Integration and Impact of Geothermal on Transmission and Distribution

2016 Power Plays

Geothermal Energy in Oil and Gas Fields

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Electric Power Engineers

- Founded in 1968 – OVER 45 YEARS of Experience
- Consulting services for electric utilities & cooperatives
- Transmission & distribution analysis
- Generation & renewable resource energy integration
- Over 150 resource & asset integration transmission assessments annually
- Projects across the United States and internationally
- Extensive experience with ERCOT, SPP, WECC, MISO, CAISO, PJM and NYISO
- Team of engineers licensed in several states

Topic Focus

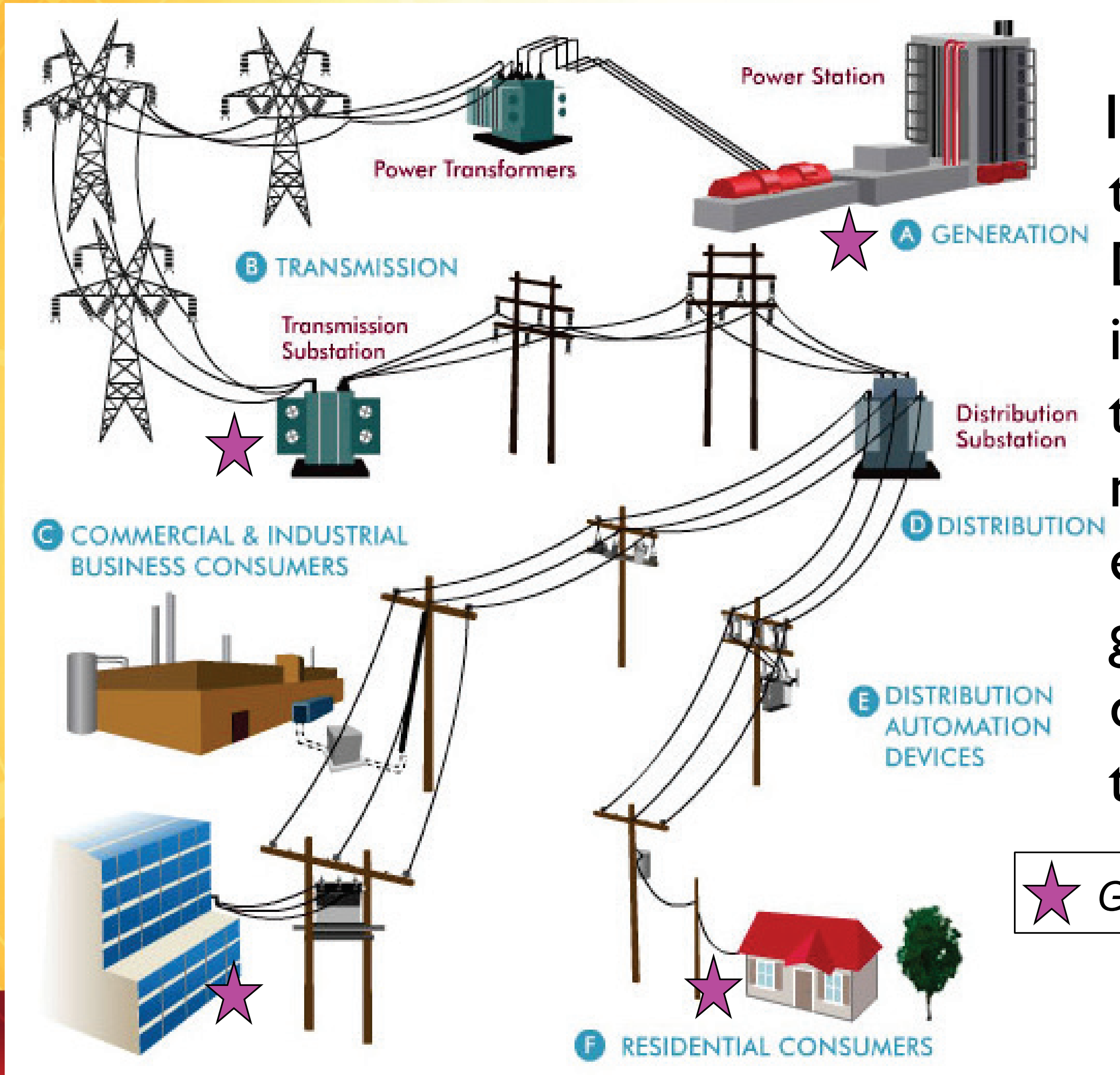
Generation Grid Interconnection Basics

Grid Integration Challenges

Geothermal Grid Interconnection Application

Grid Need Driven Geothermal Opportunities

Grid Basics



Interconnection to the Transmission/ Distribution Grid is the first step in the process necessary for an electricity generator to deliver/sell energy to load.

