OCS Study
BOEM 2017-048

# Evaluating Benefits of Offshore Wind Energy Projects in NEPA

**U.S. Department of the Interior**
**Bureau of Ocean Energy Management**
**Office of Renewable Energy Programs**
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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| BOEM | Bureau of Ocean Energy Management |
| CCR | Coal Combustion Residuals |
| CFR | Code of Federal Regulations |
| DOE | Department of Energy |
| DOI | United States Department of the Interior |
| EA | Environmental Assessment |
| EERE | Office of Energy Efficiency and Renewable Energy |
| EIA | Energy Information Administration |
| EIS | Environmental Impact Statement |
| EPA | U.S. Environmental Protection Agency |
| EPRI | Electric Power Research Institute |
| ERCOT | Electric Reliability Council of Texas |
| EWEA | European Wind Energy Association |
| FONSI | Findings of No Significant Impacts |
| GHG | greenhouse gases |
| GW | gigawatt |
| IMPLAN | Impact Analysis for Planning |
| IRENA | International Renewable Energy Agency |
| ISO | Independent System Operators |
| JEDI | Jobs and Economic Development Impact |
| km | kilometer |
| kph | kilometers per hour |
| kWh | kilowatt hours |
| LCA | Life-Cycle Assessment |
| LCOE | levelized cost of energy |
| MMS | Minerals Management Service |
| MOU | Memorandum of Understanding |
| mph | miles per hour |
| MW | megawatts |
| MWh | megawatt hours |
| NAAQS | National Ambient Air Quality Standards |
| NEPA | National Environmental Policy Act |
| NERC | North American Electric Reliability Council |
| NREL | National Renewable Energy Laboratory |
| O&M | operation and maintenance |
| OCS | Outer Continental Shelf |
| OTC | once-through cooling |

| | |
|---|---|
| PV | photovoltaic |
| RIEDC | Rhode Island Economic Development Corporation |
| RIMS II | Regional Input-Output Modeling System |
| RTO | Regional Transmission Operators |
| SEMA/RI | Southeast Massachusetts / Rhode Island |
| USGS | U.S. Geological Survey |
| WEA | Wind Energy Area |
| WECC | Western Electricity Coordinating Council |

# 1 PROJECT OVERVIEW

Pursuant to Title 30 Code of Federal Regulations (CFR) Part 585, the Bureau of Ocean Energy Management (BOEM) has regulatory authority over offshore energy development including conventional oil and gas exploration and production, and renewable energy production from wind, waves, and currents. BOEM must comply with the National Environmental Policy Act (NEPA) prior to approving a lessee's construction and operation plan for a wind or other renewable energy production project on the Outer Continental Shelf (OCS). NEPA analyses (Environmental Assessments [EAs] or Environmental Impact Statements [EISs]) typically focus on adverse impacts to the environment. However, NEPA analyses also need to include environmental and socioeconomic benefits analyses. AECOM has been contracted by BOEM to prepare this white paper to identify resources and describe technical approaches that can be used by authors of EAs and EISs to capture the beneficial effects that can accrue from the development of renewable energy sources on the OCS. This white paper is also prepared for interested members of the general public who seek a better understanding of how benefits can be captured, described, and evaluated during the NEPA process.

In 2007, the Minerals Management Service (MMS) published the report *Assessing the Costs and Benefits of Electricity Generation Using Alternative Energy Resources on the Outer Continental Shelf* (MMS 2007a). The report noted that while wind is not the only potential energy resource in the offshore environment, the commercial-scale development of energy from hydrokinetic sources (waves and tidal and ocean currents) is considerably behind the commercial-scale development of offshore wind, despite nearly a decade of development. Since October 2010, BOEM has issued 13 commercial wind energy leases consisting of 1,383,109 acres (over 559,724 hectares). In contrast, no commercially viable hydrokinetic projects have been developed on the OCS, although several demonstration projects have been proposed.

In addition, in April 2009, BOEM and the Federal Energy Regulatory Commission signed a Memorandum of Understanding (MOU) that clarified jurisdiction of each agency over renewable energy projects on the OCS. In the MOU, BOEM has jurisdiction over offshore wind and solar power projects and issues leases for hydrokinetic energy projects, while the Federal Energy Regulatory Commission issues licenses for offshore hydrokinetic energy production. Because information on wind energy production methods are more robust than other offshore alternative energy sources and offshore wind energy production falls fully within BOEM's regulatory authority, this report is primarily focused on offshore wind production. However, many of the issues considered and resources identified in this report are applicable to other renewable energy projects, independent of the offshore wind energy generation method under consideration.

This report is organized into three primary sections: Section 2 briefly discusses three factors that will be important in dictating how a NEPA-focused benefits analysis could be included in the NEPA process; Section 3 identifies tools and resources for conducting the benefits analysis; and Section 4 describes where in the NEPA process this benefit analysis could most readily fit. Section 5 provides a summary of the key features of the white paper.

# 2 EVALUATING BENEFITS IN EAS/EISS

NEPA regulations (40 CFR 1508.8) define “effects” to include both direct and indirect effects and both adverse and beneficial effects. However, while a considerable body of knowledge and standards of practice have been developed to assess adverse impacts, less effort has been invested in defining ways to determine beneficial effects. There are a variety of factors that need to be considered in developing a benefits analysis for a NEPA document. While an action may have a clear benefit to the natural or social environment, such as an environmental restoration or enhancement project, the direct environmental benefits resulting from most development projects are less clear. Rather, the potential benefits first need to be put into a context because many beneficial outcomes are predicated on other actions occurring either within or external to a proposed project. Such actions may be under the control of the project applicant or may be fully independent of the proposed project. One strategy to help establish a context is to undertake a limited Life-Cycle Assessment (LCA). The LCA can help identify factors that could contribute to or may otherwise influence the determination of benefits from the proposed project.

An EA or EIS is an informational document that identifies impacts from a proposed Federal action (e.g., approval to construct and operate an offshore wind energy facility) and determines which impacts, if any, are significant. An EA and EIS can also identify benefits, but determining whether a benefit is significant is often more complex. Generally, the analysis requires a good context against which to evaluate the magnitude and relevance of the benefits. Whether a benefit is significant or not often needs to be viewed in a context relative to other factors as noted above. In other cases, it may be inappropriate to identify a significant benefit in the same way as identifying a significant impact. It may be that the more relevant issue is whether the benefit exists at all in the context of NEPA.

Furthermore, the process for developing a benefits analysis is fairly well defined in some disciplines, but is not as well defined in others. For example, socioeconomic evaluations can be presented in a cost/benefits perspective, whereas environmental impacts analyses typically only look at costs and seldom consider benefits. These three perspectives—context, significance, and disciplines—are discussed below.

## 2.1 Context

Evaluating the benefits of a particular action typically requires a full appreciation for the impacts and benefits from associated actions and systems. These actions may be connected actions under NEPA, but may also be completely unrelated. For example, if electricity generated from an offshore wind facility displaces the burning of coal in onshore power plants, there would be a reduction in the amount of air emissions (both greenhouse gases [GHG] and criteria air pollutants), and that reduction would have relatively clear and quantifiable environmental and human health benefits.[1] However, if there is no direct connectivity between the proposed project and the presumed beneficial action, there is no guarantee that either the latter unconnected action or the anticipated benefit will actually occur.

Continuing the example above, another result of a reduction in the burning of coal in power plants is a decrease in fly ash production. This result can be seen as a both a positive and negative impact. Reducing disposal of fly ash could be beneficial in several ways, including less use of landfill space for disposal and reduced potential for spills from impoundments containing the fly ash. However, because fly ash is often used as an additive when grinding clinker to make Portland cement, the reduced availability of fly ash for cement could affect the quality or quantity of cement and could result in indirect impacts from the procurement of a replacement. Thus, the benefits of reduced fly ash production and disposal may be offset by the adverse impacts to cement quality and environmental resources. An LCA would be useful in identifying whether an overall benefit would result and, if so, what the likely magnitude of the benefit would be.

In order to fully develop the context of the potential impacts and benefits, it will be important to establish a credible baseline. As noted below in Section 3.2, there are a number of regulatory actions in process that are expected to result in the reduction of coal-burning power plants, such as the use of water for once-through cooling (OTC) and other changes in the power production industry. To properly capture the real benefits from an offshore wind project, these other changes need to be considered by properly establishing a reasonable baseline. In the absence of such an agreed-upon baseline, the benefits from a project may be missed or could be counted multiple times.

## 2.2 Significance

As implied by the name Environmental Impact Statement, most EISs by their nature consider adverse effects. To evaluate the importance of an impact from a project on a particular resource, the authors establish criteria against which to measure the significance of the identified adverse effects. Often actions have clear, measurable impacts, and often there are numeric standards against which to compare the significance of the impacts. However, it is more difficult to judge the significance of a positive effect because the benefits may be substantially affected by the context. For some situations, such as the addition of jobs feeding money into a local economy, the magnitude of the impact can be quantified. However, it is more challenging to identify whether the reduction or elimination of an impact is sufficiently large to qualify as a significant benefit. Typically, the environmental benefits resulting from an action are incidental to, or even unrelated to, the project being undertaken. For example, the addition of hard substrate in a marine area where little hard substrate occurs naturally may be beneficial to species using that hard substrate if it is in limited supply, but establishment of hard substrate is not the objective of the project. To determine if that incidental benefit is significant may be challenging, will likely not be quantitative, and will need context. Determining if an impact is beneficial would require the definition of significance criteria in the same way that significance criteria are established for adverse impacts.

An example of definitions of levels of impacts can be found in the final programmatic EIS (Final Programmatic Environmental Impact Statement for Alternative Energy Development and Production and Alternate Use of Facilities on the Outer Continental Shelf) prepared in 2007 by MMS (MMS 2007b). In that EIS, MMS identified a set of impact levels and their associated definitions, which are presented in **Table 2-1**.

**Table 2-1. Definitions of Impact Levels**

| Impact Level | Biological and Physical Resources | Societal Issues |
|---|---|---|
| Negligible | - No measurable impacts | - No measurable impacts |
| Minor | - Most impacts to the affected resource could be avoided with proper mitigation<br>- If impacts occur, the affected resources will recover completely without any mitigation once the impacting agent is eliminated | - Adverse impacts to the affected activity or community could be avoided with proper mitigation<br>- Impacts would not disrupt the normal or routine functions of the affected activity or community<br>- Once the impacting agent is eliminated, the affected activity or community will return to a condition with no measurable effects without any mitigation |
| Moderate | - Impacts to the affected resources are unavoidable<br>- The viability of the affected resource is not threatened, although some impacts may be irreversible, **OR**<br>- The affected resource would recover completely if proper mitigation is applied during the life of the project or proper remedial action is taken once the impacting agent is eliminated | - Impacts to the affected activity or community are unavoidable<br>- Proper mitigation would reduce impacts substantially during the life of the project<br>- The affected activity or community would have to adjust somewhat to account for disruptions due to impacts of the project, **OR**<br>- Once the impacting agent is eliminated, the affected activity or community will return to a condition with no measurable effects if proper remedial action is taken |
| Major | - Impacts to the affected resource are unavoidable<br>- The viability of the affected resource may be threatened, **AND**<br>- The affected resource would not fully recover even if proper mitigation is applied during the life of the project and remedial action is taken once the impacting agent is eliminated | - Impacts to the affected activity or community are unavoidable<br>- Proper mitigation would reduce impacts somewhat during the life of the project<br>- The affected activity or community would experience unavoidable disruptions to a degree beyond what is normally acceptable, **AND**<br>- Once the impacting agent is eliminated, the affected activity or community may retain measurable effects indefinitely, even if remedial action is taken |

Source: MMS, 2007b

Establishing a comparable benefit level for use in significance determinations would be challenging. In theory, it would be simple to replace “impacts” with “benefits” in these definitions, but this approach would work in only limited instances. Certainly, if there is no measurable benefit, there is little reason to include it in an analysis of project benefits. Similarly, it would be illogical to say that benefits are unavoidable or that benefits would need to be mitigated. On the other hand, characterizing benefits that would occur only during one phase, such as construction or operation, for a limited duration, or for a long duration such as the lifetime of the project would be useful for the decision-maker or general public to better appreciate the magnitude and duration of the beneficial effect.

