Socioeconomics and Land Use Issues

Generation Technologies and Socioeconomic Focus

Solar Photovoltaic – Generation Technologies and Agricultural Land Use

Siting utility-scale solar energy generating systems (SEGS) on agricultural land does not come without costs, and PPRP's role has been to weigh these costs against the benefits of renewable energy generation in its environmental reviews. Some of the issues PPRP has addressed are discussed below.

Loss of Prime Farmland

A recurring issue in the siting of SEGS on productive agricultural land is the loss of prime farmland. Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber and oilseed crops, and is also available for these uses (the land could be cropland, pastureland, rangeland, forest land or other land, but not urban built-up land or water). These soils are of the highest quality and can economically produce sustained high yields of crops when treated and managed according to acceptable farming methods.[1] Farmland is defined as prime where 50 percent or more of the soils in a map unit composition is prime. Farmland is of statewide importance where less than 50 percent of the components in the map unit is prime, but a combination of lands of prime or statewide importance is 50 percent or more of the map unit composition. Excluding federal land, urban land and water areas, about 23 percent of Maryland's soils are prime.[2] Counties with the highest amount of prime farmland are found either in the upper part of the Eastern Shore, including Kent, Caroline, Queen Anne's and Talbot counties, or along the Pennsylvania border, such as Washington, Carroll and Cecil counties. Counties with the least prime soils tend to be in Southern or Western Maryland and include Garrett, Allegany, Calvert and Charles counties.

Maryland places few restrictions on the siting of solar photovoltaic (PV) facilities on agricultural land. The state's primary policy instrument for conserving prime farmland is the Maryland Agricultural Land Preservation Foundation (MALPF), a unit within the Maryland Department of Agriculture (MDA). Created by the General Assembly in 1977, MALPF purchases agricultural preservation easements that forever restrict development on prime farmland and woodland. Through June 30, 2023, MALPF had purchased easements on a cumulative total of 2,654 properties, permanently preserving about 355,821 acres.[3] MALPF's policy on solar facilities is codified in COMAR 15.15.14, which explains the Foundation's criteria to approve an authorized renewable energy source (ARES) for commercial profit on a farm subject to an agricultural land

[1] U.S. Department of Agriculture. 1993. Soil Survey Manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. Soil Survey Division Staff. 1993.

[2] nrcs.usda.gov/wps/portal/nrcs/detail/md/technical/dma/nri/?cid=nrcs144p2_025681.

[3] Maryland Agricultural Land Preservation Foundation. Annual Report Fiscal Year 2023. https://mda.maryland.gov/malpf/SiteAssets/Pages/Reports/FY2023%20Annual%20Report.pdf Last accessed March 26, 2024.

preservation easement.[4] The Foundation may only accept applications to approve an ARES on a farm subject to an agricultural land preservation easement before June 30, 2018. The Foundation may not approve an ARES on a farm subject to an agricultural land preservation easement after June 30, 2019. No other regulations at the state level address development on prime farmland.

Property Value Impacts

As the economy transitions to clean, renewable energy, utility-scale solar projects are becoming a common feature of the landscape and, although ground-mounted solar facilities can occupy significant acreage, solar panels, racking and associated components have a vertical profile that rarely exceeds 12 feet. Still, concerns about alterations to views and other externalities lead to questions about changes to property values and reduced demand for residential properties near solar energy facilities.

Residential property value is dependent on many factors, including the size and amenities of the property itself, improvements made to the property, and the attributes of the surrounding neighborhood. Previous research has suggested that distance to "environmental disamenities" is a contributing factor in adversely affecting property value, although property value declines have been more consistently observed in residential properties that are near higher-risk disamenities (e.g., hazardous waste facilities) or facilities that lack adequate land or vegetation buffers.

Econometric Models and Property Value Impacts

In property value studies, econometric models estimate the marginal contribution of property attributes and neighborhood externalities to property values. Distance from a property to a disamenity is a neighborhood externality, one of the explanatory variables in what is known as a hedonic model. Econometric methods are used to estimate the relative contribution and statistical significance of the explanatory variables and the model as a whole to explain residential

Most research into property value impacts has derived its conclusions from appraisal studies or econometric techniques. Most appraisal studies use a comparison sales approach, which is largely dependent on the appraiser's expert judgment in locating and refining a set of comparable sales for analytical purposes. Although appraiser studies often use records of sales prices or assessments from a large number of properties, the analysis is usually confined to descriptive statistics from which only limited inferences can be made. Econometric models attempt to statistically account for factors that influence property values, such as lot size, structural attributes, neighborhood amenities, etc. Econometric studies are data-intensive and often combine data from several distinct sources such as tax rolls, real estate sales records and survey data.

Examples of appraisal studies from published literature include a past siting case in North Carolina for a 21-acre solar facility in an Agricultural-Residential district, which concluded that utility-scale PV energy systems that are not visible from surrounding properties would have no impact on their market values,[5] and a

[4] COMAR § 15.15.14.01.

[5] Franklin County 2014. Commissioner's Agenda Information Sheet. Item: Request for Special Use Permit – Sarah Solar, LLC, Parts 2 and 3. June 16, 2014.

paired comparison of market values of residential and agricultural properties near operating solar facilities in North Carolina that came to a similar conclusion.[6] While findings from the Franklin County study were based on expert opinion drawn from market valuations of a limited sample of properties near other types of industrial disamenities, the Kirkland study compared adjoining with non-adjoining residential sales prices at three comparable solar facilities in the state, as well as a survey of builders, developers and investors, which led it to conclude the project would have no impact on home values due to the adjacency and no impact to adjacent vacant residential or agricultural land. Neither has more recently published literature found a significant relationship between proximity to utility-scale solar facilities and nearby residential property values. This includes evidence gathered from a widely circulated independent survey of home appraisers from multiple states, including Maryland,[7] a study of utility-scale PV solar installations abutting residential land parcels in the seven-county Twin Cities Metro Area,[8] and a paired sales analysis of properties adjacent to operating solar projects in Indiana.[9] However, comparability with appraisal studies discussed above is unclear due to the geographic scope of potential effect (three miles), range of generating capacities (1 MW and above), non-recognition of visual encumbrances and absence of a proximity measure.

In contrast to these examples, one recent study using a hedonic price model on over 400,000 sales transactions within three miles of solar facilities in Massachusetts and Rhode Island estimated a 1.7% price decline of properties within one mile of operating solar facilities relative to those further away and substantially larger negative effects (a 7% price decline) for properties within 0.1 miles and properties surrounding solar sites built on farm and forest lands in non-rural areas.[10]

Another recent study examined over 1,500 large-scale PV projects (LSPVPs) and 1.8 million home transactions across six U.S. states that account for over 50% of the installed MW capacity of large-scale solar in the U.S. to determine what effect LSPVPs have on home prices and whether the effect changes based on a number of factors, including prior land use, LSPVP size, and the home's urbanicity. The study found that homes within 0.5 mi of an LSPVP experience an

---

[6] Letter from Richard C. Kirkland, Jr., Kirkland Appraisals, LLC to Mr. Louis Iannone, Strata Solar, July 24, 2014.

