Probabilistic Operational Reserves Strategy with Increasing Solar and Storage

A supplementary analysis to Resource Adequacy

Sean Morash, ESIG Spring 2023 Technical Workshop

TELOS ENERGY

Agenda

- Framework for Evaluating Power System Operational Strategies
- A sampling of results from a recently completed project
  - Generalized for this audience

Setting the stage

What should we build/retire?

Is that portfolio reliable?

How do we reliably operate the portfolio?

Are there electrical engineering constraints?

Capacity Expansion Planning

Determine optimal portfolio of resources

Resource Adequacy Analysis

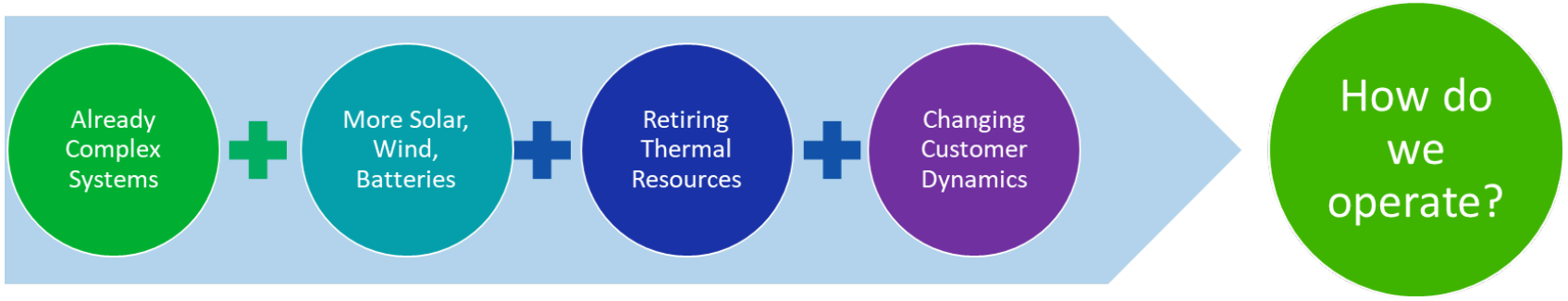
Assess reliability performance of portfolio across a variety of weather years and conditions

Operational Strategy Planning

Determine reliable operating practices for resource mix given day-to-day and hour-to-hour uncertainty

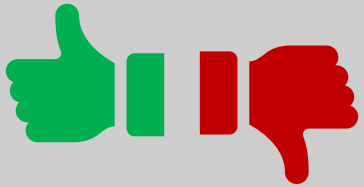
Stability and Inertia Analysis

Assess power flows and system dynamics given resource characteristics



Introduce the Modeling Challenge

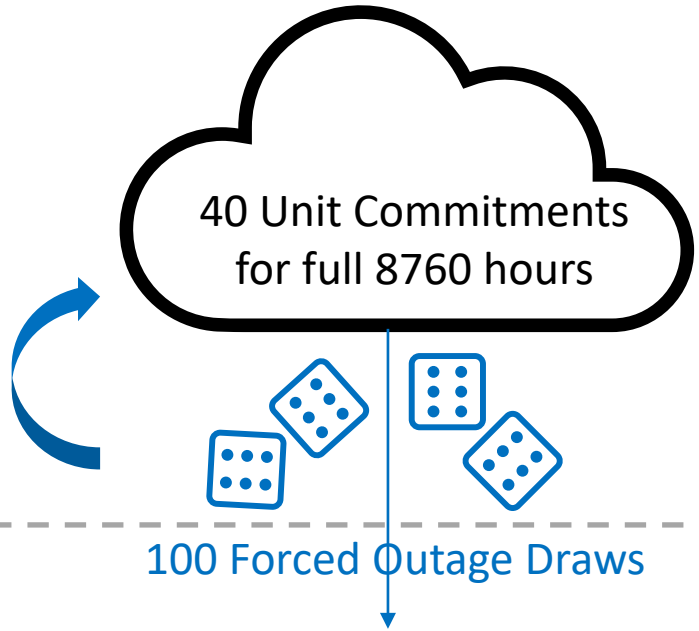
- The variety of uncertainties continues to compound
  - Generation side: weather influence, forced outages, failed starts
  - Demand side: weather influence, demand response, new load types
- Operational strategy analysis need to consider all hours of the year and uncertainty among those hours
  - Spring and Winter minimum generation mean fewer points of failure
  - Maintenance schedule could leave system vulnerable
  - Managing Peak Load

