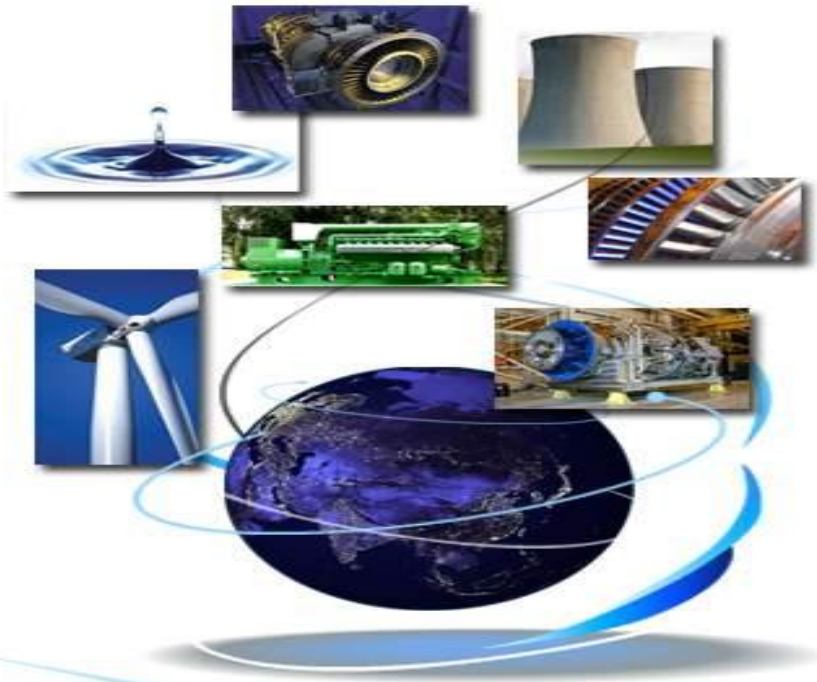
GE
Energy

PJM Renewables Integration Study

Task 2 Scenario Development and Analysis

GE Energy Consulting
January 26, 2012



imagination at work

Scenarios

Scenario	Renewable Penetration in PJM	Wind + Solar Siting
1	Reference	Existing Plants
2	Base Case	Per PJM Queue & Mandates
3a	20%	Low Offshore, best sites
3b	20%	Low Offshore, dispersed
3c	20%	High Offshore
3d	20%	High Solar
4a	30%	Low Offshore, best sites
4b	30%	Low Offshore, dispersed
4c	30%	High Offshore
4d	30%	High Solar
5	Pain-Point	One siting option from 30% penetration cases

Scenarios

Scenario	Load	% RE	% Other Renewable	% Wind	% Solar	Total RE Required (GWh)	Other Renewable Energy	Additional RE Required	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

Scenario Development

- Base-Case Scenario meets RPS targets for states within PJM footprint
- Wind/Solar Split
  - Distributed solar will be a mix of **20%** residential and **80%** commercial

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

Scenario Development

Solar Selection

1. Incremental Central & Distributed solar for all scenarios will be added to all PJM states in proportion to the ratio of PJM portion of the state load energy to the total PJM load energy

2. For the central solar, sites selected based on best sites (highest capacity factor)

3. For the distributed solar, all cities and towns that AWST identified in a state that has a solar requirement were identified.
   a) The amount of energy needed in that state was determined.
   b) The ratio of the required energy to the actual energy in the AWST solar data was determined.
   c) The ratio was then used to scale up all sites in the state proportionally to meet the energy target.
   d) This was done for the commercial and residential sites.

State	Load	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%

Scenario Development

All 20% and 30% Cases include the wind and solar sites selected in the Base Case

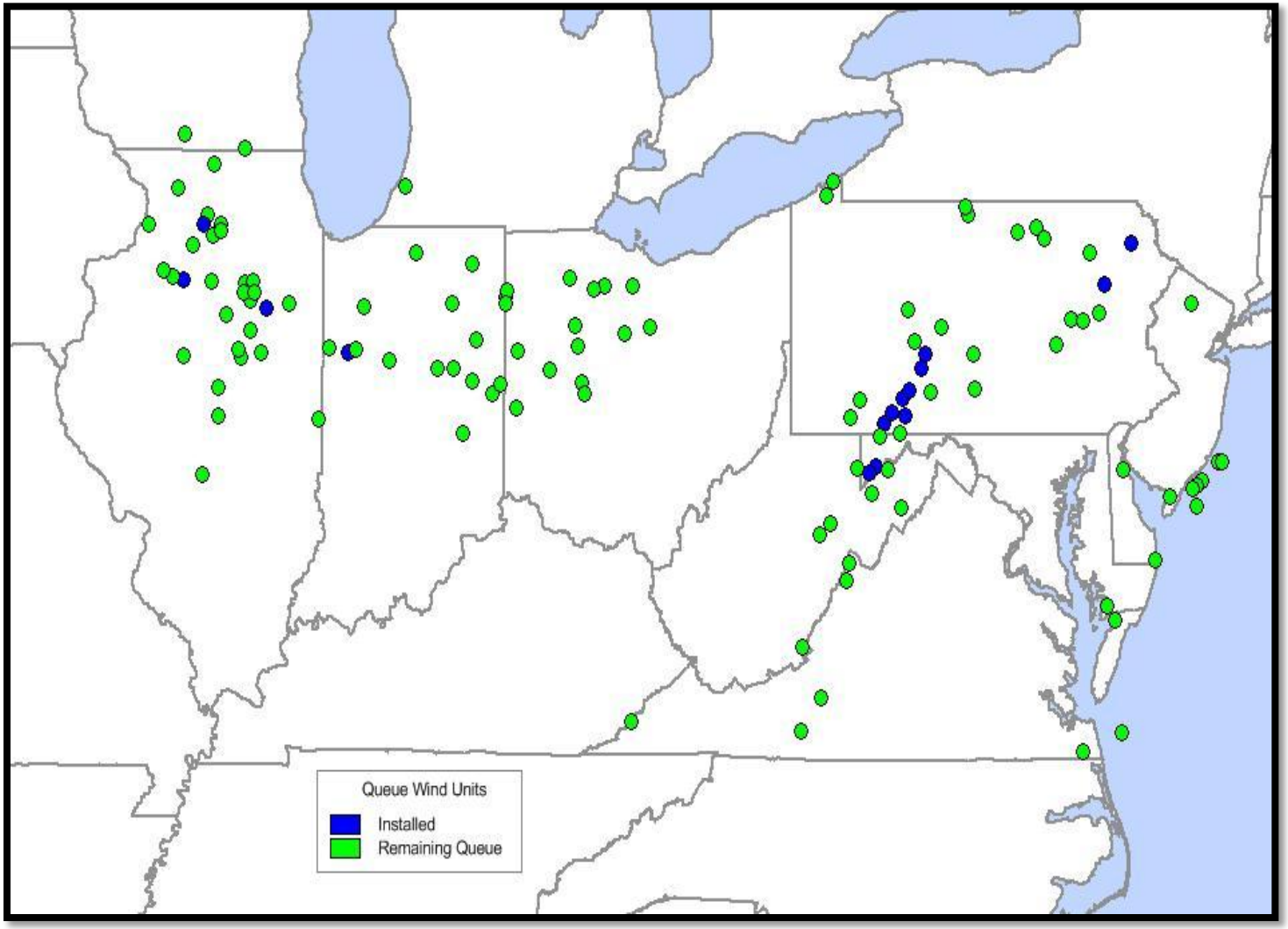
1. **Low Offshore, Best Sites Onshore**
    a) Incremental onshore and offshore wind are added using best sites (Best Capacity factors)
    b) NJ, DE, MD, NC, VA only have offshore sites.
2. **Low Offshore, Dispersed Onshore**
    a) Incremental onshore wind is added in IL, IN, OH, WV, PA.
    b) Incremental Onshore wind is added to the remaining states proportional to the ratio of PJM portion of the state load energy to the total PJM load energy
    c) Incremental Offshore wind is added using the best sites (Best Capacity factors)
        a) NJ, DE, MD, NC, VA only have offshore sites.
3. **High Offshore**
    a) Incremental Offshore wind is added based on best sites (Best Capacity factors)
        a) NJ, DE, MD, NC, VA only have offshore sites
    b) Incremental Onshore wind is added using best sites (Best Capacity factors)
4. **High Solar**
    a) Solar Selection Criteria is followed
    b) Incremental Offshore wind is added based on best sites (Best Capacity factors)
        a) NJ, DE, MD, NC, VA only have offshore sites.
    c) Incremental Onshore wind is added using best sites (Best Capacity factors)