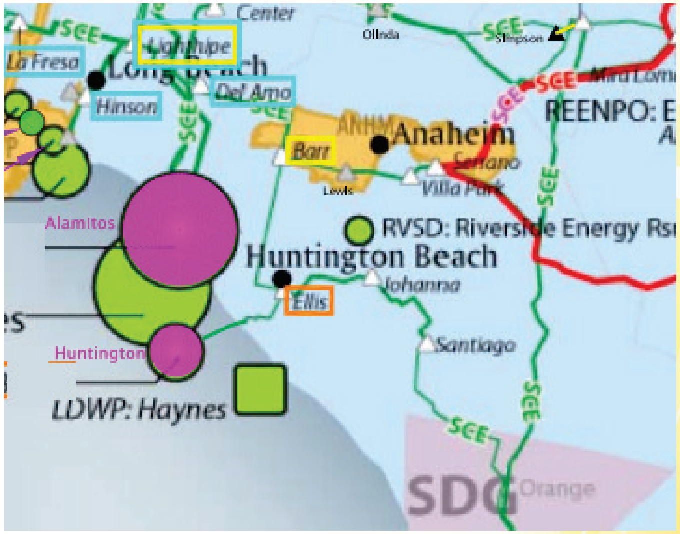
★ *Geothermal*

Generator Grid Interconnection & Integration

Generator Grid Interconnection

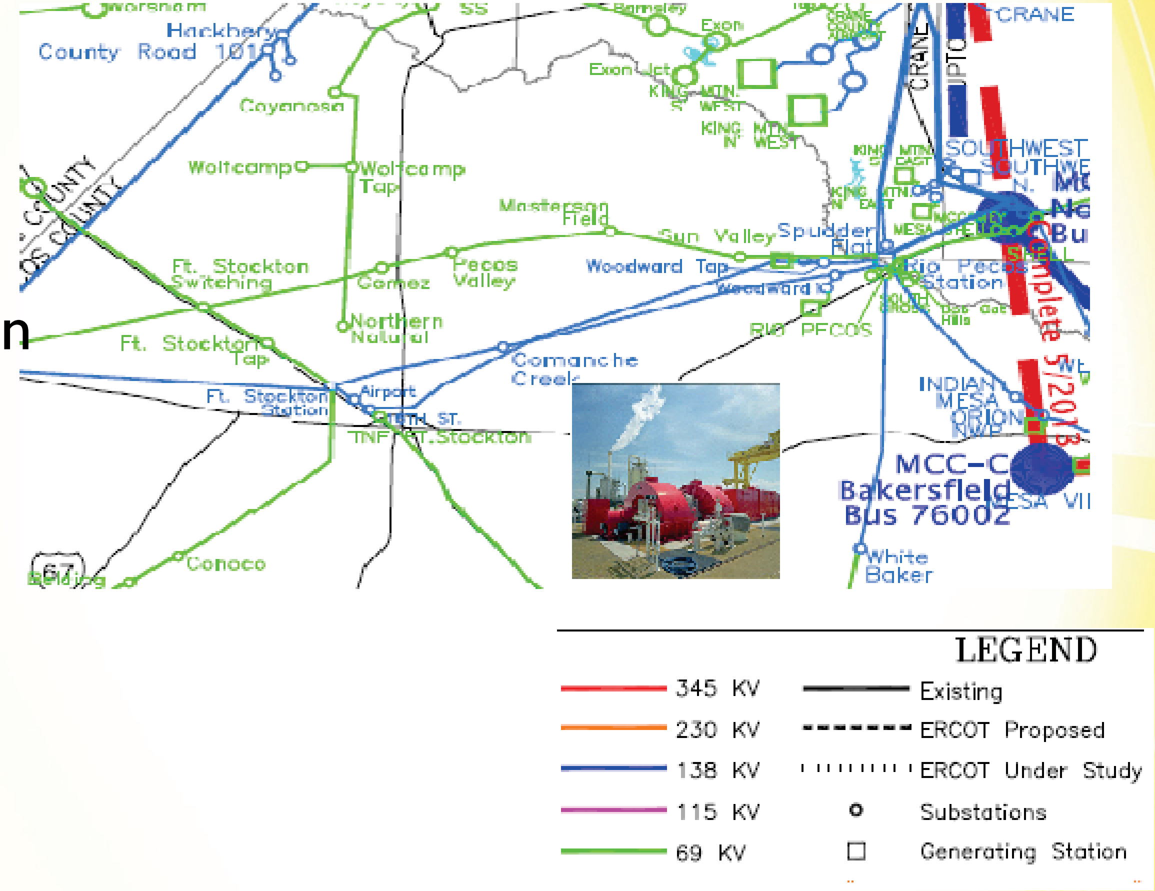
Three most important elements determining interconnection feasibility and application of governing interconnection process:

