GEEnergy

Final Report:

Task 2 Scenario Development and Analysis

Prepared for: PJM Interconnection, LLC
***Prepared by:* GE Energy Consulting**

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imagination at work

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Foreword

This document was prepared by General Electric International, Inc. It is submitted to PJM Interconnection, LLC. Technical and commercial questions and any correspondence concerning this document should be referred to:

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1.1 Growth of Renewable Power in PJM

Based on the PJM interconnection queue of June 2, 2011, approximately 5,122 MW of wind capacity will be on line in the PJM system, by January 2012. PJM has approximately 22,680 MW of larger-scale wind projects in the ISO Generator Interconnection Queue, about 3,450 MW of which represent offshore projects and about 19,230 MW represent onshore projects. Figure 1 shows a map of existing and queue wind projects in PJM interconnection.

Approximately 70MW of solar capacity will be on line in the PJM system, by January 2012. PJM has approximately 1,650 MW of solar projects in the ISO Generator Interconnection Queue. Figure 2 shows a map of existing and queue solar projects in PJM interconnection.

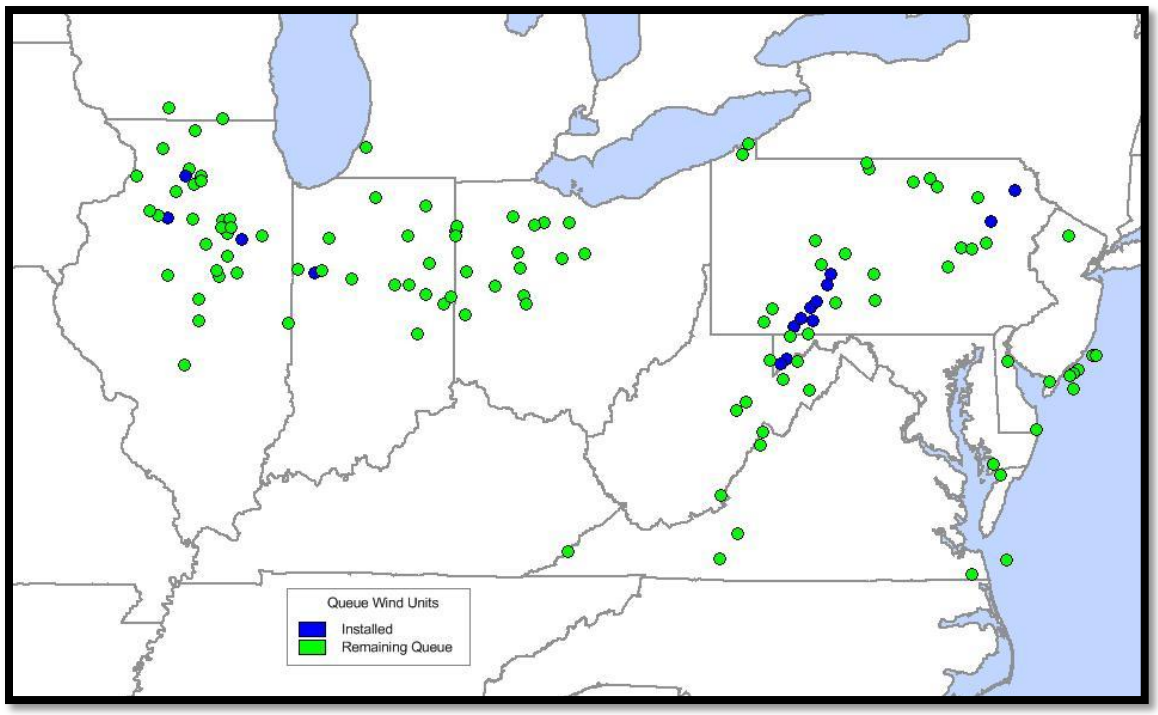

Figure 1 Existing and queue wind projects in PJM interconnection

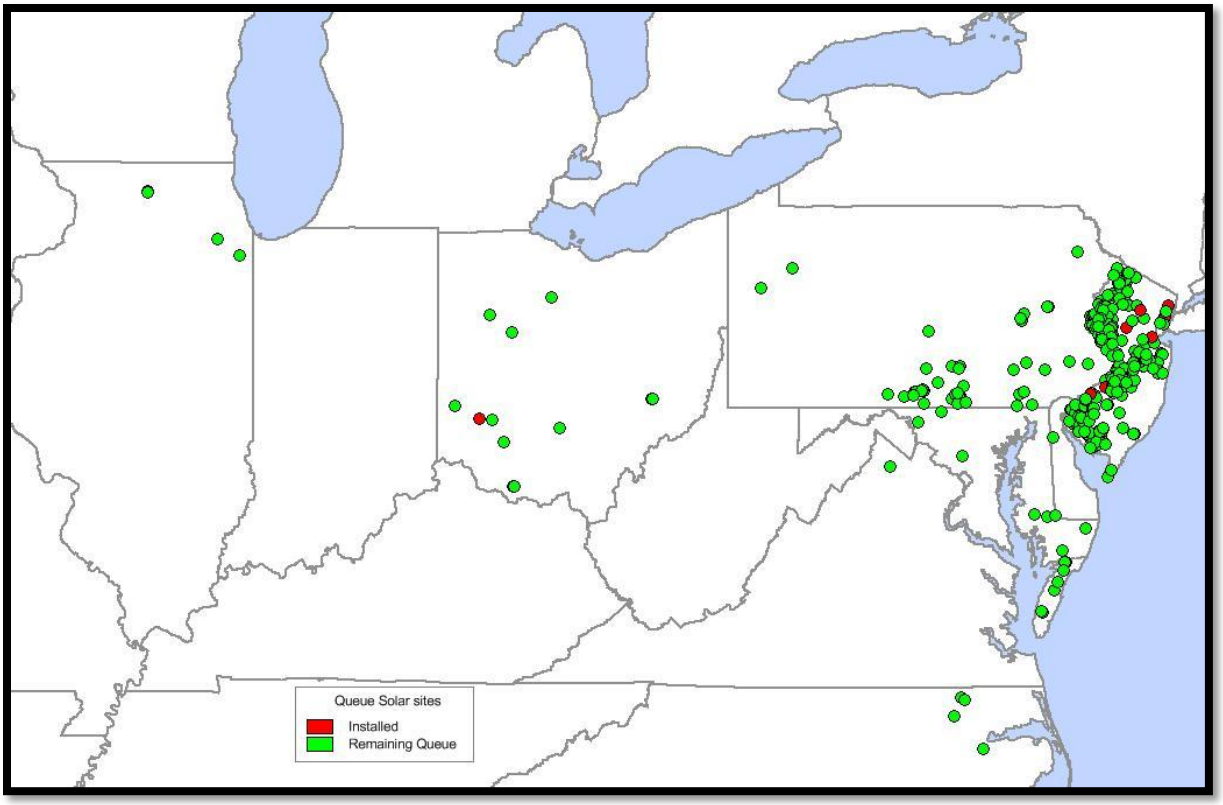

Figure 2 Existing and queue solar projects in PJM interconnection

1.2 Reference Case & Base Case Summary

All of the PRIS renewable scenarios are set to represent the 2026 timeframe. Values used for renewable energy generated in each scenario are averages of the three years (2004, 2005, & 2006) simulated via mesoscale modeling.

The **Reference Case** is comprised of the existing wind and solar plants installed as of January 1, 2012. The reference case is based on the PJM interconnection queue as of June 2, 2011. Table 1 and Table 2 summarize the wind and solar in the Reference Case and gives the breakdown by state. A majority of the installed wind is located in Illinois, Indiana, and Pennsylvania. A majority of the existing solar is located in New Jersey. This case is used as a starting point to evaluate the changes due to increased wind and solar generation.

Table 1 Reference Case Wind Summary

Reference Case	Onshore			Offshore			Total Wind		
States	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF
Illinois	1950	6,879	0.40	0	0	0.00	1950	6,879	0.40
Indiana	1102	3,629	0.38	0	0	0.00	1102	3,629	0.38
Maryland	250	761	0.35	0	0	0.00	250	761	0.35
New Jersey	8	22	0.34	0	0	0.00	8	22	0.34
Pennsylvania	1159	3,476	0.34	0	0	0.00	1159	3,476	0.34
West Virginia	654	2,017	0.35	0	0	0.00	654	2,017	0.35
Total	**5122**	**16,785**	**29.03**	**0**	**0**	**0.00**	**5122**	**16,785**	**29.03**

Table 2 Reference case Solar Summary

Reference Case	Central PV			Distributed PV			Total PV		
States	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF
New Jersey	66	113	0.19	0	0	0.00	66	113	0.19
Ohio	3	4	0.16	0	0	0.00	3	4	0.16
Pennsylvania	3	6	0.22	0	0	0.00	3	6	0.22
Total	**72**	**122**	**0.21**	**0**	**0**	**0.00**	**72**	**122**	**0.21**

The **Base Case** is comprised of qualifying projects that were in the PJM Generator Interconnection Queue as of June 02, 2011and additional wind and solar plants strategically chosen to meet the renewable energy requirements for PJM. The energy requirement is based on the Renewable Portfolio Standards (RPS) for the states that make up the PJM service territory. Table 3 summarizes the state requirements. The qualifying queue projects had either Facilities Agreement Studies (FSA) or Interconnection Service Agreement (ISA) in place. Additional onshore and offshore wind sites for the Base Case were added to meet the wind energy requirement of 11.2% of total PJM load. There is a total amount of 4 GW of offshore wind with 2GW in New Jersey, 1 GW in Delaware and 1 GW in Virginia. The additional onshore sites needed to meet the 11.2% target were added to closely match the PJM Generation Scenario Analysis, developed by PJM. The best sites within a state that had an RPS requirement were added. In addition to the wind queue plants, solar sites were added to meet the individual State solar requirements. Total solar energy serves 1.2% of the load energy in this case.

Table 3 State Renewable Energy Requirements For PJM

Year 2026	Required Energy from State Requirement									
State	Load (GWH)	%RE	%Other	%Wind	%Solar	Renewable Energy (GWh)	Projected Other Source Renewable Energy (GWh)	Net Additional Renewable (GWh)	Wind (GWh)	Solar (GWh)
Delaware	15,509	25.0%	3.1%	21.5%	3.5%	3,877	484	3,393	2,850	543
Indiana	24,971	0.0%	0.0%	0.0%	0.0%	0	0	0	0	0
Kentucky	8,567	0.0%	0.0%	0.0%	0.0%	0	0	0	0	0
Ilinois	126,569	25.0%	3.1%	23.5%	1.5%	31642.25	3,953	27,689	25,790	1,899
Maryland	83,979	20.0%	2.5%	15.5%	2.0%	16,796	2,098	14,697	13,018	1,680
Michigan	4,682	10.0%	1.2%	10.0%	0.0%	468.201	58	410	410	0
New Jersey	100,159	22.5%	2.8%	14.4%	5.3%	22,536	2,816	19,720	14,404	5,316
North Carolina	9,193	6.3%	0.8%	6.1%	0.2%	574.5625	72	503	484	18
Ohio	196,943	12.5%	1.6%	12.0%	0.5%	24,618	3,076	21,542	20,558	985
Pennsylvania	194,329	8.0%	1.0%	7.5%	0.5%	15546.32	1,942	13,604	12,632	972
Tennessee	2,341	0.0%	0.0%	0.0%	0.0%	0	0	0	0	0
Virginia	149,566	7.5%	0.9%	7.5%	0.0%	11217.45	1,401	9,816	9,816	0
Washington DC	11,537	20.0%	2.5%	17.5%	2.5%	2,307	288	2,019	1,731	288
West Virginia	41,251	12.5%	1.6%	12.5%	0.0%	5156.375	644	4,512	4,512	0
PJM 14%	**969,596**	**13.9%**	**1.5%**	**11.2%**	**1.2%**	**134,739**	**14,500**	**120,239**	**108,539**	**11,700**
PJM 20%	**969,596**	**20.0%**	**1.5%**	**15.50%**	**3.0%**	**193,919**	**14,500**	**179,419**	**150,331**	**29,088**
PJM 30%	**969,596**	**30.0%**	**1.5%**	**23.5%**	**5.0%**	**290,879**	**14,500**	**276,379**	**227,899**	**48,480**

RE = Renewable Energy

A range of wind and solar plant scenarios were developed to represent what the PJM system might look like with varying levels of wind and solar penetration, and to represent different spatial patterns of wind and solar development that could occur in the PJM system. All scenarios are described in more detail in the next section. The scenarios consider different offshore penetrations of wind as well as concentrated wind development versus dispersement across all of the states. Different penetrations of solar are also considered.

All the scenarios include 14,500 GWh (~1.5% of the PJM load energy) of other renewable sources that counts towards meeting the renewable target. The total Base Case renewable mix is 11.2% wind, 1.2% solar and 1.5% other.

1.3 20% & 30% Scenario Summary

A group of scenarios was developed to enable a detailed evaluation of the operational impacts of incremental wind and solar generation variability and uncertainty on PJM's bulk electric power system, including the incremental impact contributed by the spatial diversity of wind and solar plants.

In order to represent the impacts of renewable portfolio diversity, scenarios were developed for different wind and solar penetration build-outs, i.e. the 20% renewable energy and 30% renewable energy scenarios. All the scenarios include 14,500 GWh (~1.5% of the PJM load energy) of other renewable sources that counts towards meeting the renewable targets. Biomass plants are counted included in this category. Since these resources do not exhibit the variability and uncertainty associated with wind and solar generation, they have been blended with the rest of the PJM recourses for this study.

A description of the scenarios developed follows. All scenarios are summarized in Table 4. Each scenario is decribed in greater detail in the following sections.

20% Low Offshore, best sites onshore– This scenario includes the addition of the best wind and solar sites, within PJM, in addition to the 14% base case to meet the 20% renewable energy requirement. Additional wind sites were chosen using the best sites to meet the energy requirement of 90% of total wind through onshore and 10% of total wind requirement through offshore. 50% of the total solar energy needed for the scenario was Central PV while the remaining 50% was distributed photovoltaic (PV). The total distributed solar energy required is assumed to be provided by 80% commercial sites and 20% residential. The solar selection criteria listed in section 1.3.1 was used to select the sites.

Wind sites with the highest capacity factor were chosen to satisfy the energy target. This scenario's wind fleet is comprised predominantly of wind plants in Illinois and Indiana and therefore it exhibits low geographic diversity.

20% Low Offshore, dispersed sites onshore–This case is the same as the 20% Low Offshore, best sites case except the incremental onshore wind sites were dispersed over Illinois, Indiana, Ohio, West Virginia, and Pennsylvania. The incremental onshore wind was added to the selected states using the ratio of the PJM portion of the state load to the sum of the selected states PJM portion of the load. The ratios used to add the incremental onshore wind was Illinois

21.6%, Indiana 4.28%, Ohio 33.72%, Pennsylvania 33.27%, and West Virginia 7.06%. The best sites in each of these states were chosen.