Reference Case

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**

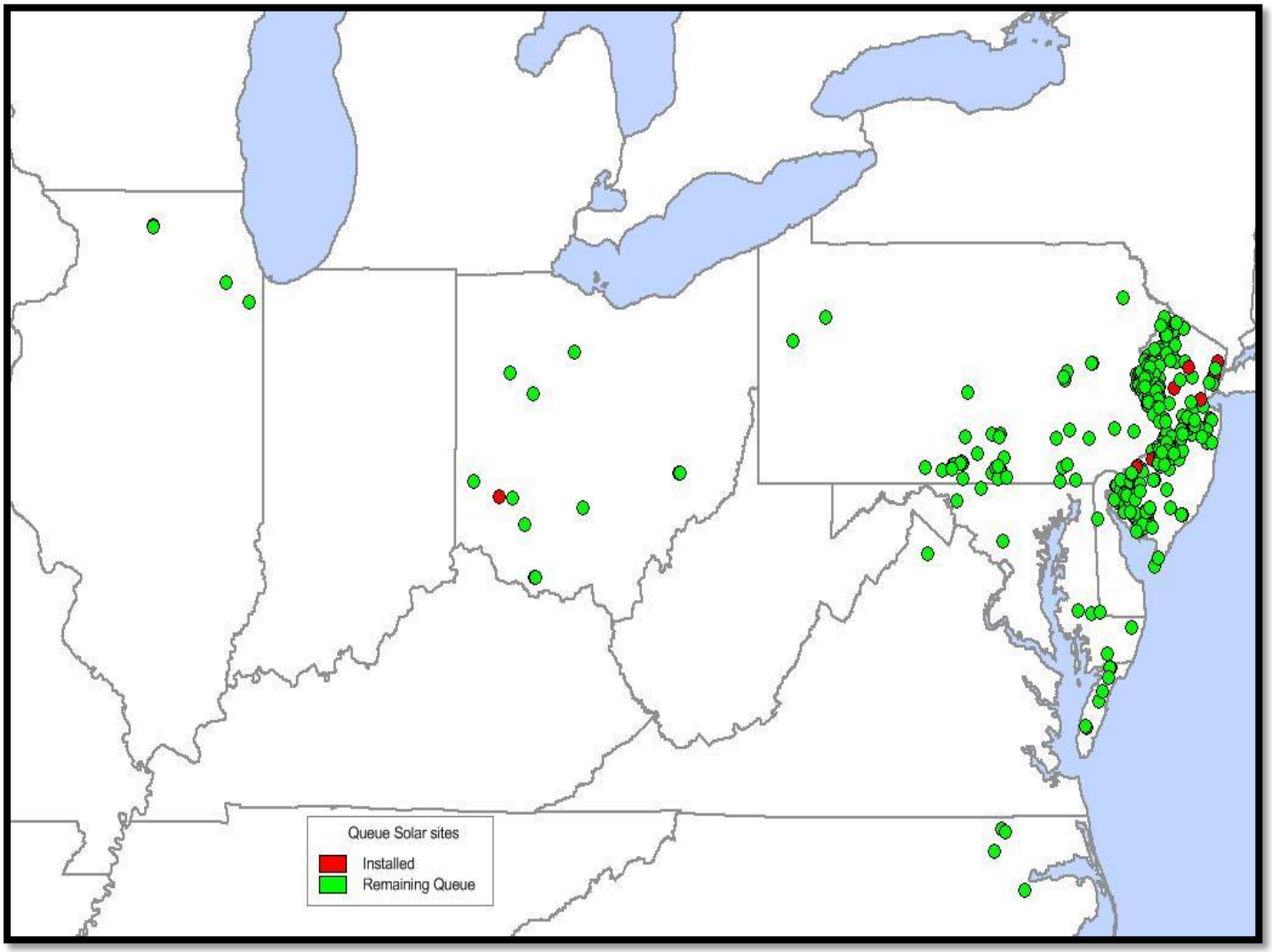
Reference Case – Wind Locations



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**

Reference Case – Solar Locations



14% Base Case

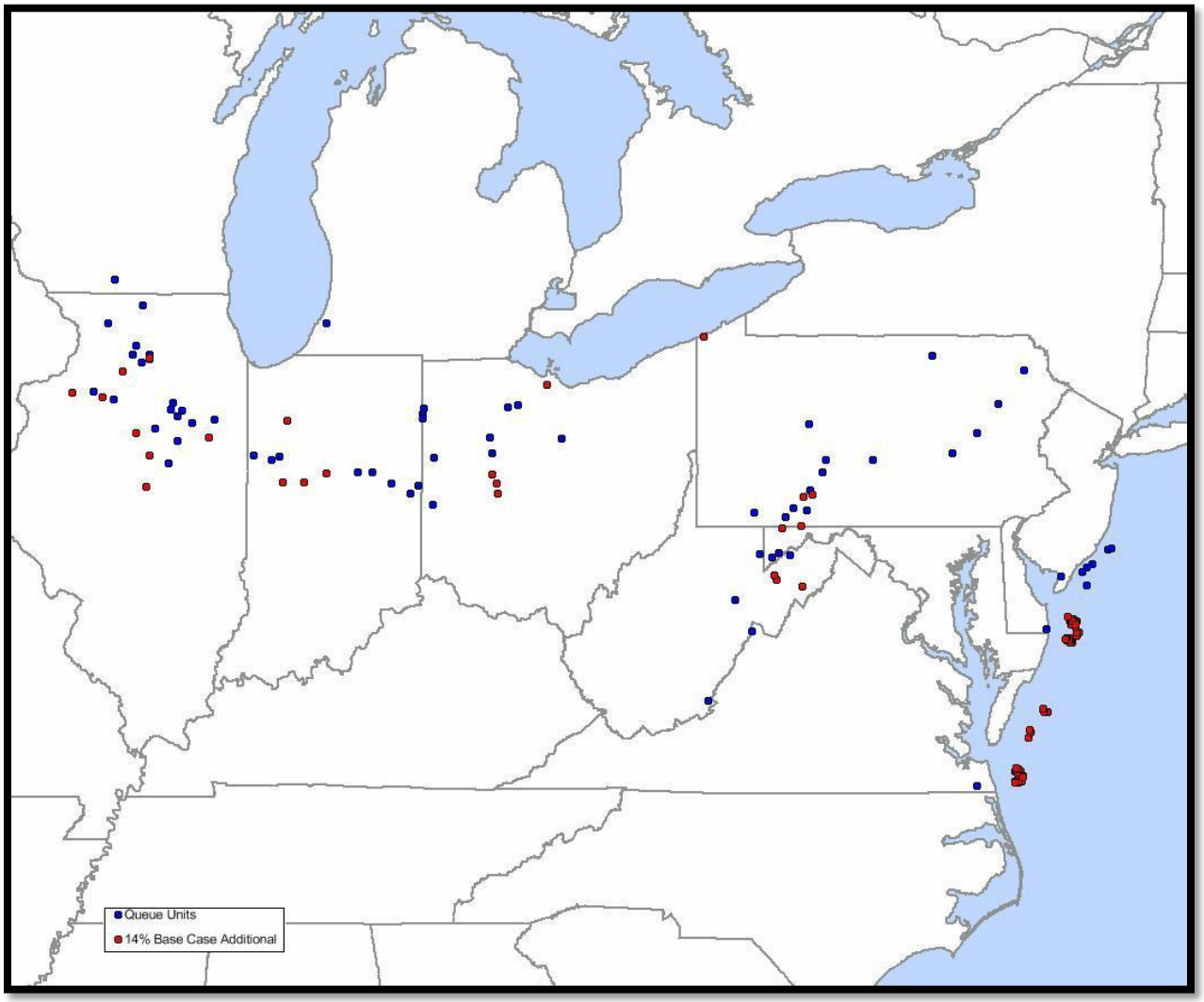
Base Case Scenario – Wind and Solar by State

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
Illinois	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**