- Size of the Generator
- Location of the Generator
- Export of Power to the "Market"



Resource Location vs. Grid infrastructure

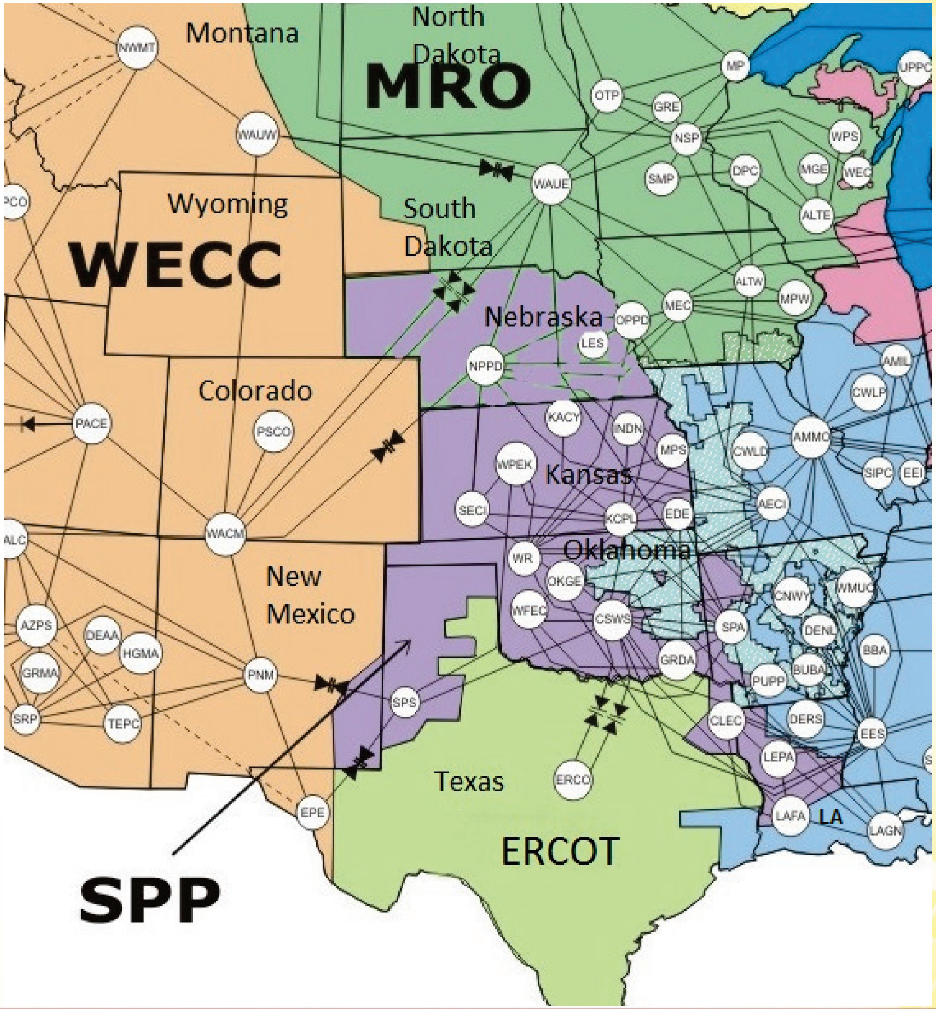
- Vicinity to Distribution/Transmission
- Infrastructure carrying capacity



Resource Location vs. Process for Interconnection

The application process, information submittals, and timelines vary amongst the different ISOs and with the individual Utilities.