The solar sites selected are the same as in the **20% Low offshore, best sites onshore scenario.**

20% High Offshore, best sites onshore– This scenario includes a higher penetration of offshore wind, with 50% of total wind energy coming from offshore wind sites and 50% of total wind energy through onshore sites. The onshore energy was reduced from the base case to allow this ratio to be met. The additional offshore wind sites with the highest capacity factor were added to satisfy the desired energy target. This alternative features the highest overall capacity factor for 20% energy scenario set, but also a low geographic diversity. For purposes of this study, no offshore wind sites were selected in the Great Lakes. Only ocean sites were only selected.

The solar sites selected are the same as in the **20% Low offshore scenarios**.

20% High Solar, best sites onshore – This alternative includes a higher penetration of solar energy. The total solar energy increases from 3% in the other 20% cases to 6% energy in this scenario. The incremental solar energy was selected using the criteria in Section 1.3.1.The wind selected in the **20% Low Offshore, best sites onshore** was reduced by the amount of additional solar added for this scenario.

30% Low Offshore, best sites onshore– This scenario builds on the **20% Low Offshore, best sites onshore** scenario to meet the 30% target. The wind required increases from 15.5% to 23.5% and the solar required increases from 3% to 5%.

30% Low Offshore, dispersed sites onshore– This scenario builds on the **20% Low Offshore, dispersed sites onshore** scenario to meet the 30% target. The wind required increases from 15.5% to 23.5% and the solar required increases from 3% to 5%.

30% High Offshore, best sites onshore–This scenario builds on the **20% High Offshore, best sites onshore** scenario to meet the 30% target.

30% High Solar, best sites onshore–This scenario builds on the **20% High Solar, best sites onshore** scenario to meet the 30% target. The solar increases from 6% total in the **20% High Solar, best sites onshore** to 10% this scenario and wind is reduced to 18.5%.

Pain-Point–The pain-point scenario will be selected after the scenarios above are evaluated. This scenario will scale up (or down) the output from wind and solar sites in one of the 30%

scenarios until "pain" becomes evident. The "pain" point will be reached when significant operation/market impacts occur and where notable mitigation measures will be required.

Table 4 Scenario Summary

Scenario	Load (GWh)	% RE	% Other Renewable	% Wind	% Solar	Total RE Required (GWh)	Other RE (GWh)	Add'l RE Required from Wind and Solar (GWh)	Wind Energy (GWh)	Solar Energy (GWh)
Base	969,596	14%	1.50%	11.20%	1.18%	134,774	14,500	120,274	108,782	11,441
Low Offshore	969,596	20%	1.50%	15.50%	3%	193,919	14,500	179,419	150,331	29,088
High Offshore	969,596	20%	1.50%	15.50%	3%	193,919	14,500	179,419	150,331	29,088
High Solar	969,596	20%	1.50%	12.50%	6%	193,919	14,500	179,419	121,243	58,176
Low Offshore	969,596	30%	1.50%	23.50%	5%	290,879	14,500	276,379	227,899	48,480
High Offshore	969,596	30%	1.50%	23.50%	5%	290,879	14,500	276,379	227,899	48,480
High Solar	969,596	30%	1.50%	18.50%	10%	290,879	14,500	276,379	179,419	96,960

RE = Renewable Energy

1.3.1 Solar Selection Criteria

The following process was used to select the solar capacity needed for each scenario.

A constant ratio of 50-50 for Centralized solar and distributed solar was used for each of the states to meet the state solar energy requirement. Distributed solar sites consist of 80% of commercial sites and 20% of residential sites. Commercial and residential sites are chosen at the same location and scaled accordingly to meet the individual energy requirements and hence shown as a single plot of the distributed solar sites for commercial as well as residential sites.

- Incremental Central & Distributed solar for all scenarios were added to all PJM states in proportion to the ratio of PJM portion of the state load energy to the total PJM load energy. Table 5 shows the ratios applied.
- For the centralized solar plants, sites were selected based on best sites (highest capacity factor)

- For the distributed solar, it was decided that commercial and residential solar resources would be spread over cities and towns with high annual irradiance.
    - The amount of distributed solar energy needed in each state was determined.
    - The ratio of the required energy to the actual energy in the AWST solar data was determined.
    - The ratio was then used to scale all sites in the state proportionally to meet the energy target.
    - This same technique was used for both commercial and residential sites.

Table 5 Distributed Solar State Ratio

State	Load (GWh)	Distributed Solar Ratio
Delaware	15,509	1.60%
Illinois	126,569	13.05%
Indiana	24,971	2.58%
Kentucky	8,567	0.88%
Maryland	83,979	8.66%
Michigan	4,682	0.48%
New Jersey	100,159	10.33%
North Carolina	9,193	0.95%
Ohio	196,943	20.31%
Pennsylvania	194,329	20.04%
Tennessee	2,341	0.24%
Virginia	149,566	15.43%
Washington DC	11,537	1.19%
West Virginia	41,251	4.25%

1.3.2 Onshore \Offshore Scenario Criteria

Table 6 shows the ratio between onshore and offshore wind that will be used in each type of scenario. For example, in all low offshore scenarios, the total wind generation will be made up of 90% onshore wind and 10% offshore wind.

Table 6 Onshore\Offshore ratio

Scenario	Onshore Wind	Offshore Wind
Base	86%	14%
Low Offshore	90%	10%
High Offshore	50%	50%
High Solar	90%	10%

1.4 14% Base Case to meet State RPS Requirements

This scenario represents a total of 14% of total annual energy demand being served by renewable resources; approximately 11.2% of total annual energy through wind, 1.2% through solar, and 1.5% through other renewable resources. The base case consists of the qualifying queue wind and solar projects and additional sites added based on the capacity factor to meet the state energy requirements. Qualifying queue wind and solar projects that are included are those either already in service, or are in the June 2011 Generation Queue that have obtained Facilities Service Agreement (FSA) or have Interconnection Service Agreement (ISA)in place. The 14% base case includes 33.1 GW of installed wind capacity and 7.4 GW of installed solar capacity. This scenario represents a regional pattern of wind and solar development that would occur by the year 2026 according to the state RPS policies. All other scenarios build on this 14% base case scenario.

Table 7 Wind Summary for 14% Base case

14% Base Case	Onshore						Offshore						Total Wind		
	Queue			Additional			Queue			Additional			14% Base Case		
States	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF
Delaware							450	1,340	0.34	550	1,653	0.34	1,000	2,993	0.34
Illinois	7,589	26,743	0.40	4,204	15,553	0.42							11,793	42,296	0.41
Indiana	4,051	12,629	0.36	3,054	10,971	0.41							7,105	23,600	0.38
Maryland	380	1,191	0.36										380	1,191	0.36
Michigan	200	633	0.36										200	633	0.36
New Jersey							1,099	3,241	0.34	901	2,757	0.38	2,000	5,999	0.34
North Carolina	374	840	0.26										374	840	0.26
Ohio	3,498	10,488	0.34	1,624	5,233	0.37							5,122	15,721	0.35
Pennsylvania	1,866	5,448	0.33	614	1,988	0.37							2,480	7,436	0.34
Virginia	38	113	0.34							1,000	3,038	0.35	1,038	3,151	0.35
West Virginia	1,237	3,812	0.35	345	1,110	0.37							1,582	4,922	0.36
Total	19,233	61,897	0.37	9,841	34,855	0.40	1,549	4,582	0.34	2,451	7,447	0.35	33,074	108,782	0.38

CF = Capacity Factor

As Table 7 illustrates, most of the onshore wind energy is located in Illinois and Ohio, followed by Indiana. New Jersey has 2 GW offshore wind, followed by Virginia and Delaware having 1GW each. States with most wind energy are Illinois (39% of total PJM wind energy), Indiana

(22%), Ohio (14%), and Pennsylvania (7%). Figure 3 shows the locations of wind projects included in the 14% Base Case scenario.

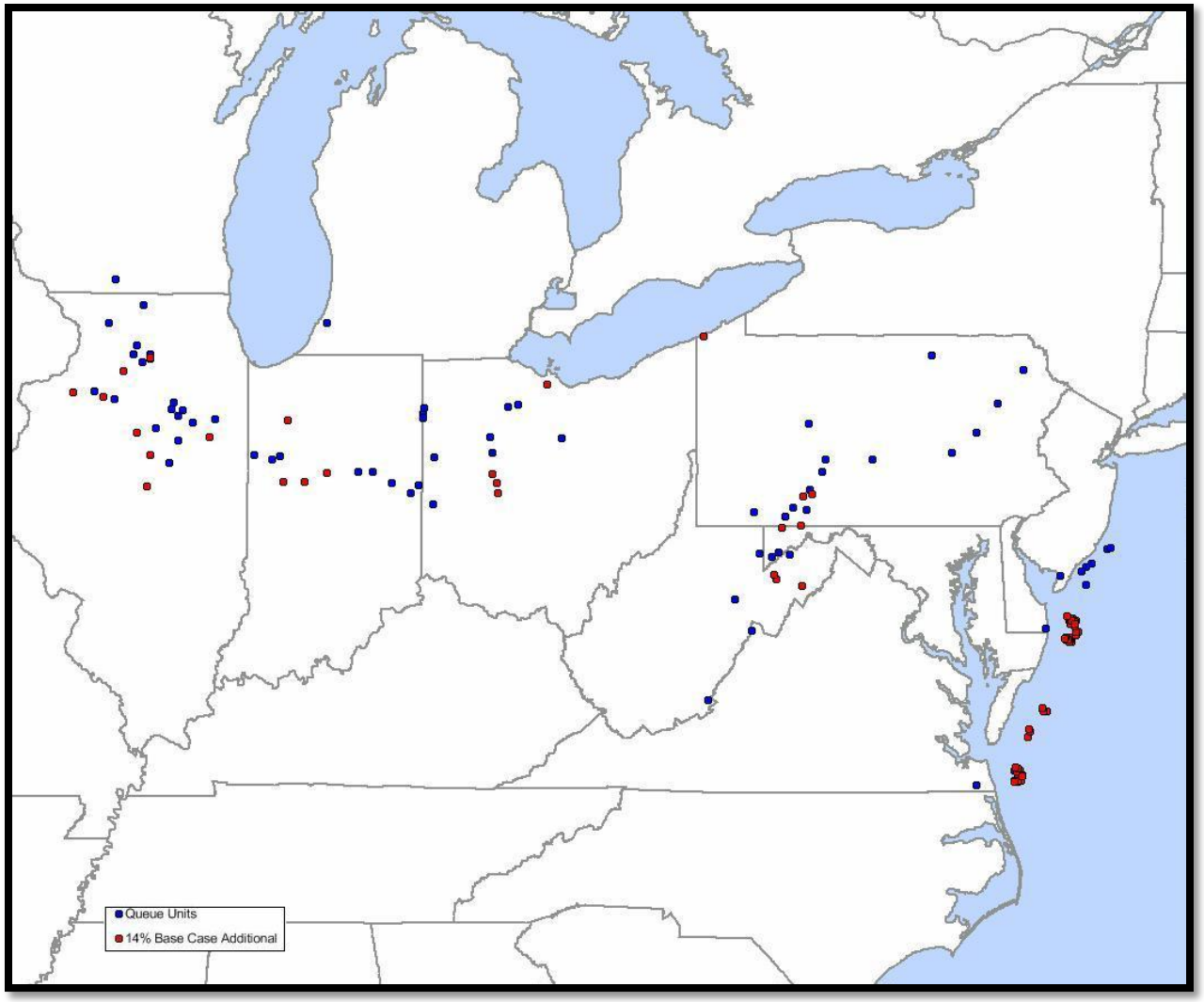

Figure 3 Wind sites for the 14% Base Case

Table 8 shows the allocation of solar resources for the base case. Central solar sites were chosen by adding the additional sites to the qualifying queue projects as described earlier.

New Jersey has the highest amount of solar energy totaling 45% of total solar requirement in PJM. Maryland contributes approximately 14.4% of the total PJM energy, followed by Illinois with 13.6%. Overall capacity factor for the Central PV solar sites is 0.20, 0.17 for the distributed commercial sites, and 0.16 for the distributed residential sites. Figure 4 and Figure 5 depict the location of the solar resources included in the 14% base case scenario.

Table 8 Solar summary for 14% Base Case

14% Base Case	Central PV						Distributed PV						Total PV		
	Queue			Additional			Queue			Additional			14% Base Case		
States	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF
Delaware	0	0	0.00	150	272	0.21	0	0	0.00	179	271	0.17	329	543	0.19
Illinois	10	16	0.19	376	629	0.19	0	0	0.00	693	949	0.16	1079	1595	0.17
Maryland	40	71	0.20	423	769	0.21	0	0	0.00	545	840	0.18	1008	1680	0.19
North Carolina	5	9	0.21	0	0	0.00	0	0	0.00	6	9	0.18	11	18	0.19
New Jersey	1171	2047	0.20	337	598	0.20	0	0	0.00	1790	2658	0.17	3298	5303	0.18
Ohio	15	22	0.18	272	470	0.20	0	0	0.00	369	492	0.15	655	984	0.17
Pennsylvania	227	399	0.20	48	86	0.21	0	0	0.00	335	486	0.17	609	971	0.18
Virginia	180	317	0.20	0	0	0.00	0	0	0.00	0	0	0.00	180	317	0.20
Washington DC	0	0	0.00	0	0	0.00	0	0	0.00	186	288	0.18	186	288	0.18
Total	**1648**	**2882**	**0.20**	**1606**	**2824**	**0.20**	**0**	**0**	**0.00**	**4102**	**5994**	**0.17**	**7169**	**11412**	**0.18**

