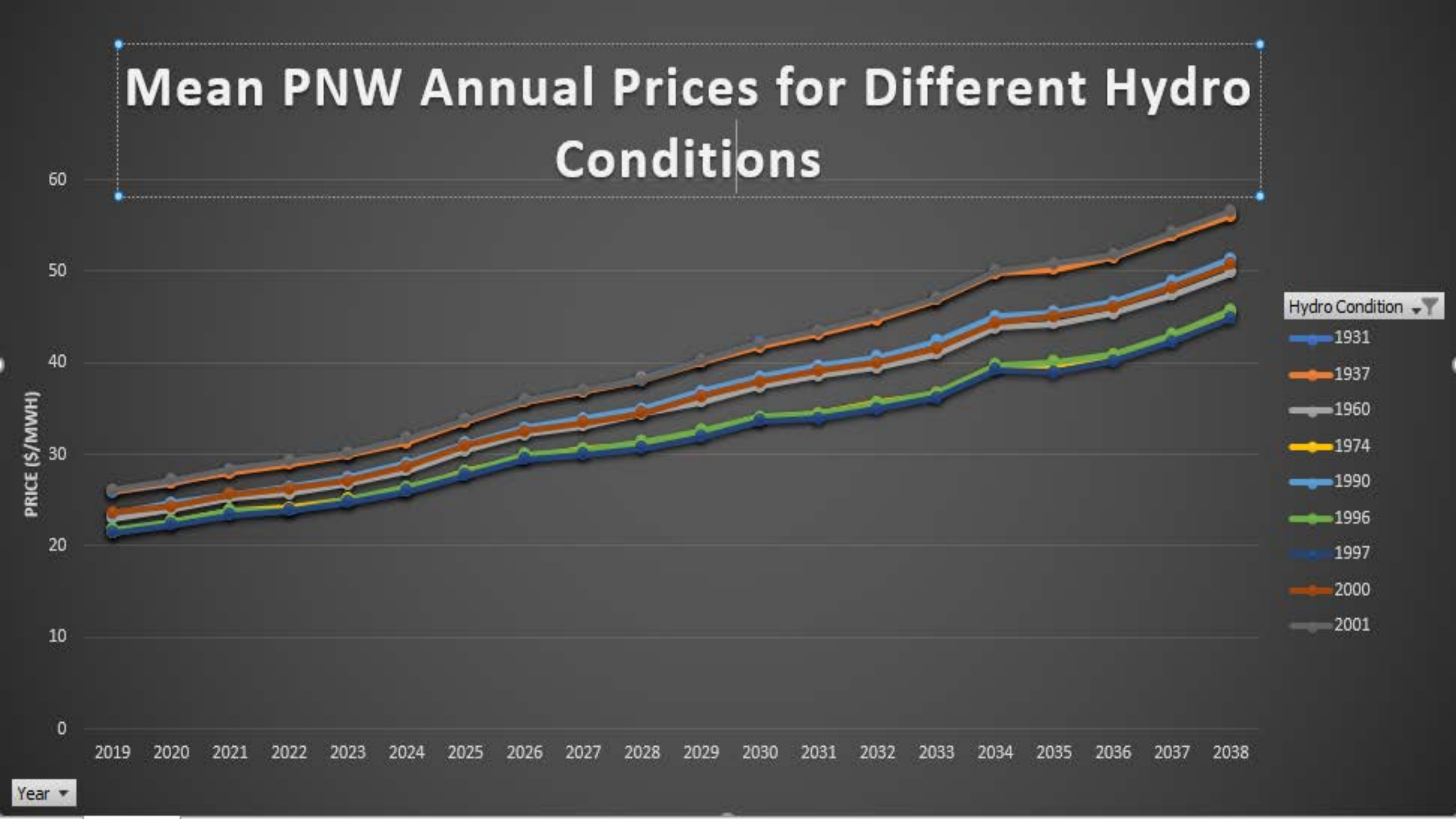
- Prices are highest with universal carbon price.
- The daily price shape is more extreme with CA building only solar to meet RPS.