Large generator interconnection process governed by RTOs/ISOs



Resource Size and Location "Transmission Deliverability"

Generator size and location determines whether the Generator will export of power to the "Market".

Implications:

- Transmission deliverability studies
- Grid infrastructure expansion.
- In some areas transmission capacity reservation

GRID Biggest Challenges

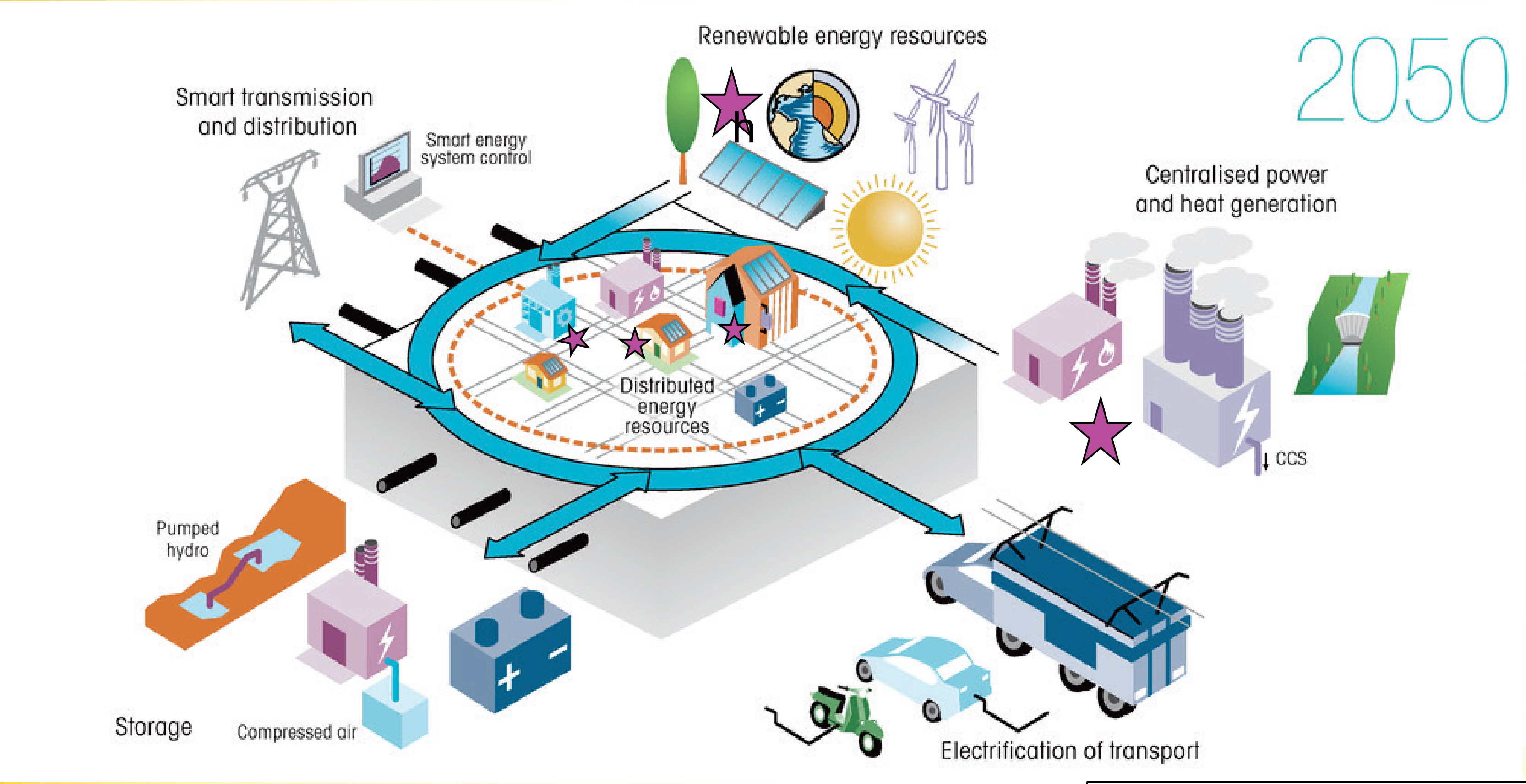
- Transmission Limitations
  - Challenges in permitting transmission expansion
  - Challenges in justifying cost with regulators
  - Congestion
- Resource Adequacy
  - Open market for generation – NO IRP challange
  - Best Resources are located away from load centers
  - Firm Generation and system Inertia Needs

