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Washington

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Montana

Jim Yost
Idaho

Jeffery C. Allen
Idaho

August 4, 2020

MEMORANDUM

TO: **Power Committee Members**

FROM: **Daniel Hua and Massoud Jourabchi**

SUBJECT: **2021 Plan Climate Scenario Load Forecasts**

BACKGROUND:

Presenter: Daniel Hua and Massoud Jourabchi

Summary: Staff will update Power Committee Members on the new regional climate scenario load forecasts for the 2021 Power Plan. The new load forecasts were calculated from a new load methodology that was developed to correct problems observed in the previous set of climate loads presented at the Resource Adequacy Advisory Committee meeting in June 2020. These new loads have reasonable daily and monthly shapes and peak magnitudes when compared to recent historical observed loads.

Relevance: Load forecast is an essential building block of the Resource Plan.

Climate Scenario Loads For the 2021 Power Plan

August 10, 2020

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FOR A SECURE & AFFORDABLE ENERGY FUTURE

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Outline

- Review of the previous set of climate scenario loads presented during RAAC June 2020
  - Comparison with historical loads
  - Comparison with RA-2024 loads
- New load methodology
- New climate scenario loads
  - Comparisons with historical loads

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Review of the *Previous* set of Climate Scenario Loads Presented at the RAAC in June 2020

3

The *Previous* Set of Climate Scenario Loads for June RAAC (I)

- The loads used in the preliminary resource adequacy studies for the 3 selected climate scenarios for the 2021 Power Plan:
  - *CanESM2_BCSD*
  - *CCSM4_BCSD*
  - *CNRM-CM5_MACA*
- for the operating year 2024 were:
  - of medium economic forecast
  - had the effects of the 7th Plan EE targets and hourly shapes (with magnitude of 1,570 aMW)
  - and DSI

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The *Previous* Set of Climate Scenario Loads for June RAAC (II)

- For comparison with other types of loads, for each of the 3 climate scenario, use the 10-year time-period: 2020 – 2029
- In aggregate, there are 30-years of loads from the 3 climate scenarios

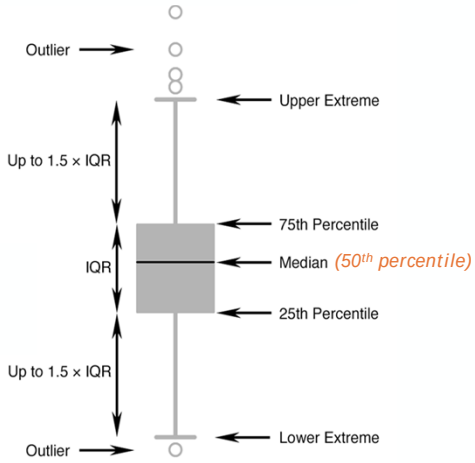
5

Comparisons with Historical Observed Loads (2002 – 2017) – *PNUCC*

6

Interpreting Box-and-Whiskers Plot

The interpretations of the upper and lower whiskers



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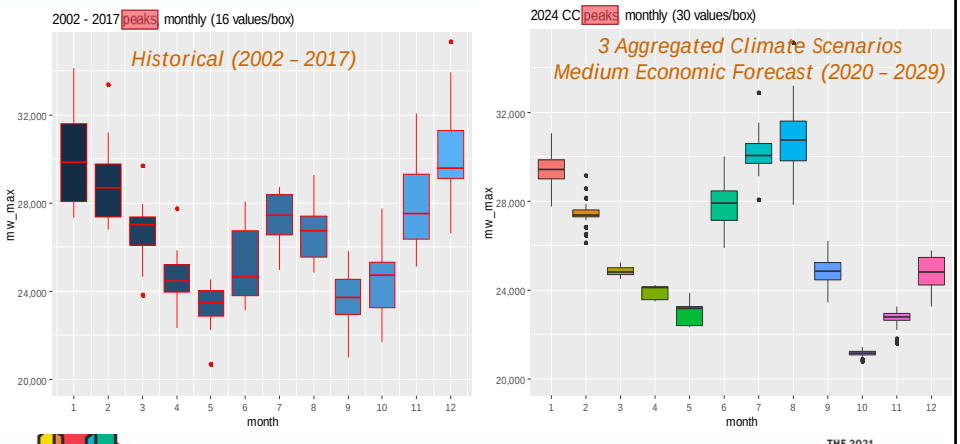
Comparison with Historical Observed Loads (2002 – 2017) – *PNUCC (I)*



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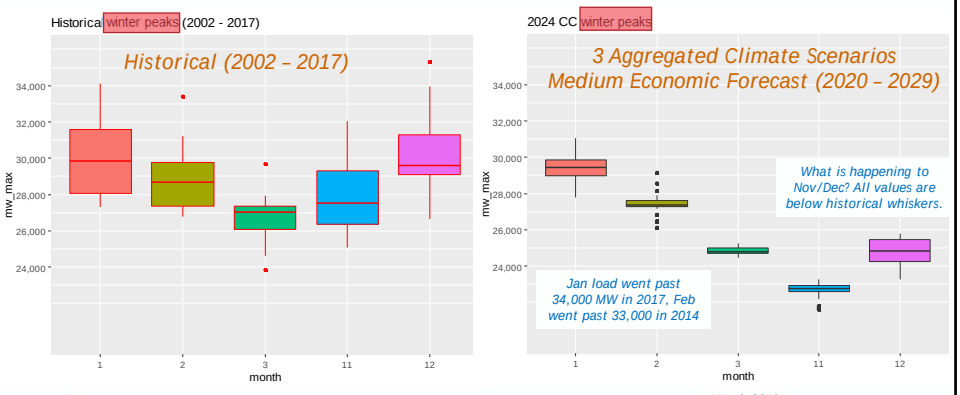
Comparison with Historical Observed Loads (2002 – 2017) – *PNUCC (II)*



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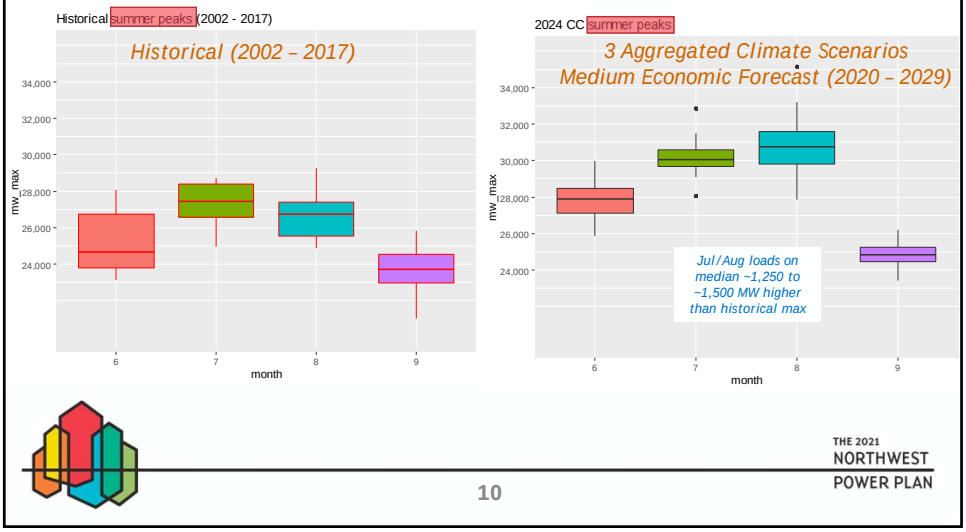
Comparison with Historical Observed Loads (2002 – 2017) – *PNUCC (III)*



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Comparisons with *Medium* Economic Forecast For the RA-2024 Loads

(with 1998 – 2017 Temperatures)

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Regional Temperature

- The regional temperature used in load forecast modeling,

$$T_{region} = a * T_{Seattle} + b * T_{Portland} + c * T_{Spokane} + d * T_{Boise} + constant$$

is a weighted sum of the temperatures of four cities: *Seattle*, *Portland*, *Spokane* and *Boise*

- the weights, a, b, c, d, and $constant$ vary by month
- For example, for Jan to Apr,
  - a = 0.49, b = 0.26, c = 0.22, d = 0.06, constant = -2.54

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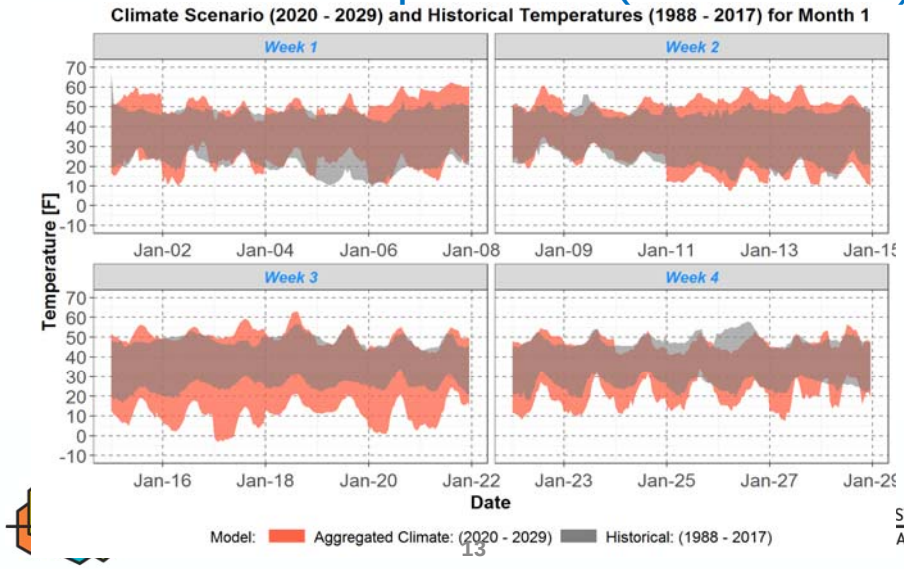
Climate Scenario (2020 – 2029) and Historical *Jan* Temperatures (1988 – 2017)



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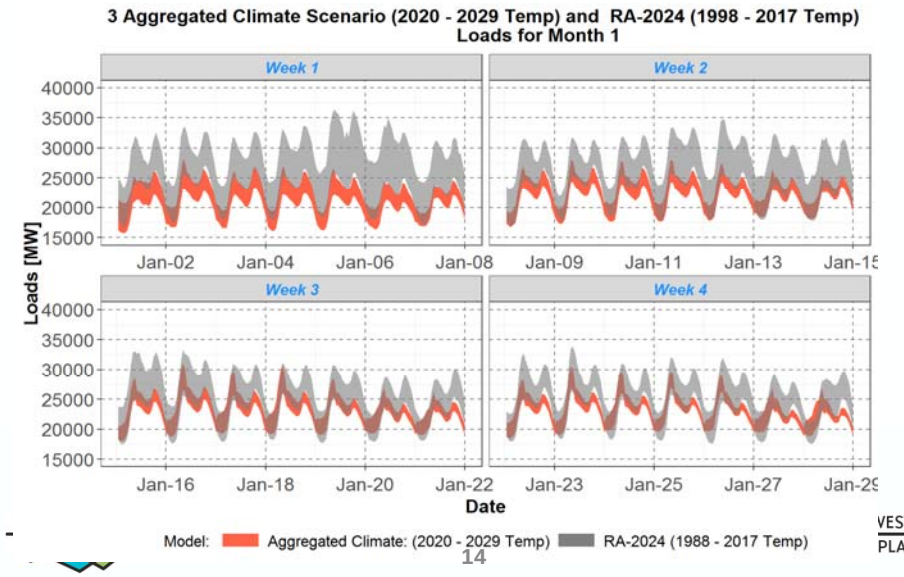
Comparison with *Jan* RA-2024 Loads



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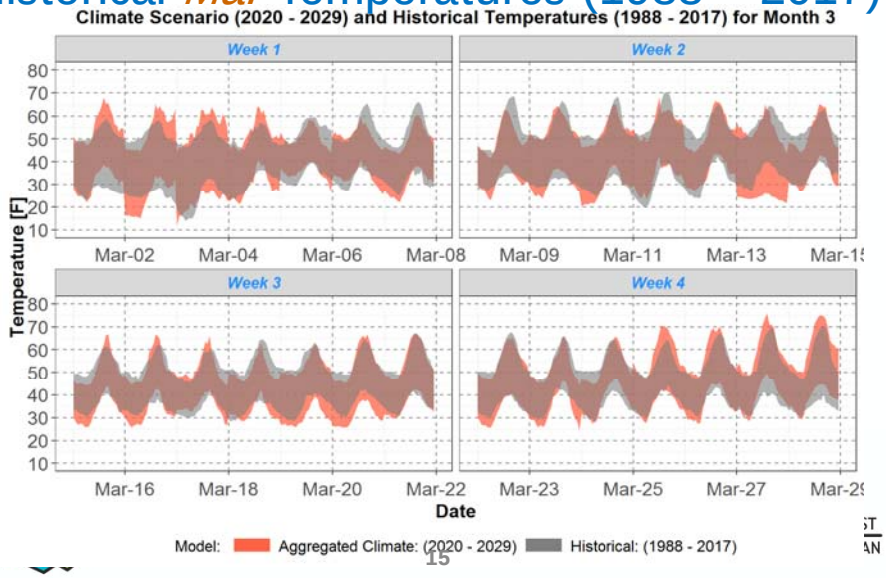
Climate Scenario (2020 – 2029) and Historical *Mar* Temperatures (1988 – 2017)



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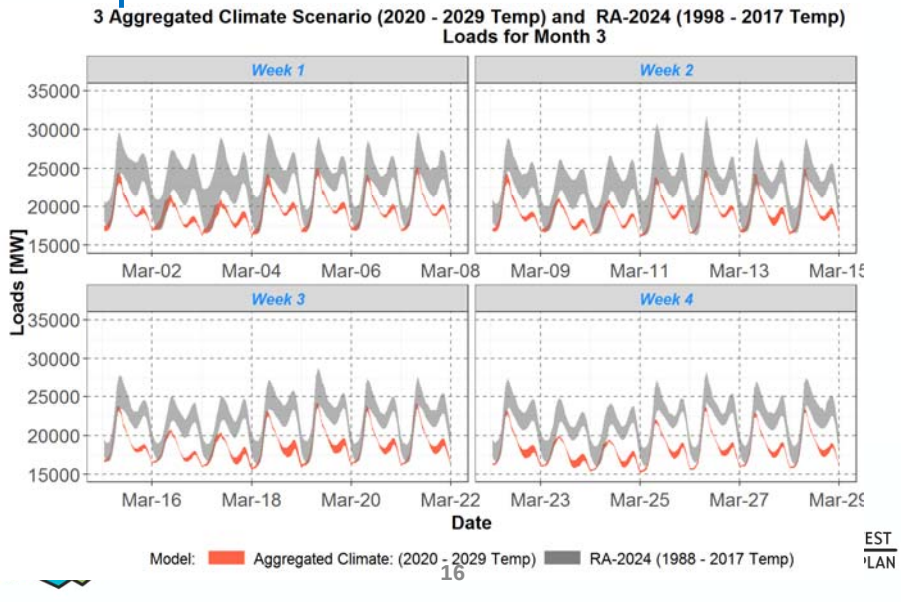
Comparison with *Mar* RA-2024 Loads



