

**Texas Waves: Increasing system reliability
in ERCOT by providing fast responding
regulation service**

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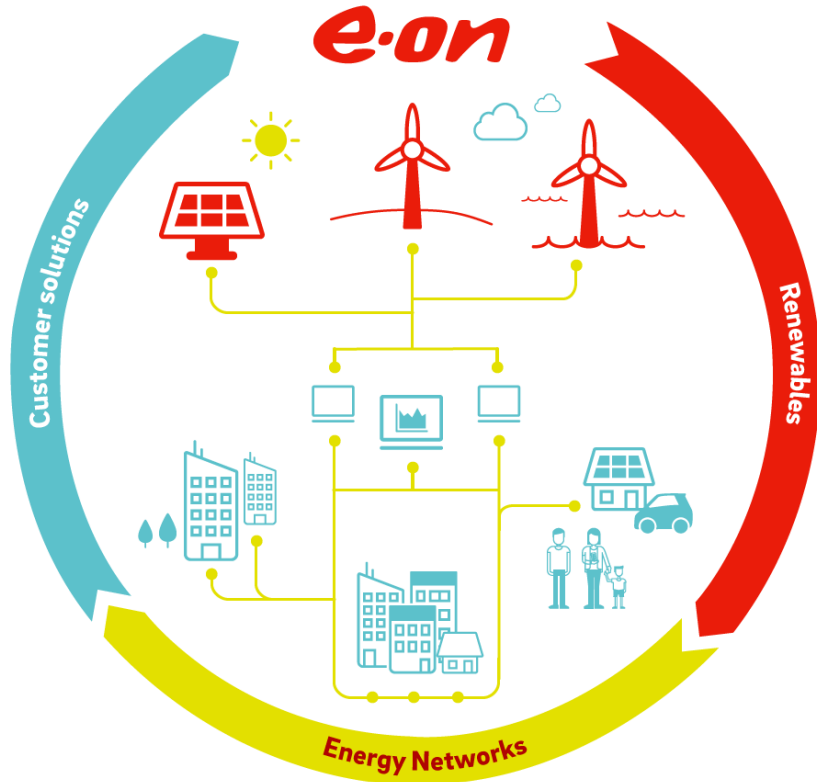


Agenda

1. **Overview of E.ON activities in the ERCOT market**
2. **How Texas Waves provides Fast Responding Regulation Service**
3. **How Energy Storage can participate in German Ancillary Service Market**
4. **Future role of Energy Storage as Renewable Integration**



E.ON strategy



Global trends like sustainability and climate protection, digitalization and technological innovation are altering the energy landscape. At the same time our customers' energy needs are changing.

A new energy world – decentralized, green, and interconnected – is emerging. Our core businesses reflect the key energy trends:

The global growth of **renewables**

The transformation of yesterday's power lines into tomorrow's smart **energy networks**

The increasing demand for innovative **customer solutions**

Partner for the New Energy World

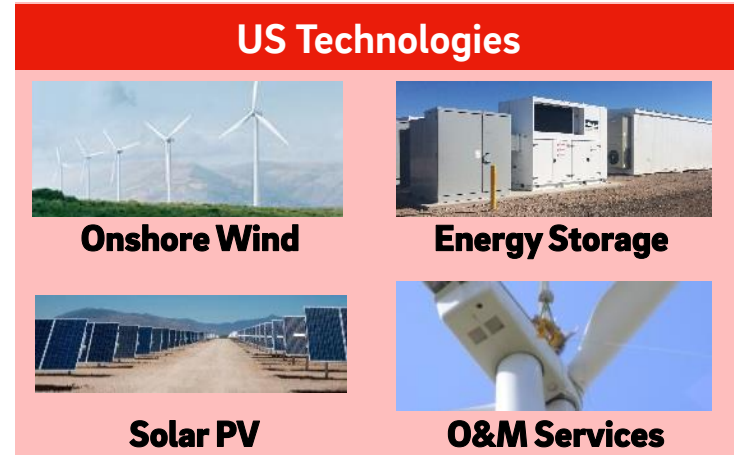
Strong US renewable player with ERCOT as key market

What we do

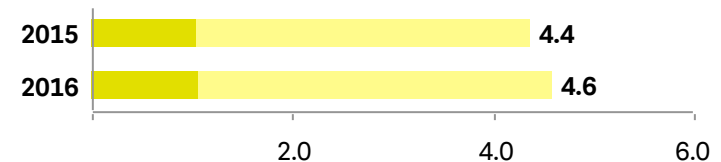
- E.ON is among the largest renewable energy players in Europe and the U.S.
- Our U.S. focus is onshore wind, utility-scale PV, energy storage and providing O&M services
- E.ON owns and operates about 4,600 MW of utility scale renewable projects and has a significant development pipeline in the U.S.
- The Company partners with investors offering stakes in our existing renewable energy assets or projects under development
- E.ON has approximately 600 E.ON employees in the U.S.