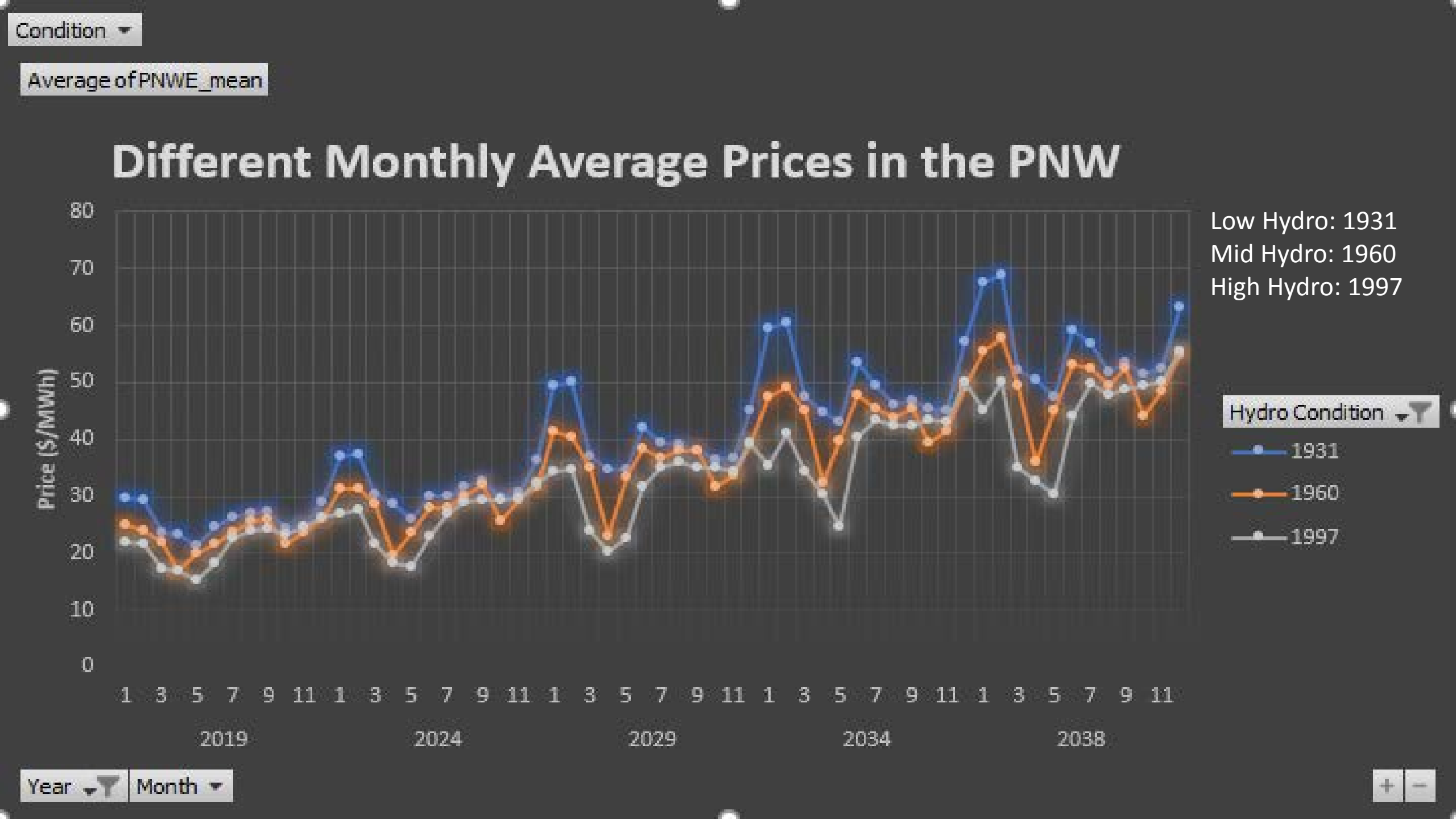


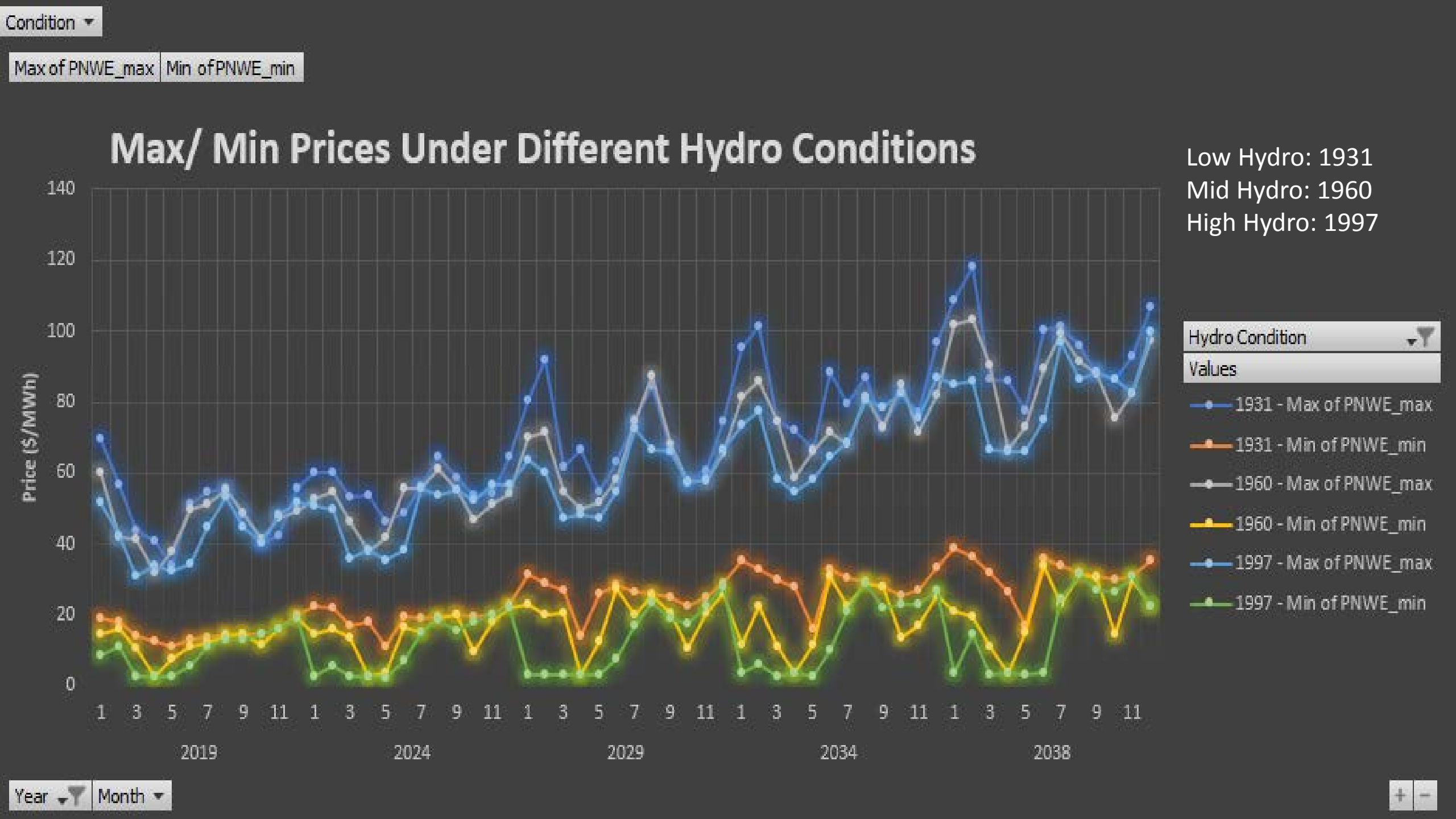
3. Hydro conditions are a big factor in variability in the wholesale electric prices in the PNW.

Mid-C Price Risk Due to Hydro Conditions

- High, Mid and Low level hydro conditions have the expected effect on an annual basis
  - At the beginning of the study, +/- 3 $/MWh price differential of high and low conditions off mid level runoff at the Dalles.
  - By the end of the study, +/- 6 $/MWh price differential of high and low conditions off mid level runoff at the Dalles.


Mean PNW Annual Prices for Different Hydro Conditions
PRICE ($/MWH)
60
50
40
30
20
10
0
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
Year
Hydro Condition
1931
1937
1960
1974
1990
1996
1997
2000
2001


Condition
Average of PNWE_mean
Different Monthly Average Prices in the PNW
Price ($/MWh)
80
70
60
50
40
30
20
10
0
1 3 5 7 9 11 1 3 5 7 9 11 1 3 5 7 9 11 1 3 5 7 9 11 1 3 5 7 9 11
2019
2024
2029
2034
2038
Low Hydro: 1931
Mid Hydro: 1960
High Hydro: 1997
Hydro Condition
1931
1960
1997
Year
Month


Condition
Max of PNWE_max
Min of PNWE_min
Max/ Min Prices Under Different Hydro Conditions
Low Hydro: 1931
Mid Hydro: 1960
High Hydro: 1997
Price ($/MWh)
140
120
100
80
60
40
20
0
1 3 5 7 9 11 1 3 5 7 9 11 1 3 5 7 9 11 1 3 5 7 9 11 1 3 5 7 9 11
2019
2024
2029
2034
2038
Hydro Condition
Values
1931 - Max of PNWE_max
1931 - Min of PNWE_min
1960 - Max of PNWE_max
1960 - Min of PNWE_min
1997 - Max of PNWE_max
1997 - Min of PNWE_min
Year
Month