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New Hourly Load Forecast Methodology

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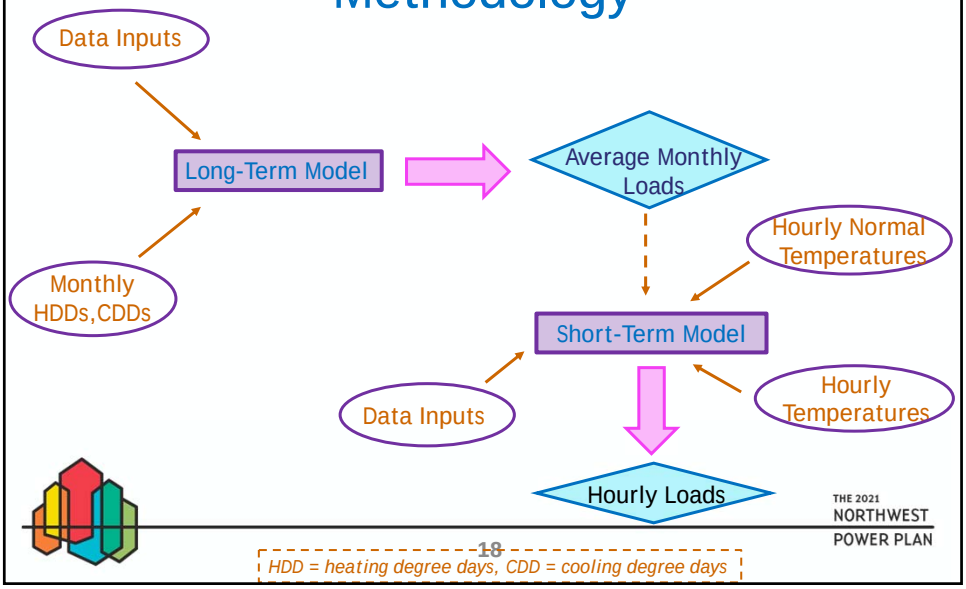
Simplified Flow Chart for Load Methodology



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Changes in Short-Term Model

- Key economic driver:

Previous Methodology	New Methodology
monthly averaged loads from long-term model	*future regional employment for 2020 – 2050**

- Normal temperatures

Previous Methodology	New Methodology
climate scenario temperatures 2020 - 2050	*historical observed temperatures 1948 - 2017*

* Source for employment projections: Global Insight 2018

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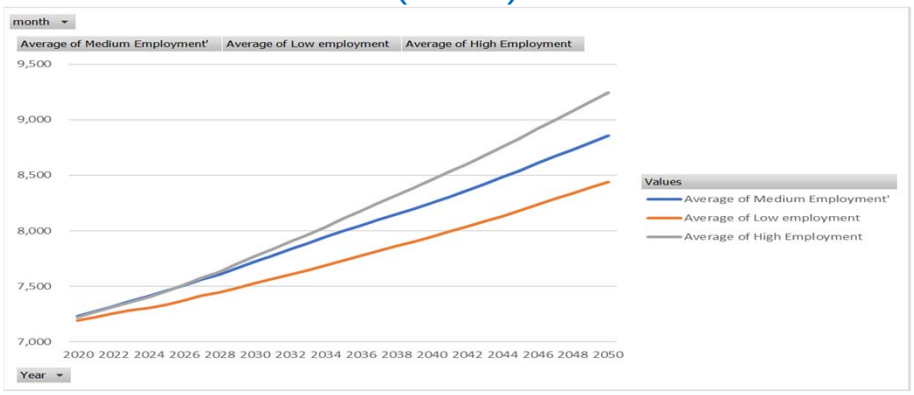
Average Annual Regional Employment* Forecast (1000s)



*Regional employment was used as economic driver for STM across all CC scenarios. LTM uses a variety of economic drivers, such as number of residences, commercial square footage, industrial output, population.

Source for employment projections: Global Insight 2018 subject to change/ Draft to final/ Covid-19 impact.

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Comparing *New* Climate Scenario with Historical Monthly-Averaged Loads

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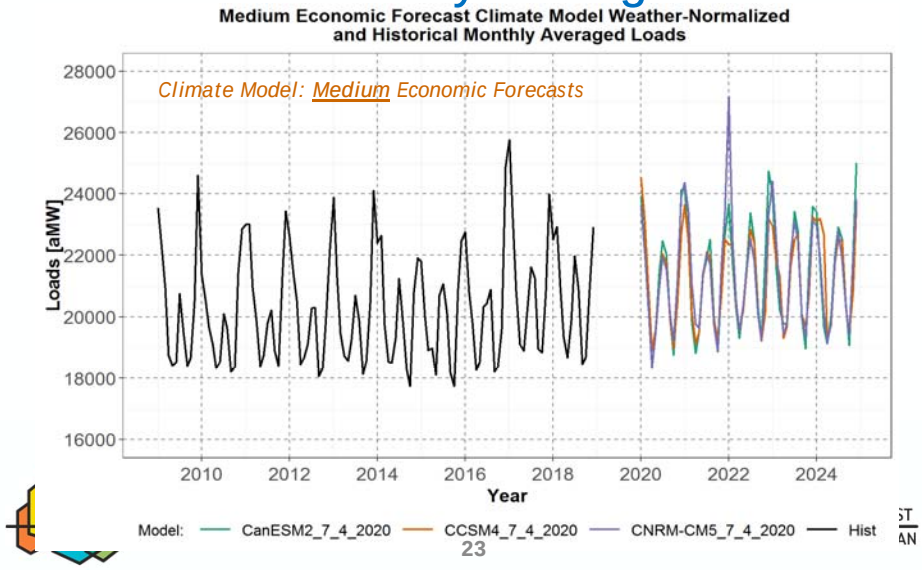
New Climate Scenario Monthly Averaged Weather-Normalized Loads

- As a check on *continuity* near the year 2020,
  - Compare the 3 climate scenario monthly-averaged loads (from the long term model) with historical monthly-averaged loads
  - For the climate scenario loads (*weather-normalized*), use the just the first few forecast years: 2020 - 2024
  - For historical loads, use the 10-year historical time period: 2009 – 2018
  - use historical *net-of DSI* loads

22

Climate Model Weather-Normalized and Historical Monthly Averaged Loads



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Comparing *New* Climate Scenario with Historical Hourly Loads

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New Climate Scenario Loads

- To validate the new climate hourly loads, use the operating year 2024 and compare with historical hourly loads
  - Compare climate scenario loads (*medium economic forecast*) with historical observed loads
  - For the climate scenarios, use temperatures for the 10-year time-period: 2020 – 2029
  - For simplicity, use *frozen-efficiency* and *net-of DSI* loads for climate scenarios
  - For historical loads, take the 10-year time period from 2009 to 2018 to match the 10-year climate scenario time-period
  - And use historical observed *net-of DSI* loads

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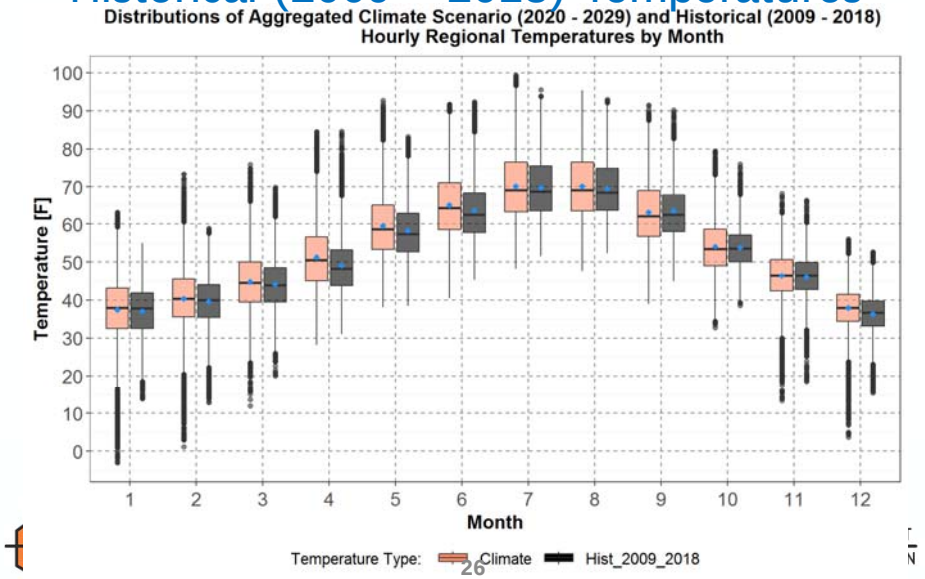
Monthly Climate Scenario (2020 -2029) and Historical (2009 – 2018) Temperatures



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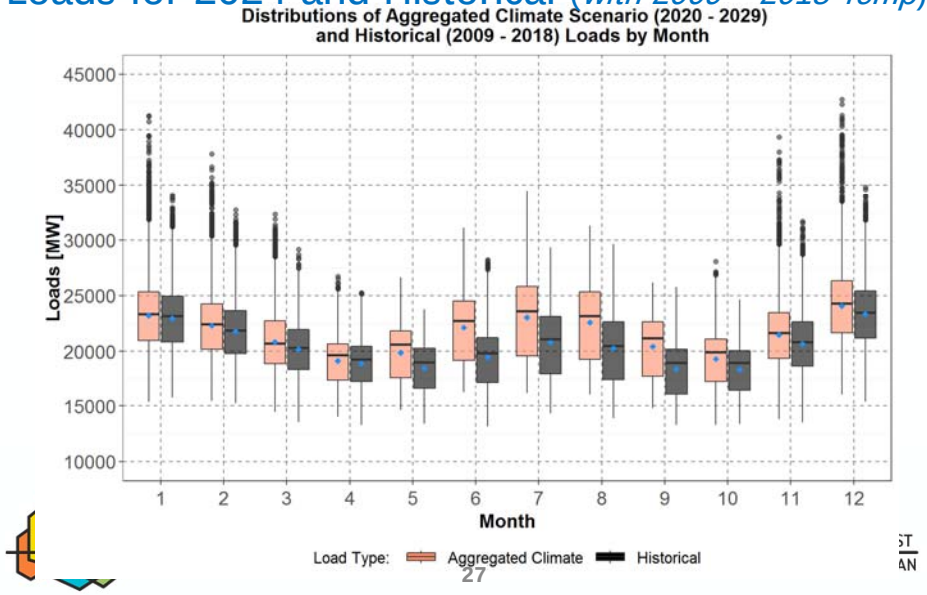
Monthly Climate Scenario *(with 2020 -2029 Temp)* Loads for 2024 and Historical (*with 2009 – 2018 Temp*)



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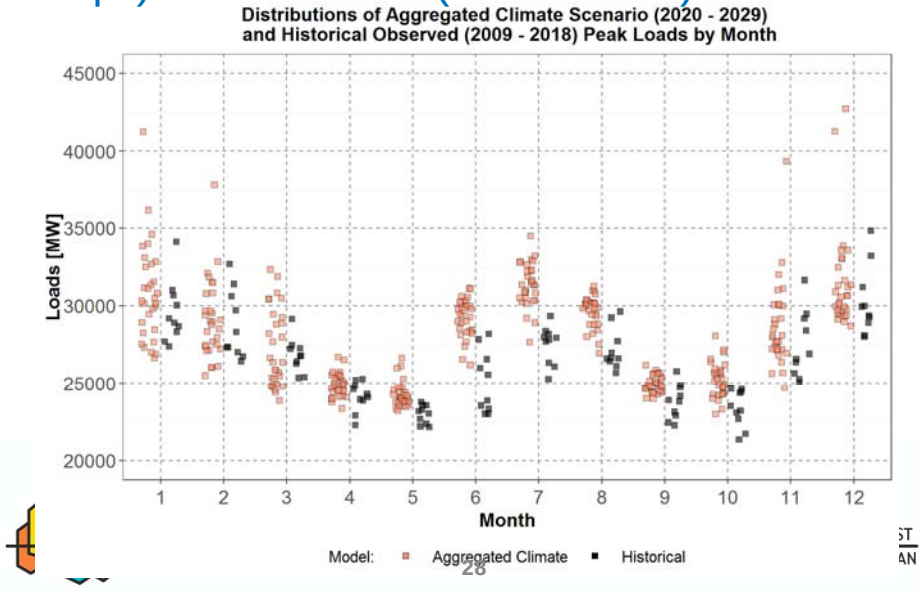
Monthly Climate Scenario 2024 (2020 – 2029 Temps) and Historical (2009 - 2018) Peak Loads



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Comparing Climate and Historical Hourly Temperatures and Loads by Month

29

Climate and Historical Temperatures

- *Maximum* and *minimum hourly* regional temperatures for the *aggregated* climate scenarios
  - *CanESM2_BCSD*
  - *CCSM4_BCSD*
  - *CNRM-CM5_MACA*

for 2020 – 2029 are plotted for each month

- *Maximum* and *minimum hourly* regional temperatures for 2009 – 2018 are plotted for each month

- Plot maximum and minimum hourly temperatures as envelopes

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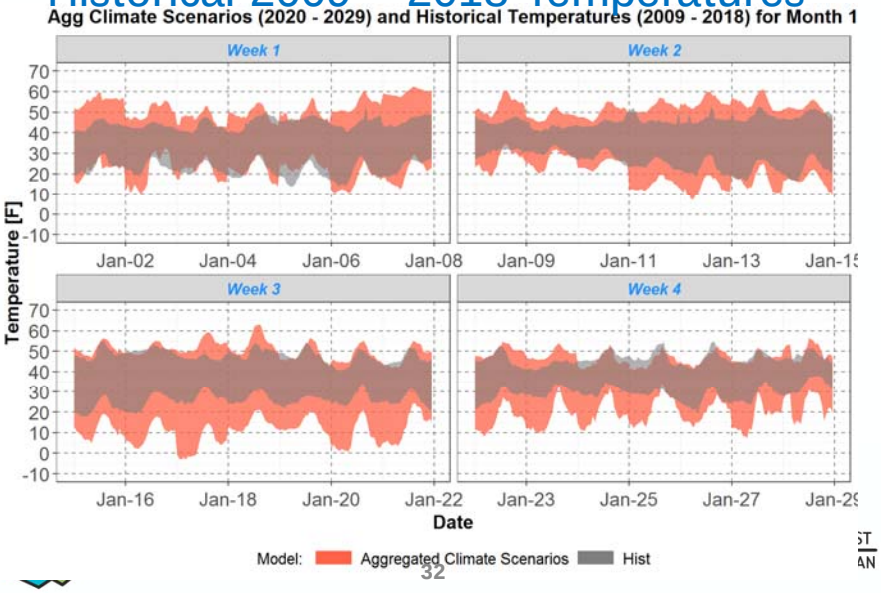
Climate and Historical Observed Loads