ERCOT Footprint

- Installed capacity 2.8 GW
- Technology installed: Wind Onshore and Energy Storage
- Employee ~400



Worldwide Owned Renewable Capacity (GW)



Texas Waves to extract co-location synergies with E.ON Wind footprint in Texas

Project Description

- Located in West Texas, Scurry and Nolan Counties
- Co-located to Pyron (265 MW) and Inadale (197 MW) Wind Farm
- 2 x 9.9 MW / 5 MWh battery storage system
- Energy Storage System participating into the day-ahead ancillary service and energy markets of ERCOT

Technology Selection

- Lithium Nickel-Manganese Cobalt (NMC) supplied by LG Chem
- Inverter manufactured in Germany and supplied by SMA
- Energy Management System provided by Greensmith/Wartsilia

Integration

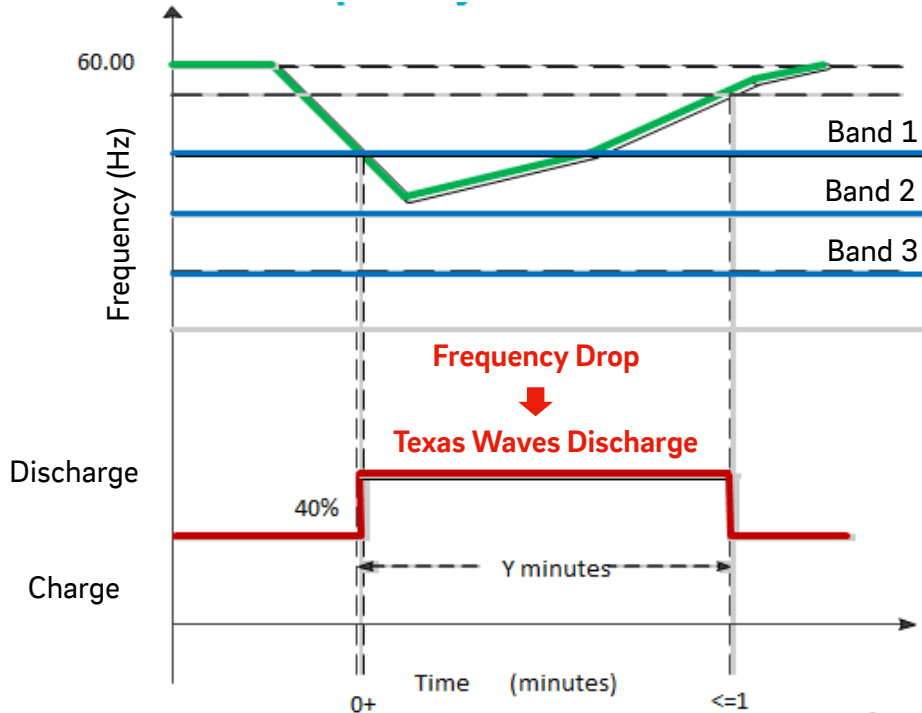
- Energy storage system integral part of the Wind Farms and eligible for Investment Tax Credit



TEXAS WAVES
PYRON
INADALE



ERCOT pioneer in utilize Energy Storage for the grid by introducing a Fast Responding Regulation Service



- In **2012**, ERCOT pioneering introduced as pilot the **FRRS market** as a fast subset of frequency regulation market
- Texas Waves is able to provide **Reg-Up** (discharge when system frequency drops) and **Reg-Down** (charge when the system frequency increases)
- An **example of Reg-Up deployment** shows how Texas Waves responds fast to a drop of the frequency into the system
- **ERCOT observed** that **FRRS can improve** ERCOT's **ability to arrest frequency decay** during unit trips²
- **ERCOT has determined** that fast and accurate responses from a portion of the Resources providing Regulation **Service can lower the overall amount of this service** that needs to be procured²

