Update on Reliability Risk Modeling

CIFP - Resource Adequacy
July 17, 2023

Purpose of this Presentation

- Provide an update on RTO reliability risk modeling
- Review and discuss the results of the updated analysis, including sensitivities on the extended weather history and climate change adjustments
- Share indicative results of accreditation by resource class reflecting contribution to reliability in the latest analysis

Review: Reliability Risk Modeling Framework

Weather Scenarios

Historical weather patterns observed from expanded history

- *Adjusted to capture impact of climate change on temperatures*

Load Scenarios

Hourly load profiles derived from PJM's Load Forecast model for each weather scenario

- *Weather patterns shifted forward and backward to account for day of the week / holiday variables*

Resource Performance Scenarios

Unit, class, & fleet historical performance (forced outages, ambient de-rates, etc.) as a function of weather for thermal and variable generation

- *Correlated outages for any reason captured in patterns and distribution of class & fleet outage rates*

Resource Adequacy Analysis

Model system resource adequacy under thousands of alternative histories

- *One alternative weather history, reflecting distribution of uncertainty given 50+ years of history*
- *One alternative load history, reflecting distribution of load forecasts given weather, time/date, etc.*
- *One alternative realization of capacity resource performance, reflecting distribution of potential performance of individual resources and historically observed correlations across resources*

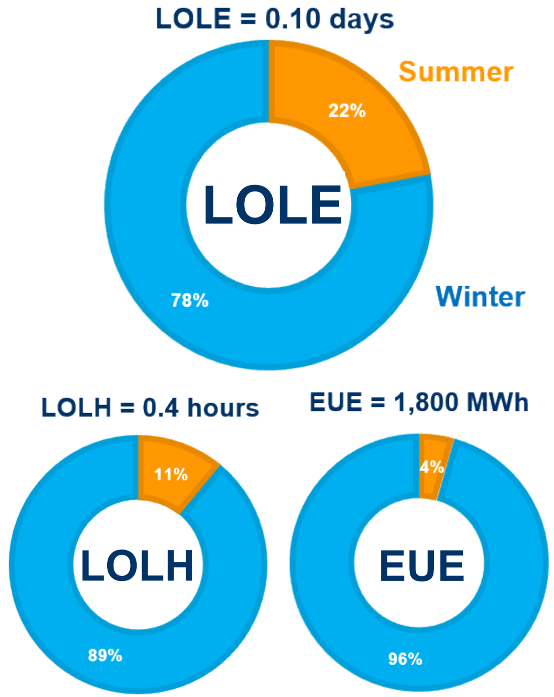
Risk Metrics & Patterns of Reliability Risk

Model Updates Since Initial Preliminary Results

Summary of Model Updates	Relative Shift in Risk
1. Adjusted modeling of resource performance in extreme hot temperatures (now slightly worse than before)	+ Summer risk
2. Applied weather rotation across days of week (impacting load forecast, not generation)	+ Summer risk
3. Updated thermal fleet to derive performance shapes	Negligible
4. Capped resource output at CIRs	Negligible
5. Expanded weather history to 50 years*	+ Winter risk
6. Applied adjustment to account for climate change*	+ Summer risk

