The State of New Energy Systems Integration in ERCOT

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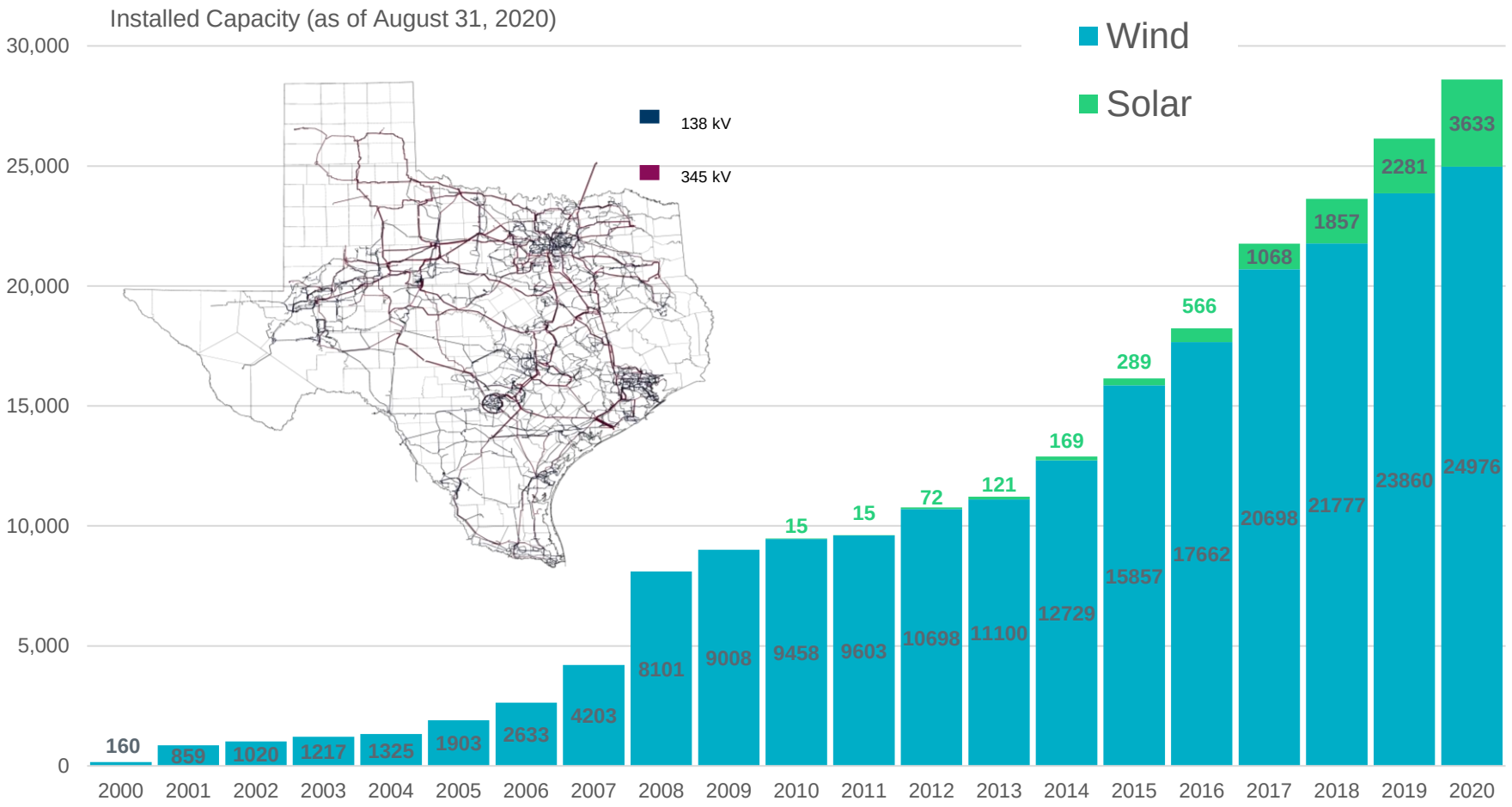
ERCOT Renewable Generation



Flow of Integration Issues Over Time – The Early Days

2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011

Transmission

McCamey area congestion

Nodal Market implementation

CREZ legislation

CREZ studies and hearings

Forecasting

Wind-related EEA

Hourly wind forecasting

Ancillary Services

GE Ancillary Services study

Interconnection Requirements

Low Voltage Ride Through

Reactive Power requirements

Primary Freq. Resp. req.