Generation - Grid Consideration

	Distributed Generation	Local Load Serving Generation	Remote Generation
Interconnection Voltage	Up to 35 kV	Generally 69 kV to 138 kV	> 138 kV
Indicative Plant Size	< 5 MW/10 MW	< 100 MW	>100 MW
Transmission Expansion	None	None	Yes
Special Characteristics	This is typically generation connected at distribution voltage (<35 kV), and/or behind the meter, sized to serve local load	This is generation that is generally connected at transmission level, studied to serve load using existing transmission infrastructure	Generation located remote from load centers due to resource requirements. Generation has to be large enough to justify building transmission (economy of scale)
Grid Interconnection Process	Local distribution company Minimal in cost and time	Transmission utility /ISO Generally will take over 1 year.	Transmission utility /ISO Generally will take over 1 year.
Grid Interconnection Facilities	Minimal	Reasonable	Could be substitutional. May take years to build
Challenges in getting to the grid	Easy to site small projects, however when industry matures, competition on commercial customer applications may be introduced	Limited Opportunities requiring searching for the right locations on the grid that offer the transmission capacity.	Requires new transmission build-out and/or upgrades, with permitting and construction challenges. Regulatory (ISO or FERC) challenges in justifying cost
Benefits to Grid	Defers transmission and distribution system upgrades	Transmission Upgrade Deferral	Project Specific
Geothermal Coproduction			
Geothermal Hydrothermal			
Engineered Geothermal System (EGS)			

Modern Grid

Distributed Generation rise



Source: International Energy Association

★ *Geothermal Application*

Examples from Texas today on Grid Needs

West Texas Load Growth

Addressing growing needs in West Texas

Peak demand up 40 percent since 2010 (Far West zone)

- Rapid growth of oil and gas exploration and production
- Higher power needs for horizontal drilling

ERCOT Planning
July 2015

Projects to address current needs

- $299 million in improvements in 2014 (mostly 69 kV and 138 kV)
- $950 million in improvements planned through 2020 (most by 2018)

	Historical Load					
	2010	2011	2012	2013	2014	2015
Total (MW)	22.4	21.6	33.4	53.2	89.7	105.4

Far West Texas Load Growth

ERCOT Planning
June 2015

- Active oil & gas rigs contribute significantly to peak Load
- Number of rigs is not firm and does not provide a long term commitment (recently number significantly dropped)

- Assume 200 KW geothermal production per Rig
  - 150 Rigs -> 30 MW load offset
  - 300 Rigs -> 60 MW Load offset

	Historical Load					
	2010	2011	2012	2013	2014	2015
Total (MW)	22.4	21.6	33.4	53.2	89.7	105.4