Robust Analytic Approach		Traditional Approaches
Probabilistic		Deterministic
8760 Hours		Single Hour
Weather Variability		Single Hour
DA Forecasting Accuracy		Single Hour
Unit Commitment Decisions		Capacity Focused

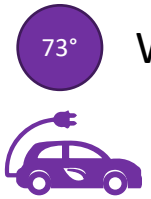
A framework for the challenge

Generation, load, and uncertainty can be integrated into multiple decision cycles within a model.

Day Ahead



Wind and Solar uses multiple weather years

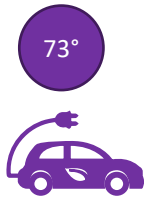


Weather-dependent load projection

Real Time

4000 Economic Dispatch
for full 8760 hours

Include Wind and Solar Forecast Error

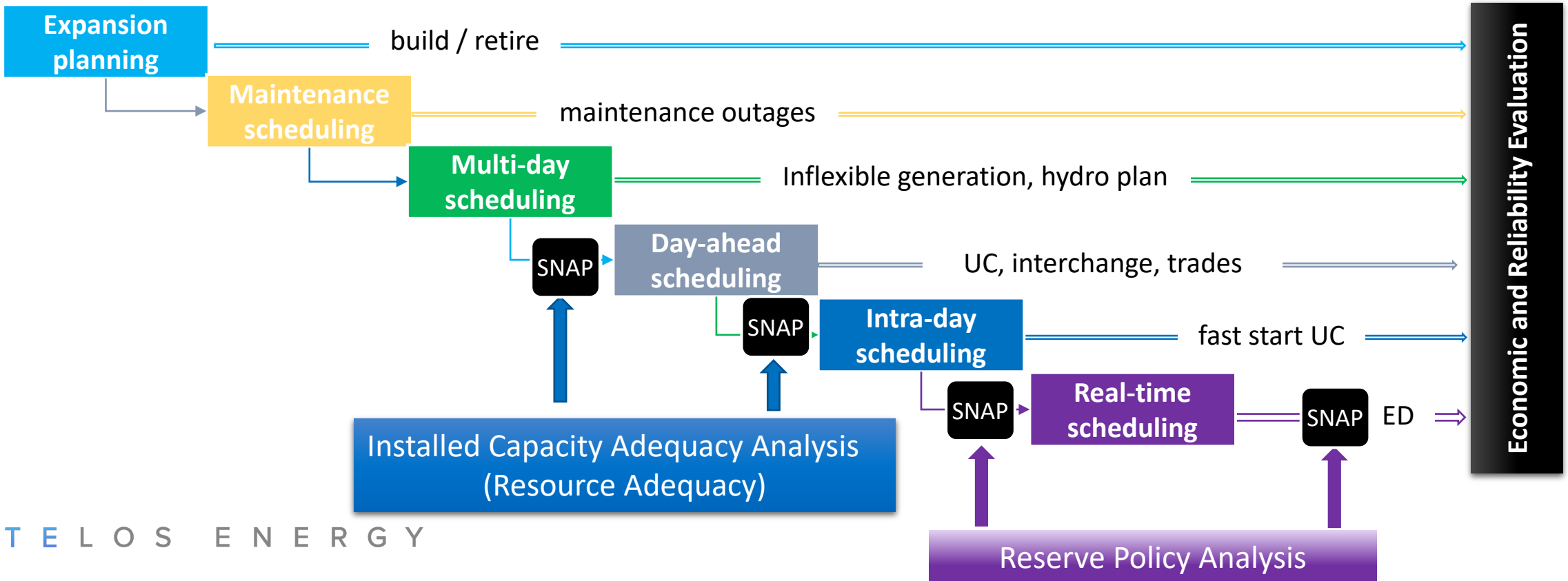


Load forecast error based on historical data

Enelytix/PSO Decision Cycle Framework and SNAP

Stochastic Nodal Adequacy Pricing (SNAP) platform supports this type of analysis by assessing the value of every resource

