POWERGEM

Power Grid Engineering & Markets

Pennsylvania 2030 Solar Generation Study

Prepared for

Community Energy

Submitted by

Scott Gass
Principal Consultant

05/07/19

POWERGEM

Power Grid Engineering & Markets

Purpose of Study

A reliability study and a market congestion study were completed for the year 2030 to determine the reliability and market impacts for a future scenario where 7.5 GW (AC) of solar generation is added in Pennsylvania.

System Model and Analysis Description

Both the reliability and market congestion studies used the PJM RTEP 2023 load flow model and associated contingency files. This is the most recent RTEP model available from PJM. Load was modeled at 2030 levels based on the PJM 2019 load forecast.

Generation retirements formally announced to PJM were modeled as retired except any future nuclear retirements were modeled in-service. The official PJM generation retirement list is available at https://pjm.com/planning/services-requests/gen-deactivations.aspx.

Future generation with an ISA, under construction and > 200 MW was modeled. Exhibit 1 contains a list of the future generation that was included in the 2030 model.

Future Queued Generation Included In 2030 Model

Queue #	Point of Interconnection	Size (MW)	Fuel	State
AA1-076	Hunterstown - Conemaugh 500 kV	1050	Natural Gas	PA
Y3-103	Valley - Raccoon 138 kV	205	Natural Gas	PA
O29	Normandy 138 kV	225	Wind	IL
Y1-001	BL England 138 kV	452	Natural Gas	NJ

Exhibit 1

Reliability Study

All generation projects were modeled at 100% commercial probability which is the assumption PJM uses during baseline studies. For any analysis that was performed, all transmission limits were calculated under contingency conditions according to the PJM reliability criteria and relevant procedures such as the PJM generator deliverability test.

A study was performed for the base 2030 system to determine the transmission upgrades needed to maintain a reliable system. After the base transmission upgrades were added to the model, 7.5 GW of solar generation was added to the 2030 model in Pennsylvania and a second reliability study was completed to determine the additional transmission upgrades required to maintain a reliable system. The centralized and decentralized solar additions by Transmission Owner are shown in Exhibit 2.

632 Plank Road, Suite 101, Clifton Park, NY 12065
(610) 960 9272 (voice) • (518) 393 8012 (fax)
sgass@power-gem.com www.power-gem.com

Transmission Owner	Decentralized Solar (MW)	Centralized Solar (MW)
APS		
ATSI		
Duquesne		
Penelec		
MetEd		
PP&L		
PECO		
UGI		
Total	2348	5140

Exhibit 2

All overloads on facilities ≥ 230 kV were quantified and a planning level transmission upgrade cost estimate was provided. Lower voltage facilities (≤ 138 kV) were not included in this study.

Market Congestion Study

PowerGEM performed a future congestion study using the PROBE market simulation software. Representative generator outages were applied to the model. A base 2030 congestion study was performed that included the transmission upgrades identified in the base 2030 reliability study. Next the 7.5 GW of solar projects and transmission upgrades identified in the reliability study were added to the model and a second 2030 congestion simulation was completed.

Only constraints on facilities ≥ 230 kV were monitored and reported.

LMPs for all PA Transmission Owners were provided for both the base and solar addition simulations.

Summary of Reliability Study Results

A study was completed to determine the transmission upgrade costs for a base 2030 PJM system. Exhibit 3 identifies the transmission upgrades required to maintain a reliable system. The total transmission upgrade cost is estimated at $368 million.

2030 Base System Upgrades

Overloaded Facility	Rating (MVA)	Overload %	Upgrade Cost Estimate (Million)	Upgrade Assumption
[redacted]	2598	118%	$10	Teminal Eq.
[redacted]	762	108%	$5	Rebuild
[redacted]	762	102%	$5	Rebuild
[redacted]	765	100%	$6	Rebuild
[redacted]	883	122%	$23	New Transformer
[redacted]	366	110%	$120	New Cable
[redacted]	2931	111%	$82	New Line
[redacted]	621	107%	$11	Reconductor
[redacted]	629	102%	$100	New Cable
[redacted]	552	103%	$6	Reconductor
Total Costs			$368	

Exhibit 3

Next, 7.5 GW of solar generation was added to the 2030 model in Pennsylvania and a second reliability study was completed to determine the additional transmission upgrades required. The results are summarized in Exhibit 4 with a total transmission upgrade cost estimate of $294 million, most of which would likely be allocated to new centralized solar projects.

2030 System Upgrades for 5140 MW Centralized Solar and 2348 MW Decentralized Solar

Overloaded Facility	Rating (MVA)	Overload %	Upgrade Cost Estimate (Million)	Upgrade Assumption
[redacted]	917	139%	$29	Rebuild
[redacted]	917	133%	$7	Rebuild
[redacted]	640	116%	$46	New Transformers
[redacted]	537	104%	$37	Reconductor
[redacted]	730	101%	$15	Reconductor
[redacted]	739	102%	$18	Reconductor
[redacted]	598	103%	$25	Reconductor
[redacted]	1667	120%	$39	Rebuild
[redacted]	1667	112%	$78	Rebuild
Total Costs			$294	

Exhibit 4

Summary of Market Congestion Study Results

A study was completed to determine the market impacts to Pennsylvania for the addition of 7.5 GW of solar generation in 2030. The congestion study was completed first without the future solar projects and then with the future solar projects added. The base 2030 congestion study included the upgrades identified in Exhibit 3 and the 2030 solar congestion study also included the upgrades shown in Exhibit 4.

Exhibit 5 shows the primary constraints resulting in congestion and Exhibit 6 shows the average annual LMP and load payments by Transmission Owner for the Base 2030 and Solar 2030 market studies (APS load was allocating 39.5% to Pennsylvania and ATSI load was allocated 7.2% to Pennsylvania based on the load flow model). The load-weighted average LMP for the Pennsylvania zones was $42.3 in the Base 2030 case and $39.6 in the Solar 2030 case. Annual load payments for load served by Pennsylvania Transmission Owners decreased by $619 million with the addition of the 7.5 GW of solar generation.

Constraints	Base 2030 (Hours)	Solar 2030 (Hours)	Base 2030 Congestion (Millions)	Solar 2030 Congestion (Millions)
[redacted]	314	367	$103	$112
[redacted]	420	369	$39	$35
[redacted]	94	369	$15	$33
[redacted]	101	143	$17	$20
[redacted]	96	105	$16	$18
[redacted]	398	0	$23	$0
[redacted]	60	0	$14	$0
[redacted]	85	75	$7	$6
[redacted]	104	108	$10	$3

Exhibit 5

Transmission Owner	Average Annual LMP		Load Payments	
	Base 2030	Solar 2030	Base 2030 (Million)	Solar 2030 (Million)
APS	$43.5	$40.7	$1,032	$954
ATSI	$44.0	$41.3	$686	$628
Duquesne	$44.2	$41.5	$245	$227
MetEd	$41.8	$38.9	$770	$701
PECO	$41.9	$39.3	$1,967	$1,797
Penelec	$42.6	$39.5	$813	$742
PP&L	$41.5	$38.8	$1,860	$1,709
UGI	$40.1	$37.6	$46	$42
Total for PA			$7,419	$6,800

Exhibit 6

Exhibit 7 shows the PJM average annual LMP and PJM load payments for the Base 2030 and Solar 2030 market studies.

	Average Annual LMP		Load Payments	
	Base 2030	Solar 2030	Base 2030 (Million)	Solar 2030 (Million)
PJM	$43.6	$41.0	$40,117	$37,057

Exhibit 7