Integrating ESRs into Electricity Markets:

Real-Time Co-optimization Plus Batteries (RTCB)

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Agenda

- ERCOT ESR background information

  Where are we? How did we get here? What does the future look like?

- Overview of the RTCB scope and specifically the “+B” changes

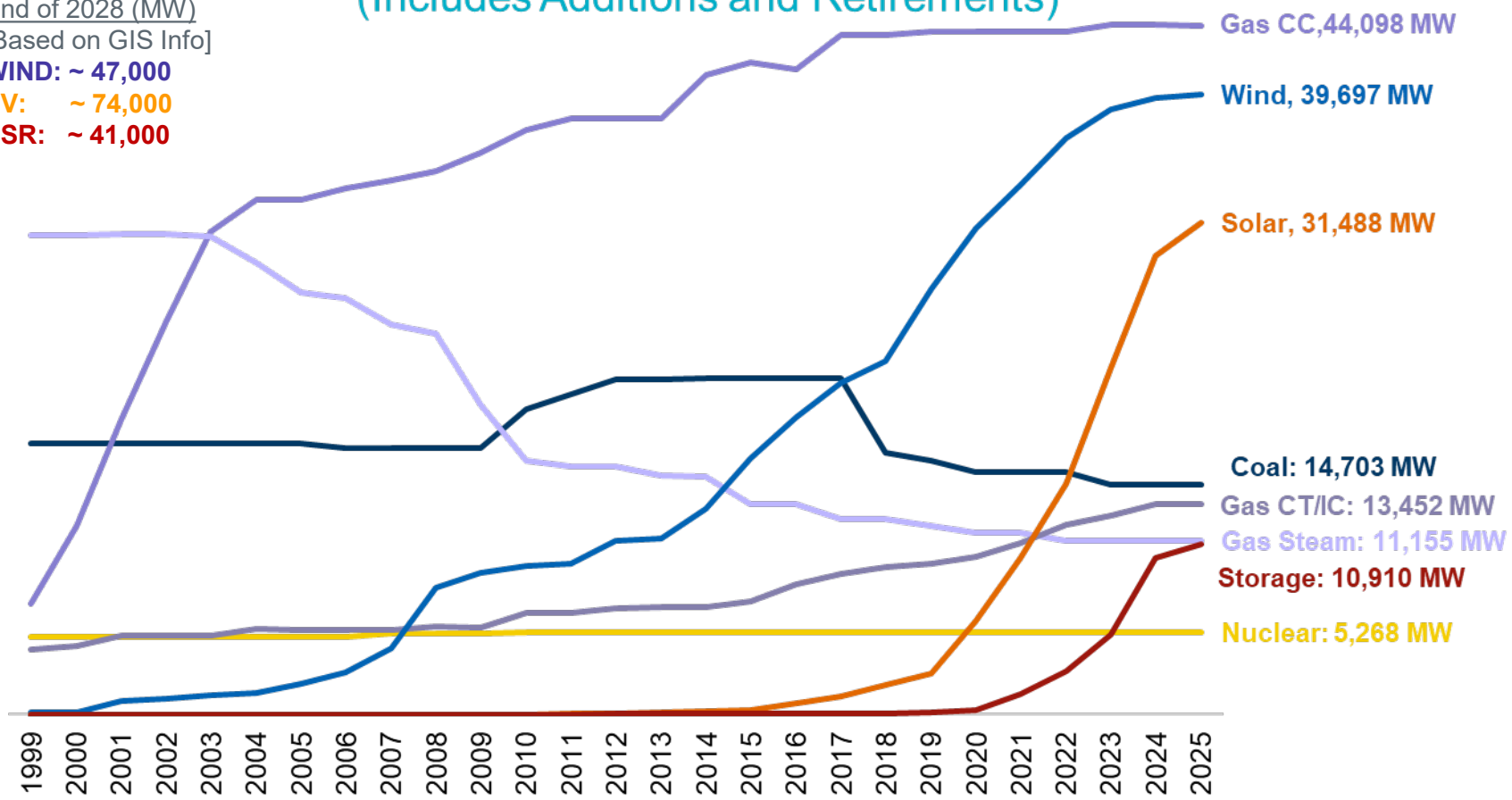
- High-level review of the “Final State” with the “+B” changes (along with RTC)

- Specific topics/details
  - Registration, qualification, and modeling
  - Day Ahead Market
  - Real-Time Market
  - EB/OCs, COP information, and telemetry
  - Set point deviation (SPD)
  - Reliability Unit Commitment (RUC) and exposure to being short

ERCOT Installed Net Generation Capacity (as of April 1, 2025)

(Includes Additions and Retirements)

End of 2028 (MW)
[Based on GIS Info]
WIND: ~ 47,000
PV: ~ 74,000
ESR: ~ 41,000



Notes:
- Capacity totals are based on the Installed Capacity Ratings for generating units. Biomass, Hydro, and Diesel were excluded from chart due to capacity being below 1 GW. Planned generation projects are added to installed capacity after approval for synchronization to ERCOT Grid. Totals include Private-Use Network generators that export to the ERCOT grid, Distribution Generation Resources (DGRs), Settlement-Only Distribution Generators (SODGs), Unavailable Switchable Capacity, Extended Outage Units, and Seasonal Mothballed Units but not Indefinite Mothballed Units.