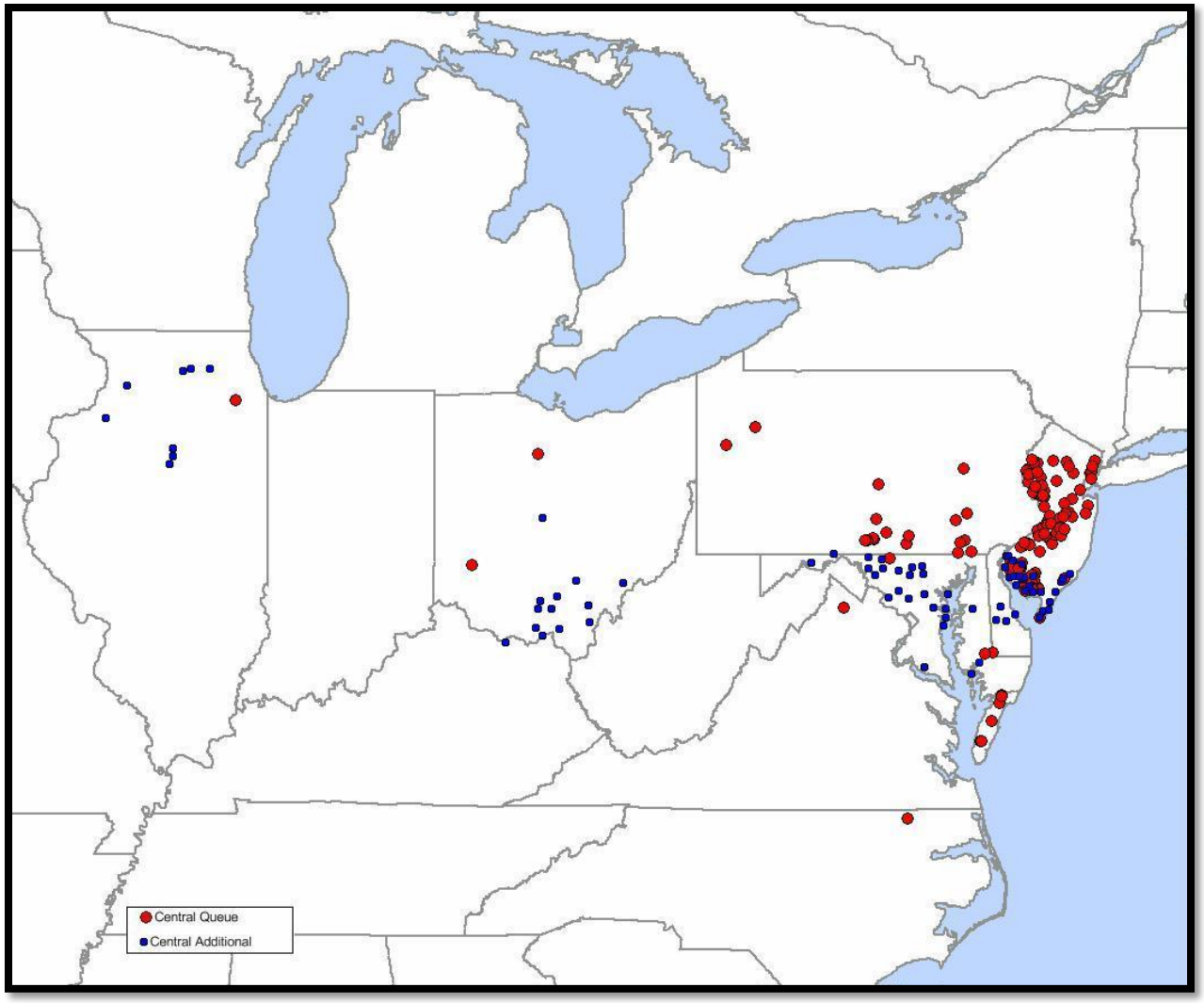

Figure 4 Central solar PV sites for 14% Base Case

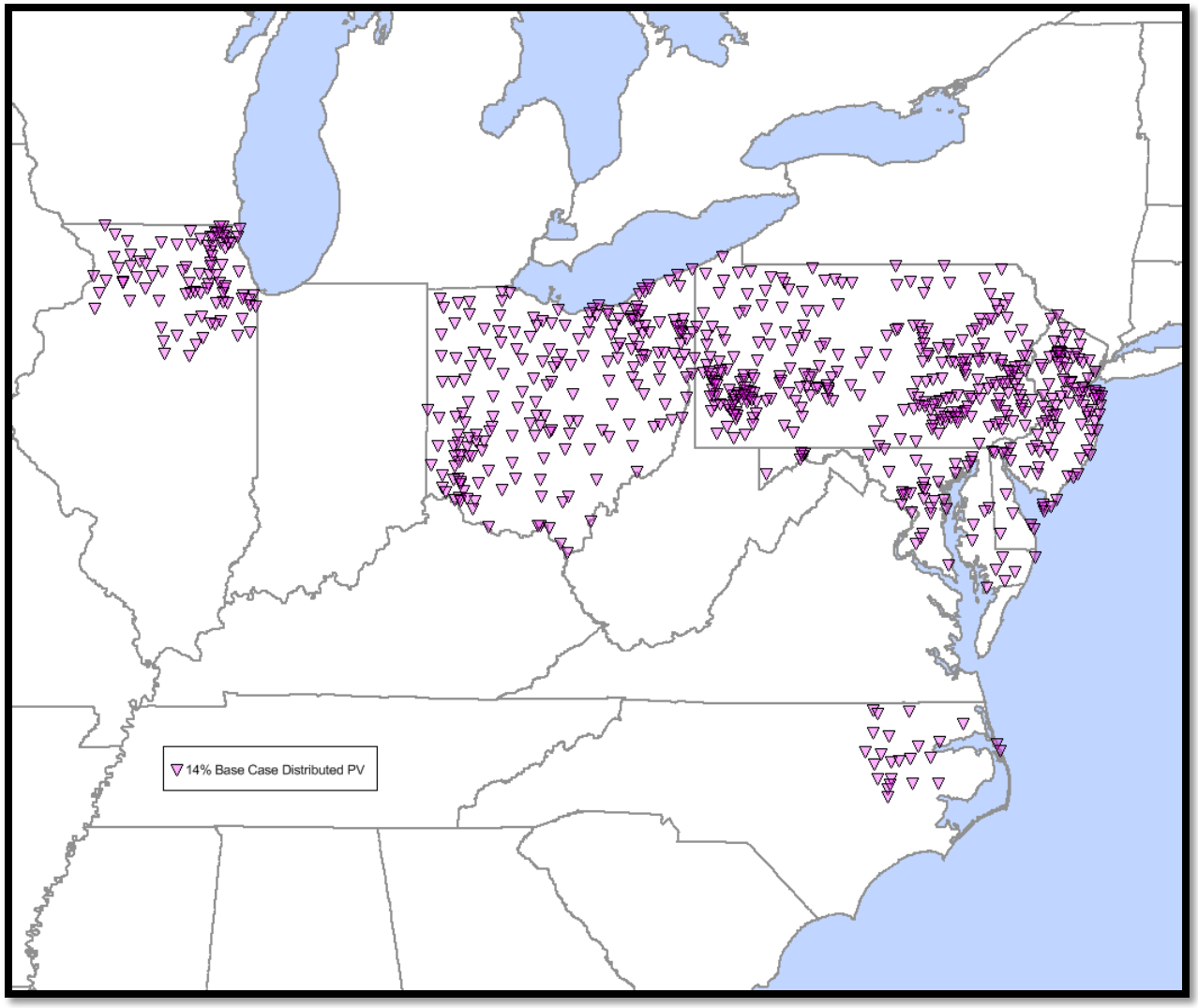

Figure 5 Distributed solar PV sites for 14% Base Case

1.5 20% Scenarios

1.5.1 20% Low Offshore, best sites onshore

In the 20% Low Offshore, best sites onshore scenario, the incremental wind needed to meet the 20% requirement was added based on the best sites (highest capacity factor). Similar to the 14% base case, approximately 1.5% of the total load energy is served by other renewable resources. Wind and solar PV constitute 15.5% and 3% of total load energy.

Table 9 Wind summary for 20% Low Offshore scenario with best wind sites onshore

20% Low Offshore, best sites	Onshore						Offshore						Total Wind		
	14% Base Case			Additional			14% Base Case			Additional			20% Low Offshore, best sites		
States	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF
Delaware							1,000	2,993	0.34				1,000	2,993	0.34
Illinois	11,793	42,296	0.41	10,618	38,546	0.41							22,411	80,842	0.41
Indiana	7,106	23,601	0.38										7,106	23,601	0.38
Maryland	380	1,191	0.36										380	1,191	0.36
Michigan	200	633	0.36										200	633	0.36
New Jersey							2,000	5,999	0.34	810	2,677	0.38	2,810	8,676	0.35
North Carolina	373	839	0.26							100	327	0.37	473	1,166	0.28
Ohio	5,123	15,720	0.35										5,123	15,720	0.35
Pennsylvania	2,480	7,436	0.34										2,480	7,436	0.34
Virginia	38	113	0.34				1,000	3,038	0.35				1,038	3,151	0.35
West Virginia	1,581	4,923	0.36										1,581	4,923	0.36
Kentucky															
Tennessee															
Washington DC															
Total	29,074	96,752	0.38	10,618	38,546	0.41	4,000	12,030	0.34	910	3,004	0.38	44,603	150,331	0.38

Additional wind sites were added to the 14% base case to meet the 20% requirement. Table 9 shows that this scenario represents a total of 44.6 GW of installed wind capacity to meet the required wind energy target of 150,331 GWh. This includes all the wind sites that were used in the 14% base case and additional sites added for the 20% Low Offshore scenario. All the additional onshore wind energy (10.6 GW) is in Illinois with a capacity factor of 0.41. Additional offshore wind was added in New Jersey and North Carolina with capacity factors of 0.38 and 0.37 respectively. Figure 6shows the locations of wind resources included in the 20% Low offshore, best sites scenario.

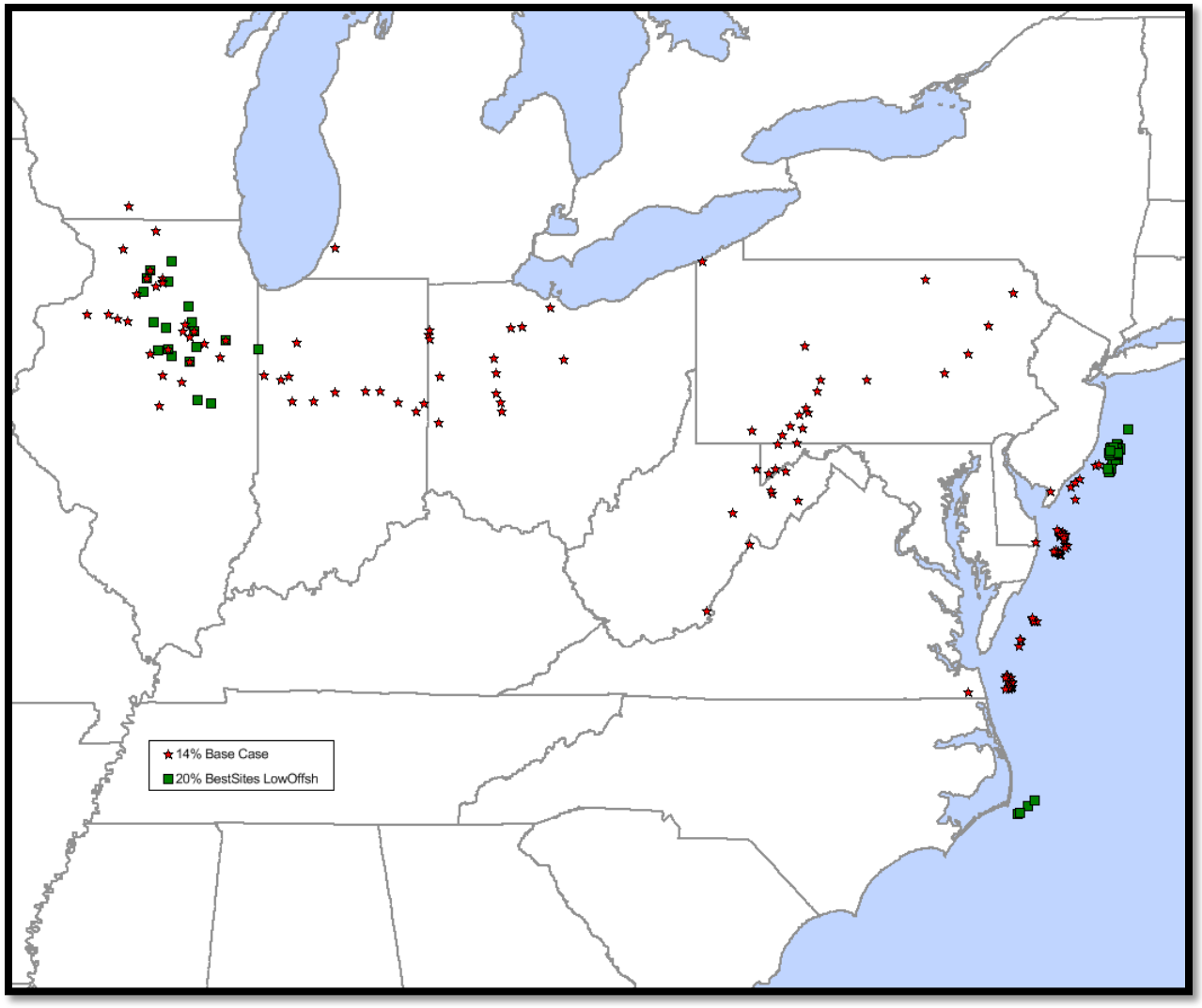

Figure 6 Wind sites for the 20% Low Offshore scenario with best wind sites onshore

Table 10 Solar summary for 20% Low Offshore scenario with best wind sites onshore

20% Low/High Offshore	Central PV						Distributed PV						Total PV		
	14% Base Case			Additional			14% Base Case			Additional			20% Low/High Offshore		
States	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF
Delaware	150	272	0.21	0	0	0.00	179	271	0.17	0	0	0.00	329	543	0.19
Ilinois	386	646	0.19	0	0	0.00	693	949	0.16	698	958	0.16	1,776	2,553	0.16
Indiana	0	0	0.00	0	0	0.00	224	300	0.15	23	29	0.14	248	329	0.15
Kentucky	0	0	0.00	20	37	0.21	0	0	0.00	77	113	0.17	97	149	0.18
Maryland	463	840	0.21	10	18	0.21	545	840	0.18	172	265	0.18	1,190	1,963	0.19
Michigan	0	0	0.00	0	0	0.00	0	0	0.00	48	62	0.15	48	62	0.15
New Jersey	1,509	2,645	0.20	1,086	1,975	0.21	1790	2658	0.17	0	0	0.00	4,384	7,278	0.19
North Carolina	5	9	0.21	0	0	0.00	6	9	0.18	73	112	0.18	84	130	0.18
Ohio	286	492	0.20	0	0	0.00	369	492	0.15	1,573	2,099	0.15	2,228	3,084	0.16
Pennsylvania	0	0	0.00	10	18	0.21	335	486	0.17	1,427	2,071	0.17	1,772	2,575	0.17
Tennessee	275	485	0.20	0	0	0.00	0	0	0.00	20	31	0.18	294	516	0.20
Virginia	180	317	0.20	3,416	6,268	0.21	0	0	0.00	1,293	1,968	0.17	4,889	8,553	0.20
Washington DC	0	0	0.00	0	0	0.00	186	288	0.18	0	0	0.00	185	288	0.18
West Virginia	0	0	0.00	284	523	0.21	0	0	0.00	381	543	0.16	665	1,065	0.18
Total	**3,253**	**5,706**	**0.20**	**4,825**	**8,837**	**0.21**	**4,326**	**6,293**	**0.17**	**5,785**	**8,251**	**0.16**	**18,190**	**29,088**	**0.18**

Additional solar sites are added to the 14% base case to meet the 20% low offshore scenario requirement. Table 10 shows that 18.5 GW of installed solar capacity was needed to meet the required solar energy of 29,088 GWh for this scenario. The central solar sites have an average capacity factor of 0.21 and the distributed solar sites have a capacity factor of 0.16.Figure 7shows the locations of the central solar sites to meet the solar plants and Figure 8 shows the locations of the distributed solar resources for this scenario.