[7] Leila Al-Hamoodah, Kavita Koppa, Eugenie Schieve, D. Cale Reeves, Ben Hoen, Joachim Seel and Varun Rai. "An Exploration of Property-Value Impacts Near Utility-Scale Solar Installations." Policy Research Project, LBJ School of Public Affairs, The University of Texas at Austin. May 2018. emp.lbl.gov/sites/default/files/property-value_impacts_near_utility-scale_solar_installations.pdf, last accessed August 30, 2020.

[8] Benjamin Marin. "Solar Installations and Property Values: An Examination of Ground Mounted, Primary Land Use, Two Plus Megawatt Solar Installations on the Total Estimated Market Value of Abutting Residential Parcels." The Hubert H. Humphrey School of Public Affairs. The University of Minnesota. April 29, 2019. conservancy.umn.edu/bitstream/handle/11299/208704/Solar%20Installations%20and%20Property%20Values.pdf?sequence=1&isAllowed=y. Last accessed February 7, 2021.

[9] CohnReznick, LLP. "Property Value Impact Study: Proposed Solar Farm, McClean County, IL." August 7, 2018. mcleancountyil.gov/DocumentCenter/View/13192/Patricia-L-McGarr--Property-Value-Impact-Study?bidId=. Last accessed February 7, 2021.

[10] Vasundhara Gaur and Corey Lang. "Property Value Impacts of Commercial-Scale Solar Energy in Massachusetts and Rhode Island." Submitted to University of Rhode Island Cooperative Extension on September 29, 2020. https://web.uri.edu/coopext/valuingsiting-options-forcommercial-scale-solar-energy-in-rhode-island/

average home price reduction of 1.5% compared to homes two to four miles away. However, these effects were only measurable in certain states, for LSPVPs constructed on agricultural land, for larger LSPVPs, and for rural homes.[11]

There is little direct evidence from Maryland licensing cases supporting or rejecting the property value impact argument. In support of two applications to build solar PV facilities in Frederick County,[12,13] a real estate appraisal study was commissioned by the project developer to investigate the potential impact of the project on neighboring property values using paired sales analysis of properties within and outside a half-mile radius of selected operational solar facilities in Maryland.[14] Although the methodology and limited sample size do not allow one to draw a statistical inference from the data, the study concluded the values of properties in proximity to solar facilities are not impacted by the presence of the solar facilities. Still, as evidenced in the Biggs Ford Solar case, where the applicant's study concluded that the project was not expected to impact adjacent property values and one commissioned by an adjacent property owner predicted a negative impact,[15] appraisal studies are not without bias.[16]

Statistical evidence in Maryland is thin because few projects granted a CPCN by the PSC are operational (see Table 1). Since the first CPCN for a utility-scale PV project was issued (Maryland Solar), only 17 projects, totaling 262.6 MW, are online. From a sample of 10 online utility-scale solar facilities depicted in Table 2, PPRP estimates 3,776 occupied residential parcels are within one mile of the project parcels containing these facilities, and 1,173 are within one-half mile. On a project-by-project basis, only areas within one mile of three project parcels have seen enough residential sales to statistically analyze with any degree of confidence. This is because most projects have been sited on rural land with few nearby residential parcels. Furthermore, one of the three, Maryland Solar, is located on the grounds of the Maryland Correctional Institution – Hagerstown that has likely had its influence on surrounding property values, which cannot be readily distinguished from the solar facility.

---

11 Elmallah et al. 2023. Shedding light on large-scale solar impacts: An analysis of property values and proximity to photovoltaics across six U.S. states. Salma Elmallah, Ben Hoen, K. Sydny Fujita, Dana Robson, Eric Brunner. Energy Policy. 113425. ISSN 0301-4215. Published Online March 2, 2023. https://www.sciencedirect.com/science/article/pii/S0301421523000101. 3

12 Maryland Public Service Commission, Case No. 9429. In the matter of the application of LeGore Bridge Solar Center LLC for a Certificate of Public Convenience and Necessity to construct a 20.0 MW solar photovoltaic generating facility in Frederick County, Maryland.

13 Maryland Public Service Commission, Case No. 9439. In the matter of the application of Biggs Ford Solar Center, LLC for a Certificate of Public Convenience and Necessity to construct a 15.0 MW solar photovoltaic generating facility in Frederick County, Maryland.

14 Treffer Appraisal Group. "An External Obsolescence Study Related to Proposed Solar Farms in Frederick County, Maryland." Prepared for Coronal Development Services. January 18, 2016.

15 Six & Associates Inc. Letter to Jack Stern, Walkersville MD. January 22, 2016. Maryland Public Service Commission Case No. 9439, ML 226957.

16 In that case, the Public Utility Law Judge (PULJ) found that both the applicant's appraisal and the appraisal submitted by the property owner had deficiencies, and contained no evidence to support the claim that property values would be impacted. Maryland Public Service Commission Case No. 9439, Phase II. Proposed Order of Public Utility Law Judge. Issued August 27, 2020.

Table 1 Operational Solar Facilities in Maryland (as of April 2023)

Name	PJM GATS Name	County	Limit of Disturbance (Acres)	PSC Case No.	Filing Date	GATS Nameplate Capacity (MW)	Date Online
Maryland Solar	AP MARLOWE 1 SP	Washington	270	9272	5/26/2011	29.1	11/1/2012
Cambridge Solar	DPL BUCKTOWN 1 SP	Dorchester	25	9348	4/1/2014	4.3	5/1/2015
Rockfish Solar	Rockfish Solar, LLC	Charles	82.5	9351	3/16/2014	13.1	6/1/2015
LS-Egret Solar	DPL HEBRON 1 SP	Wicomico	108	9366	10/20/2014	17.8	2/1/2016
Church Hill Solar	DPL CHURCH HILL 1 SP	Queen Anne's	42	9314	1/23/2013	7.3	5/1/2016
Wye Mills Solar	DPL WYE MILLS 1 SP	Queen Anne's	95	9375	2/2/2015	13.7	8/1/2016
Great Bay Solar I	DPL GREAT BAY KINGS CREEK 1 SP	Somerset	562	9380	5/11/2015	99.9	9/1/2017
Great Bay Solar II	DPL GREAT BAY KINGS CREEK 2 SP	Somerset	167.13	9380	5/11/2015	43.0	6/1/2020
Baker Point Solar	AP BAKER POINT 1 SP	Frederick	56	9399	10/8/2015	10.9	10/1/2017
Gateway Solar	DPL WORCESTER NORTH 1 SP & SOUTH SP	Worcester	120	9409	12/1/2015	10.0	3/1/2019
Blue Star Solar	OneEnergy Bluestar Solar, LLC Parcel #2 & #3	Kent	45	9387	7/10/2015	7.8	1/1/2020
Pinesburg Solar	AP PINESBURG 1 SP	Washington	55	9395	9/4/2015	5.8	5/1/2020
Todd Solar	DPL DORCHESTER COUNTY 1 SP	Dorchester	143	9412	7/28/2016	29	4/8/2021
Sol Phoenix Solar	PEP ROLLINS AVENUE 3 SP	Prince George's	12	9446	11/9/2017	3.1	12/23/2019
MD Solar 2	PEP MILLS GROVE 1 SP	Charles	215	9463	11/21/2018	34.8	3/28/2023
Bluegrass Solar	DPL PONDTOWN 1 SP DPL PONDTOWN 2 SP	Queen Anne's	528	9496	10/29/2019	101.5	5/17/2023
Citizens UB Solar	AP UNION BRIDGE 1 SP	Carroll	34	9483	4/27/2020	10.7	4/21/2022