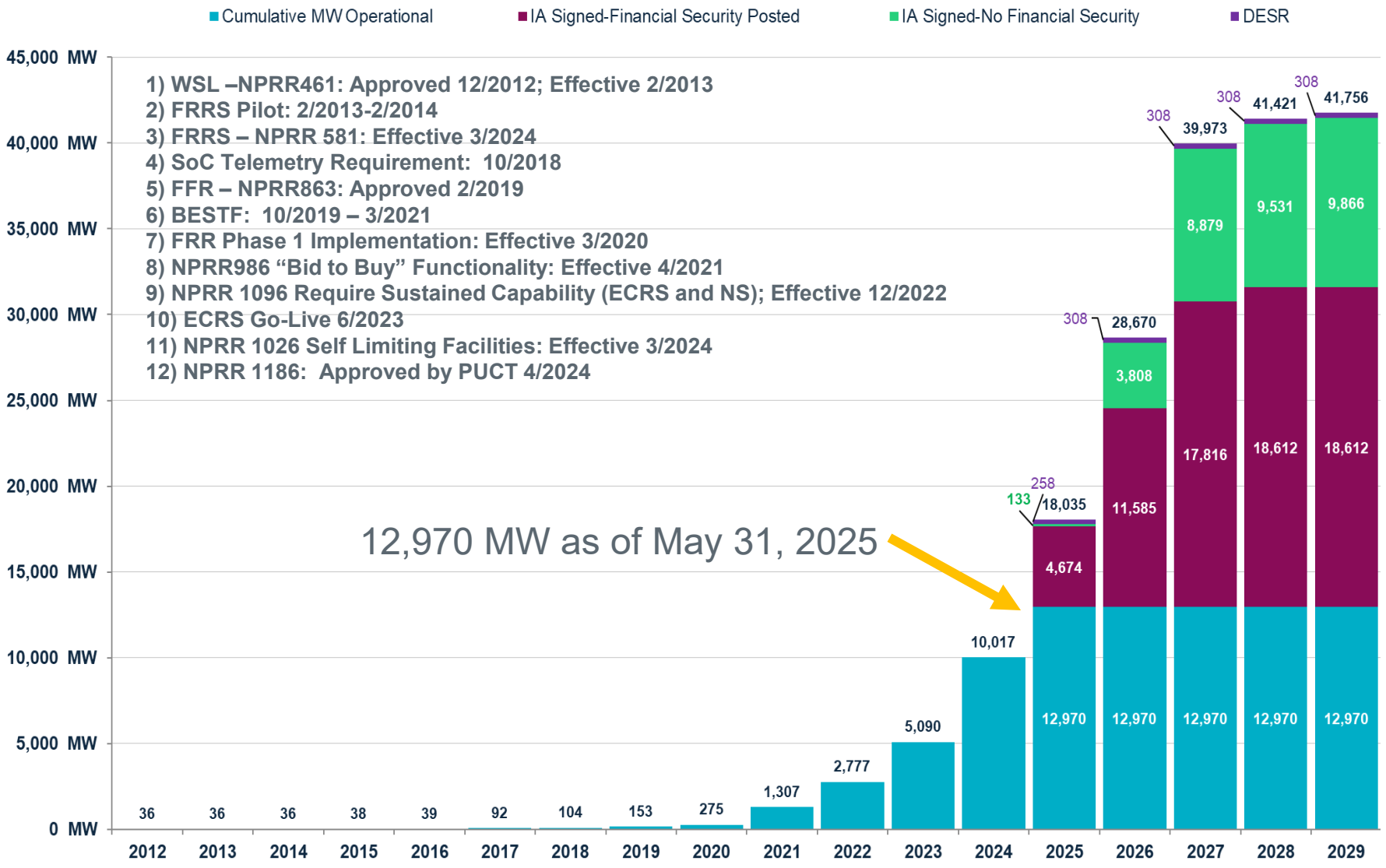
Summary of Generation Interconnection Requests (run date 6/1/25)

Fuel Type/ Technology Type	SS and FIS Completed IA (MW)	Grand Total In Progress (MW)
Combined Cycle	785	10,873
Combustion Turbine	1,158	18,443
Steam Turbine	14	1,349
ICE (Internal Combustion Engine)	565	1,824
Wind	5,893	**40,885**
Solar	30,101	**158,490**
Compressed Air Storage	0	0
Battery	19,015	**174,597**
Other (Includes Pumped Hydro 1,232 MW)	0	3,208
Total	57,531	409,669

The battery total of 174,597 MW includes requests of 417 MW of distribution connected.
It does not include requests of batteries planned at a “Self-Limiting Facility.”
SS = Security Screening Study
FIS = Full Interconnection Study
IA = Interconnection Agreement

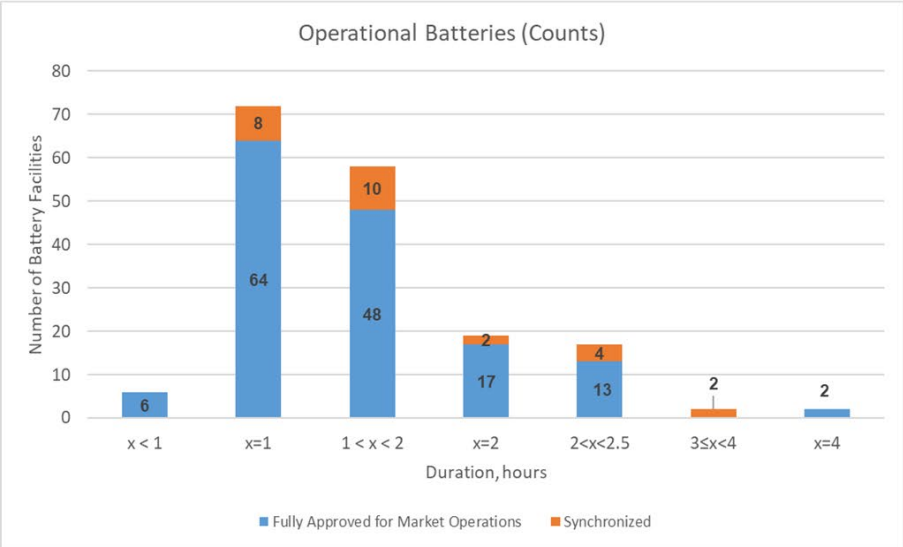
Report Run Date	Battery Qty
Dec 1, 2024:	156,730 MW
Dec 1, 2023:	124,941 MW
Dec 1, 2022:	78,746 MW
Dec 1, 2021:	46,946 MW
Dec 1, 2020:	21,404 MW
Dec 1, 2019:	7,214 MW
Dec 1, 2018:	2,048 MW

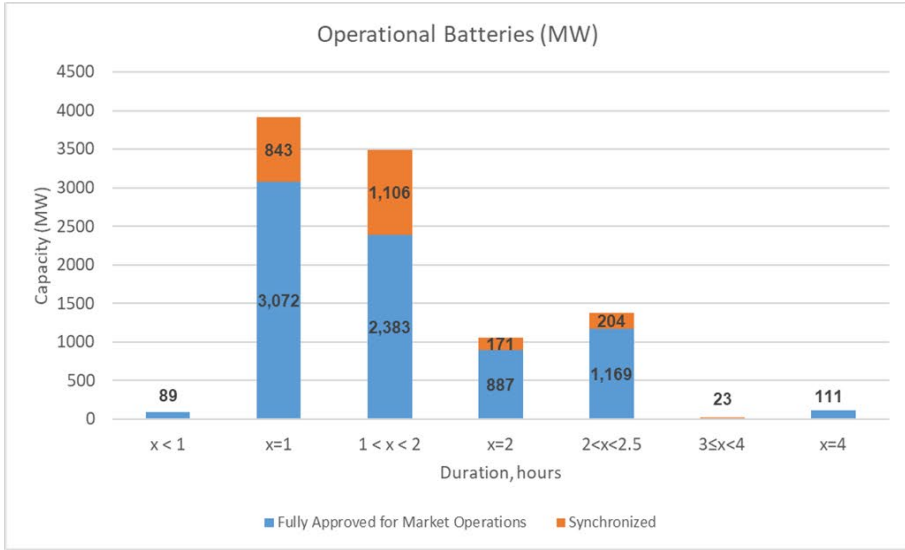
Battery Additions by Year (as of May 31, 2025)

