Load Forecast Model Development

Andrew Gledhill, Sr. Analyst
Resource Adequacy Planning

Load Analysis Subcommittee
September 21, 2020

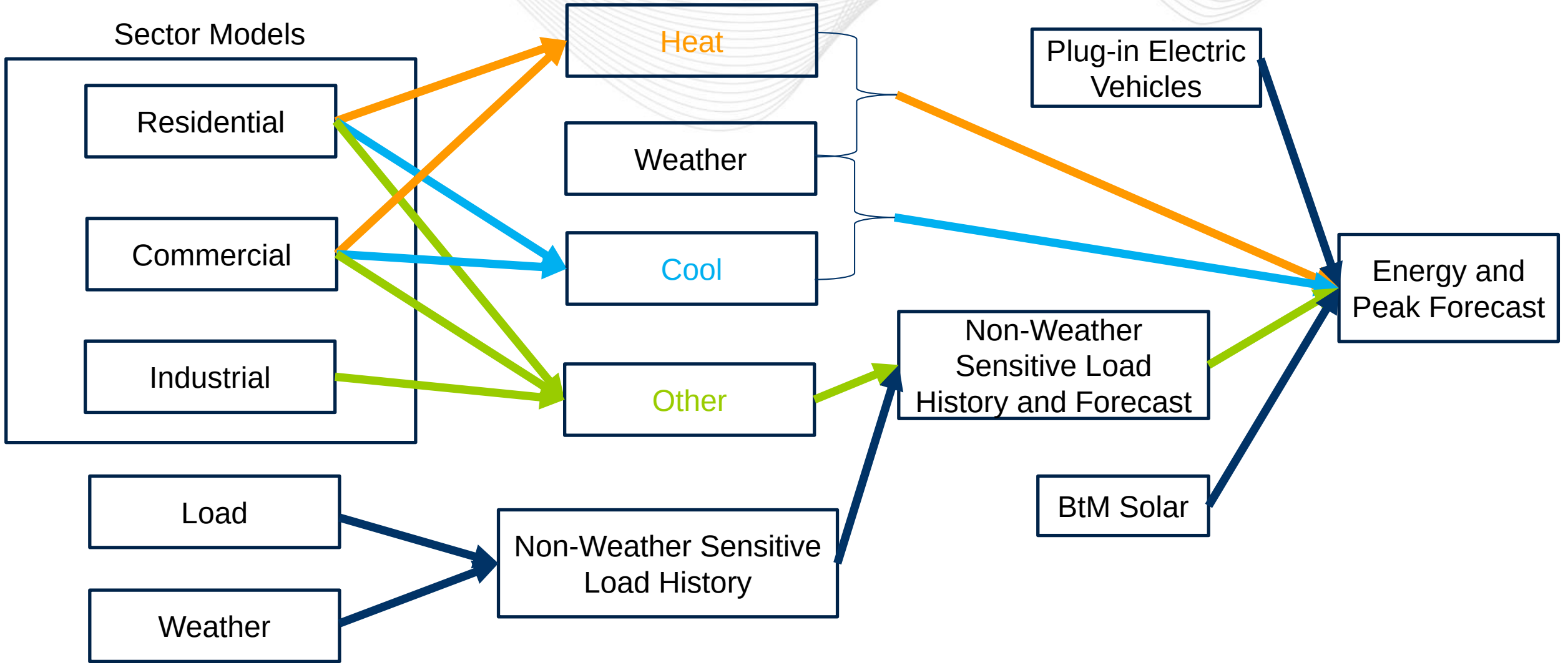
Outline

- Annual Model Development
- Addressing COVID-19

Annual Model Development

Change Summary

Overview - Load Forecast Model Flow



High-Level Summary of Proposed Changes

- Improvements to non-weather sensitive model to better align with underlying drivers and historical trends.

- Added Service Employment as an additional driver to Commercial Sector (in addition to already used working-age population).

- Additional model tweaks to reflect error trends and weather specification.

Change – Commercial Model

- Commercial Model
  - Added Service Employment
  - Driver is a weighted combination of working-age population and service employment. Weights are based on historical correlation.

Change – Non-Weather Sensitive Load

- Overview of current process to create Non-Weather Sensitive Load
  - Create historical estimates of non-weather sensitive load
    - Each season has a statistical model. This model determines historical values of non-weather sensitive load by controlling for weather and time.
  - Model estimates versus Other End-Use Index
    - Each season has a model. Model determines forecast values and historic values. Values are combined at the end into single time series.

Change – Non-Weather Sensitive Load

- Overview of current process to create Non-Weather Sensitive Load
  - Create historical estimates of non-weather sensitive load
    - Each season has a statistical model. This model determines historical values of non-weather sensitive load by controlling for weather and time.
    - ***CHANGE: Single model with seasonal variables.***
      - ***Simpler and more cohesive approach. Still allows for seasonal distinctions.***
      - ***Combining seasons helps model tease out weather impacts to better get at underlying non-weather sensitive values.***

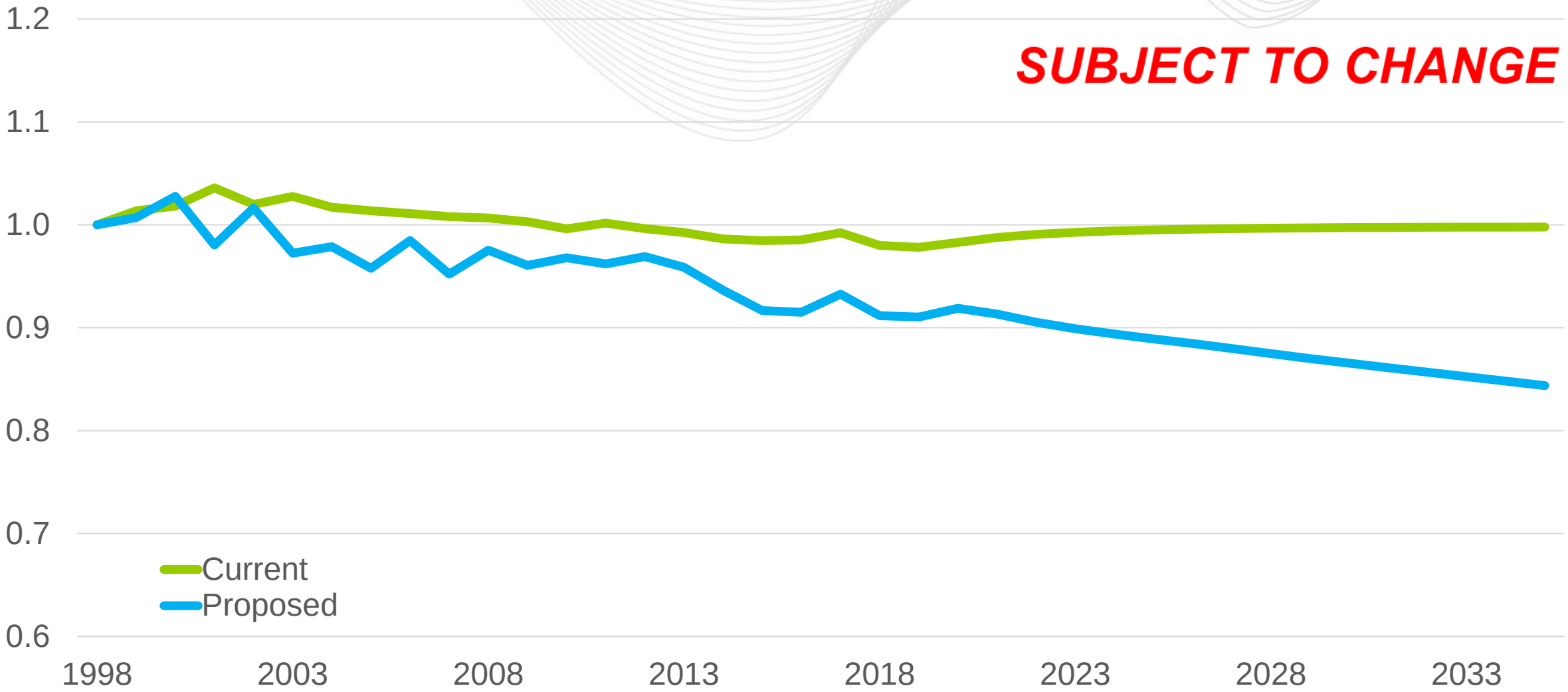
Change – Non-Weather Sensitive Load

- Overview of current process to create Non-Weather Sensitive Load
  - Model estimates versus Other End-Use Index
    - Each season has a model. Model determines forecast values and historic values. Values are combined at the end into single time series.
    - ***Change: Single model with seasonal variables. Model determines forecast values only.***