Flow of Integration Issues Over Time - Continued

2012 > 2013 > 2014 > 2015 > 2016 > 2017 > 2018 > 2019 > 2020

Transmission

CREZ completed

Weak grid issues

PSCAD modeling

Panhandle and West Texas studies

Local stability limits

Regional stability limits

Forecasting

168-hour wind forecast

2nd wind forecaster

Hourly solar forecasting

Reliability Risk Desk

Intra-hour wind forecasting

Ancillary Services

Conditional Ancillary Services quantities

Ramp rate limits

Inertia monitoring

Future Ancillary Services redesign and implementation

Interconnection Requirements

High Voltage Ride Through

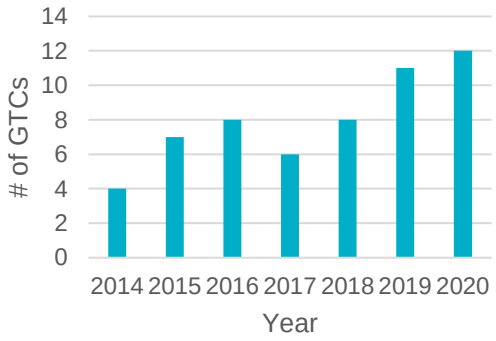
PV requirements added

Repowering clarifications

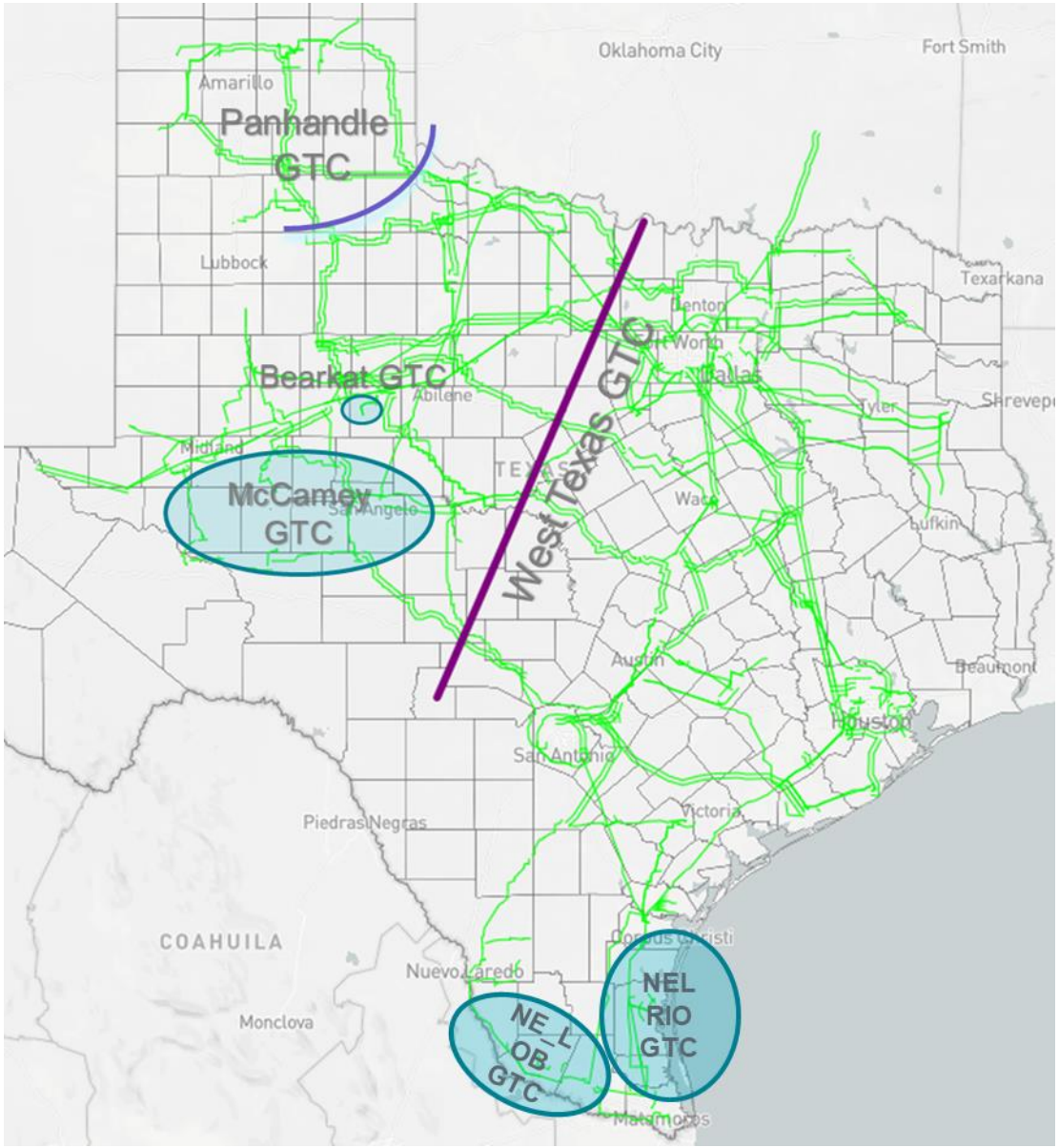
Current and Upcoming Integration Issues

Transmission	• Increase in stability constraints • Improvements in stability simulations • New transmission studies
Forecasting	• Intra-hour solar forecasting into dispatch (DOE project)
Ancillary Services	• Regulation depletion due to solar ramps • Continued monitoring of inertia • Battery Energy Storage Task Force • Real-Time Co-optimization of AS and Energy
Interconnection Requirements	• Increased dynamic model requirements • Revised resource definitions to include DERs • Batteries

Stability Limitations on Transmission



- Generic Transmission Constraint (GTC)
  - Constraint used to represent stability limitations within market systems
  - Manage these limitations using market tools



