



Solar Penetration Study

RPG Meeting
February 16, 2016

Background

- As of December 2015, 8601 MW of solar projects are going through the generation interconnection process in ERCOT.
- The majority of the projects are concentrated in the West and Far West weather zones where the transmission system is relatively weak.
- 2014 LTSA identified potential for over 16 GW of solar generation in ERCOT by 2029.
- The objective of the solar penetration study is to assess the impacts of the solar projects on ERCOT's current transmission system and get a high level understanding of the needed transmission upgrades to accommodate the solar projects should they come online as planned.

Solar Projects by Weather Zone and Commercial Operation Date (COD)

- The 8601 MW of solar projects are primarily located in the West and Far West Weather zones. The breakdown of the solar projects by weather zone is summarized below.

Weather Zone	MW Capacity	Percentage
Far West	5572	64.8%
West	1123	13.1%
North	1511	17.6%
South	250	2.9%
South Central	145	1.7%

Development of Study Cases

- Since the majority of the solar projects are located in the West and Far West, and all but one are projected to be online by the end of 2017, the latest 2018 West/Far West summer peak case from the 2015 Regional Transmission Plan (RTP) is the base case for the study.
- All solar projects in the West, Far West and North weather zones are included in the study. The solar projects in the South and South Central weather zones (395 MW in total) are not included in this study.
- Three in-service solar projects in the west (71 MW total) are included.
- For the solar penetration study, the wind generation in the West and Far West weather zones are set at the CDR summer level.

Development of Study Cases

- Three solar projects were identified as duplicates and excluded from the study. The total capacity is 157 MW.
- The remaining solar generators and projects total 8120 MW. These are grouped into three study stages based on the project status. Projects in stage 1 will be studied first. After that projects in stage 2 will be studied and finally the projects in stage 3 will be studied.

	MW	Stage 1	Stage 2	Stage 3
In Service	71	Yes	Yes	Yes
IA Signed	1860	Yes	Yes	Yes
No IA but FIS Complete	250	Yes	Yes	Yes
No IA and FIS Incomplete	5940	No	50% capacity	Yes
Total MW in Stage		2181	5151	8121

Development of Study Cases

- In-Service West & Far West Solar Generators, 71 MW
 - 10 MW Acacia + 23 MW Hovey + 38 MW Eclipse
- Signed-IA Solar Projects in West & Far West, 1860 MW

INR	Project	MW	County
12INR0059b	Barilla 1B	7	Pecos
12INR0059c	Barilla 2	21	Pecos
15INR0036	Downie Ranch	95	Uvalde
15INR0045	Riggins	150	Pecos
15INR0059	Pecos I	108	Pecos
15INR0061	SolaireHolman 1	50	Brewster
15INR0070_1	West Texas	110	Pecos
15INR0070_1b	Pearl	50	Pecos
16INR0019	Capricorn Ridge	100	Coke
16INR0023	BNB Lamesa	200	Dawson
16INR0048	RE Roserock	158	Pecos
16INR0049	Nazareth	201	Castro
16INR0052	Solara	110	Haskell
16INR0065	SP-TX-12	180	Upton
16INR0065B	SP-TX-12-Phase B	120	Upton
16INR0073	East Pecos	100	Pecos
16INR0114	Upton	100	Upton

