Operational Readiness for Inverter-Based Resources

Energy Systems Integration Group – Fall Technical Conference

Scott Anderson | October 25, 2023

Operational Readiness

- **Operational Readiness** is the capability for SRP to operate the future grid **safely**, **reliably,** and **cost-effectively** as intermittent resources are added
- **Operational Readiness Strategy**
  - Clearly and accurately represents what SRP needs to do to operate this new future grid
  - Address the **who**, **what**, **where** and **why** with an emphasis on systems, processes and tools

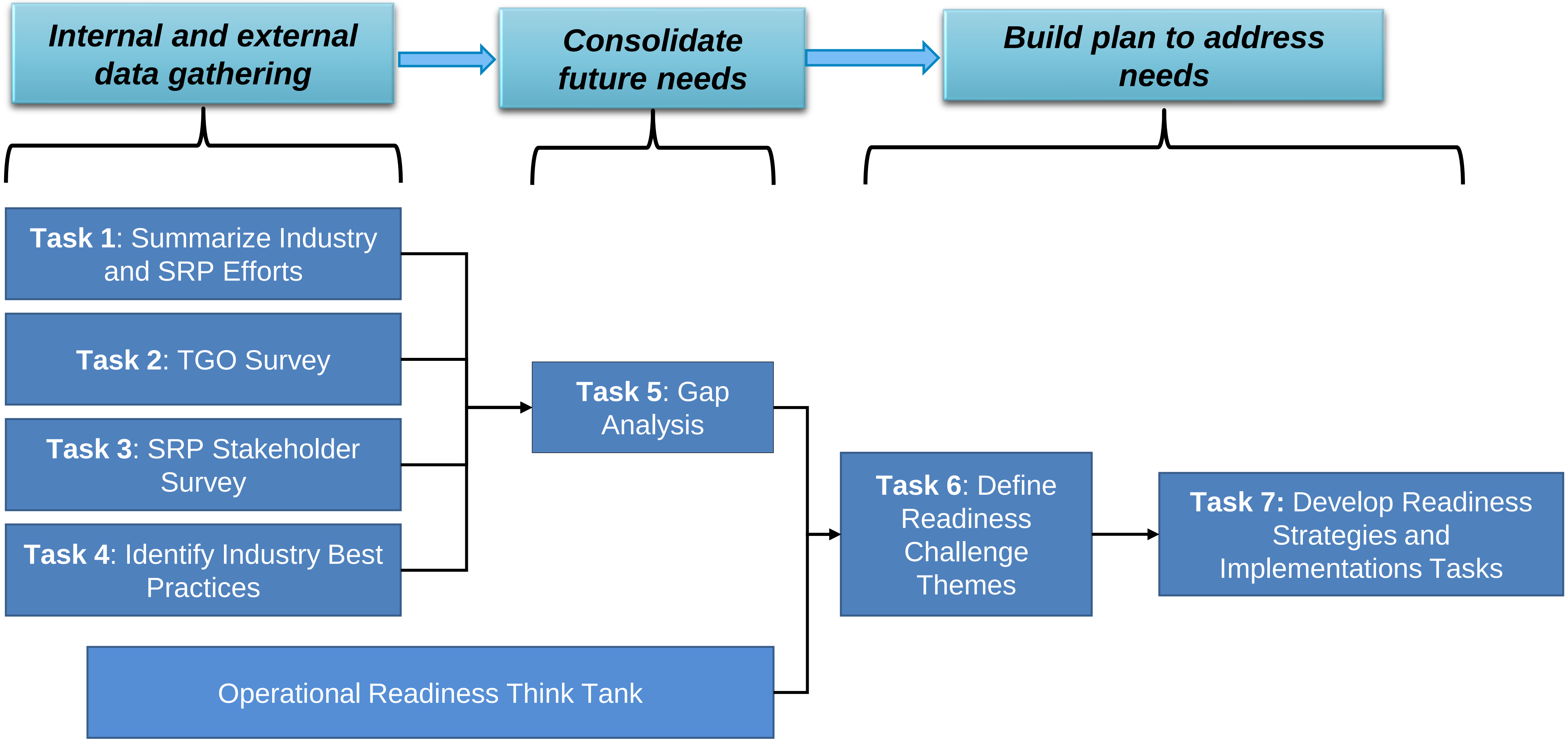
May 03, 2021

SRP to more than Double its Utility Scale Solar to 2,025 Megawatts by 2025

Salt River Project today announced plans to more than double its 2025 utility-scale solar commitment to now add a total of 2,025 megawatts (MW) of new utility-scale solar energy to its power system by the end of fiscal year 2025, driven in part by dedicated customer demand for new renewables. This is more than 1,000MW beyond SRP's original 2025 commitment of 1,000MW, announced in November 2018. As part of this 1,025MW solar increase, 450MW is enabled by an SRP commercial customer to meet its renewable energy commitments. All the renewable energy purchased is expected to be from solar energy developments built in Arizona or on the Navajo Nation and will ultimately be used by SRP commercial and residential customers.

"As we plan for our customers' increasing need for energy and their desire for a cleaner environment, solar energy is a key solution that is significantly growing our sustainable generation portfolio," said SRP's CEO and General Manager Mike Hummel. "Doubling solar purchases over the

Project Approach – Huge Lessons Learned Here



Operational Readiness Themes

Technical Readiness Themes

1. Fully Leverage New Resource Capabilities
2. Economic Dispatch with Solar + Storage
3. Risk-Adjusted Reserve Requirements
4. Advanced Forecasting Tools
5. Software and Situational Awareness