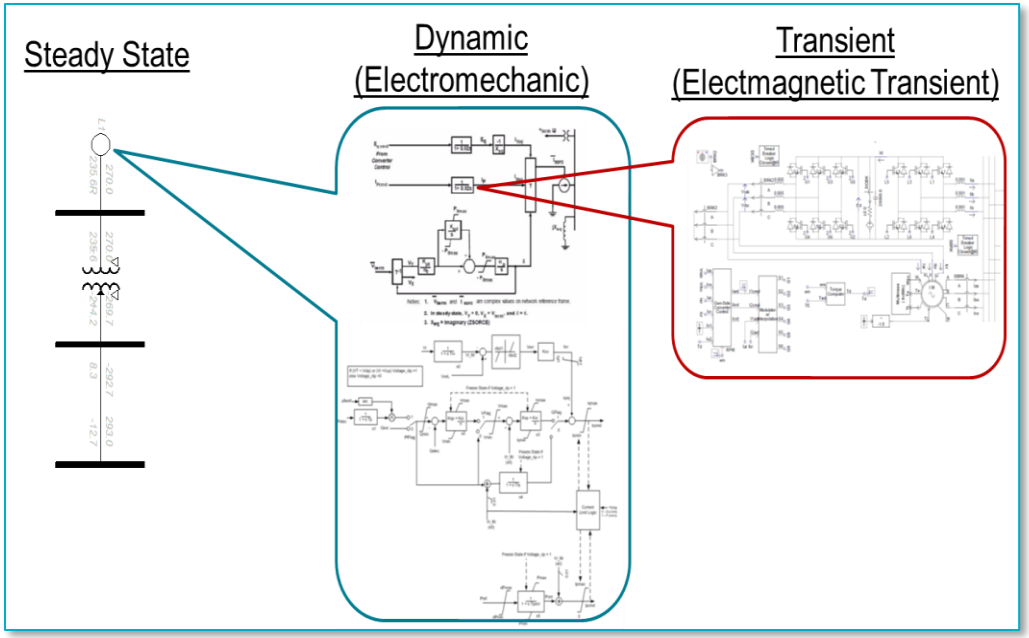
Dynamic Models, Online Stability Simulation for Limits

- Stability limits, other than voltage stability, are currently calculated using off-line studies
  - These static limits must protect the system across a range of potential operating conditions, so are necessarily conservative
- In process of implementing TSAT to calculate limits in real time, based on actual system conditions
- Generators are required to submit TSAT models to allow for this implementation
  - Many are still working with vendors to develop user-defined models for TSAT

EMTP Simulation

- As areas of the system become weaker, ERCOT has increased use of PSCAD simulation to appropriately evaluate control system effects and validate PSSE and TSAT results.

- Some study areas are large enough to have required co-simulation with PSSE.