Source: PJM Environmental Information Services. Generation Attribute Tracking System (GATS). Renewable Generators Registered in GATS.

Table 2 Residential Parcels in Proximity to Operational Solar Facilities

Name	County	Date Online	Res. Parcels < 1 mi	Res. Parcels < 0.5 mi	Post Online Res. Sales < 1 mi.	Post Online Res. Sales < .5 mi.	% Res. Sales < .5 mi.
Maryland Solar	Washington	11/1/2012	1,040	339	325	64	19.7%
Cambridge Solar	Dorchester	5/1/2015	23	11	2	1	50.0%
Rockfish Solar	Charles	6/1/2015	1,445	311	399	71	17.8%
LS-Egret Solar	Wicomico	2/1/2016	600	170	99	23	23.2%
Church Hill Solar	Queen Anne's	5/1/2016	107	3	21	1	4.8%
Wye Mills Solar	Queen Anne's	8/1/2016	53	2	6	0	0.0%
Great Bay Solar I	Somerset	9/1/2017	212	83	14	5	35.7%
Baker Point Solar	Frederick	10/1/2017	106	63	10	4	40.0%
Gateway Solar	Worcester	3/1/2019	61	23	2	2	100.0%
Blue Star Solar	Kent	1/1/2020	61	52	2	1	50.0%
Pinesburg Solar	Washington	5/1/2020	199	156	2	1	50.0%

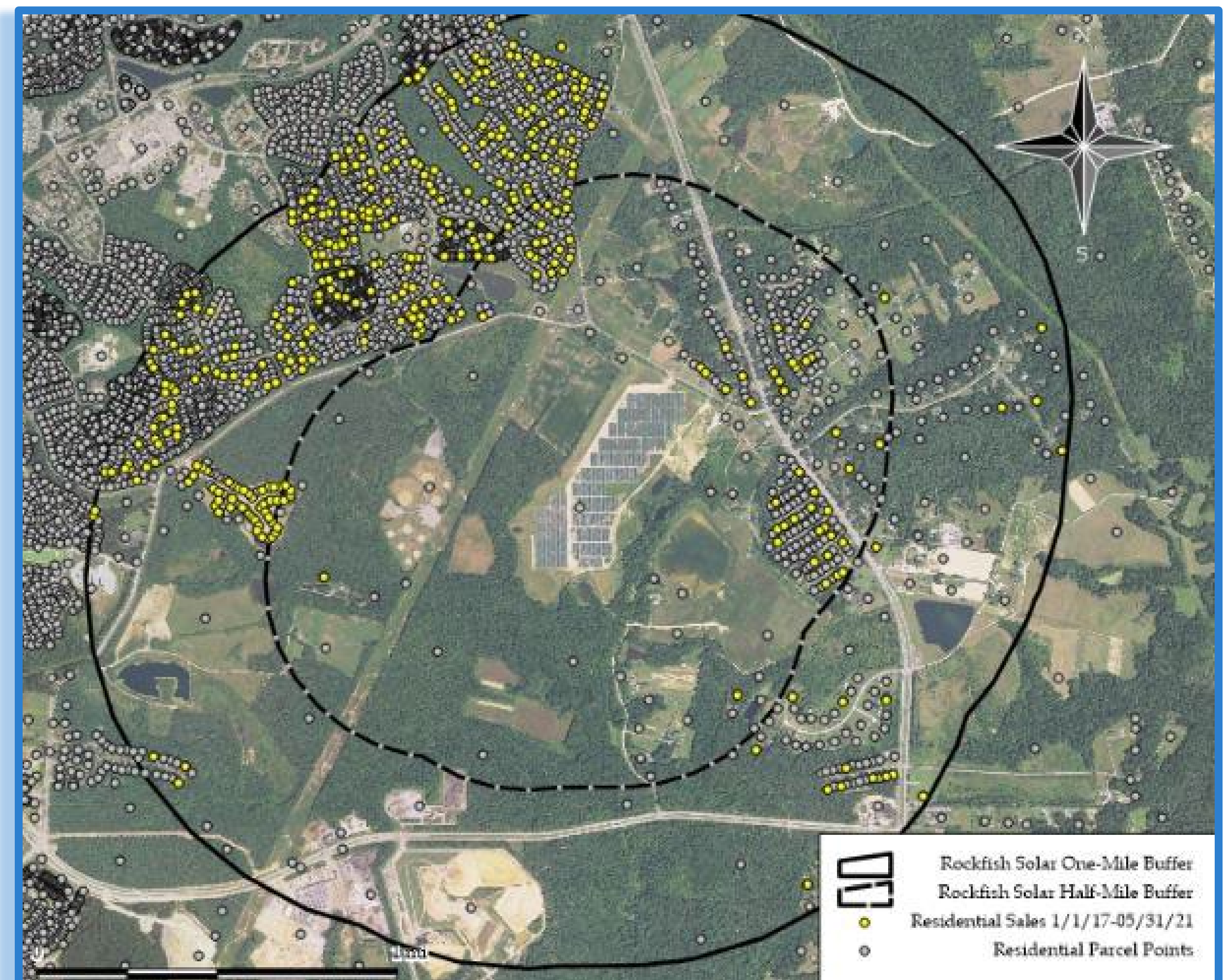
Source: Maryland Department of Planning, Sales Data, January 1, 2017 – May 31, 2021.