- Each SNAP Cycle can include probabilistic evaluation of adequacy and LMPs
- Each Monte Carlo Draw is filtered for detailed analysis based on user-defined “Shortage” conditions
- More info on Enelytix/PSO SNAP Resource Adequacy framework here: https://arpa-e.energy.gov/sites/default/files/2021-02/TCR_PERFORM%20Kickoff_Final.pdf

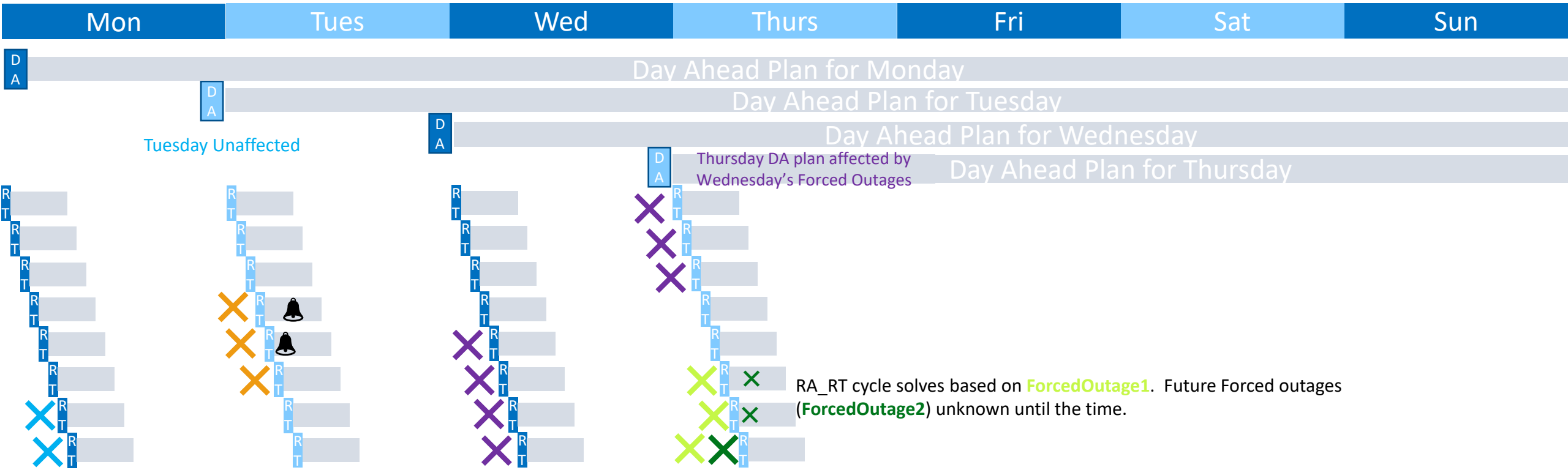


Intro to Modeling Approach

Forced Outages show up between cycles and affect subsequent cycles

Day Ahead Cycle (DA) – Solves every day, looks ahead a week and commits units for entire week

Real Time Cycle (RA_RT) – Solves every hour, looks ahead 6 hours



RA_RT cycle solves based on **ForcedOutage1**. Future Forced outages (**ForcedOutage2**) unknown until the time.

- Future needs identified
- Quick start units re-committed
- Shortage avoided

Backcast Probabilistic Results

Examine Backcast to evaluate the expectation for reliability going forward

- Monte Carlo probabilistic analysis showed a highly reliable system in 2019 under the current operational strategy
  - The definition of "short" drives a lot of the discrepancy here:
    - Is the future one in which we rely on reserve sharing group more?
    - How do we think about emergency market procurements?
    - Is the operating practice implemented differently than the operating rule?
  - Monte Carlo results align with historical EEA1 annual frequency
- The expectation for future resource mix is to identify an operational strategy that meets somewhere between the model results and the historical context

	Short (Hrs)	Extreme Shortage (Hrs)
Probabilistic Backcast	0.21	0
Historic Shortage Hours	11 / year	2.4 / year