The practical consequences of this difficulty in describing the significance or insignificance of project benefits is that, in most instances, the EA or EIS author will need to describe, and where possible quantify, the impact but may be unable to make an analogous judgment as to the significance of a beneficial outcome.

## 2.3 Disciplines

The process of identifying, evaluating, and quantifying benefits can vary substantially according to discipline. As noted above, socioeconomic analyses can be presented as cost/benefit analyses, but environmental assessments are couched in terms of adverse impacts. Systems benefits can be evaluated in terms of enhancements to the overall performance of the systems under consideration, but that requires a larger perspective. Optimizing one component of a system may result in issues in other portions of the system, and may cause indirect environmental and socioeconomic impacts. For example, it would be optimal to place an offshore wind facility in proximity to the users of that electricity to achieve system optimization benefits, but there may be other conflicts such as increased vessel traffic or concerns about aesthetics that would also need to be considered.

Because there are substantial differences among disciplines in terms of how benefits can be evaluated, the process of evaluating benefits needs to be specific to the discipline. As mentioned above, this discipline-specific approach will need to be sensitive to the larger context of issues addressed by each discipline. This discipline-specific sensitivity, therefore, requires a balanced and well-thought-out analysis rather than a one-size-fits-all approach.

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[1] Under Contract M16PC00015, BOEM has contracted Industrial Economics, Inc. to develop a model (Ben-Wind) that will estimate the air quality and energy system benefits associated with offshore wind projects defined according to their size, location, and timing, among other factors. BOEM expects the project to be concluded in the summer of 2017.

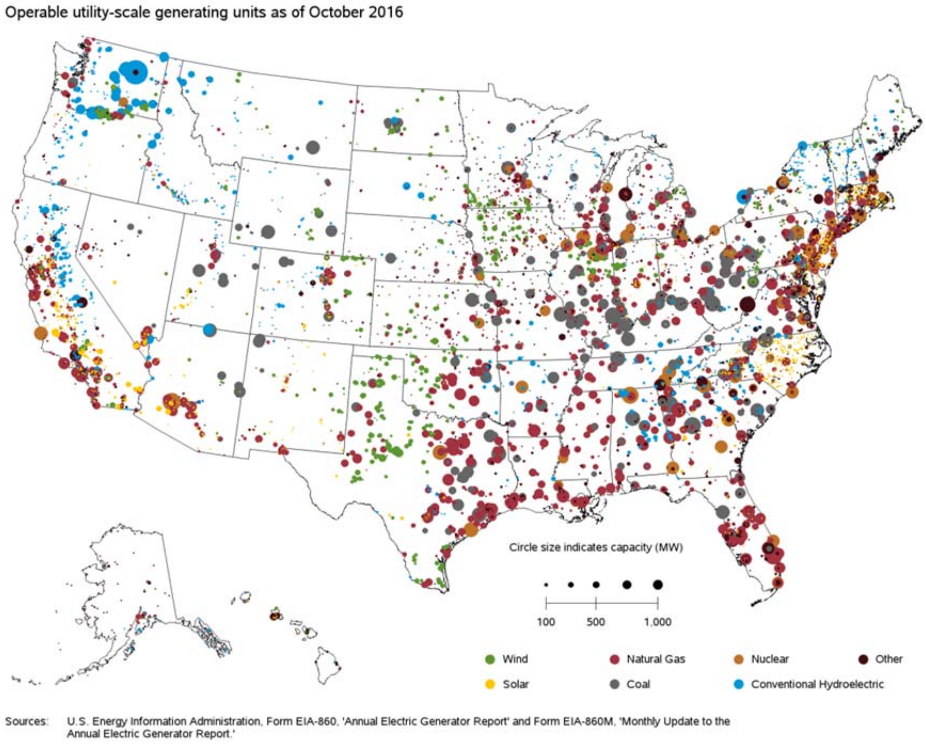
# 3 REVIEW OF EXISTING RESOURCES AND TOOLS

Benefits from the development of offshore wind energy projects, in particular offshore wind projects, can accrue in three primary areas: system benefits, environmental benefits, and socioeconomic benefits. The evaluation and presentation of benefits from each primary area relies on different data sets and uses different analytical methods. For the first area, system benefits (Section 3.1), this analysis focuses on how the development of offshore wind energy could benefit the electrical system. This system benefits evaluation is independent of environmental and socioeconomic effects that may result from the optimization of the electrical system. The evaluation of environmental benefits (Section 3.2) is based on the methods for looking at environmental impacts, but with an eye toward environmental benefits, both from the project itself and from associated changes that may occur in the overall electric-generation system, for example the reduction of coal fired power plants. The environmental benefits analysis is strongly affected by assumptions of these other activities. The socioeconomic analysis (Section 3.3) offers general guidance for conducting a socioeconomic assessment, with additional guidance on beneficial effects that could be attributed to offshore wind projects, and a discussion on conducting an economic impact analysis.

## 3.1 Electricity System Benefits

This section focuses on the system benefits that offshore wind generation can provide by reviewing existing aspects of the electrical system and examining factors that are used to optimize the location of an offshore wind generation facility. The section also examines the resources and tools for evaluating systems benefits. This section discusses system benefits without consideration of potential environmental or socioeconomic benefits or adverse impacts. Tools for evaluating environmental and socioeconomic benefits are presented in sections 3.2 and 3.3, respectively.

**Figure 3-1** is a map from the U.S. Energy Information Administration (EIA) (EIA 2016a) that shows all operating large power plants in the U.S. as of October 2016. In total, there are 17,271 electric-generating units larger than 1 megawatt (MW), which have a combined capacity of 1,117,319 MW as of October 2016.


Operable utility-scale generating units as of October 2016

Sources: U.S. Energy Information Administration, Form EIA-860, 'Annual Electric Generator Report' and Form EIA-860M, 'Monthly Update to the Annual Electric Generator Report.'

**Figure 3-1: Large Power Plants in the United States**

The *Annual Energy Outlook 2015* (EIA 2015) has projected the renewable energy sources that could serve as substitutes for new oil and gas production on the OCS through 2040. These projections are based generally on Federal, State, and local laws and regulations in effect as of the end of October 2014. The findings of the report states, “Wind energy accounts for the largest absolute increase in renewable generation and for 40 percent of the growth in renewable generation from 2013 to 2038, displacing hydropower and becoming the largest source of renewable generation by 2040.”

Although onshore wind energy is expected to account for the largest share of the projected wind energy increase, the potential for increases in offshore wind development is included in the projection.

The U.S. Department of Energy’s (DOE’s) EIA collects vast amounts of data for analysis and produces numerous reports on energy generation and consumption each year (EIA 2016a). This information is compiled using more than 200 tools for energy analysis including:

- DOE EIA Form 923, Power Plant Operations Report;
- DOE EIA Form 826, Monthly Electric Utility Sales and Revenue Report with State Distributions;
- DOE EIA Form 860, Annual Electric Generator Report;
- DOE EIA Form 861, Annual Electric Power Industry Report;
- DOE EIA Form 457, Residential Energy Consumption Survey; and

- DOE EIA Form 846, Manufacturing Energy Consumption Survey.

The information compiled in these reports is readily available and can be used as inputs to quantify the benefits of renewable energy projects. These EIA reports provided a substantial amount of information for this section.

### 3.1.1 System Organization

Electric-generating systems have three primary components: generation facilities, transmission and distribution facilities, and the end-user. The following discussion considers the first two components because they have the most direct potential for beneficial effects from an offshore wind energy production system.

#### *3.1.1.1 Current Power Generation Sources in Specific Geographic Areas*

Sources and mixes of power used by utilities vary by region.

An August 2015 article in *The Economist* (Economist 2015) stated,

> Historically, coal has been king in supplying electricity in the US. In 2005 it accounted for 51 percent of US power generation: in that year nuclear accounted for 19 percent, natural gas 18 percent, and hydropower 7 percent. Generation from non-hydro renewables (solar, wind and biomass) was negligible. Since around 2007, however, coal has been losing ground in terms of both market share and kilowatt hours (kWh) generated. Indeed, the observed trend over most of the last decade is clear: coal has been losing ground, albeit gradually, to gas (and to a lesser extent renewables). By 2014 coal’s share of generation had slipped to 39 percent, while the share for natural gas had risen to 26 percent. Meanwhile, generation from wind power nearly doubled between 2010 and 2014 (reaching over 4 percent last year), while solar PV [photovoltaic] generation has increased sharply, albeit from a small base.

Greater competition from natural gas and renewables, stagnating electricity consumption, and stricter air quality and potential carbon regulations will further reduce coal’s role in generating electricity.

The annual EIA reports continue to show a declining reliance on coal as a source of power and corroborate the market analysis showing the slow, steady decline of coal as a generation fuel.

The following three sub-sections identify the current types of electric-generation systems in each of the three geographic areas in the continental U.S. being considered in this report, the Atlantic (East) Coast, the Gulf Coast, and the Pacific (West) Coast. The relative value, and thus the benefit, from this offshore wind energy production will be strongly affected by the onshore system in place to distribute that energy to the areas where it is needed, i.e., population centers. The opportunities for incorporating the offshore electricity generated by these renewable sources and the challenges of incorporating that energy into the systems are presented in Section 3.1.3. Section 3.1.5 presents potential tools that can be used to identify and describe the benefits that an individual offshore wind energy project could contribute to the local and regional energy generation and distribution systems.

To evaluate benefits from the incorporation of electrical energy being produced offshore into the onshore grid, it is important to understand the present state of energy generation in each geographic area and how electricity from offshore wind installations could be incorporated into the grids within each area to augment existing generation or replace older, less environmentally friendly generation facilities. The following subsections provide a summary of current electricity production in each of the three geographic areas considered in this report. The charts provide a quick view of the generation capacity greater than 5 percent per region by fuel sources. The figures are followed by tables providing additional detail on the types of generators based on 2014 data (EIA 2014).

### Atlantic (East) Coast

The Atlantic Coast generation is primarily (92 percent) natural gas fired, nuclear, and coal fired (**Figure 3-2** and **Table 3-1**). For the sake of this discussion, the East Coast includes the states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, and Georgia. These regional figures used in the geographic area discussion are a gross depiction of the data and identify the dominant fuel sources. When the data are viewed on a state-by-state basis, it becomes evident that a fuel source other than those indicated on the figure may be dominant in a particular state. For instance, several states, such as Massachusetts, Connecticut, and New York, still have a considerable portion of their generation fueled by petroleum. When evaluating a system benefit, it will be necessary to consider current local fuel sources that are less environmentally friendly that may be replaced by offshore wind. The Atlantic Coast contains numerous metropolitan areas or “load centers’’ that require significant reliable supplies of electricity. There is some local generation capacity; however, electricity is directed to these load centers from generators much farther inland via the existing high-voltage transmission grid.

