Proposal for Integrating DER into ERCOT (ISO) Operations - Addressing Reliability and Wholesale Market Impacts

Sainath Moorty, Diran Obadina : ERCOT
Khosrow Moslehi : ABB

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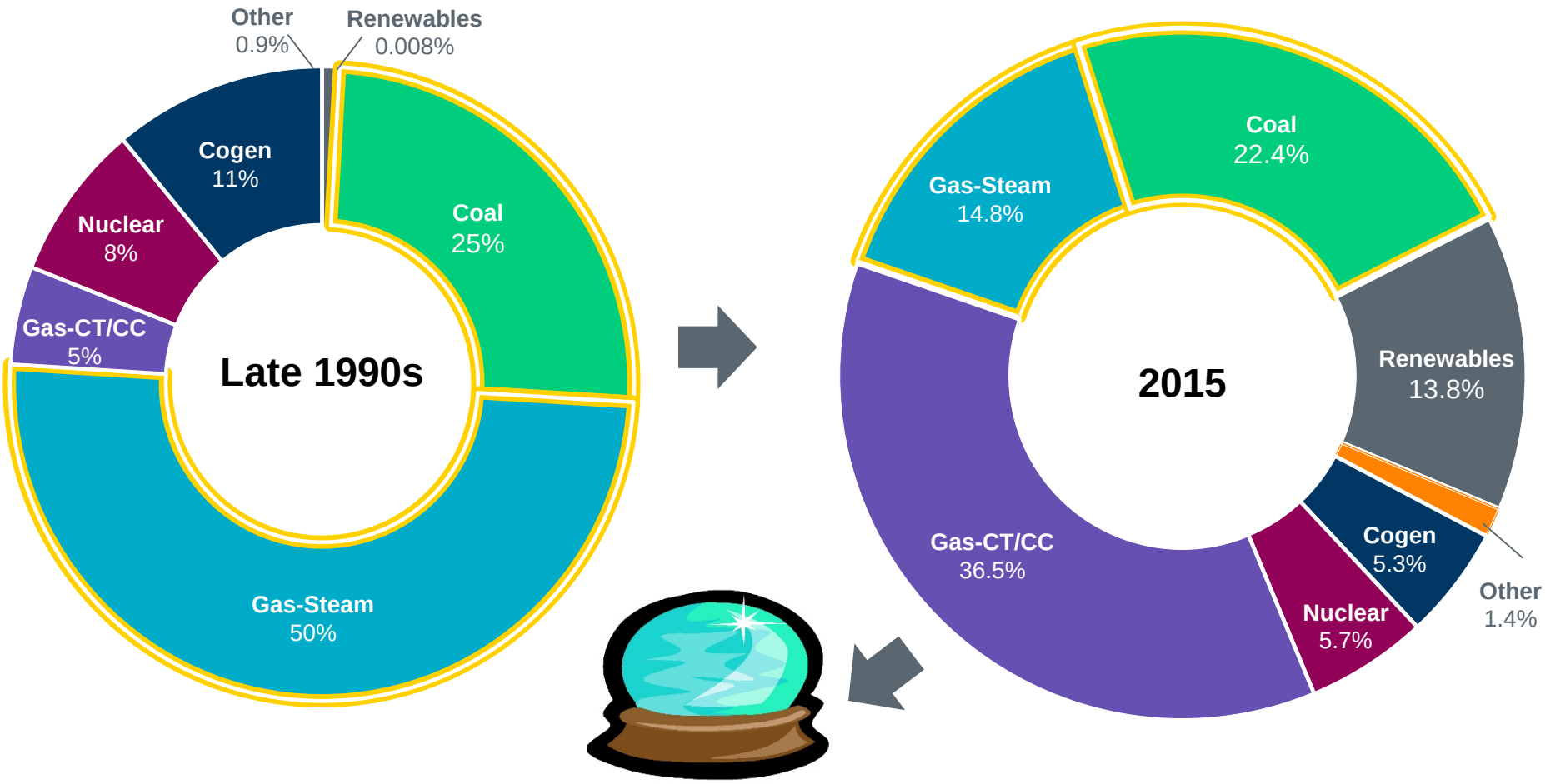
Agenda

- ERCOT's Changing Resource Mix
- Distributed Energy Resources … an ERCOT perspective
- Overview of ERCOT's Proposal To Integrate DER
- Impacts Of Significantly Large-Scale Penetration of DER on ERCOT Systems
- ERCOT's Proposal To Integrate DERs Into Wholesale Markets
- Questions

ERCOT's Changing Resource Mix

Changing Resource Mix (% Capacity)