Average Shortage Hours in Monte Carlo Run

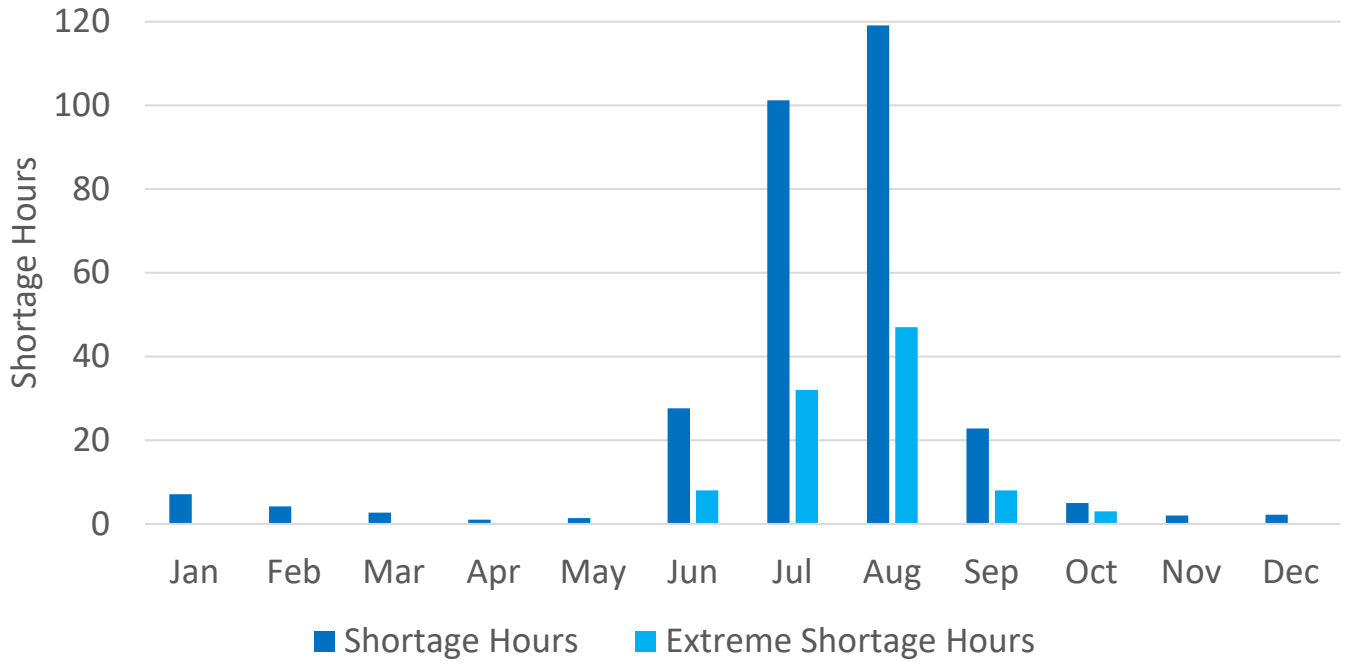
Hour of Day	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Future Year Probabilistic Results

	Short (Hrs)	Extreme Shortage (Hrs)
Probabilistic Future	294	98
Historic Shortage Hours	11 / year	2.4 / year

After adding ~4GW of Solar+Storage and significant retirements of the existing thermal fleet:

- Using the current operational strategy, the model sees significant increases in shortage situations across all non-solar hours.
- More than 26 days in August have a shortage at **11PM** probabilistically. The shortage situations seem to continually get worse after the evening peak before they get better in the overnight hours.