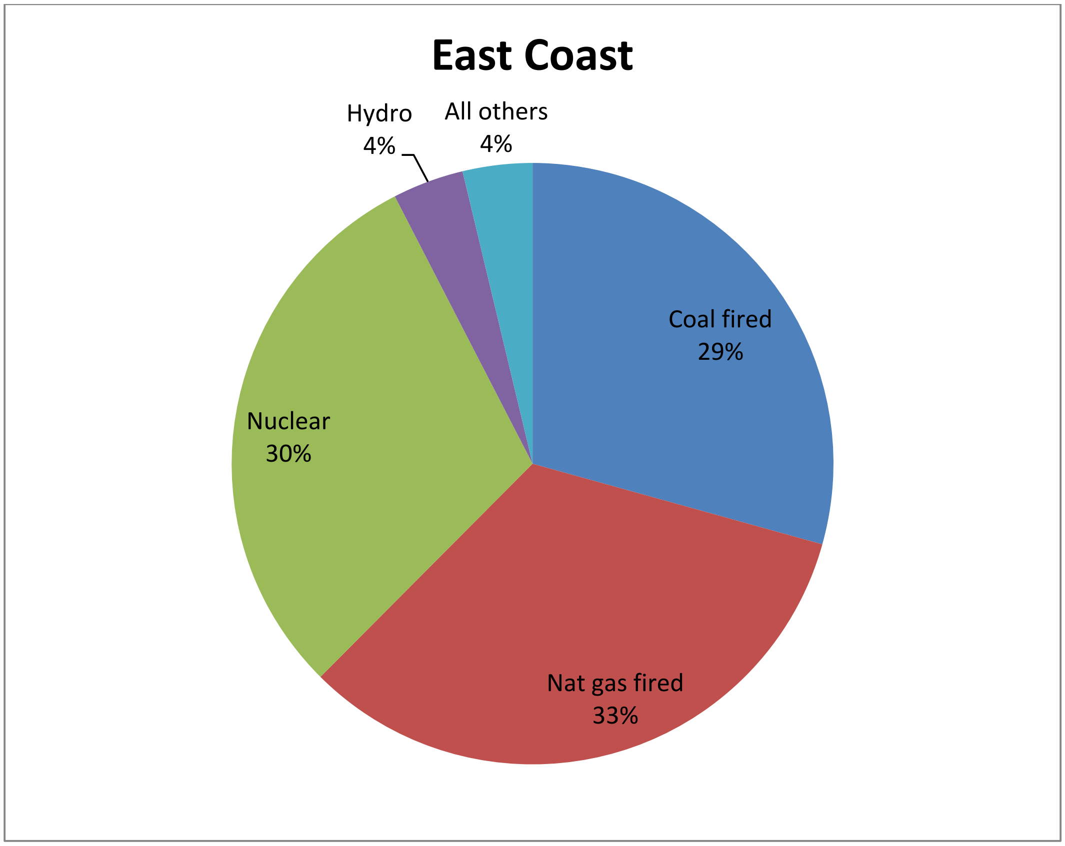


Figure 3-2. Mix of Energy Generators on the East Coast

Table 3-1. Types of Energy Generators per State on the East Coast

| State Code | Dominant Fuel Source | Generators | Facilities | Nameplate Capacity (MW) |
|---|---|---|---|---|
| ME | Coal | 1 | 1 | 102.6 |
| | Hydroelectric | 246 | 58 | 723.1 |
| | Natural Gas | 17 | 7 | 1,857.3 |
| NH | Coal | 4 | 2 | 559.2 |
| | Hydroelectric | 94 | 35 | 448.3 |
| | Natural Gas | 7 | 3 | 1,400.5 |
| | Nuclear | 1 | 1 | 1,242.0 |
| MA | Coal | 4 | 2 | 1,130.3 |
| | Hydroelectric | 75 | 29 | 268.9 |
| | Natural Gas | 92 | 34 | 7,400.3 |
| | Nuclear | 1 | 1 | 670.0 |
| RI | Hydroelectric | 5 | 2 | 2.8 |
| | Natural Gas | 23 | 7 | 1,971.1 |

| State Code | Dominant Fuel Source | Generators | Facilities | Nameplate Capacity (MW) |
|---|---|---|---|---|
| CT | Coal | 1 | 1 | 400.0 |
| | Hydroelectric | 39 | 14 | 118.5 |
| | Natural Gas | 60 | 31 | 3,430.4 |
| | Nuclear | 2 | 1 | 2,162.9 |
| NY | Coal | 18 | 7 | 2,633.7 |
| | Hydroelectric | 392 | 160 | 4,671.7 |
| | Natural Gas | 293 | 90 | 22,436.2 |
| | Nuclear | 6 | 5 | 5,708.1 |
| NJ | Coal | 6 | 5 | 2,003.0 |
| | Hydroelectric | 7 | 2 | 14.7 |
| | Natural Gas | 174 | 47 | 12,514.1 |
| | Nuclear | 4 | 3 | 4,180.7 |
| DE | Coal | 1 | 1 | 445.5 |
| | Natural Gas | 29 | 9 | 2,515.2 |
| MD | Coal | 18 | 9 | 5,139.2 |
| | Hydroelectric | 13 | 2 | 550.8 |
| | Natural Gas | 46 | 16 | 2,363.1 |
| | Nuclear | 2 | 1 | 1,828.7 |
| VA | Coal | 40 | 16 | 5,902.7 |
| | Hydroelectric | 75 | 25 | 822.4 |
| | Natural Gas | 79 | 23 | 10,704.1 |
| | Nuclear | 4 | 2 | 3,654.4 |
| NC | Coal | 33 | 14 | 11,004.0 |
| | Hydroelectric | 107 | 41 | 1,890.4 |
| | Natural Gas | 92 | 18 | 12,713.1 |
| | Nuclear | 5 | 3 | 5,394.7 |
| SC | Coal | 19 | 9 | 5,922.7 |
| | Hydroelectric | 117 | 32 | 1,364.1 |
| | Natural Gas | 69 | 19 | 6,665.1 |
| | Nuclear | 7 | 4 | 6,875.1 |
| GA | Coal | 36 | 13 | 13,444.2 |
| | Hydroelectric | 98 | 30 | 1,926.8 |
| | Natural Gas | 126 | 31 | 17,922.1 |
| | Nuclear | 4 | 2 | 4,041.8 |

The Atlantic Coast consists of diverse geography and resources, as well as a mix of electric-generation facilities as shown by Table 3-1. As a result, there is value in dividing it more finely into the Northeast, Mid-Atlantic, and Southeast sub-regions. The Northeast includes Maine, New Hampshire, Rhode Island, Connecticut, and Massachusetts, while the Mid-Atlantic includes New York, New Jersey, Delaware, Maryland, and Virginia. The Southeast includes North Carolina, South Carolina, and Georgia. These sub-regions have offshore wind resources of varying quality, with those in the Northeast being superior to those in the Southeast. When evaluating system benefits for the larger Atlantic Coast region, it will be important to research wind resource quality on a sub-regional basis or even state by state.

## Gulf Coast

Like the Atlantic Coast, in the Gulf Coast region (including the states of Florida, Alabama, Louisiana, Mississippi, and Texas for the purpose of this discussion), electricity generation is primarily (91 percent) natural gas fired, coal fired, and nuclear, with some onshore wind (6 percent) (**Figure 3-3** and **Table 3-2**). The key system issue along the Gulf Coast is similar to the Atlantic and Pacific coasts where generation facilities are often not located near the load centers. Although the Gulf Coast region is smaller than the Atlantic region, there are areas of the northcentral and northwest gulf that are better suited to offshore wind development, and this condition must be analyzed in the larger context to determine overall system benefits.

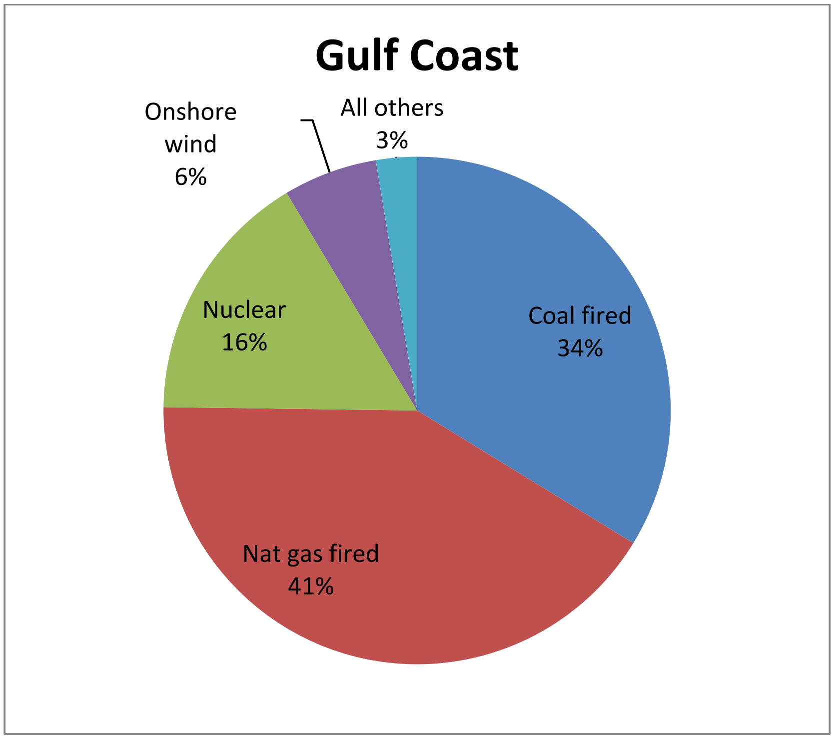


Figure 3-3. Mix of Energy Generators on the Gulf Coast

**Table 3-2. Types of Energy Generators per State on the Gulf Coast**

| State Code | Dominant Fuel Source | Generators | Facilities | Nameplate Capacity (MW) |
|---|---|---|---|---|
| FL | Coal | 30 | 14 | 11,343.3 |
| | Natural Gas | 320 | 73 | 42,453.9 |
| | Nuclear | 4 | 2 | 3,797.2 |
| AL | Coal | 33 | 9 | 11,741.6 |
| | Natural Gas | 97 | 25 | 13,329.8 |
| | Nuclear | 5 | 2 | 5,270.4 |
| LA | Coal | 6 | 4 | 3,796.2 |
| | Natural Gas | 195 | 62 | 22,933.8 |
| | Nuclear | 2 | 2 | 2,235.7 |
| MS | Coal | 7 | 4 | 2,887.5 |
| | Natural Gas | 106 | 29 | 13,482.3 |
| | Nuclear | 1 | 1 | 1,440.0 |
| TX | Coal | 41 | 21 | 25,420.4 |
| | Natural Gas | 632 | 159 | 76,085.6 |
| | Nuclear | 4 | 2 | 5,138.6 |
| | Wind | 119 | 110 | 14,000.2 |

### Pacific (West) Coast

For the purpose of this discussion the Pacific Coast includes California, Oregon, Washington, and Hawaii. Alaska has been excluded from this discussion due to its limited potential for offshore wind development. With the exception of Hawaii, electricity on the West Coast is generated primarily by natural gas and hydroelectric (74 percent), with a larger mix than the Atlantic Coast and Gulf Coast regions of other sources such as onshore wind and nuclear (15 percent) and geothermal and solar (3 percent each) (**Figure 3-4** and **Table 3-3**). The predominant fuel source used in Hawaii is petroleum, yet it has considerable wind resources, so the potential for development of offshore wind is gaining attention. The West Coast generally has higher wind speeds than the Atlantic or Gulf Coasts and, therefore, the potential for more efficient wind power generation. However, the highest sustained wind speeds are in northern California and southern Oregon, which are removed from the main population centers.

