

Uncertainty in Operations

Stephanie Schwarz

Manager, Markets Coordination

Reserve Certainty Sr. Task Force

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1. Recognize uncertainty is growing
2. Quantify operational net uncertainty & assess risks to the operating day
3. Implement uncertainty framework in Operations
4. Secure the appropriate market products to address uncertainty/risk within operations in order to limit out-of-market action in an effort to ensure reliability.



Intermittent Resources
Solar, Wind



**Generator
Performance**

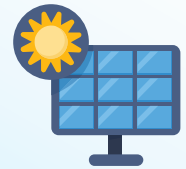
Load



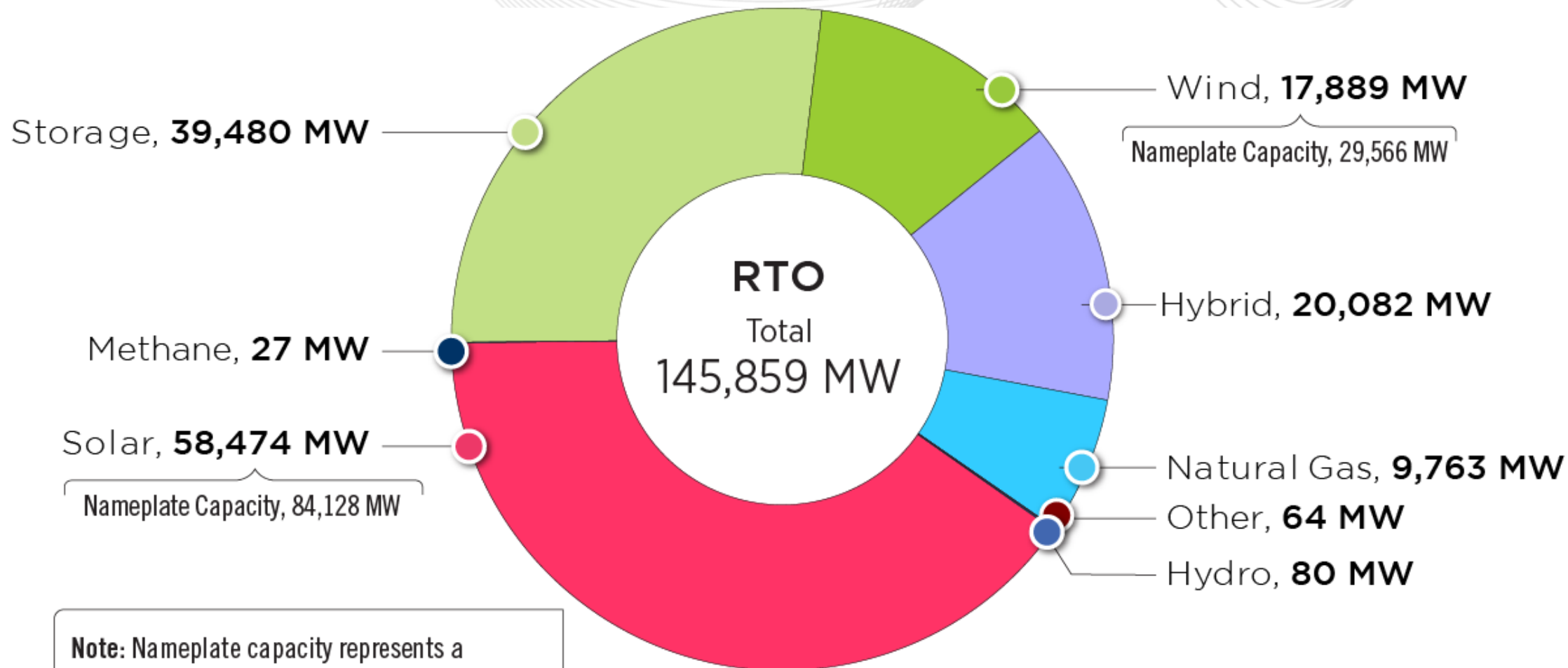
Weather



BTM Solar



RTO Queued Capacity by Fuel Type



Note: Nameplate capacity represents a generator's rated full power output capability.