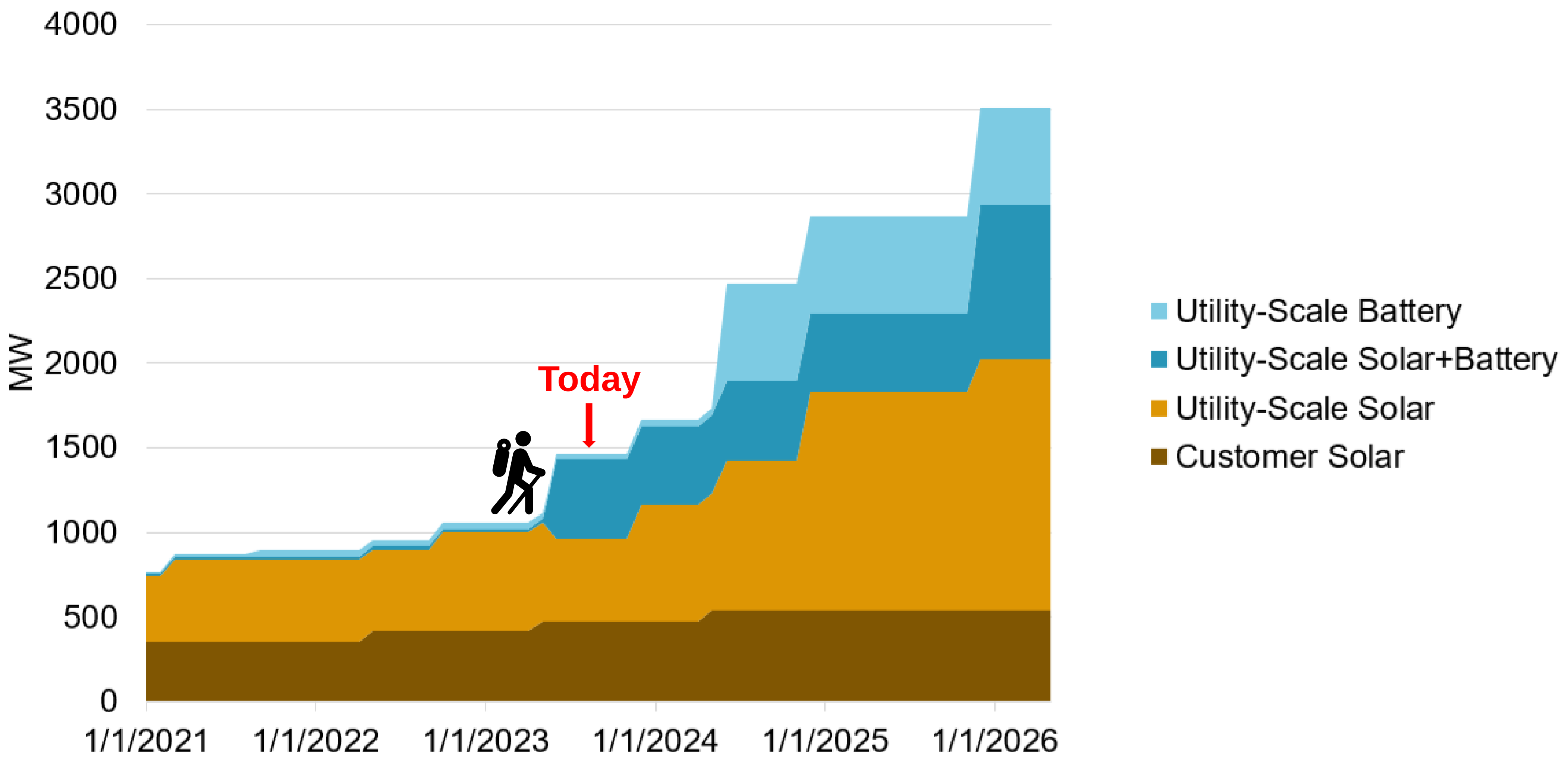
Enabling Themes

- Training
- Key Performance Metrics
- Mission Alignment
- Collaborative Workflows and Feedback

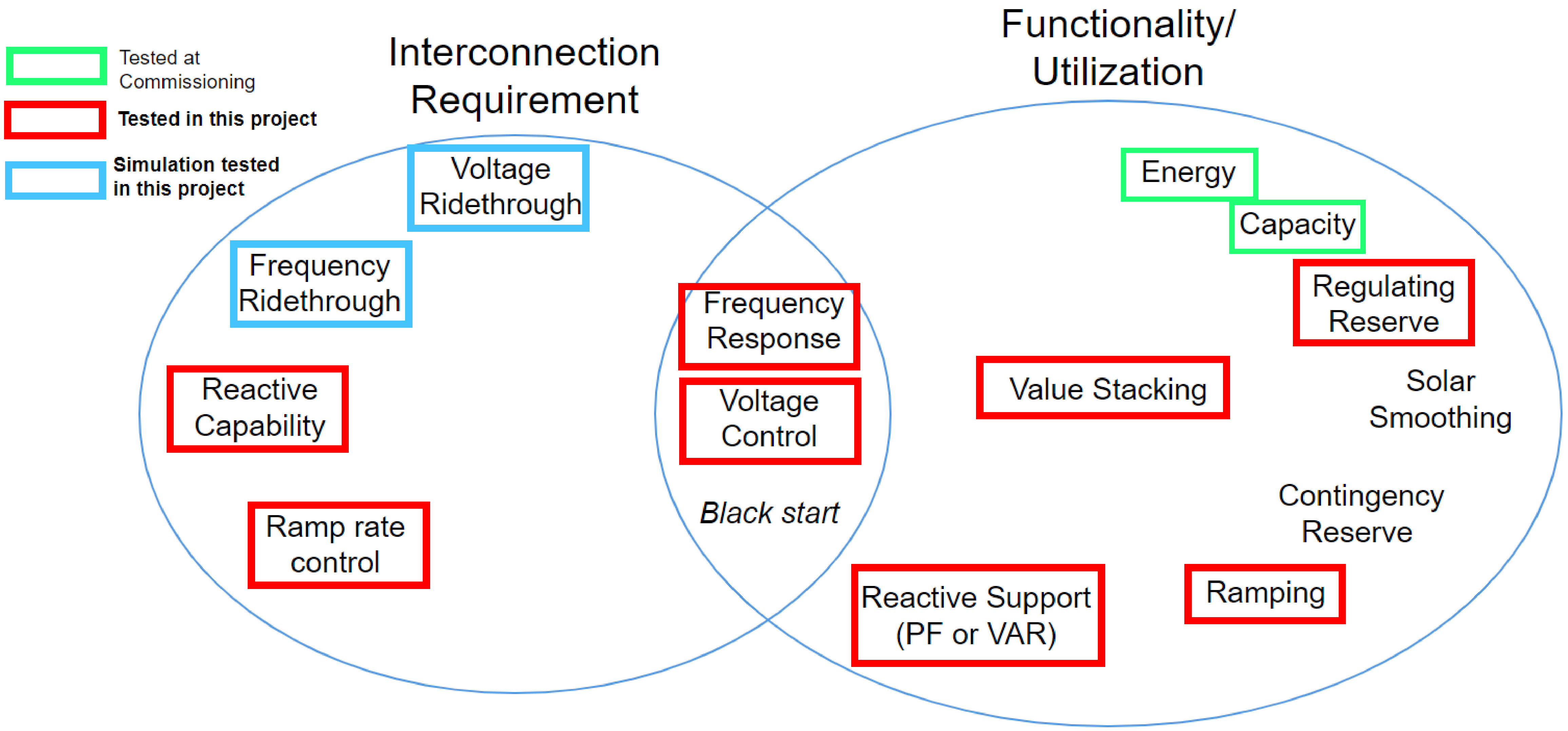
Operational Readiness Projects

Fully Leverage New Resource Capabilities	Economic Dispatch with Solar + Storage	Risk Adjusted Reserve Requirements	Advanced Forecasting Tools	Software & Situational Awareness
1 Enable visibility and physical dispatch (IBR testing and modeling*) 70%	4 Establish IBR dispatch governance* 45%	5 Develop and implement flex reserves capacity 100%	6 Advanced solar forecasting tools (merge w/ 7) * 70%	8 IBR data, communications and displays 40%
2 Add dispatch flexibility to PPAs 80% 3 IBR value stream analysis* 65%	13 PCI/Aurora economic dispatch improvements 50%	15 System variability analysis 90%	7 Solar forecast integration* 70%	9 Intra-hour solar variability 100% 17 Control room IBR video wall 40%
10 TGO renewables desk eval 65% 11 TGO/DOC coordination 80%	14 Fleet ramping capability analysis 60%		16 CAISO load forecasting improvements 35%	18 System power quality & inertia monitoring 40%
12 Inverter technical standards & system protection for IBRs 30%				19 EIM process and tools improvement 30%
21 Improve deployment process for new IBR PPA projects* 40%				20 Software infrastructure improvements 30%