14% Base Case – Wind Summary

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

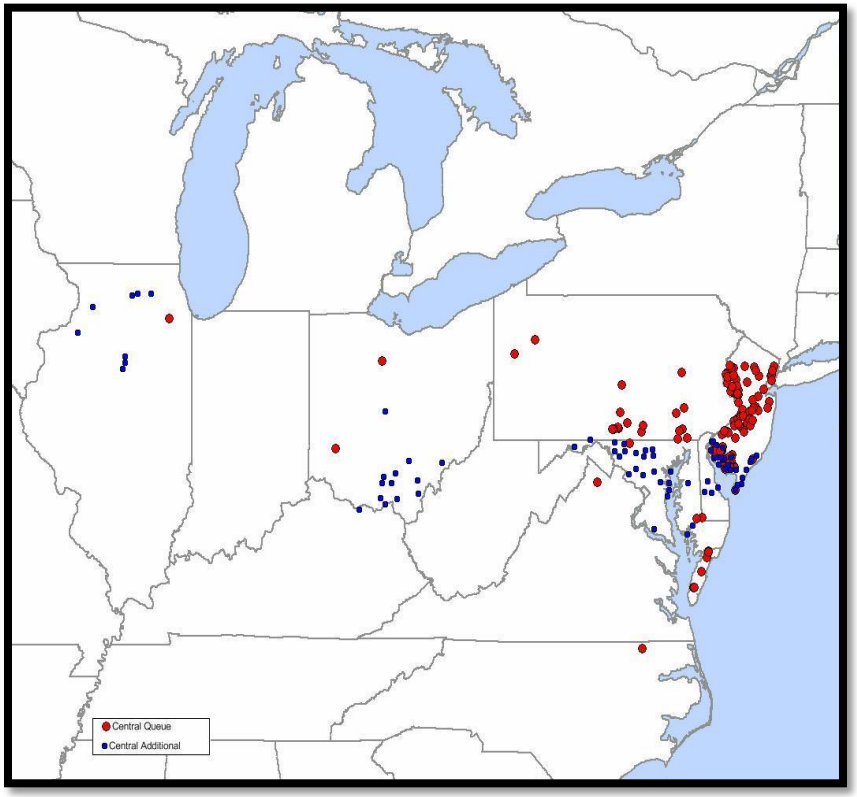
14% Base Case– Wind Locations



14% Base Case– Solar Summary

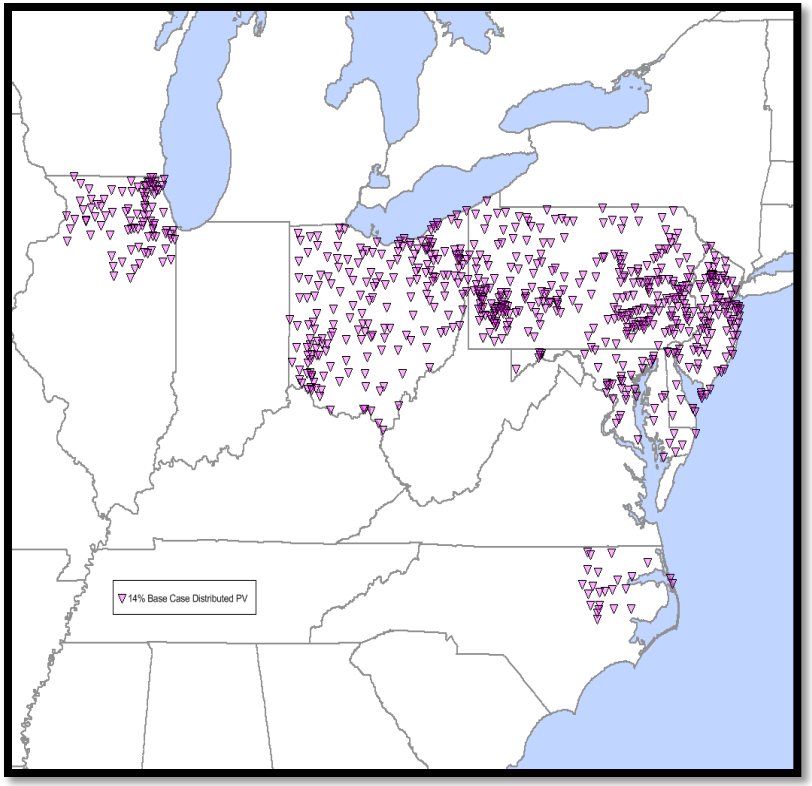
14% Base Case	Central PV						Distributed PV						Total PV		
	Queue			Additional			Queue			Additional			14% Base Case		
States	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF
Delaware	0	0	0.00	150	272	0.21	0	0	0.00	179	271	0.17	329	543	0.19
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**