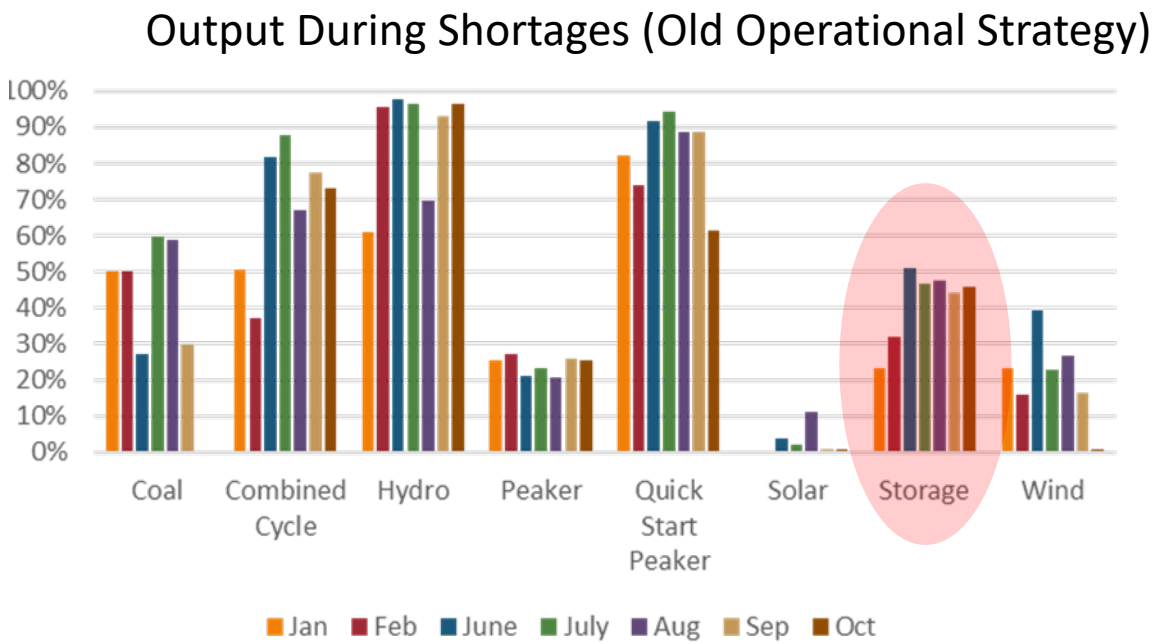


Hour of Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.2	0.2	0.1	0.2	0.3	3.4	1.0	0.0	0.0	0.0	0.0
2	0.1	0.4	0.2	0.1	0.0	0.2	0.6	0.1	0.0	0.0	0.0	0.1
3	0.1	0.3	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
4	0.2	0.3	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2
5	0.3	0.2	0.2	0.2	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.3
6	1.5	1.1	1.2	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.6	0.6
7	4.8	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6
8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.1	0.6	2.6	0.1	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.4	2.5	6.0	0.2	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.7	5.8	9.3	0.5	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	1.2	7.6	11.2	0.8	0.1	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	1.7	9.2	14.0	2.0	0.2	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	2.6	12.0	17.7	4.8	0.8	0.2	0.0
22	0.0	0.0	0.0	0.0	0.0	5.2	16.6	21.9	6.4	1.0	0.2	0.0
23	0.0	0.0	0.0	0.0	0.4	11.1	25.0	26.6	7.7	2.6	0.4	0.3
24	0.0	0.0	0.4	0.5	0.8	4.1	17.6	8.2	0.3	0.1	0.0	0.0

Who is helping/hurting?

- Examine unit performance when there is a shortage condition to determine if there is opportunity to improve operating reliability
  - Coal and Combined Cycle show that some units may be forced off, with their removal contributing to the shortage condition
  - Quick Start Peakers contribute, unless they are on maintenance (October)
  - Shortages rarely occur during the sunlight hours, so Solar rarely contributes
- Storage Shortage Situation
  - Storage is not contributing as much as quick start peakers, despite its "always online" characteristics and high capacity
  - **New question: How do we get storage to contribute when there is a shortage while also helping to meet system peak?**

% of Nameplate Generated during Shortage Conditions							
	Jan	Feb	June	July	Aug	Sep	Oct
Coal	50%	50%	27%	60%	59%	30%	0%
Combined Cycle	51%	37%	82%	88%	67%	77%	73%
Hydro	61%	95%	98%	97%	70%	93%	97%
Peaker	25%	27%	21%	23%	21%	26%	25%
Quick Start Peaker	82%	74%	91%	94%	88%	89%	61%
Solar	0%	0%	4%	2%	11%	1%	1%
Storage	23%	32%	51%	47%	48%	44%	46%
Wind	23%	16%	39%	23%	27%	16%	1%