Plausible SRP Solar/Storage Scenario



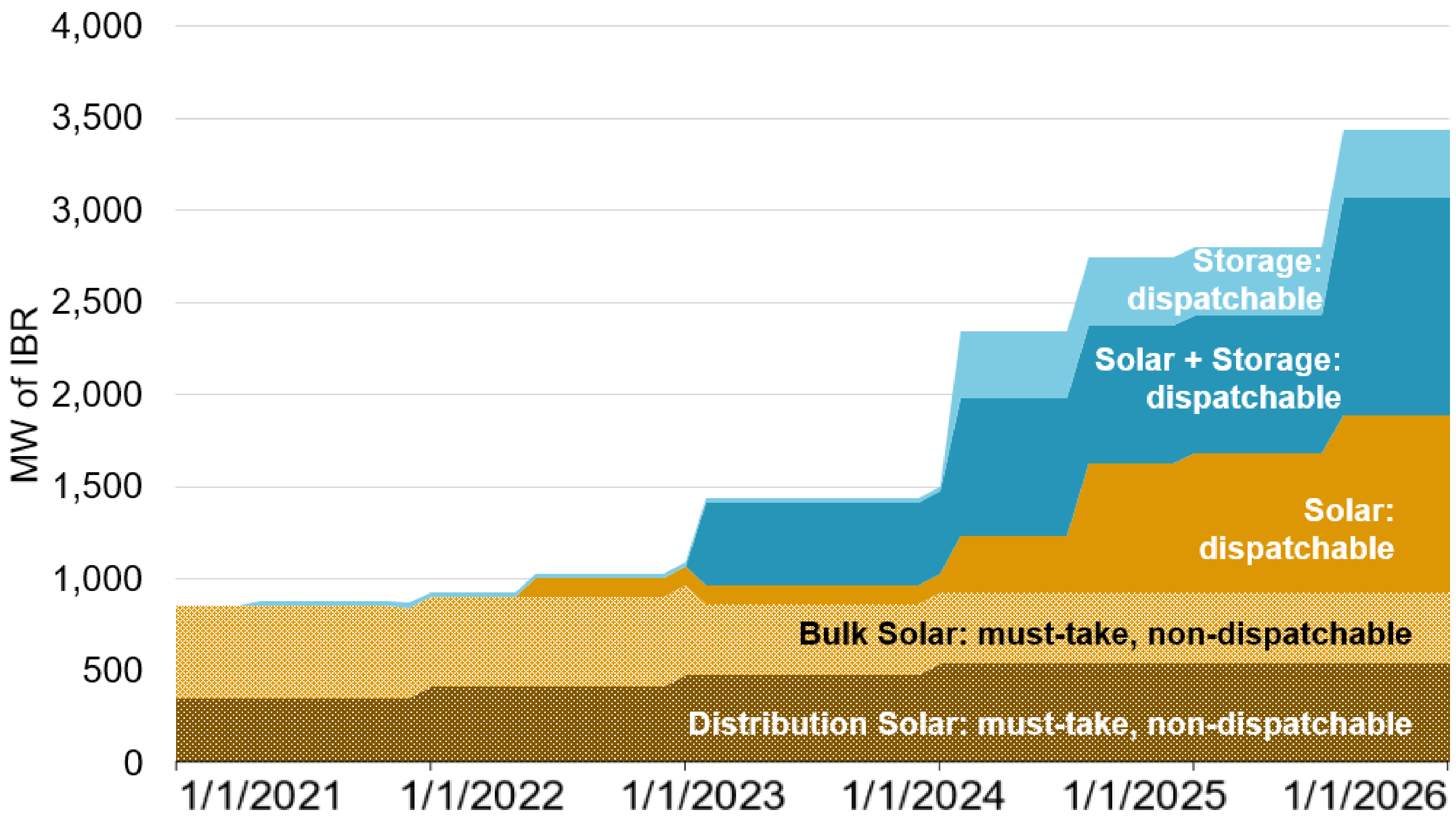
Project 1 – Bolster Testing



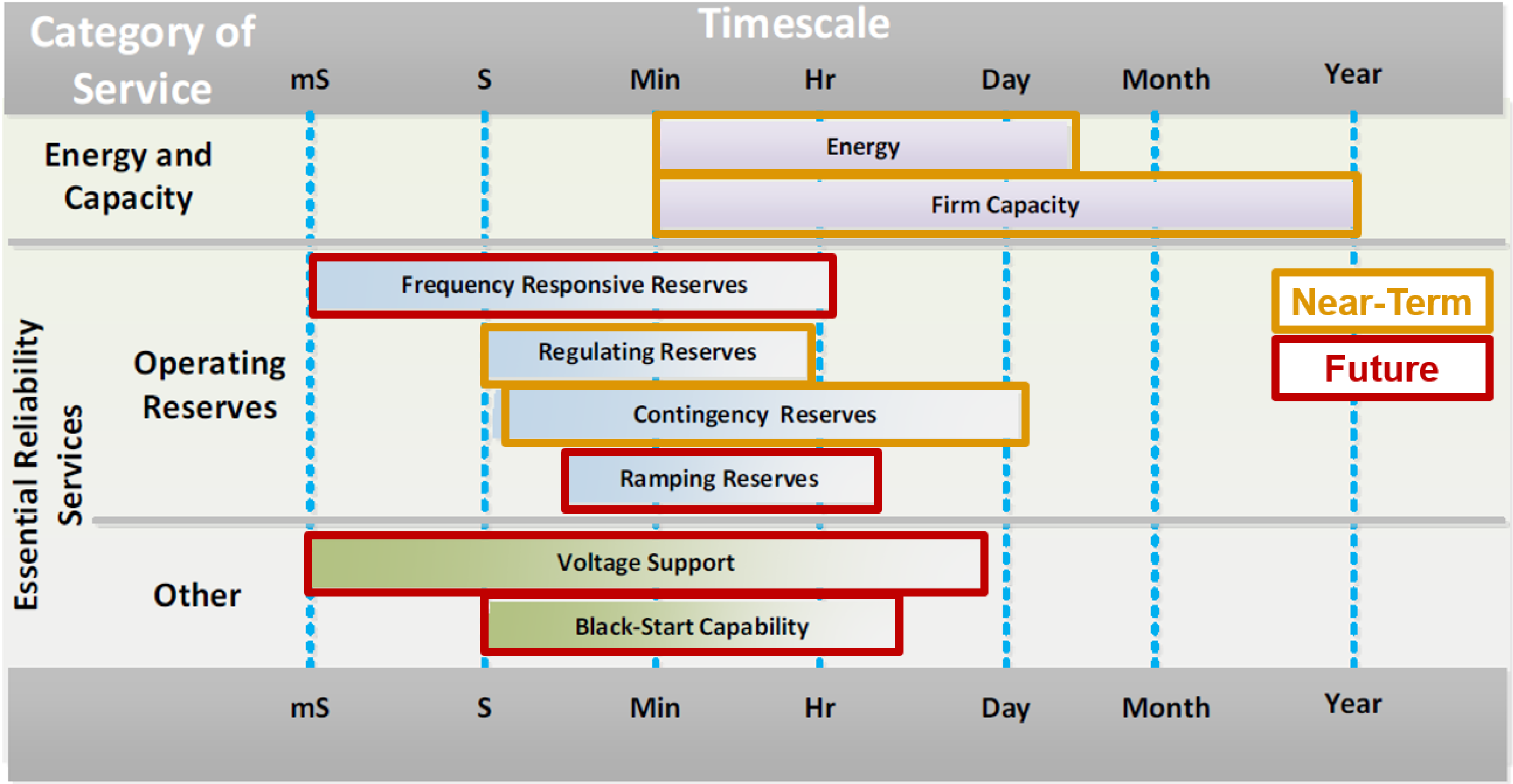
Project 2 – Add Dispatch Flexibility to IBR PPAs