14% Base Case – Solar Locations



Central

Distributed



20% Scenarios

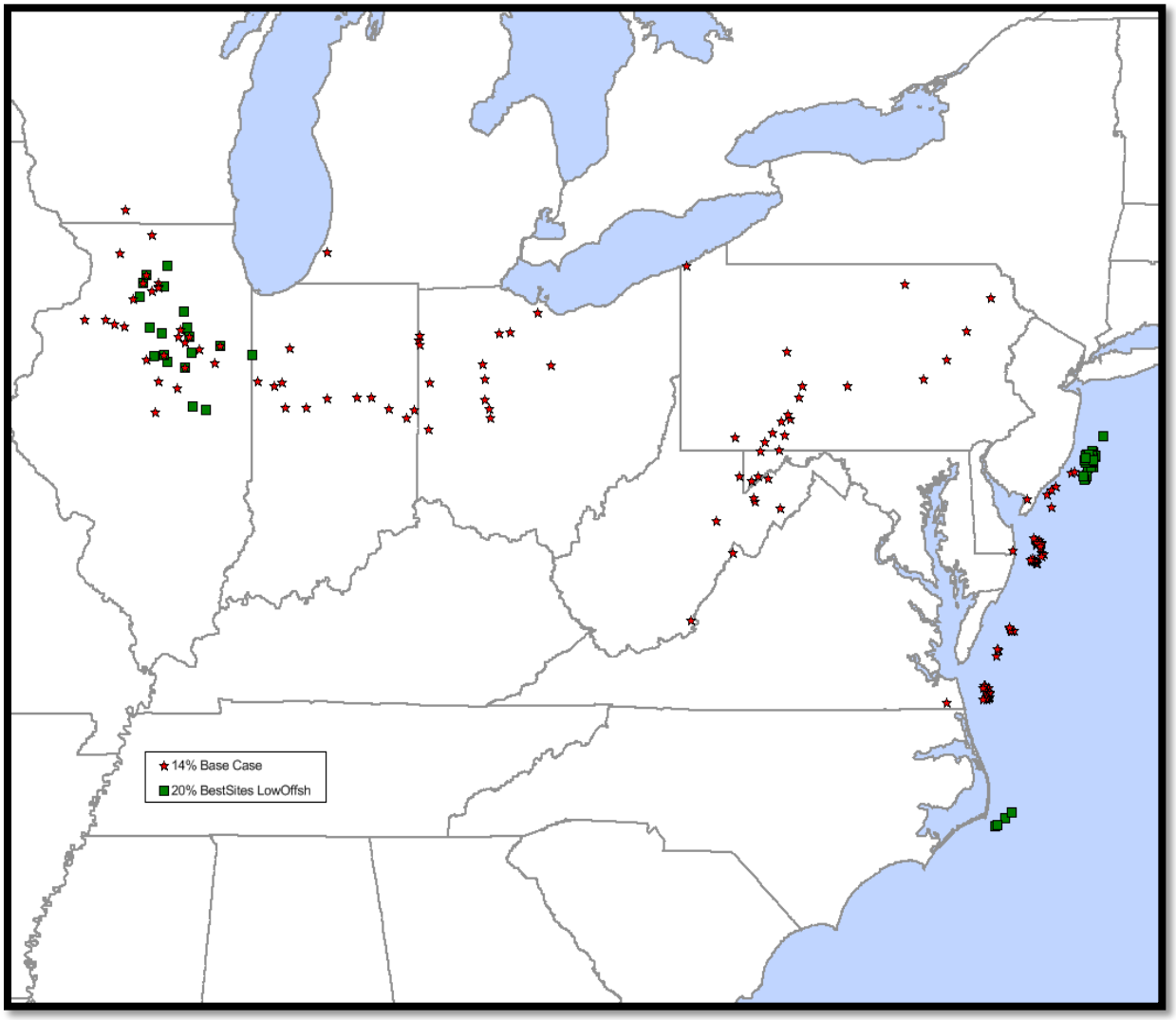
20% Low Offshore – Wind Summary

Best 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

20% Low Offshore – Wind Locations

Best Sites Onshore



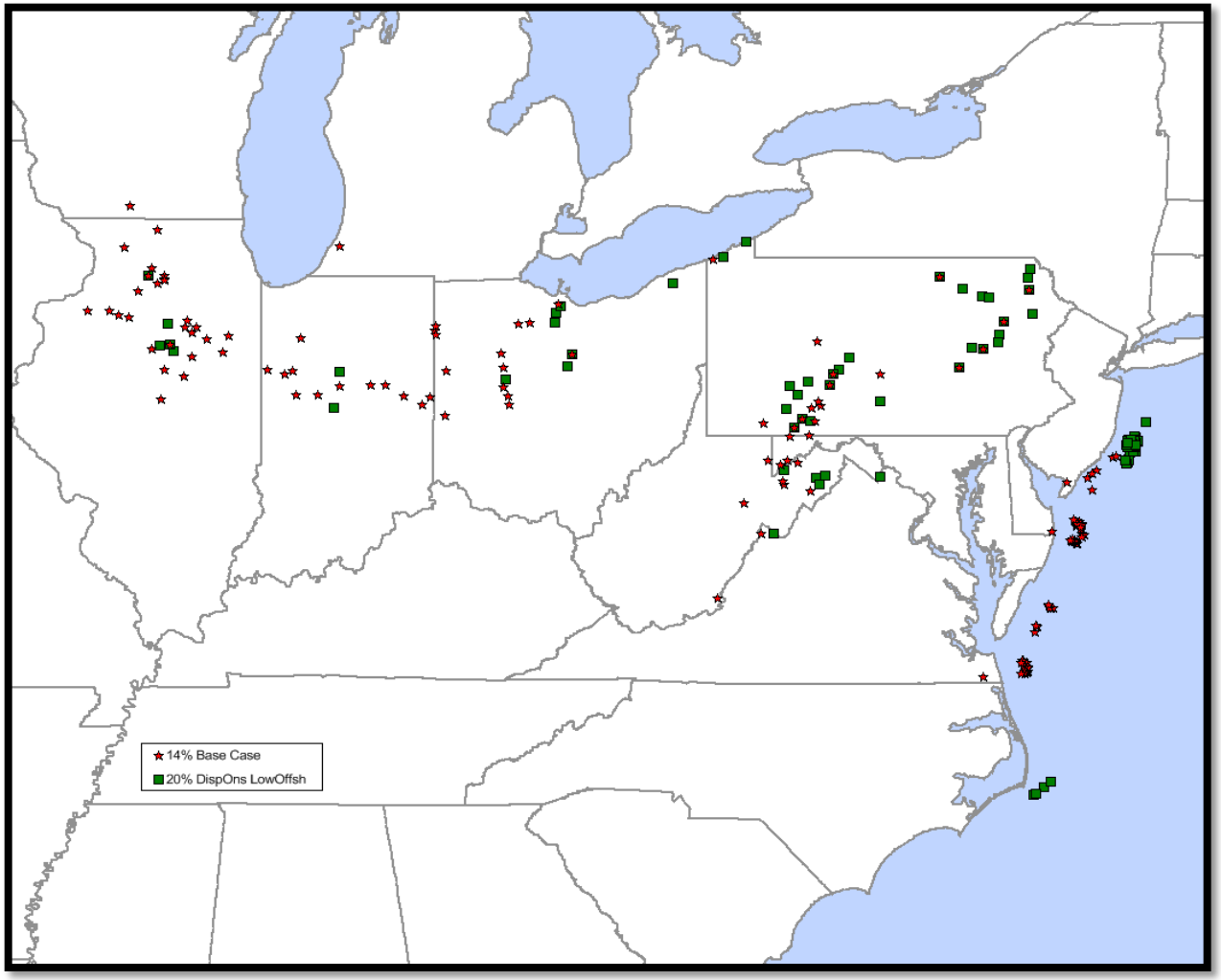
20% Low Offshore – Wind Summary

Dispersed 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

20% Low Offshore – Wind Locations

Dispersed Sites Onshore



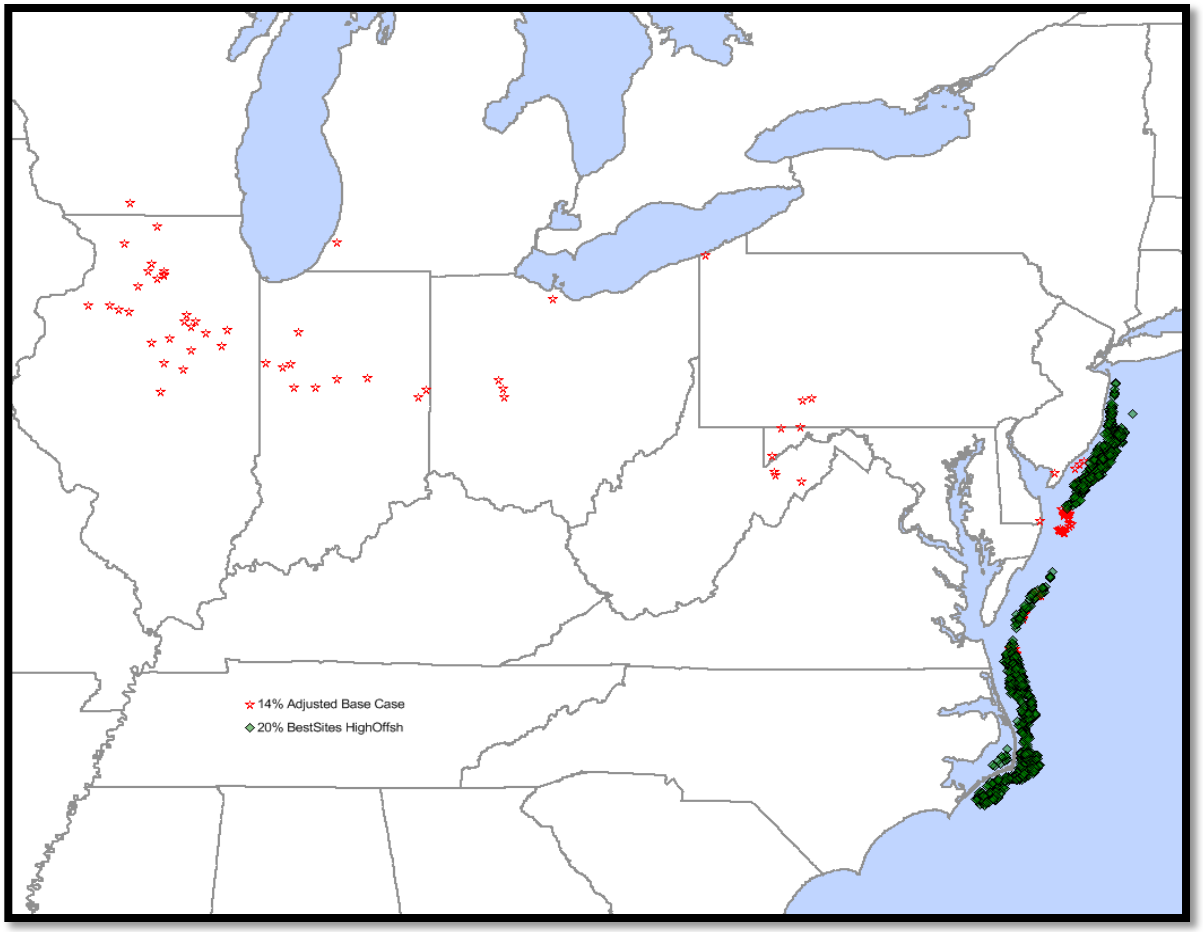
20% High Offshore – Wind Summary

Best 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

20% High Offshore – Wind Locations

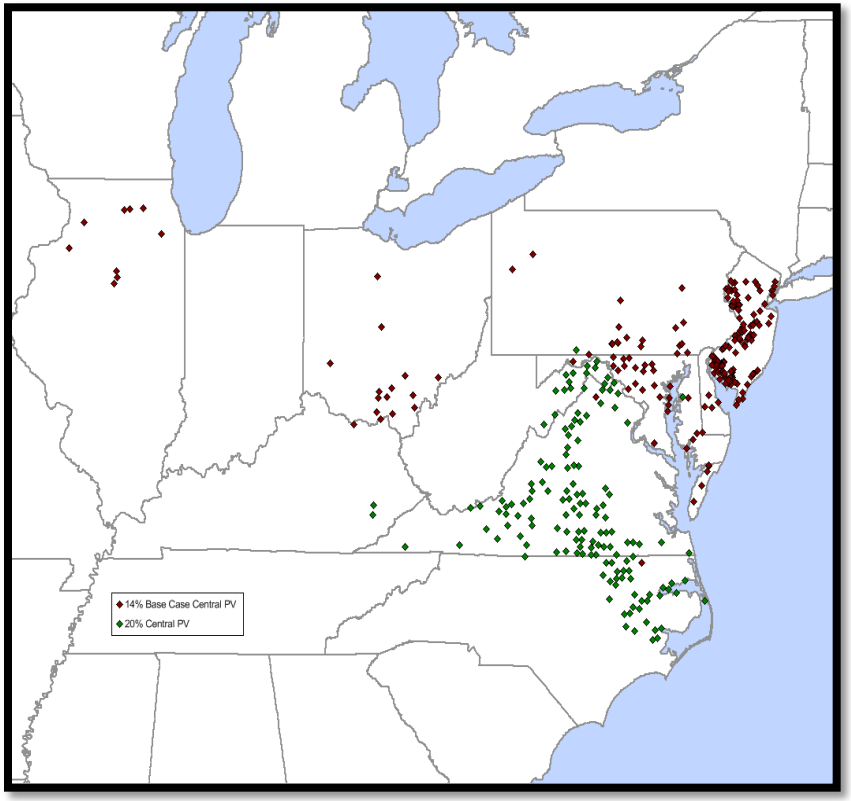
Best Sites Onshore



20% Low/High Offshore – Solar Summary

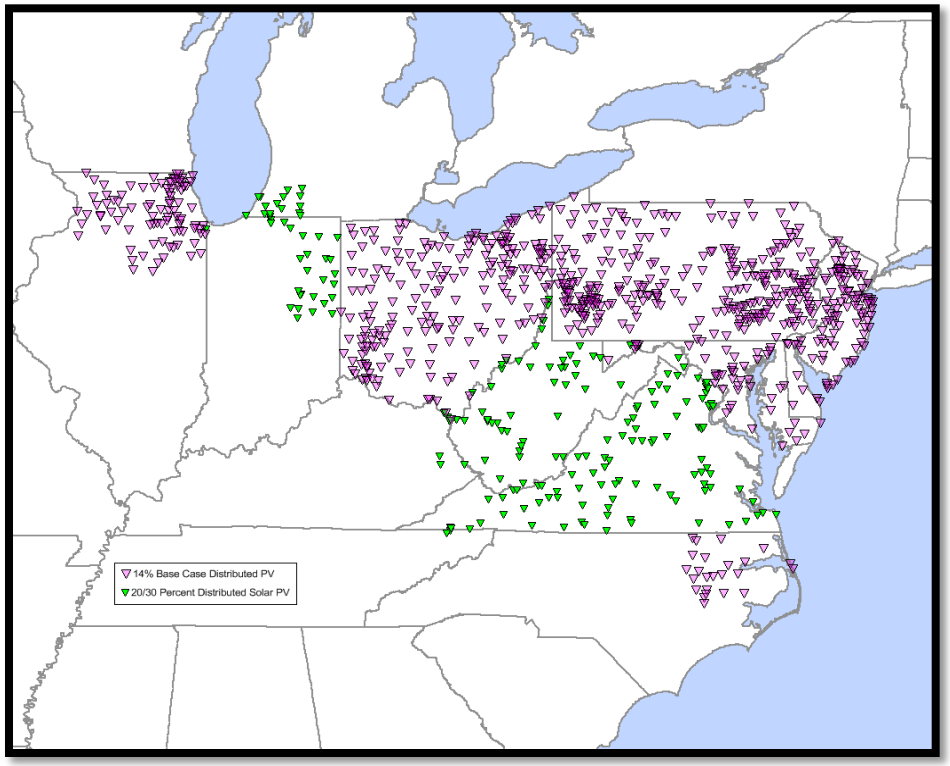
20% Low/High Offshore	Central PV						Distributed PV						Total PV		
	14% Base Case			Additional			14% Base Case			Additional			20% Low/High Offshore		
States	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF
Delaware	150	272	0.21	0	0	0.00	179	271	0.17	0	0	0.00	329	543	0.19
Illinois	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**