** Simulations run with and without extended weather history and climate change adjustments*

Previously Shared Preliminary Results

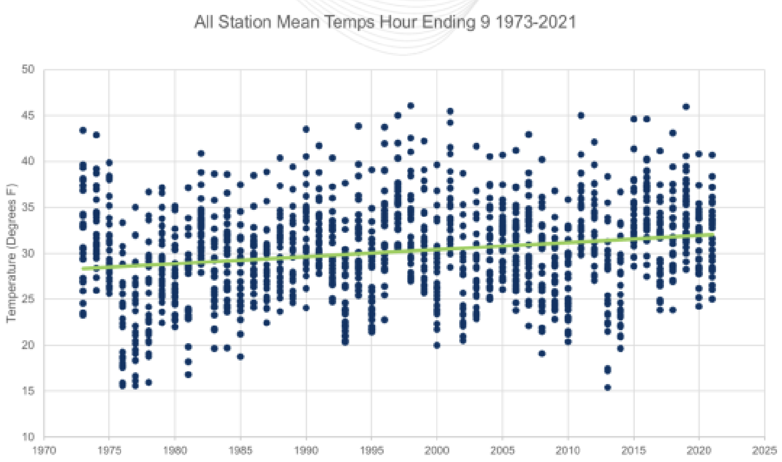


May 30 CIFP Presentation

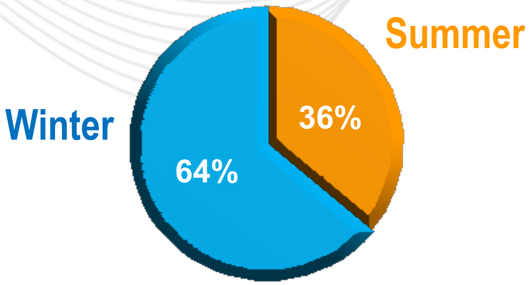
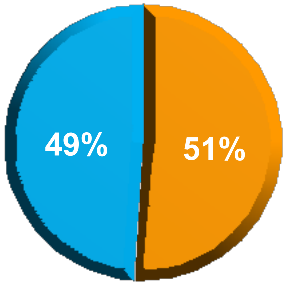
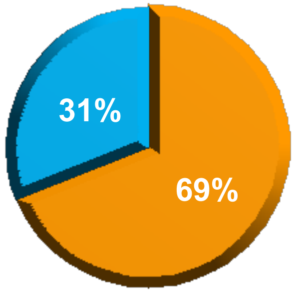
Climate Change Adjustments: Alternatives

Method A "Trends in Extremes"	Method B "Trends in Means"
For each season… For each hour of the day… - Estimate trend in seasonal minimum - Estimate trend in seasonal mean - Estimate trend in seasonal maximum - Apply adjustment to historical temperatures: • Adjust min temp by trend in minimum • Adjust mean temp adjusted by in means • Adjust max temp by trend in maximums • Adjust in between by interpolation	For each season… For each hour of the day… - Estimate trend in seasonal mean - Apply adjustment to historical temperatures: • All temps adjusted by trend in means

Additional detail provided in appendix



Summary of Latest Simulations and Results

Simulation		EUE	LOLH	LOLE
1	Updated risk modeling with: - Weather history back to **1993** - No climate change adjustment	 EUE = 1,400 MWh	 LOLH = 0.33 hours	 LOLE = 0.10 days
Simulations that use extended weather history back to **1973**				
2	With no climate change adjustment	W:71% S:29% 1,700 MWh	W:57% S:43% 0.38 hours	W:42% S:58% 0.10 days
2A	With climate change adjustment using Method A	W:35% S:65% 1,200 MWh	W:25% S:75% 0.31 hours	W:17% S:83% 0.10 days
2B	With climate change adjustment using Method B (mean trend only)	W:46% S:54% 1,400 MWh	W:30% S:70% 0.33 hours	W:21% S:79% 0.10 days

Initial PJM Reactions to Updated Analysis

Expanding weather history to 1970s introduced more uncertainty than expected:

- Additional data reduces variance but introduces bias that must be accounted for
- Alternative reasonable assessments of climate trends materially impact patterns of risk
- In-house assessment of trends found different trends than expected from climate literature, and we have not identified a scientific consensus regarding how to conduct the necessary adjustments

In other words, it is unclear what we learn from the additional data on climate extremes in the 1970s & ‘80s if, given the changing climate:

- There is uncertainty regarding how different those weather events would look today, and
- There is uncertainty regarding the probability with which they would re-occur today

Working Proposal: Maintain ~30 year weather window to 1993; may re-evaluate post CIFP

Seeking stakeholder feedback on this initial course of action

Estimated 26/27 Class Average Accreditation Values
(based on "Model 1" to 1993)

	Summer	Winter
Thermals (Overall) *	**95%**	**78%**
Nuclear *	98%	96%
Coal *	89%	86%
Gas CC *	97%	76%
Gas CT *	98%	63%
Existing ELCC Resources		
Onshore Wind	9%	36%
Offshore Wind	17%	68%
Solar Fixed Panel	19%	2%
Solar Tracking Panel	32%	2%

Accreditation for remaining classes forthcoming.
** Does not yet reflect impact of planned & maintenance outages.*