Category		Description	Sample Improvements
1	**Plant Dispatch**	How and by whom plant dispatch is accomplished, and plant operability	• **Specificity about plant dispatch and curtailment being at SRP's discretion and define terms more thoroughly** • Added requirements for voltage, frequency and ride through plant behavior
2	**Telemetry and Control Data Requirements**	The data, control points, and format required to be communicated between the plant and SRP	• **Clarity around required data points and definitions of each** • Revise language to ensure flexibility in delivery point metering locations to reduce complexity in metering calculations/adjustments • Data retention requirements
3	**Communications**	Communication hardware and network requirements to enable SRP/plant com	• Provide preferences for communications protocol for real time telemetry and controls (DNP3) • **Specify frequency of real-time telemetry, aligned to current AGC operations (8 seconds)** • Specify latency of plant response
4	**Forecasts**	Methodology and responsibility for creating and sending plant output forecasts	• Update forecast requirements for 7-day rolling hourly forecast for plant • **Add language to ensure planned outages, plant partial operations and plant tests are considered in forecasting**
5	**Operating Procedures and Dispatch Constraints**	Process and limits by which the plant can be operated and dispatched	• **Add requirements to ensure actual plant output at POI matches schedule** • Improve language to cover notification timing and requirements for outages that are outside of the yearly planned schedule

Project 2 – Future of Dispatch Flexibility

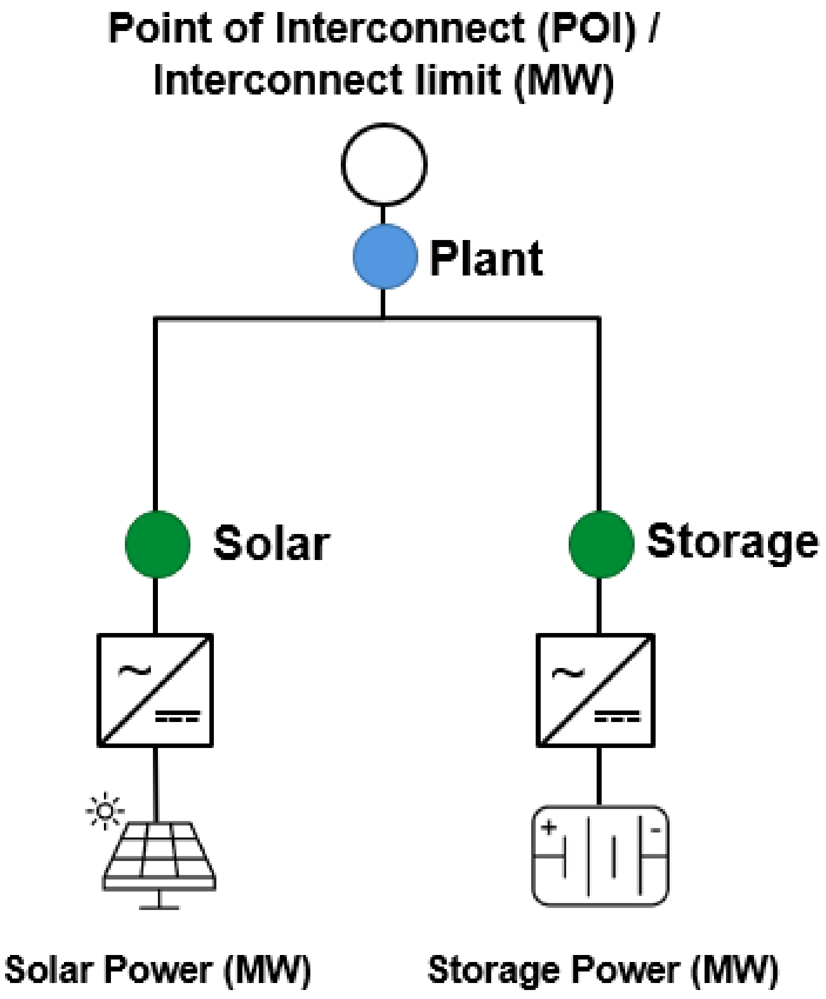


Project 3 – IBR Value Stream



Source: Intro to Grid Services. Jan 2019.

Project 3 – Hybrid or Co-Located Control Configuration



Hybrid

CALCULATED
(by plant controller)

CALCULATED
(by plant controller)