- *Maximum* and *minimum hourly* regional loads for 2024 (*medium economic forecast, frozen efficiency, net of DSI*) for the aggregated climate scenarios:
  - *CanESM2_BCSD*
  - *CCSM4_BCSD*
  - *CNRM-CM5_MACA*

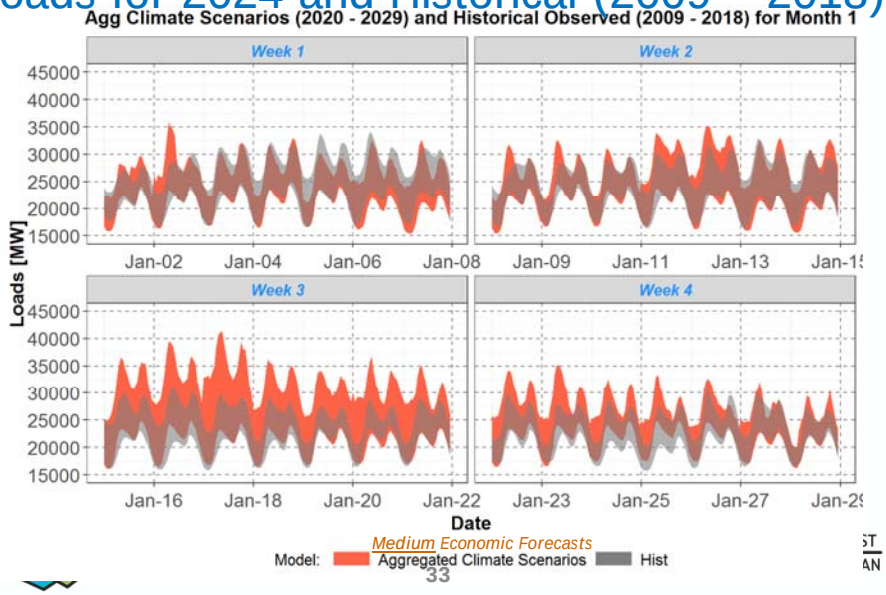
with *2020 – 2029 temperatures* are plotted for each month

- *Maximum* and *minimum hourly* historical observed loads (*net of DSI*) for 2009 – 2018 are plotted for each month
  - Plot maximum and minimum loads as envelopes

Jan Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



Jan Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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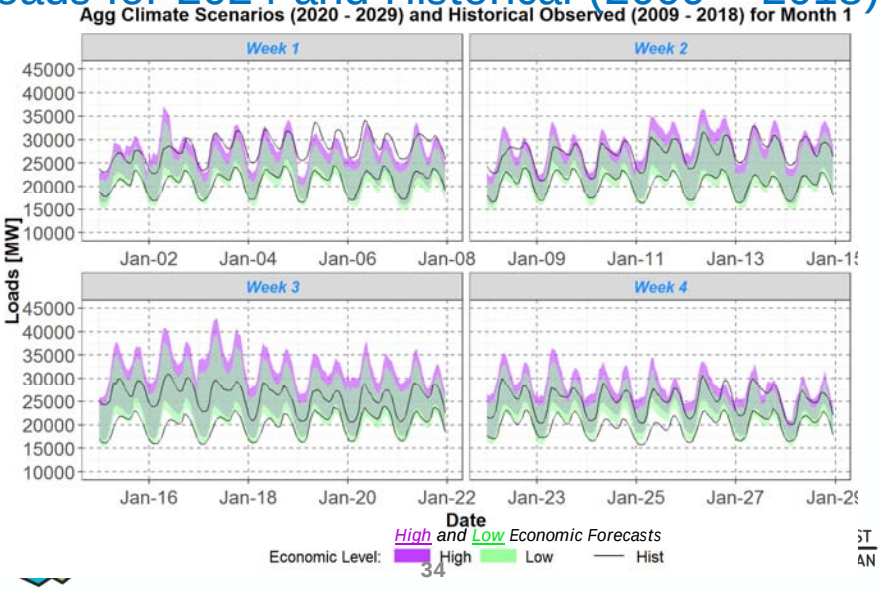
Jan Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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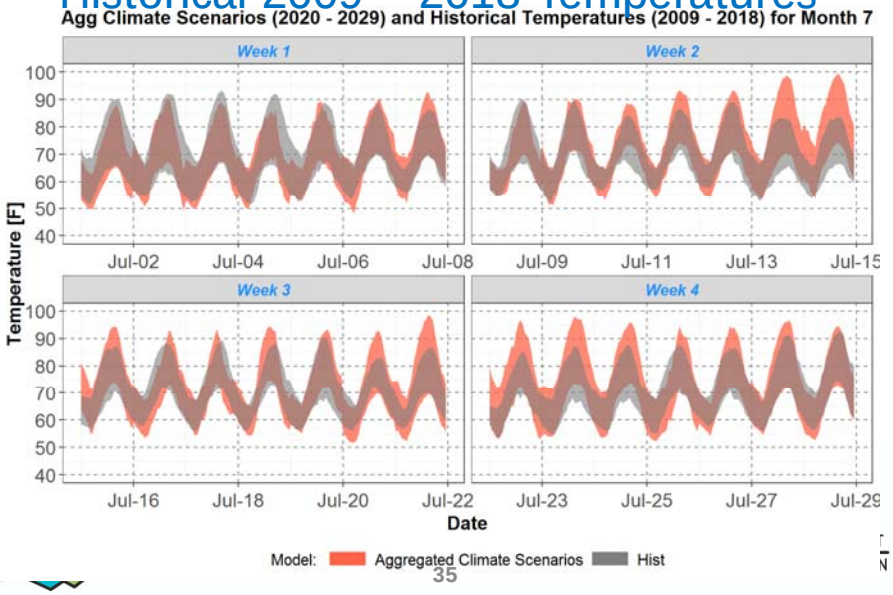
Jul Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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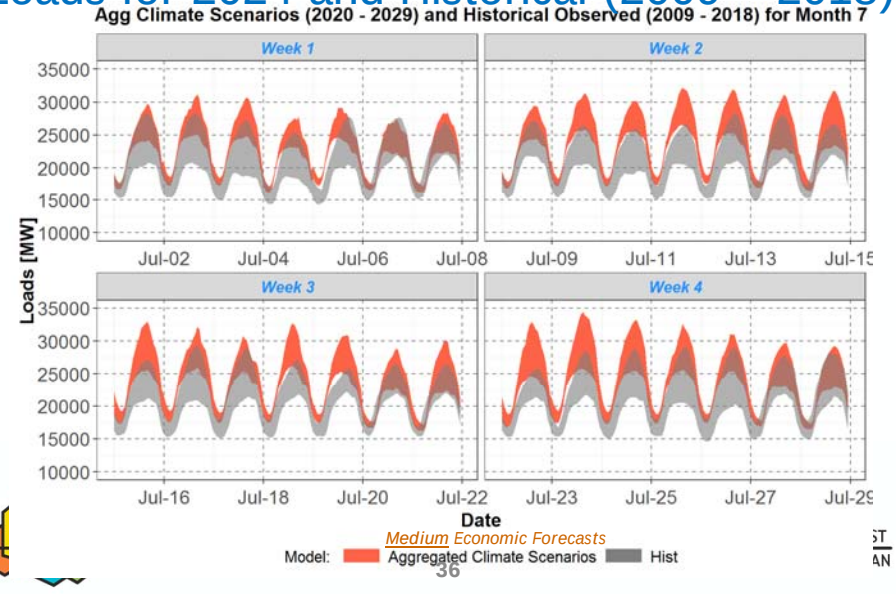
Jul Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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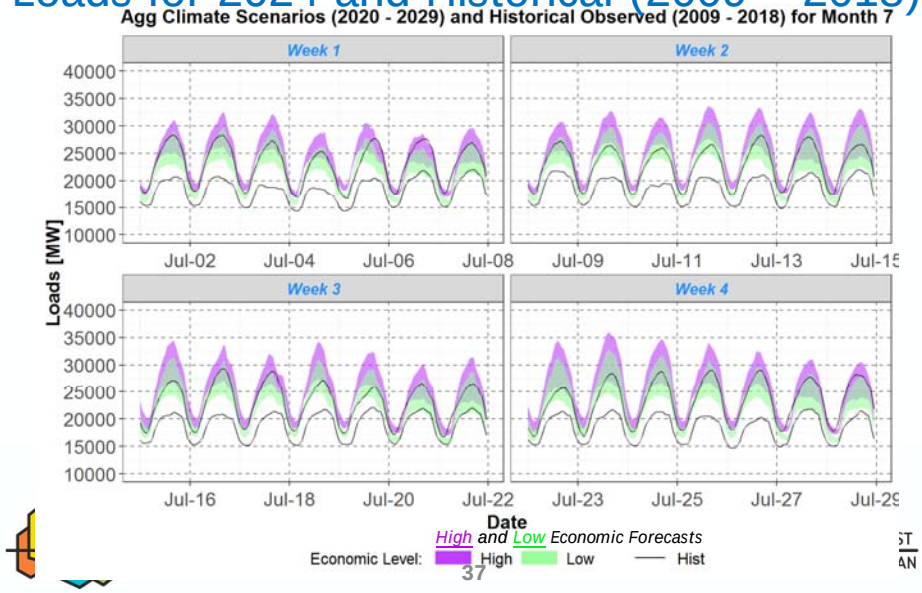
Jul Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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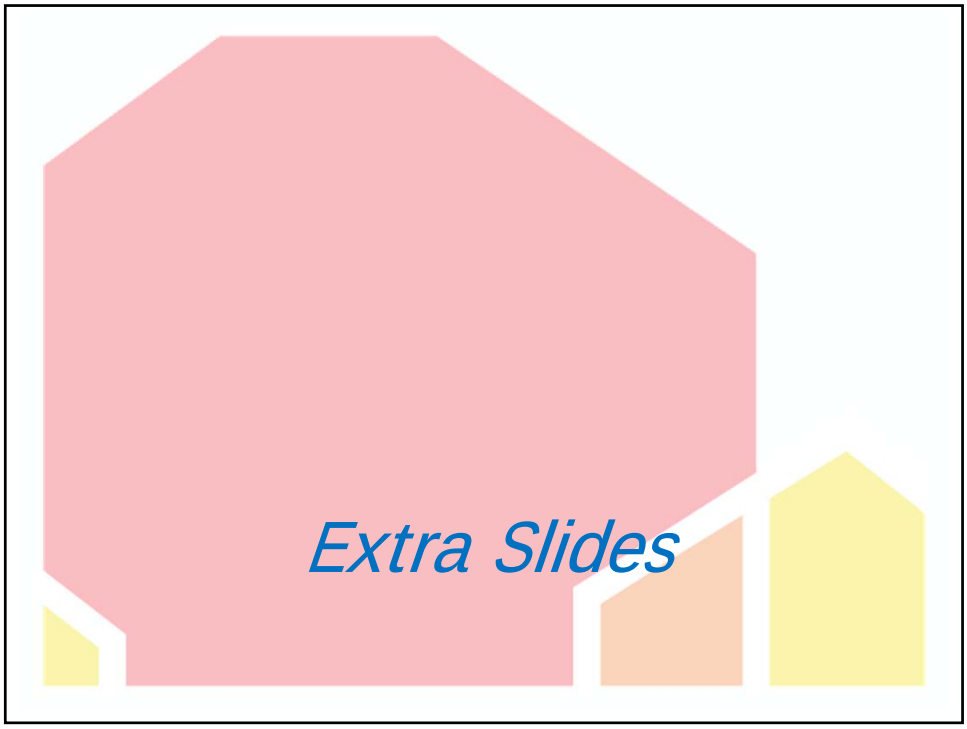

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Methodology: Weather Normalized Loads

- Using 1995-2018 *historical observed* temperature and load data, we estimate the following equation.

$$log(L) = \alpha + \beta S + \gamma C + \delta Log(Emp) + \theta I + u + \omega \log(\Delta \boldsymbol{T})$$

where:

L: is the log of net hourly load for electricity.

S, C: *are a set of Fourier sine and cosine series capturing seasonal and trends.*

$\Delta \boldsymbol{T}$: Deviations from "normal/mean" temperatures.

Emp: is seasonally adjusted monthly employment (history).

I: are the indicator or dummy variables,

u: is the error term of the regression model

- Parsing Loads: Weather Normalized and Temp. Sensitivity Multiplier

We take Coefficients from above equation to estimate WN and TSM

WN load $= \alpha + \beta S + \gamma C + \delta Log(Emp) + \theta I + u$

where Emp is forecast for 2020-2049 period. This provides a forecast void of temperature deviations from Normal, but it includes impact of normal temps.

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New Methodology: Temperature Sensitivity Multipliers

- To forecast loads that are sensitive to temperature variations. We need to incorporate coefficients from temperature deviations in the load equation. using the coefficient from

$$TSM = \omega \log(\Delta T) \text{ where:}$$

  - ω is set of coefficients showing relationship between hourly load and Δt.
  - ΔT is (Climate Change temperature forecast from CC models) minus (Deviation from Normal historical temperatures).