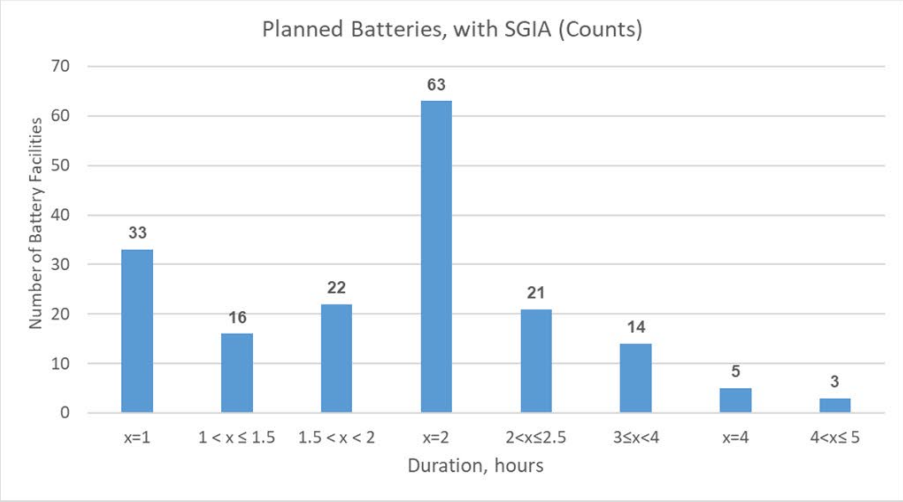


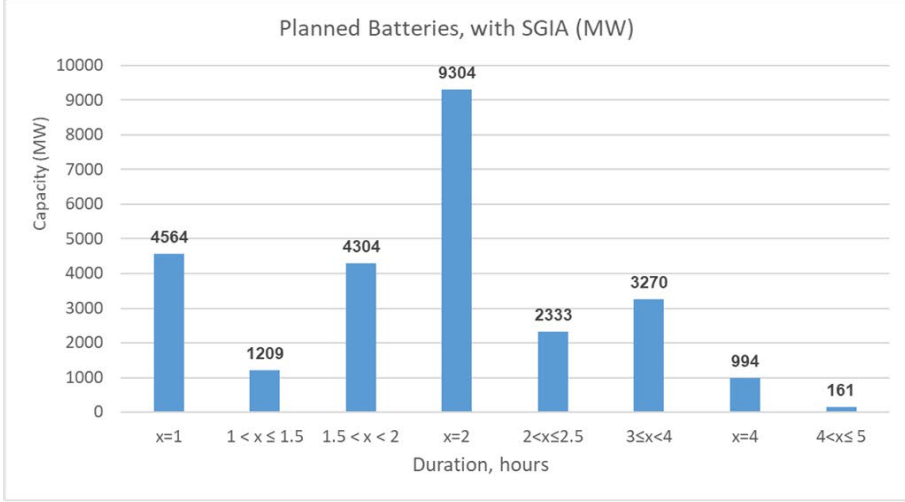
Dec 2024 CDR: 63 DESRs Total = 628 MW. September 2019 DGR moratorium lifted Jan. 4, 2022

Duration Information (Based on Feb 2025 GIS Report – posted 3/6/25)