Dispatch

$$Solar + Storage = Plant$$

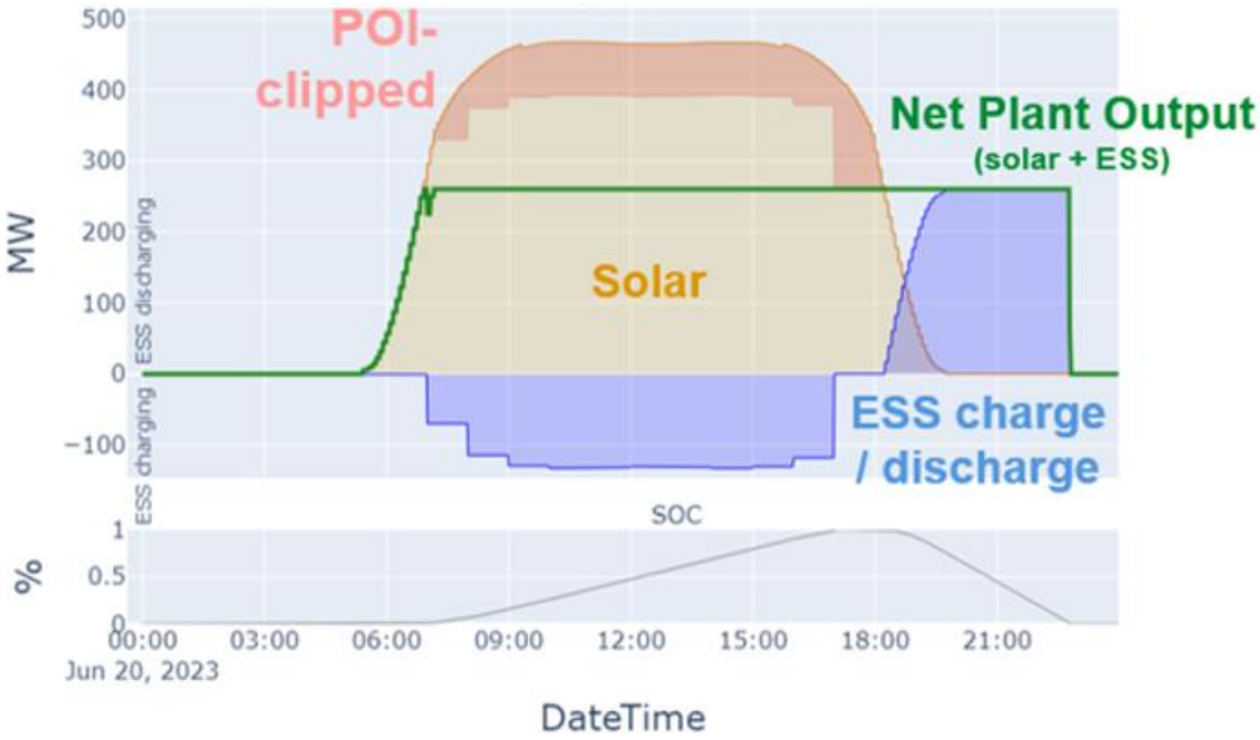
Dispatch

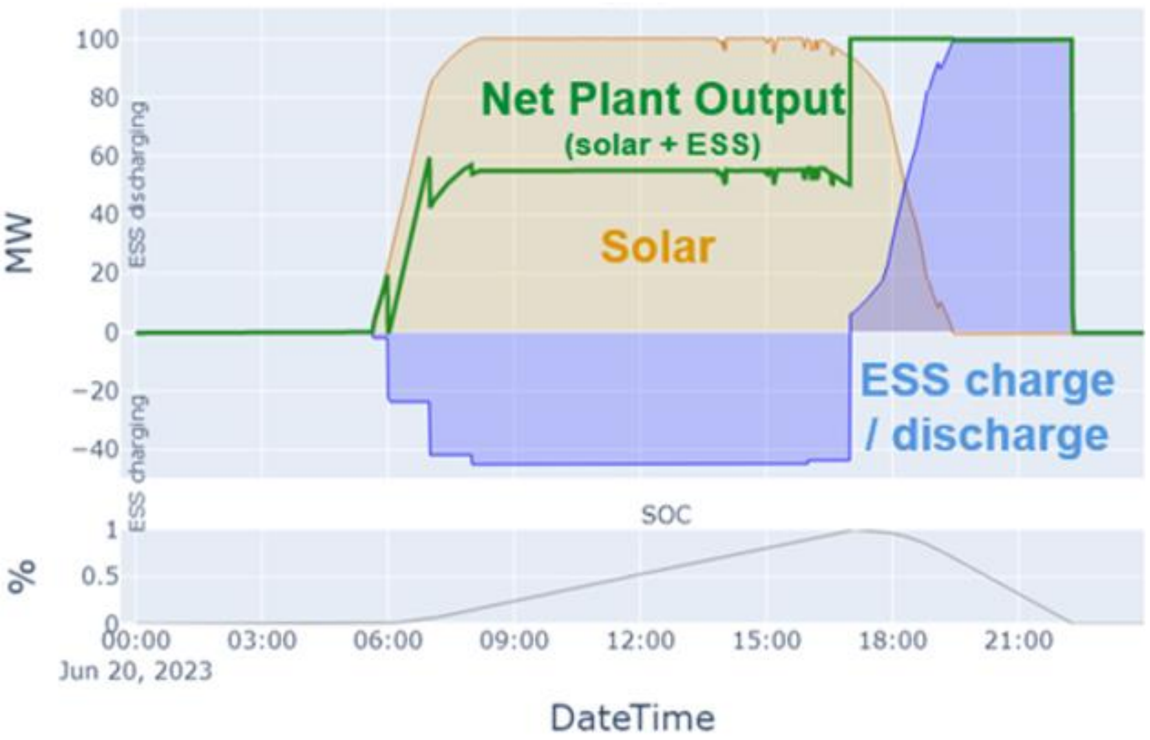
Dispatch

CALCULATED
(by utility EMS)