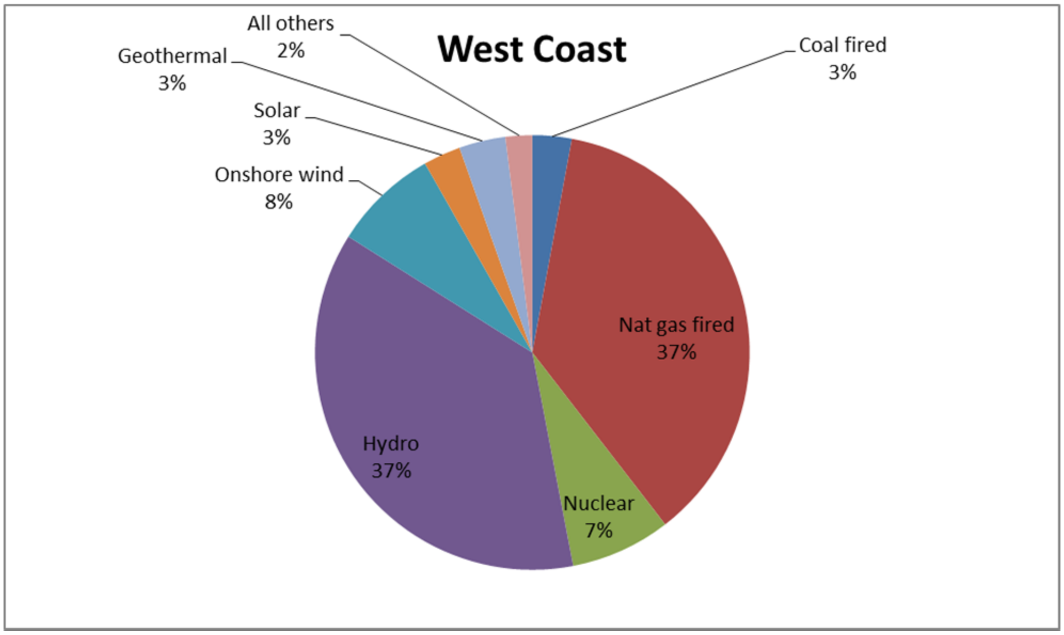


Figure 3-4. Mix of Energy Generators on the West Coast

Table 3-3. Types of Energy Generators per State on the West Coast

| State Code | Dominant Fuel Source | Generators | Facilities | Nameplate Capacity (Megawatts) |
|---|---|---|---|---|
| CA | Coal | 6 | 3 | 130.7 |
| | Geothermal | 102 | 35 | 2,940.9 |
| | Hydroelectric | 439 | 251 | 10,042.5 |
| | Natural Gas | 687 | 290 | 46,154.2 |
| | Nuclear | 2 | 1 | 2,323.0 |
| | Solar Thermal and Photovoltaic | 433 | 302 | 5,829.2 |
| | Wind | 130 | 113 | 5,832.8 |
| OR | Coal | 1 | 1 | 642.2 |
| | Geothermal | 3 | 1 | 33.0 |
| | Hydroelectric | 194 | 64 | 8,448.4 |
| | Natural Gas | 44 | 12 | 3,811.9 |
| | Solar Thermal and Photovoltaic | 7 | 7 | 13.9 |
| | Wind | 38 | 34 | 3,158.4 |
| WA | Coal | 2 | 1 | 1,459.8 |
| | Hydroelectric | 281 | 74 | 20,977.1 |
| | Natural Gas | 47 | 19 | 4,045.3 |
| | Nuclear | 1 | 1 | 1,200.0 |

| State Code | Dominant Fuel Source | Generators | Facilities | Nameplate Capacity (Megawatts) |
|---|---|---|---|---|
| | Solar Thermal and Photovoltaic | 1 | 1 | 0.5 |
| | Wind | 24 | 21 | 3,077.8 |
| HI | Coal | 1 | 1 | 203.0 |
| | Hydro | 14 | 8 | 26.2 |
| | Geothermal | 12 | 1 | 51.0 |
| | Wind | 7 | 7 | 205.6 |
| | Petroleum | 102 | 19 | 2059.5 |
| | Solar Thermal and Photovoltaic | 20 | 9 | 44.2 |
| Note: Alaska was excluded due to very limited potential for offshore wind energy development | | | | |

Generally, an evaluation of system benefits must also include how the current systems already successfully integrate renewables that fluctuate on a daily and seasonal basis.

#### *3.1.1.2 Transmission System Bottlenecks/Constraints*

Constraints reflect a transmission flow threshold for reliable operations. Power is moved from generator to load center, often across long distances, between states and regions to address and supplement demand. There are daily and seasonal fluctuations that must be considered, and the current transmission infrastructure is often not capable of adequately supplying power where it is needed when it is needed. To add generation along these already congested transmission corridors could exacerbate the situation. Therefore, developing offshore wind generation relatively close to major load centers and metropolitan areas will reduce demand for transmission system upgrades along the existing transmission corridor (DOE 2002). In 2002, the North American Electric Reliability Council (NERC) reported that investment in new transmission facilities was lagging far behind the investment in new generation facilities and growth in electricity demand (DOE 2002). Construction of high-voltage transmission facilities was expected to increase by only 6 percent (in line-miles) during the next 10 years, in contrast to the expected 20 percent increase in electricity demand and generation capacity (in MW). The concern was that this disparity would create new transmission bottlenecks or exacerbate existing ones. These bottlenecks create congestion that could significantly decrease reliability, restrict competition, and enhance opportunities for suppliers to exploit market power, increase prices to consumers, and increase infrastructure vulnerabilities (DOE 2002).

When DOE issued its 2006 *National Electric Transmission Congestion Study* (DOE 2006), the U.S. electric industry was still in a long period of relatively low investment in additional transmission facilities. Transmission planning was conducted independently by individual utilities and by Independent System Operators (ISOs) and Regional Transmission Operators (RTOs), and most new transmission projects were built to serve local needs only. Multi-utility, multi-state transmission cost allocation methods were still being negotiated in the East, and while the West had, in the 1970s and early 1980s, built a number of large transmission projects, it did not add much new capacity thereafter. During the first part of the decade (2000–2006), transmission project construction was at relatively low levels, and observers were concerned that if transmission investment continued to lag behind the growth in demand, grid reliability could be at risk.

Transmission constraints and congestion occur in particular locations and affect individual regions. They are influenced both by broad national or economy-wide trends and by the unique circumstances of each region. Recent circumstances such as the following have reduced the overall transmission congestion and constraints (DOE 2015a):

- The economic recession of 2008–2009 and the relatively slow rate of electricity demand growth during the economic recovery,
- State and Federal policies to increase energy efficiency,
- State policies to increase use of renewable generation,
- Low natural gas prices resulting in the construction of new locally sited facilities,
- Construction of additional transmission capacity in many areas,
- New environmental regulations that may have affected the composition of regional generation facilities, and
- Trends in older fossil fuel generation retirements.

In spite of the general reduction in congestion due to these circumstances, there are still areas where congestion continues to be an issue. This congestion will be exacerbated as the economy improves and demand rises.

## East Coast

To address the sub-regional differences, the sub-regions in the East Coast are discussed as Northeast/Mid-Atlantic and Southeast.

### *Northeast/Mid-Atlantic*

Transmission constraints continue to restrict delivery of power into load centers in central New York and the New York City and Long Island areas. Increased quantities of low-cost onshore wind generation in concentrated locations remote from major load centers are shipped during off-peak hours as “as available capacity,” because they exceed the throughput capability of existing transmission facilities. These facilities were originally designed to meet the on-peak demands of load centers rather than deliver off-peak generation from the remote wind locations (DOE 2015b). They have yet to function as initially proposed due to congestion. Administrative and institutional issues arising from different market rules, scheduling practices, and transmission reservations hinder more effective use of facilities between neighboring RTOs and ISOs and result in congestion at locations along the seams between markets. RTOs and ISOs in the Northeast are aware of these issues and in many cases are actively working to address them, but they still have not been resolved.

In their Draft economic study of offshore wind deployment, ISO New England (ISO New England 2016) evaluated the addition of offshore wind generation in the context of currently identified transmission constraints. The results of the study showed that the addition of offshore generation actually reduced transmission system constraints. "Transmission constraints on the major interfaces are less binding with the addition of offshore wind interconnected to the Barnstable, Brayton Point, and Kent County substations. Addition of offshore wind reduces total constrained hours seen on the SEMA/RI [Southeast Massachusetts / Rhode Island] Import Interface and the North-South Interface." In this scenario, interconnecting into specific onshore substations with existing capacity alleviated some previous local constraints.

In September 2014 the *Offshore Wind Transmission Study: Final Report* was prepared for the Massachusetts Clean Energy Center by the ESS Group (ESS 2014). The study reviewed the feasibility of several proposed offshore wind generation projects. One project was the Deepwater Wind project.

Deepwater Wind proposed a 900 to 1,200 MW wind farm (Deepwater Wind 2016) to be located in the Rhode Island and Massachusetts Wind Energy Area (WEA), approximately 48 kilometers (km) (30 miles) east of Montauk, New York and 24 km (15 miles) southwest of Martha's Vineyard, Massachusetts. Assuming an annual capacity factor of 48 percent, this project could generate approximately 3,800,000 to 5,000,000 megawatt hours (MWh) of energy annually. Deepwater Wind proposed to access the New York ISO and ISO Northeast electricity markets via the coincident development of a "regional" offshore high-voltage direct-current transmission system. This system would enable Deepwater Wind to interconnect in Long Island at the Long Island Power Authority Shoreham Substation (138 kilovolts) in Brookhaven, New York and in New England at the National Grid Brayton Point Substation (345 kilovolts) in Somerset, Massachusetts. As described in Deepwater Wind's submission to the New York Energy Highway, the New England-Long Island Interconnector would be the first link between Long Island and southeastern New England; this link would reduce constraints on the flow of electricity from southern New England to the New York downstate area and expand the diversity of power generation sources. It is expected that it would also increase system reliability by providing a new source of locational capacity and creating a link between New York and a new section of the ISO Northeast system.

The November 2010 *Virginia Offshore Wind Integration Study* (Dominion Virginia Power 2010) concludes that the potential interconnection of a large-scale offshore wind facility with the transmission system in the Virginia Beach area is technically feasible. Whether this facility is one single-wind facility or multiple smaller facilities, the aggregate generation amount is the factor that will drive transmission improvements. The results indicated that it is possible to interconnect large-scale wind generation facilities up to a total installed capability of 4,500 MW with the existing transmission system in the Virginia Beach area. The study recommended that once the level of total wind generation capability exceeded 2,700 MW, multiple interconnections should be considered. The study also indicated that when the actual output of the wind farm or farms approaches 2,700 MW, it is highly probable that the output will have to be limited due to transmission constraints unless transmission infrastructure improvements are made. The developers of these wind farms will have to decide if they want to spend $30 million to $70 million to potentially minimize the amount of time that the output of the wind farms is restricted.

### *Southeast*

There are no reports on the economic cost of congestion because no organized wholesale electricity markets operate in the Southeast that produce locational marginal prices reflecting differences in production costs due to congestion. This lack of information makes it difficult to assess congestion issues for this region. There are no clear trends in the application of administrative congestion management procedures over the period 2006–2011, with the exception of an increase in level 5 Transmission Load Relief, the most severe Transmission Load Relief level, because it involves curtailment of firm transactions. This information suggests congestion or constraint issues exist in the Southeast for local transmission (DOE 2015c).