20% Low/High Offshore – Solar Locations



Central

Distributed



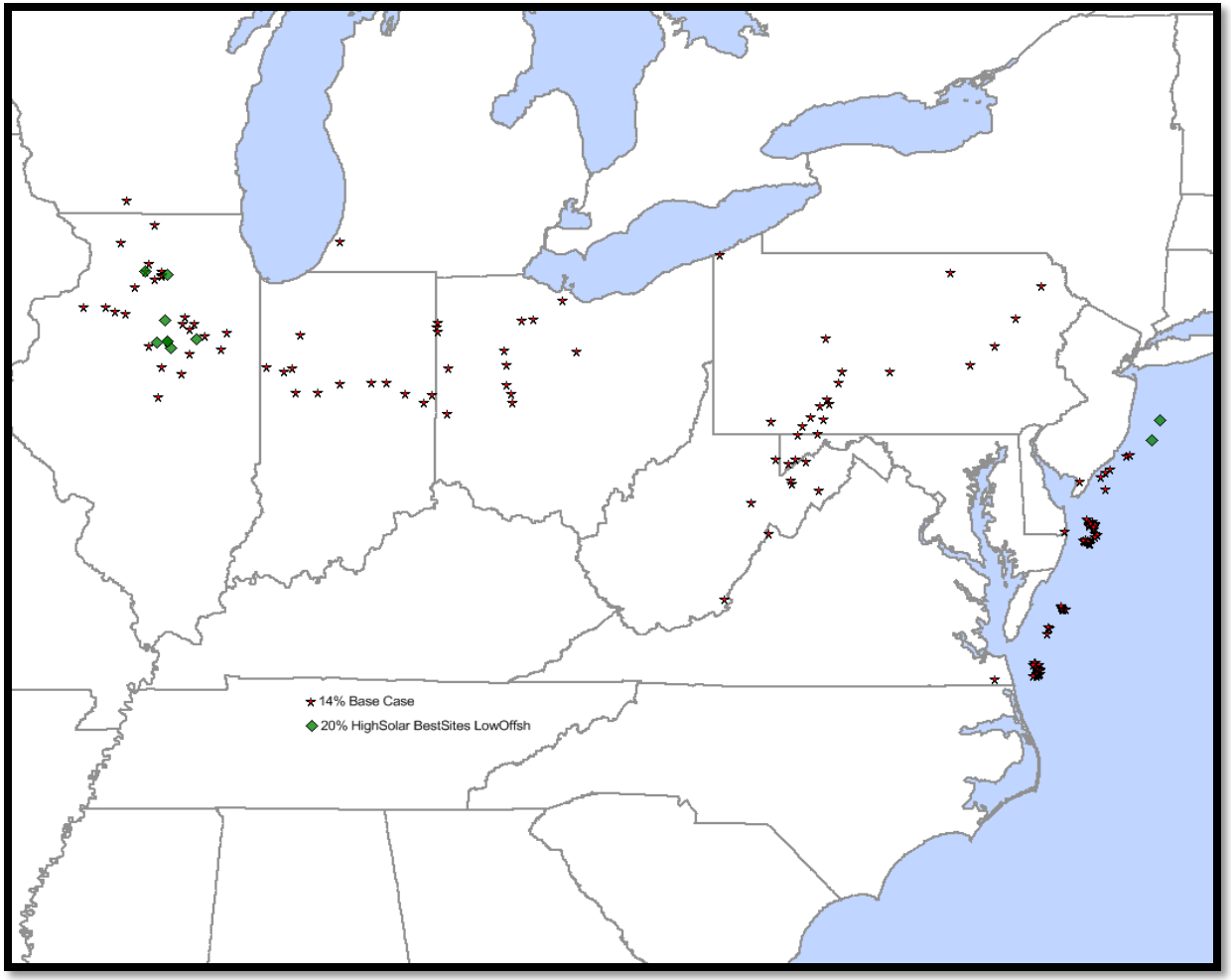
20% High Solar – Wind Summary

Best Sites Onshore

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

20% High Solar – Wind Locations

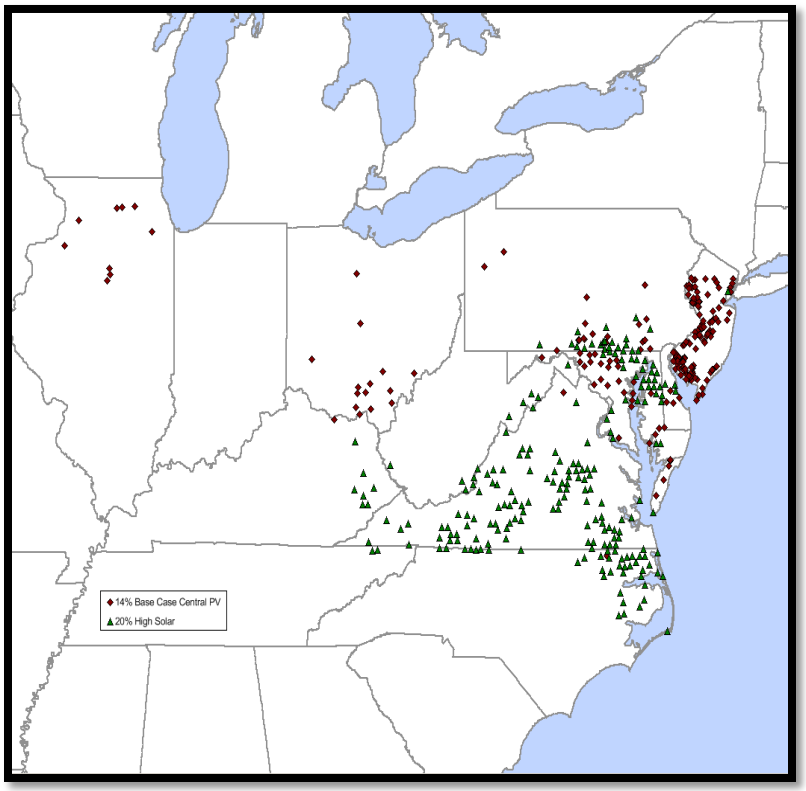
Best Sites Onshore



20% High Solar – Solar Summary

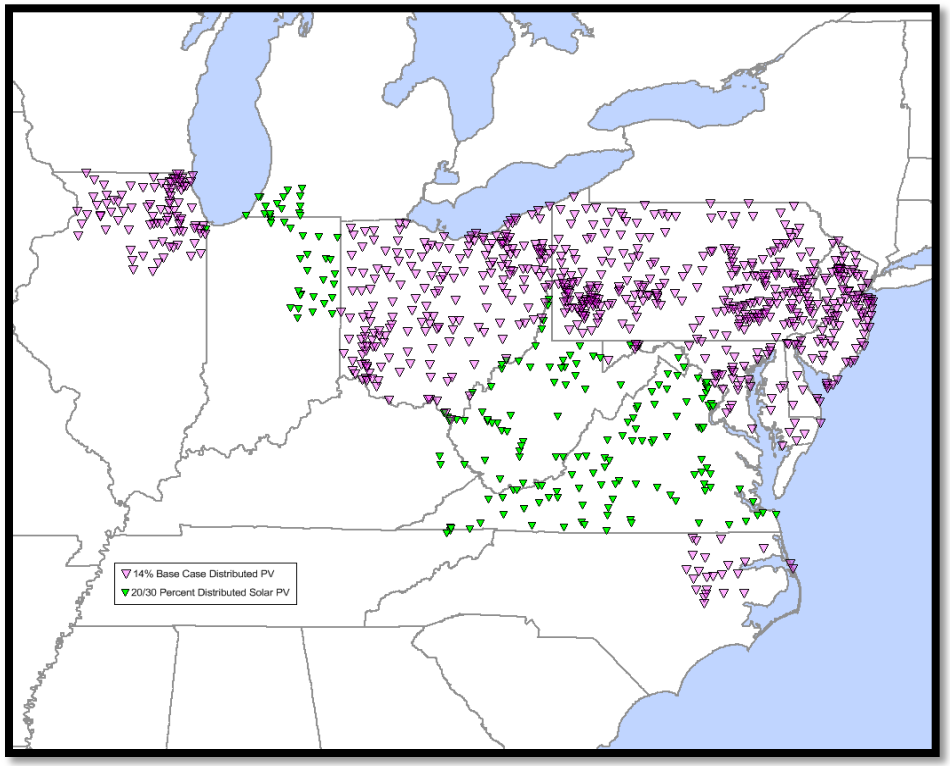
20% High Solar	Central PV						Distributed PV						Total PV		
	14% Base Case			Additional			14% Base Case			Additional			20% High Solar		
States	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF
Delaware	0	0	0.00	82	146	0.20	179	271	0.17	128	194	0.17	389	612	0.18
Illinois	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**