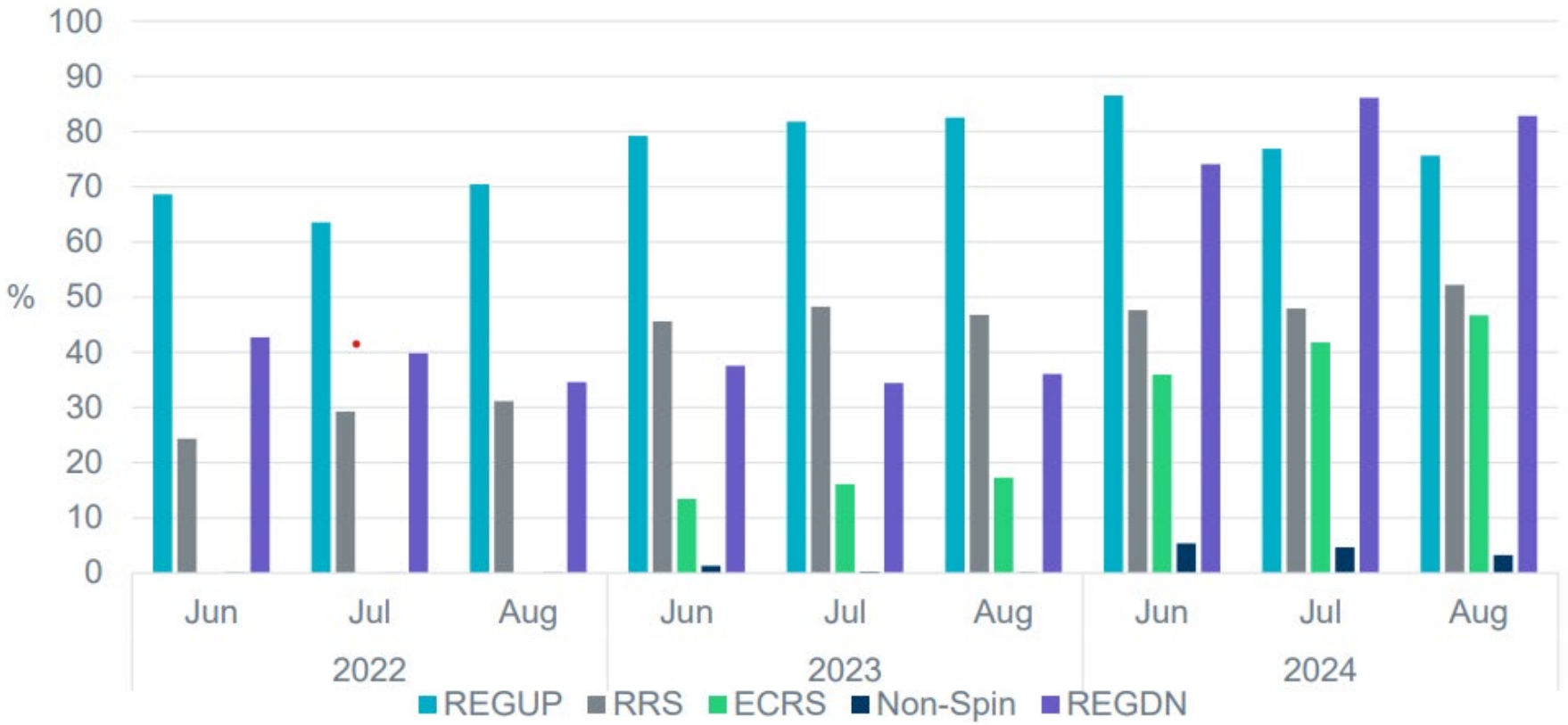




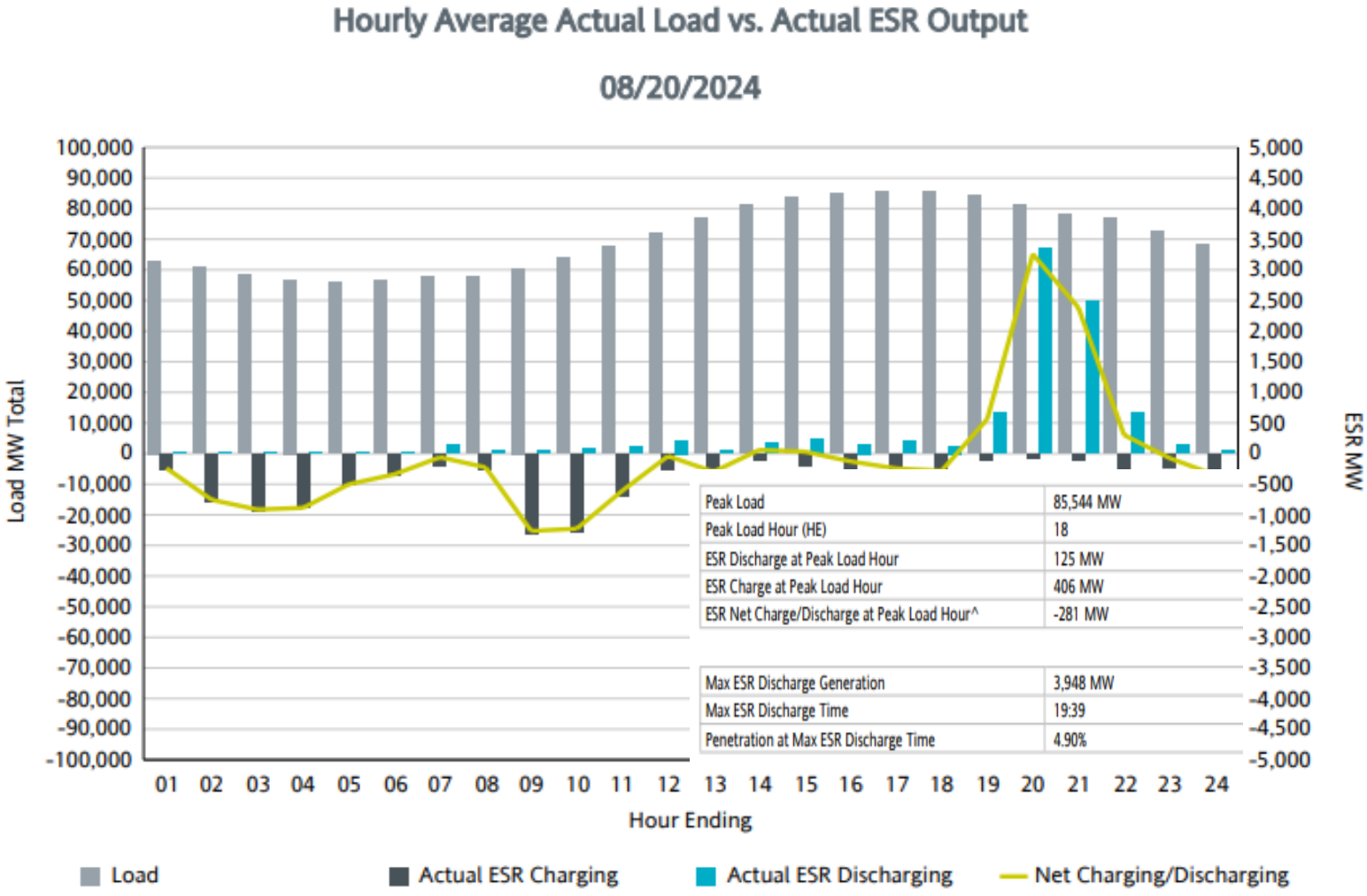




Energy Storage Resource (ESR) Percent of Total System-Wide Ancillary Service Procurement in Day-Ahead Market (DAM)