## Gulf Coast

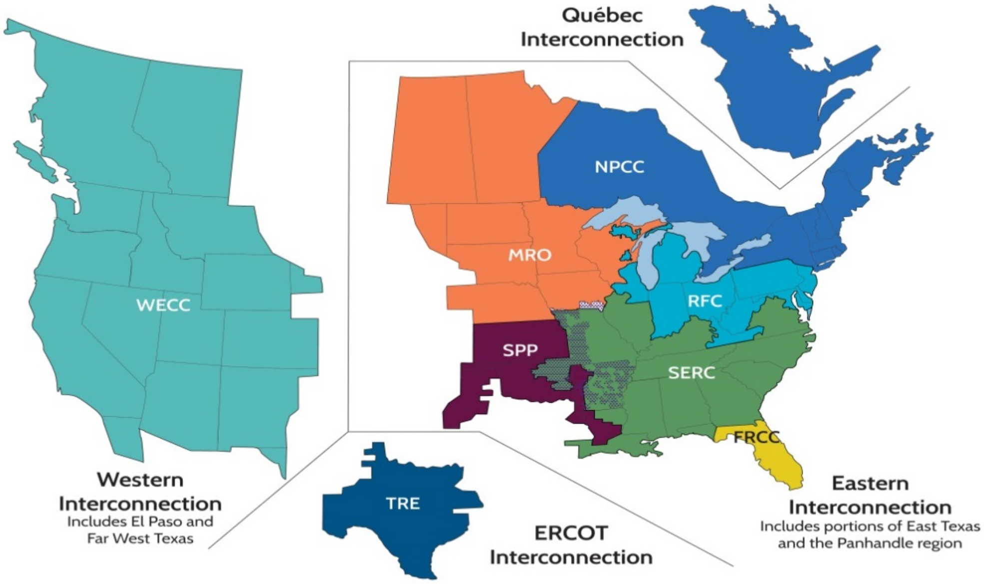
Except for the Electric Reliability Council of Texas (ERCOT), similar transmission congestion data deficiencies exist for the Gulf Coast as described above for the Southeast.

According to the ERCOT 2015 *Report on Existing and Potential Electric System Constraints and Needs*, the most significant constraint on the ERCOT system was related to the import of power into the Houston area from the north. Congestion in this area has been high for several years. In addition to the observed congestion, reliability studies have identified possible overloads in the next several years on transmission lines along this path. This means that the area has required increasing amounts of power to be imported from elsewhere in the ERCOT system. Additionally, a changing resource mix in Texas could lead to constraints in several areas. Wind generation development in the panhandle will soon exceed the capability of the transmission system to export power out of the region (ERCOT 2015).

## West Coast

Although current congestion in the West Coast is relatively low, more congestion is expected in the next few years due to transmission constraints related to new development of renewable resources and upcoming generator retirements. This is evidenced by Western Electricity Coordinating Council's (WECC's) list of Common Case Transmission Projects (WECC 2016), which are not yet built or operational, but are expected to become so within 10 years for the purposes of WECC's interconnection-wide planning studies. Congestion resulting from these constraints could be exacerbated by increasing demands for electricity induced by extreme weather or an increase in economic activity.

It should also be noted that electricity cannot be sent across the contiguous U.S. because there are distinct and separate interconnection regions. **Figure 3-5** identifies the three primary interconnection systems in the continental U.S.: the Western Interconnection, the Eastern Interconnection, and the majority of Texas in the separate ERCOT Interconnection, the State's main grid operator. Currently, these systems operate independently and are not capable of transmitting power outside their respective regions. This situation significantly impedes the ability to balance generation and loads within the larger contiguous U.S. and much of Canada.



Source: http://www.ercot.com/content/news/mediakit/maps/NERC_Interconnections_color.jpg

**Figure 3-5. North American Interconnections**

This grid separation creates transmission bottlenecks during periods of peak demand in the U.S. along the Gulf Coast. The situation is exacerbated in the State of Texas because it is not interconnected with the Eastern or Western Interconnection grid. The Tres Amigas superstation proposed in eastern New Mexico is planned to connect the three U.S. power grids through a direct-current hub that can regulate the direction and level of power flows between the grids, thereby improving the efficiency of the transmission systems in all regions (Choose Energy 2015). However, as of the end of 2016, this superstation has not yet been constructed.

To evaluate system benefits of offshore wind, it will be important to identify local rather than just regional transmission constraints to determine whether there is existing transmission capacity. If there is insufficient transmission due to congestion, then developing offshore wind generation that sends electricity directly into the local load center grid via a shore interface would be a system benefit. Transmission congestion data can be obtained from the most recent DOE *National Electric Transmission Congestion Study*, directly from local ISOs and RTOs, and from NERC and ERCOT publications.

The examples and discussion above indicate how local the congestion issues are and how the addition of offshore wind generation can have different implications depending on where they are sited. This issue must be taken into consideration when evaluating the benefits of offshore wind systems. In addition to siting, congestion status can change as transmission capacity is made available by upgrading or adding infrastructure. It is important that persons assessing the benefits of offshore wind research congestion issues with the local ISOs and RTOs as part of the evaluation. The Annual U.S. Transmission Data Review developed by DOE (DOE 2015a) provides detailed constraints evaluations by region. The constraints change over time, so it is incumbent upon the reviewer to research the most recent data.

## 3.1.2 General Considerations for Using Offshore Wind Energy Production in the Existing Grid

Maximum system benefits can be determined by evaluating the proposed offshore wind facilities against the criteria below. Understanding the criteria will facilitate the creation of wind generation development strategies to optimize electric generation from this renewable resource. Using these same criteria, the reviewer can analyze whether a proposed offshore wind facility is a viable alternative to other forms of onshore power generation and document it in the EIS. This section looks at the factors for evaluating an offshore wind energy facility in a given area. These factors would include:

- Quality of the local offshore wind resources,
- Optimal ocean depth for foundation-based installations,
- Distance of power generation facility from centers of electricity use or load centers,
- Proximity to suitable port facilities to support construction and operation and maintenance (O&M), and
- Potential for offshore wind generation to displace aging or limited infrastructure.

**Figure 3-6** shows a typical configuration of an offshore wind generation facility.

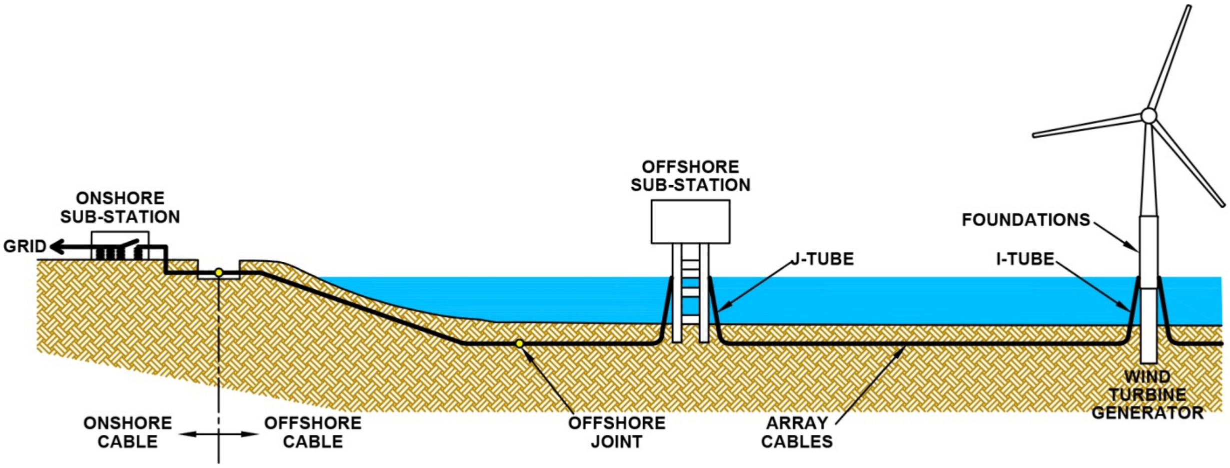


**Figure 3-6. Typical Offshore Wind Generation Facility**

### *3.1.2.1 Quality of the Local Offshore Wind Resources*

The global offshore wind resource is abundant, with the U.S. potential ranked second only to China. For instance, the wind resource potential at 9 to 93 km (5 to 50 nautical miles) off the U.S. coast is estimated to be more than the total currently installed electrical-generating capacity of the U.S. (more than 1,000 gigawatts [GW]). Offshore wind-generated electricity in the U.S. has the potential to become a major contributor to the domestic energy supply, on par with onshore wind, because it can compete in local, highly populated coastal energy markets where onshore wind energy is not usually available.

Offshore winds are typically stronger and more constant than onshore winds, and tend to increase with distance from shore. As a result, turbines are expected to operate at their maximum capacity for a larger percentage of the time, and the reliability of wind speed reduces wear on the turbine and provides a more constant source of power to the electrical grid, reducing the need for other sources of electricity to serve as backups. The higher wind speed increases electricity production for offshore wind turbines by 150 percent and the capacity of the wind farm from about 25 to 40 percent. This increase in production can offset the higher costs for offshore installation.

The potential energy produced from wind is directly proportional to the cube of the wind speed, which means that an increase in wind speeds of only a few miles per hour can produce significantly more electricity. For instance, a turbine at a site with an average wind speed of 25 kilometers per hour (kph) (16 miles per hour [mph]) would produce 50 percent more electricity than at a site with the same turbine and average wind speeds of 22.5 kph (14 mph). Additionally, offshore turbines are larger and have a larger capacity, which also offsets a higher installation cost (BOEM 2016a).

To determine whether offshore wind facilities would be a system benefit for a region, the local wind resource quality must be considered in the EIS. For grid-connected systems, the required annual average wind speed is 6.5 meters per second (21 feet per second) at 90 meters (295 feet) height above surface. There are several resources that provide information on the quality of offshore wind. The National Renewable Energy Laboratory (NREL) and AWS Truepower, LLC publish wind speed maps by state as does DOE’s WindExchange website (DOE, Office of Energy Efficiency and Renewable Energy [EERE] 2016).

#### *3.1.2.2 Optimal Ocean Depth for Foundation-Based Installations*

There are constraints to offshore installation, one of which is water depth. The optimal depths for foundation-based installations depend on the depths of current and planned development. The water depths of constructed and proposed projects cluster around 40 meters (130 feet) or less, with the majority being around 30 meters (100 feet) deep. Some approved projects and projects in the permitting phase are shown to be in water as deep as 50 meters (165 feet), with very few deeper at this time. Technological advances in foundation construction and the potential for floating facilities are expected to expand the development of offshore wind into deeper waters. There are currently areas offshore that have high-quality wind resources and water depths suitable for construction. It is expected that offshore wind installations could have electricity outputs 50 percent larger than equivalent onshore wind farms because of the higher sustained wind speeds that exist at sea (International Renewable Energy Agency [IRENA] 2012). Additionally, offshore turbines are larger and have a larger capacity, which also offsets a higher initial installation cost. Installation of these larger turbines with greater output can provide a system benefit. The ocean depth and therefore the constructability are important factors to consider when determining whether an offshore wind facility will be a system benefit.