- Note that in the past RA analysis, ΔT had come from historic observed temperatures. For example for RA-2024, normal temperature calculated from 1948 – 2017, and deviations from normal temperature calculated for 1948 – 2017 hourly temperatures

- However for 2021 Plan/future RA, we are using future temperatures from CC models to develop TSM. This shift to future temps. is a new methodology and has implication for future RA analysis. It increases uncertainty of the load forecast.
  - Normal temperature calculated from historical observed 1948 – 2018 temperatures. But deviations from normal temperature calculated from climate temperatures from 2020 - 2049

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CCSM4 Loads for 2024 for February and March Show a Jump due to jump in Heating Degree Days

	2021	2022	2023	2024
Oregon HDD January	805	591	662	659
Oregon HDD February	681	616	536	715
Oregon HDD March	533	525	652	823
Washington HDD January	846	611	677	689
Washington HDD February	718	659	569	752
Washington HDD March	574	582	689	882

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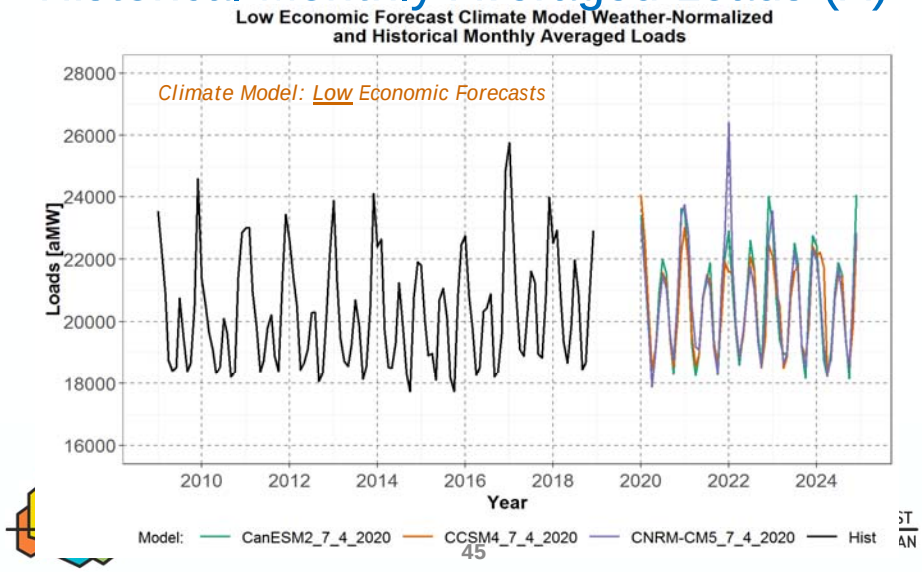
Climate Model Weather-Normalized and Historical Monthly Averaged Loads (A)



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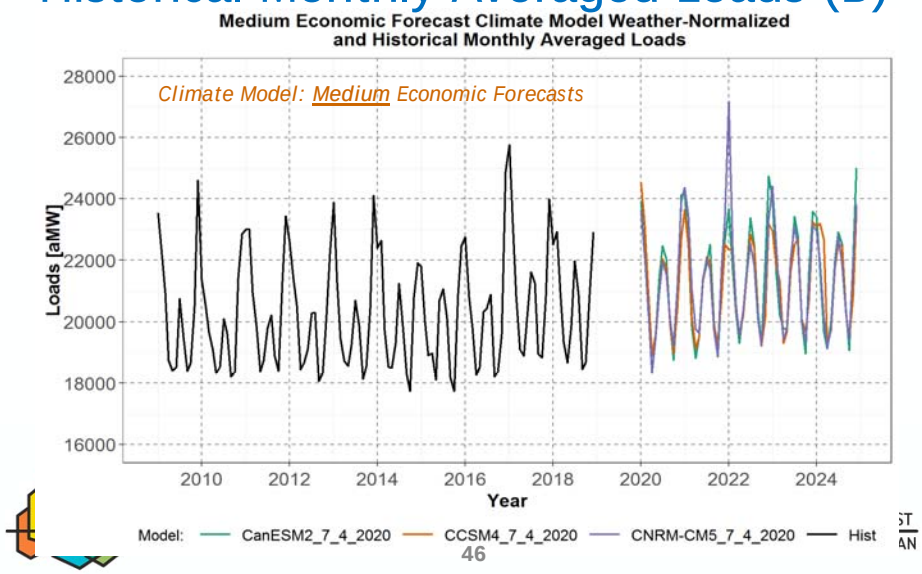
Climate Model Weather-Normalized and Historical Monthly Averaged Loads (B)



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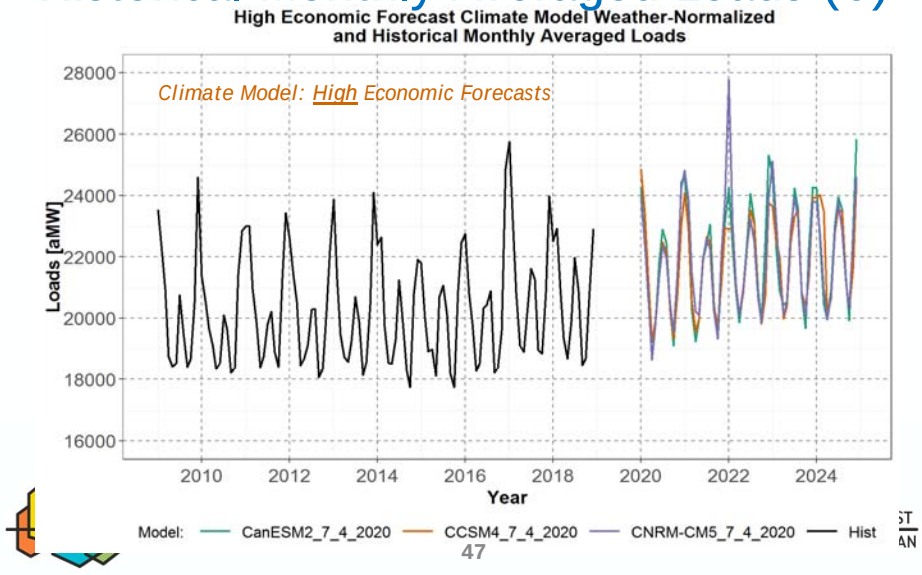
Climate Model Weather-Normalized and Historical Monthly Averaged Loads (C)



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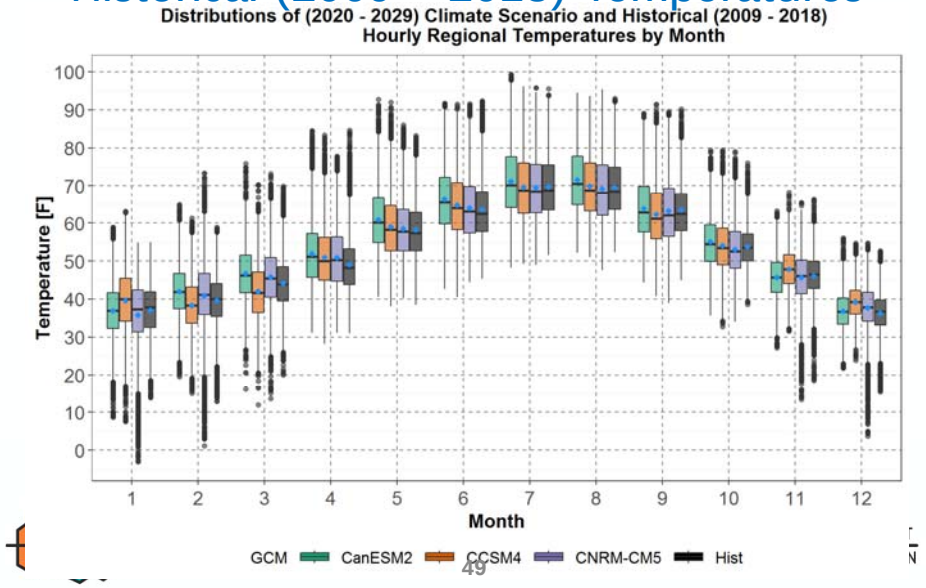
Monthly Climate Scenario (2020 -2029) and Historical (2009 – 2018) Temperatures



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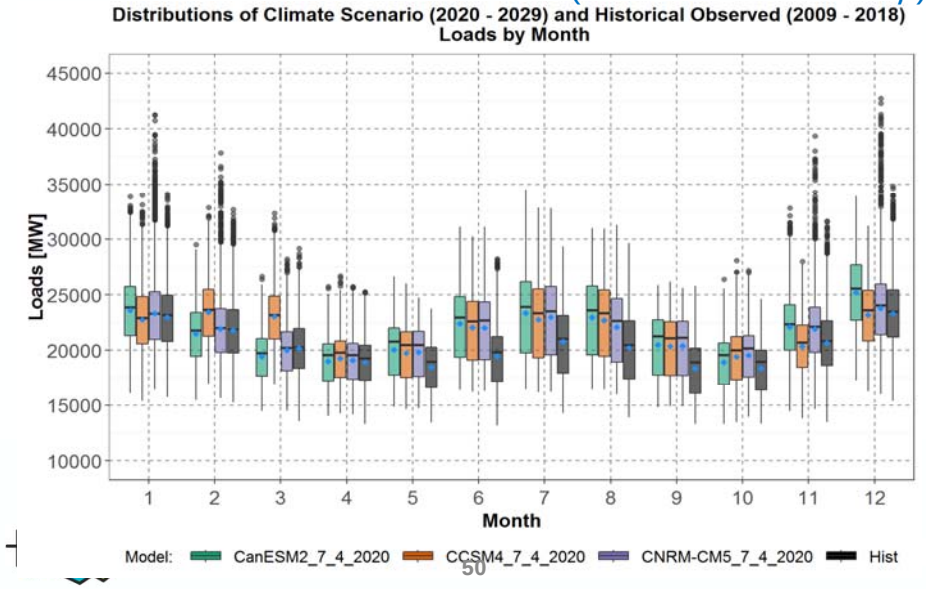
Monthly Climate Scenario *(with 2020 -2029 Temp)* Loads for 2024 and Historical (*with 2009 – 2018 Temp*)



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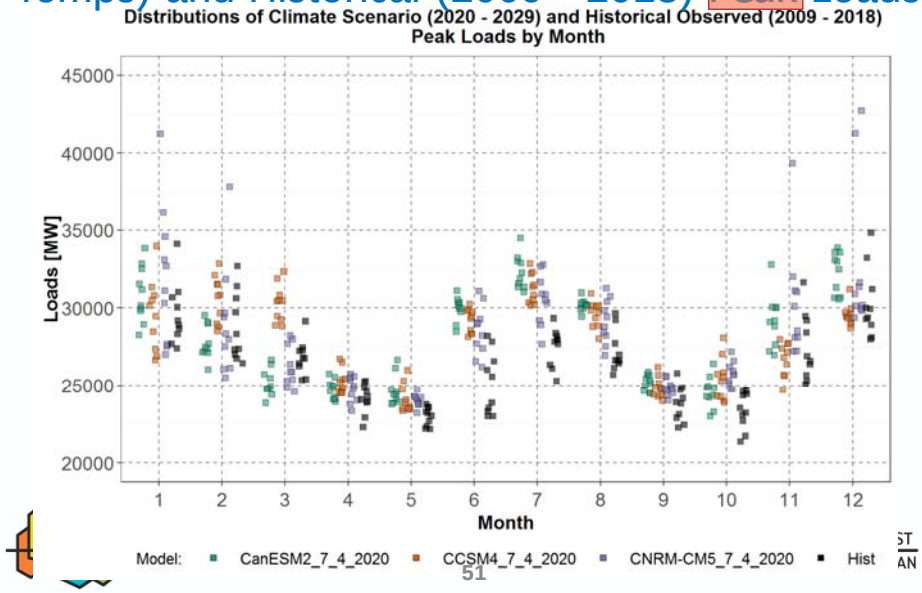
Monthly Climate Scenario 2024 (2020 – 2029 Temps) and Historical (2009 - 2018) Peak Loads