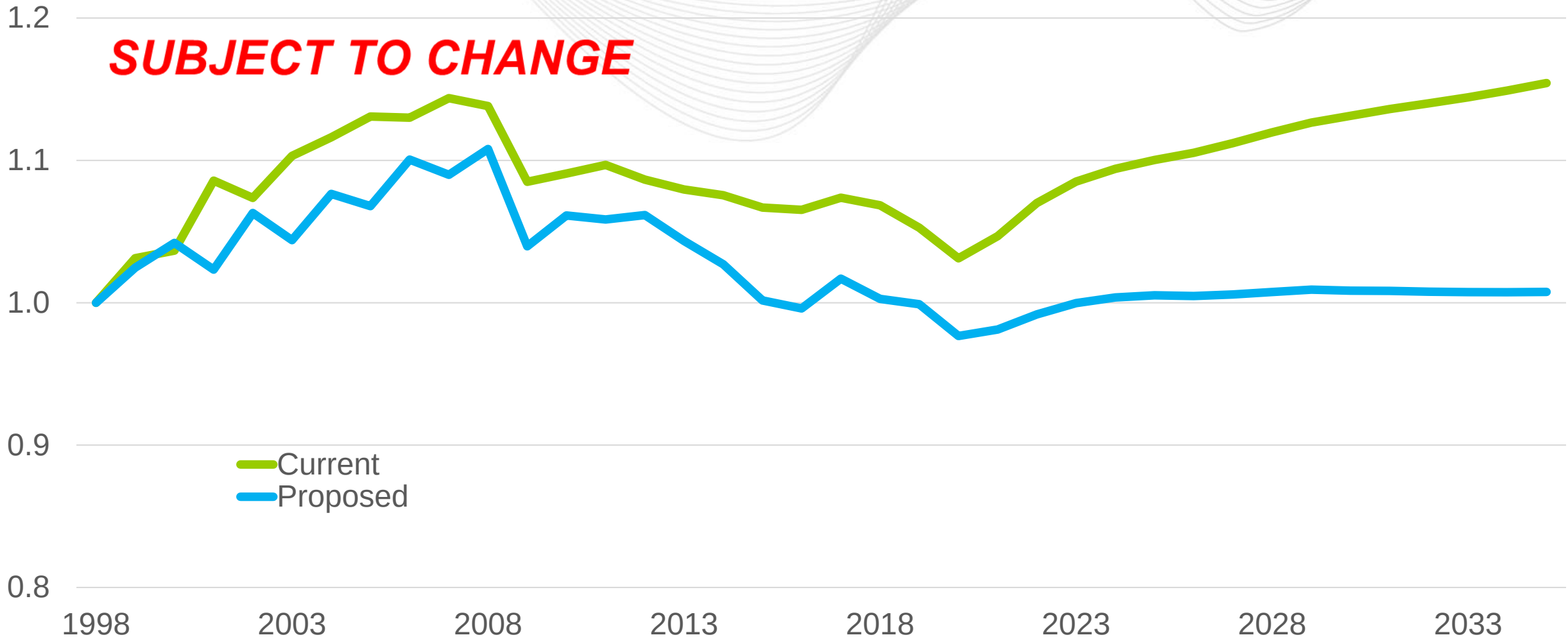
Change – Non-Weather Sensitive Load

- Number of Non-Weather Sensitive Models
  - Current – Uses each zone's NCP to create the non-weather sensitive series. This series is used in the final model for all model types (CP, NCP, Energy)
  - ***Change – Separate non-weather sensitive series for each NCP, Energy, and CP model.***

Non-Weather Sensitive Load
Relative to Other End-Use Index (Driver)



Non-Weather Sensitive Load (1998=1.0)



Change – Quarterly Variation

- Currently all end-use variables (Heat, Cool, Other) are based on annual series and thus have the same value across the year.
- ***Change: Convert annual figures to quarterly frequency using economic variables. Average for the year is the annual figure, individual quarters are moved up/down relative to that number based on economics.***
  - ***Allows model to better reflect progression across a year, like in the current situation where recession hit in 2020Q2 and then eased in 2020Q3.***

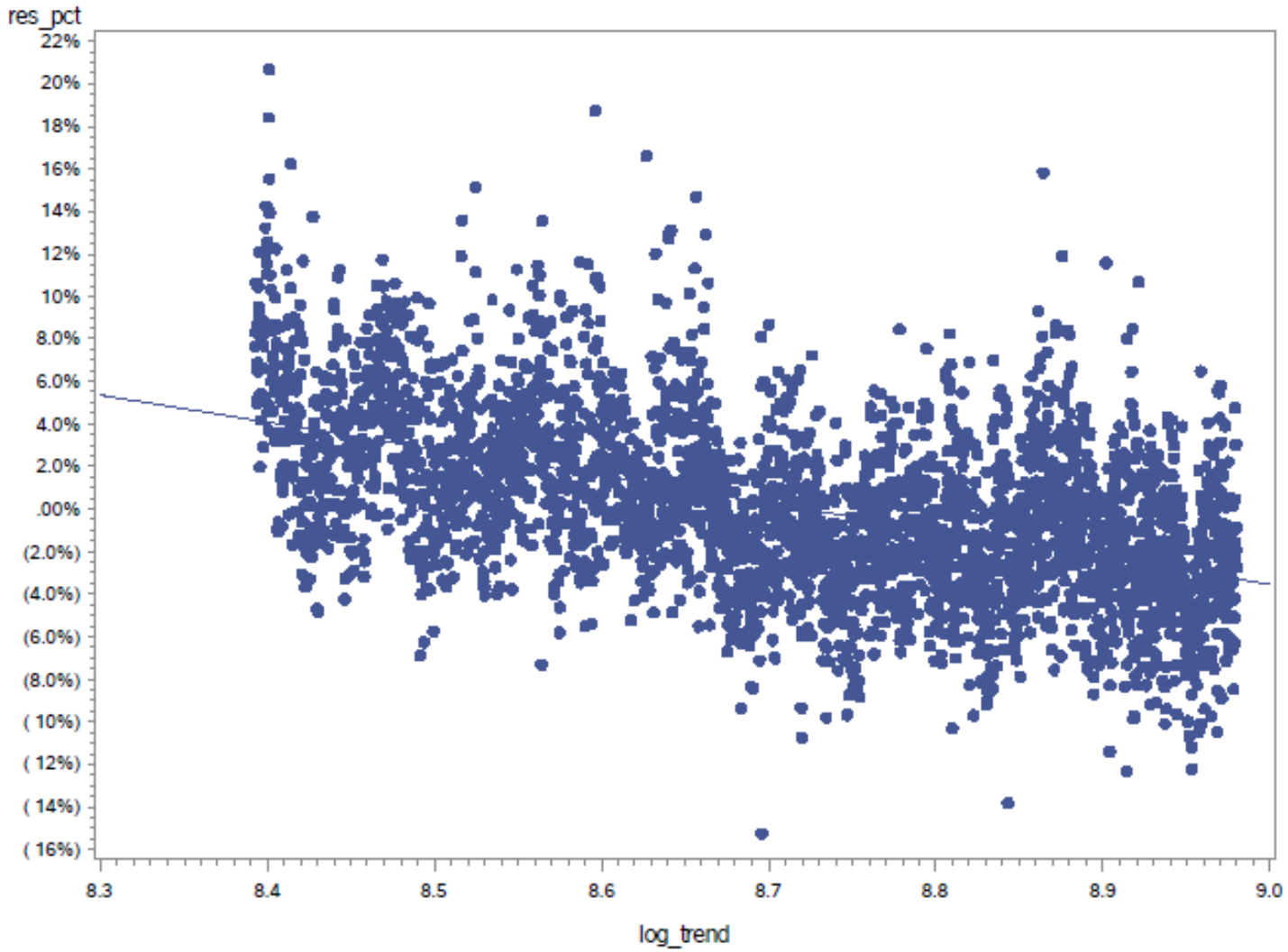
Change - Weather

- Added cloud variables
  - Summer – Increased cloud cover *reduces* load
    - Variables for afternoon and evening cloud cover
  - Winter – Increased cloud cover *increases* load
    - Variables for morning and evening cloud cover