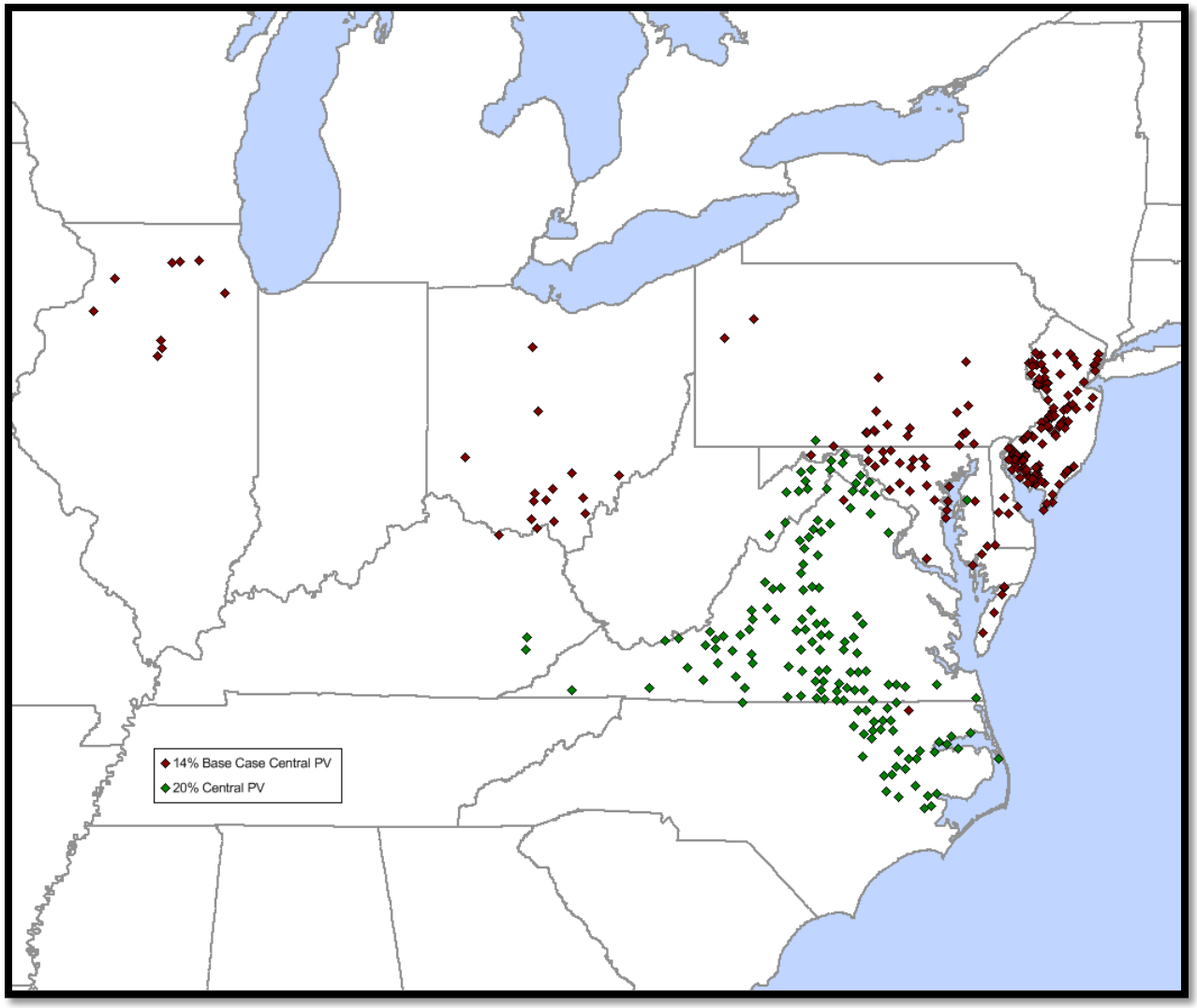

Figure 7 Central solar sites for the 20% Low Offshore scenario

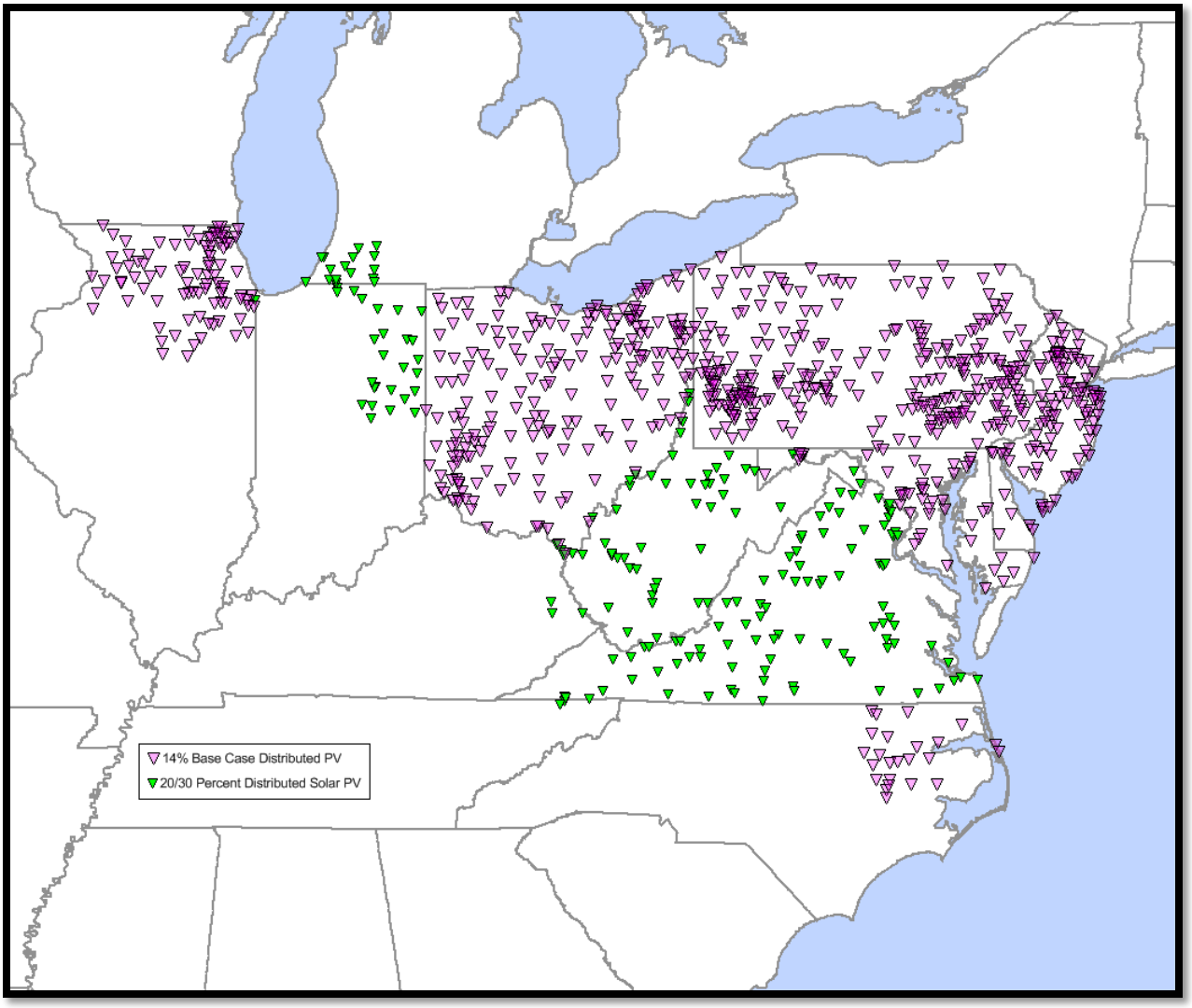

Figure 8 Distributed solar sites for the 20% Low Offshore scenario

1.5.2 20% Low Offshore, dispersed sites onshore

The 20% Low Offshore dispersed scenario is similar to the 20% Low Offshore, best scenario sites except that the additional onshore sites were dispersed across several states in PJM rather than strictly choosing the best sites with highest capacity factors. Similar to the 14% base case, 1.5% of the total load energy is served by other renewable resources. Wind and solar PV constitute 15.5% and 3% of total load energy respectively for the 20% low offshore scenario.

Table 11 Wind summary for 20% Low Offshore scenario with dispersed wind sites onshore

20% Low Offshore, dispersed	Onshore						Offshore						Total Wind		
	14% Base Case			Additional			14% Base Case			Additional			20% Low Offshore, dispersed		
States	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF
Delaware							1,000	2,993	0.34				1,000	2,993	0.34
Illinois	11,793	42,296	0.41	2,291	8,353	0.42							14,084	50,649	0.41
Indiana	7,106	23,601	0.38	474	1,648	0.40							7,579	25,249	0.38
Maryland	380	1,191	0.36										380	1,191	0.36
Michigan	200	633	0.36										200	633	0.36
New Jersey							2,000	5,999	0.34	810	2,677	0.38	2,810	8,676	0.35
North Carolina	373	839	0.26							100	327	0.37	473	1,166	0.28
Ohio	5,123	15,720	0.35	4,177	12,998	0.36							9,300	28,718	0.35
Pennsylvania	2,480	7,436	0.34	4,287	12,825	0.34							6,768	20,261	0.34
Virginia	38	113	0.34				1,000	3,038	0.35				1,038	3,151	0.35
West Virginia	1,581	4,923	0.36	879	2,722	0.35							2,460	7,645	0.35
Kentucky															
Tennessee															
Washington DC															
Total	29,074	96,752	0.38	12,108	38,546	0.36	4,000	12,030	0.34	910	3,004	0.38	46,092	150,331	0.37

For this scenario, 46.1 GW of installed wind capacity is required to supply 150,331 GWH of wind energy. Ohio and Pennsylvania have 4.2GW and 4.3 GW of wind capacity respectively, as shown Table 11. Since the capacity factor decreased from 0.38 in the 20% Low offshore, best sites to 0.37 in this case, higher amount of installed wind capacity is needed to meet the same energy requirement. Offshore wind sites and solar sites remain the same as in the previous scenario. Figure 9 shows the locations of the wind projects included in the 20% Low offshore, dispersed sites.

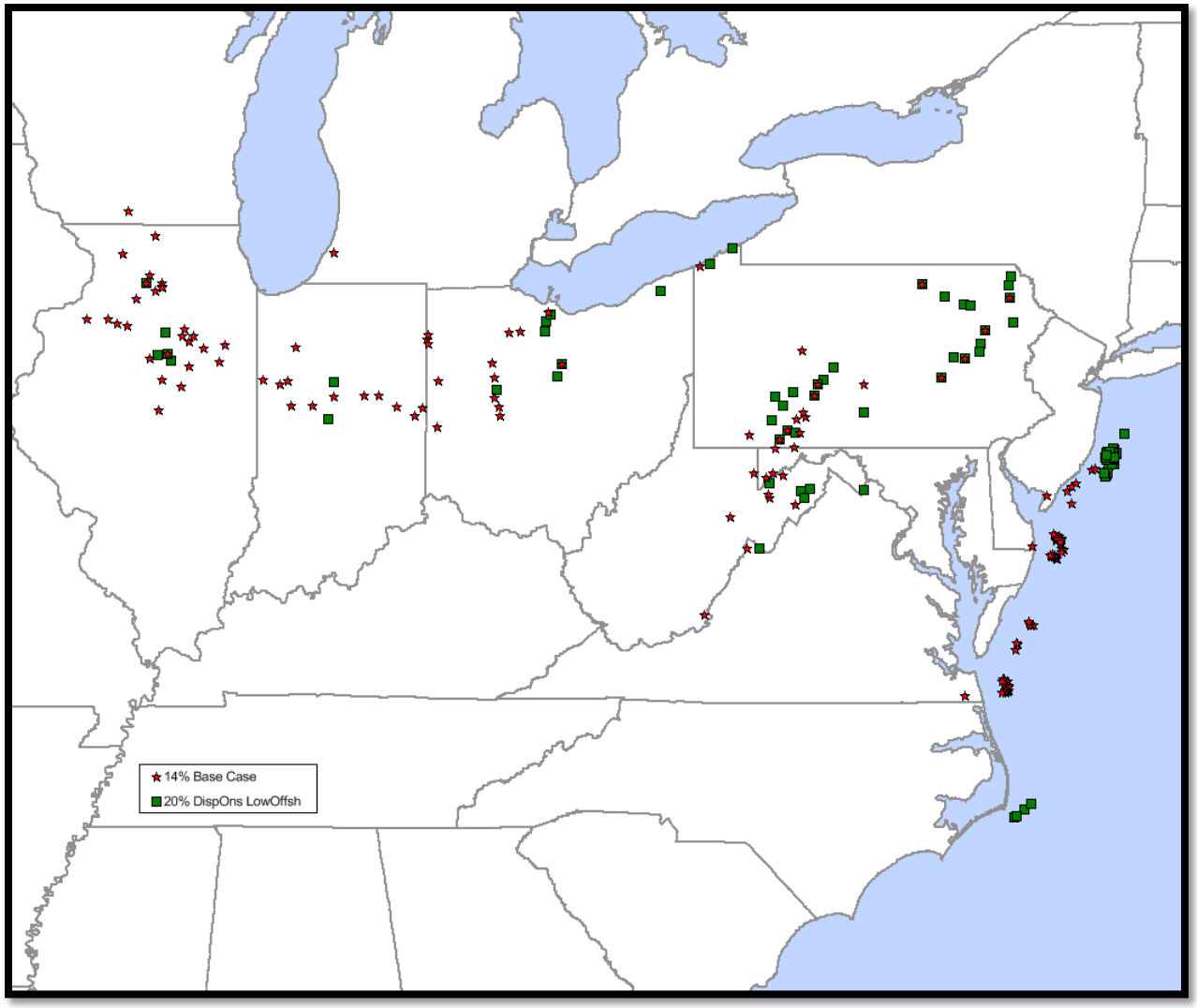

Figure 9 Wind sites for the 20% Low Offshore scenario with dispersed wind sites onshore

1.5.3 20% High Offshore, best sites onshore

The 20% High Offshore case has equal amounts of wind energy from offshore and onshore resources. The solar energy requirement remains the same as the 20% Low offshore scenario

Table 12 Wind summary for 20% High Offshore scenario with best wind sites onshore

20% High Offshore, best sites	Onshore						Offshore						Total Wind		
	14% Adjusted Base Case			Additional			14% Adjusted Base Case			Additional			20% High Offshore, best sites		
States	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF
Delaware							1,000	2,993	0.34				1,000	2,993	0.34
Illinois	11,793	42,296	0.41										11,793	42,296	0.41
Indiana	5,326	18,359	0.39										5,326	18,359	0.39
Maryland	180	594	0.38							40	122	0.35	220	716	0.37
Michigan	200	633	0.36										200	633	0.36
New Jersey							2,000	5,999	0.34	7,380	23,138	0.36	9,380	29,137	0.35
North Carolina										11,453	35,655	0.36	11,453	35,655	0.36
Ohio	2,309	7,428	0.37										2,309	7,428	0.37
Pennsylvania	703	2,279	0.37										703	2,279	0.37
Virginia							1,000	3,038	0.35	1,380	4,221	0.35	2,380	7,259	0.35
West Virginia	1,123	3,576	0.36										1,123	3,576	0.36
Kentucky															
Tennessee															
Washington DC															
Total	21,634	75,166	0.40				4,000	12,030	0.34	20,253	63,136	0.36	45,887	150,331	0.37

Since the base case contained a higher percentage of onshore wind than offshore, the onshore wind was reduced in this scenario to achieve the onshore/offshore 50/50ratio. Additional offshore wind was added. As shown in Table 12, 20.3 GW of offshore wind was added to get the total energy requirement of 150,331 GWH. North Carolina had the maximum amount of the additional offshore wind with 11.5 GW followed by New Jersey with 7.4 GW. Overall capacity factor dropped from 0.38 in the 20% Low offshore scenario to 0.37 in this case. As a result, higher amount of wind capacity was needed to meet the same energy requirement. Figure 10shows the locations of the wind projects included in the 20% High offshore, best sites.