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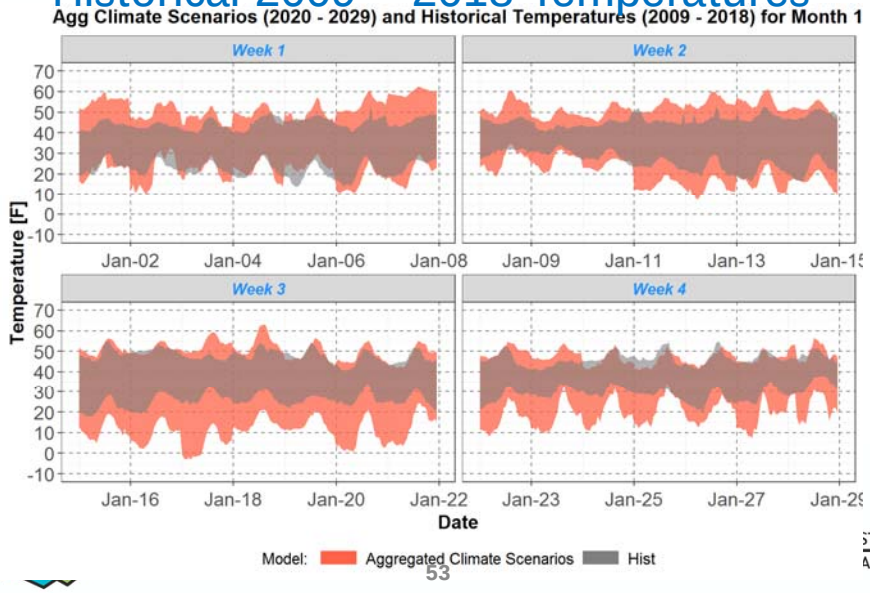
Jan Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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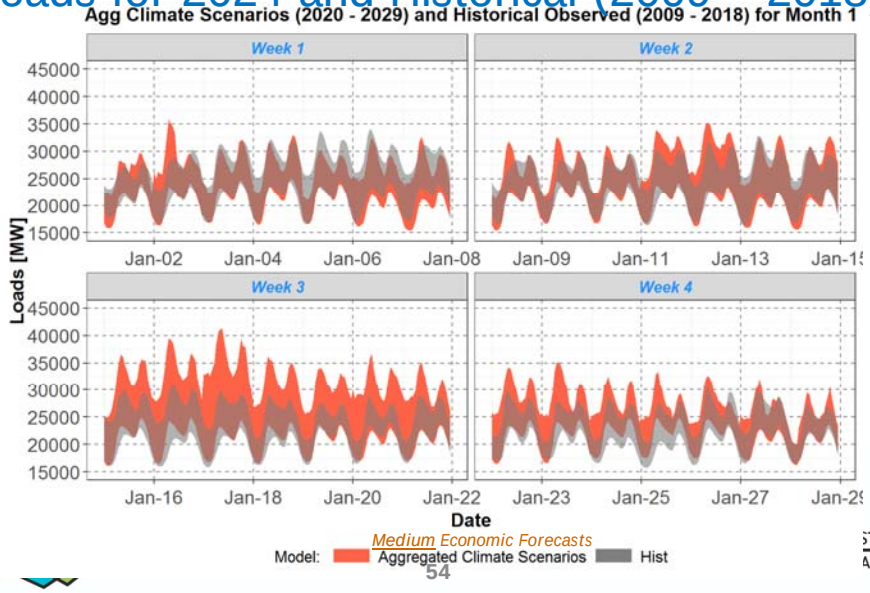
Jan Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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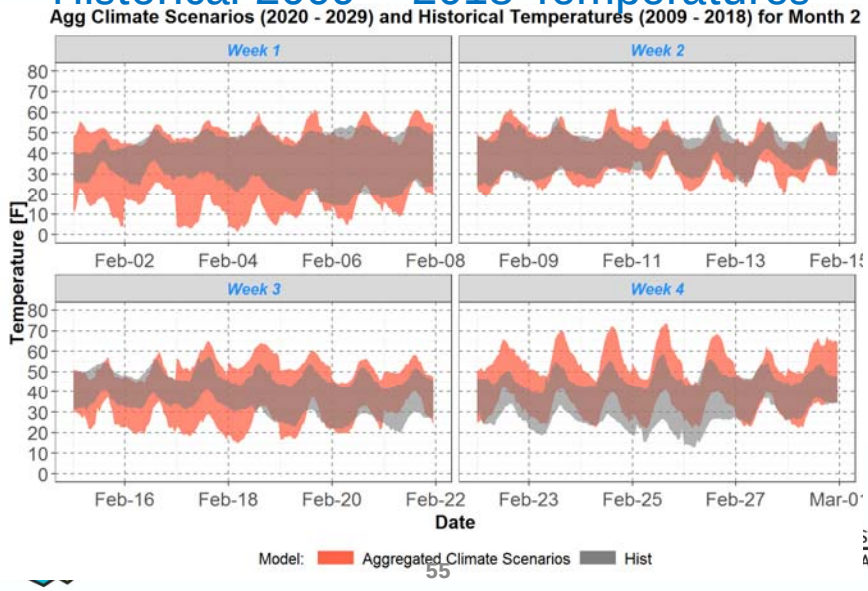
Feb Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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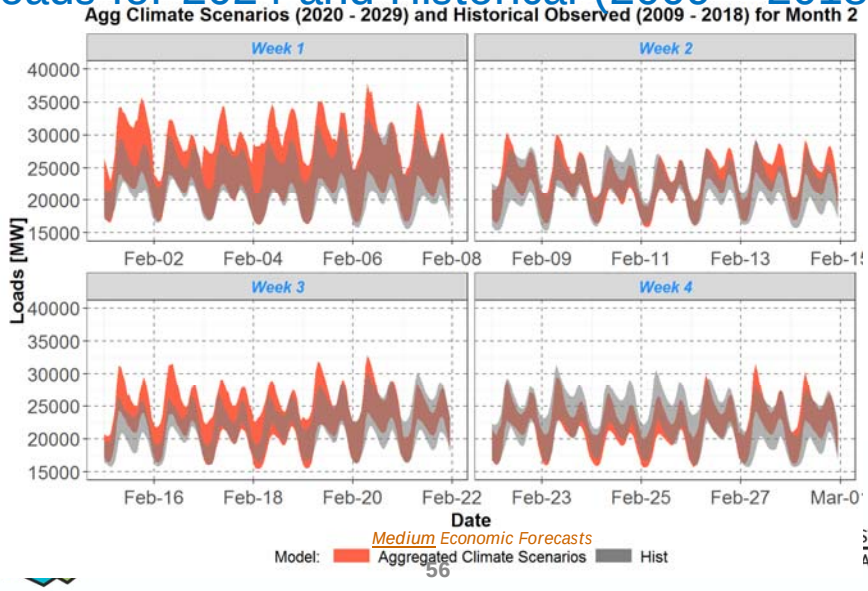
Feb Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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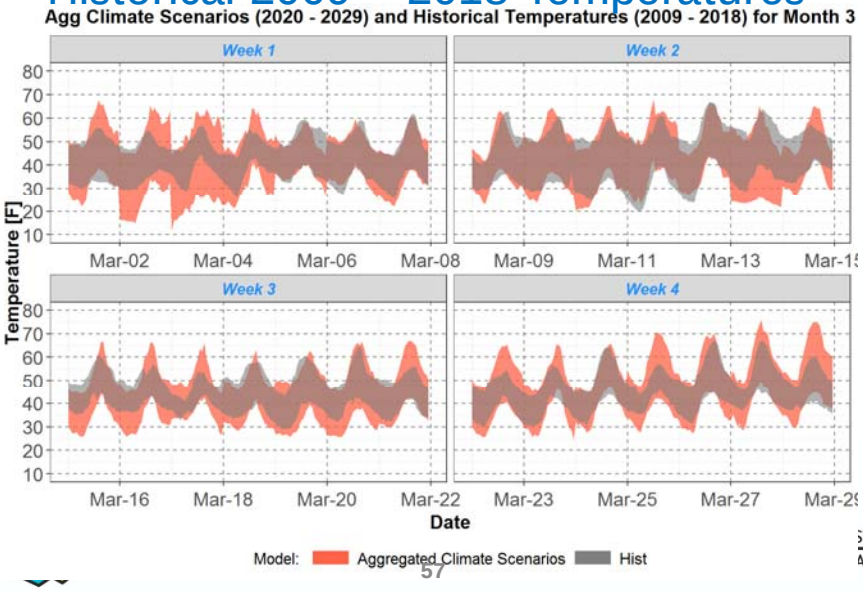
Mar Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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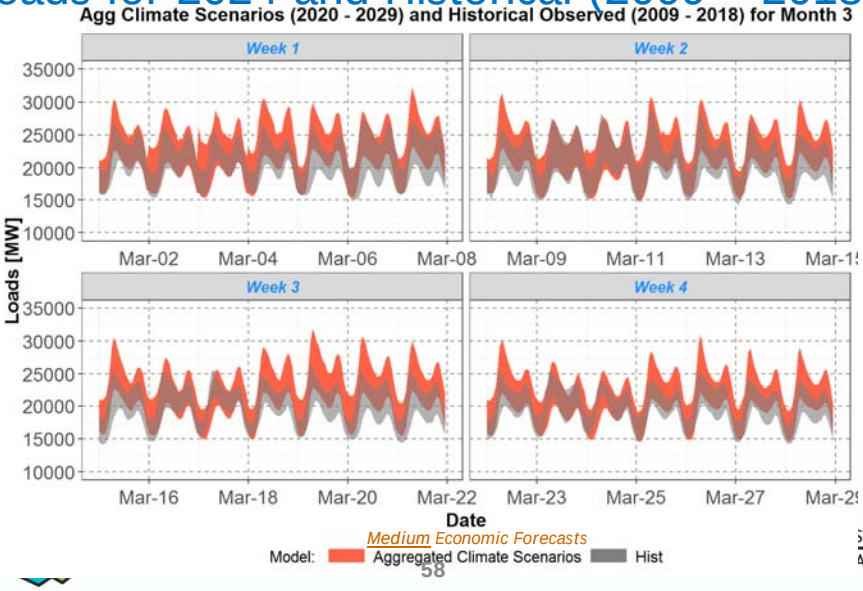
Mar Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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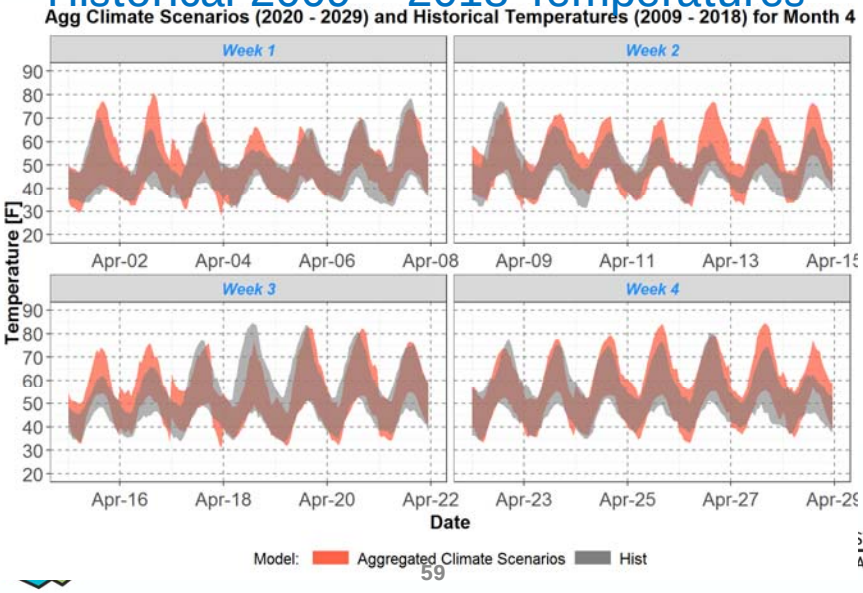
Apr Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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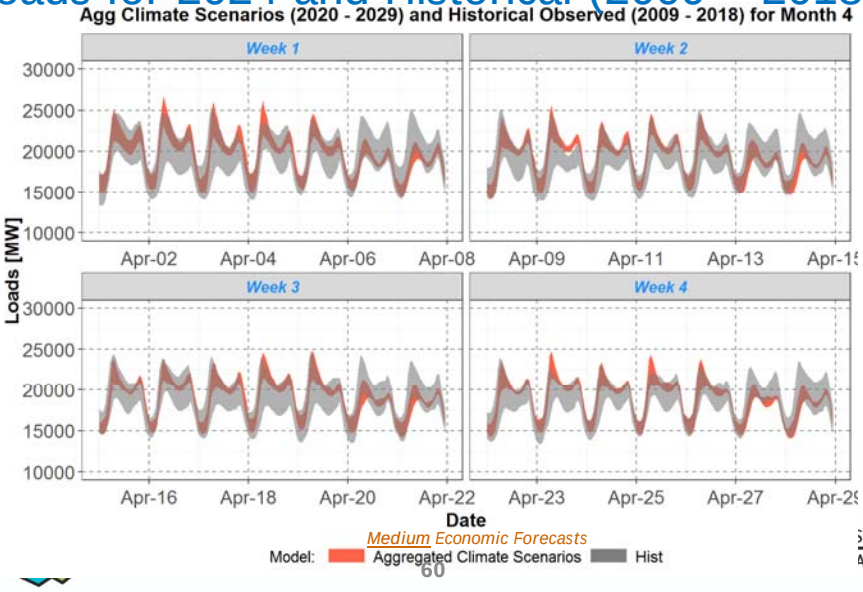
Apr Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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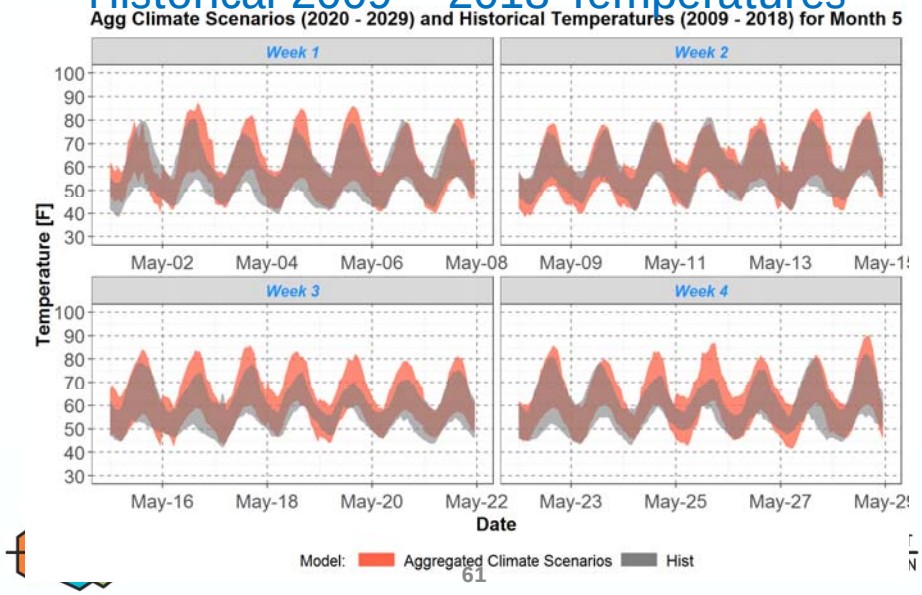
May Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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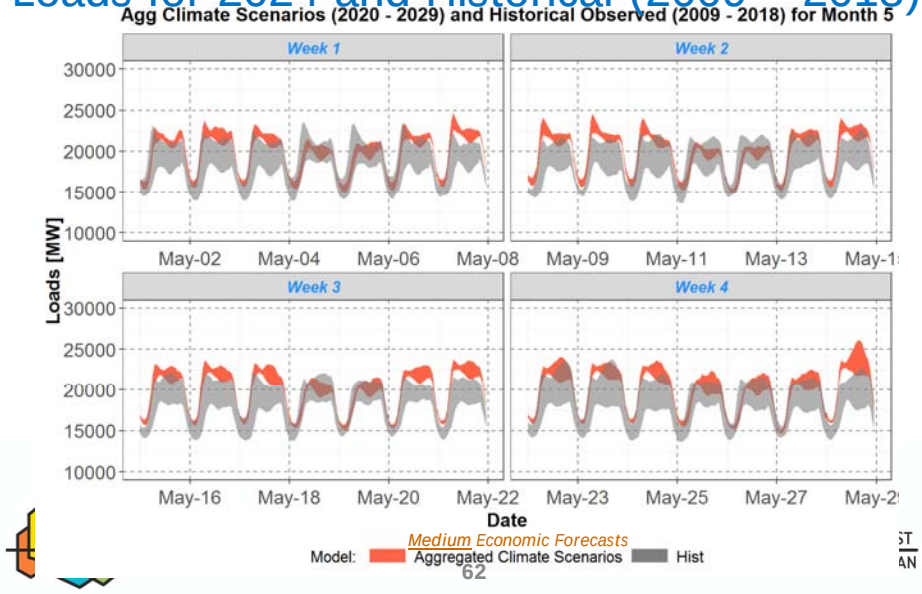
May Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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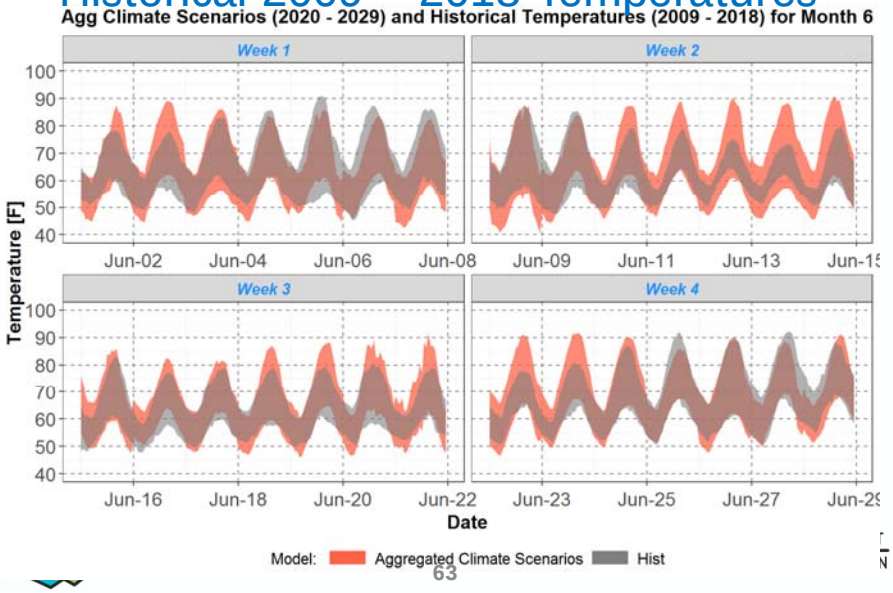
Jun Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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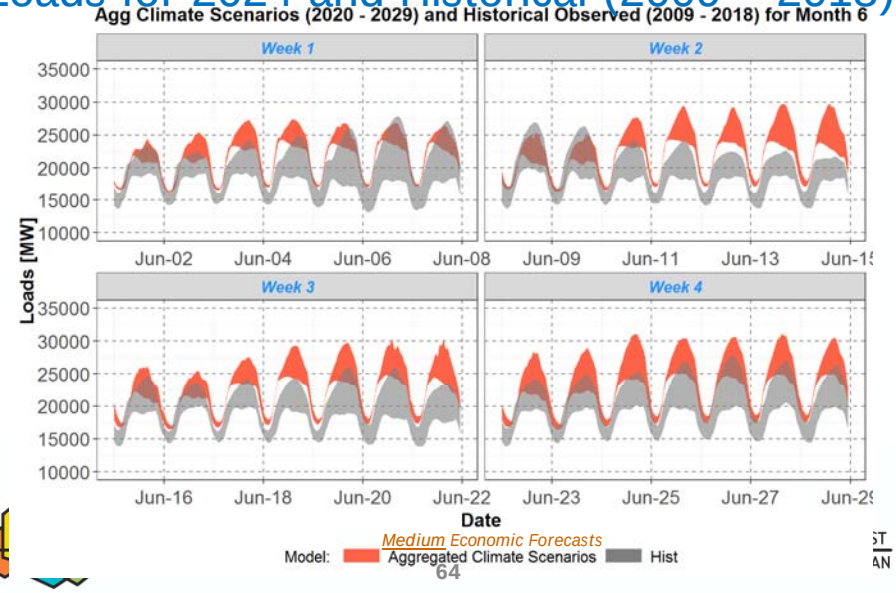
Jun Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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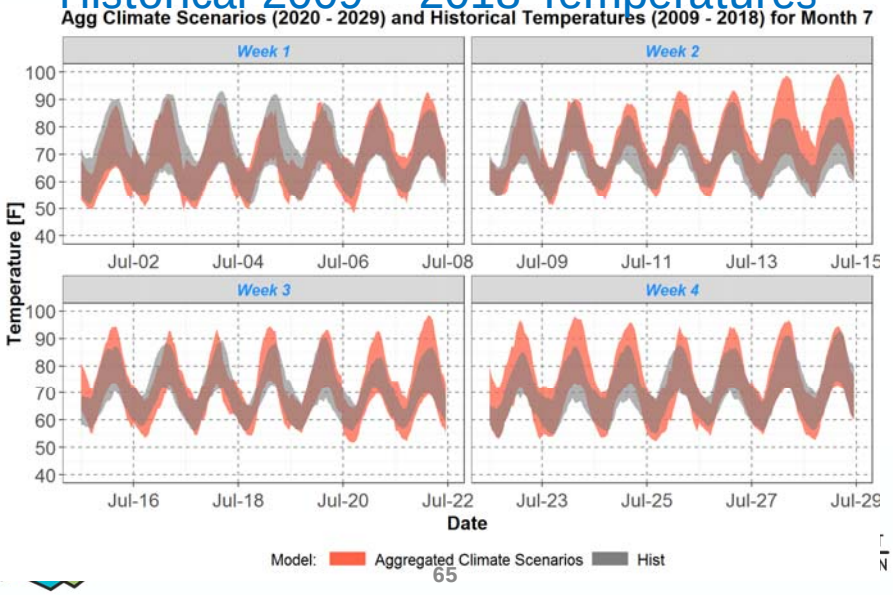
Jul Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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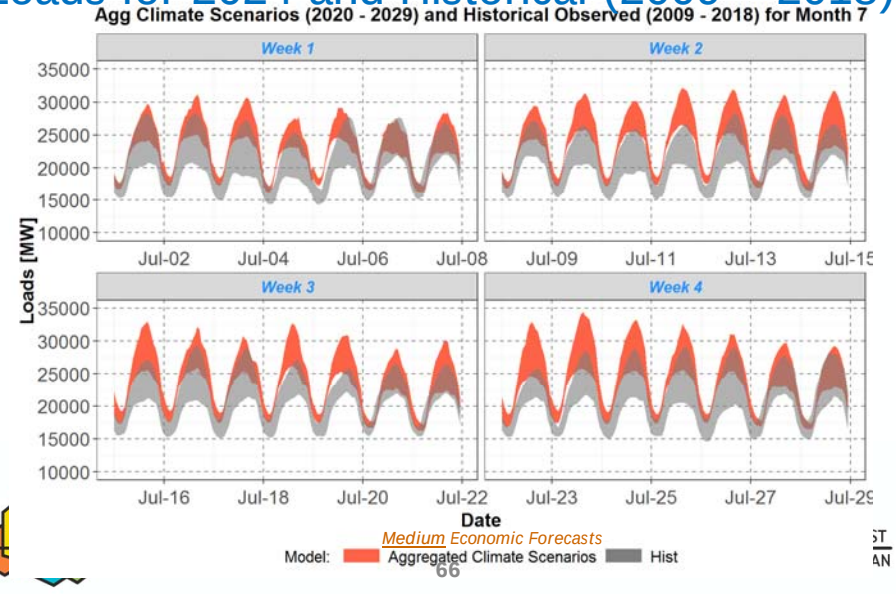
Jul Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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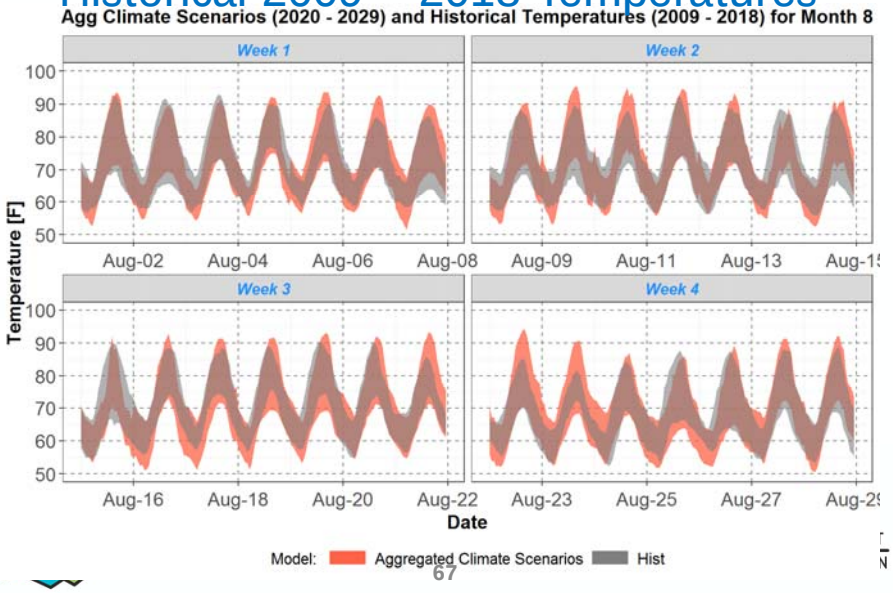
Aug Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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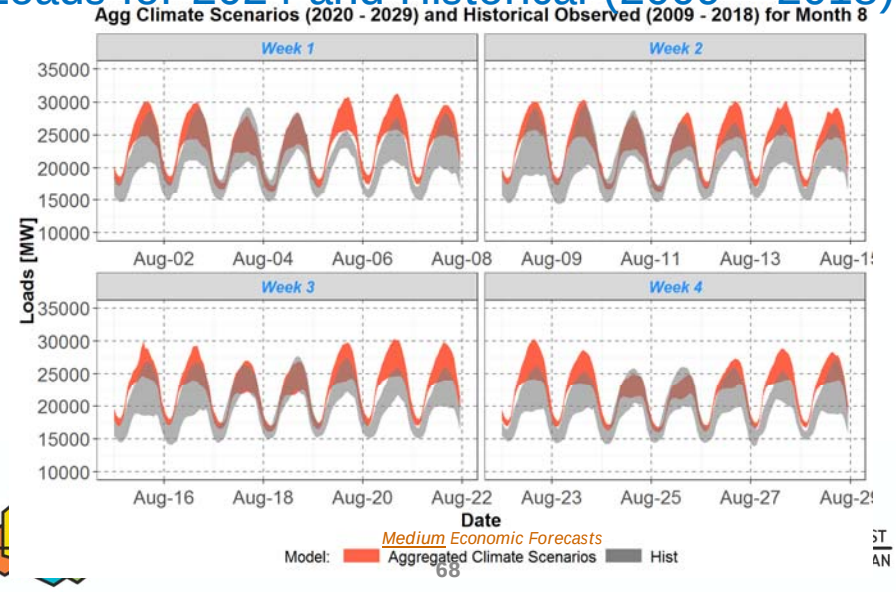
Aug Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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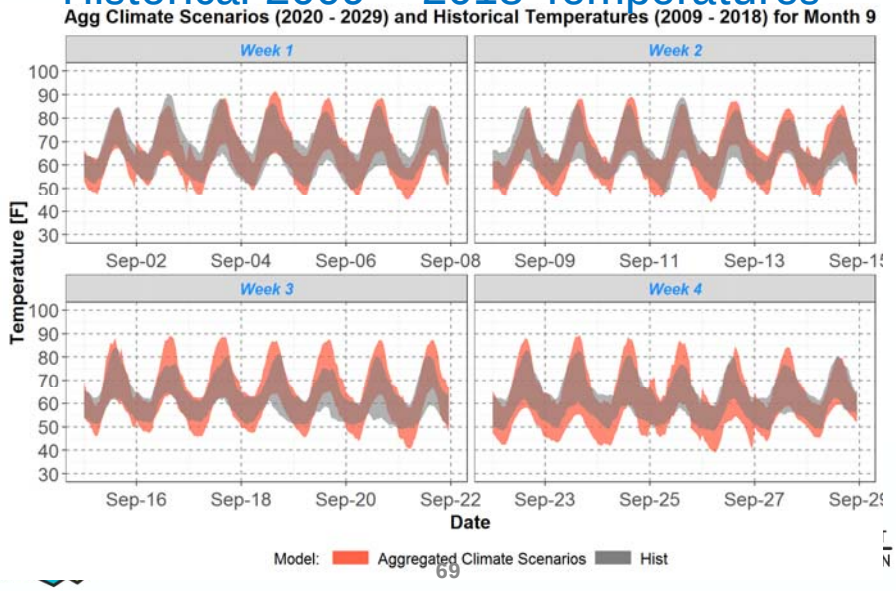