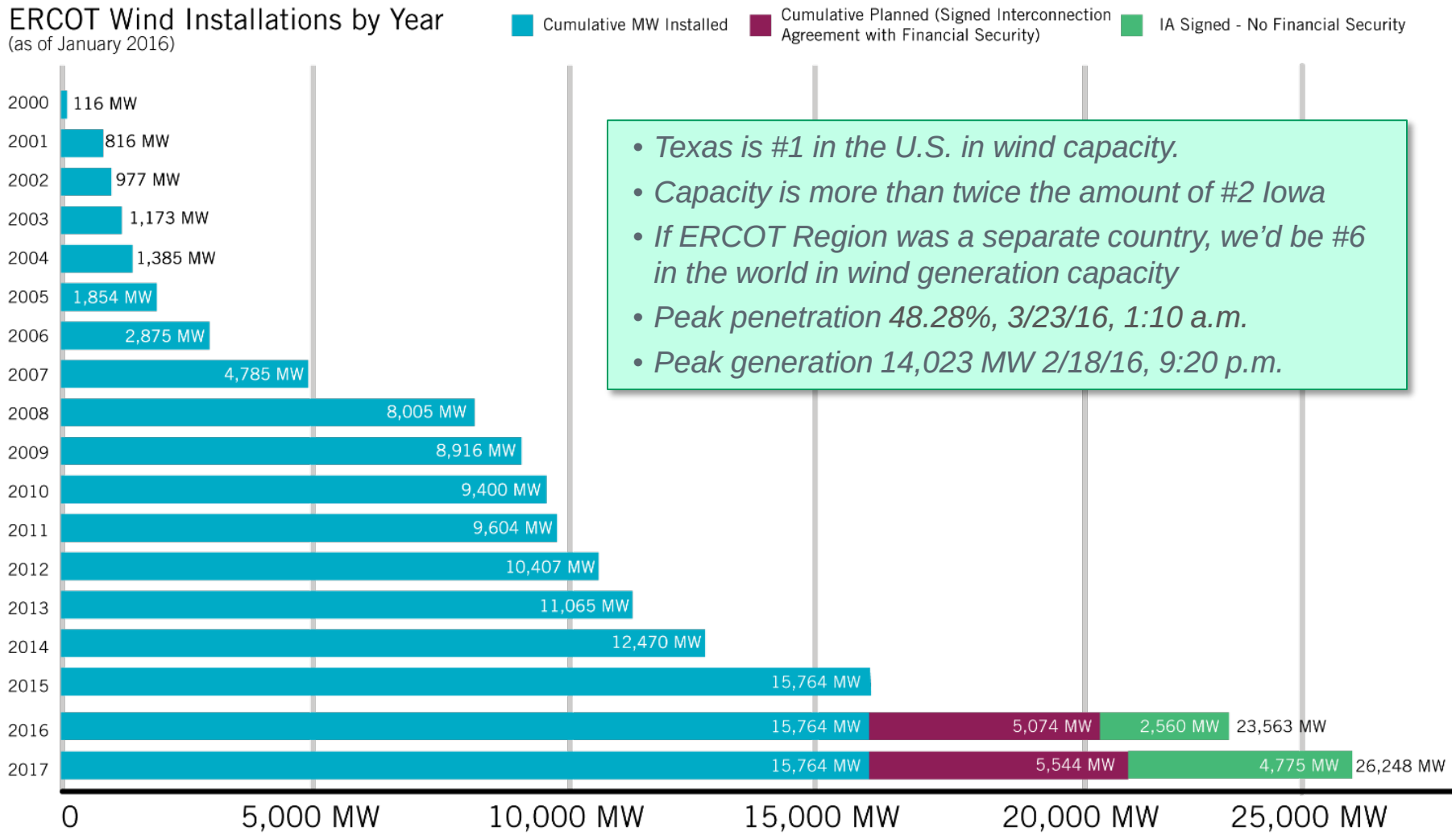


The Future

Potential impacts of new and pending environmental regulations, lower PV costs, extension of tax subsidies