Far West Texas more Load Growth

WINK – CULBERSON – YUCCA DRIVE LOOP

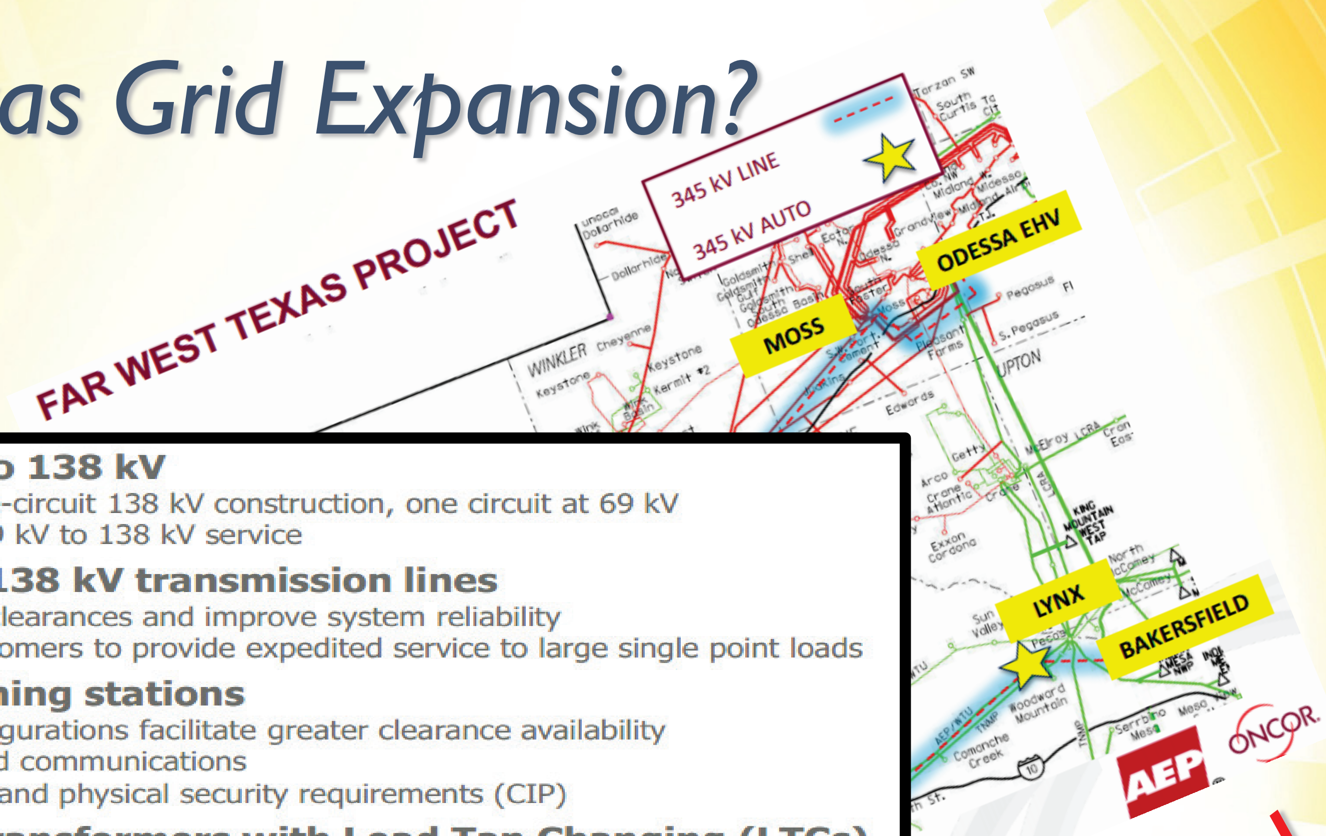
	Historical Load						Projected Load					
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total (MW)	22.4	21.6	33.4	53.2	89.7	105.4	231	304	343	391	[illegible]	426

Projections only include confirmed load increases from normal load forecasting and signed customer agreements.

AEP/ONCOR Planning April 2016

AEP ONCOR

Far West Texas Grid Expansion?



- **Convert 69 kV system to 138 kV**
  - Rebuild 69 kV Lines with double-circuit 138 kV construction, one circuit at 69 kV
  - Gradually migrate loads from 69 kV to 138 kV service
- **Add New and Upgrade 138 kV transmission lines**
  - Create 138 kV loops to enable clearances and improve system reliability
  - Work closely with oil & gas customers to provide expedited service to large single point loads
- **Upgrade and add switching stations**
  - Increase capacity, modern configurations facilitate greater clearance availability
  - Improved system protection and communications
  - Provisions for future expansion and physical security requirements (CIP)
- **Upgrade and add autotransformers with Load Tap Changing (LTCs)**
  - Increase capacity and voltage support; operational flexibility for clearances
- **Upgrade and add substations with LTCs and Dynamic Reactive**
  - Increase load serving substation capacity to meet growth plans
  - Increase distribution voltage control capability
- **345 kV Infrastructure**
  - Provide backbone support
  - Reach out to areas where there is extreme load and generation growth, but there is a lack of adequate transmission grid infrastructure