Sep Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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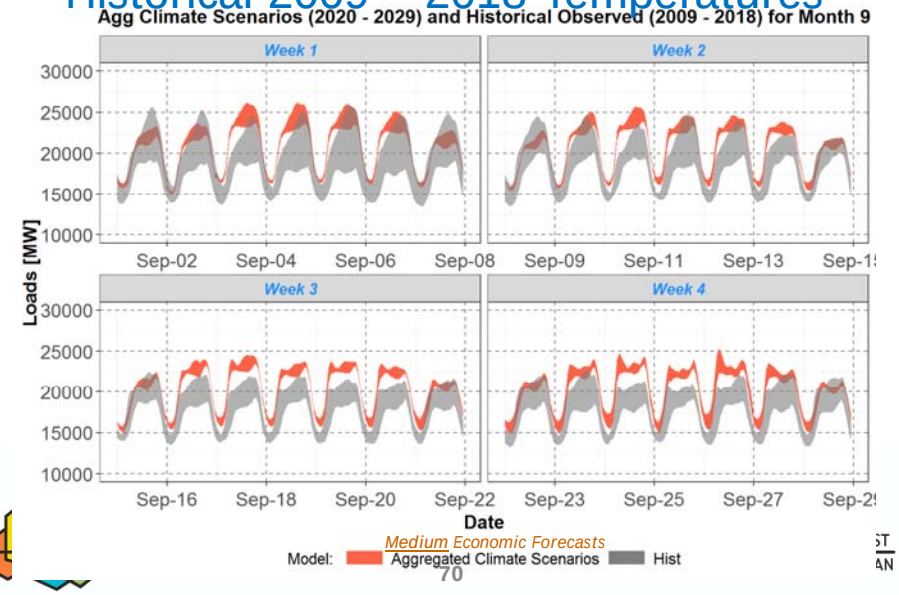
Sep Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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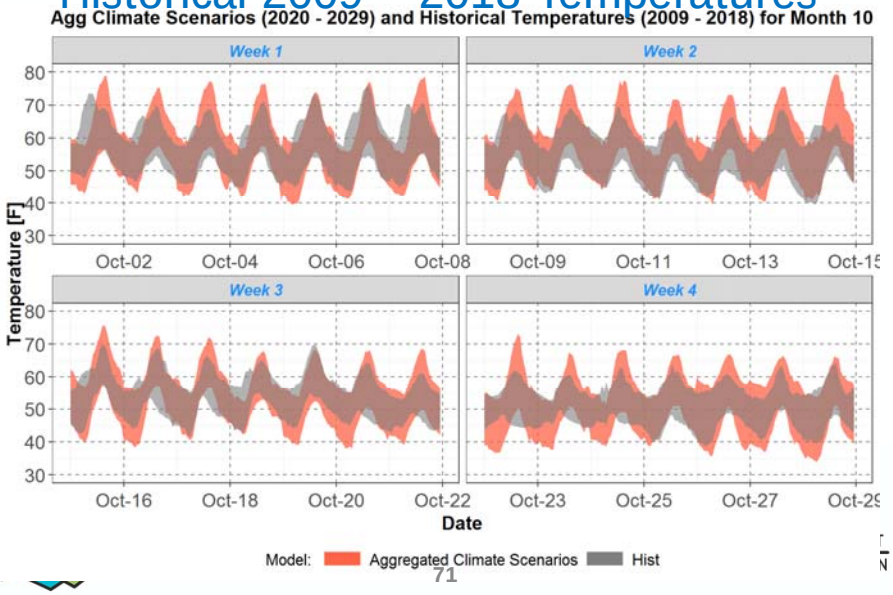
Oct Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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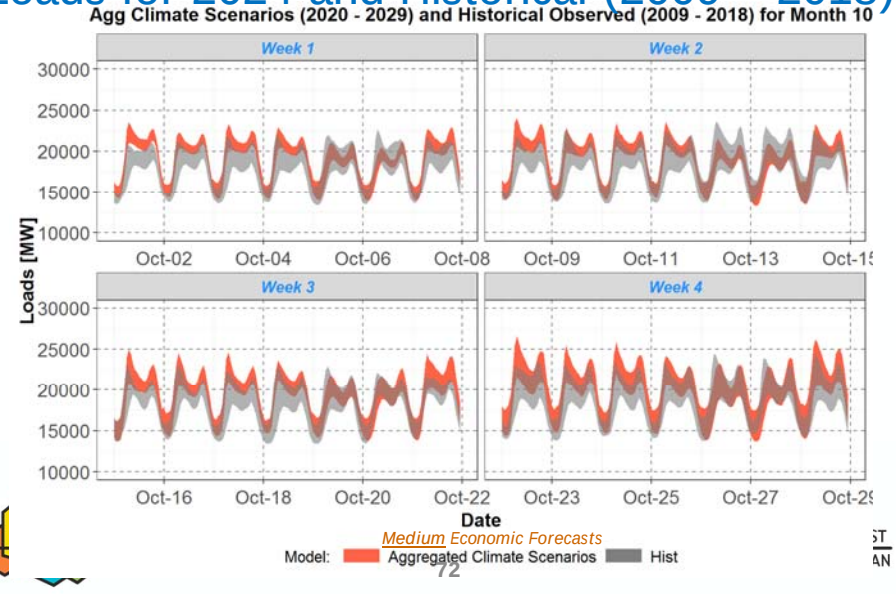
Oct Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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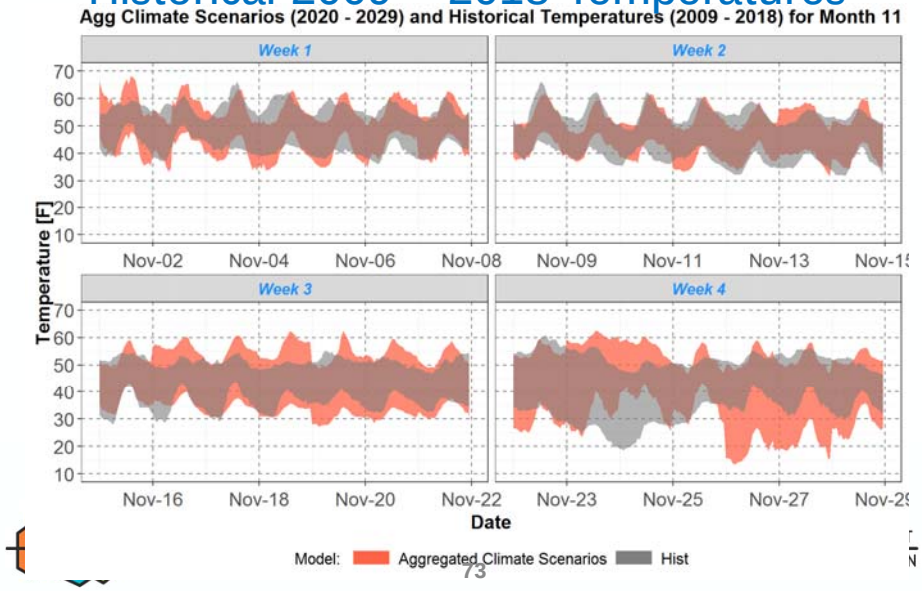
Nov Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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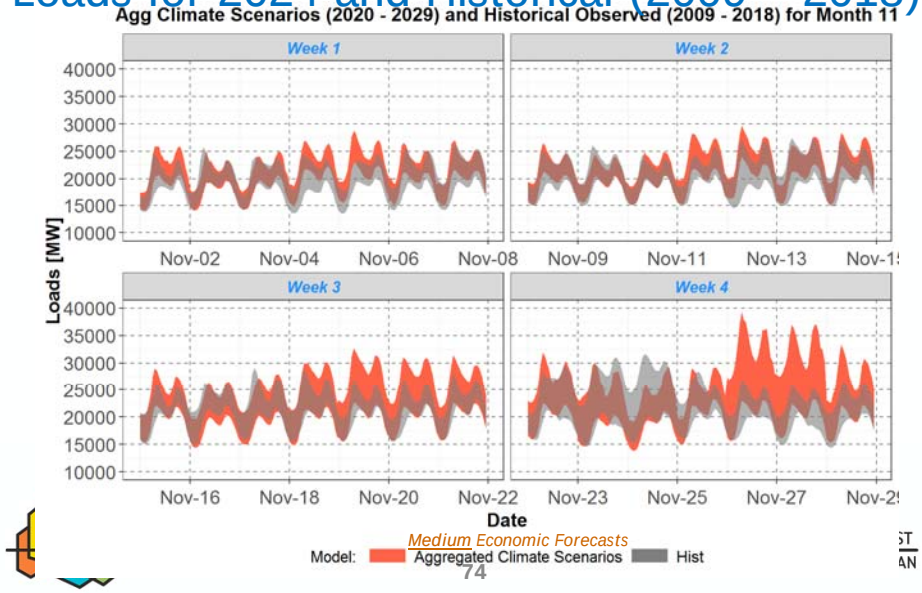
Nov Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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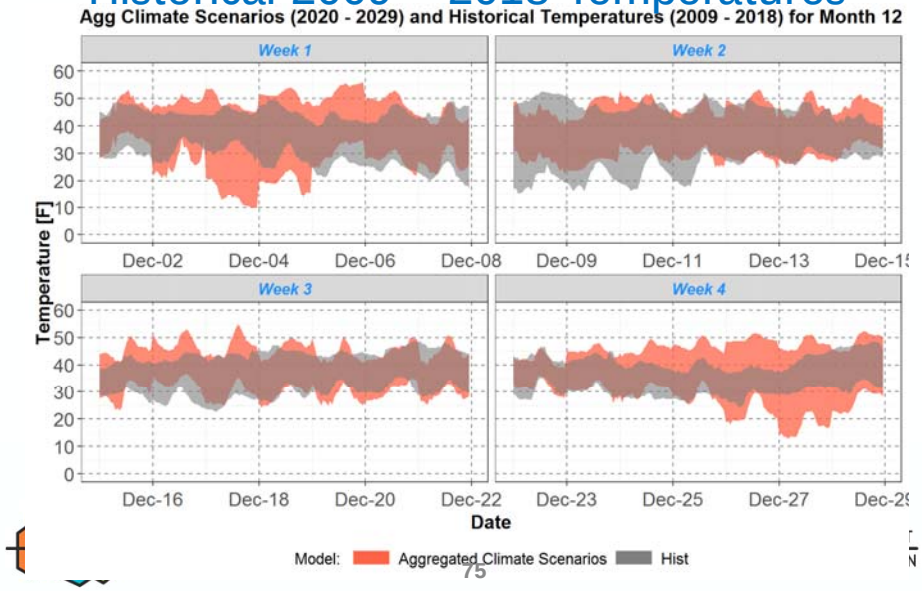
Dec Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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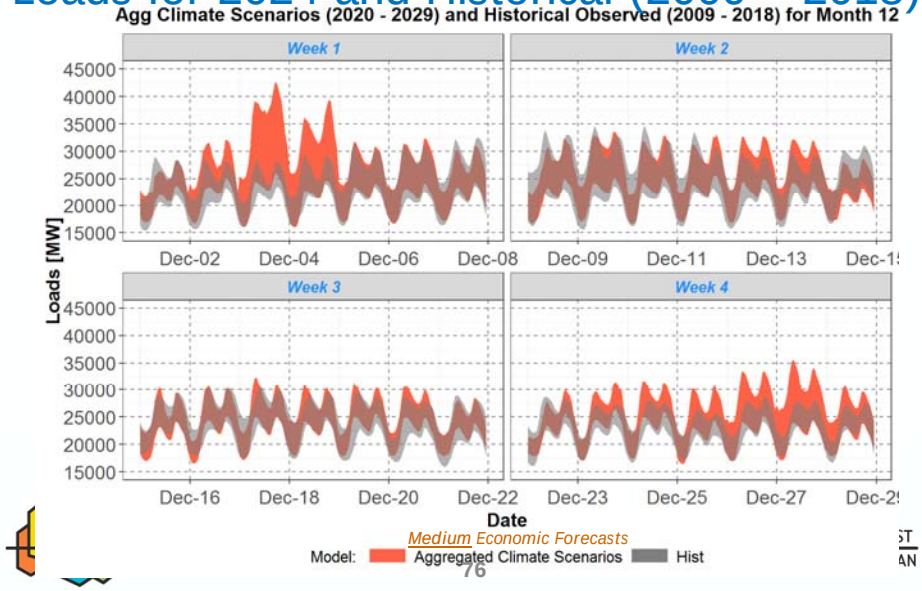
Dec Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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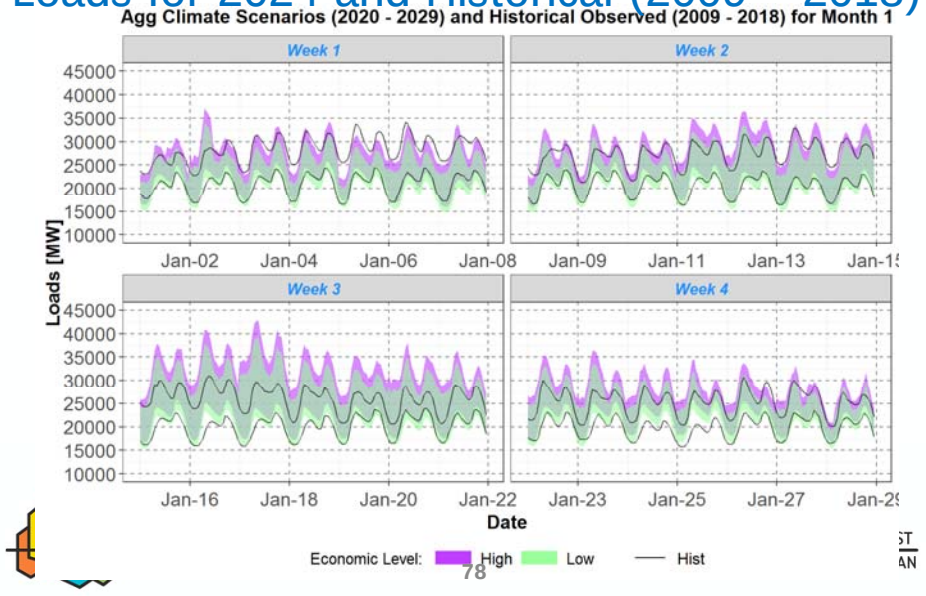
Climate *(High and Low Economic Forecasts)* vs Historical Hourly Loads by Month