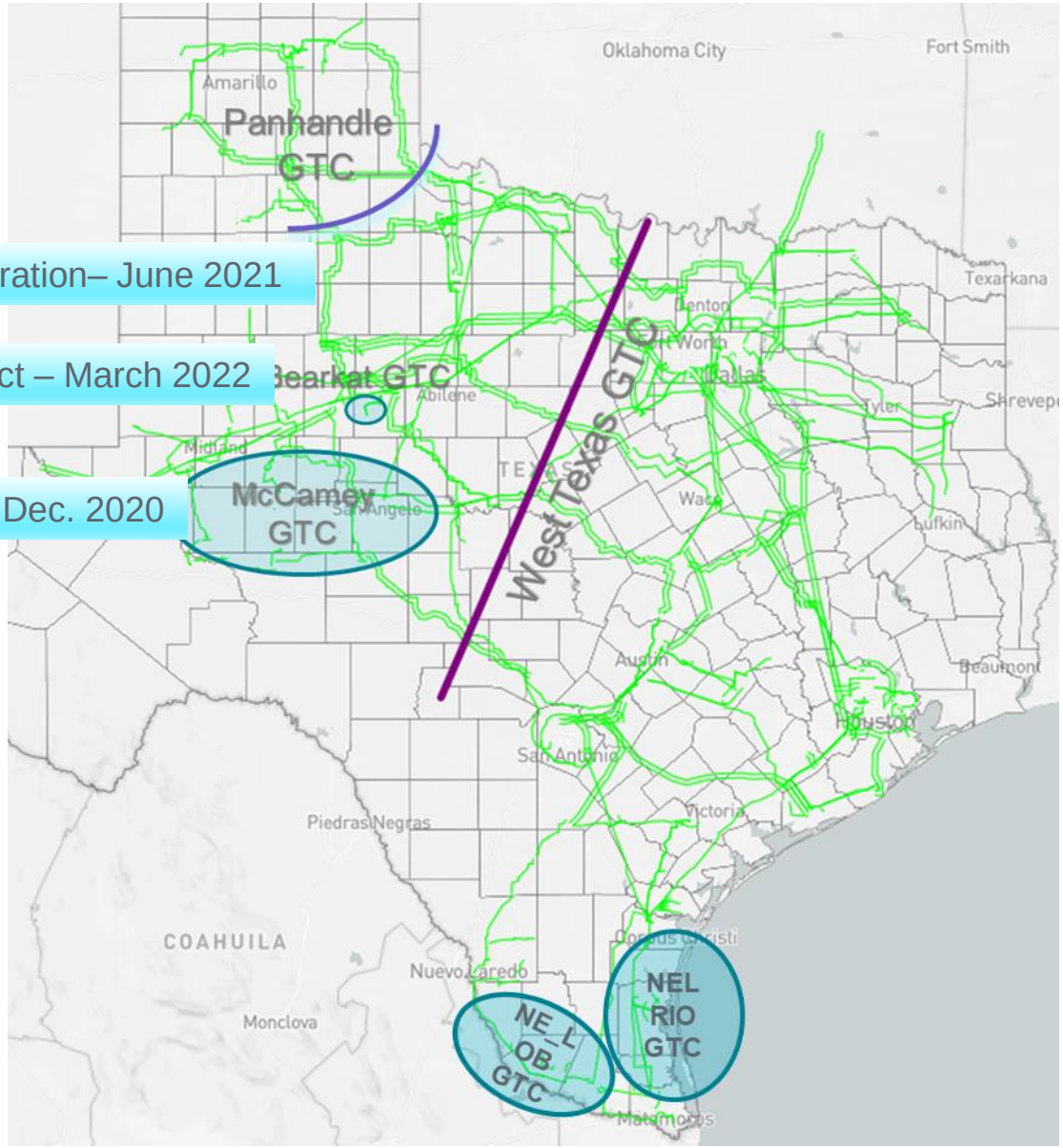


Near-Term Transmission Projects

Lubbock Integration– June 2021

Bearkat Project – March 2022

Far West Project – Dec. 2020



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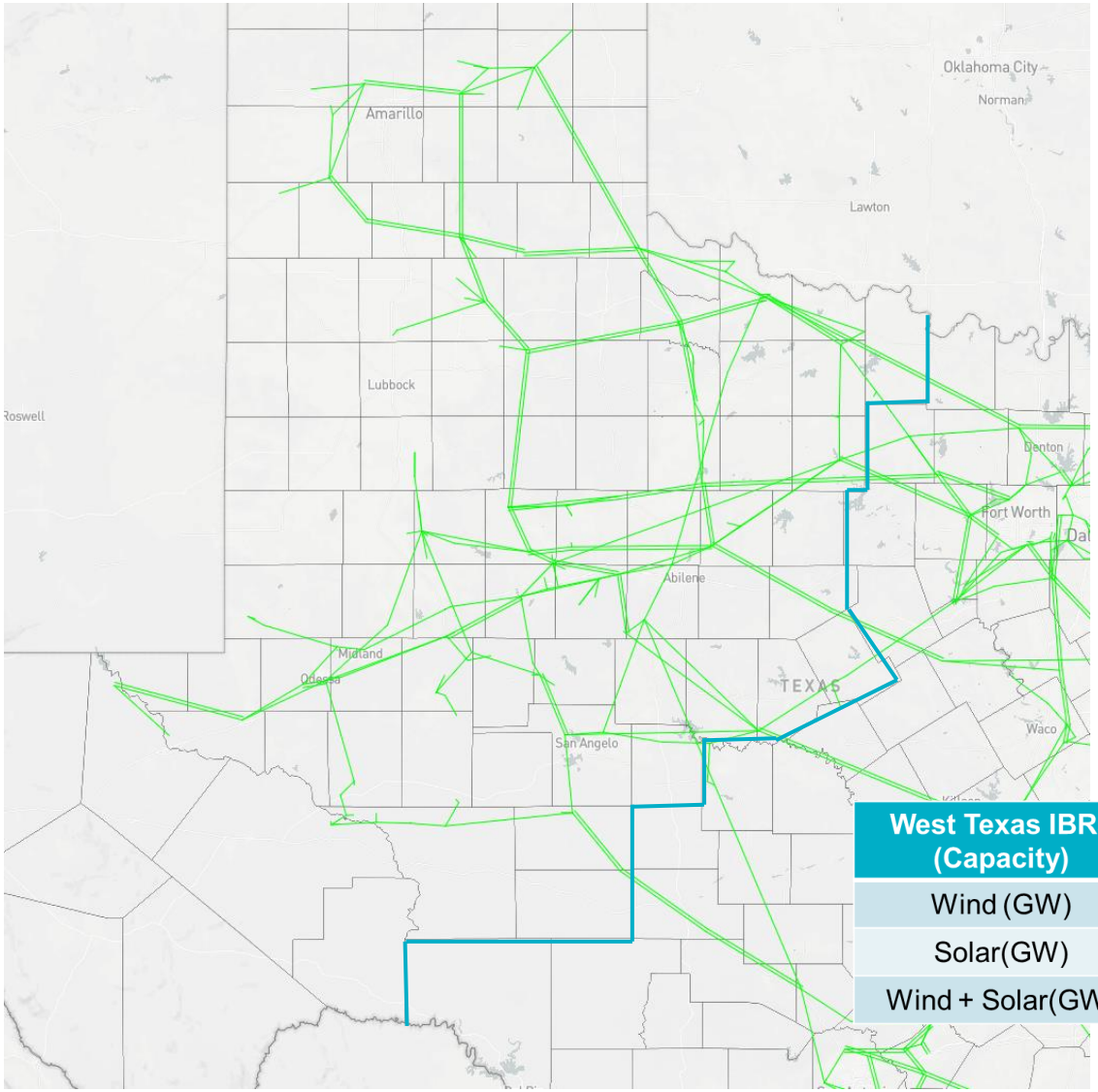
West Texas Export Study Area