More renewables, especially distributed

Wind Power Queue

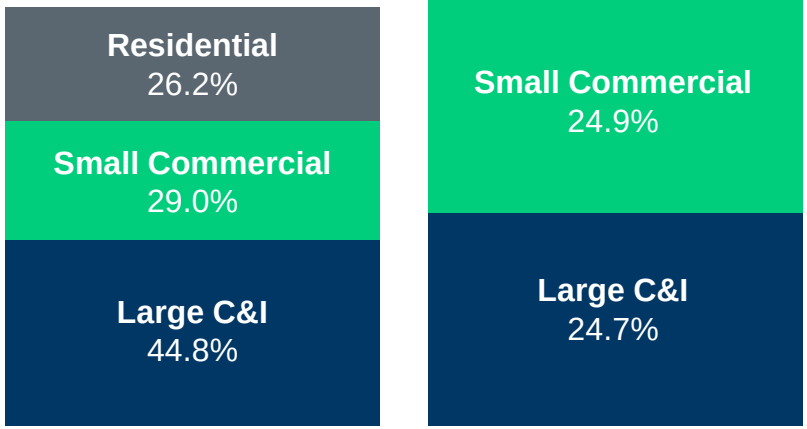


- *Texas is #1 in the U.S. in wind capacity.*
- *Capacity is more than twice the amount of #2 Iowa*
- *If ERCOT Region was a separate country, we'd be #6 in the world in wind generation capacity*
- *Peak penetration 48.28%, 3/23/16, 1:10 a.m.*
- *Peak generation 14,023 MW 2/18/16, 9:20 p.m.*

Weather Impacts on Load by Customer Type

Thursday,
March 12, 2015
5:00 PM
ERCOT Load: 32,955 MW
Temperature in Dallas: 69°

Mon., Aug. 10, 2015
5:00 PM
ERCOT Load: 69,659 MW
Temperature in Dallas: 107°



~37,000 MW of weather-sensitive load -- 53% of peak

- Customer class breakdown is for competitive choice areas; percentages are extrapolated for munis and co-ops to achieve region-wide estimate
- Large C&I are IDR Meter Required (>700kW)
- 15-minute settlement interval demand values

Distributed Energy Resources (DERs)

…an ERCOT perspective

Distributed Energy Resources

- **DERs potentially include:**
  - Rooftop solar - intermittent
  - Fossil fuel generators
  - Storage devices
  - Fuel cells

  } Self Dispatched – Backup, Price Response, etc.

  - Combinations of the above at single or multiple points of interconnection at <60kV

- **DERs may be co-located with load behind the meter**
- **Many DER management systems include distribution level demand response (DR) as part of the DER performance**
- **However, integrating Demand Response (DR) into a DER involves some issues specific to ERCOT**
- **The PUC Rule that established ERCOT's Nodal Market Design requires:**
  - Generation to be settled at a (Nodal) Locational Marginal Price
  - Load to be settled at the weighted average price of all LMPs in a Load Zone
    - Exception: Load (energy) used to charge a storage device
    - There are 4 competitive Load Zones in ERCOT: North, South, West and Houston
- **This implies that DR cannot be part of a DER that may seek to be settled at a Nodal price, absent a Rule change.**

How much DER capacity is out there?

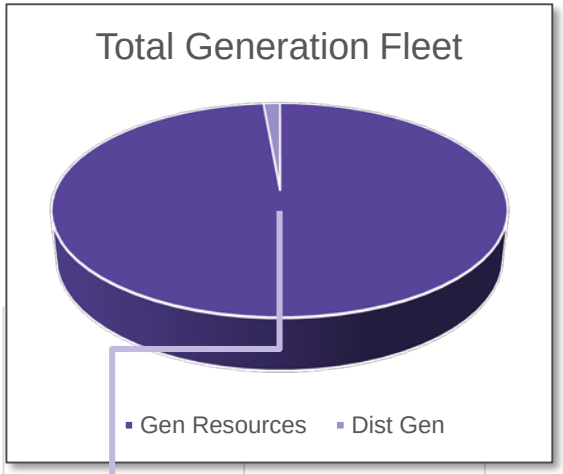
- DG reporting is a work in progress
  - All DG >1 MW must register with ERCOT
    - Assuming it injects to the grid and..
    - Is not registered with PUC as Self-Generation
  - Investor-owned TDSPs submit:
    - Annual DG Interconnection reports to PUC
    - Regular updates to ERCOT Profile Codes
  - Muni's and Co-ops (NOIEs) report:
    - Data on units >50 kW that inject energy to the grid
    - Some anecdotal summaries to City Councils, etc.
- With all that in mind, here's what we have:

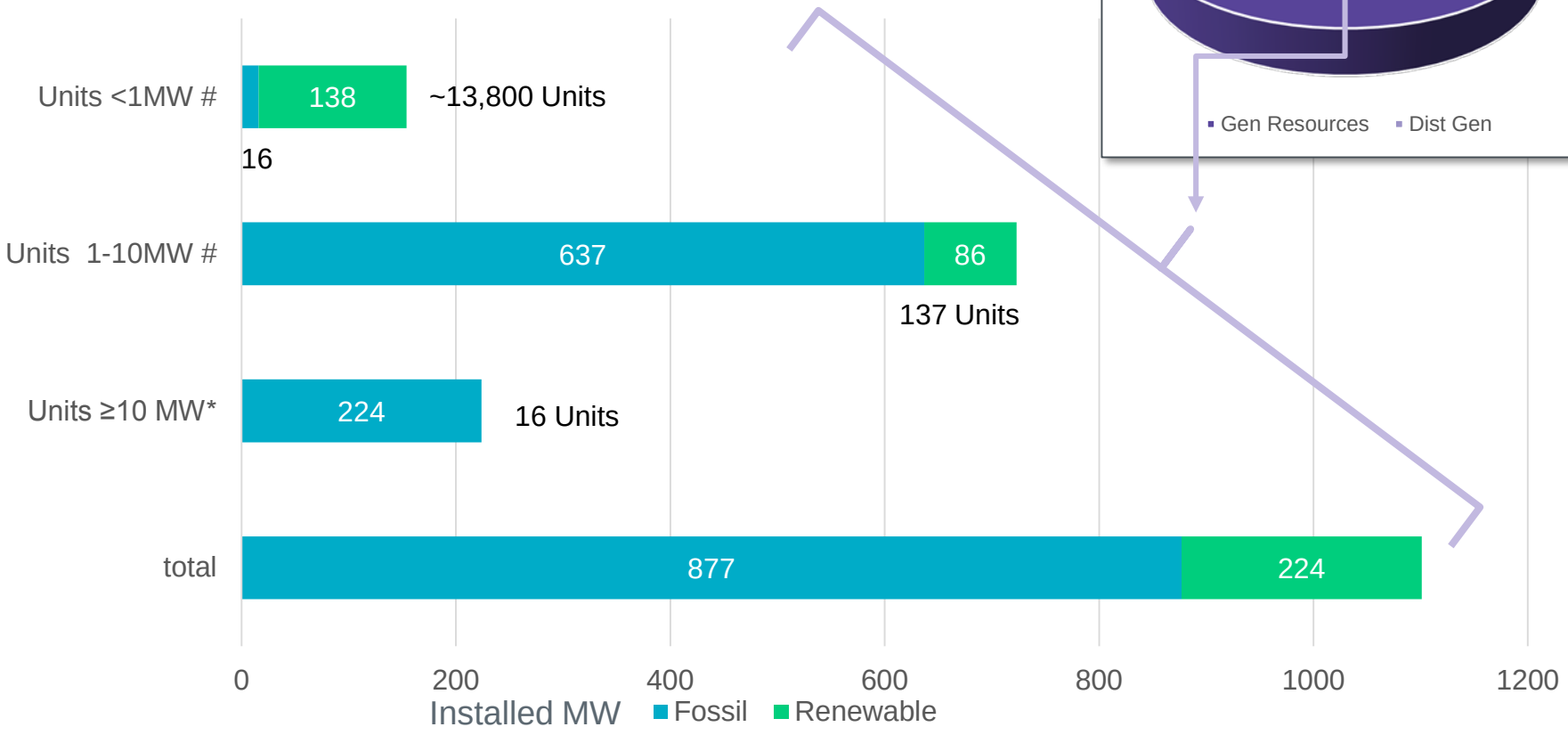
DG snapshot as of Dec. 31, 2015

From Competitive Choice TDSP annual reports to PUC, plus estimated NOIE DG

DG Capacity based on these reports: **1,101 MW**

Capacity from Generation Resources based on Dec. 2015 CDR: **79,280 MW**





* An unknown number of these units may be among the 77 units registered with PUC as Self-Generators.

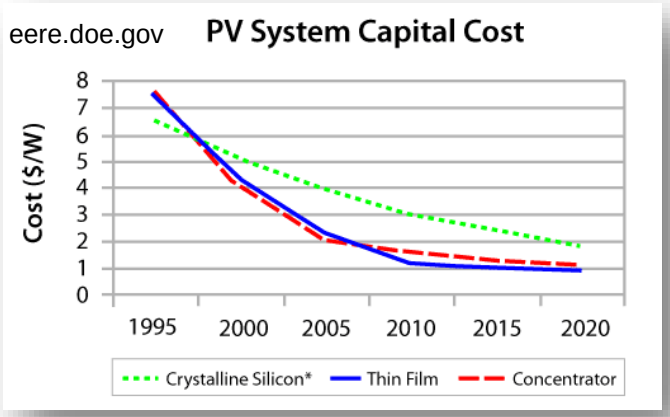
Anecdotal as reported by Austin Energy & CPS Energy, plus some other NOIE >50kW. NOIEs are not required to report unregistered DG to ERCOT unless >50kW and injects to grid.

Why DER is Growing?