20% High Solar – Solar Locations



Central

Distributed



30% Scenarios

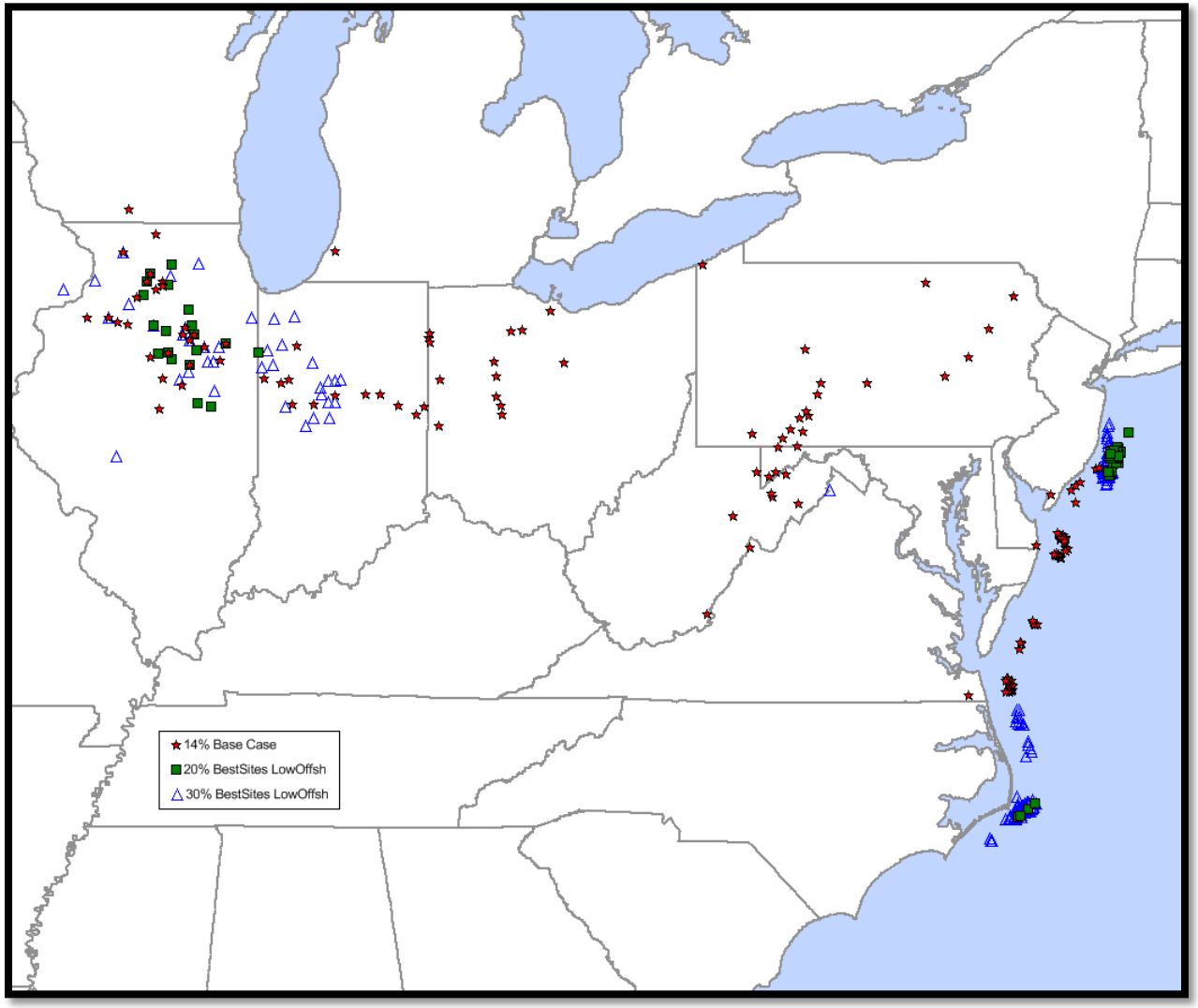
30% Low Offshore – Wind Summary

Best 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

30% Low Offshore – Wind Locations

Best Sites Onshore



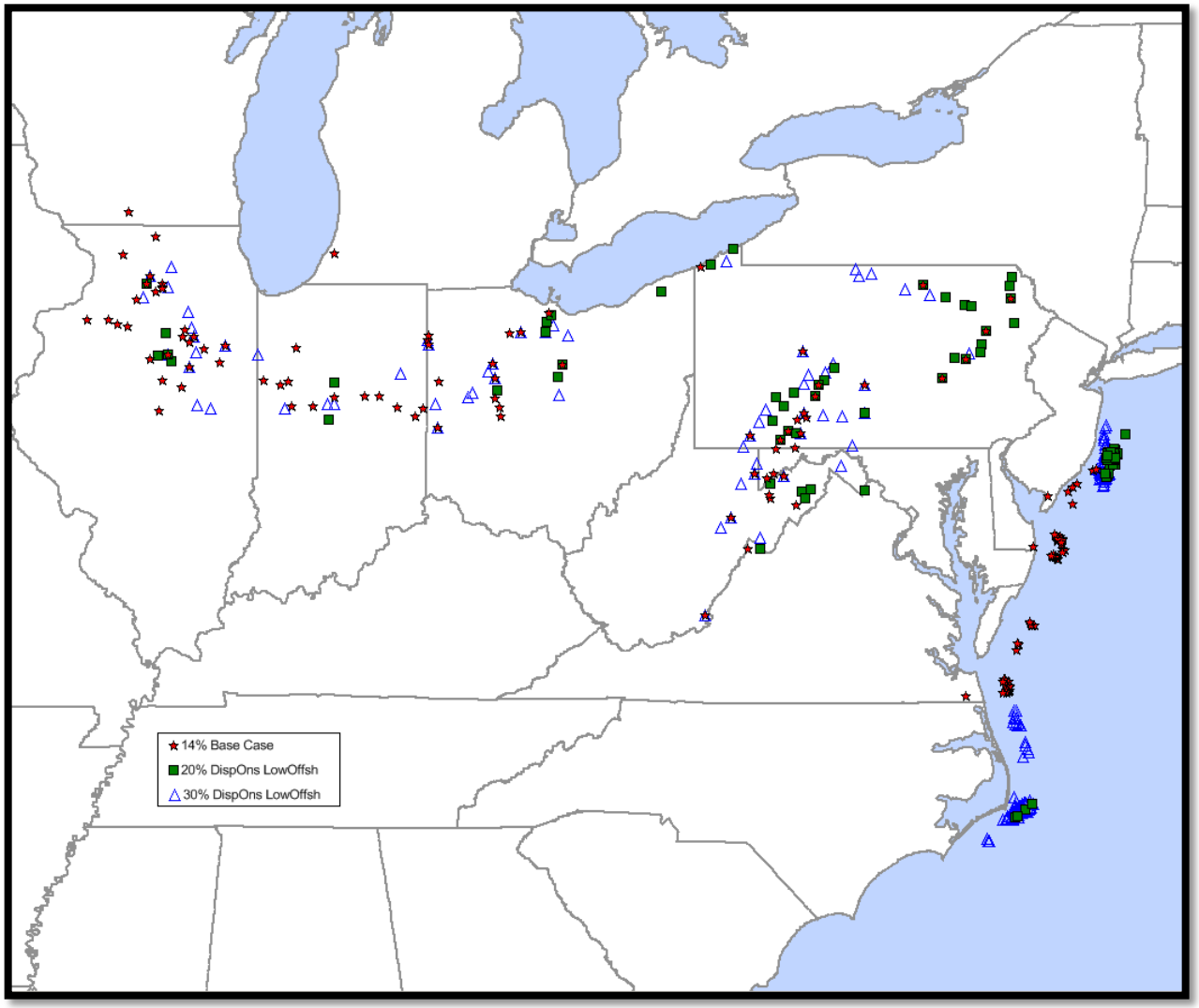
30% Low Offshore – Wind Summary

Dispersed 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

30% Low Offshore - Wind Locations

Dispersed Sites Onshore



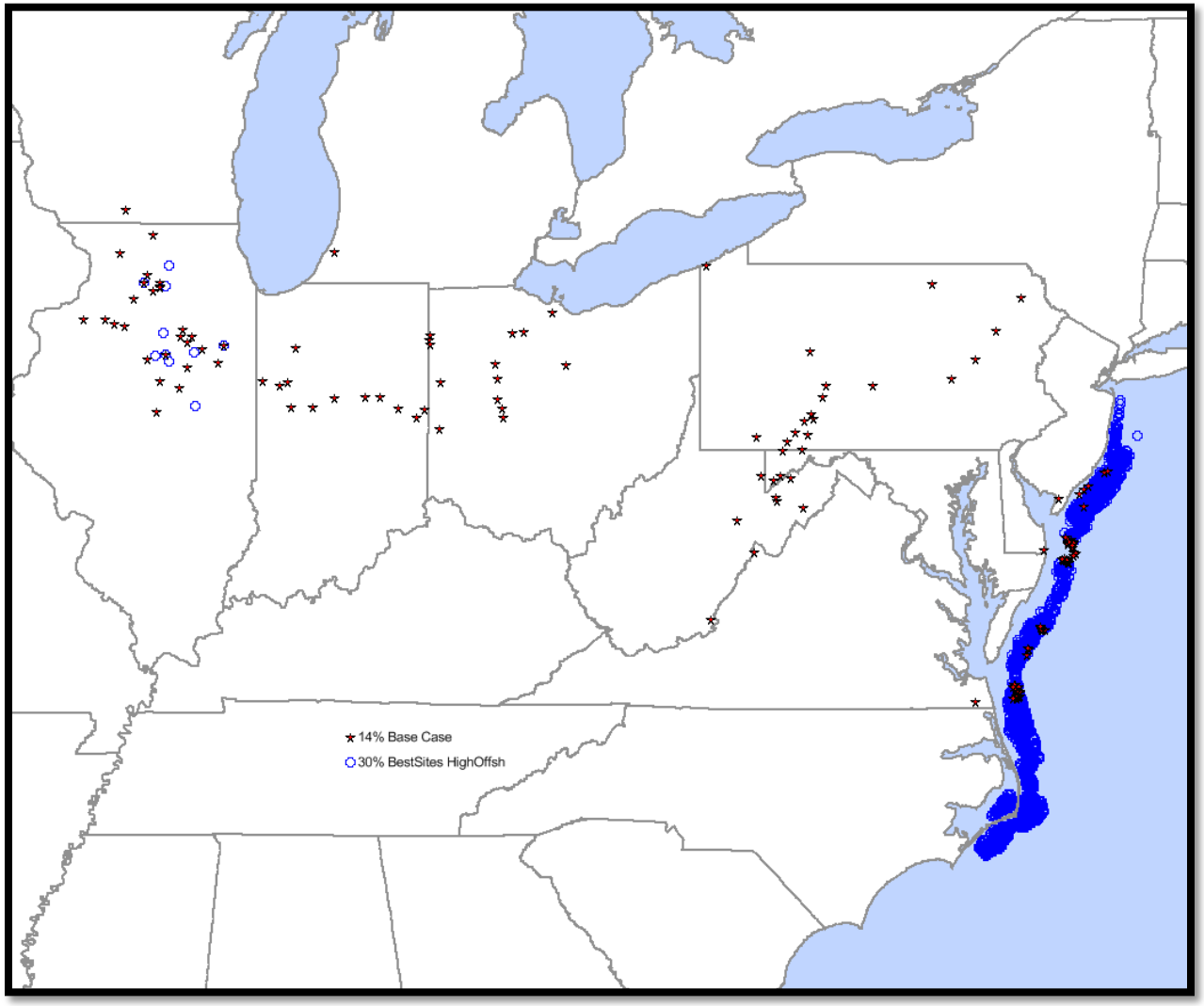
30% High Offshore – Wind Summary

Best 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