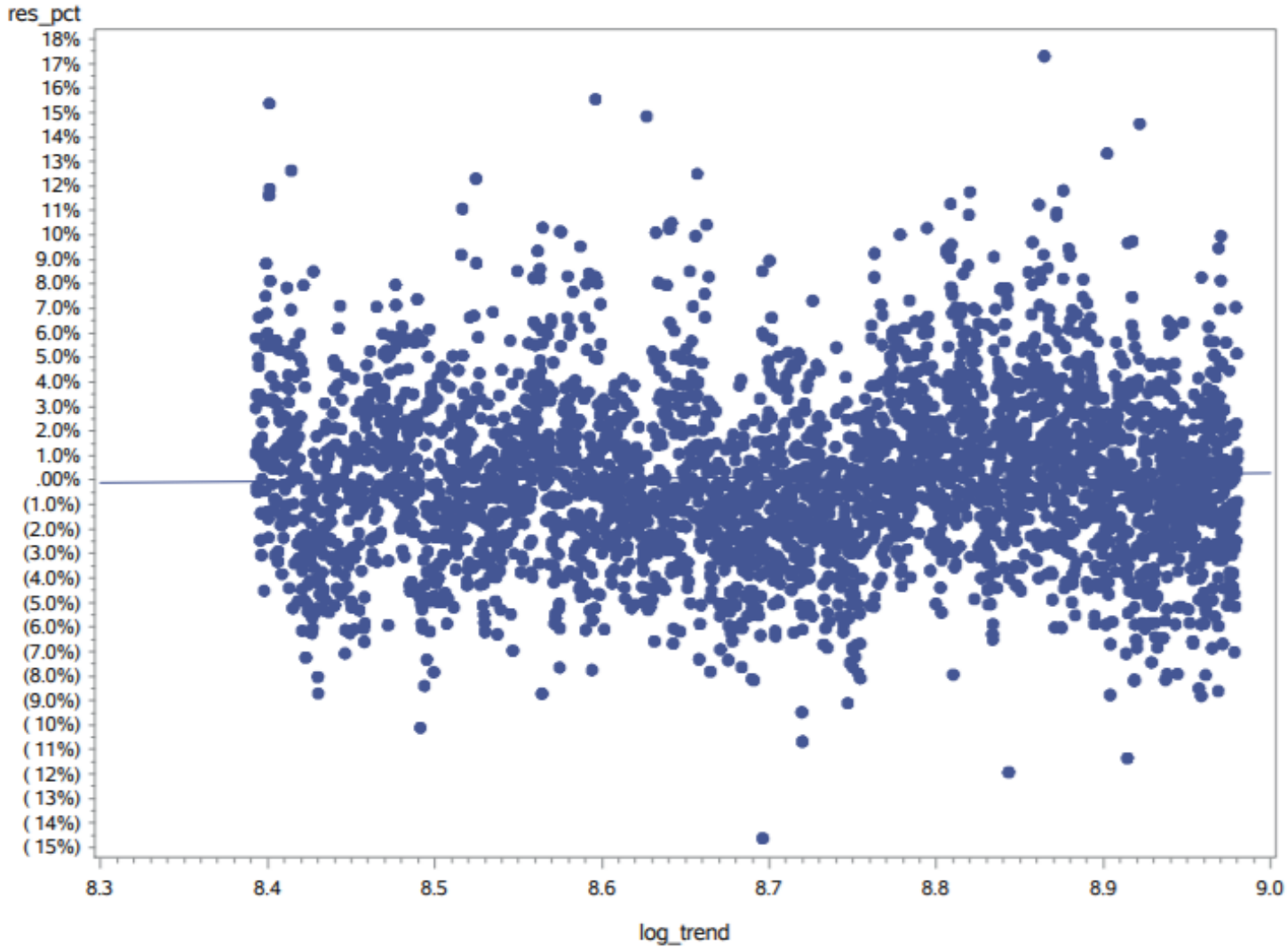
Change – Added Log Trend

- Percentage residual pattern shows trend over time, where the fitted values show over-fit in early years towards under-fit in later years. This indicates some missing variable or missing phenomenon not captured by the explanatory variables.
  - If not controlled for, will contribute to under-forecast
  - Add a natural log time trend to the model. Natural logs have the property that they mimic percentage changes, which is the phenomenon in the residuals we are attempting to capture.

Change - Log Trend (before)



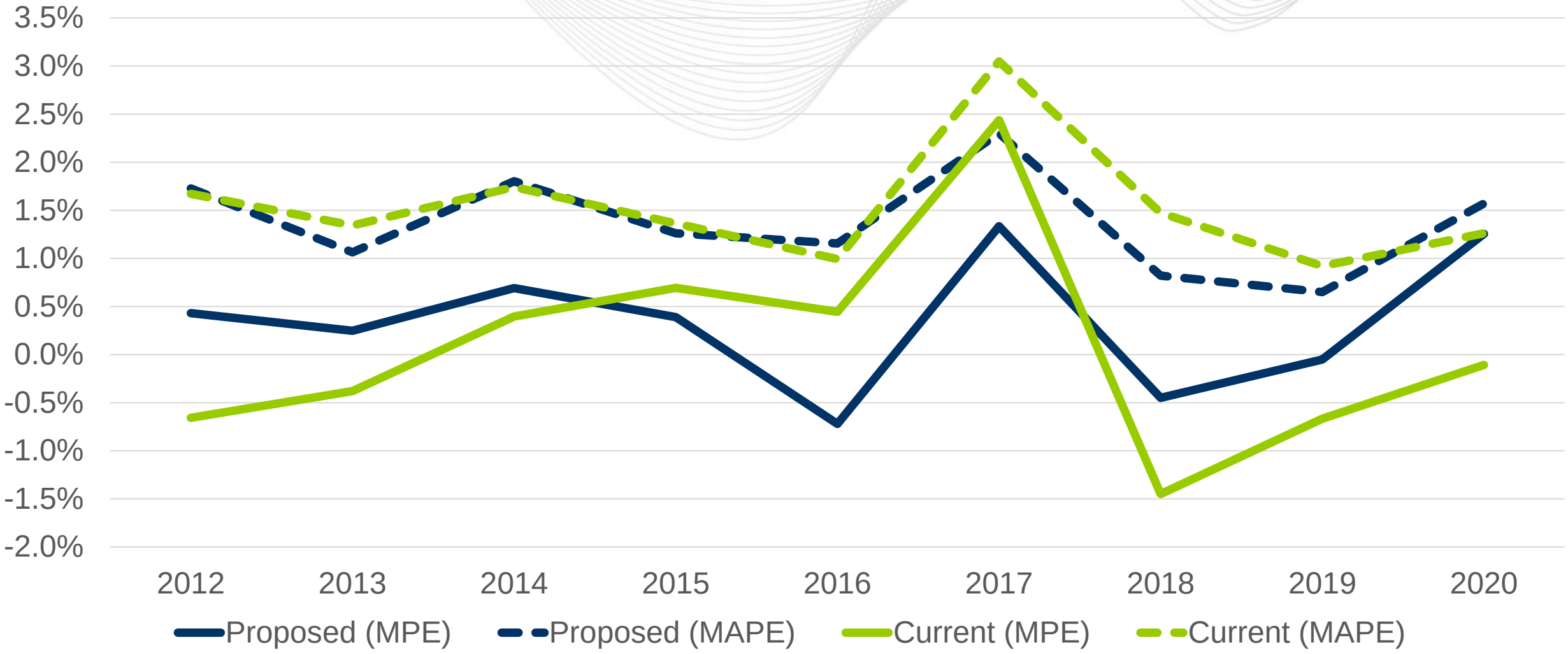
Change - Log Trend (after)