1. Customer desire for independence
   a) Mandated or strongly encouraged for critical infrastructure
   b) Economically desirable to guarantee limited interruption of service

2. Environmental consciousness
   a) Non-economic reasons

3. Declining costs of DER acquisition and operation
   a) Tax credits
   b) Reduction in costs

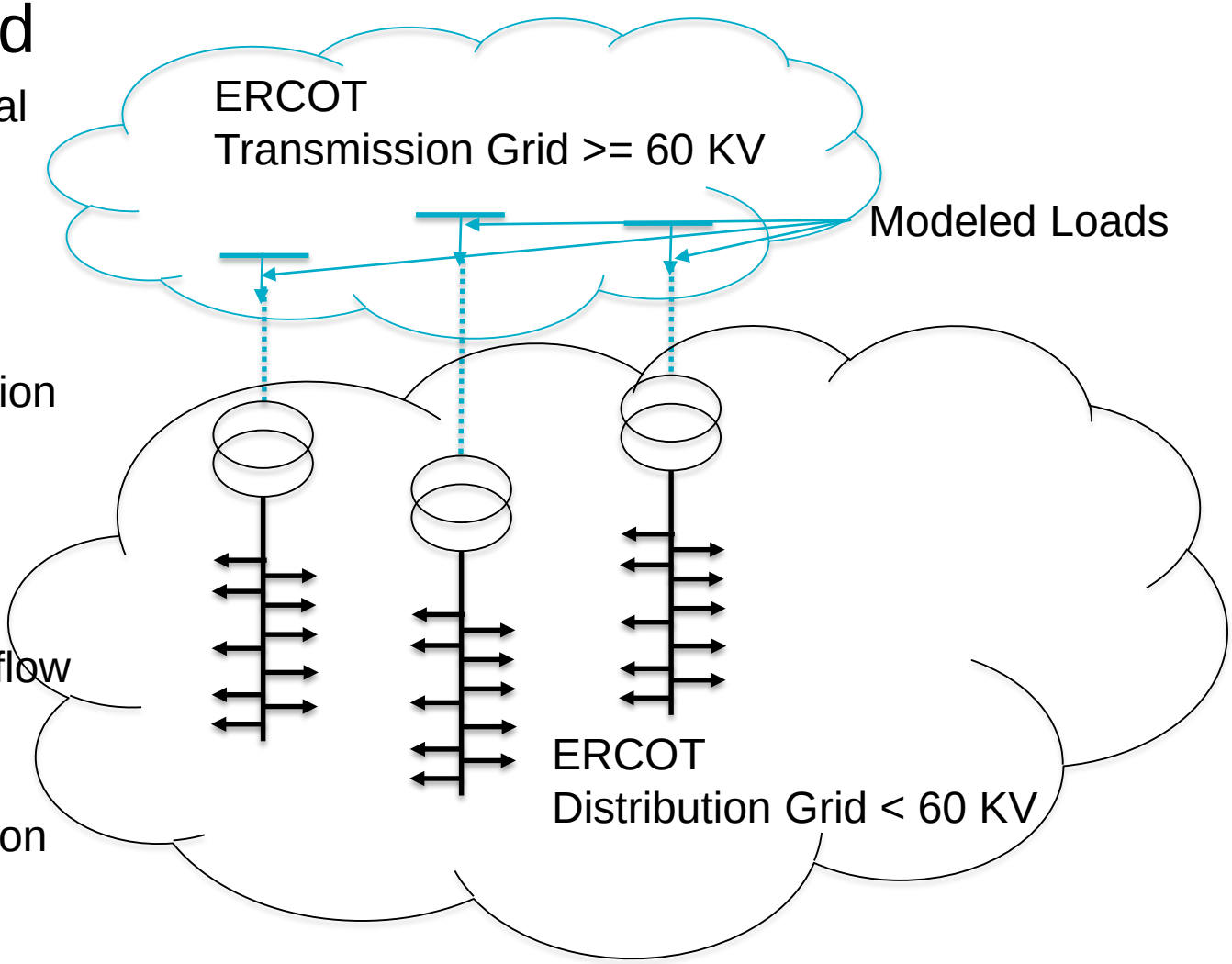


Overview of ERCOT's Proposal To Integrate DER

Typical Distribution Grid Topology

Distribution Grid

- Predominantly Radial Topology
- Urban Areas more meshed
- Limited telemetry available at distribution voltage relative to available telemetry transmission level
- More resilient to unbalanced 3 phase flow
- Mainly designed for unidirectional power flow from transmission to consumer
- DER can be single phase - residential



Integrating DERs into ERCOT ISO Operations – Starting Points

1. ERCOT is responsible for reliable operation of the transmission grid (>=60 KV). The interface to the distribution grid is modeled as a **Load** (i.e. substation transformer interconnecting transmission to distribution is represented as a Load)

2. Increased DER penetration will have reliability impacts on the distribution grid (< 60 KV) **well before** measurable reliability impacts occur on the transmission grid reliability operations that ERCOT is responsible for.