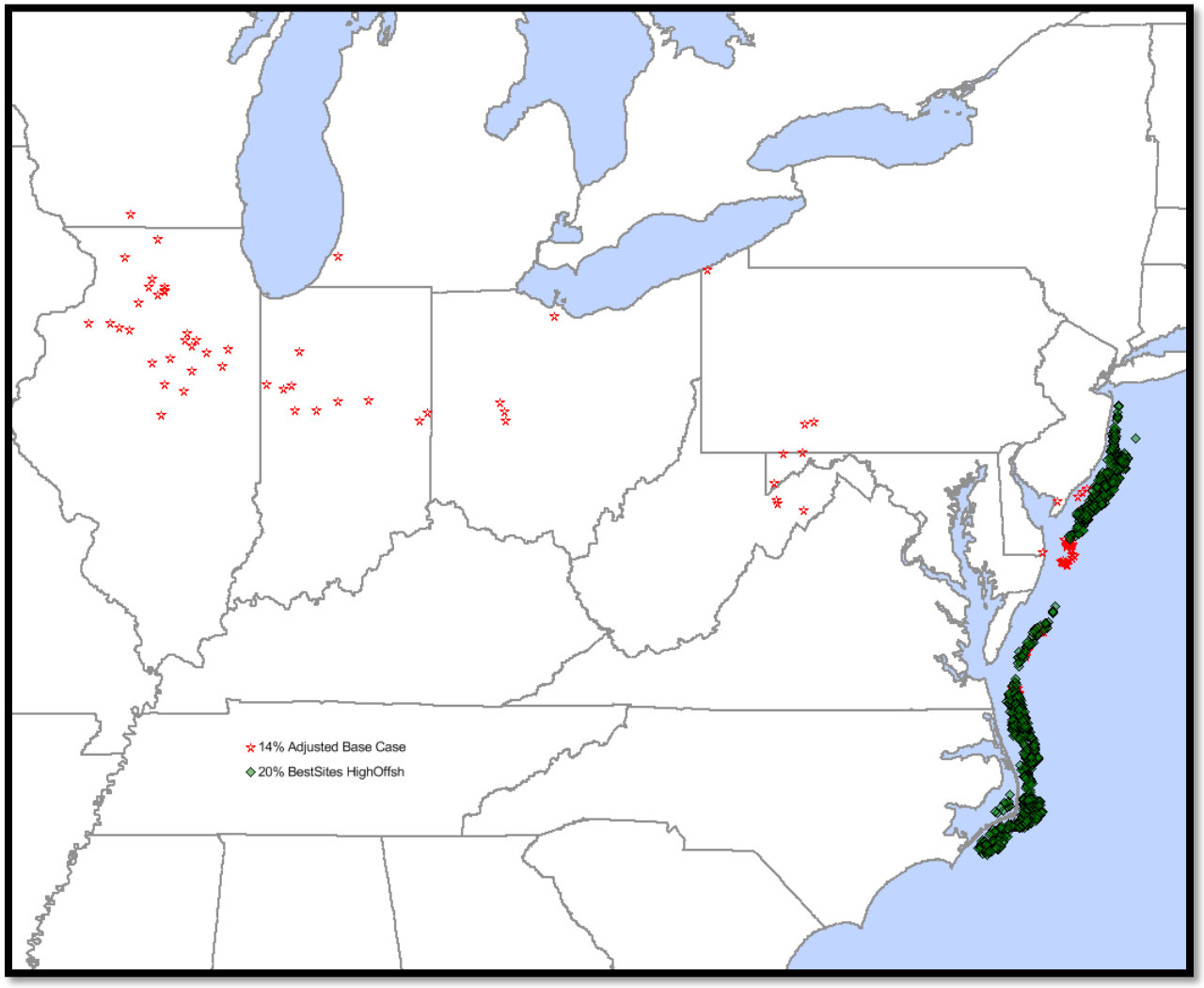

Figure 10 Wind sites for the 20% High Offshore scenario with best wind sites onshore

1.5.4 20% High Solar, best sites onshore

In this scenario, the solar energy requirement increases from 3%, in the previous 20% scenarios, to 6% of the total load energy. As a result, the wind energy requirement decreases from 15.5% as in previous 20% scenarios to 12.5% for the high solar case. However, similar to the 20% Low Offshore scenario, 90% of total wind energy comes from onshore wind and the remaining 10% comes from offshore wind.

Table 13 Wind summary for 20% High Solar scenario with best onshore wind sites

20% High Solar, best sites	Onshore						Offshore						Total Wind		
	14% Base Case			Additional			14% Base Case			Additional			20% High Solar, best sites		
States	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF
Delaware							1,000	2,993	0.34				1,000	2,993	0.34
Illinois	11,793	42,296	0.41	3,394	12,367	0.42							15,187	54,663	0.41
Indiana	7,106	23,601	0.38										7,106	23,601	0.38
Maryland	380	1,191	0.36										380	1,191	0.36
Michigan	200	633	0.36										200	633	0.36
New Jersey							2,000	5,999	0.34	28	95	0.39	2,028	6,094	0.34
North Carolina	373	839	0.26										373	839	0.26
Ohio	5,123	15,720	0.35										5,123	15,720	0.35
Pennsylvania	2,480	7,436	0.34										2,480	7,436	0.34
Virginia	38	113	0.34				1,000	3,038	0.35				1,038	3,151	0.35
West Virginia	1,581	4,923	0.36										1,581	4,923	0.36
Kentucky															
Tennessee															
Washington DC															
Total	29,074	96,752	0.38	3,394	12,367	0.42	4,000	12,030	0.34	28	95	0.39	36,496	121,244	0.38

The 20% Low offshore, best sites as used as a starting point to build this scenario. The total wind in 20% Low offshore, best sites was reduced because of the increased solar energy requirement. Table 13 shows that this scenario has a total of 36.5 GW of installed wind capacity to meet the required wind energy target of 121,244 GWH. Figure 11shows the locations of wind projects included in the 20% High Solar, best sites.

Table 14 Solar summary for 20% High Solar scenario

20% High Solar	Central PV						Distributed PV						Total PV		
	14% Base Case			Additional			14% Base Case			Additional			20% High Solar		
States	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF
Delaware	0	0	0.00	82	146	0.20	179	271	0.17	128	194	0.17	389	612	0.18
Ilinois	275	485	0.20	0	0	0.00	693	949	0.16	2,078	2,848	0.16	3,046	4,282	0.16
Indiana	180	317	0.20	0	0	0.00	224	300	0.15	340	449	0.15	744	1,066	0.16
Kentucky	0	0	0.00	171	307	0.20	0	0	0.00	176	257	0.17	347	564	0.19
Maryland	150	272	0.21	1,429	2,559	0.20	545	840	0.18	1,090	1,680	0.18	3,215	5,350	0.19
Michigan	0	0	0.00	0	0	0.00	0	0	0.00	109	140	0.15	109	140	0.15
New Jersey	0	0	0.00	2,526	4,556	0.21	1790	2658	0.00	233	347	0.00	4,549	7,561	0.19
North Carolina	5	9	0.21	1	2	0.20	6	9	0.18	173	267	0.18	185	287	0.18
Ohio	286	492	0.20	0	0	0.00	369	492	0.15	4,058	5,416	0.15	4,714	6,400	0.16
Pennsylvania	463	840	0.21	567	1,012	0.20	335	486	0.17	3,682	5,344	0.17	5,046	7,682	0.17
Tennessee	0	0	0.00	77	137	0.20	0	0	0.00	45	70	0.18	122	208	0.19
Virginia	1,509	2,645	0.20	7,670	13,892	0.21	0	0	0.00	2,948	4,487	0.17	12,127	21,024	0.20
Washington DC	386	646	0.19	0	0	0.00	186	288	0.00	37	58	0.00	609	992	0.19
West Virginia	0	0	0.00	422	770	0.21	0	0	0.00	868	1,238	0.16	1,290	2,008	0.18
Total	**3,253**	**5,706**	**0.20**	**12,945**	**23,381**	**0.21**	**4,326**	**6,293**	**0.17**	**15,968**	**22,794**	**0.16**	**36,492**	**58,176**	**0.18**

37.0 GW of the solar was needed in this scenario to meet the total energy requirement of 58,176 GWH, as shown in Table 14. The solar selection criteria used can be found in section 1.3.1. Figure 12 shows a plot of the central solar sites for the 20% High Solar scenario. Distributed solar sites remain the same as the 20% Low Offshore scenario and they are scaled to meet the increased energy requirements.