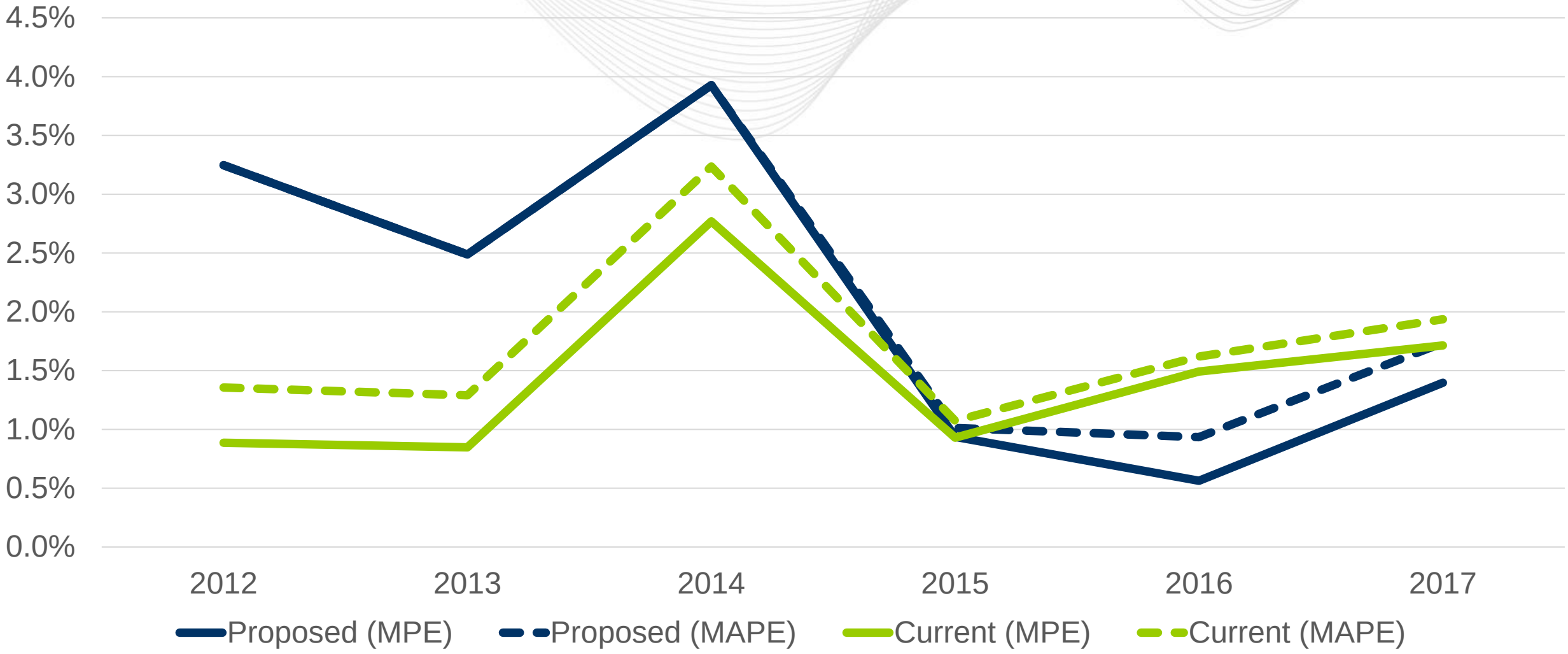
Annual Model Development

Summer Accuracy

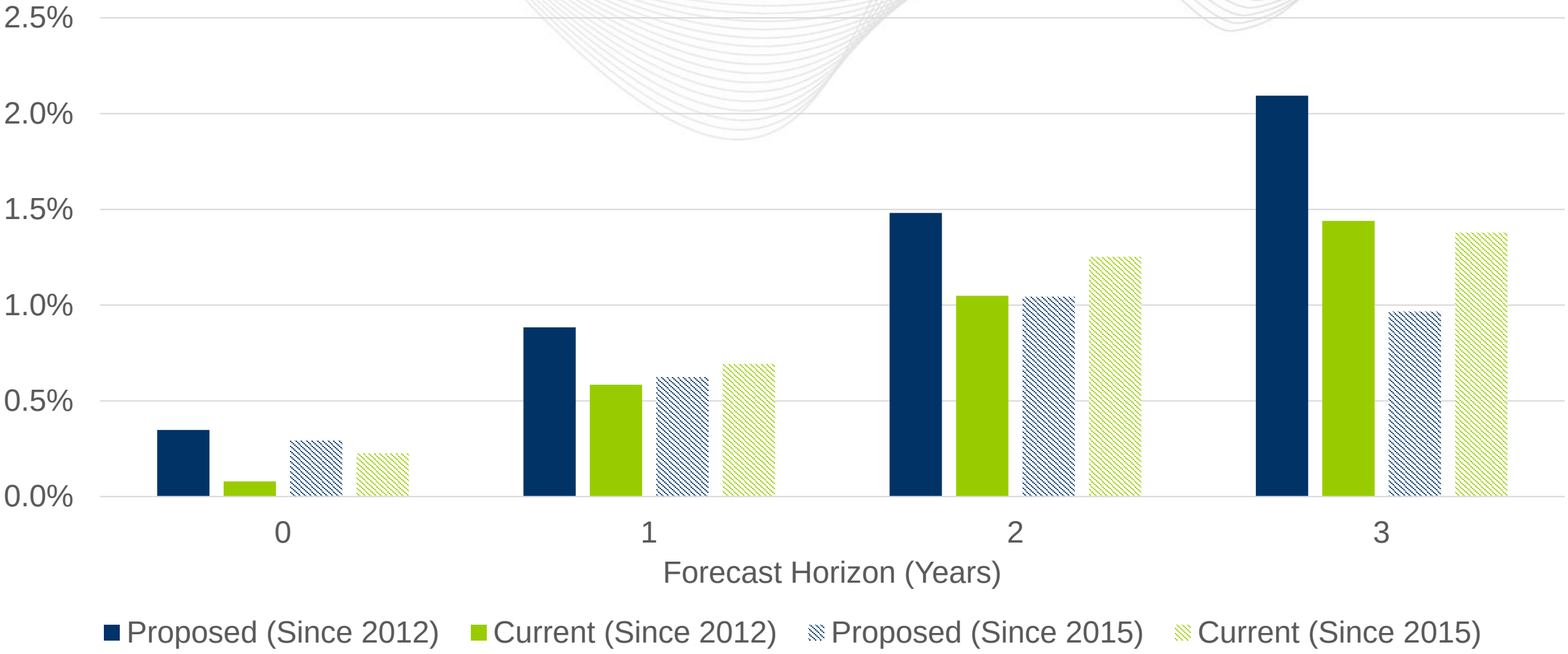
RTO Summer Accuracy on Top 10 Days - Zero Years Out



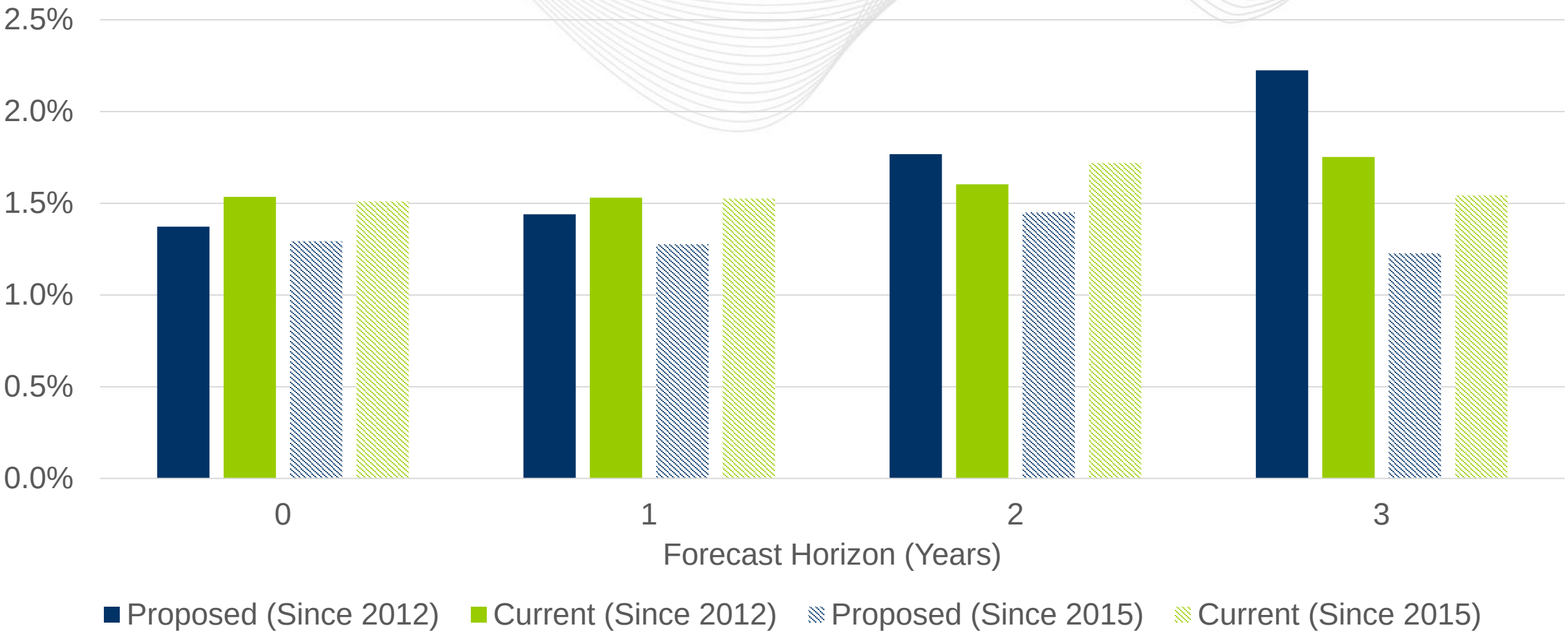
RTO Summer Accuracy on Top 10 Days - Three Years Out



RTO Summer Accuracy on Top 10 Days
Mean Percent Error



RTO Summer Accuracy on Top 10 Days
Mean Absolute Percent Error



Summer Conclusions

- Investigated over the entirety of years tested, the current model seems to have an edge in the two and three-year out horizon. Proposed model has the edge at zero and one-year horizons. However, when looking at only more recent years, the proposed model performs better at all horizons.