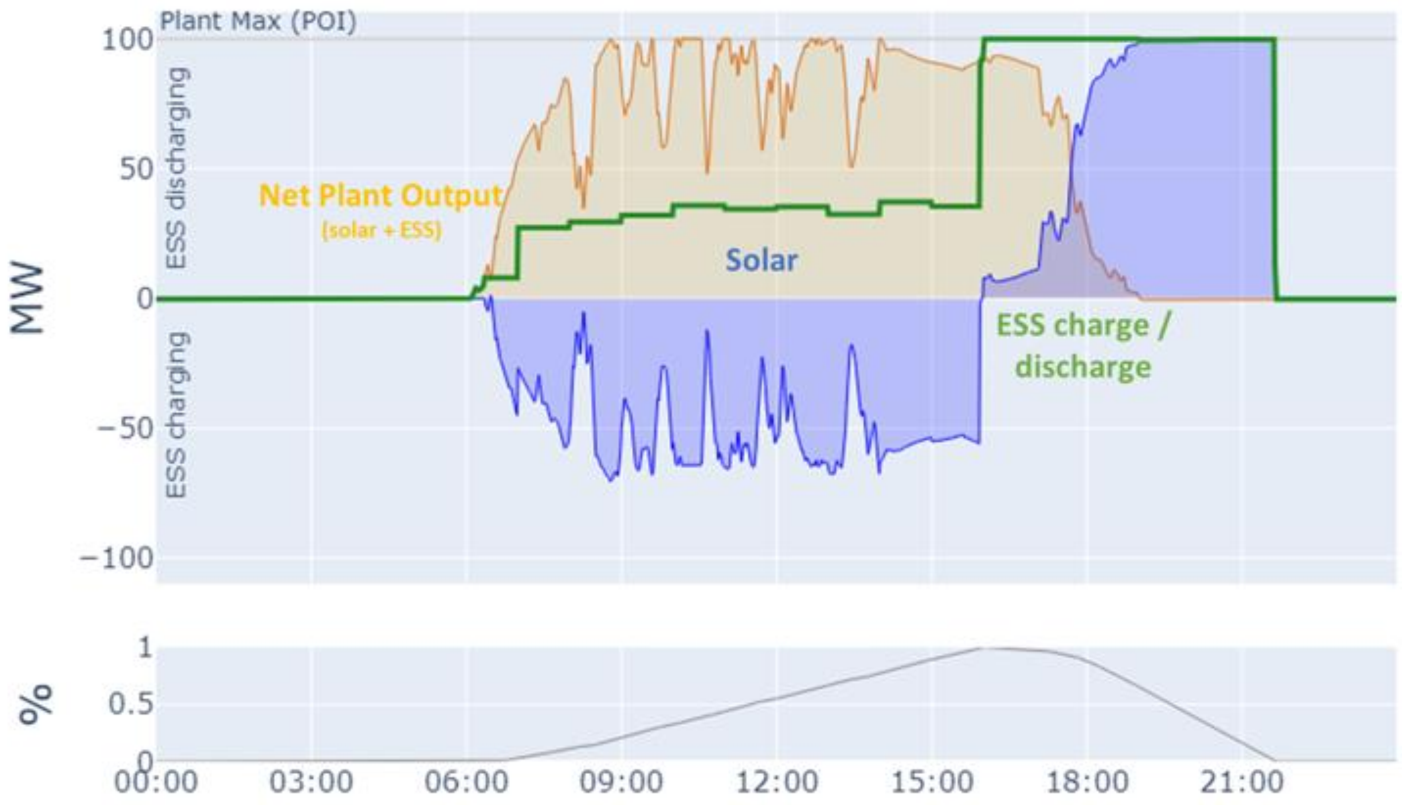
Co-Located

Project 3 – Hybrid Control on a Sunny Day





Project 3 – Hybrid Control on a Not So Sunny Day



Project 4 – Enhance IBR Dispatch Governance

Decision Category	Level	TGO and STF Dir.	IBR Dispatch Gov	Res. Gov.	EIM BPRT	EIM AT	TGO - G	TGO - E	TGO - OCOE	TP	STF - DA	STF - RT	STF - EST	STF - MOS	ACE	PAC	PDTS - BSA	PDTS - EMSS	DS	DO	RA	RP	Ops Plng	SI	Gen Eng	PAS	CMS	Econ. Dev.	SEM	Legal
Applications - Contingent Reserves	1	A	R	C			C	C	I	I	C	C	I	C	I		I	C	I	I	I	I	C	C	I	I		C	C	C
	2	A	R	R			C	R	I		C	C	I	R	I		R	R				C	C		C	C	C	C	C	C
	3		C	C			A	C			R	R	I	C																
Applications - Energy Value	1	A	R				C	C	I		C	C	I	C			I	C	I	I	C	I	C	C	I	I		C	C	C
	2	A	R				C	R	I	C	R	C	I	R	R		R	R			C	C	C		C	C	C	C	C	C
	3		C				R	C			A	A	I	R																
Applications - Frequency Response	1	A	R	C			C	C	I		I	I		I	I			C	I	I	I	I	C	C	I			C	C	C
	2	A	R	R			C	R	I						I			R					C		R		C	C	C	C
	3		C	C			A	C						I	I						I	I								
Applications - Reactive Power	1	A	R				C	C	I								I	R	I	I	I	I			I	I		C	C	C
	2	A	R				C	R	I		I	I	I	I	I		I	R			I	I			I	I	C	C	C	C
	3		C				A	C						I	I						I	I								
Applications - Regulation	1	A	R	C			C	C	I		C	C	I	C	I		I	C	I	I	C	I	C	C	I	I		C	C	C
	2	A	R	R			C	R	I		R	I	I	R	I		R	R			C	C	C		R	C	C	C	C	C
	3		C	C			A	C	I		R	R	I	C	I															
Availability	1	I	R				C	C	A		C	I	I	C							I		C		C					
	2	I	C				C		A		C	C		R									C		C					
	3		I				I	I	A		C		I	R								I	R		I	I				
Markets and trading	1	C	R		A	R	C	C	I		C	C	I	C	I		I	C	I	I	C	I	C		I	I		C	C	C
	2	I	I		I	A	C	R	R		R	C	R	A	I		R	R			I	C	R	C	R	R	C	C	C	C
	3		C		C	C	R	C	I		R	A	I	C	I		I				I	I	C		I	I				
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	3		C				I	I	I		I	A	I	C							I	I	C							
Solar curtailment	1	A	R				C	C	I		C	C	I	C	I		I	C	I	I	C	I	C	C	I	I		C	C	C
	2	A	R	I			C	R	R		C	I	I	R			R	R			R	C	R		C	C	C	C	C	C
	3		C				A	C			R	R		C	I						I	I	C							
Control Strategy	1	A	R	I	I	C	R	C	I	I	C	C	I	C	I		C	C	I	I	C	I	I	I		I	I		I	
	2	A	R		C	C	R	C			R	R		R			R	R			C			C			C			
	3		I	I	I	I	A	I			R	R		R			I	I					R	I						

Project 5 – Flex Reserves

Current Reserves Strategy

- Reserves are a mix of NERC Standards and BA discretion
- Operating reserves at SRP are determined through annual review in collaboration with TGO and STF

Reserve	Quantity (MW)
Contingency	250-550
Frequency	31
Replacement	395
Reg Up	100
Reg Down	50

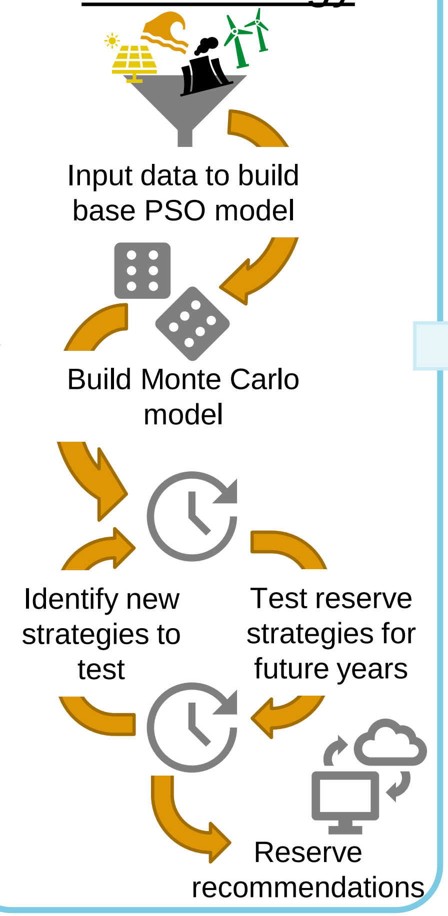
Modeled Years

Past Baseline Year

Post Solar Year

Post Coal Closure Year

Methodology



Reserve Changes

- Increase regulating reserves as solar intermittency increases diurnally (algorithm based)
- Establish a Reserves Governance Committee
- Evaluate/implement new tools
- Integrate consistent reserves approach across SRP
- Incorporate dynamic reserves
- Maximize battery storage

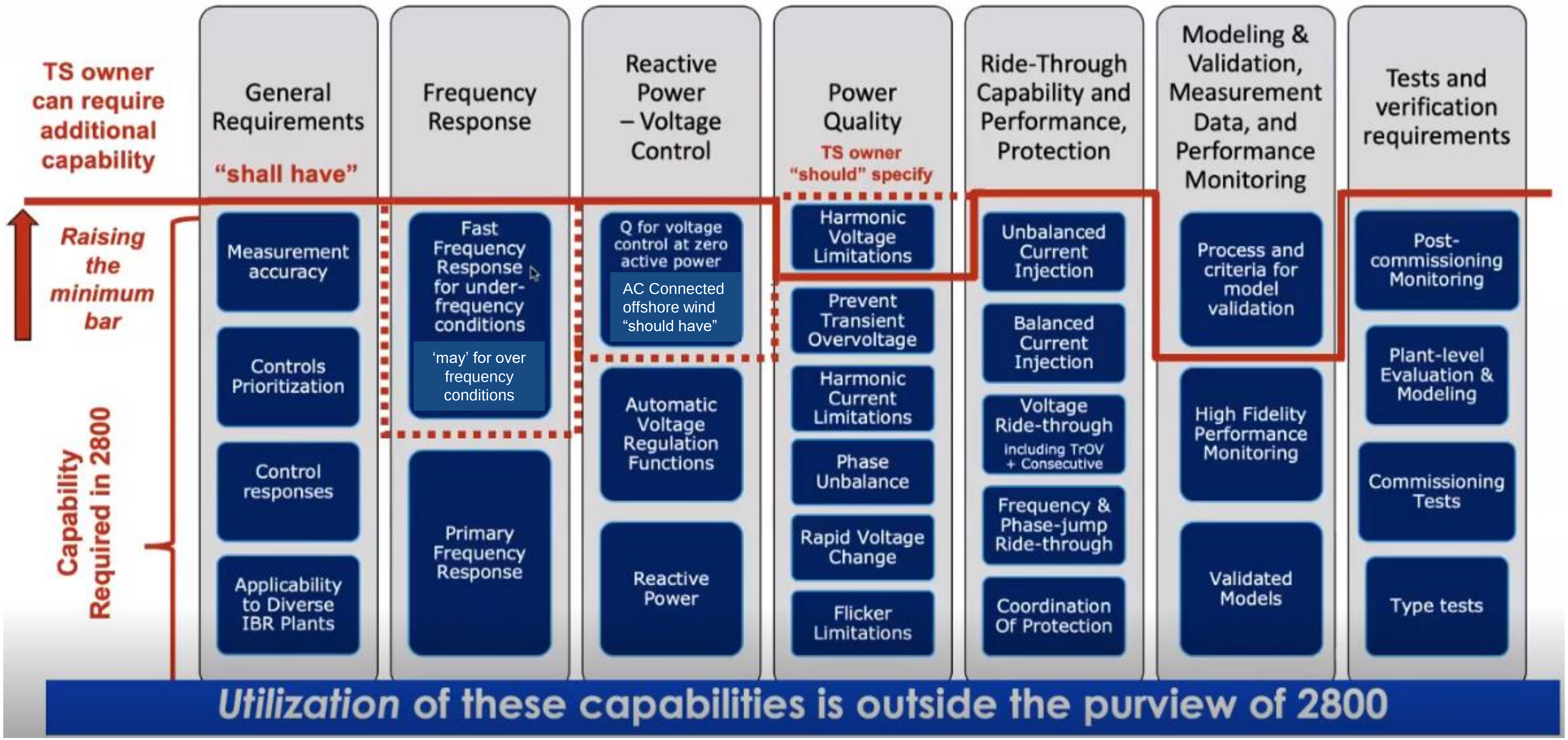
Project 6/7 – Solar Forecasting Improvements