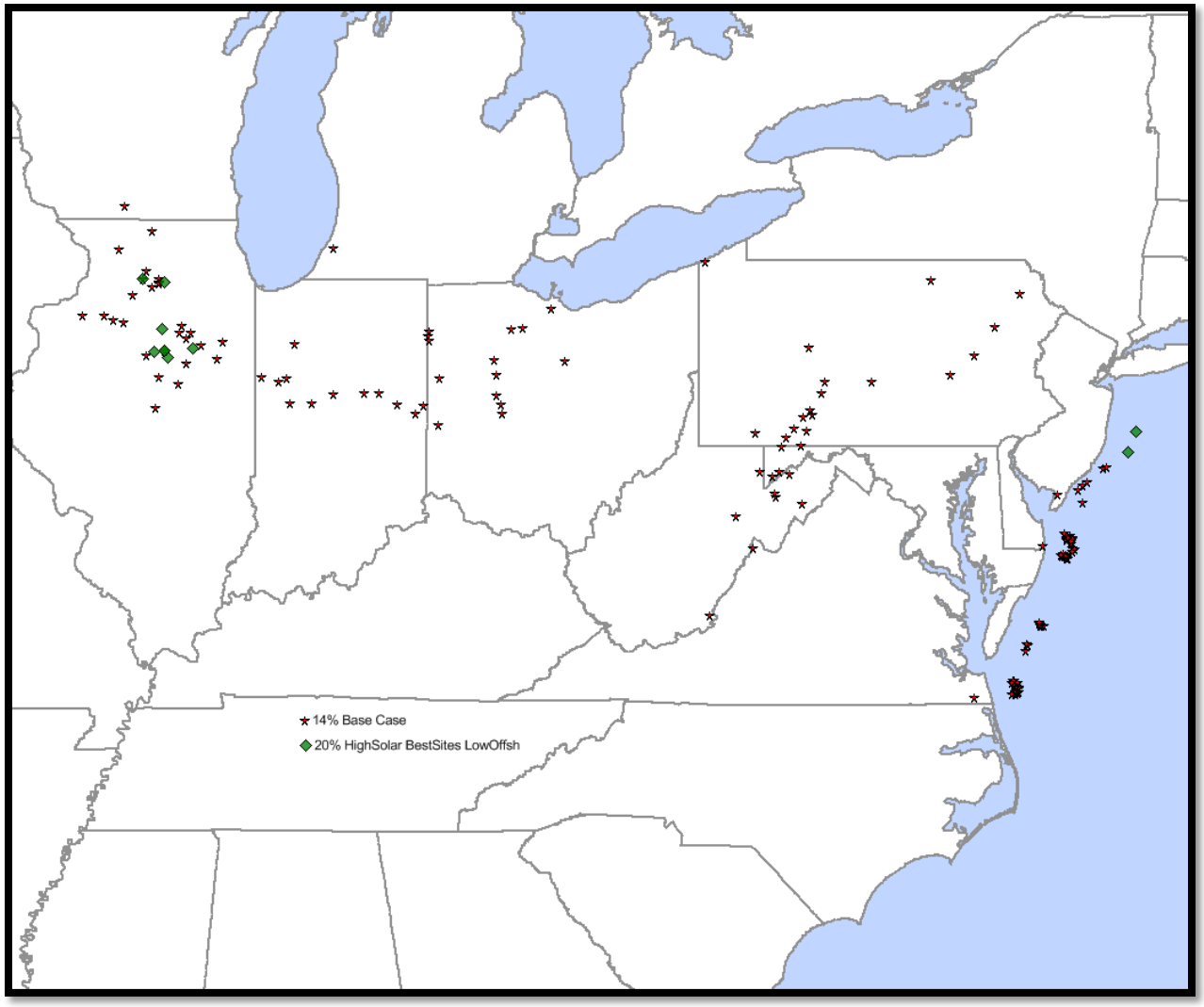

Figure 11 Wind sites for the 20% High Solar scenario, best wind sites onshore

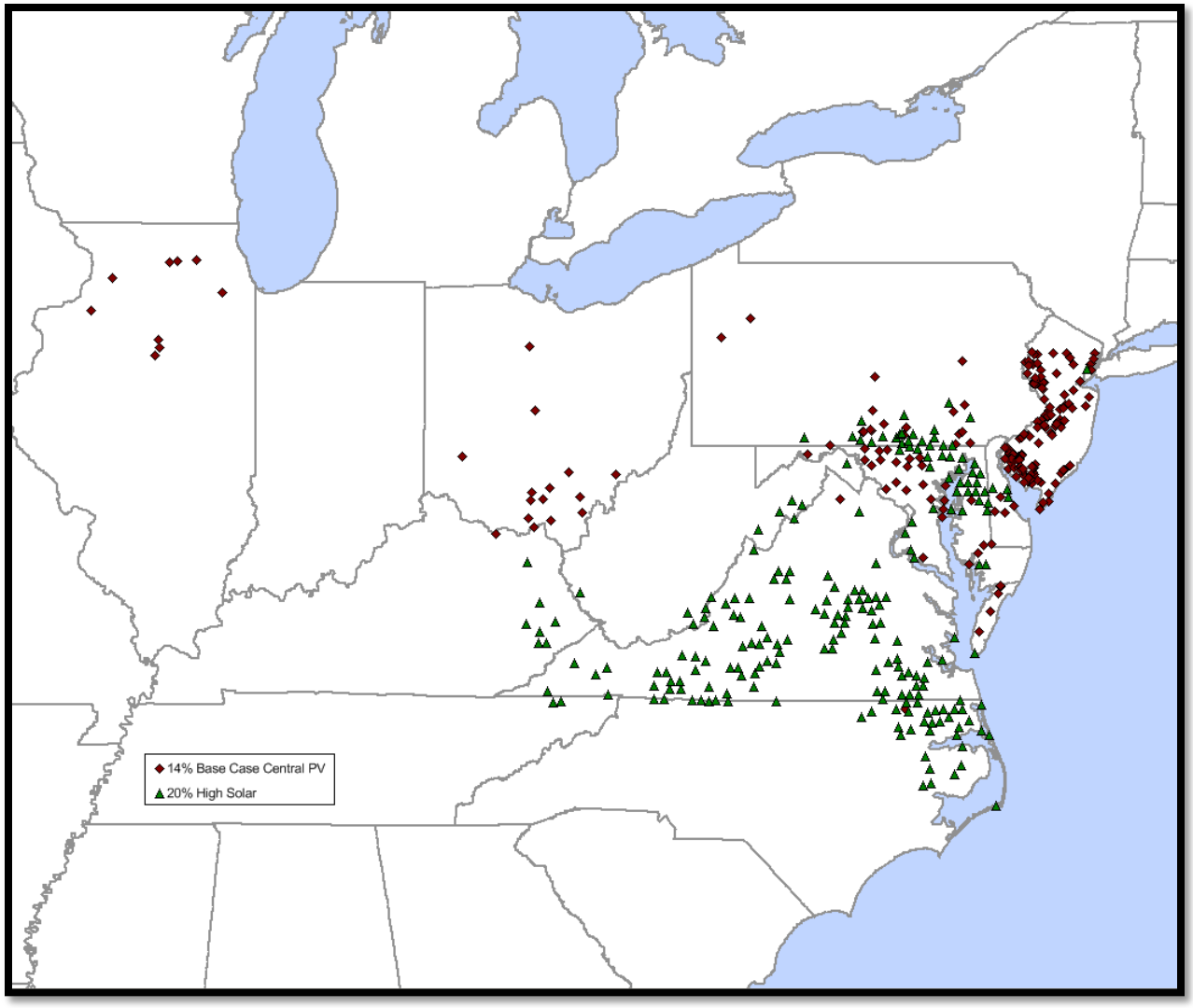

Figure 12 Central solar sites for the 20% High Solar, best wind sites onshore

1.6 30% Scenarios

1.6.1 30% Low Offshore, best sites onshore

The 30% Low Offshore best sites scenario is based on best available sites to meet 30% of forecasted energy demand through the renewable resources. Similar to the all other previous cases, 1.5% of the total load energy is served by other renewable resources. Wind and solar PV constitute 23.5% and 5% of total load energy. Distributed sites for all the 30% cases are same as that of 20% scenarios and the capacity and energy values are scaled accordingly to meet the energy requirements.

Table 15 Wind summary for 30% Low Offshore scenario with best wind sites onshore

30% Low Offshore, best sites	Onshore						Offshore						Total Wind		
	20% Low Offshore			Additional			20% Low Offshore			Additional			30% Low Offshore, best sites		
States	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF
Delaware							1,000	2,993	0.34				1,000	2,993	0.34
Illinois	22,411	80,842	0.41	12,371	43,082	0.40							34,782	123,925	0.41
Indiana	7,106	23,601	0.38	7,372	25,346	0.39							14,478	48,946	0.39
Iowa				301	1,042	0.40							301	1,042	0.40
Maryland	380	1,191	0.36										380	1,191	0.36
Michigan	200	633	0.36										200	633	0.36
New Jersey							2,810	8,676	0.35	1,160	3,733	0.37	3,970	12,409	0.36
North Carolina	373	839	0.26				100	327	0.37	1,255	4,023	0.37	1,728	5,190	0.34
Ohio	5,123	15,720	0.35										5,123	15,720	0.35
Pennsylvania	2,480	7,436	0.34										2,480	7,436	0.34
Virginia	38	113	0.34	100	340	0.39	1,000	3,038	0.35				1,138	3,491	0.35
West Virginia	1,581	4,923	0.36										1,581	4,923	0.36
Kentucky															
Tennessee															
Washington DC															
Total	39,692	135,298	0.38	20,144	69,811	0.40	4,910	15,033	0.34	2,415	7,757	0.37	67,162	227,899	0.39

Wind sites were added to the 20% Low Offshore, best sites to meet the 30% target. Table 15 shows that this scenario has a total of 67.1 GW of installed wind capacity to meet the wind energy target of 227,899 GWH. Illinois has the highest additional wind capacity addition of 12.4 GW, followed by Indiana with 7.4GW. Additional offshore wind capacity of 1.2 GW and 1.3 GW respectively was added in New Jersey and North Carolina with a capacity factor of 0.37 each. Figure 13 shows the locations of wind projects included in the 30% Low offshore, best sites scenario.

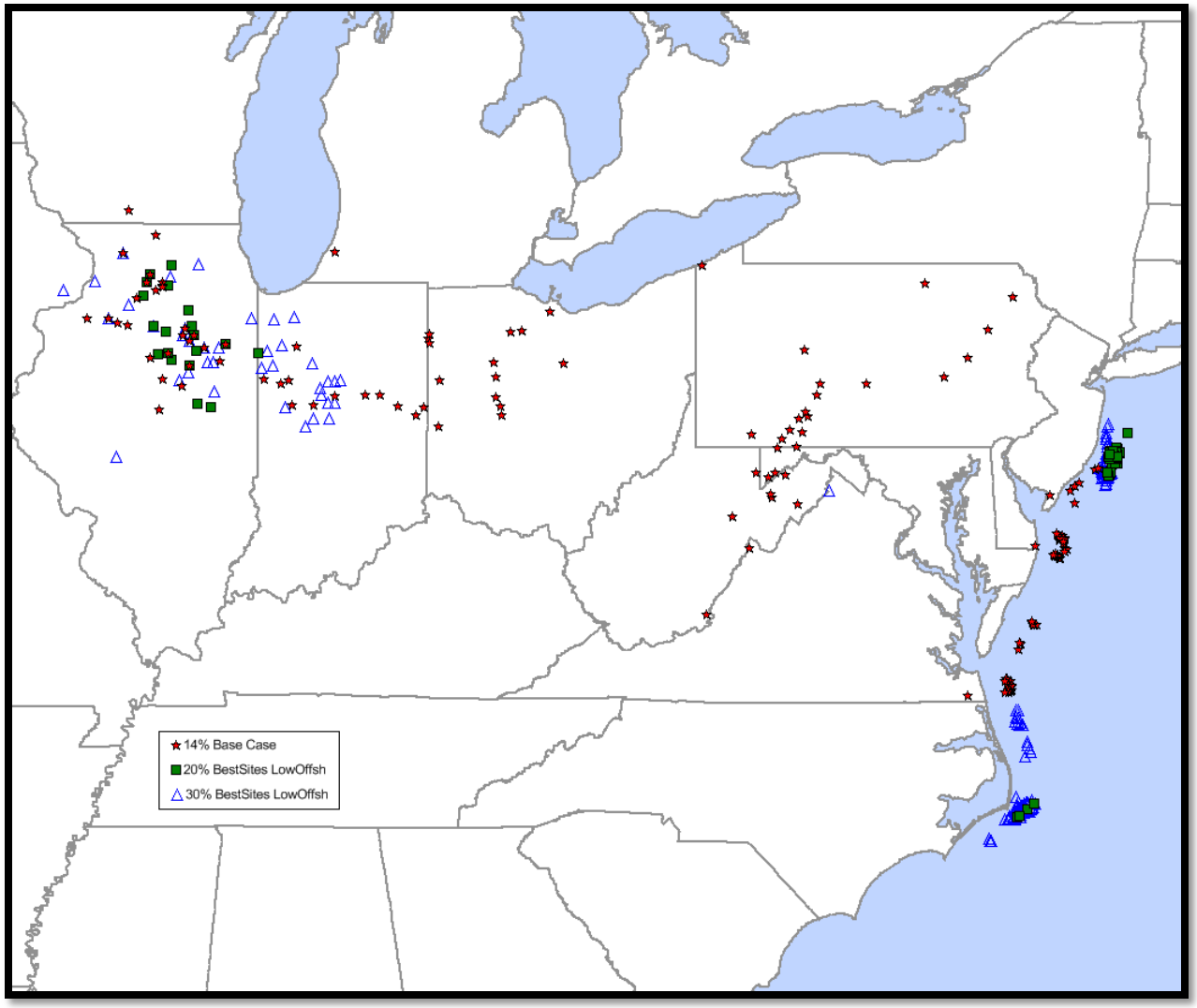

Figure 13 Wind sites for the 30% Low offshore scenario with best wind sites onshore

Table 16 Solar summary for 30% Low Offshore, best wind sites onshore

30% Low/High Offshore	Central PV						Distributed PV						Total PV		
	20% Low/High Offshore			Additional			20% Low/High Offshore			Additional			30% Low/High Offshore		
States	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF
Delaware	150	272	0.21	20	35	0.20	179	271	0.17	75	114	0.17	424	692	0.19
Ilinois	386	646	0.19	0	0	0.00	1,391	1,908	0.16	902	1,234	0.16	2,679	3,787	0.16
Indiana	0	0	0.00	0	0	0.00	248	329	0.15	219	291	0.15	467	620	0.15
Kentucky	20	37	0.21	100	179	0.21	77	113	0.17	68	100	0.17	265	428	0.18
Maryland	472	858	0.21	1,029	1,846	0.20	717	1,105	0.18	636	979	0.18	2,854	4,788	0.19
Michigan	0	0	0.00	0	0	0.00	48	62	0.15	42	55	0.15	90	116	0.15
New Jersey	2,595	4,620	0.20	1,008	1,812	0.21	1,790	2,658	0.17	0	0	0.00	5,392	9,090	0.19
North Carolina	5	9	0.21	1	2	0.20	79	121	0.18	70	107	0.18	154	239	0.18
Ohio	286	492	0.20	0	0	0.00	1,942	2,592	0.15	1,721	2,297	0.15	3,949	5,380	0.16
Pennsylvania	10	18	0.21	146	261	0.21	1,762	2,557	0.17	1,561	2,266	0.17	3,479	5,102	0.17
Tennessee	275	485	0.20	77	137	0.20	20	31	0.18	18	27	0.18	389	681	0.20
Virginia	3,596	6,585	0.21	2,910	5,231	0.21	1,293	1,968	0.17	1,146	1,744	0.17	8,945	15,528	0.20
Washington DC	0	0	0.00	0	0	0.00	185	288	0.18	0	0	0.00	185	288	0.18
West Virginia	284	523	0.21	108	194	0.21	381	543	0.16	337	481	0.16	1,110	1,741	0.18
Total	**8,079**	**14,544**	**0.21**	**5,397**	**9,696**	**0.21**	**10,111**	**14,545**	**0.16**	**6,796**	**9,695**	**0.16**	**30,383**	**48,480**	**0.18**

Additional central solar sites were added and the distributed sites scaled up accordingly to meet the 5% solar target in 30% Low offshore scenario. Table 16 shows that 30.8 GW of installed solar capacity is needed to meet the required solar energy of 48,480 GWH for this scenario. The Central solar has a capacity factor of 0.21 and the distributed solar sites have a capacity factor of 0.16.Figure 14 shows the locations of Central solar sites, for this scenario.

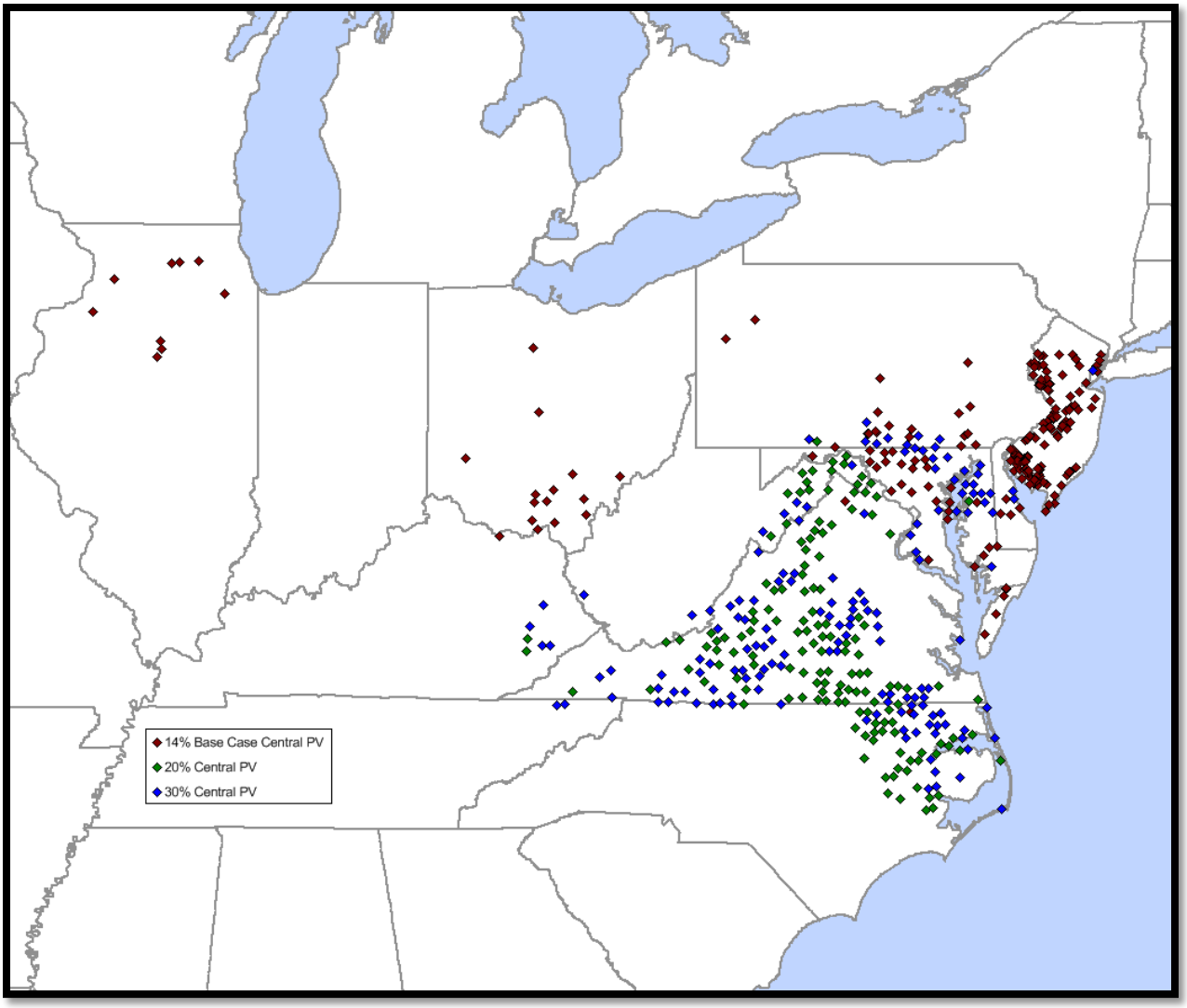

Figure 14 Central solar sites for 30% Low offshore, best wind sites onshore

1.6.2 30% Low Offshore, dispersed sites onshore

This scenario is the same as the 30% Low offshore, best sites scenario except the additional onshore sites are dispersed rather than best sites.