To date, PPRP's analysis of the Rockfish Solar facility in Charles County has yielded the most information on property value impacts. The facility, which came online in June 2015, is located off Renner Road, approximately 2.3 miles southeast of the communities of St. Charles and Waldorf, on nearly 90 acres of a 165-acre parcel formerly cultivated for agricultural use after being reclaimed from a sand and gravel surface mine. The site is generally flat land with minimal topographical variation. Land use near the facility is within a Rural Residential district, a designation intended to allow for rural development at one unit per three acres while preserving the rural character and open space whenever possible. Other surrounding land uses are Residential (St. Charles), Employment & Industrial Park and Rural Conservation Districts.

Views toward the project are limited because there are few adjacent residential properties and solar arrays have a minimal vertical profile. Homes in the St. Charles planned unit development north of Piney Church Road (west of the facility) are separated by distance and forest, as are homes in the Cedar Pines and Broadview Farm subdivisions to the south. A transmission corridor and mature woodland buffer views toward the project from playing fields within the nearby Robert D. Stethem Memorial Complex. The only "near" views are from a small number of residences along Renner Road opposite the property and from Renner Road itself. PPRP conditioned the project on a landscaping plan in substantial conformance with Charles County's buffering requirements for large solar energy systems. It also required a setback greater than Charles County's minimum 50-foot setback from any property line due to the planned future widening of Renner Road. Solar panels are about 150 feet from Renner Road at their closest point, and views are mitigated by a 50-foot landscaped buffer of trees and shrubs that appears to be largely effective.

According to MD Property View residential sales data, between January 1, 2017 and May 31, 2021, 399 residential properties within one mile of the project parcel, or 27.6 percent of all residential parcels within a mile, changed hands in arms-length transactions. Within half a mile, 71 arms-length residential sales were recorded. The average sale price for all transactions within one mile was $306,145, and $316,779 within one-half mile (see Figure 1). While the sale price difference does not take property attributes into account, it suggests proximity to the solar facility may not have been a major factor in homebuyer decision-making, which could be attributable to visual mitigation from mature woodlands surrounding much of the project and effective landscaping along the northern edge of the parcel.

Figure 1 Residential Parcel Sales Near Rockfish Solar Facility



Source: Maryland Department of Planning.

Transmission Lines

Proximity to high-voltage transmission lines has been associated with changes in property values due to visual intrusion and perceived risk. Most evidence, however, has been based on impacts upon residential properties in urban and suburban settings. There have been relatively few studies that address the impact on rural land used for agricultural or recreational purposes.[17,18]

Most studies have, however, shown little to no effect on sales price from transmission lines, beyond the loss associated with ROW acreage. A regression analysis on sales of farm land in the Canadian province of Saskatchewan between 1965 and 1970, for example, found that the relationship of land value to the number of power line structures was not statistically significant and that the lines did not negatively affect property value.[19] In another study, a hedonic price model of sales data from several hundred rural land transactions in Wisconsin found a small difference (< 2.5 percent) in sales prices of online and offline properties, but the difference was not statistically significant. An analysis of transactions involving agricultural properties in Montana found that on productive agricultural lands (cropland and range lands), there was no evidence supporting a transmission line effect on the sales price.

Some exceptions do exist in the literature.[20] A sales comparison study of farmland in Minnesota found price effects ranging from zero to 20 percent where transmission lines were highly intrusive on farm operations, although the latter finding was from a single appraiser study.[21] Another study of transactions involving agricultural land in rural Alberta found a decrease in property values on parcels with irrigation potential hosting multiple transmission lines. In general, however, the findings of the most recent research suggest that a transmission line crossing an agricultural parcel has either no effect or an effect in the range of several percentage points that is not statistically significant.

County Ordinances

While CPCNs are required for generating stations over 2 MW, generating stations under 2 MW are subject to county ordinance and permitting. With the increase in renewable energy projects in Maryland, particularly solar and wind, many counties have established ordinances pertaining to the approval and siting of generation. Although the PSC has the regulatory authority to approve

---

17 Thomas Jackson. "Electric Transmission Lines: Is There an Impact on Rural Land Values?" Right of Way. November/December 2010.

18 Thomas Priestley. "Transmission Lines and Property Values: Briefing Paper." Prepared for Clean Line Energy Partners LLC. CH2MHill. Houston, Texas. April 2015.

19 D.J.A. Brown. "The effect of power line structures and easements on farm land values." Right of Way. December/January 1975-1976.

20 Julia Haggerty. "Transmission Lines and Property Value Impacts: A Review of Published Research on Property Value Impacts from High Voltage Transmission Lines." Produced for Mountain States Transmission Intertie (MSTI) Review Project by Headwaters Economics. July 2012.

21 C.A. Kroll and T. Priestley. "The Effects of Overhead Transmission Lines on Property Values." Report to Edison Electric Institute Siting & Environmental Planning Task Force. 1992.

electric generating stations above 2 MW, it takes into consideration a county's ordinances, if applicable, and concerns when reviewing an application for a CPCN.

Ordinances related to renewable energy can be found within a county's zoning documents. The level of detail and extent of ordinances vary based upon the county, with some counties adopting ordinances specific to certain renewable energy technologies, such as wind or solar. In 2017 and 2018, some counties issued moratoriums on the siting of renewable energy projects while they reevaluated or established ordinances related to renewable energy. As of 2021, all county moratoriums had expired. Some of the ordinances currently in effect include:

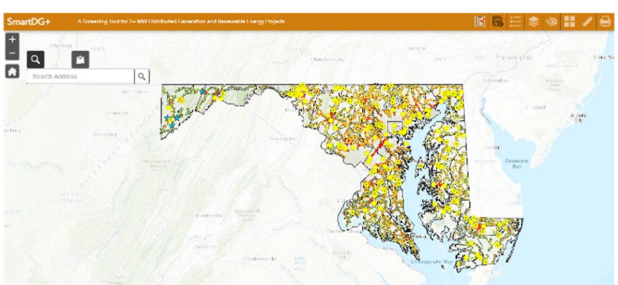
- Limit on the number of acres that can be utilized by commercial solar systems;
- Maximum capacity per renewable energy project;
- Height restrictions on wind turbines;
- Limitations on which zoning areas renewable energy projects may be sited within; and
- Bans on certain renewable energy projects (e.g., Charles County zoning prohibits large-scale wind energy projects with turbines and towers exceeding 150 feet in total height).