Study Area Tie Lines

- 345-kV lines: 16
- 138-kV lines: 8
- 69-kV lines: 7
- Counties: 82

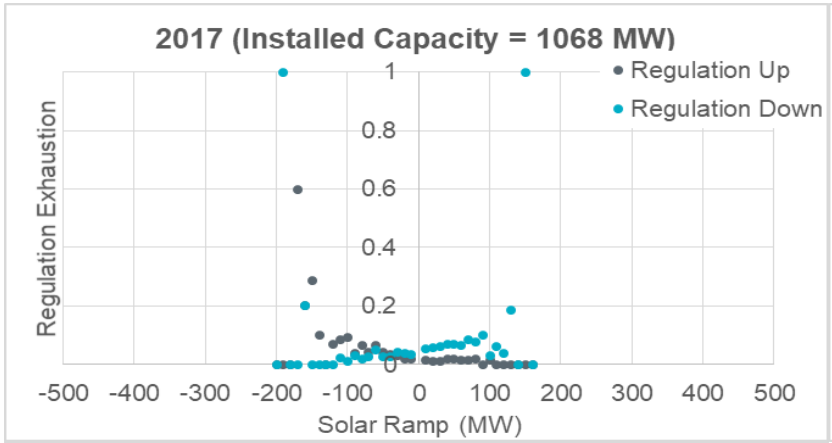
IBR Generation Installed Capacity

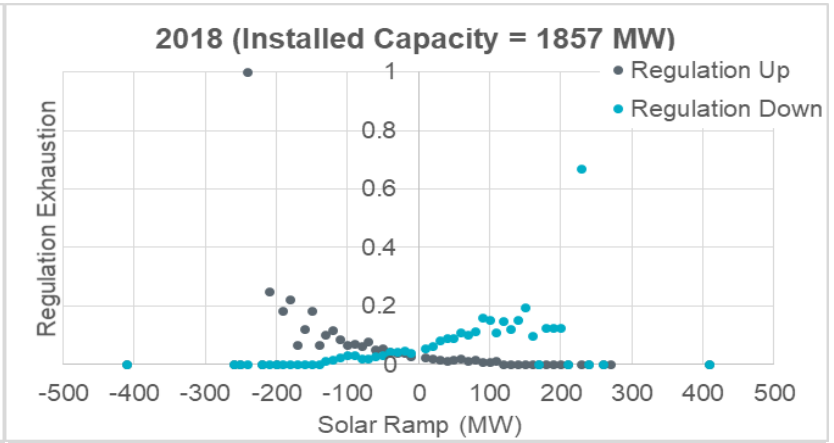
- ~22 GW wind
- ~6 GW solar

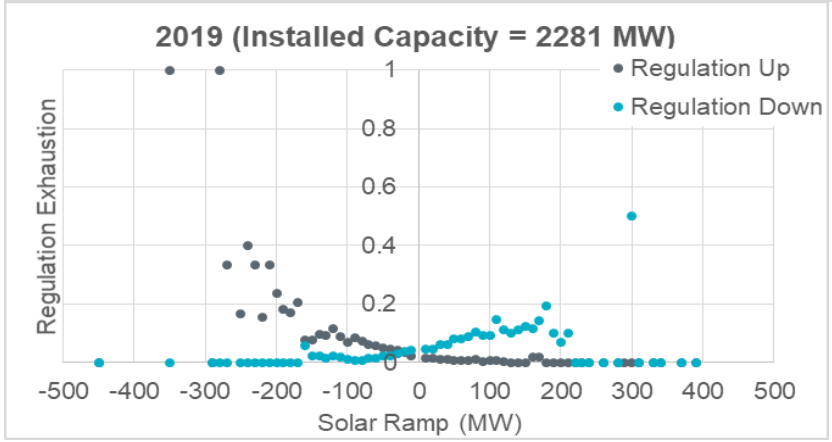
West Texas IBRs (Capacity)	QSA Q2 2020/ W_TO_C GTC	QSA Q3 2020	QSA Q4 2020
Wind (GW)	21.8	22.2	22.3
Solar(GW)	3.8	4.3	5.7
Wind + Solar(GW)	25.6	26.5	28

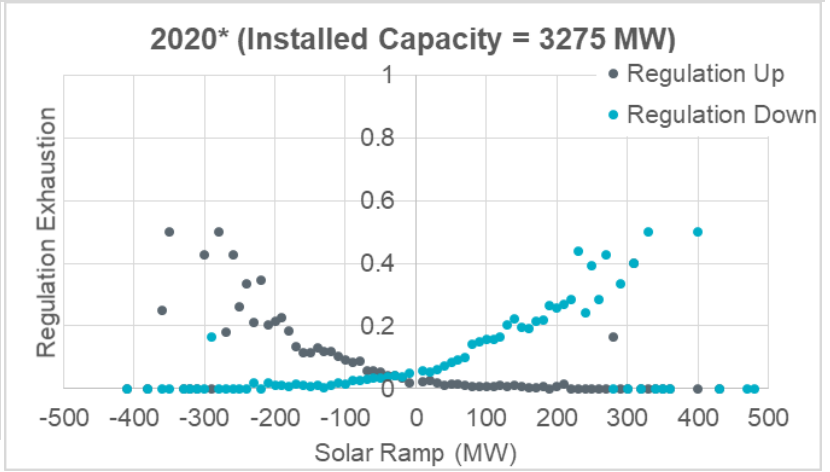
Solar Ramps (5 min.) and Regulation Exhaustion

- As installed solar capacity increases, and thus the magnitude of 5-minute solar ramps increases, there are more intervals with regulation exhaustion.