Development of Study Cases

- Completed FIS but no IA Solar Projects in West and Far West, 250 MW

INR	Project	MW	County
13INR0032		100	Andrews
16INR0066		150	Mitchell

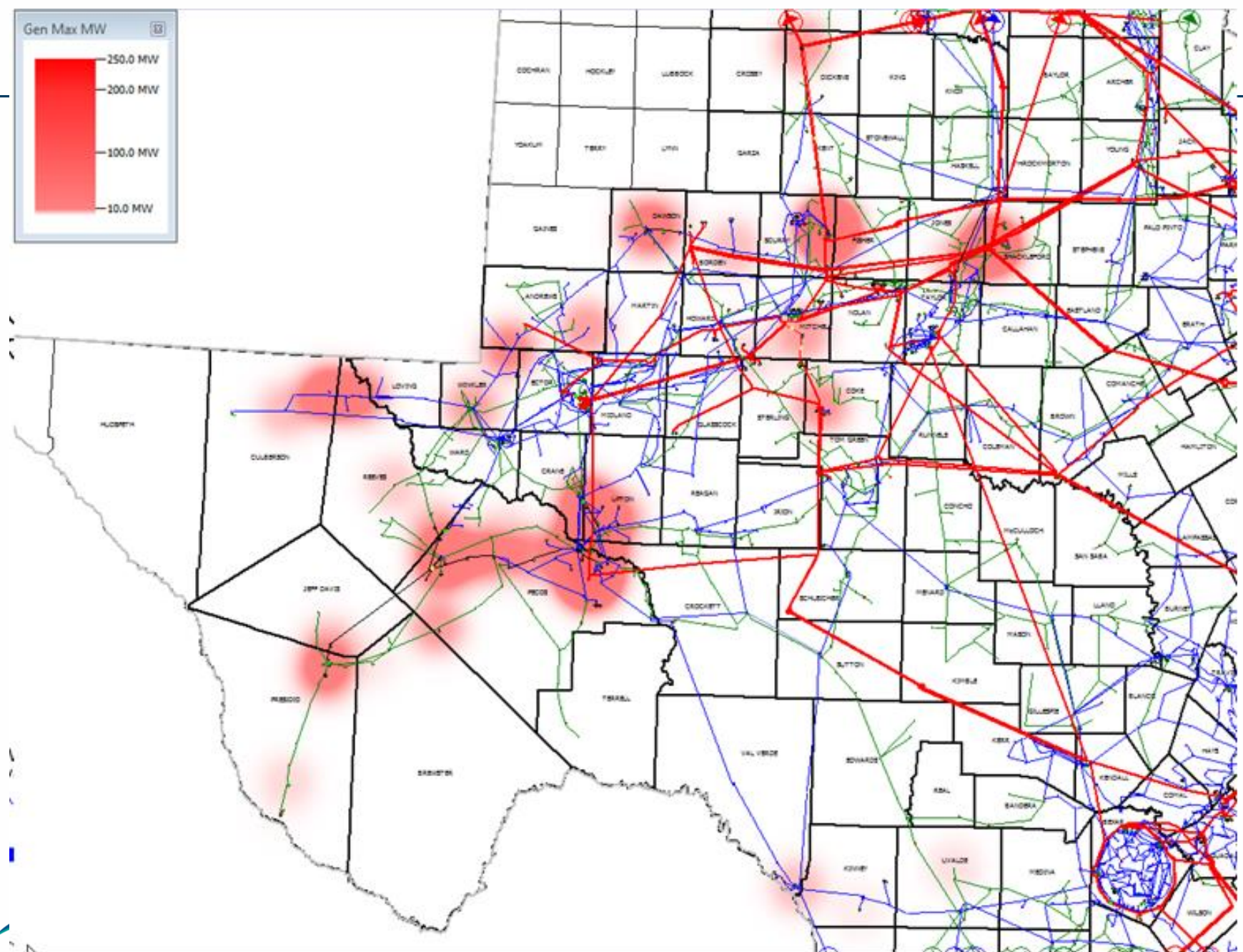
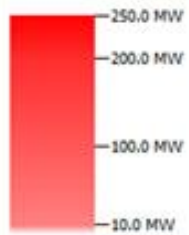
Development of Study Cases

- West & Far West Solar without IA or completed FIS, 5940 MW

INR	MW	County	INR	MW	County
14INR0014	100	Val Verde	16INR0070	150	Winkler
14INR0026	30	Presidio	16INR0072	50	Pecos
14INR0043	40	Sterling	16INR0075	100	Culberson
14INR0044	100	Reeves	16INR0079	56	Brewster
15INR0040	60	Presidio	16INR0080	56	Brewster
15INR0047	42	Presidio	16INR0089	60	Andrews
15INR0067	80	Reeves	16INR0092	50	Brewster
15INR0068	20	Sterling	16INR0093	48	Reeves
15INR0069	110	Pecos	16INR0094	280	Culberson
15INR0072	140	Pecos	16INR0096	102	Pecos
15INR0086	45	Uvalde	16INR0097	200	Upton
16INR0018	40	Upton	16INR0100	150	Brewster
16INR0020	55	Presidio	16INR0102	130	Pecos
16INR0021	150	Pecos	16INR0103	73	Coke
16INR0022	100	Borden	16INR0106	150	Andrews
16INR0039	100	Reeves	16INR0115	182	Pecos
16INR0040	105	Reeves	16INR0119	150	Crosby
16INR0050	50	Brewster	17INR0020	500	Pecos
16INR0058	88	Brewster	17INR0023	200	Castro
16INR0060	150	Upton	17INR0029	500	Jones
16INR0063	98	Pecos	17INR0030	100	Deaf Smith
16INR0067	100	Dawson	16INR0068	100	Andrews

Gen Max MW

13



Development of Study Cases

- Turned off generation to balance dispatch changes (total 7789 MW):
7 big remote lignite plants, single trains of 2 remote combined-cycle plants, and 2 big remote natural gas plants.
- Added placeholder +/-300 Mvar synchronous condensers to prop voltage. (Needed for stage 3, modeled in all three cases.)
 - 6653 Barilla 69 kV
 - 4001 () 138 kV
 - 6630 Fort Stockton 69 kV
 - 1074 Wink 138 kV
 - 38092 TNMP Tie 138 kV