30% High Offshore – Wind Locations

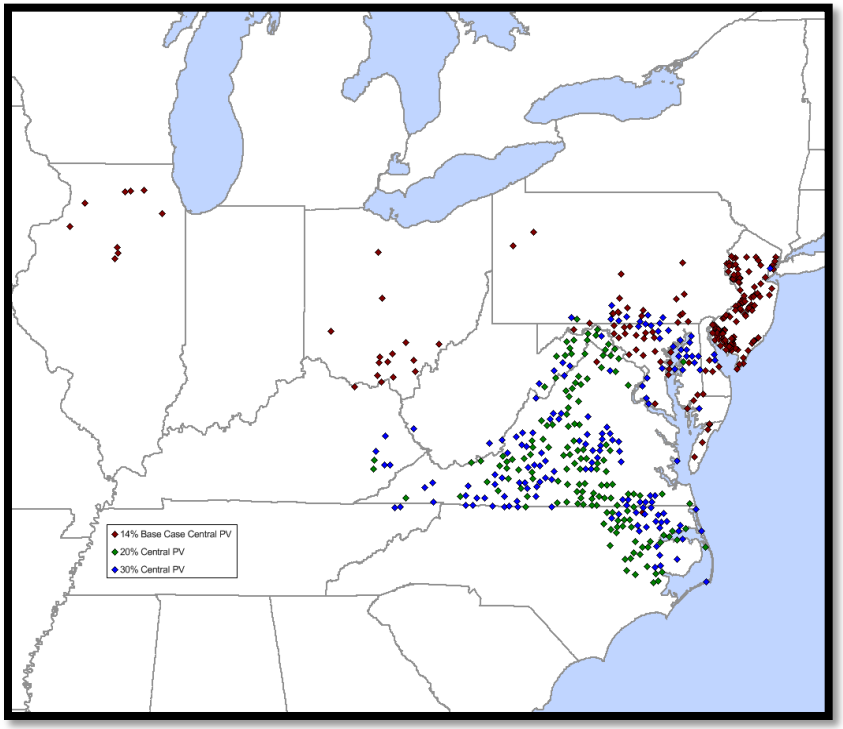
Best Sites Onshore



30% Low/High Offshore – Solar Summary

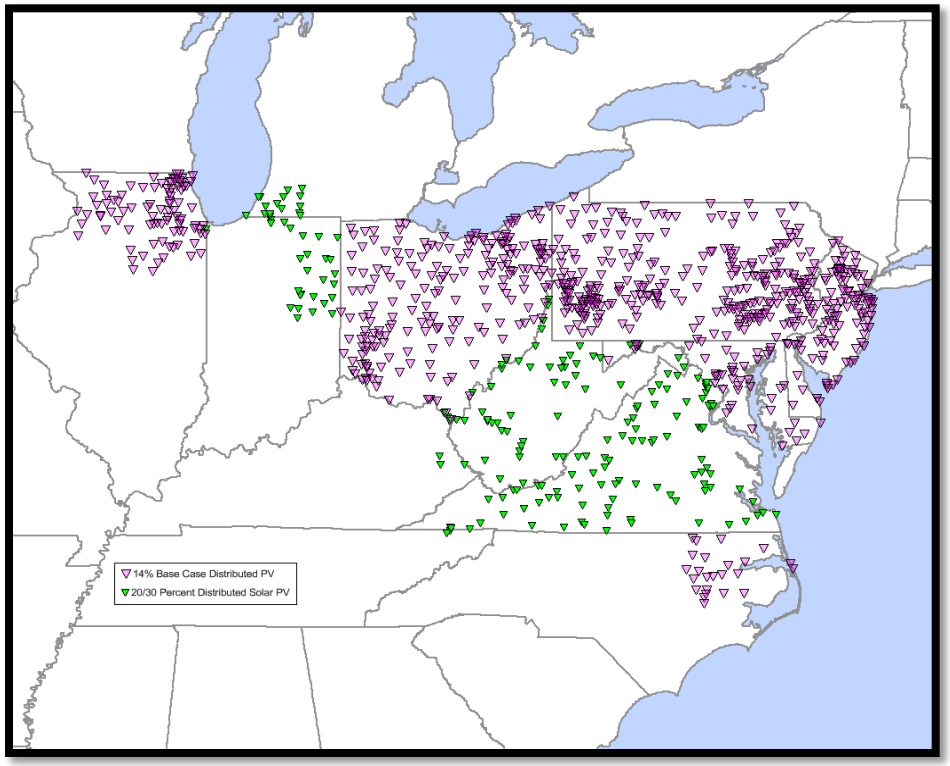
30% Low/High Offshore	Central PV						Distributed PV						Total PV		
	20% Low/High Offshore			Additional			20% Low/High Offshore			Additional			30% Low/High Offshore		
States	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF
Delaware	150	272	0.21	20	35	0.20	179	271	0.17	75	114	0.17	424	692	0.19
Illinois	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**