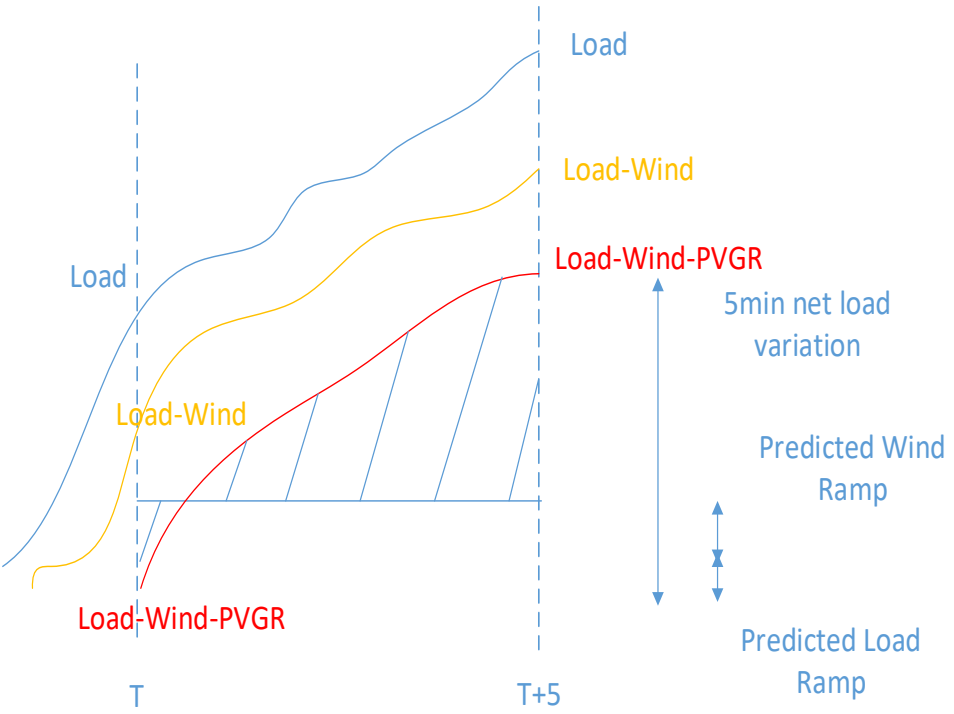


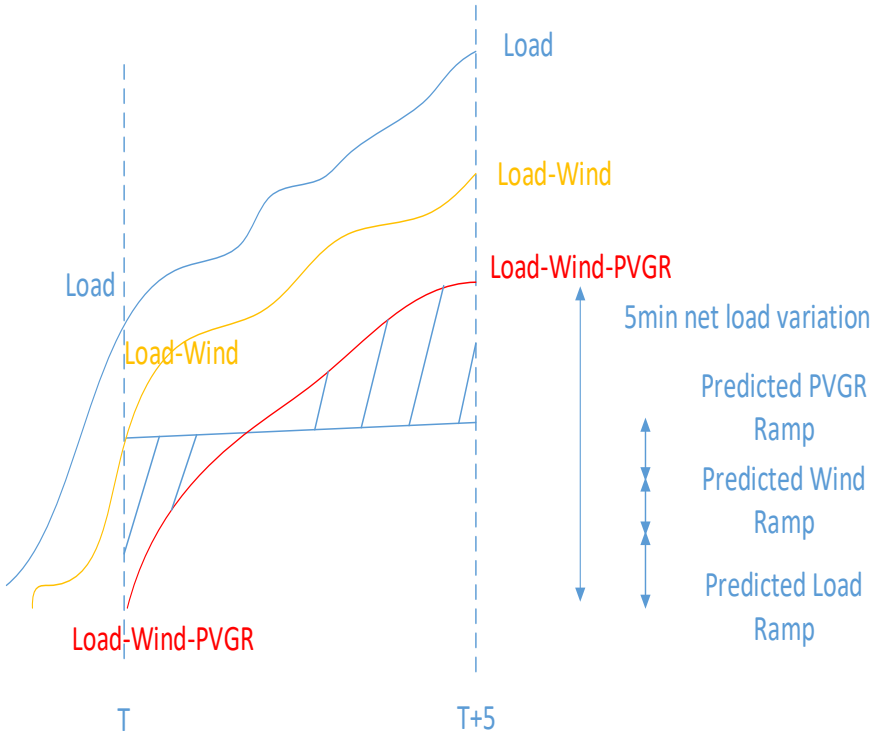






Including Solar Ramp in Dispatch





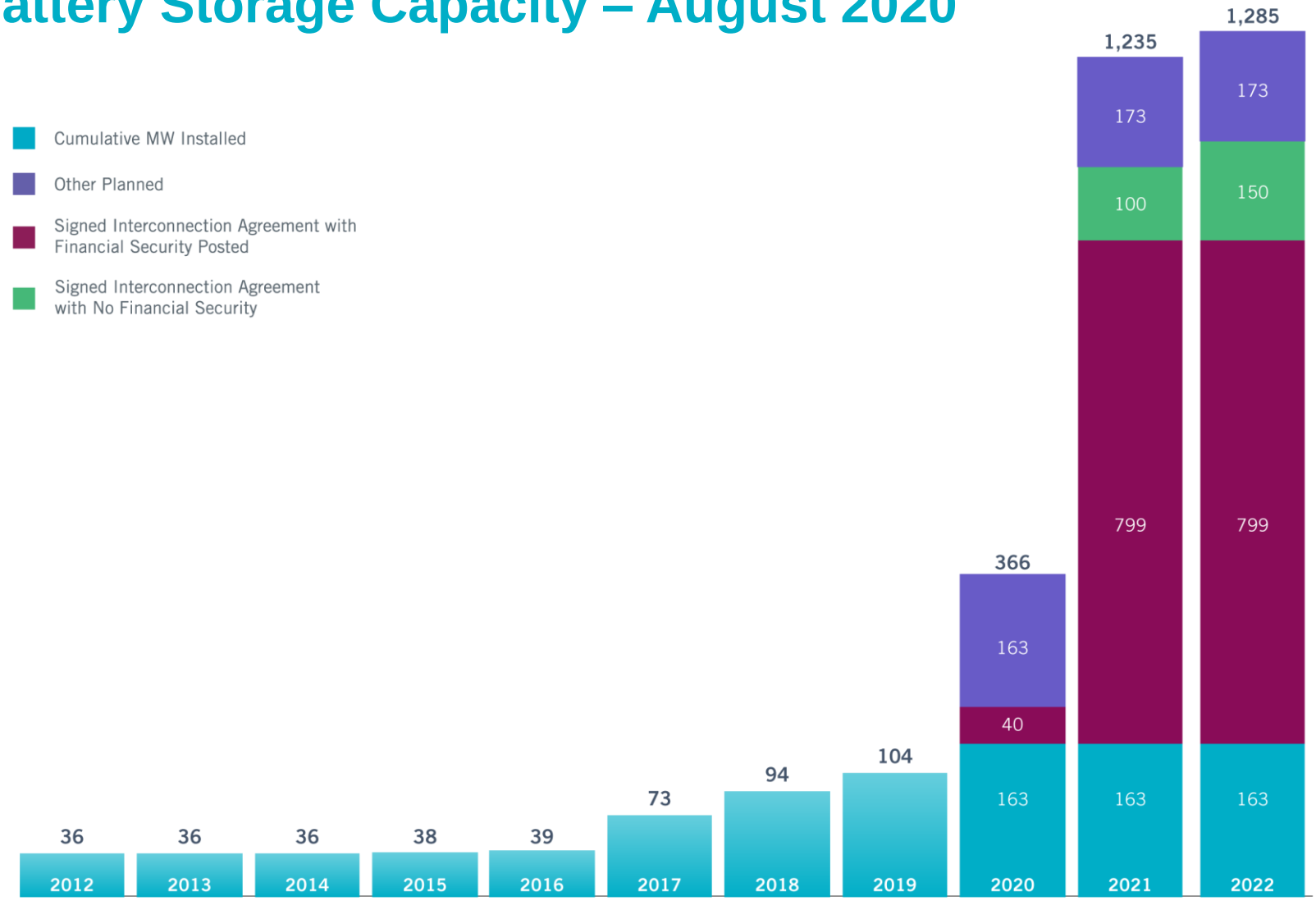
Pre-SCR 811 Method

Only Short-Term Load and wind ramps are included in Net Load variation assessment similar to current GTBD practice

Post-SCR 811 Method

Solar ramp is also included along with Short-Term Load and wind ramps in Net Load variation assessment

Battery Storage Capacity – August 2020



- Cumulative MW Synchronized pertains to projects that ERCOT has approved to generate energy for the grid but have not passed all qualification testing necessary to be approved for participation in ERCOT market operations.
- Other Planned capacity reflects registered projects under 10 MW in size that are not included in the Resource Integration and Ongoing Operations Interconnection Services (RIOO-IS) System.

Battery Energy Storage Initiatives

1
- Single model Energy Storage Resource (ESR) registration
- ESR charging restrictions during an EEA

2
- PRC reserve contribution from ESR taking SOC into account
- ORDC reserve calculation for an ESR taking SOC into account

3
- Dispatching ESR represented as Gen and CLR using nodal shift-factors
- Nodal pricing for both Gen and CLR and mitigation

4
- VSS and governor response for full range of charging and discharging capability
- Extends the under-frequency ride through, VRT, and AVR requirements to ESR

5
- Pricing, dispatch, ESR energy/bid offers, COPs, telemetry
- Base Point Deviation, ESREDP, disclosure reports

6
- Allow ESRs to maintain their SOC by extending the window to submit/update their energy offers and bid-to-buy, to real time