Daily Power Price Shape

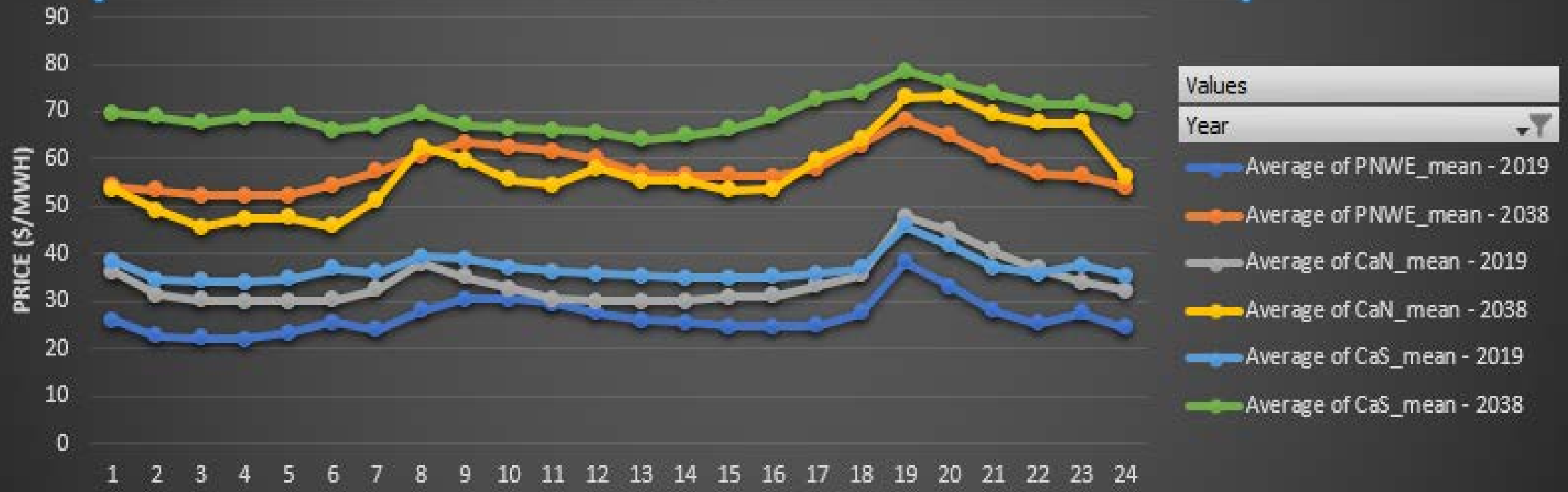
- How does daily shape change under different hydro conditions?
  - Average daily shape by sample month in each season at 5 year intervals throughout study.

- What do the extremes look like?
  - The days containing the extreme high and low price hours for PNW and California.