30% Low/High Offshore – Solar Locations



Central

Distributed



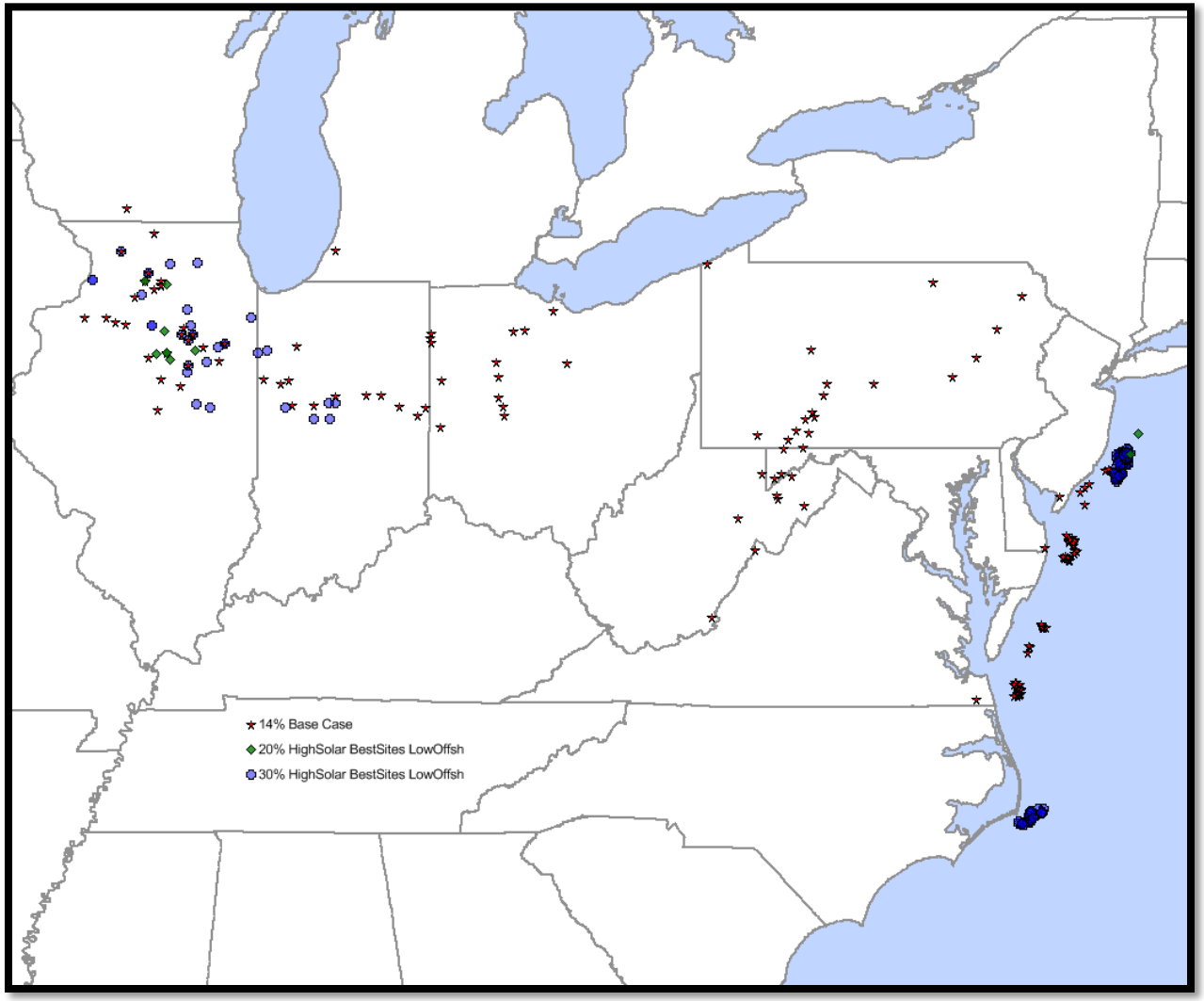
30% High Solar – Wind Summary

Best 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

30% High Solar – Wind Locations

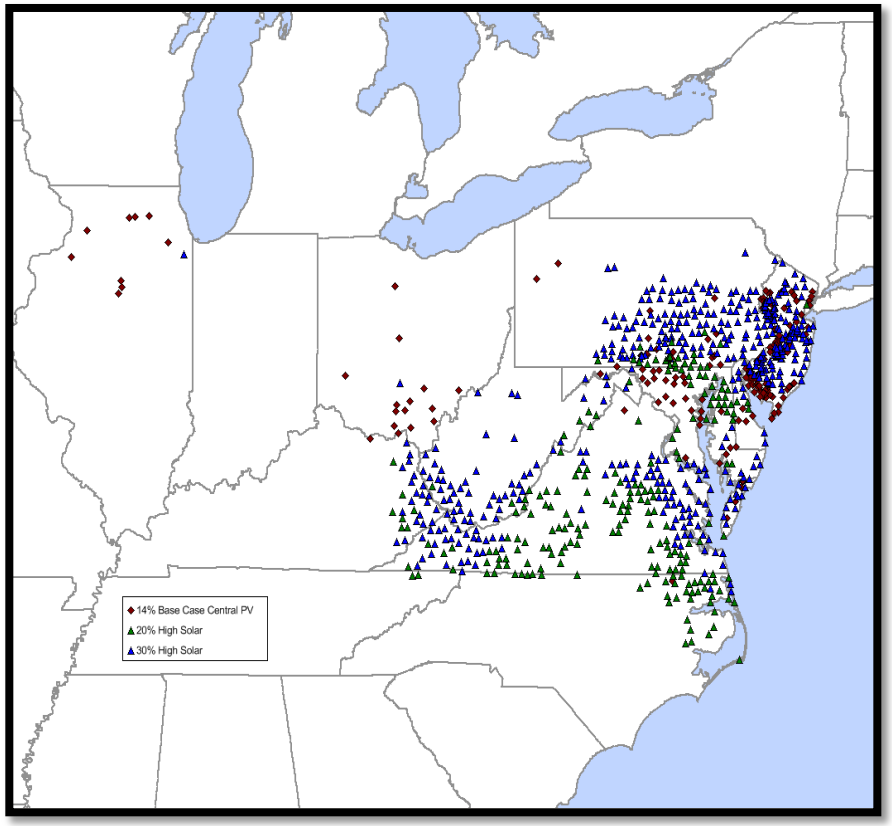
Best Sites Onshore



30% High Solar – Solar Summary

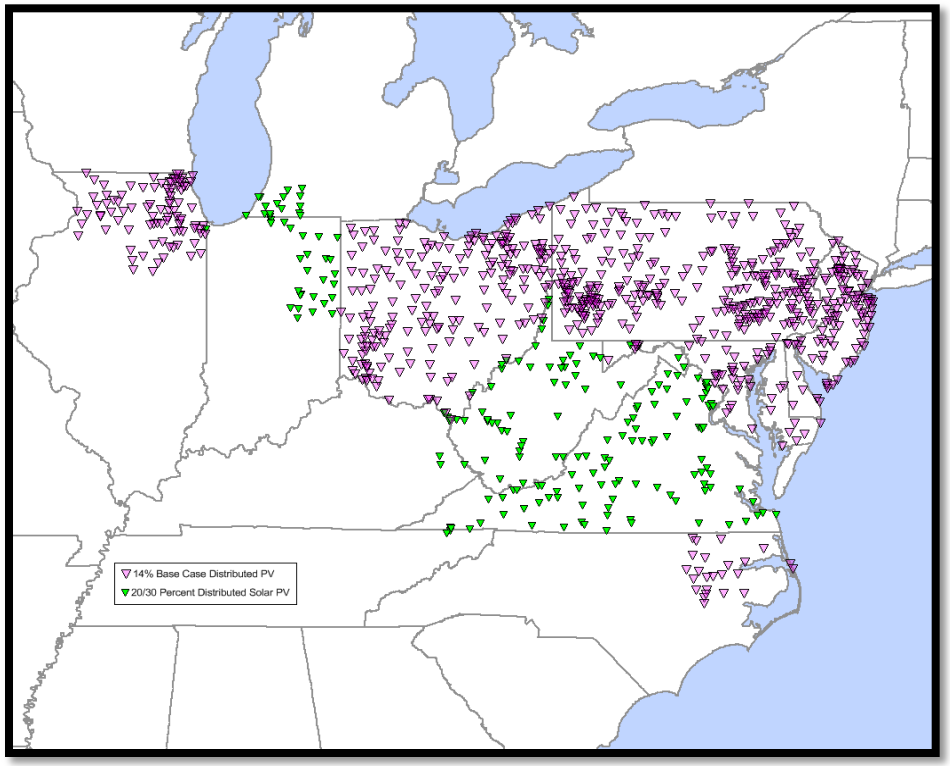
30% High Solar	Central PV						Distributed PV						Total PV		
	20% High Solar			Additional			20% High Solar			Additional			30% High Solar		
States	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF	MW (AC rating)	GWH	CF
Delaware	82	146	0.20	236	418	0.20	307	465	0.17	204	310	0.17	830	1,340	0.18
Illinois	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**

30% Low Offshore – Solar Locations



Central

Distributed



Renewable Penetration Rest of Eastern Interconnect

Renewable Energy Penetration in the rest of the Eastern Interconnection

- Rest of EI does not grow its overall renewable penetration as quickly as PJM
- Eastern Wind Integration and Transmission Study (EWITS) Scenario 2 (20% Hybrid with Offshore) used as guide to determine allocations to other NERC Regions

EWITS Executive Summary and Project Overview Table 1

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.*

PJM and EI Renewable Energy Penetration for Each Scenario

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%

Renewable Energy Penetration for the rest of the Eastern Interconnection

- Renewable Energy in the rest of the Eastern Interconnection was distributed according to EWITS Scenario 2
- Distribution Ratio (%) was calculated for each region from this table →

NERC Region
RE Distribution Ratio

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%**

Ratio Equation:

$$\frac{(\text{EWITS Scen2 NERC Region}_x\ \text{RE})}{(\text{EWITS Scen2 Total RE} - \text{EWITS Scen2 PJM RE})}$$