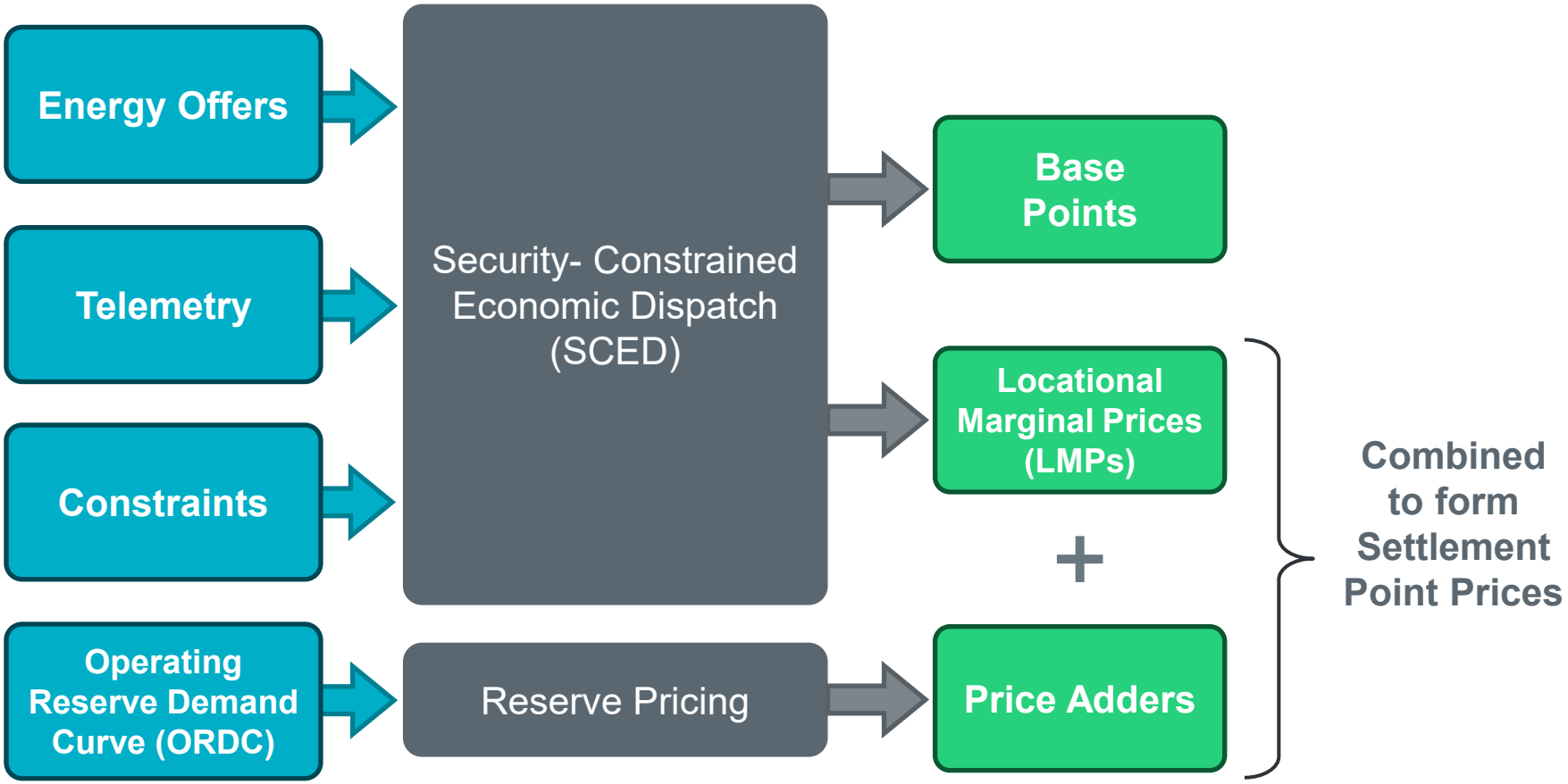


ERCOT-wide Load and Energy Storage Resource (ESR) Injection and Withdrawal



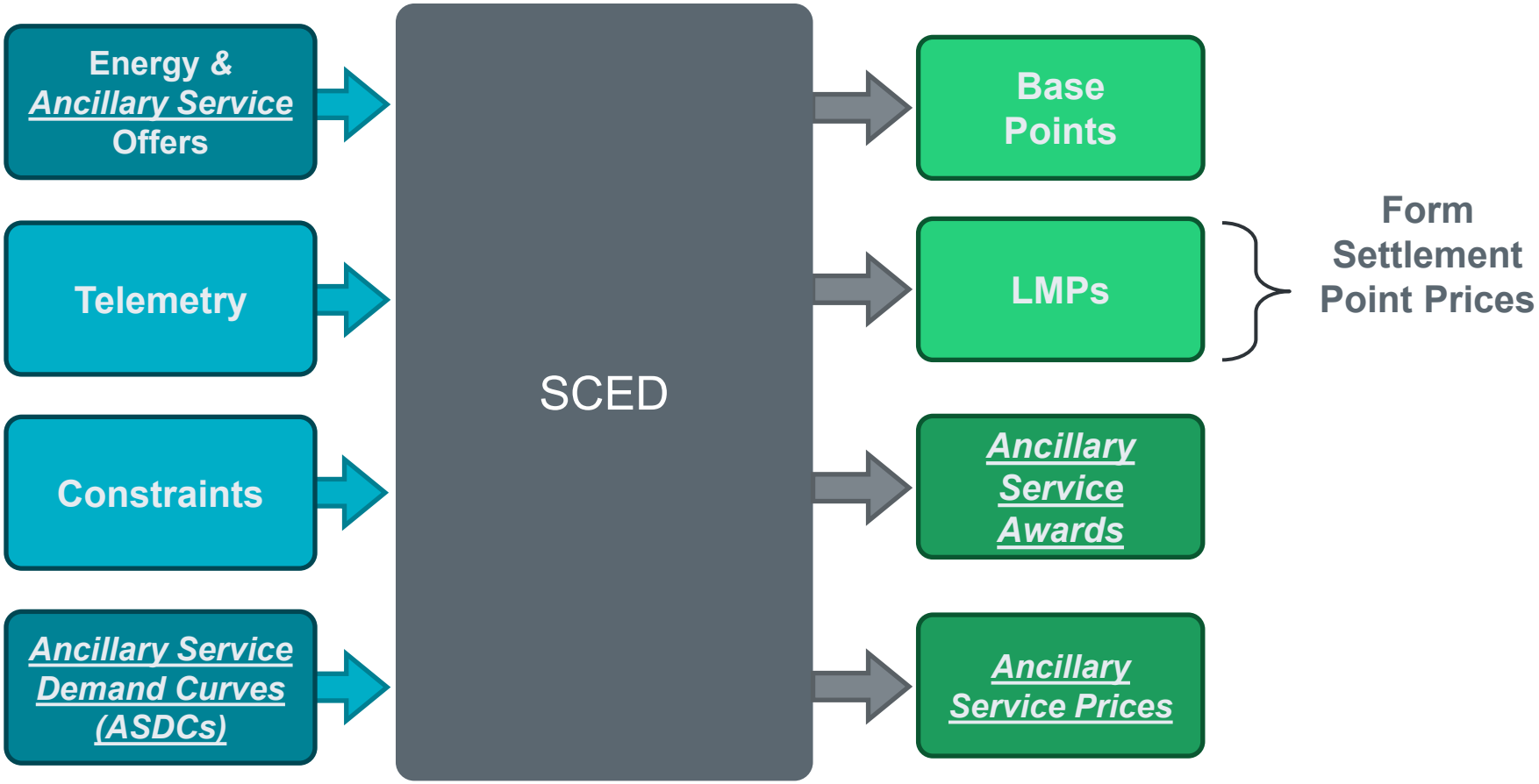
Current Real-Time Market

Today's market is designed to reflect scarcity through a process that is outside of the optimization.



Real-Time Market under RTCB

Also designed to reflect scarcity, but with RTCB it occurs within the optimization



High Level Scope of "+B"

1. NPRR 1014: BESTF-4 Energy Storage Resource Single Model (Approved December 2020)

2. NPRR 1204: Considerations of State of Charge with Real-Time Co-Optimization Implementation (Approved February 2024)

3. NPRR 1236: RTC+B Modifications to RUC Capacity Short Calculations (Approved November 2024)

4. NPRR 1246: Energy Storage Resource Terminology Alignment for the Single-Model Era (Approved March 2025) [NOGRR 268, OBDRR 052, PGRR 118]