Condition | Hydro Condition | Month | Day

Average of PNWE_mean | Average of CaN_mean | Average of CaS_mean

January Average Daily Shape 2019 and 2038: 2001 Hydro Conditions

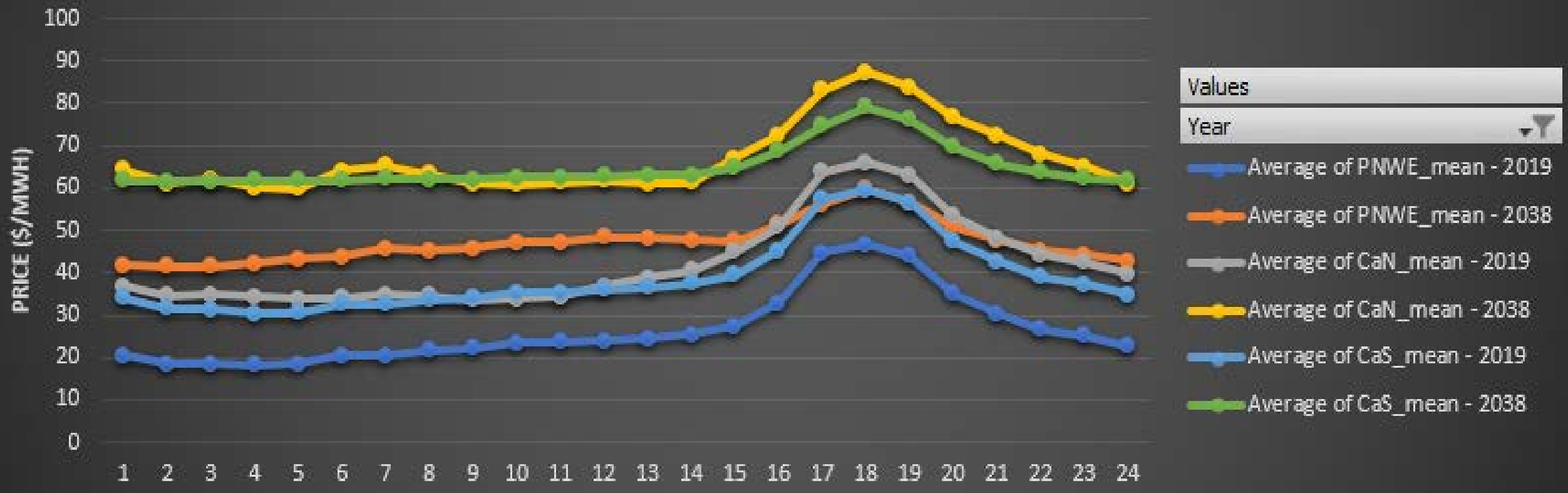


Hour

Condition | Hydro Condition | Month | Day

Average of PNWE_mean | Average of CaN_mean | Average of CaS_mean