#### *3.1.2.3 Distance of Power Generation Facility from Load Centers*

Approximately 50 percent of the U.S. population lives within 80 km (50 miles) of a coast, and about 80 percent live within 320 km (200 miles). Onshore wind resources in the U.S. are localized in the middle of the country, far away from large population centers. Offshore wind power is physically close to the major population centers of the coastal U.S., thereby removing the need for expensive high-voltage transmission (United States Geological Survey [USGS] 2014).

Coastal areas are substantially more crowded than the country as a whole, and population density in coastal areas will continue to increase in the future. In fact, the population density of coastal shoreline counties is over six times greater than inland counties (National Oceanic and Atmospheric Administration [NOAA] 2016).

The wind is stronger and more uniform at sea than on land. A stronger, steadier wind means less wear on the turbine components and more electricity generated per turbine. Because wind speed increases rapidly with distance from the coast, excellent wind sites exist within demonstrated constructible distances from major urban load centers, reducing the concern of onshore systems that require long-distance power transmission. In addition to being closer to the demand, offshore resources tend to be near the states that pay the highest electric utility rates in the U.S. (University of Massachusetts 2014)**.**

Offshore wind resources of the U.S. are not only plentiful, they are broadly distributed. Thirty U.S. states border an ocean or a great lake. The offshore wind resources exist within reasonable distances from major urban load centers, reducing the need for long-distance power transmission. The electricity generated in the coastal states represents 16.6 percent of the world's total electricity (NREL 2010a). In coastal areas of the country, offshore resources tend to dwarf the land-based wind component. For many of these states, offshore wind is the most abundant indigenous energy source and the only commercial option for renewable power generation (NREL 2010b).

The focus of early-stage offshore wind energy development along the Eastern seaboard of the U.S. is based on many potential value propositions. For one, wind conditions near major load centers are much stronger offshore than on land. These windy offshore areas are a relatively short interconnection distance from urban electrical grids. Annual average wind speeds within 20 km (12 miles) of New York City and Boston, for example, are 9 meters per second (30 feet per second) or greater at a 100-meter (330 feet) hub height, rivaling conditions at operating offshore wind plants in Europe. Land-based wind development in the Eastern U.S., on the other hand, is limited by less windy sites and requires delivery through a significant distance of constrained transmission networks to reach lucrative coastal urban energy markets. These markets can more simply satisfy their hefty need for green energy by pursuing offshore wind power.

For another value proposition, the diurnal pattern of offshore wind speeds along the East Coast is starkly different from inland. In the marine environment, winds normally peak in the afternoon and evening hours; inland winds, on average, peak during the overnight hours and are relatively light in the afternoon. The significance of this contrast is that the offshore wind pattern more closely resembles that of electricity demand. This stronger load coincidence has positive implications for how the output of offshore wind plants can be valued (Bailey and Wilson 2016).

These factors would be considered a system benefit where local offshore generation can effectively and efficiently displace distant onshore wind generation, or local less environmentally friendly generation to provide reliable unconstrained capacity to onshore load centers. It will be incumbent upon the document preparer to research the major load centers and then identify the closest offshore locations where wind facilities can be located.

#### *3.1.2.4 Proximity to Suitable Port Facilities to Support Construction and O&M*

Many large and small ports around the country would be able to support offshore wind project O&M needs with little or no upgrade cost, but small ports are unlikely to have or develop capacity to support offshore wind construction. However, existing large ports will likely require investment in infrastructure for them to adequately support construction of offshore wind facilities (ESS Group, Inc. 2016). Infrastructure needs include deep draft facilities, large staging areas with appropriate loading equipment, a dedicated fleet of maintenance and construction vessels, transmission system availability, reliable communication systems, skilled personnel, and safety and rescue provisions (Pace Energy and Climate Center 2011).

To achieve DOE’s moderate growth scenario of 28 GW of offshore wind in the U.S. by 2030, it is estimated that approximately 24 projects (12 GW) in the Atlantic Coast region, eight projects (4 GW) in the Gulf Coast, and 16 projects (8 GW) along the Pacific Coast are needed (GL Garrad Hassan 2014).

As U.S. ports and offshore wind developers work together on specific projects, they will encounter synergies and challenges. The challenges they face will include identifying sources of funding for the facility improvements required, and engaging in long-term partnerships, on the order of 10 to 20 years. Early projects will especially feel these challenges as they set the precedent for these partnerships in the U.S. (GL Garrad Hassan 2014).

On behalf of DOE, to assess port readiness for offshore wind in the U.S., GL Garrad Hassan developed a Port Assessment Tool on the basis of current and anticipated technology trends and installation techniques for the offshore wind industry. This tool is meant to be publicly available and can be used by all stakeholders of the U.S. offshore wind industry to assess and plan for port readiness for offshore wind. It also serves in assessing the current status of the port infrastructure and readiness for offshore wind in the form of opportunity assessments, cost-benefit analyses, and case studies. This tool can be found in Chapter 6 and the Appendices of the GL Garrad Hassan 2014 report. The tool walks the user through input assessments and key assumptions to identify suitable port facilities, conduct gap analyses, and determine a total number of gaps to be mitigated for the respective port, as well as costs to remedy those gaps.

Although offshore wind generation is currently in its infancy in the U.S., it is expected to grow as a viable component of the U.S.’s energy generation mix. As such, the development of suitable port facilities near potential offshore development can be considered a system benefit for both the construction and O&M phases of offshore wind generation.

#### *3.1.2.5 Potential to Displace Aging or Limited Power Plants*

In addition to the benefit that offshore wind power has with respect to shorter distances to load centers along the coast, the planned decommissioning of conventional power generation facilities should be considered. As can be seen in **Table 3-4**, coal and petroleum generation are the sources anticipated to be retired in the greatest numbers through 2019.

**Table 3-4. Planned Generating Capacity Changes (in MW), by Energy Source, Years 2015–2019**

| Energy Source | Generator Additions | | Generator Retirements | | Net Capacity Additions | |
|---|---|---|---|---|---|---|
| | Number of Generators | Net Summer Capacity | Number of Generators | Net Summer Capacity | Number of Generators | Net Summer Capacity |
| U.S. Total | 1,412 | 96,536.3 | 451 | 39,593.9 | 961 | 56,942.4 |
| Coal | 5 | 694.2 | 178 | 28,892.3 | -173 | -28,198.1 |
| Petroleum | 31 | 59.0 | 72 | 1,621.5 | -41 | -1,562.5 |
| Natural Gas | 389 | 54,893.3 | 131 | 7,887.1 | 258 | 47,006.2 |
| Other Gases | 3 | 403.0 | -- | -- | 3 | 403.0 |
| Nuclear | 3 | 3,322.0 | 1 | 609.9 | 2 | 2,712.1 |
| Hydroelectric Conventional | 66 | 1,088.1 | 22 | 433.1 | 44 | 655.0 |
| Wind (onshore) | 198 | 21,623.9 | 6 | 59.5 | 192 | 21,564.4 |
| Solar Thermal and Photovoltaic | 627 | 13,219.8 | 1 | 1.0 | 626 | 13,218.8 |
| Wood and Wood-Derived Fuels | 5 | 199.2 | 6 | 36.5 | -1 | 162.7 |
| Geothermal | 8 | 191.8 | -- | -- | 8 | 191.8 |
| Other Biomass | 57 | 263.0 | 32 | 52.0 | 25 | 211.0 |
| Hydroelectric Pumped Storage | -- | -- | -- | -- | -- | -- |
| Other Energy Sources | 20 | 579.0 | 2 | 1.0 | 18 | 578.0 |

EIA Annual Electric Generator Report, 2014

The projections above indicate that 258 natural gas, 192 onshore wind, and 626 solar thermal/photovoltaic generation facilities are planned to be constructed through 2019. Onshore wind and solar facilities have the disadvantage of being located considerable distances from load centers and natural gas, while inexpensive now, is subject to commodity market fluctuations. The current estimated cost of offshore power is higher than other sources of generation. However, offshore wind has the potential to have competitive electricity rates while being located near load centers. The time frame in which this will happen is greatly dependent on the number of facilities constructed, their generation capacities, the cost of construction, regulatory climate, and the negotiated price of power.

Recent spatial-economic modeling of the U.S. offshore wind technical resource area shows that offshore wind has the ability to achieve cost levels at or below $100/MWh by 2030 (DOE and DOI 2016). This levelized cost of energy (LCOE) has the potential to be competitive in many U.S. regions with relatively high electricity prices. The economic model shows that between 2015 and 2030, average cost reductions of approximately 5 percent can be achieved annually, and by 2030, offshore wind may become competitive in parts of the North Atlantic. These modeled U.S.-based cost data correspond to recent European cost reduction estimates. The alignment of these cost reduction trends depends strongly on continued global technology innovation (e.g., increase in turbine size) in conjunction with increasing levels of domestic deployment and future market visibility, leading to the near-term establishment of a sustained domestic supply chain.

The development of offshore wind generation will also be a factor, as continued energy demand will require that aging coal and petroleum generation sources be replaced. Since offshore winds blow more regularly and tend to peak during times of peak daily demand, they can more effectively replace or augment conventional generation. This feature can be viewed as a system benefit and should be evaluated during the course of EIS development.

The reviewer should consult EIA’s annual reports to accurately identify generator retirements and additions by particular region, and if possible by proximity to specific load centers, to accurately evaluate whether adding offshore wind to the local energy mix could be a benefit.

### 3.1.3 Regional Opportunities or Limitations for Using Offshore Wind Energy

When developing an analysis in the EIS for offshore wind generation as a viable alternative for energy production, the particular regions, sub-regions, or localities where conditions of existing systems may be more or less favorable to development of such facilities must be considered. Offshore wind power has been identified, analyzed, and discussed for a decade as a potential electricity resource for the coastal U.S., with the Northeast of particular interest due to resource quality and proximity to end users. Studies have identified the Northeast resource as a much larger clean energy source than onshore wind or rooftop solar, with the offshore wind potential being enough to supply all electricity used by Northeast coastal states. The resource is close to Eastern load centers, and many areas have strong winds at times approximately corresponding to peak load hours (University of Delaware 2016). The most recent information provided by BOEM should also be reviewed when identifying potential development areas.

According to the July 2016 report by WindEurope (WindEurope 2016), the average distance to shore for European wind farms is 42 km (26 miles), and the average water depth is 25 meters (82 feet.) The overwhelming number of installations use monopoles, which is currently the most cost-effective method.

Because of the long, shallow OCS, Gulf Coast states can likely deploy wind farms in shallower water than the Northeast Atlantic or Pacific Coasts. The Pacific Coast has high wind resource quality, but water depths are much greater than the Gulf Coast or East Coast. While locating the facilities in deeper water increases development costs and creates technological challenges, the development of offshore wind generation for systems that can take advantage of deep water could result in new technologies that would be beneficial both locally and nationally (NREL 2010a).

The addition of offshore wind to the mix of electric-generation facilities into a particular system may provide greater flexibility to system operators by decentralizing the system if the current system generation is transmitted from generators far from load centers. Additionally, the benefit to the system is that there are no fuel costs, so the energy generated does not fluctuate in price. These factors should be taken into consideration when evaluating offshore wind projects in an EIS.

### 3.1.4 Average Retail Cost of Power

As of the date of publication of this white paper, there are no large-scale offshore wind generation facilities operational in the U.S. There have been many projects in the proposal stages, with two contracted and only one under construction. The Offshore Wind Market and Economic Analysis - 2014 Annual Market Assessment contains a list of projects (DOE 2014). The retail cost of electricity is determined by combining generation costs from multiple sources and fuel types to spread the cost of higher-priced sources across the entire customer base. This calculation is the LCOE (**Table 3-5**). There are two previously contracted projects in New England: the Cape Wind project proposed for Massachusetts and the Block Island Wind farm off the coast of Rhode Island. The Block Island Wind farm is the country's first operational offshore wind farm, and the LCOE was above 24 cents per kWh. The high cost is attributable to the project being a demonstration project that does not benefit from economies of scale or local industry efficiencies.