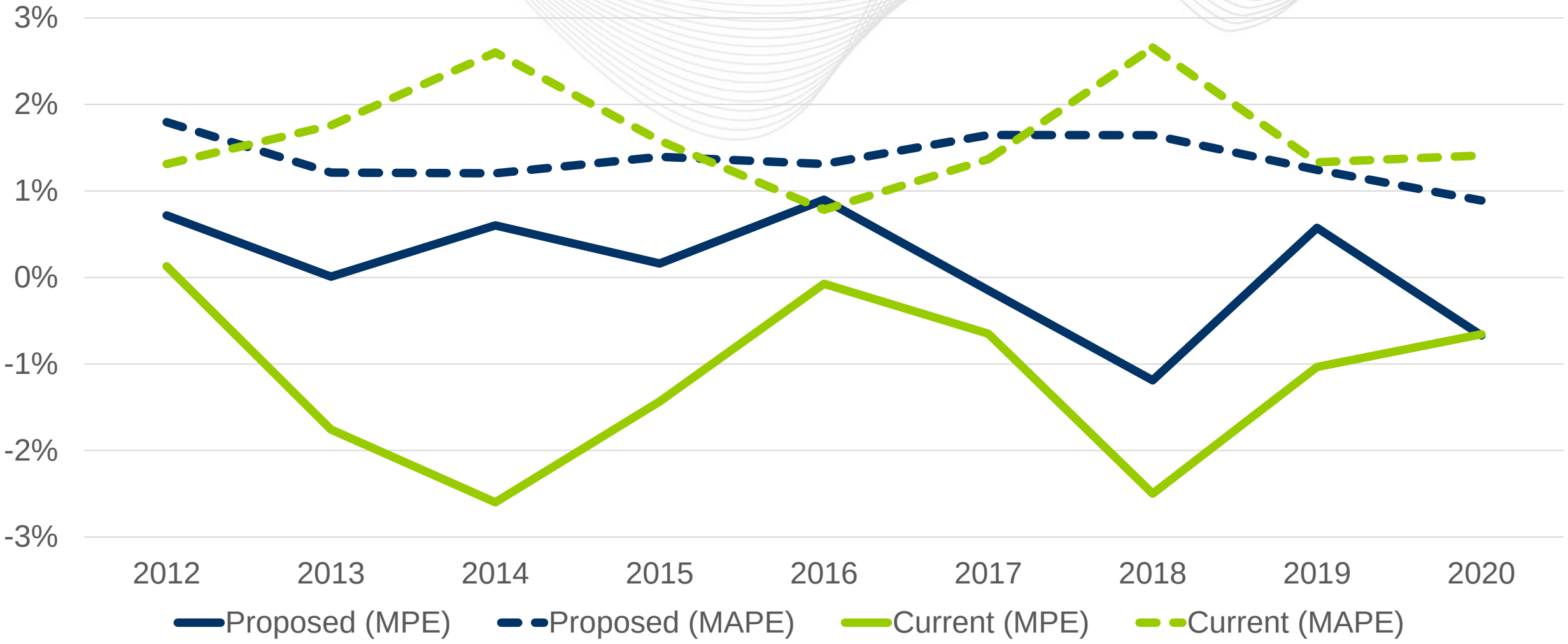
- Proposed model has less positive bias in three-year out horizon, as evidenced by the mean percent error.

- Additional accuracy info in Appendix slides.

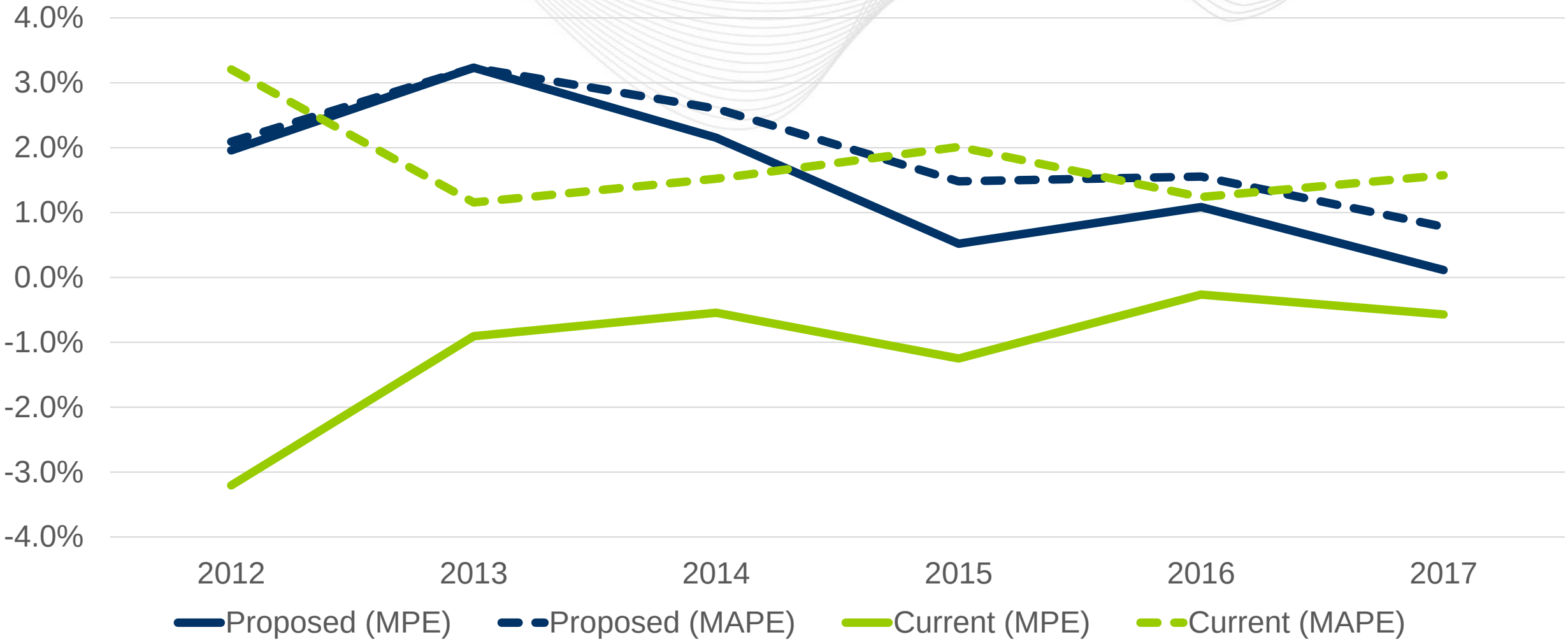
Annual Model Development

Winter Accuracy

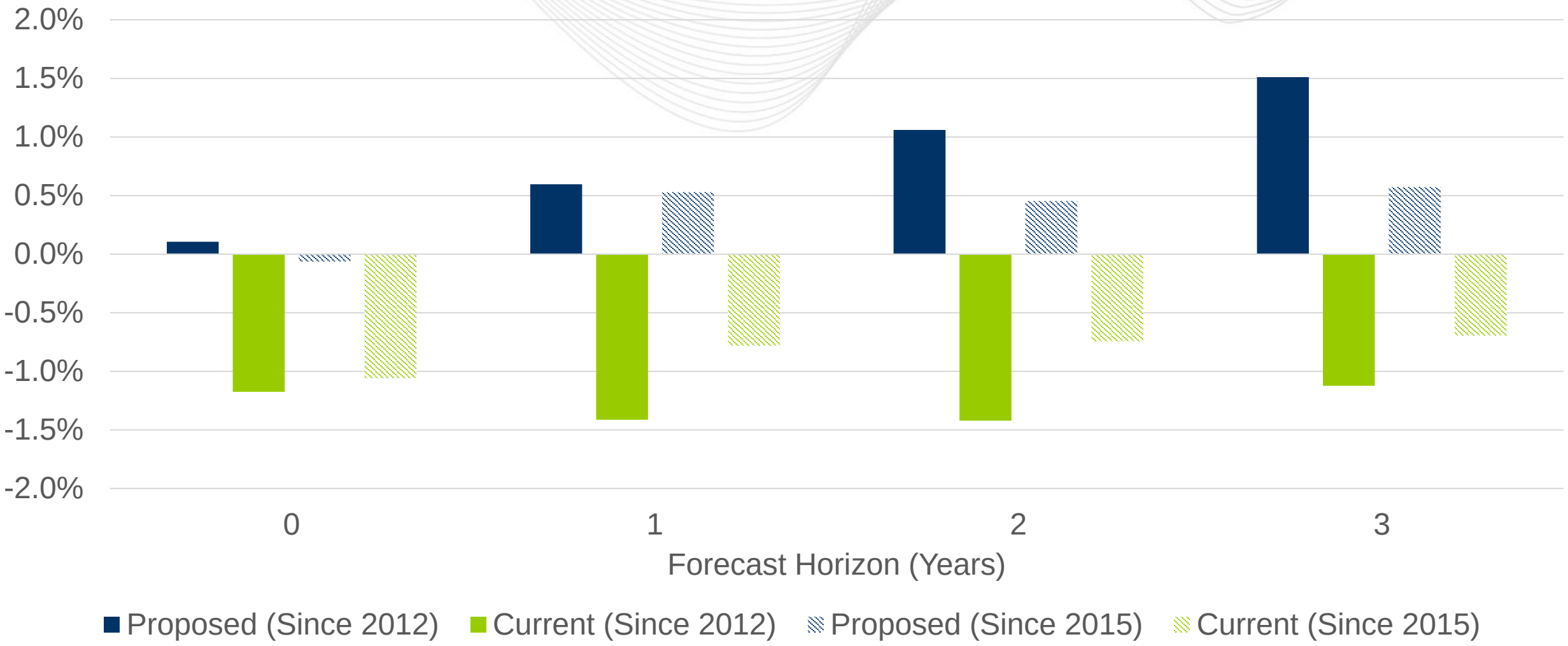
RTO Winter Accuracy on Top 10 Days - Zero Years Out