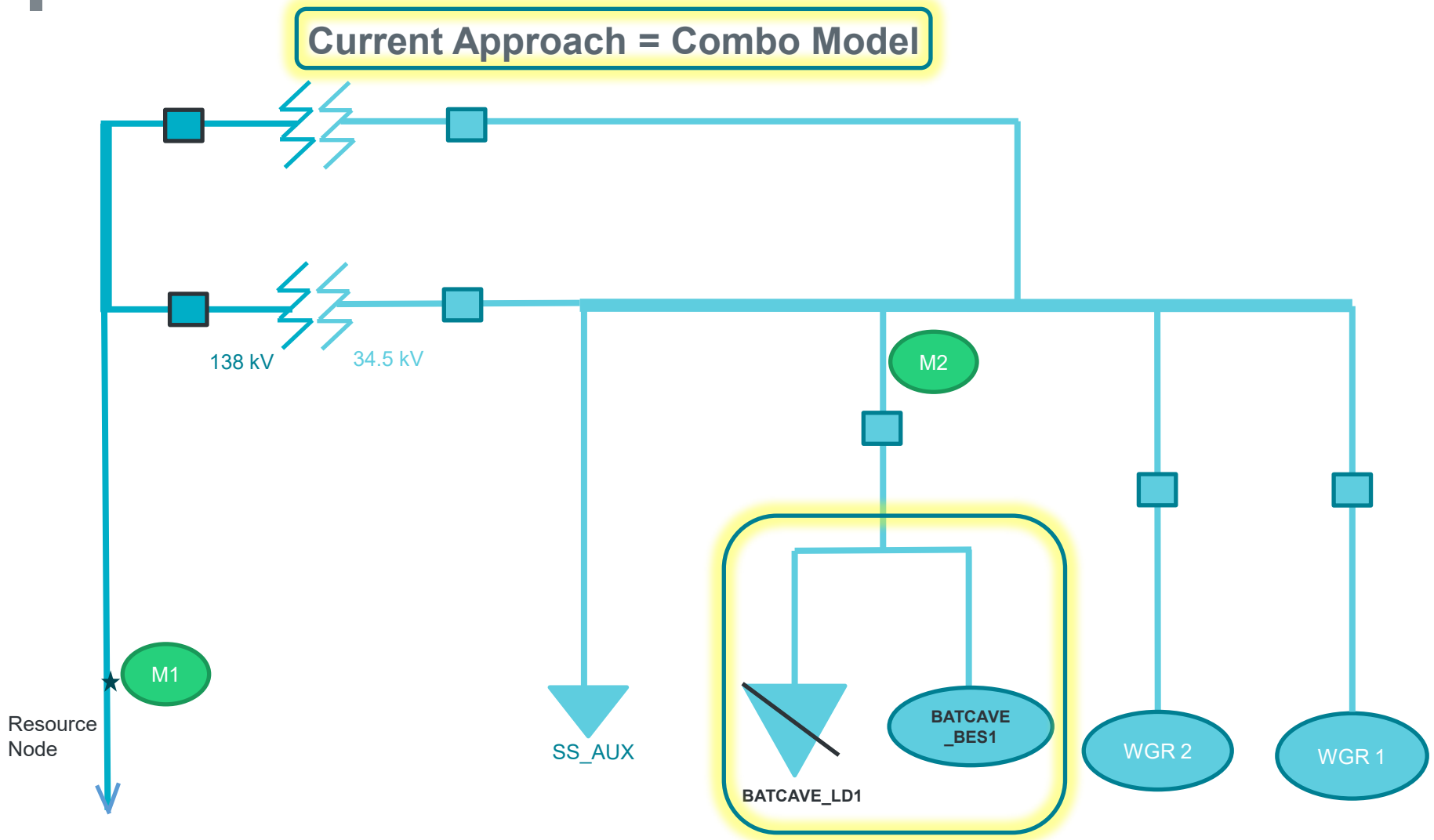
5. NPRR 1282: Ancillary Service Duration under Real-Time Co-Optimization **(At the ERCOT Board of Directors for approval June 24, 2025)**

6. *Not part of RTC+B Project. (On the back burner. "Way back" burner.)* NPRR 1029: BESTF-6 DC-Coupled Resources (Approved December 2020)

NPRR 1014: Energy Storage Resource (ESR) Single Model

- **Registration, Qualification and Modeling** (An ESR is represented (as it is) – as one physical Resource)
- **Single** set of telemetry
- **Single** "energy bid/offer curve" submittal (covering both the charging and discharging MW range) and **Single** "COP" submittal
- **Single** Performance Monitoring (Note: Tolerance for Set Point Deviation is smaller.)
- **Single** Settlements
- **Single** entry into Outage Scheduler

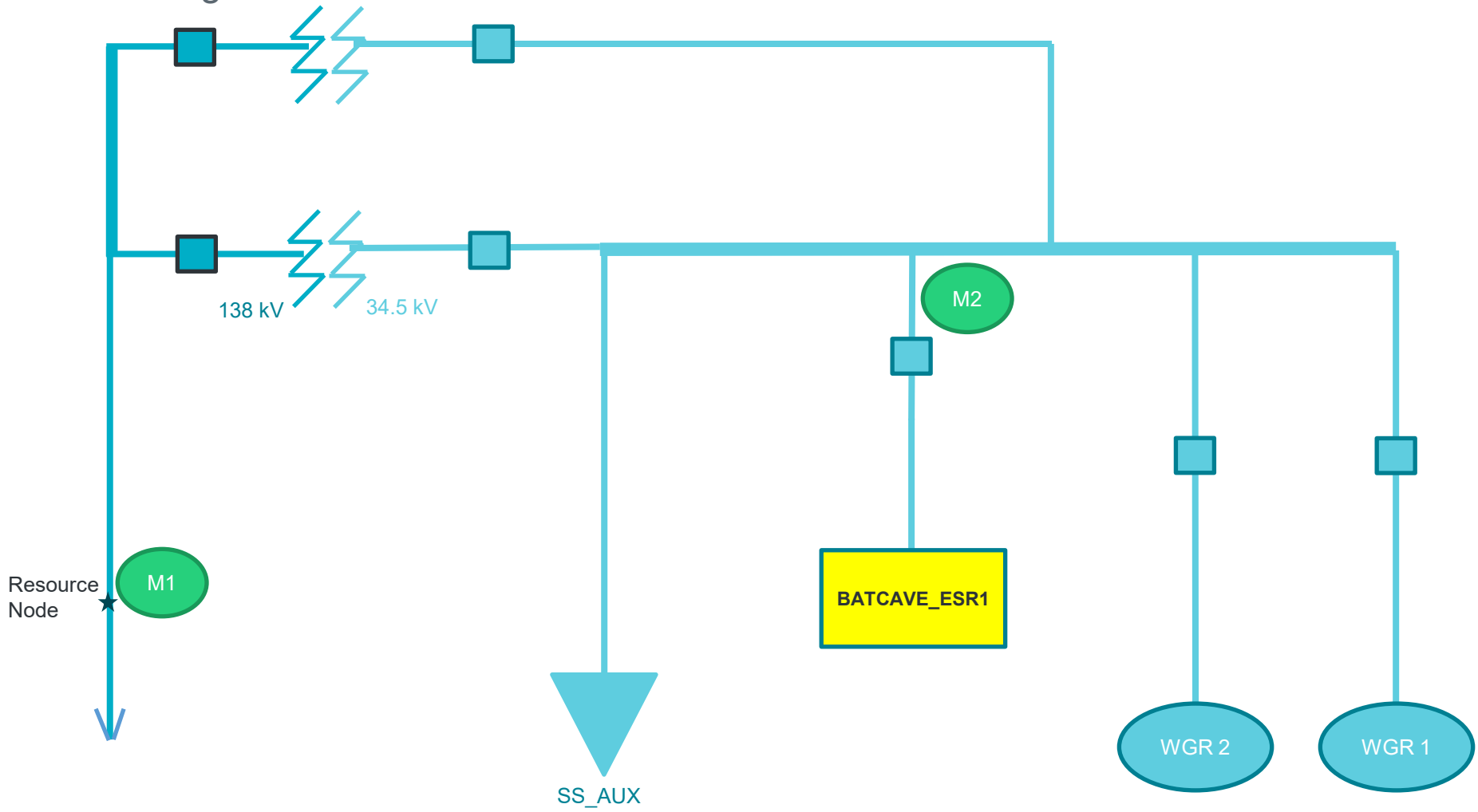
Typical One-Line (Battery and Other Generation Resources)



Typical One-Line (Battery and Other Generation Resources)

with Single Model (After RTC+B Go-live)

No changes to meter locations and Resource Node locations



Registration/Qualification

1. ERCOT initiated Request for Information (RFIs) from August 6 through September 26, 2024, to support Resource Integration and Ongoing Operations (RIOOs) transition to a single model representation of ESR. Data collection through DocuSign was sent to the Authorized Representative as stated in the Market Notice https://www.ercot.com/services/comm/mkt_notices/M-A071024-02. ERCOT may need to reach out to the REs to provide additional or missing information. For projects in the interconnection process, we are currently collecting the necessary data for single model ESR via RIOO.