77

Jan Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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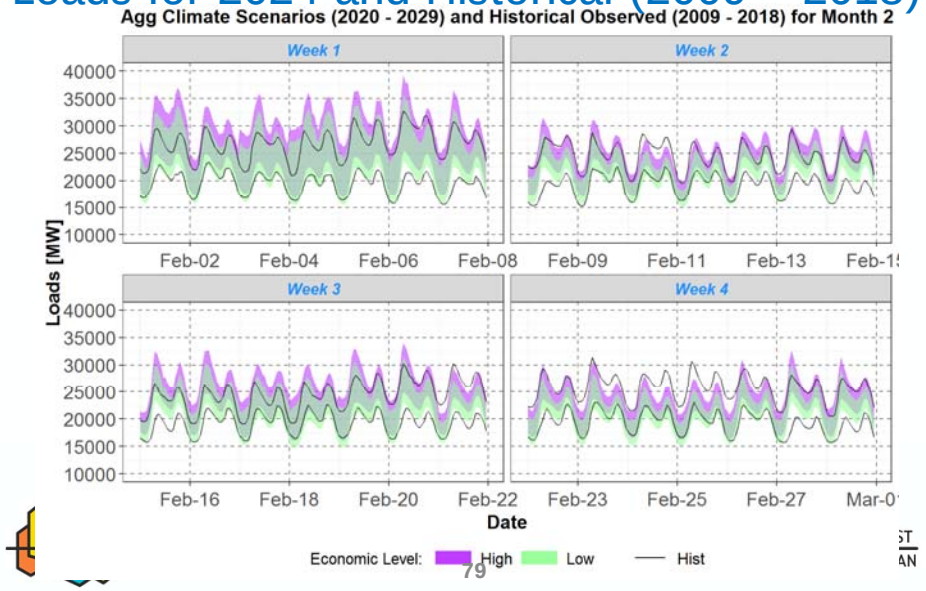
Feb Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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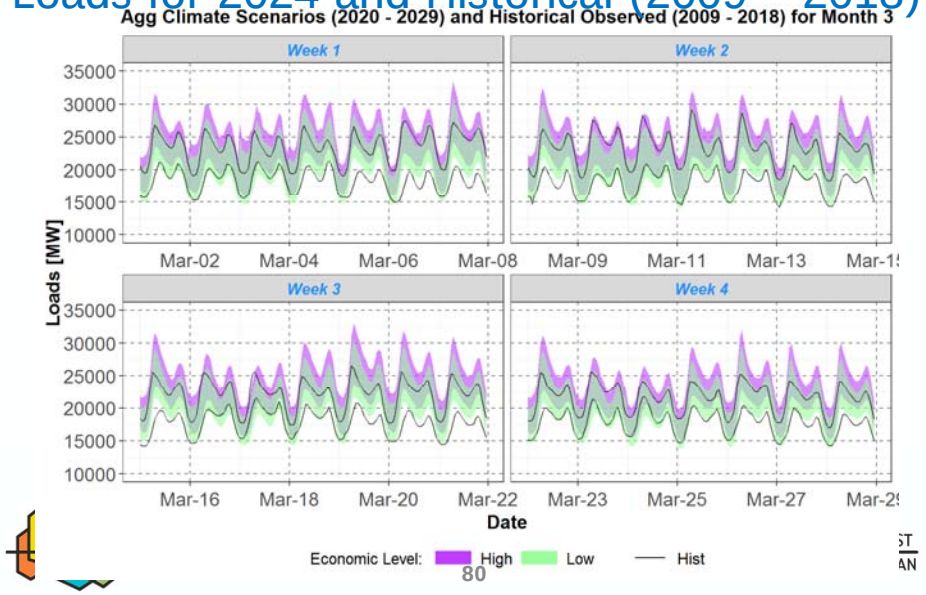
Mar Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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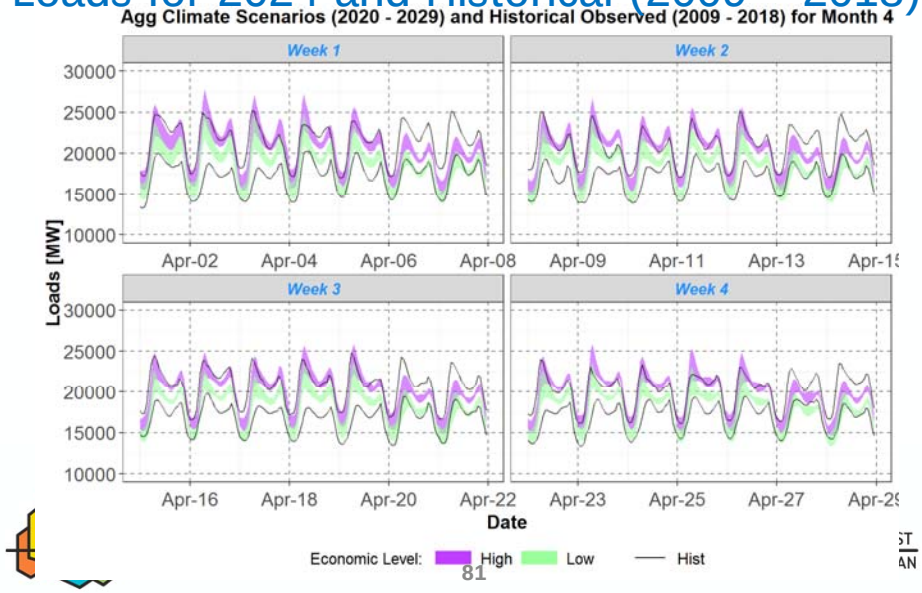
Apr Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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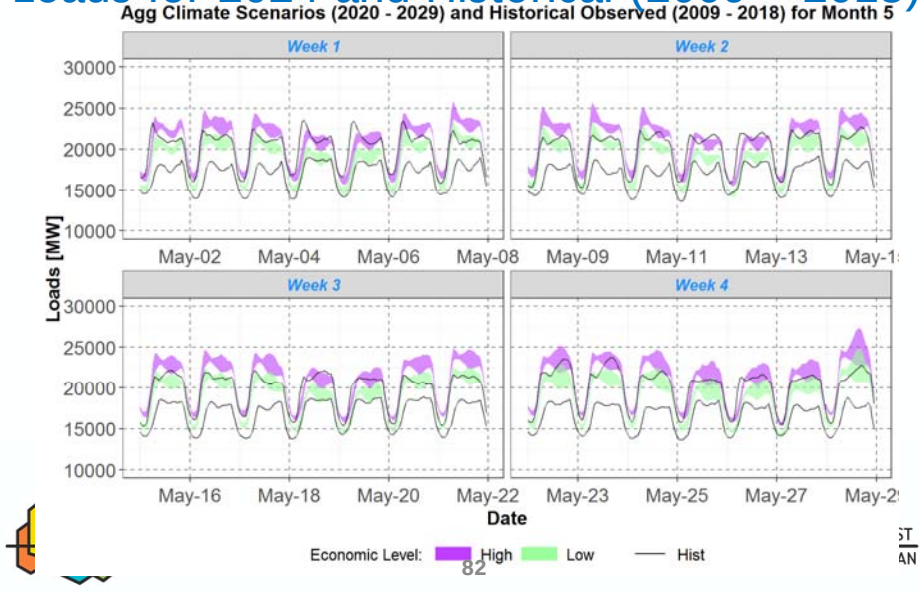
May Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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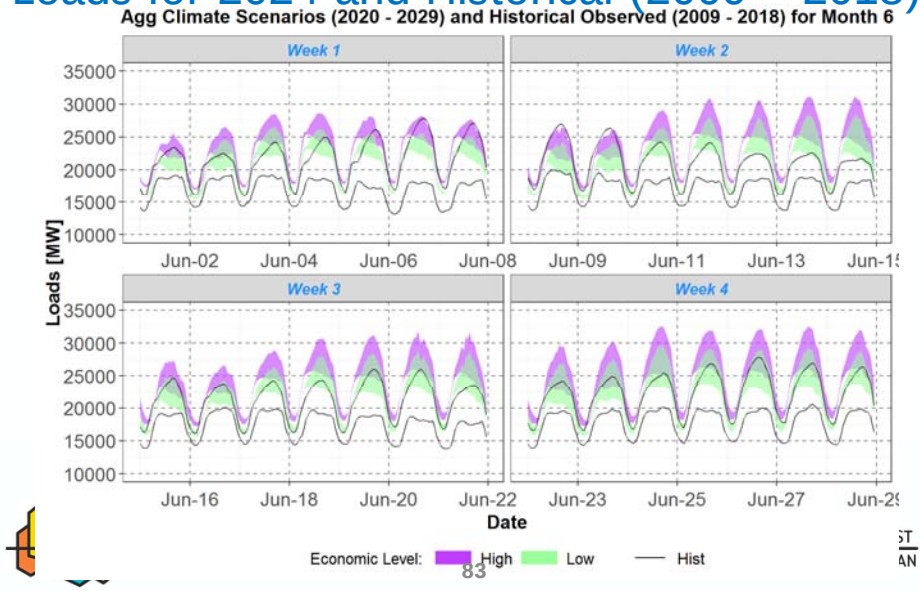
Jun Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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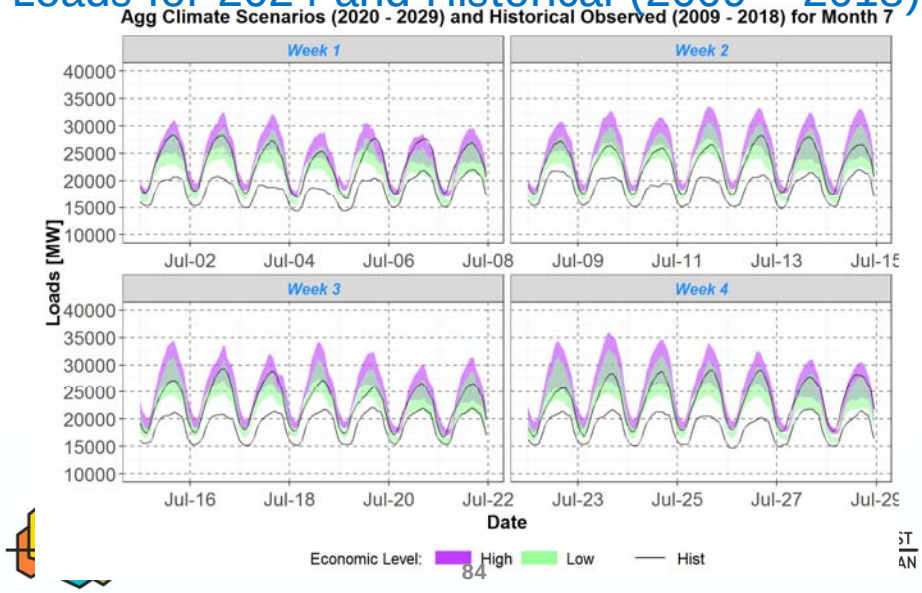
Jul Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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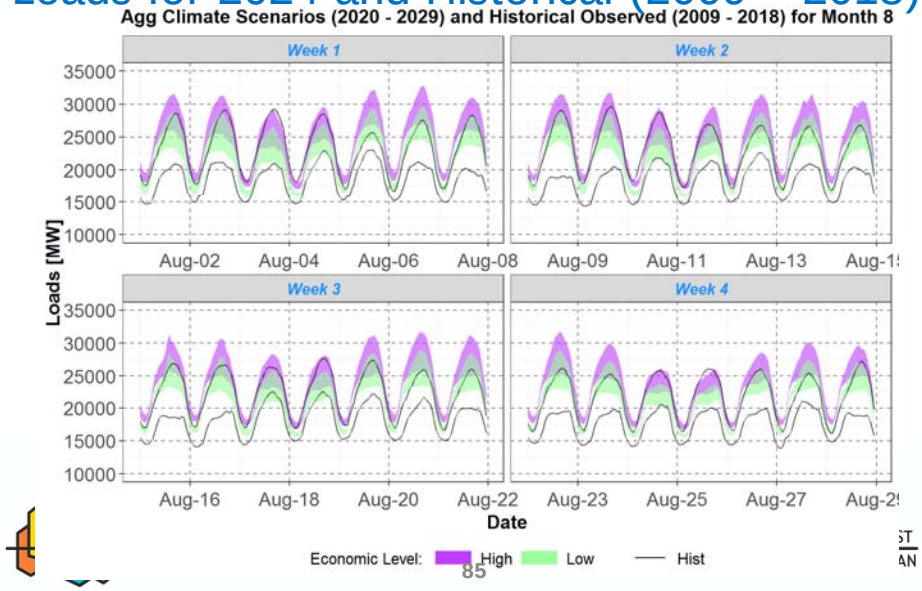
Aug Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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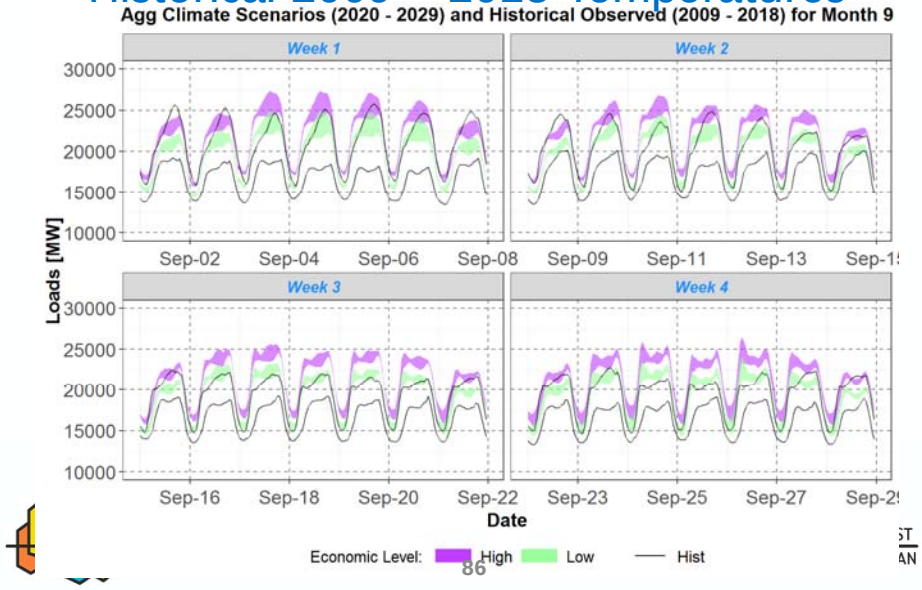
Sep Climate Scenario 2020 - 2029 and Historical 2009 – 2018 Temperatures



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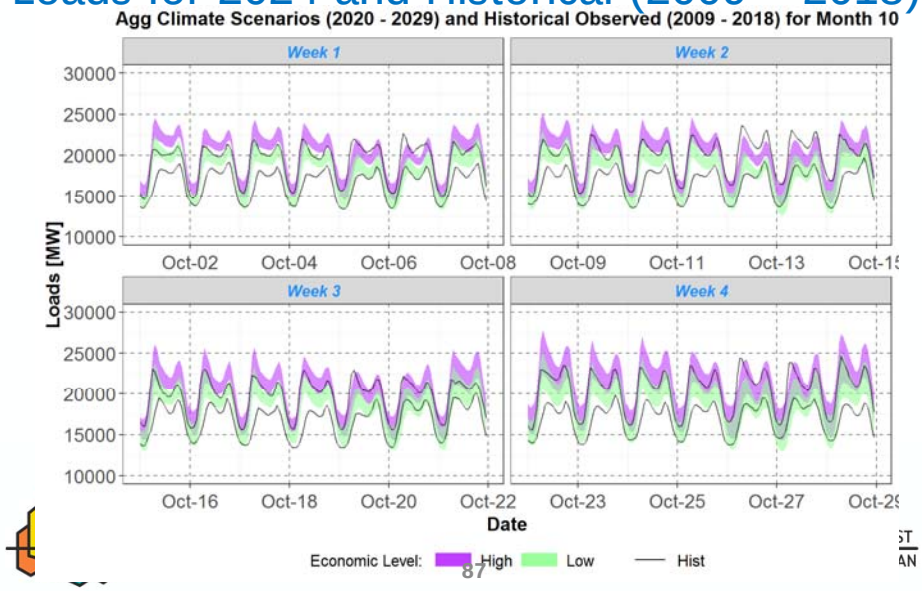
Oct Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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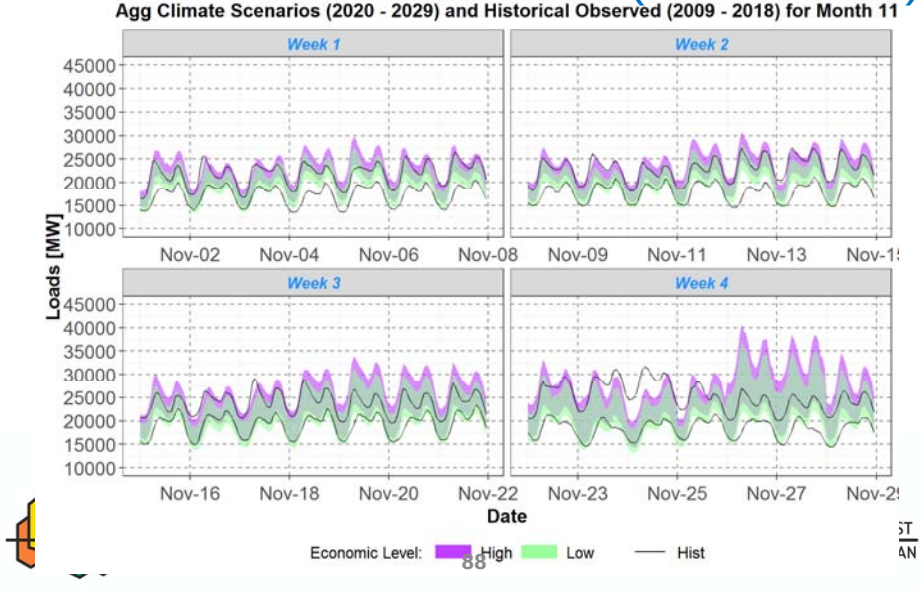
Nov Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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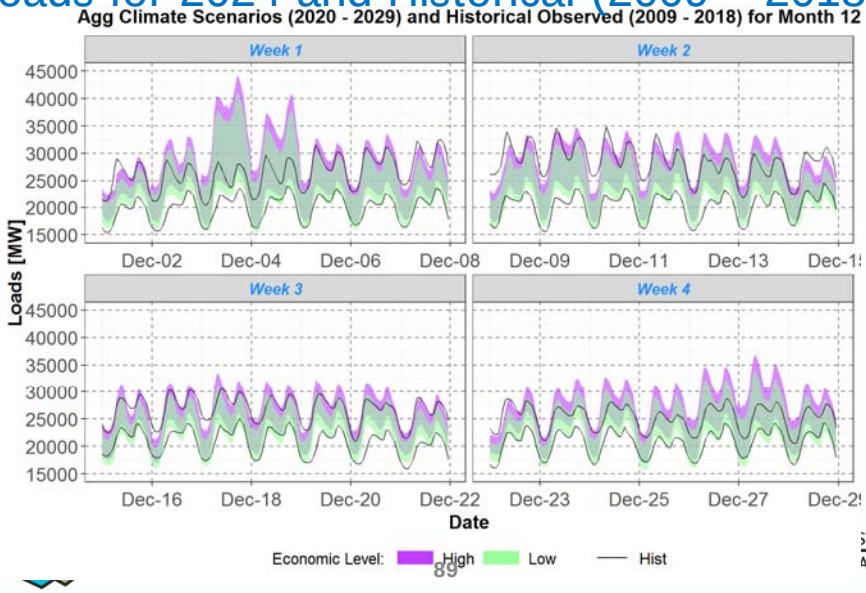
Dec Climate Scenario (2020 -2029 Temp) Loads for 2024 and Historical (2009 – 2018)



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