Intermittent Resources



13,260 MW
Solar

11,740 MW
Wind

134 MW
Battery

- Quick moving
- Weather dependent
- Ramp periods a concern

Uncertainty with solar and wind is analyzed in conjunction with weather but no current product or construct to manage the potential fluctuations caused by the intermittency

Key Stakeholder Processes in Progress

RCSTF Addressing appropriate procurement of reserve quantities

DISRS Addressing dispatchability of intermittent resources (ramp volatility and dispatch accuracy)



Generator Performance

- Cold weather operating limitations
- 42,000 MWs at risk observed during 2025 Artic Weather Event
- Forced outages



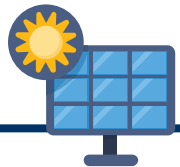
Load

- Growing non-conforming load
- Data center growth



Weather

- Extreme weather is a challenge
- Sudden temperature drops
- Timing of weather fronts
- Impact on generation output



BTM Solar

Increasing penetration altering load shapes

Some of the uncertainty reflected in the **DA Scheduling Reserves** based on historical load error and forced outages but not considered in the Day Ahead market

Extreme weather analysis is a manual process and accounted for in load forecast adjustments

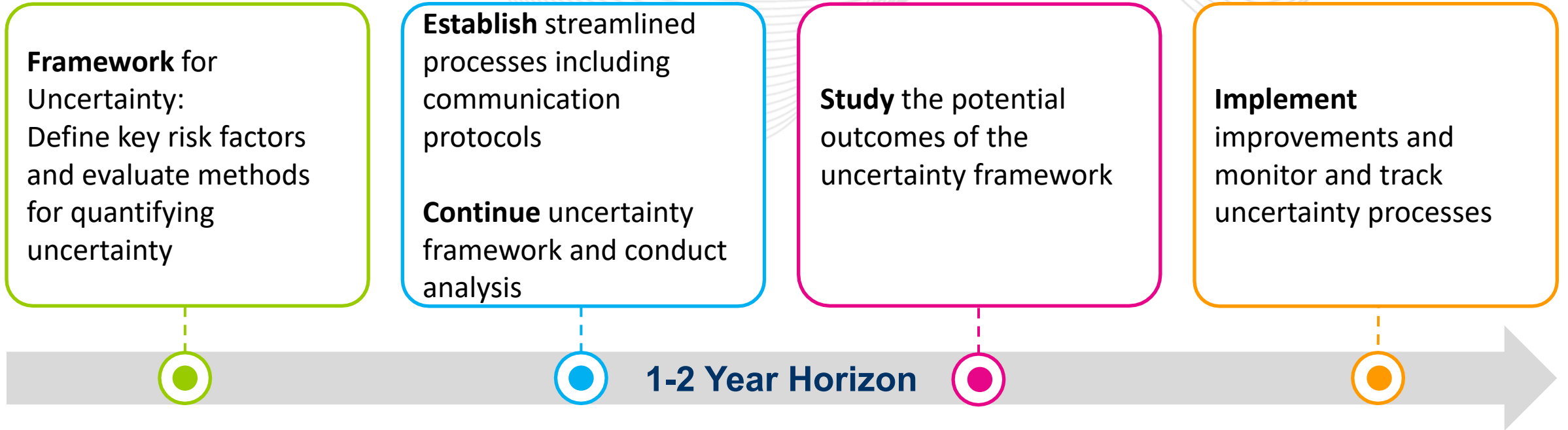
Uncertainty with BTM is considered in development of the overall load forecast

- Operations Day-ahead Scheduling Reserve (DASR) requirements have diminished over time, however, uncertainty and risk are increasing due to an increase in resources that are not fuel secure (<https://www.pjm.com/markets-and-operations/ops-analysis/day-ahead-scheduling-reserve>)
- The Day-ahead market secures even less reserves, a flat requirement of 3,000 MW, which had no basis and does not reflect how risk changes based on operational conditions
 - Based on DASR approach, any time peak load is greater than 66,518 MW, 3,000 MW of 30-Minute Reserves is not sufficient to manage operational risk
- Both Day-ahead and Real-time must secure the necessary reserves to address uncertainty and risk.

	PJM	SPP	MISO	CAISO	ERCOT
Peak Load MW	165,000	53,243	130,897	52,061	85,464
Metered Solar MWs	13260	1,437	6,000	26,000	24,000
BTM Solar MW	7,000	500	5,000	17,000	1,500 (growing rapidly)
Wind MW	11740	32,000	30,000	8,120	39,000
Storage MWs	134	213	0	13,000	7,000
Total Metered IBRs	22,240	33,650	36,000	47,120	70,000
Operating Reserve Requirement	DASR	Uncertainty Risk Team use Operational Capacity Outlook to evaluate risk as part of Multi-day Reliability Assessment	Risk Based: 4% - 11%	Originally DASR, then Net Load Uncertainty, now Condition Based Approach (percent increases based on risk).	Minimum 6500 MW Probabilistic Risk Based Tool under development

Note: Table compiled based on notes from PJM site visits conducted in April/May 2024.