To ensure that a renewable energy project does not negatively impact existing operations, such as radar, a county may include a zoning provision requiring approval from multiple county agencies and/or an entity besides the county. For example, St. Mary's County requires wind and solar developers to receive permission from the U.S. Department of the Navy for projects they wish to site within a certain area around Naval

SmartDG+

MEA and PPRP developed a free, online, map-based screening tool, SmartDG+, to assist developers and officials in identifying areas to locate new wind and solar projects. The tool maps 1- to 4-mile-wide corridors surrounding electric distribution and transmission lines that are likely able to handle renewable energy projects that are 2 MW or higher. Users can choose from the following screen factors/data layers to find potential project siting areas:

- Infrastructure Proximity
    - Electricity lines
    - Gas lines
- Renewable Resource Availability
    - Viable wind speeds
- Land Suitability
    - Protected areas
    - Flood zones
    - Land cover/land use
    - Airports
    - DOD no-go zones
    - County zoning
- Installed wind and solar projects



Source: dnr.maryland.gov/pprp/Pages/SmartDG.aspx

Air Station Patuxent River to prevent radar interference. A comprehensive list of county ordinances is provided as part of the SmartDG+ tool, located on the PPRP website. The SmartDG+ tool and accompanying resources are designed to guide developers as they begin the process; however, developers should contact county planning/zoning offices when planning their project to ensure that a site meets county ordinance requirements.

Renewable Technology Supply Chains

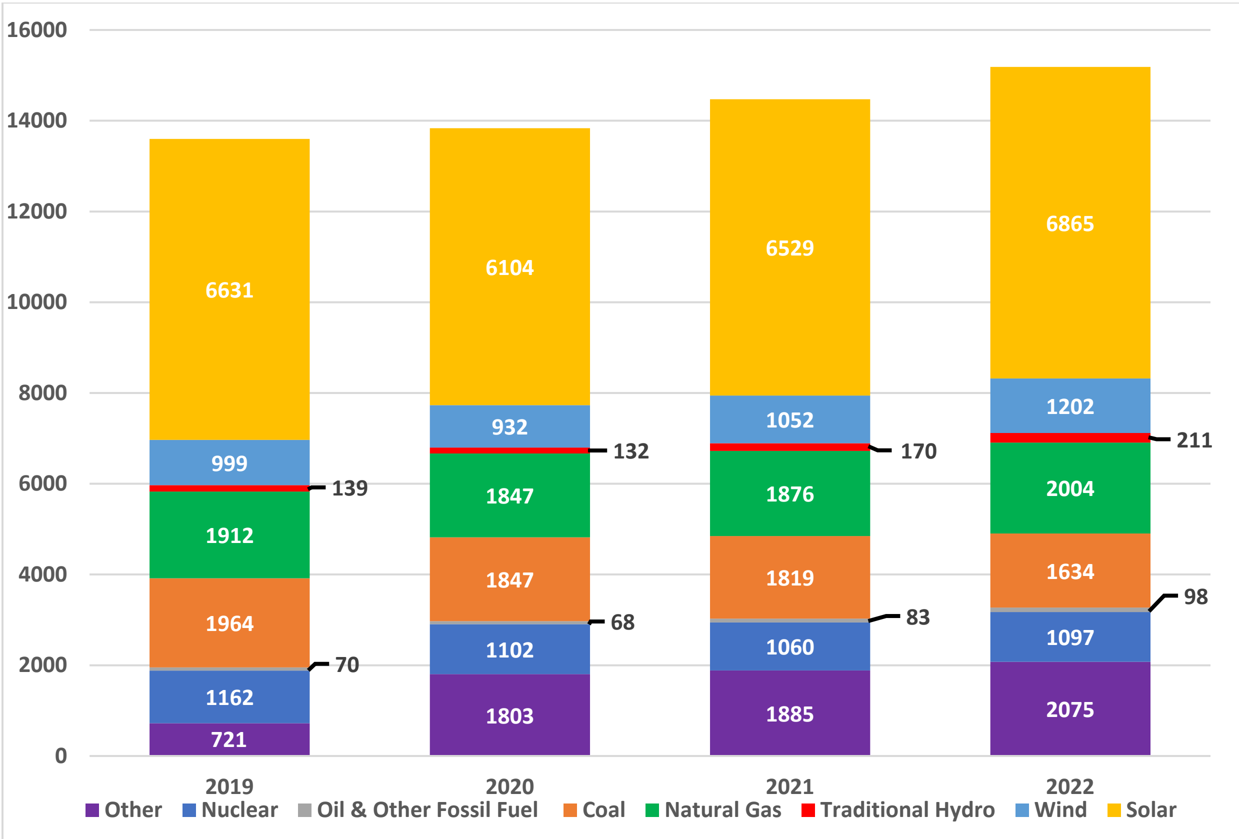
Energy Employment

In 2022, the electric power generation sector employed 15,187 workers in Maryland.[22] The majority of the jobs were construction-related (45.7 percent), followed next by the utility industry (19.7 percent). As noted in Figure 2, approximately 8,275 of Maryland's electric power generation jobs focused on renewable energy (solar, wind and hydropower), with 84 percent attributed by the solar industry (including full time and part time). Based on a forecast by the Energy Futures Initiative and the National Association of State Energy Officials, Maryland's electric power generation sector is expected to grow by approximately 6.8 percent.[23] In addition to the electric power generation industry, there were approximately 954 jobs in the transmission, distribution and storage sector related to energy storage in Maryland in 2022 (this number is not reflected in Figure 2).

22 Energy Futures Initiative and National Association of State Energy Officials. U.S. Energy and Employment Report: State Factsheet: Maryland 2023,2023 USEER States Complete.pdf (energy.gov).

23 Ibid.

Figure 2 Electric Power Generation Sector Employment in Maryland by Fuel Type (2019-2022)



Note: "Other" includes other biofuels and all other fuels, including employers that cannot assign employment to a single technology/fuel type.

Source: Energy Futures Initiative and National Association of State Energy Officials, 2023 U.S. Energy and Employment Report: Energy Employment by State.

The instate solar carve-out requirement of the RPS is partially responsible for existing solar jobs in Maryland; however, despite increases in the carve-out, Maryland experienced a decline in solar jobs between 2016 and 2020. Full-time, solar-related employment in Maryland peaked in 2016 with 7,729 jobs, but declined through 2020 despite the instate solar carve-out increasing from 0.7 percent in 2016 to 6 percent in 2020.[24] One explanation for this shift, as put forth by industry participants, is that the initial RPS requirement levels, coupled with federal and other state incentives, created significant demand that the industry met and exceeded.[25] A resultant glut in solar generation resulted in early compliance with the solar carve-out of the RPS and put

---

[24] Full-time, solar-related employment is defined as a worker who spends more than 50 percent of its hours working on solar projects.

[25] MDV-SEIA, ccanactionfund.org/media/MD-Solar-Jobs-Losses-Press-Release.pdf.

downward pressure on solar renewable energy credit (SREC) prices, making it less economic for the continued development of new solar projects. COVID-19 also played a role, as companies were unable to conduct door-to-door marketing and sales, and local governments were less able to process building permit applications. The number of full-time, solar-related jobs has been on the rise since 2020 but has yet to surpass the peak that it achieved in 2016.