Early 2022	Today
9-12% Day-Ahead Error (2022)	**6-9%** Day-Ahead Error (2023)
6-8% 5-minute Error (2022)	**5-6%** 5-minute Error (2023)
No Direct Forecast Involvement	Implementing SRP-Internal Data Infrastructure
CAISO Hybrid Requirements Not Defined	Hybrid Forecasts & Dynamic Limit Readiness
No Probabilistic Forecasts	Hourly and 5-minute Confidence Intervals
Single Site Meteorological Station Data	Meteorological Station Data on Points Template
Minimal Vendor Collaboration	Biweekly Forecast Improvement Meetings
Minimal Peer Utility Collaboration	Local & National Collaboration
Research Indirectly Targets Forecasts	Research Specifically Targets Forecasts
Single Employee Point of Failure	Actively Hiring Additional Talent
“Forecasts are just Data”	Actively Engaging the Organization in Forecasting

Source: Intro to Grid Services. Jan 2019.

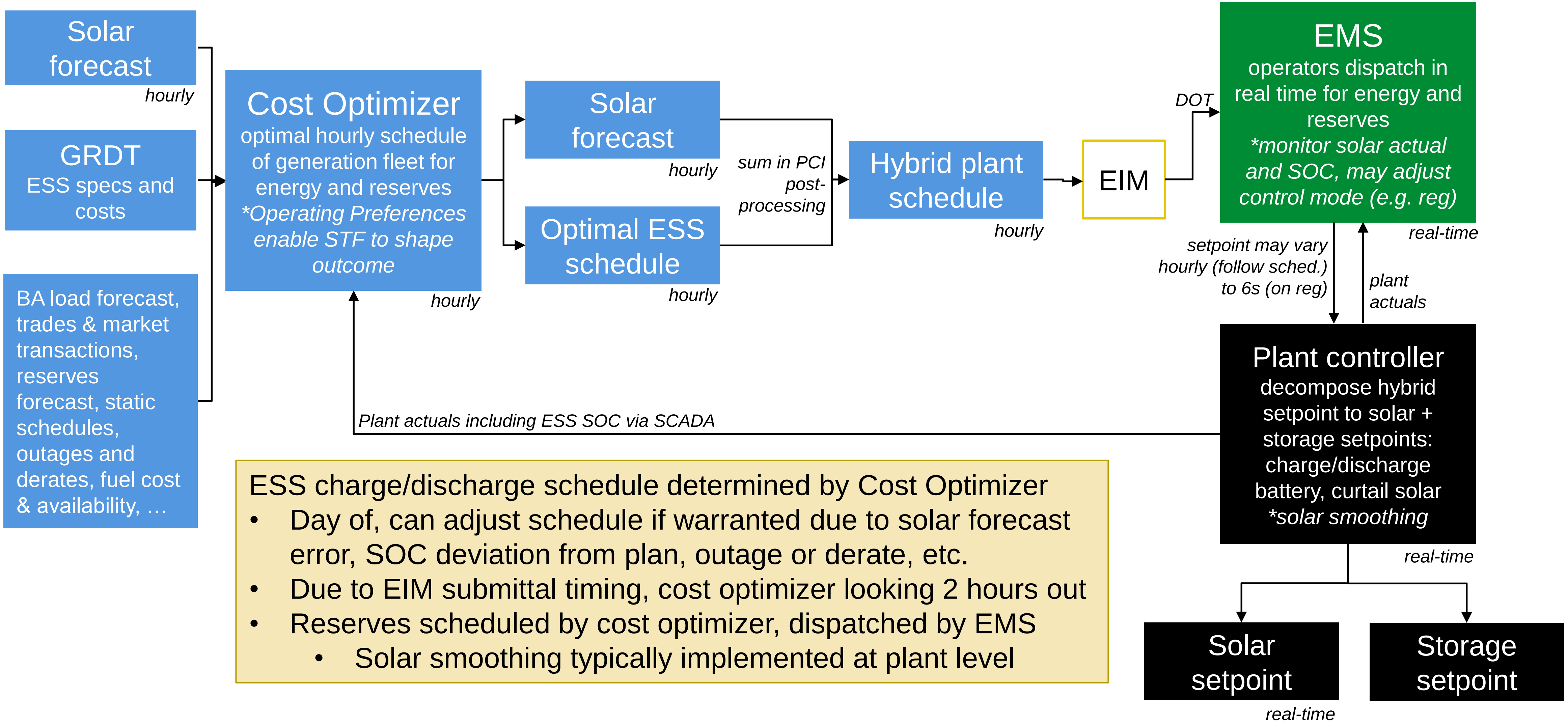
Project 12a – Inverter Technical Standards

IEEE 2800 Standard - Interconnection/Interoperability of IBR w Transmission



Source: EPRI

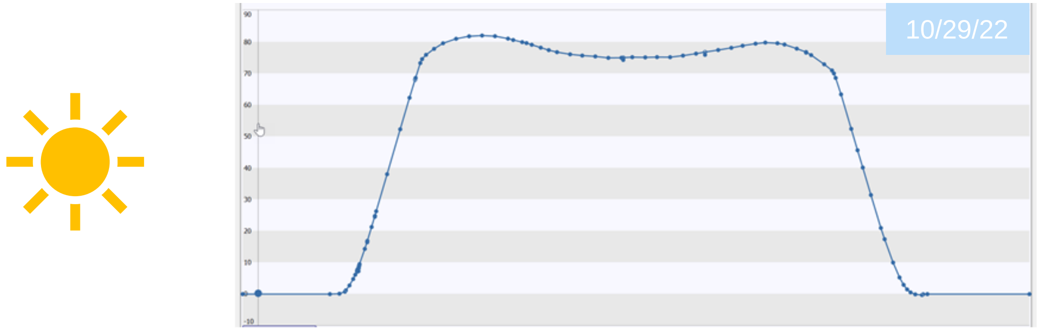
Project 20 – Software Infrastructure Improvements