Table 17 Wind summary for 30% Low Offshore scenario with dispersed wind sites onshore

30% Low Offshore, dispersed	Onshore						Offshore						Total Wind		
	20% Low offshore			Additional			20% Low Offshore			Additional			30% Low Offshore, dispersed		
States	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF
Delaware							1,000	2,993	0.34				1,000	2,993	0.34
Illinois	14,084	50,649	0.41	7,857	28,488	0.41							21,940	79,138	0.41
Indiana	7,579	25,249	0.38	843	2,985	0.40							8,422	28,233	0.38
Iowa															
Maryland	380	1,191	0.36										380	1,191	0.36
Michigan	200	633	0.36										200	633	0.36
New Jersey							2,810	8,676	0.35	1,160	3,733	0.37	3,970	12,409	0.36
North Carolina	373	839	0.26				100	327	0.37	1,255	4,023	0.37	1,728	5,190	0.34
Ohio	9,300	28,718	0.35	8,026	23,540	0.33							17,326	52,258	0.34
Pennsylvania	6,768	20,261	0.34	4,030	10,919	0.31							10,797	31,180	0.33
Virginia	38	113	0.34				1,000	3,038	0.35				1,038	3,151	0.35
West Virginia	2,460	7,645	0.35	1,324	3,879	0.33							3,785	11,524	0.35
Kentucky															
Tennessee															
Washington DC															
Total	41,182	135,298	0.38	22,080	69,811	0.36	4,910	15,033	0.35	2,415	7,757	0.37	70,587	227,899	0.37

Table 17 shows that this scenario has a total of 70.6 GW of installed wind capacity to meet the required wind energy of 227,899 GWH. Since the capacity factor decreased from 0.39 in the 30% Low offshore, best sites to 0.37 in this case, 3.5 GW more installed wind capacity is needed to meet the same amount of energy requirement. Figure 15 shows the locations of wind projects included in the 30% Low offshore, dispersed scenario.

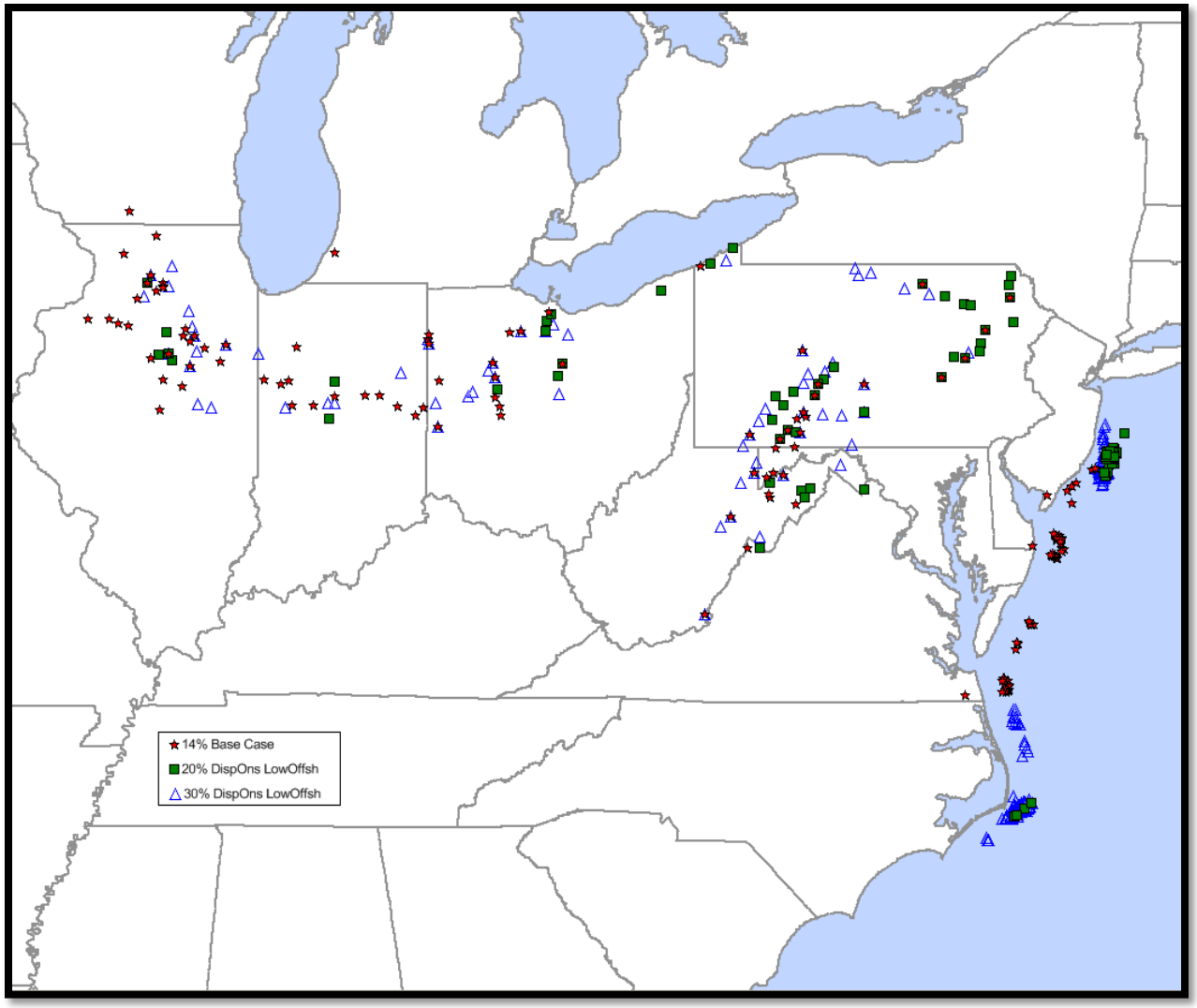

Figure 15 Wind sites for the 30% Low offshore scenario with dispersed wind sites onshore

1.6.3 30% High Offshore, best sites onshore

Since the 20% high offshore, best sites scenario provides 23.5% of PJM energy from wind power; half onshore and half offshore, incremental energy was added to the base case for this scenario.

Table 18 Wind summary for 30% High Offshore scenario with best wind sites onshore

30% High Offshore, best sites	Onshore						Offshore						Total Wind		
	14% Base Case			Additional			14% Base Case			Additional			30% High Offshore, best sites		
States	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF
Delaware							1,000	2,993	0.34				1,000	2,993	0.34
Illinois	11,793	42,296	0.41	4,723	17,198	0.42							16,516	59,494	0.41
Indiana	7,106	23,601	0.38										7,106	23,601	0.38
Maryland	380	1,191	0.36							1,520	4,558	0.34	1,900	5,749	0.35
Michigan	200	633	0.36										200	633	0.36
New Jersey							2,000	5,999	0.34	10,300	31,913	0.35	12,300	37,912	0.35
North Carolina	373	839	0.26							16,440	50,655	0.35	16,813	51,495	0.35
Ohio	5,123	15,720	0.35										5,123	15,720	0.35
Pennsylvania	2,480	7,436	0.34										2,480	7,436	0.34
Virginia	38	113	0.34				1,000	3,038	0.35	4,899	14,793	0.34	5,937	17,944	0.34
West Virginia	1,581	4,923	0.36										1,581	4,923	0.36
Kentucky															
Tennessee															
Washington DC															
Total	29,074	96,752	0.38	4,723	17,198	0.42	4,000	12,030	0.34	33,159	101,920	0.35	70,957	227,899	0.37

Table 18 summarizes this scenario. The additional onshore wind was added in Illinois totaling 4.7 GW with a capacity factor of 0.42. North Carolina had the highest addition of the offshore wind of 16.4 GW, followed by New Jersey with 10.3 GW. Figure 16 shows the locations of wind projects included in the 30% High offshore, best sites scenario.

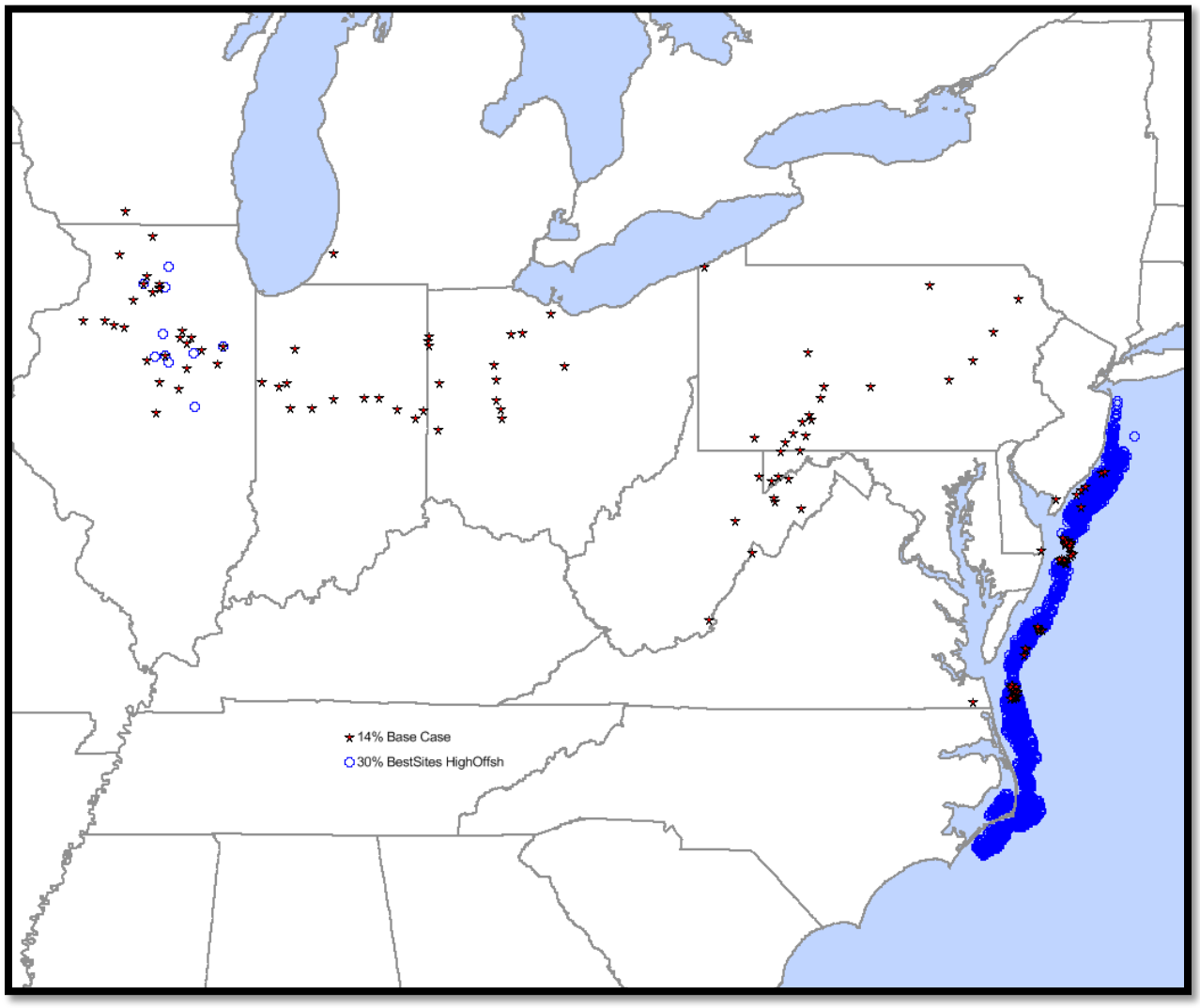

Figure 16 Wind sites for the 30% High Offshore scenario with best wind sites onshore

1.6.4 30% High Solar, best sites onshore

In this scenario, the solar energy requirement increases from 5%, in the other 30% scenarios, to 10%. As a result, the wind energy requirement decreases from 23.5% as in previous 30% scenarios to 18.5% for the high solar case. The additional onshore wind sites for this scenario are chosen based on the best sites (according to the high capacity factor).