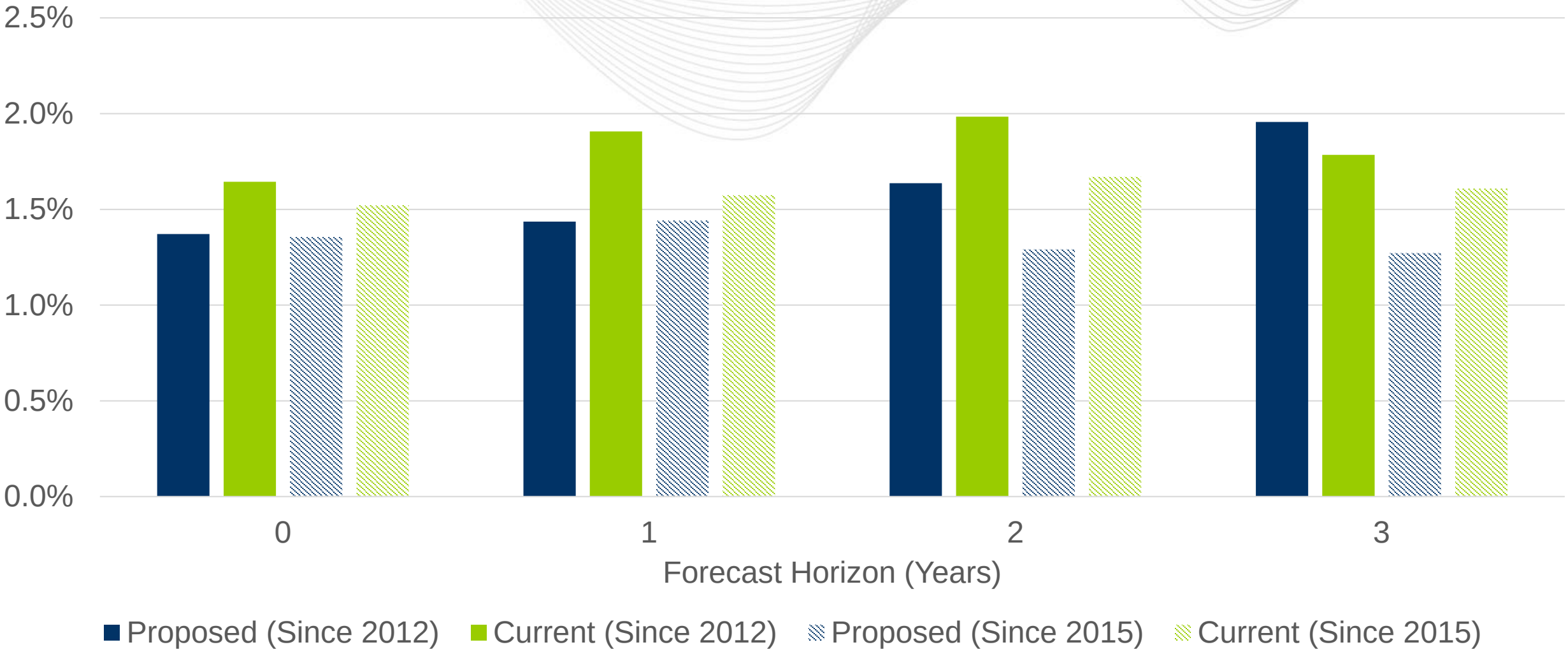
RTO Winter Accuracy on Top 10 Days - Three Years Out



RTO Winter Accuracy on Top 10 Days
Mean Percent Error



RTO Winter Accuracy on Top 10 Days
Mean Absolute Percent Error



Winter Conclusions

- Proposed model has superior accuracy.
- Proposed model has a better bias pattern. Current model tends to have negative bias at all forecast horizons. Proposed model has no bias at zero years out. While the proposed model does have a slight positive bias in the three year out horizon, it is a smaller bias than exists in the current model.
- Additional accuracy info in Appendix slides.

Annual Model Development

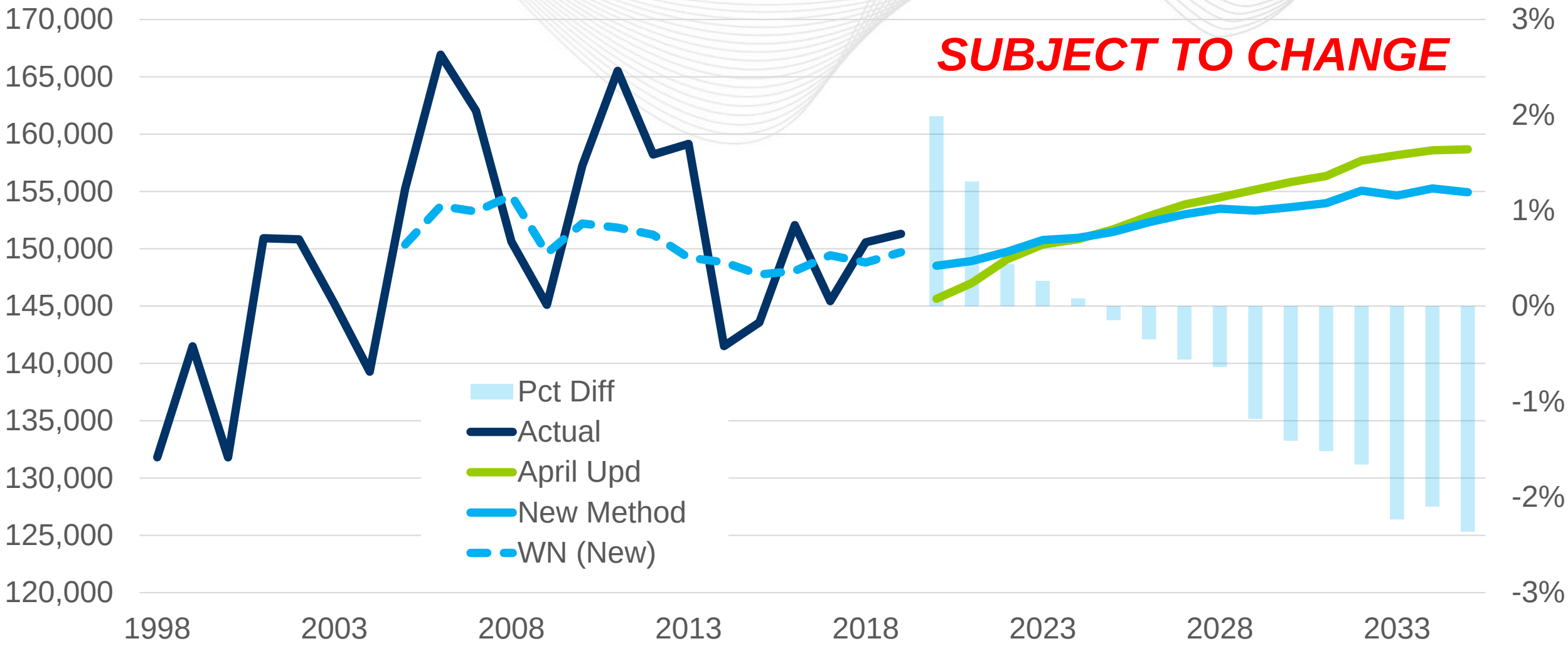
Summer Results

Forecast Overview

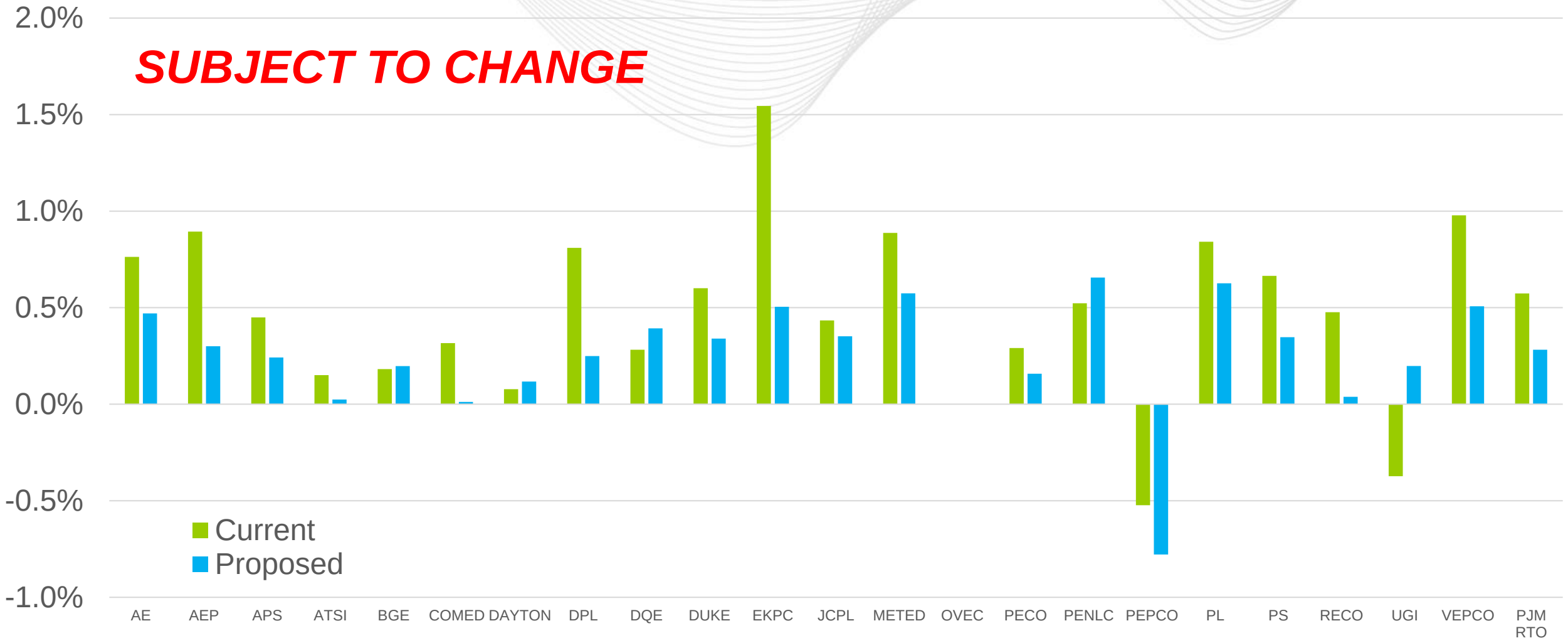
- Both forecasts use the same input data
  - ***April 2020 Economics***
  - 2019 End-Use data
  - 2019 BtM Solar Forecast
  - Weather Rotation 1994-2018
  - ***No Forecast Adjustments***