3. DER installation requires interconnection agreement with the local Distribution Service Provider (DSP).

4. Typically DSPs have a limit on the total aggregate DER capacity allowed on a feeder or the secondary of a substation transformer before distribution grid upgrades are required, the cost of which are borne by the DER owner

From ERCOT's perspective as the transmission grid operator:

Very significant DER penetration at individual substation transformers will need to happen before DER operations -- intermittent or self-dispatched -- at that location will overshadow the natural hourly variability of the actual demand at that location

ERCOT's Proposal to Integrate DER

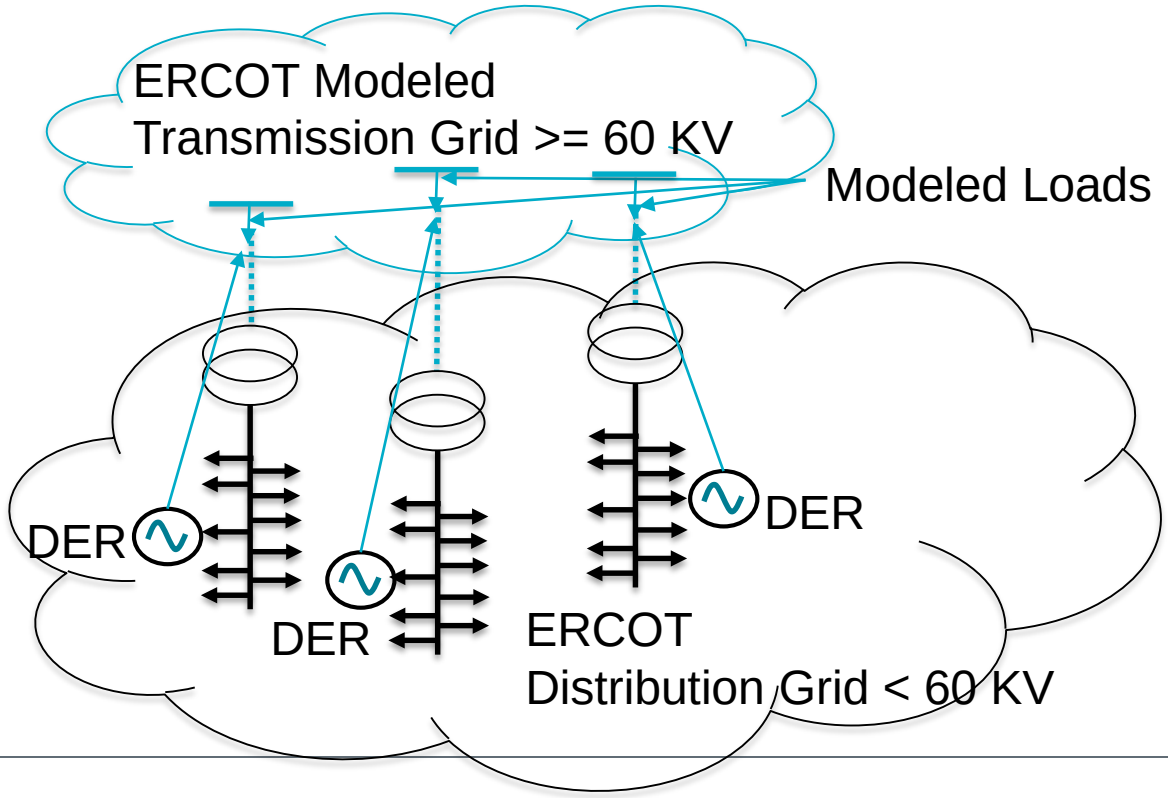
1. Key areas pertaining to DERs that ERCOT has identified as gaps:
    1. Lack of DER visibility (location, type, capacity)
    2. What are they doing ? (forecast of intermittent DER – solar forecast)
2. Monitor growth of DER by collecting data:
    1. Location information relative to the transmission grid (e.g. closest station, bus)
    2. DER type and capacity (Fuel: Solar, Natural Gas, Diesel, etc., Storage, MW and MWh capacity)
    3. Others (if available)
3. Review ERCOT software systems and processes to prepare a plan to address scenario where there is significant DER penetration, e.g. (short list below)
    1. Load Forecast
    2. State Estimator
    3. Contingency Analysis
4. Develop a market framework that enables DERs to participate in wholesale markets for energy and Ancillary Services.