Operations Uncertainty Road Map



TODAY:

- Process to assess uncertainty is not streamlined
- Handling uncertainty on a case by case basis
- Fixed (seasonal) market products and not dynamic risk-based products

TOMORROW:

- Streamlined uncertainty evaluation
- Markets products that support uncertainty in operations

Facilitator:

Lisa Morelli, Lisa.Morelli@pjm.com

Secretary:

Amanda Egan, Amanda.Egan@pjm.com

SME/Presenter:

Stephanie Schwarz

Stephanie.Schwarz@pjm.com

Dave Souder David.Souder@pjm.com

RCSTF Reserve Certainty Senior Task Force

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Member Hotline

(610) 666 – 8980

(866) 400 – 8980

custsvc@pjm.com

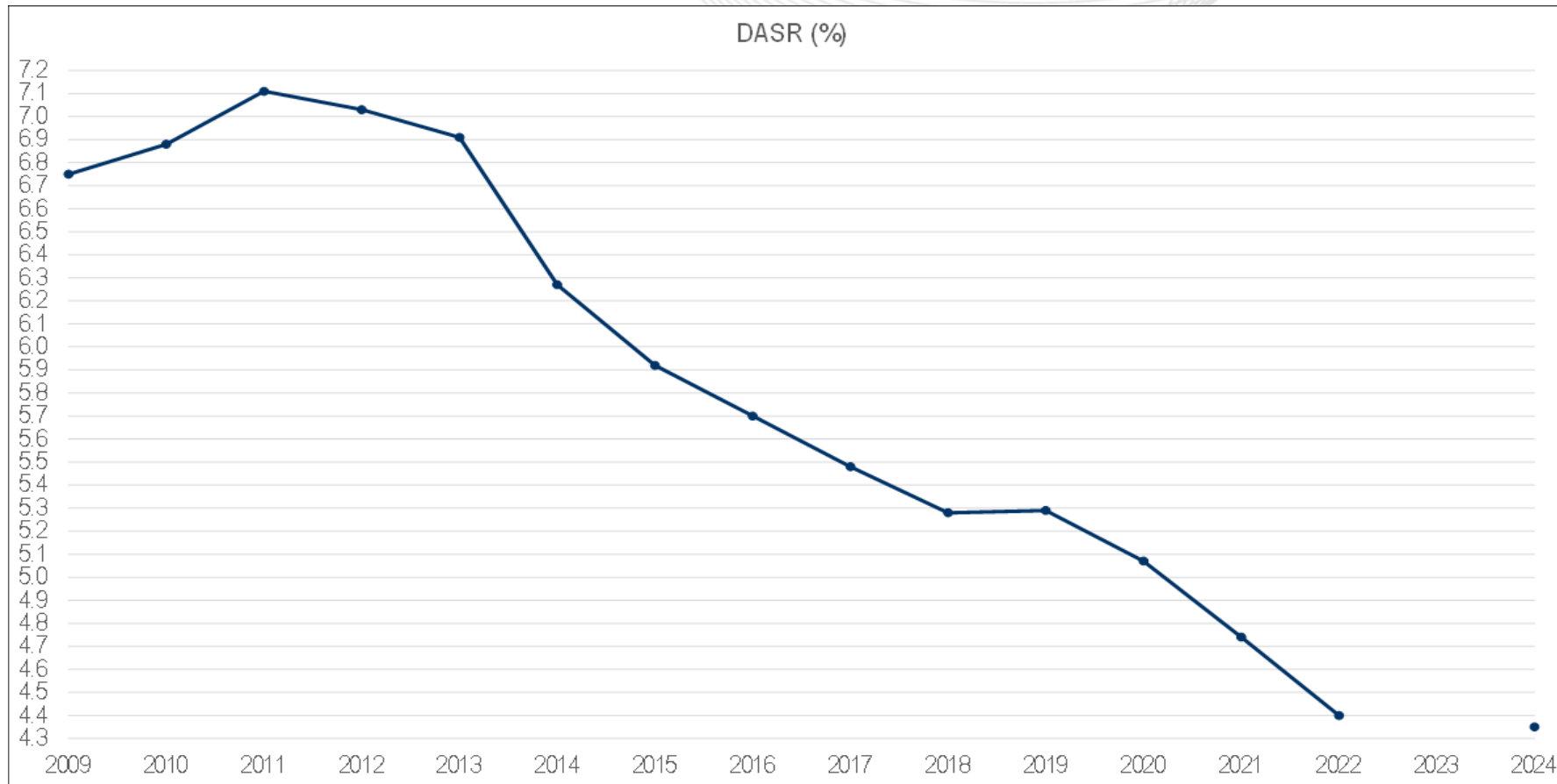
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Year Effective	DASR (%)
2009:	6.75
2010:	6.88
2011:	7.11
2012:	7.03
2013:	6.91
2014:	6.27
2015:	5.92
2016:	5.70
2017:	5.48
2018:	5.28
2019:	5.29
2020:	5.07
2021:	4.74
2022:	4.40
2023:	None
2024:	4.35