- Results are from a model in development. Meant to be illustrative.

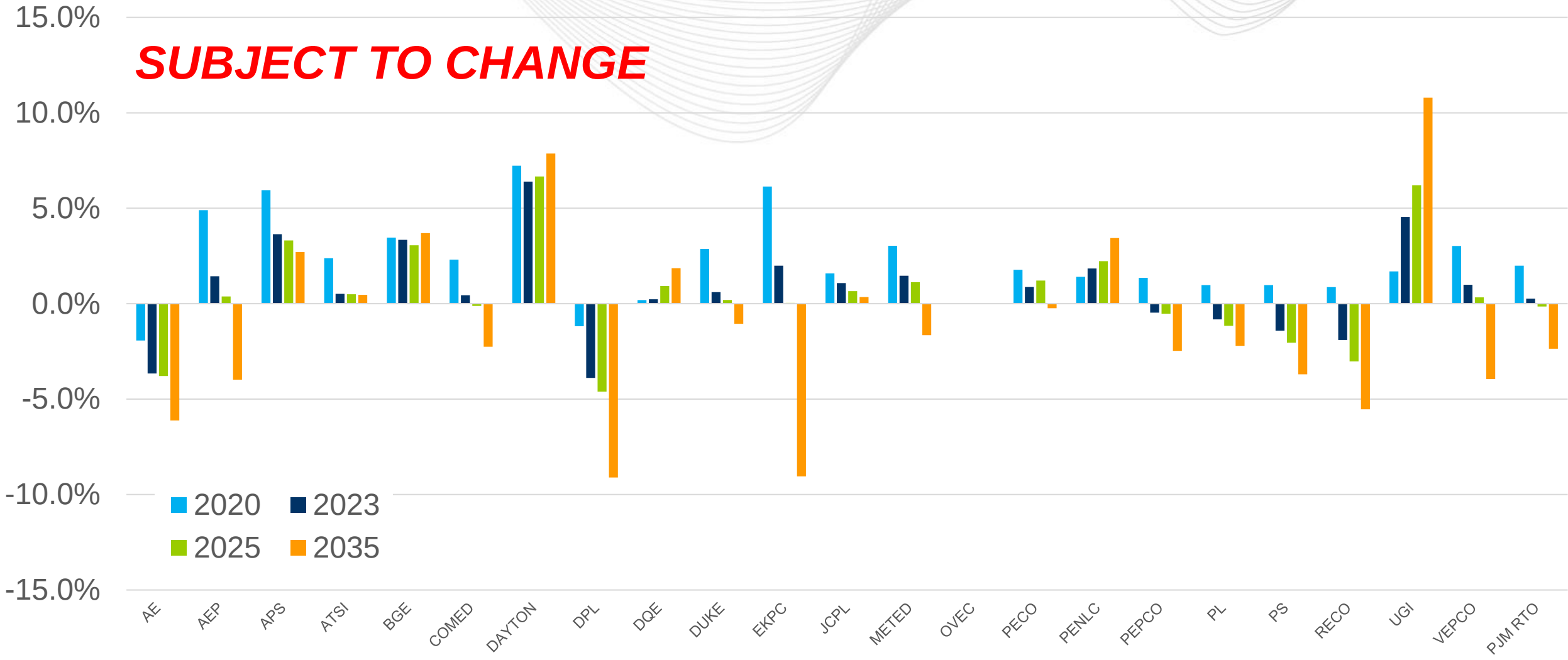
PJM RTO Summer Peak Forecast



15-yr Summer Growth Rate Comparison



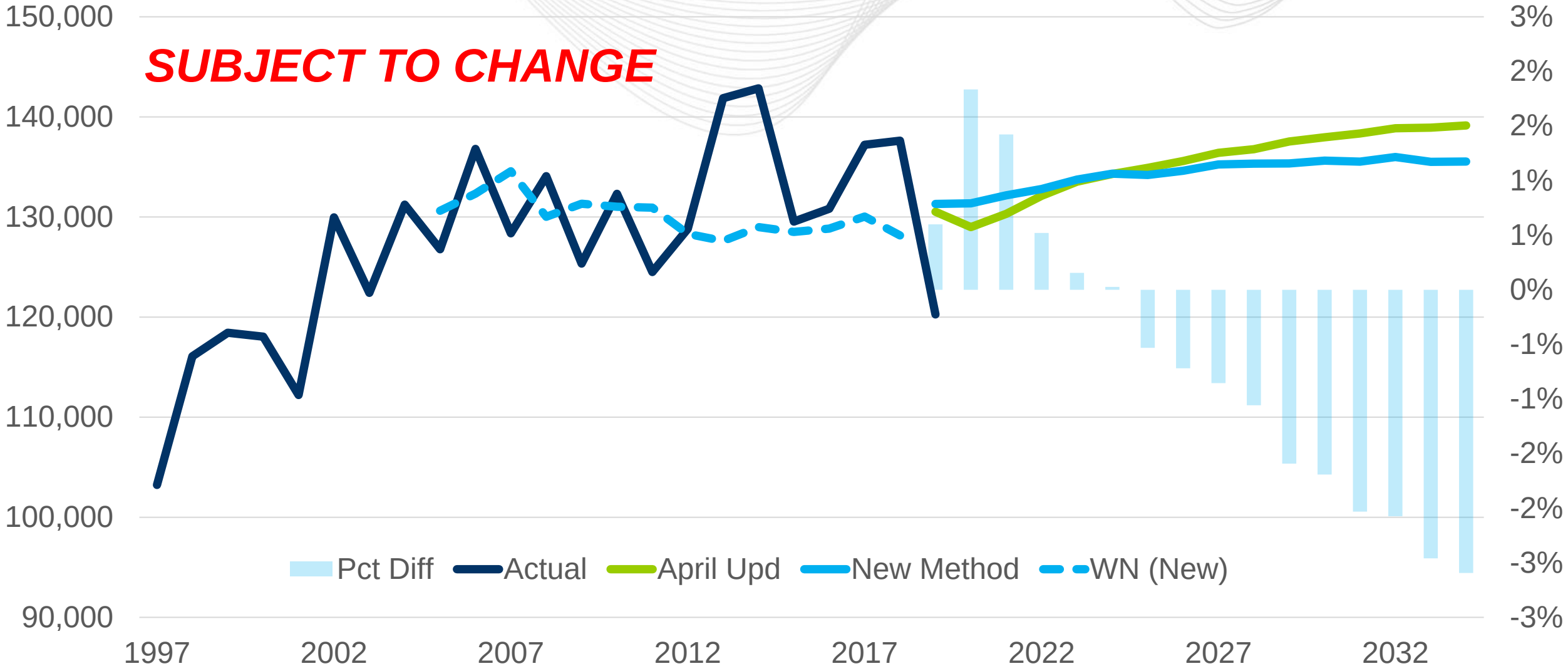
Zone Summer Peak Changes



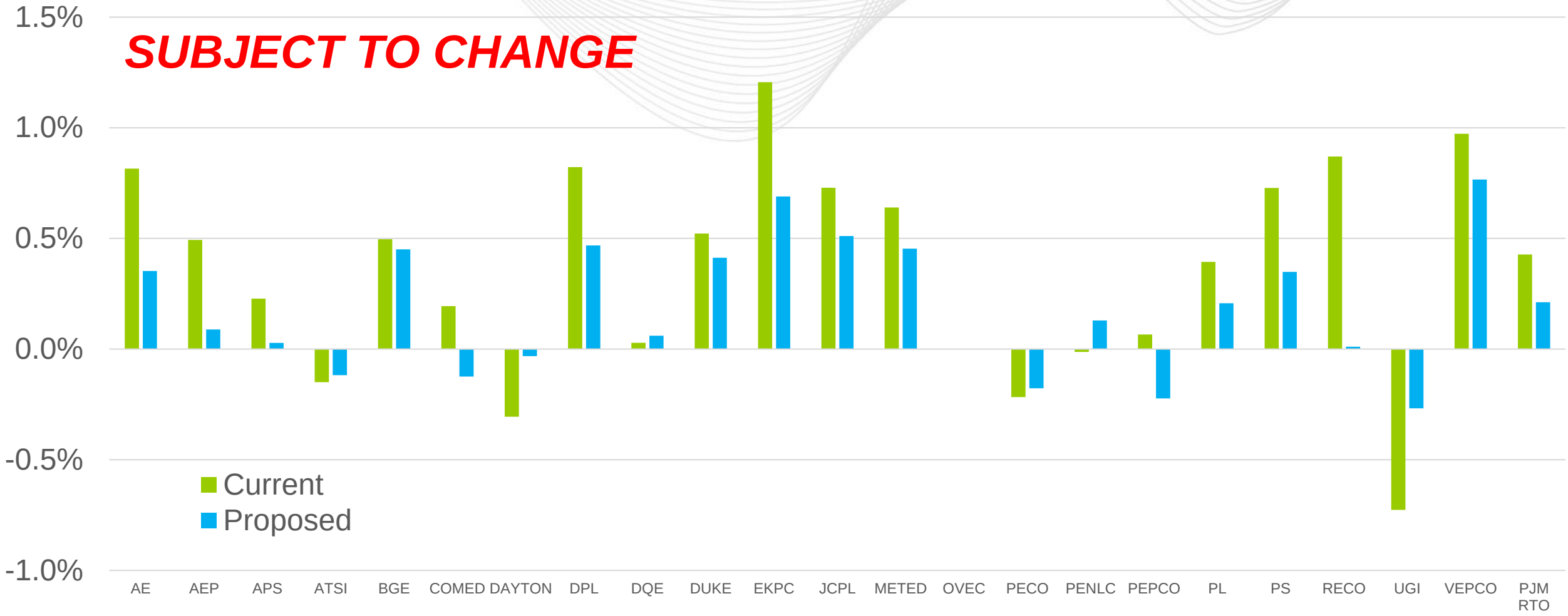
Annual Model Development

Winter Results

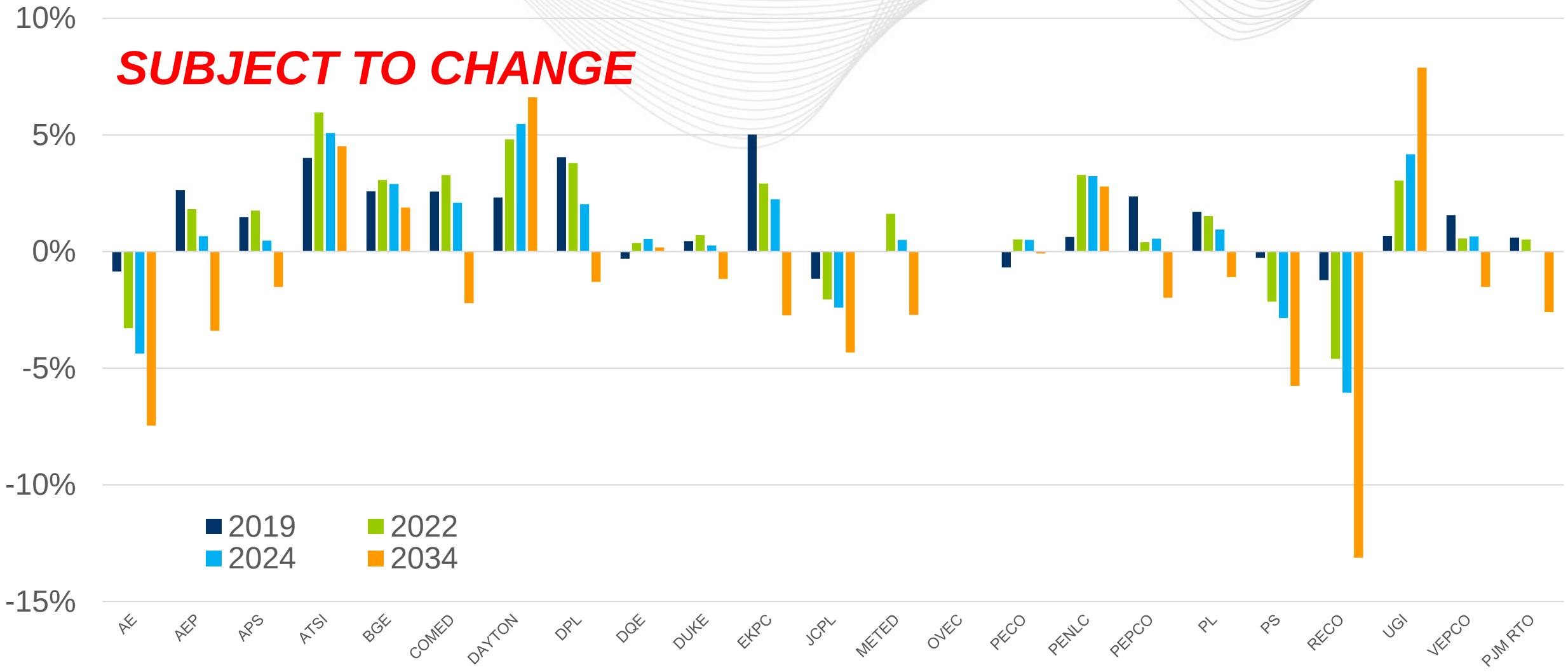
RTO Winter Peak Forecast



15-yr Winter Growth Rate Comparison



Zone Winter Peak Changes



Addressing COVID-19

- COVID-19 has had a significant impact on load that extends beyond just pure economic impacts due to stay-at-home restrictions.

Plan

- Model estimation period for 2021 Load Forecast will extend through August 31, 2020. Two options:
  - Control: Limit the impact of current situation on the assumption of future trends. (***our current recommended approach***)
    - Add binary variables that represent time during COVID-19 and apply throughout model. Variables would take value of 1 during 2020 and 0 otherwise.
    - What this says is that in the long-run that load behavior will return more or less to normal. We do know that the current period is extraordinary, but don't know the lasting implications.
  - Status Quo: Do nothing additional.
    - What this says is that in the long-run that load behavior will resemble a weighted average of COVID and historic time periods (i.e. there are lasting impacts to relationships).

Approach

- Model has monthly variables to account for non-weather sensitive load.
  - Jan_NWS Feb_NWS Mar_NWS Apr_NWS May_NWS Jun_NWS Jul_NWS Aug_NWS Sep_NWS Oct_NWS Nov_NWS Dec_NWS

Approach

- Estimation period for 2021 Load Forecast will extend through August 31, 2020. Create COVID versions of applicable monthly variables and add to model.
  - COVID_Mar_NWS COVID_Apr_NWS COVID_May_NWS COVID_Jun_NWS COVID_Jul_NWS COVID_Aug_NWS
    - Each monthly variable is the same as the usual but multiplied by a dummy variable COVID that is 1 for 2020 and 0 for all other times