August Average Daily Shape 2019 and 2038: 2001 Hydro Conditions

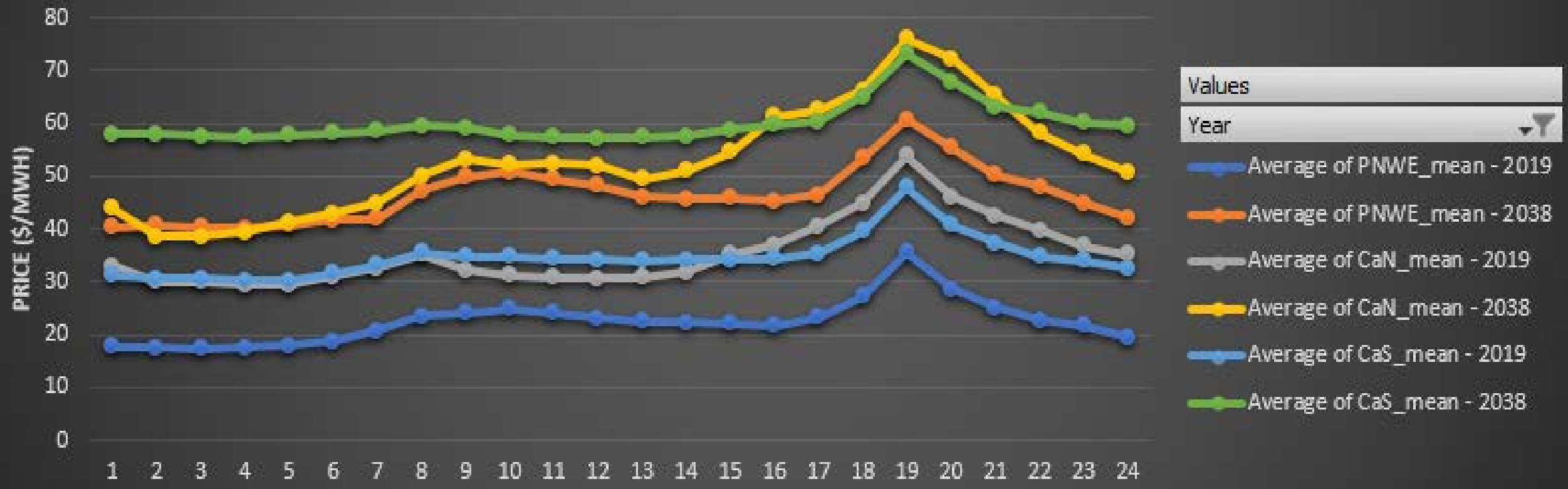


Hour

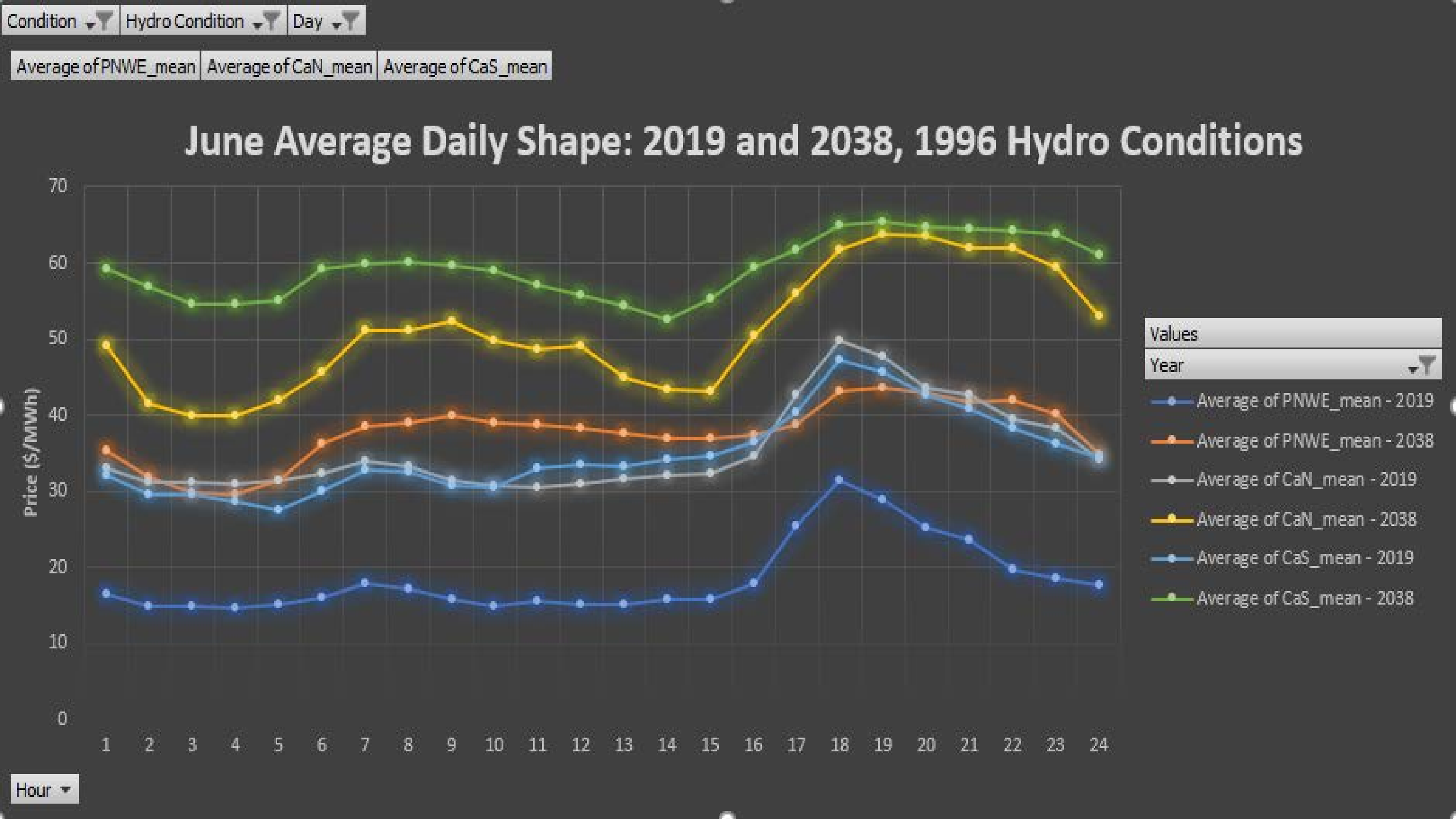
Condition | Hydro Condition | Month | Day

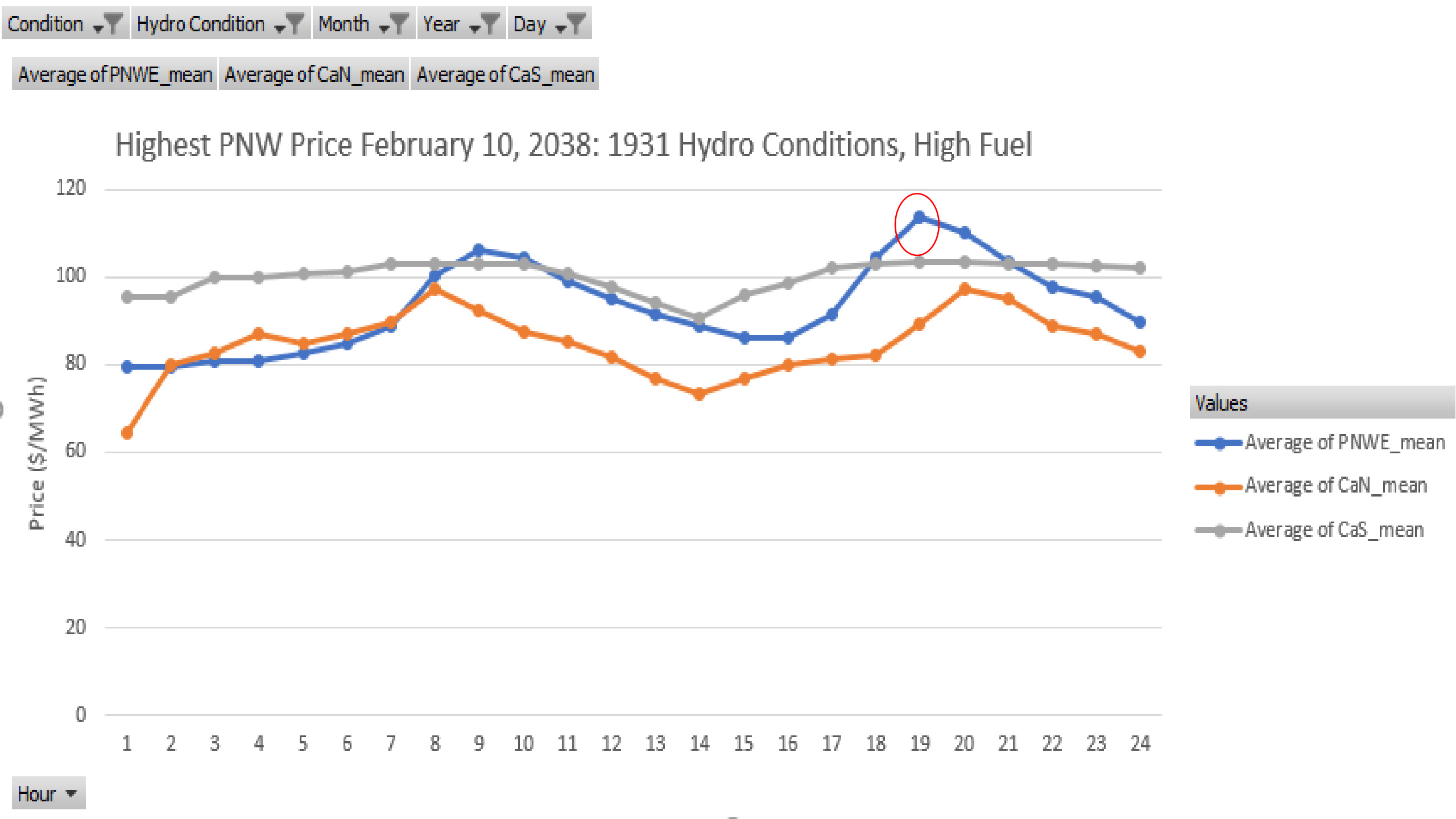
Average of PNWE_mean | Average of CaN_mean | Average of CaS_mean