For reference: Current 25/26 BRA ELCC for certain classes

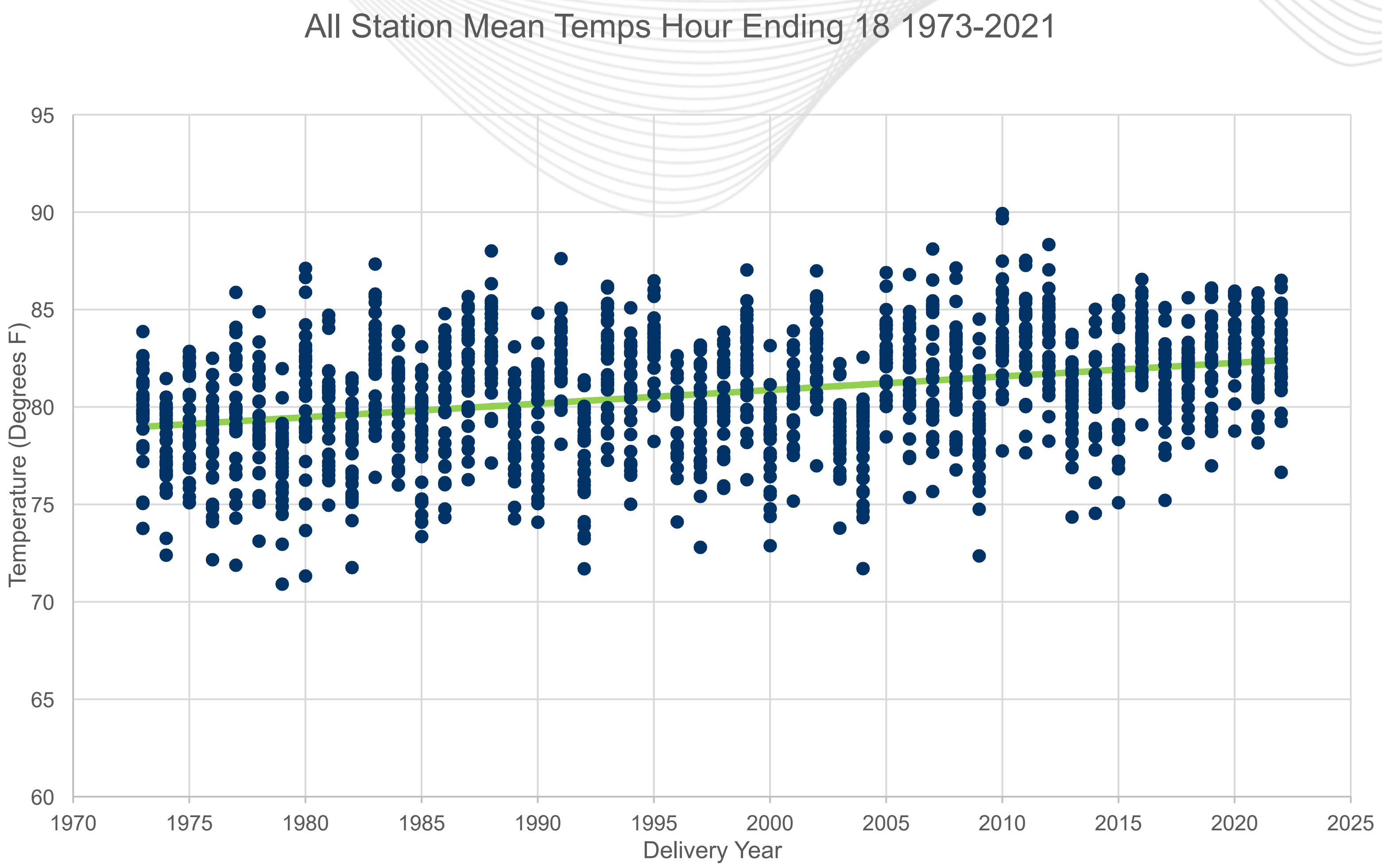
	Class Rating
Onshore Wind	**10%**
Offshore Wind	**21%**
Solar Fixed Panel	**30%**
Solar Tracking Panel	**50%**