ERCOT published a concept paper on 8/20/15 describing a proposal for DERs to participate in wholesale markets (energy and Ancillary Service) where their energy injection is settled at the closest transmission bus LMP:

http://www.ercot.com/content/wcm/key_documents_lists/72784/DER_Whitepaper_082015.docx

ERCOT's Proposal to Integrate DER - continued

5. ERCOT operations model used in Energy Management System (EMS) and Market Management System (MMS) **will not be expanded** to include modeling the distribution grid (<60KV) down to DER location
6. Map DERs to the closest transmission modeled load (representing substation transformer). i.e. not explicitly modeled in power flow or state estimation. Mapping provides alternate mechanism for handling DER, e.g. LMP at Load Bus, Bus Load Forecast.



Impacts Of Significantly Large-Scale Penetration of DER on ERCOT Systems

Load Forecast

Difficulties in creating an accurate load forecast - short term and mid term

Cause:

a) Lack of DER visibility (location, type, capacity)
b) Lack of ISO control over dispatch (not participating in wholesale markets)
c) Variability of PV generation (lack of solar forecasting)

Effect:

a) Potential need to procure additional Ancillary Services
b) Potential for inaccuracies in Reliability Unit Commitment (RUC)
c) Potential for an increase in price volatility

Mitigation Plan:

Enhance Load Forecast tools/processes to consider solar insolation at various locations coupled with locational awareness of DER installations (type, capacity)

State Estimator (SE)

Difficulties with State Estimator accuracy, load distribution factor (LDF) adaptation

Cause:

a) State estimation of Loads typically are not allowed to be negative. State Estimator output processing will floor the load MW value to zero. This may be inaccurate with significant penetration of DER at certain locations, where, there could be back-feed into the transmission grid

Effect:

a) Inaccurate LDFs (zero instead of negative)

b) Real-Time Contingency Analysis may start with inaccurate Base Case (some loads are zero instead of negative)

c) Other applications that use these inaccurate LDFs can be impacted

   a) Outage evaluation at different load load levels use LDFs to scale up/down individual loads

   b) Day-Ahead Market (DAM) , Reliability Unit Commitment (RUC) applications, similarly use LDF to scale up/down individual loads based on hourly load bids or hourly load forecast

Mitigation Plan:

1. Modify State Estimator and LDF adaptation system to use DER locational data that allows for loads MW values to be negative
2. Modify how Outage Evaluation, DAM and RUC utilizes LDFs

Contingency Analysis (CA)

Inaccuracies in the results of Contingency Analysis

Cause:

a) Lack of DER visibility (location, voltage response characteristics, type, capacity)

Effect:

a) False positive: Incorrectly mark an analyzed contingency as being secure where, a voltage drop on a transmission bus can cause tripping of DER, which causes an increase in load. This is not captured in the contingency definition.

b) False negative: If DERs provide reactive support, then a low voltage due to a contingency may be incorrectly analyzed as being insecure

Mitigation Plan:

1. Enhance Contingency Analysis tool to consider locational DER information
2. Develop models to simulate voltage response characteristics of DER at relevant transmission bus