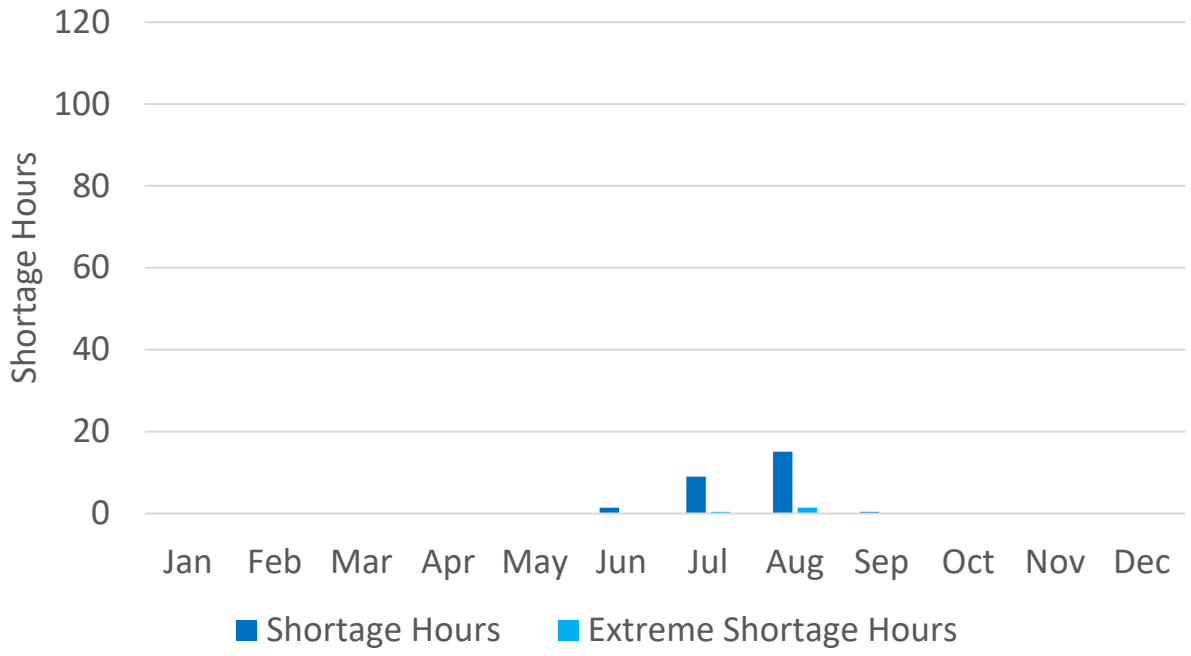


TELOS ENERGY

New Operational Strategy

Operational strategy boils down to how and when storage dispatched:

1. Includes a strategic hourly storage target
   a) Helps ensure storage is fully charged heading into evening ramp period
   b) Could become a dynamic function of expected VER generation or load
2. Adjusts reserves hierarchy around that storage target
   a) Allows the model to dispatch certain units in RT, rather than keep them for later to save the energy in storage
3. Storage helps with regulation - Minimal reliability benefit



	Short (Hrs)	Extreme Shortage (Hrs)
Future Year Current Operational Strategy	294	98
Future Year New Operational Strategy	26	1.8
Historical Context	11 hrs/ year	2.4 hrs/year

Same Portfolio + New Operating Practice = Better Reliability

Hour of Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.4	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.1	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.5	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.1	0.5	1.6	0.1	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.1	1.2	2.5	0.2	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.6	2.0	4.2	0.1	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.2	1.1	1.6	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.1	0.9	1.4	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.1	1.1	1.2	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.6	0.0	0.0	0.0	0.0

Wrap Up

- Operating Practices Strategy is a next step after Resource Adequacy analysis
  - Incorporates additional system characteristics, uncertainty, granularity
- Operational Reserves ≠ Planning Reserve Margin
- Evaluate and update operational practices with new resource types
  - Possible to evaluate through the framework described herein
- Operational practices around Storage will become increasingly important
  - Potential need for a new Energy Reserve
  - How do you incentivize resource owners to provide the best response?
- Future Work could use this analysis as an input into:
  - Long-term resource planning
  - Daily unit commitment to enable variable reserves strategies dependent upon inputs