Solar PV

The National Renewable Energy Laboratory (NREL) estimates that about 60-70 percent of utility-scale PV installation costs are for hardware (i.e., module, inverter, structural balance-of-system (BOS) and electrical BOS), with the remaining costs evenly split between construction and services. For distributed systems, less of the project cost goes to manufactured components and more to services. Operations and maintenance (O&M) costs, which include warrantied and non-warrantied parts replacement, monitoring and property maintenance, are weighted toward services, which are usually fulfilled locally. O&M costs vary by technology, system size, location and other factors.

Solar PV systems are constructed of highly recognizable components like solar cells, modules, racking and inverters, but also hardware such as monitoring equipment, cabling, connectors, nuts and bolts and other manufactured products that knit the system together. Major components, such as modules and inverters, are largely imported. In comparison, there is a greater domestic presence of manufacturers of structural and electrical BOS. In 2022, approximately 88 percent of modules were imported.[26] According to Solar Power World, there are 26 domestic solar panel manufacturing facilities, although most of these manufacturers import key components from other countries for assembly in the U.S. or are vertically integrated companies that provide end-to-end services (i.e., design through installation).[27] Twenty companies manufacture some, or all, of their solar panels in the U.S. (see Table 3).

---

[26] U.S. Energy Information Administration, https://www.eia.gov/todayinenergy/detail.php?id=60261#:~:text=In%202022%2C%20about%2088%25%20of%20U.S.%20solar,panel%20shipments%20were%20imports%2C%20primarily%20from%20Asia.

[27] Solar Power World. "U.S. Solar Panel Manufacturers." solarpowerworldonline.com/u-s-solar-panel-manufacturers/.

Table 3 Companies Manufacturing Solar PV Panels in the U.S.

COMPANY	MANUFACTURING LOCATION	HEADQUARTERS
Auxin Solar	San Jose, CA	California
Canadian Solar	Mesquite, TX	Canada
Crossroads Solar	South Bend, IN	Indiana
First Solar	Lake Township, OH	Arizona
GAF Energy	San Jose, CA	California
Heliene	Mountain Iron, MN	Canada
Hightec Solar	Michigan City, IN	Indiana
Jinko Solar	Jacksonville, FL	China
LONGI (Illuminate USA)	Pataskala, OH	China
Merlin Solar	San Jose, CA	California
Mission Solar	San Antonio, TX	Texas
QCells	Dalton, GA	California
Silfab Solar	Bellingham, WA	Canada
Sinotec	City of Industry, CA	California
Sirius PV (Elin Energy)	Brookshire, TX	Turkey
Solaria	Fremont, CA	California
SPI Energy/ Solar4America	Sacramento, CA	California
SunSpark	Riverside, CA	China
SunTegra	Binghamton, NY	New York
Toledo Solar	Perrysburg, OH	Ohio

Source: news.energysage.com/u-s-solar-panel-manufacturers-list-american-made-solar-panels/.

Inverters, which convert direct current (DC) output from a solar panel into utility frequency alternating current (AC), are an integral component of every solar PV system. Fourteen companies manufacture inverters domestically, ranging from standalone to grid-tie models,[28] but

[28] solarpowerworldonline.com/global-inverter-manufacturing-locations/.

only four of the leading utility-scale inverter manufacturers are located in the U.S.[29,30] U.S. Section 301 tariffs on Chinese goods could shift inverter manufacturing from China to India, Mexico and the U.S.[31]

Other solar components are generally categorized as structural BOS and electrical BOS. Structural BOS includes racking, mounting and tracking systems plus any other materials needed to support the modules. ENF Solar, a consultancy, lists more than 100 solar-mounting manufacturers in the U.S.[32] Forty-six companies manufacture solar-tracking systems.[33] None of the companies listed by ENF Solar selling structural BOS components are located in Maryland. Electrical BOS comprises equipment that transports DC energy from solar panels through the conversion system that produces AC power. Components include conductors, conduits, combiner boxes, disconnects and monitoring systems. ENF Solar lists 37 solar charge controller manufacturers and 36 solar monitoring system manufacturers in the U.S.

Opportunities for manufacturing growth in Maryland from continuing solar PV deployment are likely limited to the structural and electrical BOS supply chains. This is because the solar installers tend to be vertically integrated, that is, they own or control manufacturing, sales and installation which limits opportunities for other companies to enter the market.

Onshore Wind

More than half of capital expenditures for a land-based wind power plant project are for turbines, with another near 30 percent for electrical infrastructure and balance of system.[34] Assembly and installation account for only 3 percent of construction costs, while site access and staging, foundation and engineering management account for another 7 to 8 percent. About 59 percent of O&M expenditures are for maintenance and 15 percent for land lease payments.[35]

As the cumulative capacity of U.S. wind projects has grown over the last decade, foreign and domestic turbine equipment manufacturers have localized and expanded operations in the U.S. There are more than 500 wind turbine and component manufacturing and assembly facilities in

---

29 wiki-solar.org/company/inverters/index.html.

30 ABB acquired GE's inverter business in mid-2018.

31 The Solar Foundation. National Solar Jobs Census 2018. 2019.

32 enfsolar.com/directory/component/mounting_system?country=187.

33 greenworldinvestor.com/2011/07/06/solar-tracker-manufacturers-usachinaindia-list-and-market-review-of-sale-price-and-cost/. Updated September 2016.

34 Tyler Stehly, Patrick Duffy and Daniel Mulas Hernando, 2022 Cost of Wind Energy Review. National Renewable Energy Laboratory. Technical Report NREL/PR-5000-88335. December 2023. https://www.nrel.gov/docs/fy24osti/88335.pdf.

35 Ryan Wiser, Mark Bolinger and Eric Lantz, Benchmarking Wind Power Operating Costs in the United States, Lawrence Berkeley National Laboratory, January 2019, eta-publications.lbl.gov/sites/default/files/opex_paper_final.pdf.

U.S. as of 2023[36] although only three are located in Maryland.[37] Most manufacturers have chosen to locate in markets with substantial wind power capacity or near already established large-scale original equipment manufacturers.