Next Steps

1. Complete accreditation calculation for all classes
    - Demand response, storage, hydro, etc.
2. Calculate summer & winter reliability requirements
3. Based on stakeholder feedback, assess sensitivity of risk modeling and accreditation results to:
    - Changes in assumed resource mix
4. Implement final changes to risk model:
    - Winter planned outages

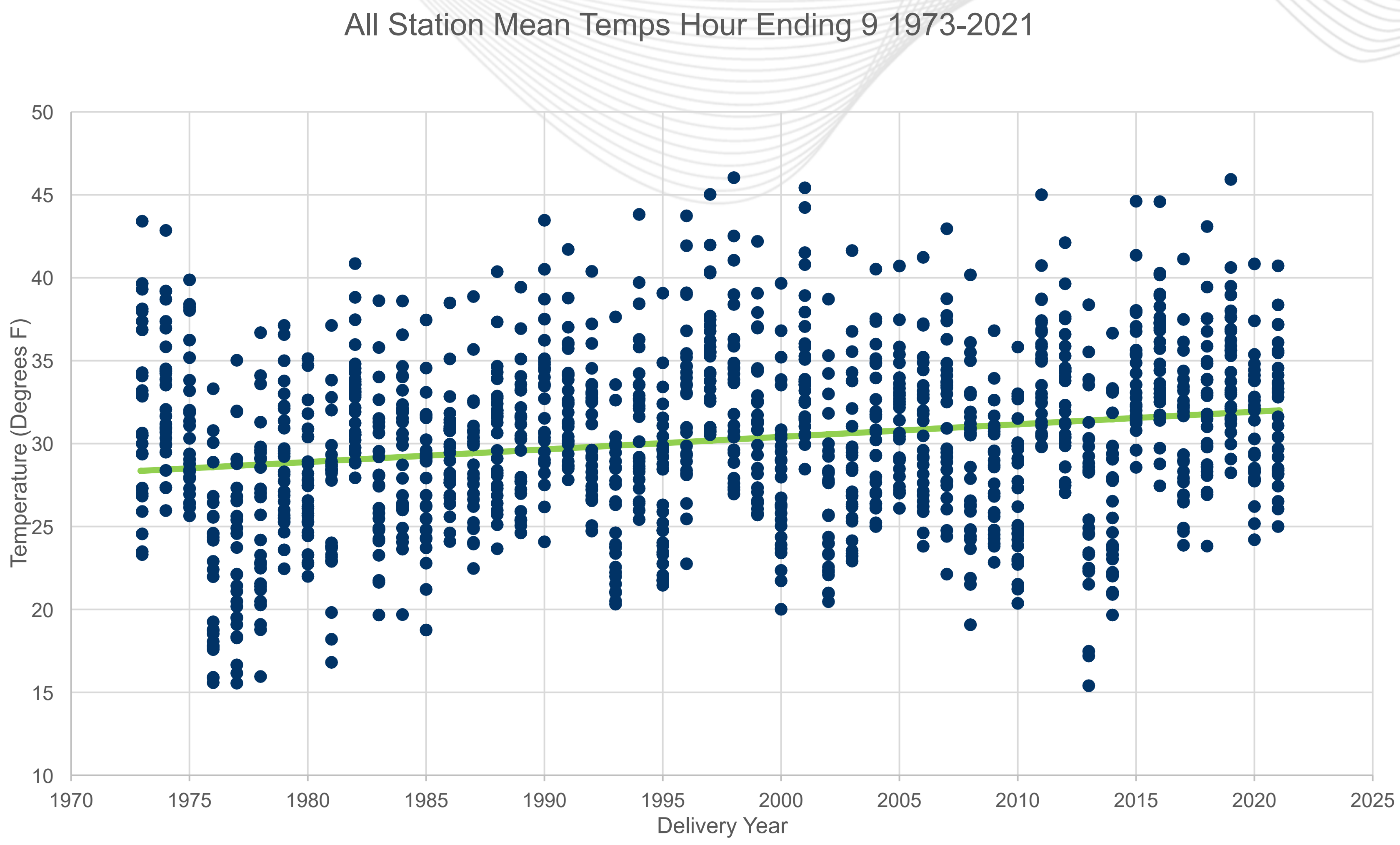
Appendix

All Stations Mean Temp Trend since 1973 (Summer)