2. Relevant References: https://www.ercot.com/files/docs/2024/08/21/RIWG_ERCOT_ESR_RFI_Updates_Aug24.pptx

3. If there are any Protocol changes that impact qualification or qualified MW based on duration, ERCOT will plan to interact with the appropriate entities prior to transitioning to RTC.

Energy Bid/Offer Curves (EB/OC), Current Operating Plan (COP), and Telemetry

1. EB/OC, COP information, and telemetry are provided for the ESR as a single device to cover the entire range from Low Sustained Limit (LSL) to High Sustained Limit (HSL); the maximum charging MW a negative number to maximum discharging MW positive number.

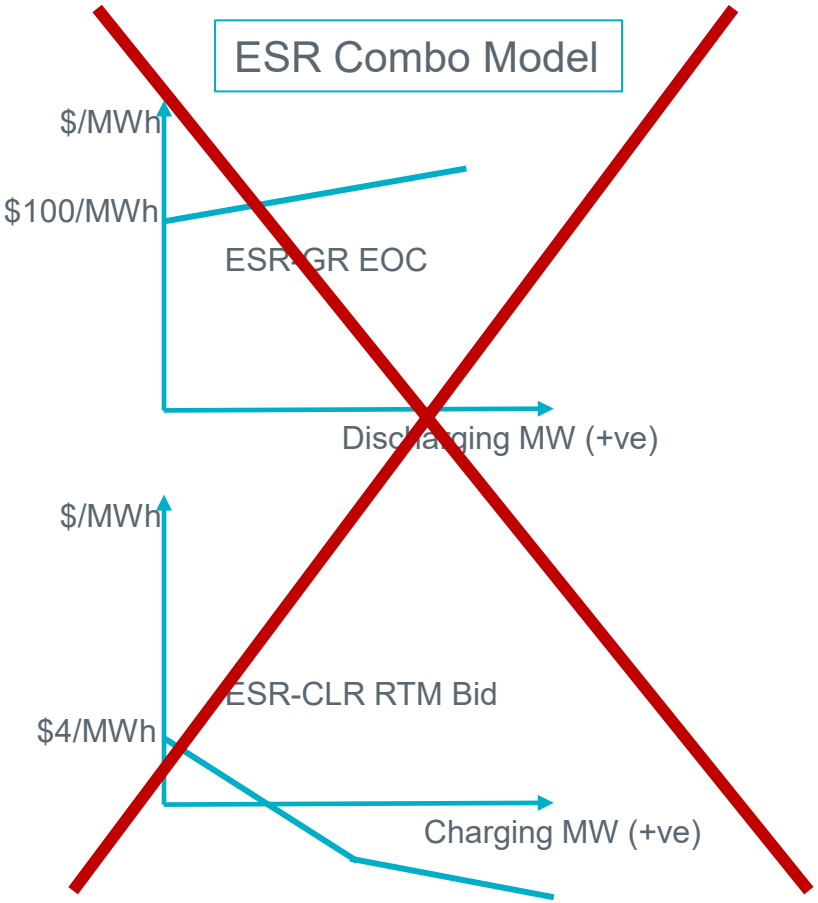
2. Continue to provide Hour Beginning State of Charge information for future hours in the COP for the ESR.

3. Telemetry is for the ESR as a single device.

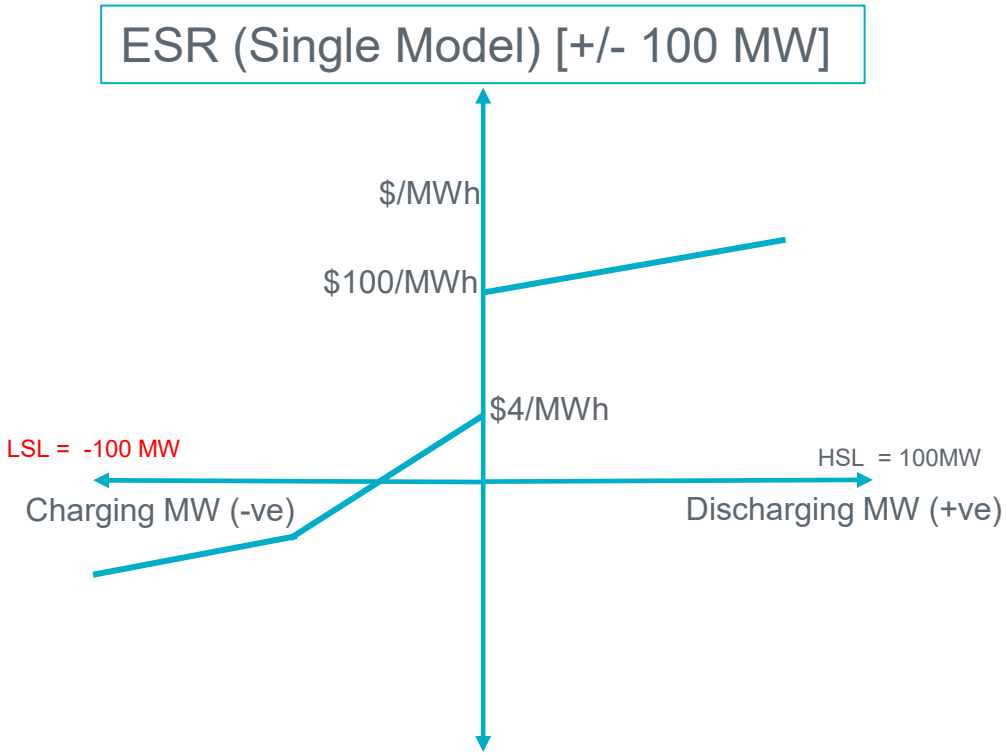
4. All ERCOT systems including the Outage Scheduler, DAM, RT Market, RUC, and Settlements will “handle” the ESR as a single device.

5. The implementation of the Single Model will eliminate extra coordination currently required with the Combo Model and reduce administration for ERCOT and QSEs.

Single Model ESR: Energy Bid/Offer Curve (EB/OC)



- Single EB/OC curve shall be monotonically non-decreasing from maximum charging MW (negative) to maximum discharging MW.
- The maximum price on the charging curve is less than the minimum price on the discharging curve
- 10 Pairs of $/MWh and MW level.