The trend in onshore wind turbines has been toward greater capacities, larger rotor diameters and higher hub heights. Wind turbines installed in the U.S. in 2020 had an average nameplate capacity of 2.75 MW, 125-meter rotor diameter and 90-meter hub height.[38] By 2022, the average capacity, rotor diameter, and hub height had all increased to 3.2 MW, 131.6 meters and 98.1 meters, respectively. In addition, 13 wind projects had been partially repowered with significantly larger rotors and power ratings in 2022.[39]

The domestic supply chain faces competitive pressures from foreign manufacturers. There continues to be increased industry concentration among top original equipment manufacturers and centralization of manufacturing operations to gain economies of scale. Despite its domestic presence, the U.S. wind industry remains reliant on imports, particularly on turbines and components.[40]

Offshore Wind

NREL estimates between nearly 37 percent of construction costs for a fixed bottom offshore wind project are for the turbines and almost 46 percent are for balance of system costs.[41] Although the majority of onshore wind turbine components (as a fraction of total equipment-related turbine costs) installed in the U.S. are domestically sourced, offshore wind installations require many specialized components that are not currently produced in the United States.[42] Even where facilities serving the U.S. onshore wind market may be capable of manufacturing offshore wind components, logistical concerns primarily related to the long-distance transport of large components may limit their ability to supply the offshore market. As a result, an offshore wind supply chain has not yet developed in the U.S.

Because of this, most near-term manufacturing opportunities for offshore wind are limited to upstream materials and subcomponents that can be easily transported. Upstream products include scaffolding, coatings, ladders, fastenings, hydraulics, concrete and electrical components. Table

---

36 U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Securing the U.S. Supply Chain for the Wind Energy Industry. Last accessed April 29, 2024.

37 U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Land-Based Wind Market Report: 2021 Edition. emp.lbl.gov/sites/default/files/land-based_wind_market_report_2021_edition_final.pdf.

38 Land-Based Wind Market Report: 2021 Edition, op. cit.

39 U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Land-Based Wind Market Report: 2023 Edition. Wind Market Reports: 2023 Edition | Department of Energy.

40 Ibid.

41 Tyler Stehly, Patrick Duffy and Daniel Mulas Hernando, 2022 Cost of Wind Energy Review. National Renewable Energy Laboratory. Technical Report NREL/PR-5000-88335. December 2023. https://www.nrel.gov/docs/fy24osti/88335.pdf.

42 Navigant Consulting Inc. U.S. Offshore Wind Manufacturing and Supply Chain Development. Prepared for U.S. Department of Energy. February 22, 2013, 19.

4 identifies some businesses in the Mid-Atlantic region that have the potential to support the offshore wind supply chain.[43,44]

Table 4 Number of Existing Companies and Firms Identified in the Mid-Atlantic Region with the Potential to Supply Offshore Wind Components

INDUSTRY	MD	DE	NJ	PA	VA
Electronics	**1**	0	3	15	2
Manufacturing & assembly	**17**	0	1	17	6
Installation, construction, materials	**13**	2	1	28	5
Maintenance, logistics, transportation	**16**	0	4	6	34
Services	**6**	2	6	4	34
TOTAL	**53**	**4**	**15**	**70**	**81**

Source: Offshore Wind Jobs and Economic Development Impacts in the United States: Four Regional Scenarios. National Renewable Energy Laboratory. Technical Report NREL/TP-5000-61315. February 2015.

Both existing offshore wind renewable energy credit (OREC) applications (US Wind and Skipjack)[45] to the Maryland PSC allocate significant percentages of construction costs to Maryland and specifically target investment in a Maryland steel fabrication facility. Apart from these projects, however, there is considerable uncertainty about which industries in Maryland will benefit from offshore wind development. Both US Wind and Skipjack are attempting to develop relationships with instate businesses that traditionally have not participated in energy development projects and markets.[46] In May 2021, Maryland entered into a partnership with NREL, the Business Network for Offshore Wind, the New York State Energy Research and Development Authority, the National Offshore Wind Research and Development Consortium, and the U.S. Department of Energy for creating an offshore wind supply chain roadmap.[47] Separately, Maryland entered into a Memorandum of Understanding with the states of Virginia and North Carolina under the Southeast and Mid-Atlantic Regional Transformative Partnership

---

43 issues.nawindpower.com/article/maryland-prepares-offshore-wind-push.

44 S. Tegen, D. Keyser and F. Flores-Espino, et al., Offshore Wind Jobs and Economic Development Impacts in the United States: Four Regional Scenarios, National Renewable Energy Laboratory. Technical Report NREL/TP-5000-61315. February 2015.

45 Maryland Public Service Commission, Case No. 9341.

46 bizjournals.com/baltimore/news/2019/01/23/maryland-offshore-wind-developers-look-to-partner.html

47 Maryland Energy Administration, "National Offshore Wind Research and Development Consortium Announces Offshore Wind Supply Chain Roadmap Project," May 13, 2021, news.maryland.gov/mea/2021/05/13/national-offshore-wind-research-and-development-consortium-announces-offshore-wind-supply-chain-roadmap-project/.

for Offshore Wind Energy Resources for expanding offshore wind energy generation and to develop a supply chain.[48]

Some studies predict future opportunities for suppliers will be greatest in industries responsible for providing foundations and substructures, towers, blade materials, power converters and transformers.[49,50] NREL has taken this outlook further by estimating the share of critical offshore wind component manufacturing that could take place in the Mid-Atlantic region. These estimates are broken down into three investment scenarios (see Table 5).

Table 5 Regional Investment Paths for the Dynamic Components for Offshore Wind in the Mid-Atlantic

	LOW INVESTMENT		MEDIUM INVESTMENT		HIGH INVESTMENT	
YEAR:	2020	2030	2020	2030	2020	2030
Deployed capacity (MW)	366	3,196	1,912	7,832	4,100	16,280
Turbines	32%	68%	35%	95%	65%	100%
Blades & towers	13%	71%	25%	95%	30%	95%
Substructures & foundation	11%	30%	20%	50%	30%	85%

Source: Offshore Wind Jobs and Economic Development Impacts in the United States: Four Regional Scenarios. National Renewable Energy Laboratory. Technical Report NREL/TP-5000-61315. February 2015.

However, while there exists domestic infrastructure for the manufacture of some offshore wind components (e.g., offshore oil and gas industry suppliers), a more complete domestic supply chain is unlikely to be built until sufficient demand exists to justify the investment in new, dedicated facilities. This is particularly the case because the offshore wind market faces rapidly changing technologies and continued regulatory uncertainty. Deployment has lagged to date and, as a result, installed offshore wind capacity projections have been consistently pushed into the future and, with it, the development of a domestic offshore wind supply chain. Demand along the

---

48 Chris Carnevale and Heather Pohnan, "Regional Offshore Wind Agreement will Lead to more Smart Power for the South Atlantic," cleanenergy.org, November 2, 2020, cleanenergy.org/blog/regional-offshore-wind-agreement-will-lead-to-more-smart-power-for-the-south-atlantic/.

49 Navigant Consulting Inc. U.S. Offshore Wind Manufacturing and Supply Chain Development. Prepared for U.S. Department of Energy. February 22, 2013.