Table 19 Wind summary for 30% High Solar scenario with best wind sites onshore

30% High Solar, best sites	Onshore						Offshore						Total Wind		
	20% High Solar, best sites			Additional			20% High Solar, best sites			Additional			30% High Solar, best sites		
States	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF	MW	GWH	CF
Delaware							1,000	2,993	0.34				1,000	2,993	0.34
Illinois	15,187	54,663	0.41	12,679	45,462	0.41							27,866	100,126	0.41
Indiana	7,106	23,601	0.38	1,959	6,896	0.40							9,064	30,497	0.38
Maryland	380	1,191	0.36										380	1,191	0.36
Michigan	200	633	0.36										200	633	0.36
New Jersey							2,028	6,094	0.34	1,286	4,213	0.37	3,314	10,307	0.36
North Carolina	373	839	0.26							495	1,604	0.37	868	2,444	0.32
Ohio	5,123	15,720	0.35										5,123	15,720	0.35
Pennsylvania	2,480	7,436	0.34										2,480	7,436	0.34
Virginia	38	113	0.34				1,000	3,038	0.35				1,038	3,151	0.35
West Virginia	1,581	4,923	0.36										1,581	4,923	0.36
Kentucky															
Tennessee															
Washington DC															
Total	32,468	109,119	0.38	14,637	52,358	0.41	4,028	12,124	0.34	1,781	5,818	0.37	52,915	179,419	0.39

Additional wind sites were added to the 20% High Solar, best sites to meet the 30% High Solar, best sites scenario requirement. Table 20 shows that this scenario has a total of 52.9 GW of installed wind capacity to meet the required wind energy target of 179,419 GWH. The additional onshore wind energy of 12.7 GW and 1.9 GW was added in Illinois and Indiana respectively. Additional offshore wind of 1.3 GW and 0.5 GW was added in New Jersey and North Carolina respectively with a capacity factor of 0.37 each. Figure 17shows the locations of wind projects included in the 30% High Solar, best sites.

Table 20 Solar summary for 30% High Solar scenario

30% High Solar	Central PV						Distributed PV						Total PV		
	20% High Solar			Additional			20% High Solar			Additional			30% High Solar		
States	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF
Delaware	82	146	0.20	236	418	0.20	307	465	0.17	204	310	0.17	830	1,340	0.18
Ilinois	275	485	0.20	6	10	0.20	2,771	3,797	0.16	1,847	2,531	0.15	4,899	6,824	0.16
Indiana	180	317	0.20	0	0	0.00	564	749	0.15	376	499	0.15	1,121	1,566	0.16
Kentucky	171	307	0.20	611	1,058	0.20	176	257	0.00	117	171	0.16	1,075	1,793	0.19
Maryland	1,580	2,831	0.20	393	692	0.20	1,636	2,519	0.18	1,090	1,680	0.17	4,699	7,722	0.19
Michigan	0	0	0.00	0	0	0.00	109	140	0.00	73	94	0.14	182	234	0.15
New Jersey	2,526	4,556	0.21	78	138	0.20	2,023	3,005	0.00	1,349	2,003	0.16	5,976	9,702	0.19
North Carolina	6	11	0.21	1,748	3,048	0.20	179	276	0.18	120	184	0.17	2,053	3,519	0.20
Ohio	286	492	0.20	12	21	0.20	4,427	5,908	0.15	2,952	3,939	0.15	7,677	10,360	0.15
Pennsylvania	1,029	1,852	0.21	3,360	5,878	0.20	4,017	5,830	0.17	2,678	3,887	0.16	11,084	17,446	0.18
Tennessee	77	137	0.20	0	0	0.00	45	70	0.00	30	47	0.17	152	254	0.19
Virginia	9,179	16,537	0.21	3,639	6,415	0.20	2,948	4,487	0.00	1,965	2,991	0.17	17,732	30,431	0.20
Washington DC	386	646	0.19				223	346	0.00	149	231	0.17	757	1,222	0.18
West Virginia	422	770	0.21	989	1,713	0.20	868	1,238	0.00	579	825	0.16	2,857	4,545	0.18
Total	**16,198**	**29,088**	**0.20**	**11,072**	**19,392**	**0.20**	**20,294**	**29,088**	**0.16**	**13,529**	**19,392**	**0.16**	**61,093**	**96,959**	**0.18**

Table 20 shows that 62.0 GW of solar capacity is needed in this scenario to meet the total energy requirement of 96,960 GWH. Figure 18 shows the plot of the central solar sites for the 30% High Solar scenario. Distributed solar sites remain the same as the 20% Low Offshore scenario and they are scaled to meet the increased energy requirements.

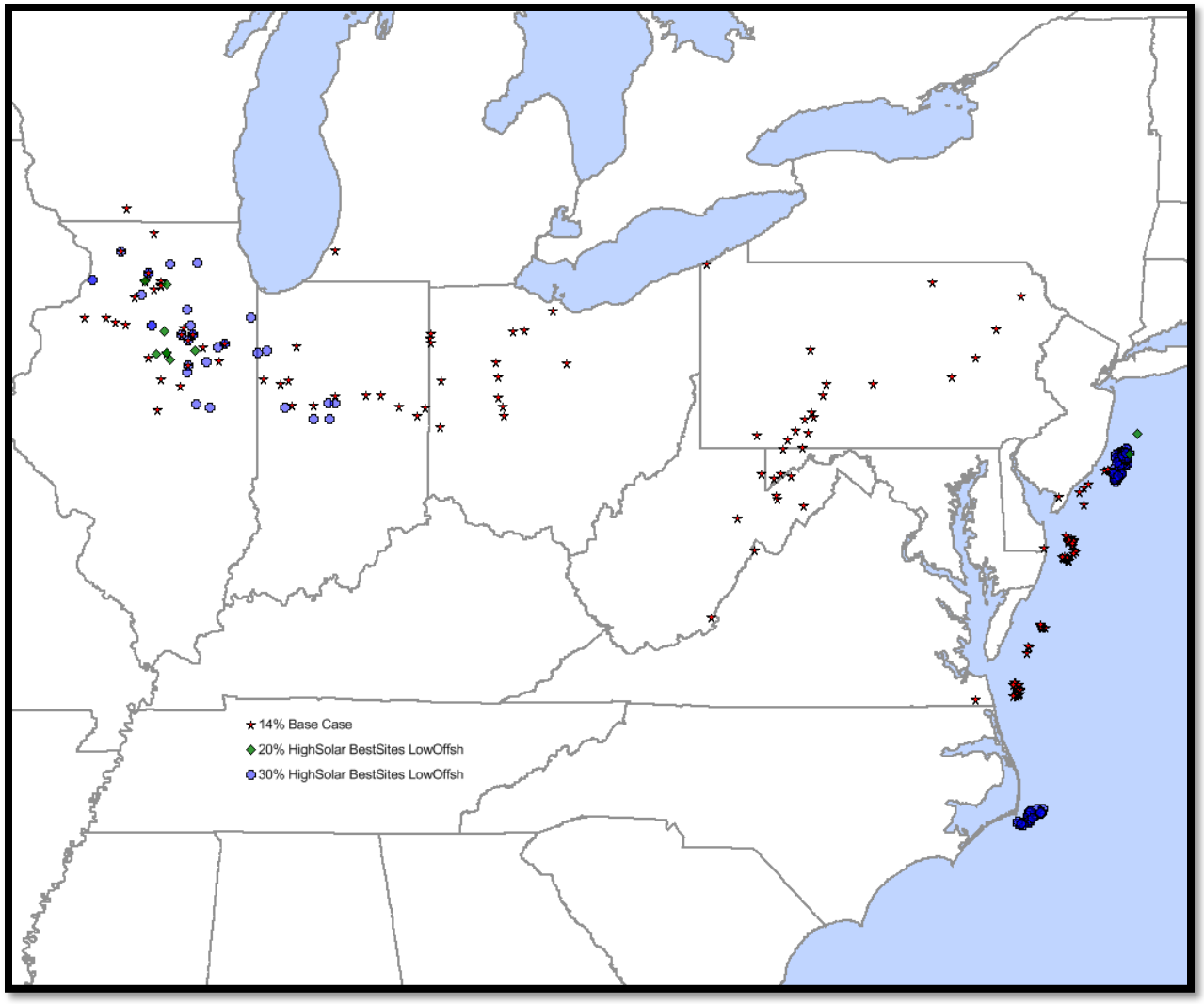

Figure 17 Wind sites for the 30% High solar, best wind sites onshore

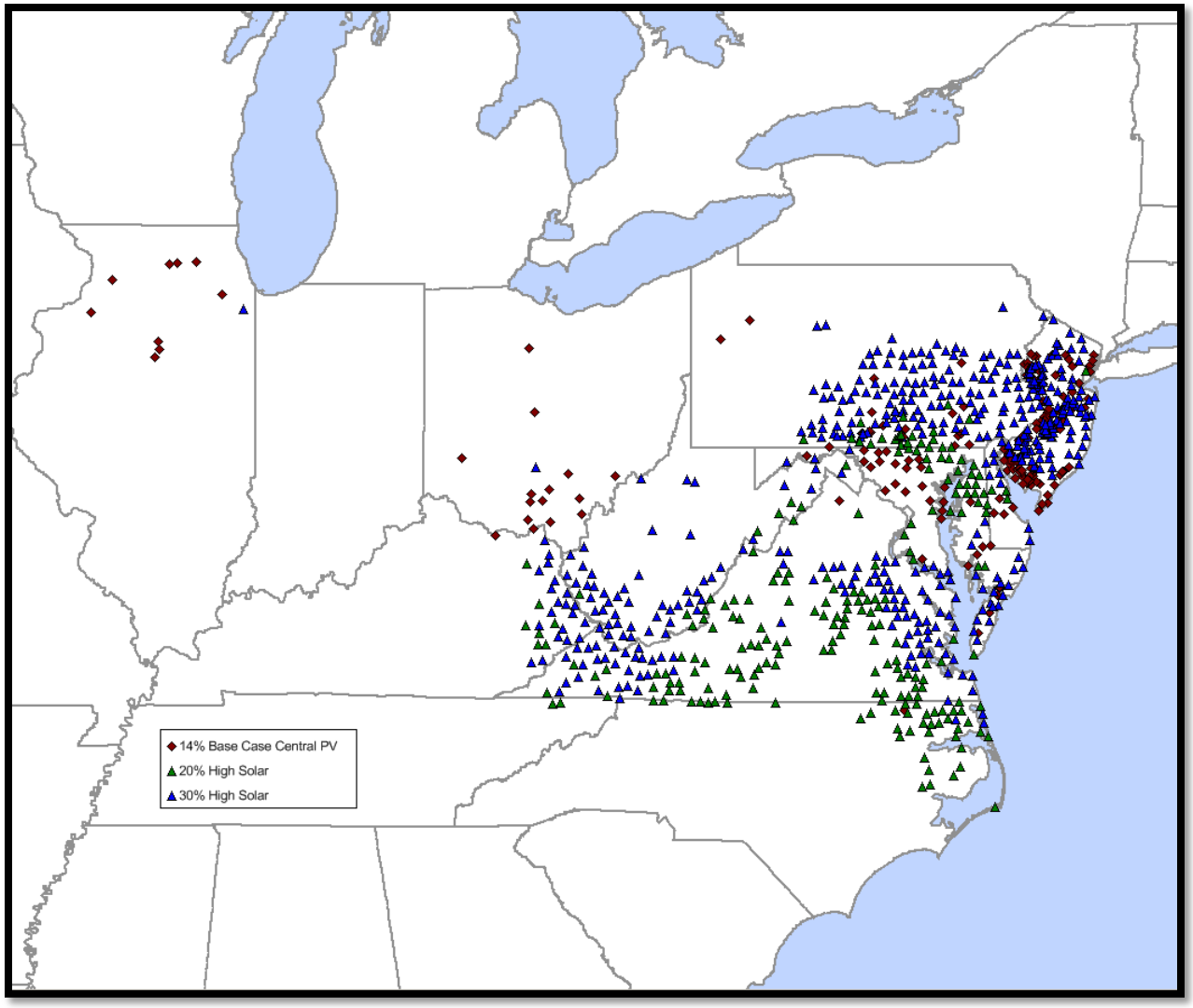

Figure 18 Central solar sites for the 30% High Solar scenario, best wind sites onshore

1.7 Wind Penetration for rest of Eastern Interconnect

For purposes of this study, it is assumed that the rest of the Eastern Interconnect (EI) will grow its overall renewable penetration somewhat more slowly than PJM. Table 21 summarizes what the rest of the EI renewable penetration is for each of the study scenarios. For example, for the 14% PJM base case, the rest of the EI will have an overall renewable penetration of 10%.

Table 21 Renewable Energy Penetration in Eastern Interconnection

Scenario	PJM % RE	EI % RE
Base	14%	10%
Low Offshore	20%	15%
High Offshore	20%	15%
High Solar	20%	15%
Low Offshore	30%	20%
High Offshore	30%	20%
High Solar	30%	20%

The Eastern Wind Integration and Transmission Study (EWITS) Scenario 2 (20% Hybrid with Offshore) was used to guide how the rest of EI renewable penetration for each scenario would be allocated to other NERC regions in the Eastern Interconnect. Table 22 is taken directly from the EWITS Executive Summary and Project Overview. This table was used to determine the allocation of total renewable energy for the rest of the Eastern Interconnect to the NERC regions other than PJM. This was done by taking the amount of renewable energy in each of the other NERC regions in EWITS scenario 2 and dividing it by the total EI renewable energy minus PJM. The equation is (EWITS Scenario 2 NERC Region$_x$RE)/ (EWITS Scenario2 Total RE – EWITS Scenario 2 PJM RE). Table 23 summarizes the other NERC region ratios.

Table 22 Wind Renewable Allocation for the Eastern Wind and Transmission Study (EWITS) Scenarios

TABLE 1. TOTAL AND OFFSHORE WIND IN THE SCENARIOS								
Region	Scenario 1 20% High Capacity Factor, Onshore		Scenario 2 20% Hybrid with Offshore		Scenario 3 20% Local, Aggressive Offshore		Scenario 4 30% Aggressive On- and Offshore	
	TOTAL (MW)	Offshore (MW)	Total (MW)	Offshore (MW)	Total (MW)	Offshore (MW)	Total (MW)	Offshore (MW)
MISO/ MAPP[a]	94,808		69,444		46,255		95,046	
SPP	91,843		86,666		50,958		94,576	
TVA	1,247		1,247		1,247		1,247	
SERC	1,009		5,009	4,000	5,009	4,000	5,009	4,000
PJM	22,669		33,192	5,000	78,736	39,780	93,736	54,780
NYISO	7,742		16,507	2,620	23,167	9,280	23,167	9.280
ISO-NE	4,291		13,837	5,000	24,927	11,040	24,927	11,040
TOTAL	223,609	0	225,902	16,620	230,299	64,100	337,708	79,100

[a] *MAPP stands for Mid-Continent Area Power Pool.*

Source: Eastern Wind Integration and Transmission Study (EWITS) Executive Summary and Project Overview Table 1

Table 23 Renewable Energy Allocation for Eastern Interconnection NERC Regions, Excluding PJM

Region	EWITS Scenario 2 Wind Energy (GWh)	Rest of EI NERC region RE ratio
ISO-NE	46,000	7%
MISO+MAPP	288,000	45%
NYISO	48,000	7%
SERC	16,000	2%
SPP	245,000	38%
TVA	4,000	1%
Total - PJM	**647,000**	**100%**

The 2026 load energy forecast for the rest of the EI's NERC regions is from the 2011 NERC Electric Supply and Demand report.