    - The resulting coefficients will reflect the estimated difference in NWS from non-COVID periods.

Weather Sensitive

- The current model has a number of variables to account for weather, primarily Cool3, Cool2, Cool1, Heat2, and Heat1
  - Create COVID versions of these variables
    - The weather response in future years will not be influenced by what happened this year.

Estimation Period

- Currently using 10 years for the estimation period.

- Under *Control approach, s*hould we use 11 years since we are in essence removing nearly an entire year?

Plan

- Produce forecasts using both *Control* and *Status Quo* approaches and report on differences.

- Use *Control* approach unless there is a compelling reason to do otherwise.

Additional Items

Estimation Period of Sector Models

- Residential, Commercial, and Industrial sector models are based on annual data. Because of data limitations, we use back to 1998. The 2021 Forecast will have data from 1998-2019 or 22 observations.
  - There is no rule on minimum observations.
  - Some say should target at least 10 observations per explanatory variable (sector models have 1-3 variables), thus ideally would have a minimum of 10-30 observations.
  - Stakeholder has expressed an interest in sector models only being run on most recent 10 years.
  - We have concerns that this would add instability in model fit.

Spreadsheets

- To increase transparency, we have posted a number of spreadsheets with LAS materials covering the following issues.
  - Residential Model
  - Commercial Model
  - Industrial Model
  - End-Use Indices
  - Non-Weather Sensitive – History, Fit, and Forecast
  - Statistical Appendix (final model coefficients and regression information)
  - Residuals (final model fitted values versus actual)

Contact

Presenter/SME:

Andrew Gledhill

andrew.gledhill@pjm.com

Load Forecast

Member Hotline

(610) 666 – 8980

(866) 400 – 8980

custsvc@pjm.com