50 Massachusetts Clean Energy Center. 2018 Massachusetts Offshore Wind Workforce Assessment., 46. files.masscec.com/2018%20MassCEC%20Workforce%20Study.pdf

Atlantic coast may not be sufficient to attract a wind turbine generator manufacturing facility until the mid-2020s or later.[51,52]

Onshore Hubs for Offshore Wind

Even though offshore wind has been slow to develop in the U.S., supportive state policies have the potential to leverage the development of offshore wind resources and industries.[53] If offshore wind is developed to projected capacities, multiple U.S. ports will need to be improved to support staging and manufacturing operations.[54]

Known as onshore hubs for offshore wind, these facilities can generate significant economic impacts, potentially leveraging existing manufacturing competencies in a region and adding new ones. The Port of Bremerhaven on the North Sea is an example of a successful onshore wind hub. The harbor has attracted more than $325 million of investment to create a major onshore wind energy cluster.[55] Three turbine manufacturers, a blade manufacturer and a foundation manufacturer are located in the harbor area, and the region hosts over 300 suppliers, service providers and research institutions. An estimated 1,500 local jobs around Bremerhaven are directly attributable to offshore wind energy. With projected annual installation and repowering approaching 200 wind turbines in the North Sea, a 500-acre expansion of Bremerhaven's harbor was initiated in 2011 to accommodate Germany's offshore wind strategy.

In 2022, investments of nearly $1 billion were announced for marshaling, manufacturing and operations and maintenance ports in the United States. Several Atlantic coastal states, including Virginia, Massachusetts and others, have identified potential onshore hubs for offshore wind. Virginia took a step in October 2021 when Siemens Gamesa announced plans to build the nation's first offshore wind turbine blade factory at the Portsmouth Marine Terminal. The company will invest over $200 million in the facility and the facility will create over 300 jobs.[56] Also in Virginia, Fairwinds Landing LLC plans to devote $100 million to develops a maritime operations and logistics center in Norfolk for the offshore wind, defense and transportation

---

51 Navigant Consulting Inc. U.S. Offshore Wind Manufacturing and Supply Chain Development. Prepared for U.S. Department of Energy. February 22, 2013.

52 BVG Associates Ltd. U.S. Job Creation in Offshore Wind. NYSERDA Report 17-22. October 2017.

53 S&P Global Market Intelligence. "Offshore Wind Ready to Take Off in the United States." July 20, 2018. spglobal.com/marketintelligence/en/news-insights/research/offshore-wind-ready-to-take-off-in-the-united-states, last accessed February 27, 2019.

54 GL Garrad Hassan. Assessment of Ports for Offshore Wind Development in the United States. Prepared for U.S. Department of Energy. March 21, 2014.

55 BIS Economic Development Company Ltd. Offshore Terminal Bremerhaven: Information for Infrastructure Investors. Bremerhaven, Germany. January 2011.

56 Sarah Vogelsong and Virginia Mercury, "Siemens Gamesa chooses Virginia for offshore wind turbine blade factory," Energy News Network, October 25, 2021, energynews.us/2021/10/25/siemens-gamesa-chooses-virginia-for-offshore-wind-turbine-blade-factory/.

industries.[57] Table 6 lists the announced investments in offshore wind and manufacturing facilities between January 2022 and May 2023.

Table 6 Investments in Offshore Wind Ports and Tier 1 Manufacturing Facilities from January 1, 2022, to May 2023

Port	State	Type of Investment	Announced Investment ($ Million)	Funding Source
New Bedford Marine Commerce Terminal	MA	Marshaling Port	45	MA Clean Energy Center
Salem Wind Port	MA	Marshaling Port	108.8	MA Clean Energy Center, U.S. DOT
New Bedford Foss Marine Terminal	MA	O&M Port	15	MA Clean Energy Center
Prysmian Marine Terminal at Brayton Point	MA	Subsea Cable Manufacturing	225	Prysmian, MA Clean Energy Center
Bridgeport	CT	O&M Port	10.5	U.S. DOT
South Brooklyn Marine Terminal	NY	Marshaling Port	200	Equinor, BP
Arthur Kill Terminal	NY	Marshaling Port	48	U.S. DOT
Quonset State Airport	RI	Helicopter Operations	1.8	Ørsted, Eversource
Tradepoint Atlantic	MD	Monopile and Tower Manufacturing	$150*	US Wind*
Portsmouth Marine Terminal	VA	Marshaling Port	223	Virginia Port Authority
Norfolk	VA	Operation and Logistics Center	100	Fairwinds LLC
Port of Humbolt	CA	Marshaling Port	10.5	CA Energy Commission
Total			**987.6**	

Source: U.S. Department of Energy, Offshore Wind Market Report: 2023 Edition, August 2023, https://www.energy.gov/sites/default/files/2023-09/doe-offshore-wind-market-report-2023-edition.pdf. * is from US Wind, https://uswindinc.com/momentumwind/.

In return for Round 1 ORECs, both US Wind and Skipjack were required to invest in a Maryland steel fabrication facility, use a port facility in the greater Baltimore region for marshaling project components, use Ocean City as the O&M port and invest in upgrades to the Tradepoint Atlantic shipyard. As such, Tradepoint Atlantic has positioned itself to potentially become a hub for

[57] U.S. Department of Energy, *Offshore Wind Market Report: 2023 Edition*, August 2023, https://www.energy.gov/sites/default/files/2023-09/doe-offshore-wind-market-report-2023-edition.pdf.

offshore wind on the East Coast, with space for offshore wind laydown, manufacturing and vessel loading.[58] US Wind plans to invest $150 million in a new monopole fabrication facility at Sparrows Point.

In December 2021, the PSC issued awards for Round 2 ORECs to US Wind and Skipjack for the 808 MW Momentum Wind and the 846 MW Skipjack projects, respectively. The PSC order had several conditions such as: the creation of at least 10,324 direct jobs during the development, construction and operating phases of the projects; committing to certain goals to engage small, local and minority businesses; passing 80 percent of any construction costs savings to ratepayers; and contributing $6 million each to the Maryland Offshore Wind Business Development Fund. The two projects were expected to contribute about $1 billion in in-state spending.

In January 2024, Ørsted made the decision to withdraw the Skipjack 1 (120 MW) and Skipjack 2 (846 MW) projects from the OREC program, as the company deemed the projects to be economically unviable. As of now, Maryland has a total of 1,056.5 MW of approved offshore wind projects (Round 1 and 2) which is expected to generate more than 8,000 direct jobs during the development and construction phase and approximately 2,500 direct jobs during the 20 to 30-year operations and maintenance phase. The latest estimates for in-state spending for these projects amount to around $831 million.[59]

---

[58] Tradepoint Atlantic. Offshore Wind Factsheet. tradepointatlantic.com/downloads/.

[59] Offshore Wind (maryland.gov)