7
- ESR settlement in the Day-Ahead and Real-Time Markets
- Base Point Deviation tolerances, make-whole payments, RUC, RUC capacity short calculation

8
- Existing WSL rules sufficient
- For non-WSL ESR, nodal pricing of charging load and zonal pricing for auxiliary load

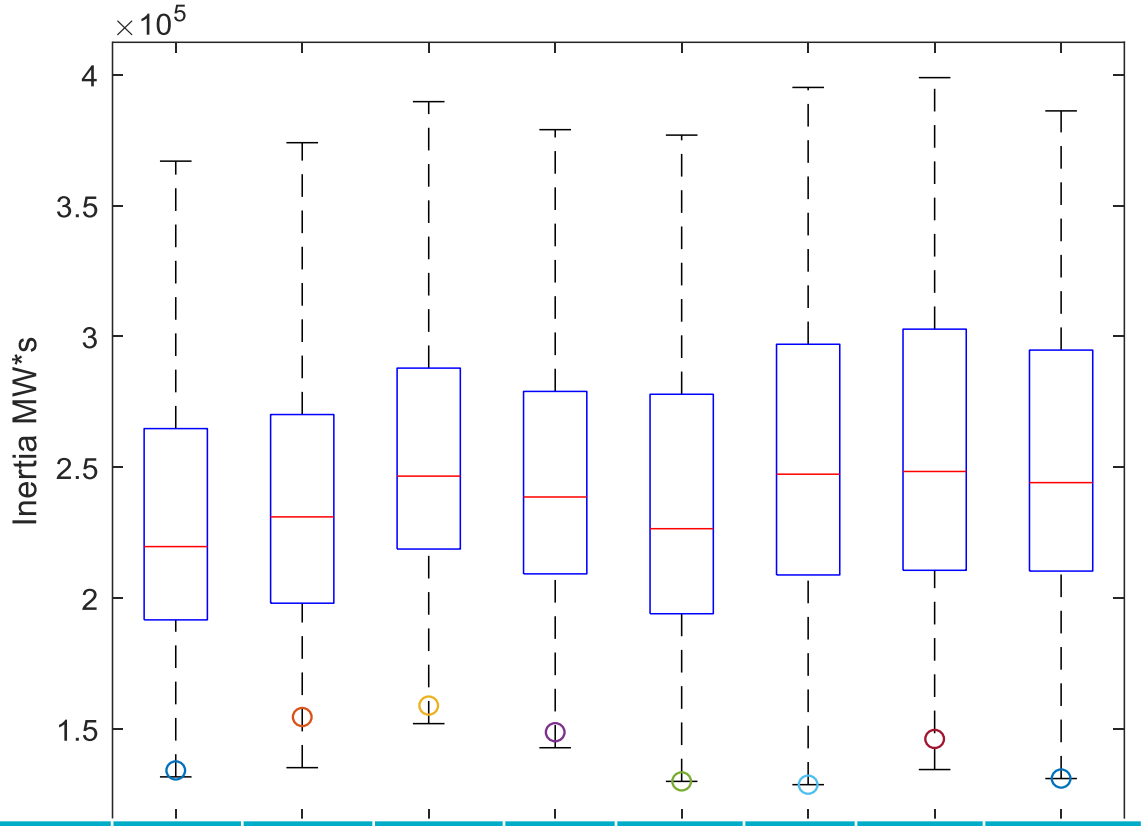
10
- Outage coordination studies, Reliability Unit Commitment studies, operational studies and transmission planning studies; peak average capacity percentage to be used in CDR for ESR

11
- Definition, registration, modeling, telemetry, COPs and settlements
- Forecasting, IRR/ESR- ESREDP and BPD

13
- Self-Limiting Facility definition, monitoring, reports, and telemetry
- Generator interconnection process using the Self-Limiting Facility MW limit instead of name plate rating

Inertia

- Minimum inertia has remained stable, above critical level
  - Off-peak load growth
  - Higher AS requirements in off-peak hours, supplied by synchronous gen
- If batteries provide more of off-peak AS, does this change?



Date and Time	2013 3/10 3:00 AM	2014 3/30 3:00 AM	2015 11/25 2:00 AM	2016 4/10 2:00 AM	2017 10/27 4:00 AM	2018 11/03 3:30 AM	2019 3/27 1:00 AM	2020 (J-A) 5/1 2:00 AM
Min synch. Inertia (GW*s)	132	135	152	143	130	128.8	134.5	131.1
System load at minimum synch. Inertia (MW)	24,726	24,540	27,190	27,831	28,425	28,397	29,883	30,679
Non-synch. Gen. in % of System Load	31	34	42	47	54	53	50	57

Registered DG in ERCOT*

*NPRR 889

Settlement-Only Distributed Generation

DG units > 1 MW that export are required to register with ERCOT. QSEs representing these units are settled by ERCOT at wholesale prices.

Ex: Typically fossil or landfill gas-based generators or larger solar PV. Approximately **850 MW** currently.

Distribution Generation Resource

A DG unit that chooses to register as a **G**eneration **R**esource to participate in the ERCOT Energy and Ancillary Services markets.

Ex: ERCOT currently processing approximately **360 MW** of DGR applications; most are batteries.

The Future?