Contingencies and Criteria

- NERC TPL-001-4 Contingency categories P0, P1, and P7 will be studied.
- Thermal Criteria
 - Monitor all transmission lines and transformers (excluding generator step-up transformers) 60-kV and above in the study region
 - Rate A under pre-contingency conditions
 - Rate B under post-contingency conditions
- Voltage Criteria
 - Monitor all buses 100-kV and above in the study region to ensure that they do not exceed their pre-contingency and post-contingency limits.
 - Monitor the post-contingency voltage deviation for all buses 100-kV and above in the study region

Preliminary Results

		Stage 1	Stage 2	Stage 3
Contingency Failed to Converge		0	0	19
Number of Unique Circuits Overloaded in Base Case				
	138 kV	1	16	26
	69 kV	0	7	15
	138-69 kV autotransformers	0	3	5
Number of Unique Circuits that Overload for Contingencies				
	345 kV	0	0	1
	138 kV	5	20	62
	69 kV	4	21	39
	138-69 kV autotransformers	3	8	10

Stage 1 Worst Overloads

Base Case Overload

138 kV	153 MVA radial from 6584 Indian – 6601 Rio Pecos	102%
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Contingency Overloads

138 kV	6630 Ft Stockton - 38340 TN Airport, 143 MVA (one contingency)	118%
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69 kV	6575 Iraan - 60372 Dinny, 35 MVA (one contingency)	145%
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	38040 TN IH20 – 38090 TN Pecos (11 different contingencies)	130%
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138-69 kV	76013-6556 West Yates, 55 MVA (one contingency)	121%
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Average o/l = 110% Sum(o/l line lengths) = 69 miles

Stage 2 Worst Overloads

Base Case Overload

138 kV	6673 Musquiz - 38092 TNMP Tie, 151 MVA	169 %
69 kV	6666 Alpine - 38490 TN Belding, 60 MVA	143 %
138-69 kV	6680-6678 Alamito #1 auto, 33 MVA	188 %

Contingency Overloads

138 kV	6630 Ft Stockton - 60385 Solstice, 170 MVA	258 %
	(74 different contingencies)	
69 kV	6667 Paisano - 6672 Alamito B, 27 MVA	297 %
	(2 different contingencies)	
138-69 kV	6680-6678 Alamito #1 auto, 33 MVA	339 %
	(46 different contingencies)	

Average o/l = 172% Sum(o/l line lengths) = 459 miles


Stage 3 Worst Overloads

Base Case Overload

138 kV	6673 Musquiz - 38092 TNMP Tie, 151 MVA	361 %
69 kV	6653 Barilla – 6665 Alpine REA, 60 MVA	252 %
138-69 kV	6680-6678 Alamito #1 auto, 33 MVA	369 %

Contingency Overloads

345 kV	1030 Morgan – 11048 Tonkawas, 1045 MVA	114 %
	(3 different contingencies)	
138 kV	38310 TN16 th St - 38330 TNWoodward tap, 143 MVA	403 %
	(106 different contingencies)	
69 kV	38040 TN IH20 - 38090 TN Pecos, 57 MVA	355 %
	(140 different contingencies)	
138-69 kV	6680-6678 Alamito #1 auto, 33 MVA	661 %
	(47 different contingencies)	

 Average o/l = 175 % Sum(o/l line lengths) = 1116 miles

Especially Difficult Contingencies

- North part of the Culberson County 138 kV Loop
 - Total length of these sections is more than 50 miles.
 - The rest of the loop out to Culberson and back around to Permian is another 101 miles.
- Smaller 138-69 kV Alamito autotransformer
- 138 kV Solstice lines (Ft Stockton, or TNMP Tie8, or Alamito)
- 69 kV Ft Stockton – Alpine
- 69 kV Alpine REA lines (Barilla or Alpine)

Next Steps

- Model TSP-proposed transmission projects
 - LCRA Camp Wood – Leahey rebuild
 - Brazos Salt Creek area project
 - AEP and Oncor Barilla area improvements
 - Oncor Andrews County – N Andrews – Holt project
 - Oncor Riverton – Sand Lake new 138kV line
- Re-run stage 1, stage 2, and stage 3 case calculations
- Test alternative additional transmission and/or voltage support projects
- Draft report for RPG
- Based on stakeholder feedback and time constraints ERCOT may perform system strength calculations, economic analysis, and further voltage analysis.

Questions?