ERCOT's Proposal To Integrate DERs Into Wholesale Markets

ERCOT Proposal For Integrating DER Into Wholesale Markets

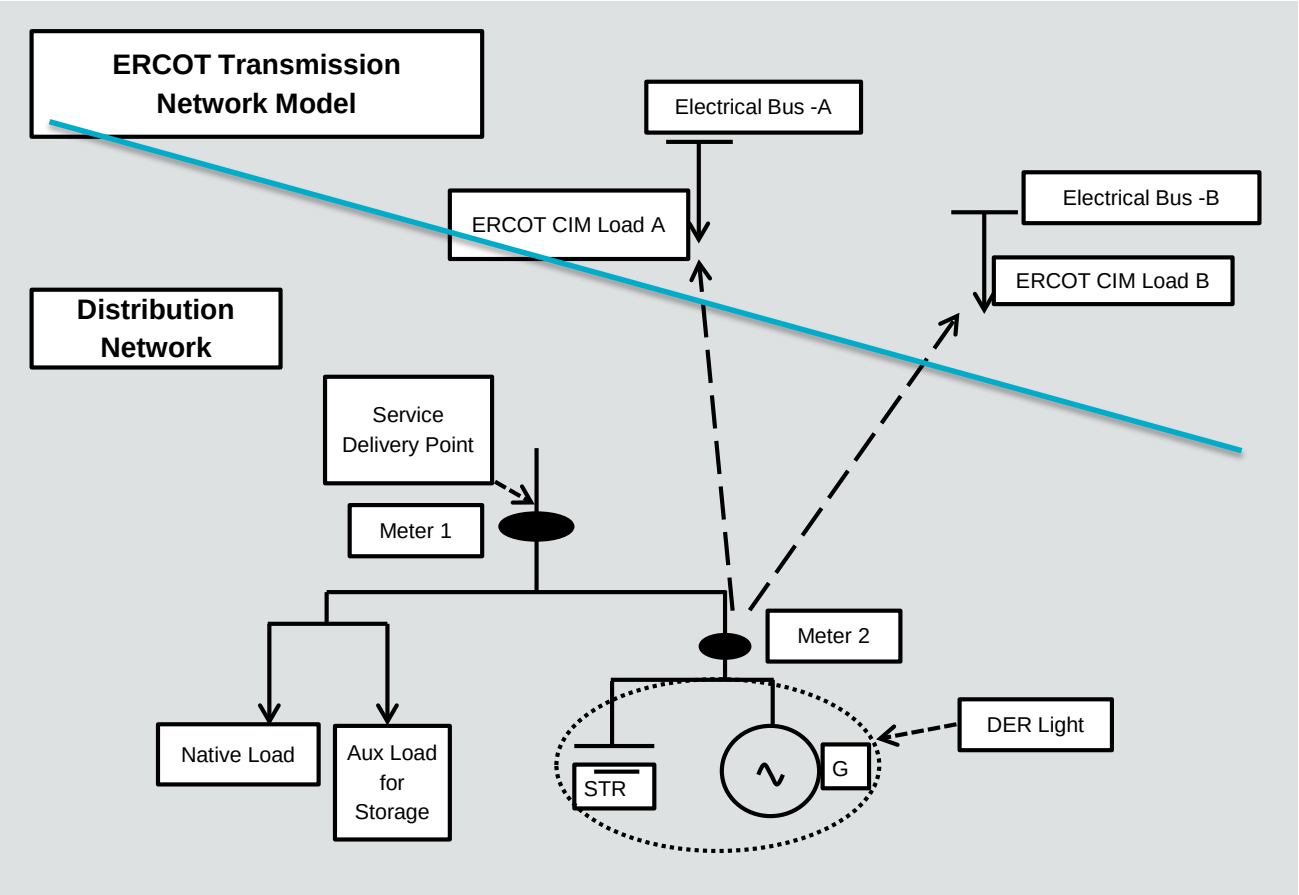
- 3 potential categories:
  - DER Minimal: Business as usual, what we have today, passive participation, price takers, settled at Load Zone LMPs
  - DER Light: Passive participation (no ERCOT dispatch) but settled at the Nodal (local) wholesale price, rather than at the average price at the Load Zone
    - Would require separate metering of gross load and gross generation
  - DER Heavy: Active participation in Energy and AS, much like Generation Resources today
    - Would require:
      - Separate metering of gross load and gross generation
      - Significant real-time data to ERCOT

DER Types

Features	DER Minimal	DER Light	DER Heavy
Energy Settled at:	Load Zone SPP	Price at Local electrical bus(es)	Logical Resource Node (price at Local electrical bus(es))
Energy Market Participation	Self-responding	Self-responding	SCED-dispatched
Ancillary Service Market Participation	Not eligible	Not eligible	Eligible
Aggregation Allowed?	N/A	Yes	Yes
Metering Required	Single meter OK (15-minute revenue quality) at POI	Separate (dual) metering for Generation and native Load	Separate (dual) metering for Generation and native Load
Telemetry or telemetry-light to and from ERCOT	Not required	Real-time or near real-time with multiple attributes	Real-time or near real-time with multiple attributes
COP, Outage Schedule, Offers/Bids, etc.	N/A	Possible “light” version required	Required
CRR/PTP Implications	None	None	Maybe

Distributed Energy Resource Modeling
DER Heavy/Light

- ERCOT has developed a concept paper to help integrate DERs into the wholesale market
- Main concept is to allow DERs to be settled at local (Nodal) prices instead of zonally-averaged prices
- Would provide proper incentives for DER locating and could contribute to local congestion management



Hypothetical DER configuration: Generator and storage device combination metered separately from native and auxiliary load; DER mapped to one or more Load Points in the transmission network model

Aggregated DER Modelling and Challenges

- Modeling – ERCOT proposal based on combined cycle model
  - ERCOT current proposal allows for multiple generation technologies (Solar, Solar+Storage, etc.) to make up a given DER aggregation
- Managing aggregation membership (move-in, move-out)
- Measurement & Validation
  - Required for ensuring telemetry of aggregation (virtual in many cases) is sufficiently accurate
  - Big Data Analytics & statistical sampling

Questions?