November Average Daily Shape 2019 and 2038: 2001 Hydro Conditions



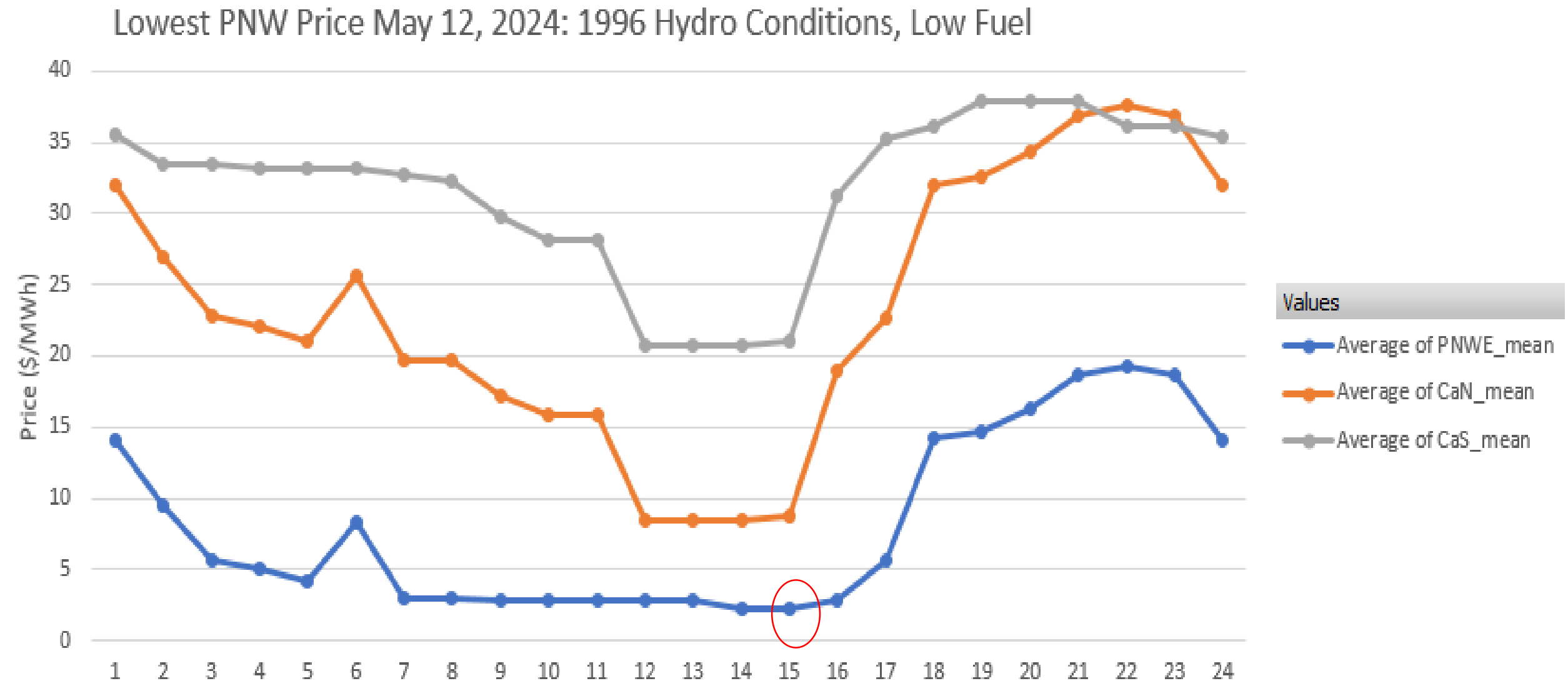
Hour


Condition
Hydro Condition
Day
Average of PNWE_mean
Average of CaN_mean
Average of CaS_mean
June Average Daily Shape: 2019 and 2038, 1996 Hydro Conditions
Price ($/MWh)
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
Values
Year
Average of PNWE_mean - 2019
Average of PNWE_mean - 2038
Average of CaN_mean - 2019
Average of CaN_mean - 2038
Average of CaS_mean - 2019
Average of CaS_mean - 2038