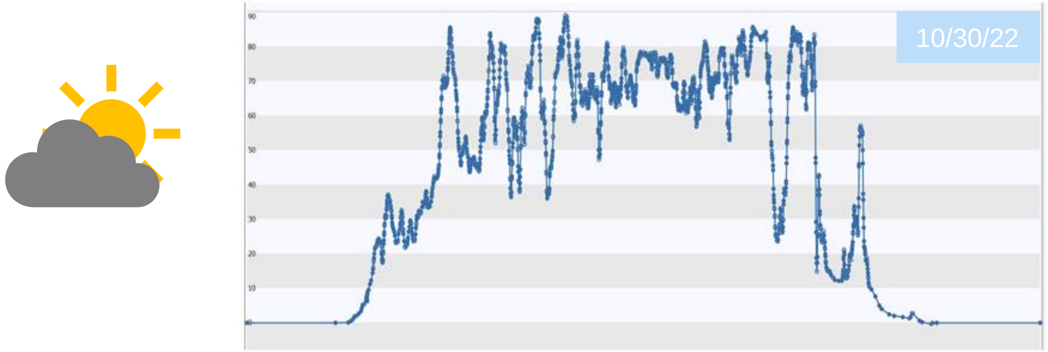


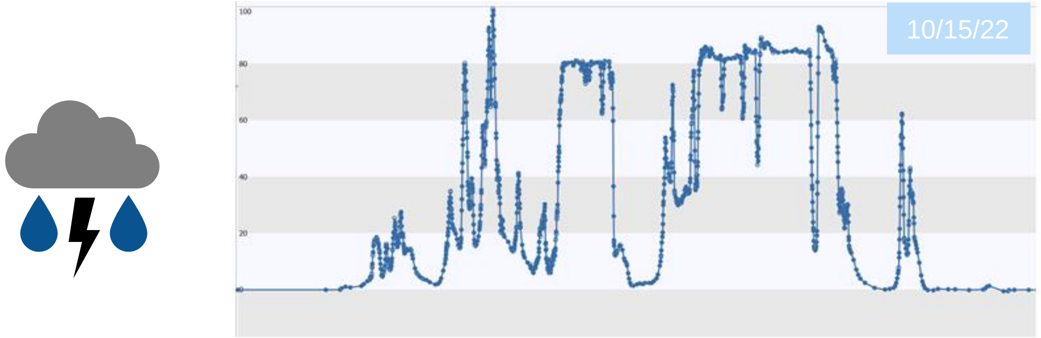
ESS charge/discharge schedule determined by Cost Optimizer

- Day of, can adjust schedule if warranted due to solar forecast error, SOC deviation from plan, outage or derate, etc.
- Due to EIM submittal timing, cost optimizer looking 2 hours out
- Reserves scheduled by cost optimizer, dispatched by EMS
  - Solar smoothing typically implemented at plant level

Operational Readiness Challenge







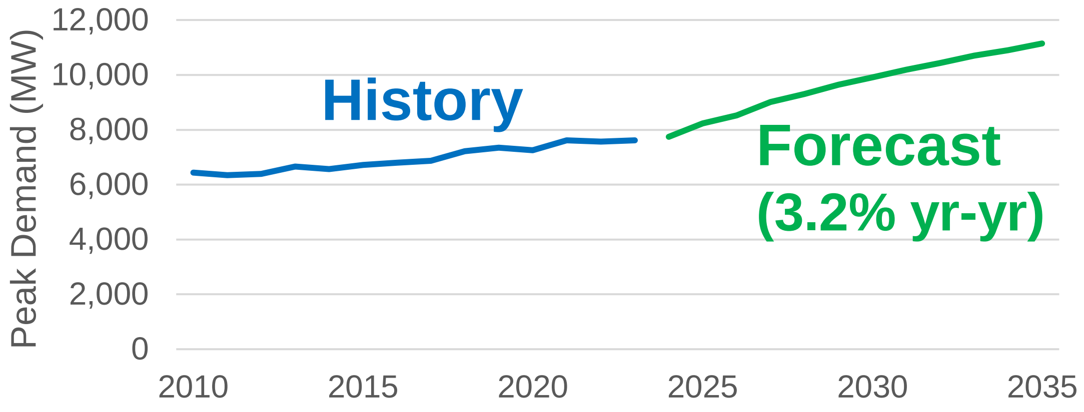
*Analyzing and responding to the **variability** and the **uncertainty** of solar energy are at the core of the Operational Readiness challenge* thank you!

Appendix

Our Drivers for Increased Levels of Renewables

Transformative trends

- Public awareness of utilities' societal impact
- All sectors of economy adopting environmental programs
- Evolution in customer expectations
- Remarkable growth amid an accelerated energy transition



SRP Corporate Goals

- Take meaningful action to address climate change
- Reduce SRP's carbon emissions by 65% from 2005 levels by 2035

1300 MW of coal retired since 2005

Another 1300 MW announced coal retirements by 2035

Gaps Identified

GENERATION	TOOLS	PEOPLE
Dispatchability	Forecasting	Training
Reserves	Situational Awareness	Expertise
Grid Services	Analysis	Collaboration & Feedback
New Technology	Software Integration	Mission

Theme 1: Fully leverage new resource capabilities

Key Challenges

- **Physical dispatch** of solar is essential for energy and ancillary services
- Not all solar can be must-take
- **Value streams** must be defined/agreed upon
- **Ideal configuration of resources** needs to be identified
- Enable and apply the **full technical capabilities of inverters**

Peer utility dispatch examples

- ***Utility 1:*** All future solar connected to AGC/EMS to adjust settings based on system conditions.
- ***Utility 2***: Reworking existing PPAs to be fully dispatchable via AGC/EMS.
- **Utility 3:** Changing hybrid configurations to maximize value streams.
- ***Utility 4***: Standing up Distributed Energy Resource / Renewable Operations Center. Will receive dispatch signals from AGC; will then “re-dispatch” the renewable fleet to meet AGC command.

Theme 2: Economic dispatch with solar + storage

Key Challenges

- **Economic dispatch** tools should include solar and storage in model that co-optimizes energy and reserves
- Tools should be consistent with actual dispatch processes and constraints
- Real Time operators need **information in real time** about economic impact of dispatch decisions

Peer utilities have not yet implemented economic dispatch of solar and storage for energy and reserves

- ***Utility 1:*** storage used for peak load serving, may consider reserves down the road.
- ***Utility 2:*** small batteries now focused on ancillary services, will have larger storage system for regulating and arbitrage in 4-5 years.
- ***Utility 3*:** battery storage pilot focused on reserves.

Theme 3: Risk-adjusted reserve requirement

Key Challenges

- Analytical process needed to **characterize evolving variability** as a function of system conditions
- Integrated process needed for making risk-based adjustments to **right-size reserves** for system conditions
- Reserves need to accommodate for changes in intermittent resources

Peer utilities have developed flex reserves strategies that reflect specific observed system variability

- ***Utility 1:*** contingent reserves scale with MW wind online and regulating reserves scale with MW solar online.
- ***Utility 2:*** flex reserves per operator discretion, generally 50% MW wind online and 30% MW solar online.
- ***Utility 3:*** additional reserve at 50% when online renewables up to 400 MW.
- ***Utility 4:*** additional 2% contingency reserves at peak.

Theme 4: Advanced forecasting

Key Challenges

- Existing **solar forecasting** tools are **inaccurate**
- **Higher accuracy**, more granular solar forecasting for intermittency is needed
- Quantify Distributed Energy Resources
- **Inaccuracy of load forecasting** and real time challenges this creates

Peer utilities are implementing a combination of in-house and commercial tools – no one-size-fits-all

- ***Utility 1:*** forecasting group analyzed historical wind output and developed / refined in-house forecast over years.
- ***Utility 2:*** developed in-house tool to accurate predict renewable output during “volcanic fog” events.
- ***Utility 3:*** uses three forecast tools for 5-min forecast; then adjusts forecasts based on historical error seen on their system.
- **Utility 4**: uses an algorithm to calculate distribution resources.

Theme 5: Software & Situational Awareness

Key Challenges

- Software “ecosystem” continues to evolve and be more complex
- Little standardization between critical systems
- Software redundancies and overlap
- Manual data transfer
- Systems need to provide state of the art situational awareness

Peer utilities are implementing new software and situational awareness tools to visualize resource intermittency and help operators make better decisions

- ***Utility 1:*** New alarms for operators related to changes in solar/wind resources. New visualization of intermittent resources on digital map boards in control room.
- ***Utility 2:*** monitors system inertia levels and has operating practices and remedial action schemes in place to respond if inertia gets below specified thresholds.
- **Utility 3**: Aggregation of data from revenue meters, power quality monitors and synchrophasors for analysis of resource performance.

Questions

Contact Information

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