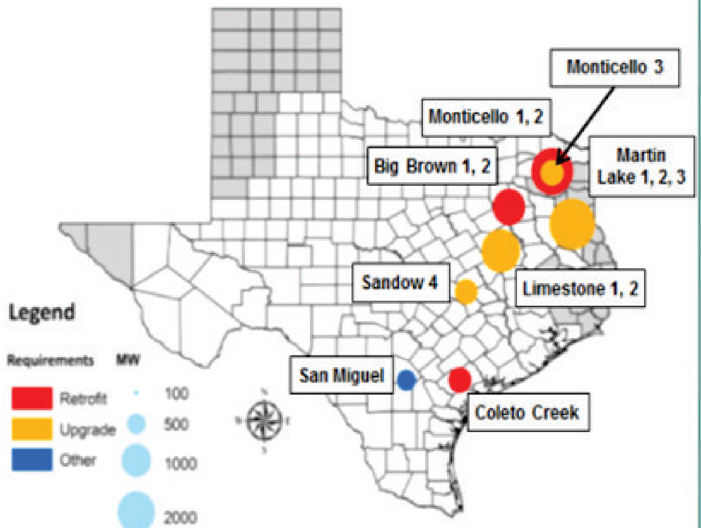
AEP/ONCOR Proposal
April 2016

Central Texas Potential Coal Retirements

ERCOT study results with Regional Haze Implementation

- 3,000 to 8,500 MW of coal unit retirements over next 5 to 7 years

Regional Haze Affected Units in ERCOT



ERCOT 2/12/2015

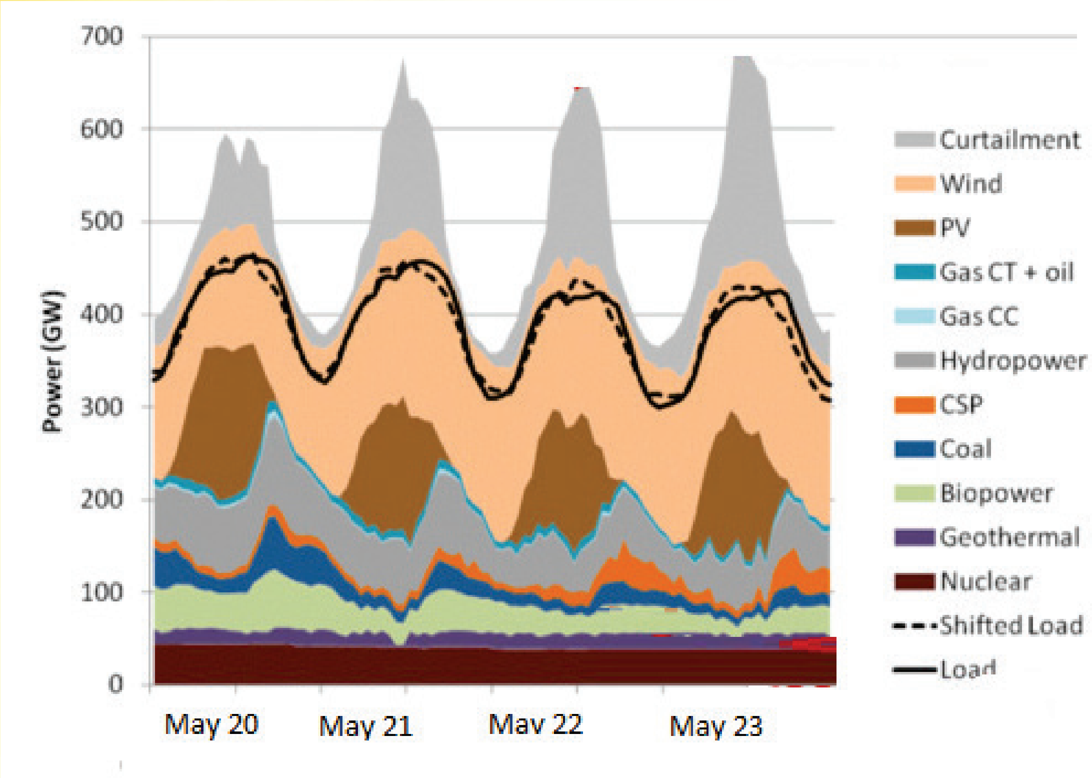
ERCOT study results with Clean Power Plan Implementation

- Up to 9,000 MW of coal unit retirements by 2022
- 33,000 MW total renewable capacity in scenarios with Clean Power Plan
  - Includes more than 15,000 MW in renewable capacity additions, most of which is solar

$$$Transmission Solutions?
Generation Replacement?

Opportunities?

Grid Friendly Geothermal



- Geothermal generation is firm and can be run as base load
- Geothermal generation contributes to system inertia
- Distributed generation and co production to offset load

Geothermal Grid Driven Opportunities*

Congestion Relief
Deferral or mitigation of Grid Expansion
Load Offset

- Coproduction to offset Oil & Gas demands
- EGS optimally located to replace coal or other Grid generation pocket needs
- Distributed resources offsetting load

**Assuming costs reach grid parity*

QUESTIONS

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