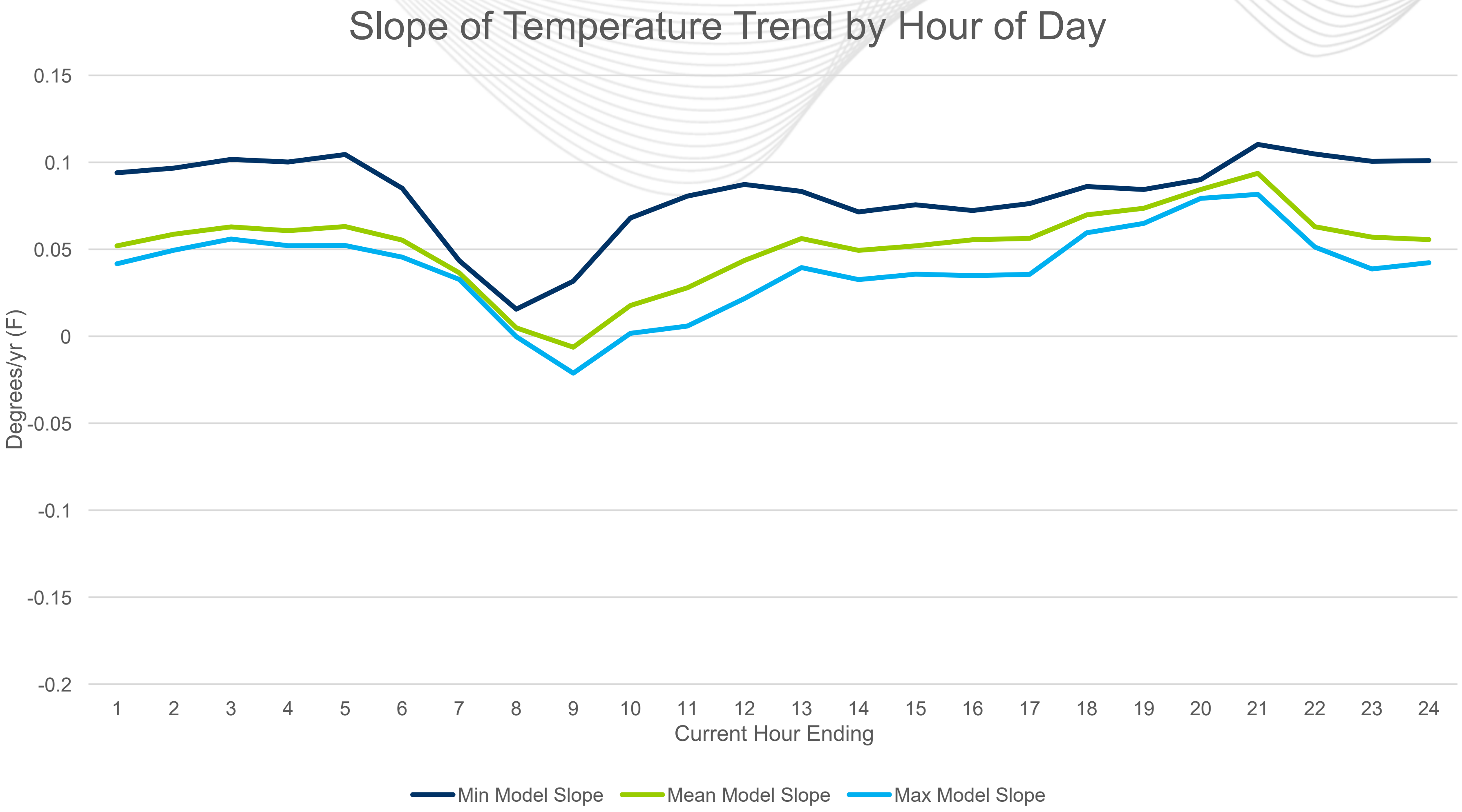
Mean temperature trending up by 0.07 degrees/yr

All Stations Mean Temp Trend since 1973 (Winter)



Mean temperature trending up by 0.08 degrees/yr

Slope of Estimated Linear Trend by Hour (Summer)



Slope of Estimated Linear Trend by Hour (Winter)