Condition
Hydro Condition
Month
Year
Day
Average of PNWE_mean
Average of CaN_mean
Average of CaS_mean
Highest PNW Price February 10, 2038: 1931 Hydro Conditions, High Fuel
120
100
80
60
40
20
0
Price ($/MWh)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Hour
Values
Average of PNWE_mean
Average of CaN_mean
Average of CaS_mean

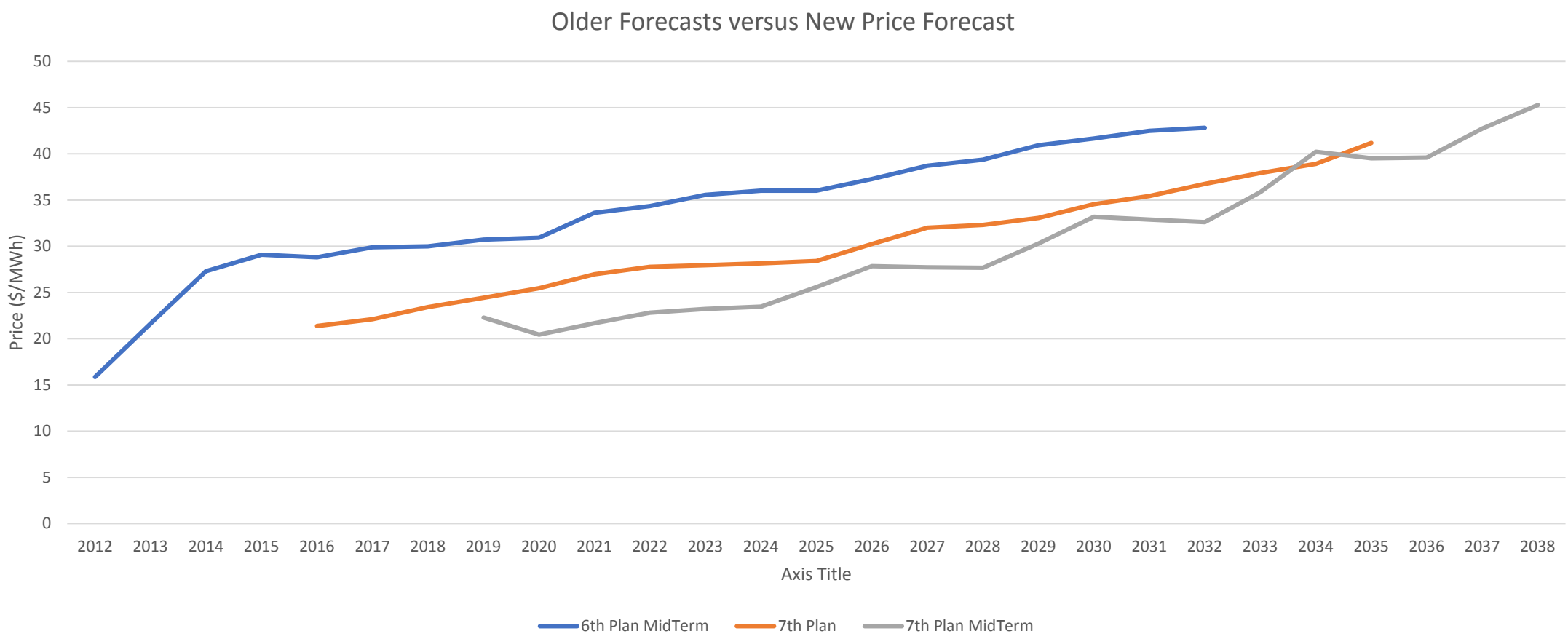
Condition | Hydro Condition | Month | Year | Day

Average of PNWE_mean | Average of CaN_mean | Average of CaS_mean



Hour

Comparison Versus Old forecasts



Jumping to Conclusions…

1. Wholesale prices in the PNW depend on PNW demand, more so on gas prices.
   - Increasing fuel price forecast over time drives the increase in power prices throughout the WECC.

2. Renewable resources buildout external to region makes hourly prices more volatile, and influences daily price shape in PNW.
   - Buildout to meet California RPS significantly influences daily shape.

3. Hydro conditions are a big factor in variability in the wholesale electric prices in the PNW.
   - Hydro mitigates fuel price correlation less if more gas plants built in WECC.