**Table 3-5. Average Retail Cost of Power by Region**

| Region | States | Number of Power Plants (Coal, Natural Gas, Nuclear, Hydro, Petroleum & Wind) | Average Retail Price of Electricity (cents per kWh) August 2016 |
|---|---|---|---|
| USA | All | | 10.83 |
| Atlantic Coast | ME, MA, NH, VT, CT, RI, NY, NJ, PA, DE, DC, MD, VA, NC, SC, GA, FL | 1,267 | 13.19 |
| Gulf Coast | TX, LA, MS, AL | 528 | 8.78 |
| Pacific Contiguous | WA, OR, CA | 941 | 14.45 |
| Pacific Hawaii | HI | 45 | 24.48 |

Note: Hawaii is kept separate because the cost would skew the average upward
Source: EIA, Electricity Data Browser 2016.

Lacking any real U.S. offshore wind projects to assess, the University of Delaware conducted an "Offshore Wind Future Cost Study" that took into account a phased build-out of a 2,000-MW offshore wind farm project (University of Delaware 2016). Data analyzed incorporated actual data from current offshore European facility construction and operation. The results of the modeled 2,000-MW build-out between 2020 and 2030 show first that the LCOE for the initial offshore wind project, 16.2 cents per kWh, will be much lower than projects to date. Second, the study shows that costs continue to decline in subsequent builds, so that by the last tranche of a 2,000-MW pipeline of projects, the LCOE reaches 10.8 cents. According to the University of Delaware study, this result is in line with other studies that report costs and cost trends in Europe.

The offshore wind industry in Europe has realized significant cost reductions as the industry and supply chains have grown and matured. Analysis of projects installed or that reached final investment decision between 2010 and 2014 has indicated the LCOE of offshore wind projects installed in the United Kingdom decreased from £136/MWh to £121/MWh, representing an 11-percent reduction in LCOE (University of Delaware 2016).

In the January 2016 *Wind Power Monthly* David Milborrow (2016) indicated that the upward trend in offshore wind installation costs has halted, and that barring commodity shortages, the median installed cost for offshore wind will be about $5 million per MW. At the lower bound of installed costs, and assuming an average wind speed of 9 meters per second (30 feet per second), offshore wind's generating costs fall from the current ballpark figure of about $200 per MWh to about $150 per MWh, or from about 20 cents per kWh to about 15 cents per kWh. The commitment to construct utility-scale offshore wind generation will become a system benefit over time by introducing large quantities of comparably priced energy into local onshore load centers.

### 3.1.5 Guidance for Evaluating System Benefits from Offshore wind energy Production

When evaluating system benefits from offshore wind energy production in the context of the EIS, each of the criteria previously discussed should be considered. The current system configuration should be reviewed to see if it would be improved with the addition of offshore alternative energy generation. The proposed facility and the alternatives should then be evaluated against the above-listed criteria and the findings tabulated. The results would then be reviewed to compare the relative system benefits from each alternative.

This section has identified sources that represent a sampling of the available system information. The energy industry, energy trade organizations, and Federal and State governments prepare a variety of reports that should be reviewed for the most recent findings. For example, congested transmission corridor issues can change positively with the addition of new transmission pathways, or negatively with the addition of new renewable and non-renewable generation on an existing transmission line that currently has no congestion issues. Additionally, advances in technology and methods of construction can make installing offshore systems in deeper waters more attractive and feasible.

## 3.2 Environmental Benefits

Offshore wind power has environmental benefits such as very low carbon dioxide emissions over its life cycle, as well as negligible emissions of mercury, nitrous oxides, and sulfur oxides compared to conventional electrical power generation.[2] Also, wind power generation does not produce the solid or liquid wastes associated with electricity generated from coal, oil, natural gas, biomass, or nuclear power. Furthermore wind power does not rely on large sources of freshwater or sea water for cooling as conventional sources of power commonly do. More directly, the installation of offshore structures may benefit marine communities because additional hard substrate would be introduced in areas where hard substrate is limited.

The area surrounding an offshore wind energy project is likely to be restricted for shipping, commercial, and recreational boating. The impact of this restriction would be specific to the site and the safety regulations imposed. In Denmark, transit through offshore wind energy plants is possible via designated routes and has not caused any negative impacts on boat traffic (South Baltic Programme 2013). In Germany, boats can navigate as close as 500 meters (1,640 feet) from an offshore wind energy plant (except installation and service vessels) (South Baltic Programme 2013). Noise and shadow flickering would not be perceivable from shore and would have a minimal impact on vessels near the offshore wind energy plant (ARCARDIS 2010)To estimate the magnitude of a potential benefit, it needs to be considered in context because many environmental benefits need to have other, potentially unrelated events to occur for the benefits to be realized.

Section 3.2.1 identifies potential benefits in a variety of environmental disciplines typically evaluated in an EIS. Because such an evaluation can be complex and strongly affected by context, one effective way to begin considering environmental benefits is to use an LCA of the offshore wind energy project and the associated projects that may be displaced by the offshore project. Section 3.2.2 briefly describes the LCA methodology and presents some resources that can be used to conduct a limited LCA that could be included in an EA or EIS. Sections 3.2.3 and 3.2.4 focus on two environmental areas, water quantity and quality, and waste generation, respectively, because these are two environmental disciplines where maximum benefits may occur with the retirement of conventional thermoelectric plants, and the analyses are straightforward.

### 3.2.1 Potential Environmental Benefits

**Table 3-6** presents a partial list of potential benefits that could result from implementing an offshore wind energy generation project and that may need to be considered for inclusion in a NEPA analysis (EIS or EA). These benefits would include both direct and indirect benefits that could arise from various activities that might be associated with or result as a consequence of the offshore wind project. One group of potential benefits results from retiring older power sources that have emissions or discharges, generate wastes, and consume fuels. Another group of potential benefits results from developing local infrastructure to support an offshore wind project. The list in Table 3-6 is not a comprehensive compilation of all potential and expected effects, but rather a sampling of potential effects from a variety of different offshore alternative energy projects. However, as noted above, many of the benefits need to be viewed in context, as some of the benefits trade a removal of impacts from one area for the addition of impacts in other areas.

**Table 3-6. Potential Environmental Benefits from an Offshore wind energy Project**

| Topic | | Potential Benefit | |
|---|---|---|---|
| | | During Construction | During Operation |
| Water | Water Use | • No water use for dust control<br>• No need for hydrotest water for boilers or feed gas pipelines | • Displaces OTC from coastal thermal generating plants (coal, natural gas, fuel oil, nuclear)<br>• No water needed for wet cooling towers cooling water<br>• No water used to clean solar panels |
| | Wastewater Discharges | • No discharges of hydrotest water from boilers or feed gas pipelines | • No discharge of thermal effluent in OTC<br>• No discharge of concentrated blow-down water |
| | Wetlands | • No disruption of wetlands by construction of feed gas | |

| Topic | | Potential Benefit | |
|---|---|---|---|
| | | During Construction | During Operation |
| | | pipeline or other infrastructure | |
| Resources | Biological Resources | • Minimal fragmentation of habitat, e.g., access roads and pipeline corridors | • Additional hard substrate offshore in (likely) areas of relatively uniform, soft bottom substrate<br>• No impeded rivers (hydroelectric)<br>• Hard substrate may lead to more fish and increased biodiversity in local area |
| | Cultural Resources | • Identification of previously unknown submerged cultural resources | |
| | Recreation and Tourism | • Tourists traveling to see wind farms offshore | • Tourists traveling to see wind farms offshore |
| | Fisheries | | • Recreational fisheries increase due to greater (or at least more concentrated) fish resources<br>• Benefit to fisheries that use gear that would be especially well-suited for operation within a wind farm |
| Safety | Safety | | • Wind turbine generator structures could assist navigation in low-visibility situations by providing landmarks, both for boaters and the U.S. Coast Guard for search and rescue |
| Geology | Soils | | • No removal of sediments from stream systems (hydropower) |
| | Land Use | • Reduced need to condemn private property (except for power cable coming ashore) | |
| Public Health | Solid Wastes | | • No fly ash or bottom ash (coal-fired plants)<br>• No spent fuel rods (nuclear) |
| | Air Quality | | • Reduction or elimination of GHG emissions<br>• Reduction or elimination of criteria pollutant emissions<br>• No associated public health effects<br>• No volatile organic compounds/nitrous oxides, so no contribution to smog<br>• No particulate emissions, so no particulate matter of less than 10 microns, or less than 2.5 microns |
| | Noise | • Isolation of construction noise away from residences and population centers | • Isolation of operational noise away from residences and population centers |

### 3.2.2 Life-Cycle Assessment

LCA is a tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle (United Nations Environment Programme 2016). Using an LCA approach to consider environmental benefits from offshore wind is an effective method to compare substantially different types of energy projects. However, because a full LCA can entail considerable time and effort and require the acquisition of a substantial amount of data from a variety of sources, NEPA documents do not typically include an LCA. This section describes the key elements that go into an LCA and suggests key inputs that an EIS/EA author may wish to review when developing a benefits analysis for inclusion in a NEPA document. As discussed in Section 4, the comparison of LCAs for different power generators would likely fit within the alternatives analysis of the EIS/EA.

The life cycle of an energy-generation facility begins with the gathering of raw materials from the earth to create the product and ends when all materials are returned to the earth. LCA enables the estimation of the cumulative environmental impacts resulting from all stages in the facility's life cycle, often including activities not considered in more traditional analyses such as raw material extraction; material transportation; and ultimate disposal, decommissioning, and removal (EPA 2006). By including these activities throughout the facility's life cycle, LCA provides a comprehensive view of the environmental aspects of the product or process and a more accurate picture of the true environmental trade-offs when comparing different types of energy generators.

The most critical element of an LCA is the initial definition of the LCA goals and scope, including the all-important definition of the LCA boundary. Without proper goal and scope definitions, the output of the LCA is unlikely to satisfy the needs for which the LCA is being prepared. The scope (or encompassing boundary) defines what is included in the LCA analysis (and by exclusion, what is not). Improper definition of the boundary can leave significant energy and material flow outside of the analysis, or include extraneous elements that, while important in one application, may be inappropriate for consideration for another analysis. Including unnecessary items or excluding necessary items may introduce unintended bias in the LCA and limit the applicability of the final study to meet the intended goals of the LCA.

Key elements of the boundary decision are the limits in time and space from the entry into the boundary to the exit from the boundary. For example, there is an ever increasing degree of separation between the actual project (operation of an offshore wind plant or coal-fired power plant) and elements needed to develop the project, starting with energy and material use during facility operation, preceded by uses for construction of the project, preceded by manufacture of the construction materials from raw materials, and so on. This chain can continue backward until the relationship to the project is tenuous and the analytical precision is within the uncertainty bounds defined for the overall analysis. The same type of chain can extend into the future. The more tenuous the relationship becomes, the less important the incremental analysis element becomes to the LCA. Proper setting of boundaries in a NEPA analysis can lead to a well-balanced alternatives assessment and an effective EIS/EA.