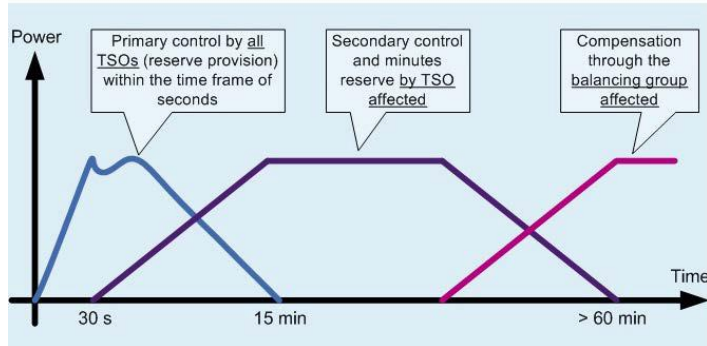
Sources:

- 1) ERCOT, "Fast Responding Regulation Service (FRRS) Overview", May 2016;
- 2) ERCOT, "Final Assessment for Fast-Responding Regulation Service Pilot Project", March 2014

Batteries participating into the ancillary flexibility power market, but no dedicated fast response products

German Ancillary Service market provides flexibility at grid scale

- Control power divided in 3 different markets:
 - Primary reserve (PR)
 - Secondary Reserve (SR)
 - Minute Reserve (MR)
- Market accessible via common auction: day/ ahead weekly tender and clearance by merit order

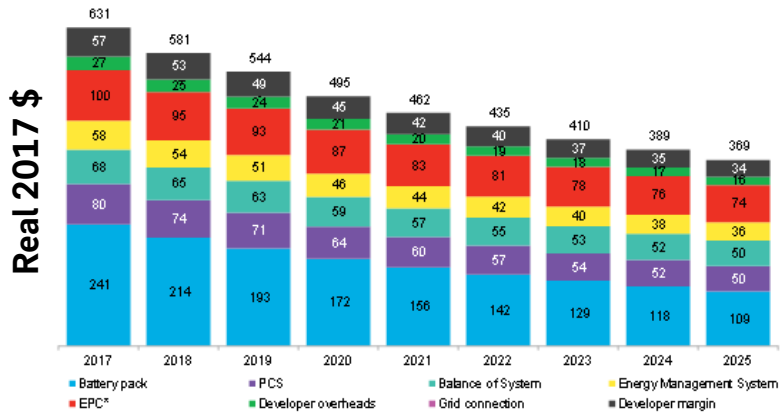


Energy storage participation in the primary and secondary reserve

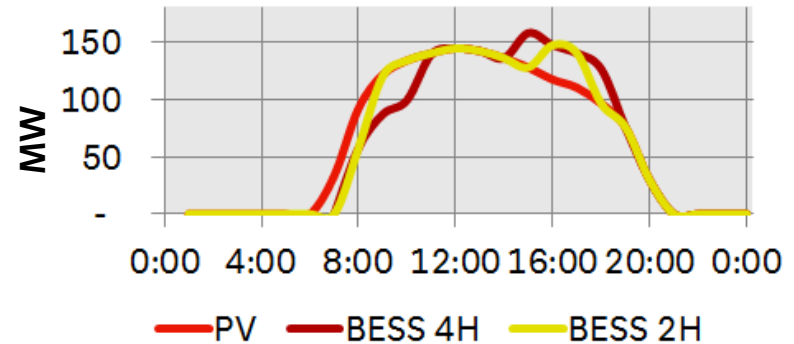
- Energy storage participation focuses on primary and secondary reserve markets
- Primary and secondary reserve market participation require longer duration battery (e.g. STEAG project 90MW/138MWh)
- Symmetric design, with 30 s response time
- Last years weekly PRL tender average price was 2,800 – 3,500\$/MW/month
- Market does not benefit from fast response potential of batteries

Effectiveness of storage as renewable integration driven by energy storage system costs decrease

- Energy storage system costs **function of kWh**
- **Short duration** ancillary services **first applications** to become **economically viable**
- Further **decrease of storage system costs** will **unlock** storage for **longer duration** application such as **renewable integration**



- Energy storage to be used to shift energy from renewable generation to high value hours of the evening peak
- Example with 150 MWac Solar PV coupled with 20 MW of energy storage in 3 configuration:
 - 20 MW/80 MWh (4 h BESS)
 - 20 MW/40 MWh (2 h BESS)



Thank You