Telemetry with the Implementation of the RTC+B Project (1 of 2)

Continue 5 State of Charge telemetry items for each ESR:

ESR State Of Charge (SOC) Telemetry
SOC (MWh)
Max SOC (MWh)
Min SOC (MWh)
Max Operating Discharge Power Limit (MW)
Max Operating Charge Power Limit (MW)

ESR telemetry includes:

ESR Telemetry
Resource Status (ON,ONOS,ONTEST, ONEMR, ONHOLD, OUT)
Gross (MW) (positive for discharge, negative for charge)
Gross (MVAr)
Net MW (positive for discharge, negative for charge)
Net MVar
HSL
LSL (can be negative)

Telemetry with the Implementation of the RTC+B Project (2 of 2)

1. Net MW telemetry of the ESR, when it is charging or when it receives a Base Point of zero, should NOT include internal losses in the Battery (electro-chemical) and inverter.

2. Net MW (charging or discharging) represents the ESR response to UDSP (plus any frequency response) at the Point Of Interconnection. Thus, the Net MW telemetry when the ESR is discharging includes the internal losses in the battery (electro-chemical) and inverter.

3. The Gross MW telemetry is the actual charging or discharging MW as measured at the modeled terminals of the ESR and includes all internal losses in the battery (electro-chemical) and inverter.

4. Including the losses, when there is no expected injection from the ESR, could lead to SPD charges – that may not be appropriate.

5. With the implementation of NPRR 1014, the Base Point Deviation (DPD) calculation from the past is replaced with the Set Point Deviation (SPD) calculation and the tolerances for ESRs are smaller (3% or 3 MW).

Introduction – ERCOT's Analysis and Conclusion

- To inform appropriate duration needs for every Ancillary Service type under Real Time Co-optimization (RTC) paradigm, ERCOT has conducted analysis of the (1) duration of historic risks that drive the need for these reserves and (2) length of historic deployment events, some of these deployments occurred in response to the sustained risks.

- Below is a summary of the minimum duration for various Ancillary Service types that ERCOT is recommending based on this analysis. Red text identify values that are different from or not stated in the current RTC Protocols.

Ancillary Service Type	Real-Time		Qualification		RUC
	Duration	Protocol Reference	Duration	Protocol Reference	Duration Award and Deployment
Regulation Service*	30 minutes	8.1.1.3.1 (2)	30 minutes	8.1.1.2.1.1 (5)	1 hour
Responsive Reserve Service (excluding FFR)	30 minutes	8.1.1.3.2 (4)	30 minutes	8.1.1.2.1.2 (9)	1 hour
ERCOT Contingency Reserve Service	1 hour	8.1.1.3.4 (2)	1 hour	8.1.1.2.1.7 (3)	1 hour
Non-Spinning Reserve Service	4 hours	8.1.1.3.3 (2)	4 hours	8.1.1.2.1.3 (8)	1 hour

*Note FRRS is being eliminated with RTC.

ESR Participation in the DAM with the RTC+B Project

1. EB/OCs for the ESR is input to DAM. Resource-specific DAM energy sales and purchases that are cleared are cleared at the Resource Node of the ESR.

2. State of Charge (SOC) is not considered in the clearing for Energy and Ancillary Services in the DAM. (If not careful, a QSE representing ESRs could "oversell" its capability in DAM. Financial Exposure is based on imbalance between DAM and Real-Time. [DAM Ancillary Service awards, Real-Time Ancillary Service awards, self-arrangement of Ancillary Services, and trades].)

3. The ESR will be awarded DAM Resource-specific energy sales and purchases and Resource-specific Ancillary Service sales.

4. Fast Responding Regulation Service (FRRS) is no longer a subset of Regulation.

5. For details on how the DAM will "convert" various EB/OCs; See 2-7-25 RTCBTF "DAM ESR Offers" presentation: https://www.ercot.com/files/docs/2025/02/07/7b.%20ESRs%20in%20DAM.pptx

Real-Time Market With the Implementation of the RTC+B Project

1. EB/OCs for the ESR and the Ancillary Service offers are input data to SCED process. EB/OC can be updated anytime. SCED uses the most recent EB/OC that is available in the database and the telemetered physical capability of the resource in determining awards (along with other information).

2. **SCED incorporates SOC accounting within the optimization.** This is to ensure that awards to ESRs are feasible and that there is sufficient energy to sustain the MW awards for energy (Base Points) and Ancillary Services for their respective SCED duration requirements. SCED will not violate the telemetered minimum and maximum SOC values for ESRs.

3. **The awards for each Resource are limited based on the Resource's qualification,** telemetered physical capabilities, **SoC information**, ramp rates, and **duration requirements for each Ancillary Service type**. This is different from today where it is the QSE's responsibility to ensure sufficient SoC is reserved to cover their Ancillary Service Responsibility and duration requirements. Multiple Ancillary Service types and energy can be awarded to an ESR in a SCED execution.

4. QSE management of Ancillary Service responsibility across their portfolio no longer exists.

RUC with Implementation of RTC+B Project

1. DRUC and HRUC will be the tools to assess if enough capacity is available (and in the right locations) to ensure RTC SCED will have enough capacity to solve for energy and Ancillary Services.

2. Similar to today, ESRs will NOT be seen as OFF and available to be RUCed, and therefore, the RUC software will NOT RUC an ESR to come online. (ESRs should have a status of “ON”, “ONOS” “ONTEST”, “ONEMR”, “ONHOLD” or “OUT.” “OUT” should be used only if the resource is “broken.”)

3. In evaluating the capability of the online Resources (and those shown off-line), the full capability of the Resources (including ESRs) planned to be available will be “fair game” for the RUC software. In other words, with the RTC+B implementation the RUC software will not assume Ancillary Services are carried by any particular Resource and will consider all possibilities of where to carry Ancillary Services for future hours.

RUC with Implementation of RTC+B Project: Continued

4. The RUC software will **use the Hour Beginning SoC (HB SoC)** provided by the QSEs in their COPS for each ESR to appropriately limit the possible use/capability of each ESR.

5. RUC self-schedules ESRs to their HB SoC. The process of self-scheduling evaluates the change in the COP submitted HB SoC (change in stored energy SoC) across two consecutive hours and determines the best use of that change in energy – combination of charging or discharging the ESR as Base Points and/or procuring Ancillary Services considering Deployment Factors for that hour. **Deployment Factors are used to simulate deployment of Ancillary Services for an hour**.

6. The RUC Capacity Short calculations use optimization techniques to minimize a QSE's potential energy and/or Ancillary Service shortfall. This optimization process, will also consider the change in the COP submitted HB SOC across consecutive hours for an ESR to determine the **best use of that change in energy to cover the QSE's energy and Ancillary Services position for each hour in the RUC study period**.

Thank You!