For example, to compare the impacts or benefits of an offshore wind energy facility to an onshore conventional or renewable energy generator, the analyst would need to consider the methods and costs associated with fuel production (e.g., coal mining, natural gas production, nuclear fuel generation), water use and consumption (for dissipating waste heat), waste production, (e.g., coal fly ash, bottom ash, waste heat), and air emissions. These components and costs of the LCA for an onshore power generator can then be compared with similar components and costs for an offshore wind energy facility. **Table 3-7** summarizes the elements that may be considered in an alternatives analysis.

**Table 3-7. Elements Worth Considering in an LCA for Comparing Offshore and Onshore Energy Production Alternatives**

| Analysis Elements | Thermoelectric | | Renewables |
|---|---|---|---|
| | Fossil Fuel | Nuclear | |
| Raw material use for construction | X | X | X |
| Generation fuel extraction, processing, and delivery | X | X | |
| Generator and supporting structure | X | X | X |
| Electrical substation | X | X | X |
| On-shore transmission line to grid connection | X | X | X |
| Operation and maintenance resource use (fuel, energy, material) | X | X | [1] |
| Waste disposal (solid and liquid) | X | X | [1] |
| Highly hazardous waste disposal (solid and liquid) | - | X | - |
| Waste heat disposal system (wet cooling tower, wet once-through, dry) | X | X | [1] |
| Construction resource use (energy, material) | X | X | [1] |
| Greenhouse gas emissions | X | [1] | [1] |
| Operation and maintenance | X | X | X |
| Decommissioning | X | X | X |
| Demolition | X | X | X |
| Restoration | X | X | X |

[1] All electric-generation technologies produce waste heat, generate solid and liquid wastes, and consume energy during operations. For certain technologies, the energy use or waste generation rates per unit of electrical production are likely to be *de minimis* over the lifecycle of the facility. For these elements, screening analyses likely can be used to demonstrate *de minimis* input and/or output.

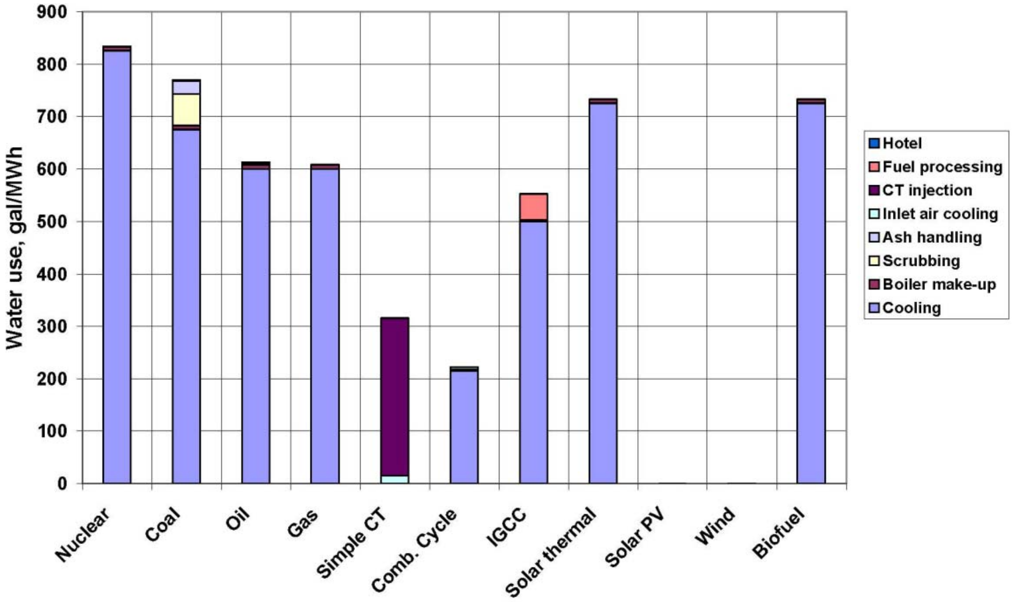
### 3.2.3 Water Quantity and Quality

Water is an important component in conventional electrical energy production. While water is used in thermoelectric plants in a variety of ways, it is primarily used for cooling purposes. Depending on the type of cooling system, there may be different types and quantities of water discharges. As discussed above, the introduction of offshore wind energy production may allow for the retirement of thermal power plants. The associated benefits to water quality from these potential retirements may include:

- Decreased impacts on the aquatic resources due to less cooling water being withdrawn (e.g., impingement and entrainment),
- Decreased thermal discharge, and
- Decreased adverse impacts associated with cooling towers.

The majority of power plants in the U.S. generate electricity by using steam to drive a turbine, which in turn drives an electric generator. In the context of quantifying the amount of water used for cooling, the term "water use" consists of two processes: withdrawal and consumption. Water withdrawal occurs when it is removed from a specific water source (e.g., lake, river, or ocean). In this case the water should not necessarily be considered permanently lost, as it is often returned to its original source. Water is consumed when it ceases to exist as a liquid through evaporation. While both water withdrawal and consumption values are important indicators for those determining power plant impacts on water resources, water use is the more general term and is used to refer to both withdrawal and consumption. Typically, water use is quantified in terms of a flow rate per unit of energy produced over time (e.g., liters or gallons per megawatt hour).

Two important considerations when assessing potential water quantity benefits are the type of power plant (i.e., by what primary source does the power plant generate energy) and design of the plant's cooling system. **Figure 3-7** below, based on information gathered from the Electric Power Research Institute (EPRI), suggests that there are substantial variances in water use among the different types of power plants: nuclear power plants use between approximately 3125 and 3220 liters per MWh (825 and 850 gallons per MWh); coal-fired plants use between approximately 2840 and 2930 liters per MWh (750 and 775 gallons per MWh); and renewable energy generation methods, such as wind, use minimal water (if any) during energy generation operations.



*Source: EPRI, Report 1014026, February 2008.*

**Figure 3-7. Water Use by Plant Type**

However, the cooling system employed at a power plant is often a better determinant of water use than the particular energy source generating electricity, both in terms of water consumption and water withdrawal (Macknick et al. 2012). Three main types of cooling processes are used in thermoelectric power plants: direct or OTC, recirculating or indirect cooling, and dry cooling. In addition, in an effort to minimize environmental effects and maintain thermal efficiency year-round, newer power plants are implementing a hybrid system of wet and dry cooling (World Nuclear Association 2015). Because direct and indirect cooling systems use water, the potential benefits of decreasing water use by generating energy from a renewable source vary substantially. For example, in an OTC system, water is withdrawn from a water source, such as a lake, river, or ocean, passed through a condenser, and then returned to its original source. In a recirculating or indirect cooling system, cooling water is pumped from the condenser to a “wet” cooling tower, where the heat of the water transfers to the ambient air by evaporation, lowering the temperature of the cooling water. The cooler water is then returned to the condenser, and the amount of water that evaporates in the cooling tower is replenished. Because of such water-use processes, indirect cooling systems consume up to 80 percent more water than OTC, but withdraw 95 percent less water than OTC systems (Natural Resources Defense Council 2014).

While various studies have attempted to consolidate estimates of water use impacts from electricity generating facilities, Macknick et al. (2012) provides a strong guide for conducting water use impact assessments (broken down by cooling technology), as well as identifies assumptions and potential limitations of statistical data generally used to characterize water use. In addition, Strzepek et al. (2012) establishes a methodological model for the withdrawal and consumption for thermoelectric systems and employs a framework that uses specific water-use rates obtained from USGS inventories and NREL reports. Such models can be used to characterize and quantify the potential water-reduction benefits of offshore wind energy production. Power sector water use data on a national level are collected by two Federal agencies: USGS and EIA. The USGS reports water withdrawals for thermoelectric power production by geography every 5 years, although the 2015 report is not yet published. In addition, EIA publishes official energy statistics on an annual basis, and EIA Form 923 reports, among other data, water withdrawal, discharge, and consumption rates in Schedule 8D (EIA 2016a). However, it is important to note that the data from both USGS and EIA are not entirely comprehensive and in the past have omitted nuclear facilities and some natural gas combined-cycle technologies.

USGS developed estimates of water use at thermoelectric power plants based on heat and water budgets that were complemented by EIA-reported thermoelectric water withdrawals and consumption. The heat- and water-budget models produced withdrawal and consumption estimates, including thermodynamically plausible ranges of maximum and minimum withdrawal and consumption, for 1,290 power plants in the U.S. for 2010. Total estimated withdrawal for 2010 was approximately 488 billion liters (129 billion gallons) per day, and total estimated consumption was about 13.2 billion liters (3.5 billion gallons) per day. In contrast, total withdrawal reported by EIA was about 24 percent higher than the modeled estimates, and total EIA-reported consumption was about 8 percent lower. Appendix 1 of the USGS report is a Microsoft Excel spreadsheet of estimated and reported water withdrawals and consumption for 1,290 power plants in 2010 and may be filtered by each plant’s respective EIA-assigned plant code, county, state, and water cooling system (Diehl and Harris 2014).

Accurate estimates of water use in individual power plants, and the effect of this water use on a regional scale, may be elusive until more studies are conducted for the technologies and cooling systems currently in operation, as well as those expected to be developed and deployed in the future. Furthermore, calibration of these values on national and regional scales will remain challenging until methods for collecting and evaluating data by Federal agencies has improved. Nonetheless, certain conclusions regarding the overall effect that power plants have on water resources can be drawn on regional levels from existing water use data. Published academic literature, State and Federal government agency reports, and non-governmental organization reports indicate that significant reductions in water use are achieved under the renewable technology portfolio (Macknick et al. 2012, Strzepek et al. 2012, World Nuclear Association 2015, IRENA 2016).

#### *3.2.3.1 Potential Reductions in OTC Water Use*

EPA has identified over 500 power plants in the country that use waters of the U.S. for OTC. Over half of all water withdrawn in the U.S. each year is for cooling purposes, with power generation being the largest user of cooling water. The withdrawal of cooling water by existing power facilities removes and kills billions of aquatic organisms from waters of the U.S. each year, including plankton (small aquatic animals, including fish eggs and larvae), fish, crustaceans, shellfish, sea turtles, and marine mammals. In addition, waste heat is discharged in the form of heated cooling water, which decreases oxygen supply and affects the ecosystem composition. In many cases, biocides are added to the cooling water to prevent fouling of the cooling water system.

Clean Water Act § 316(b) regulations under the National Pollutant Discharge Elimination System program have been implemented to reduce impingement and entrainment of fish and other aquatic organisms at cooling water intake structures. Reduction in flow-through volumes would also reduce thermal impacts on receiving waters.

The implementation of § 316(a) and (b) regulations requires that a thermal discharge not adversely impact the balanced indigenous population of the receiving water and that the cooling water intake use Best Technology Available to reduce impingement and entrainment. Thus, impacts on waters of the U.S. would be reduced but not eliminated. However, the § 316(b) regulation has a site-specific Best Technology Available requirement for entrainment that includes a cost-benefit determination. EPRI has investigated the implications of a potential EPA Clean Water Act § 316(b) rulemaking that would force plants with open-cycle cooling water systems to retrofit to closed-cycle cooling. In Report 1023401 National Benefits of a Closed-Cycle Cooling Retrofit Requirement (EPRI 2011a), EPRI determined that the costs of impingement and entrainment controls far outweighed the benefits. Because of the high cost of entrainment control technologies, many facilities will not be impelled to install any entrainment control; therefore, the new § 316(b) regulations for existing facilities may not significantly reduce entrainment.

#### *3.2.3.2 Potential Reductions in Water Consumption from Wet Cooling*

Power plants that have or plan to install closed-cycle cooling are considered to use Best Technology Available under § 316(b). Although wet cooling towers greatly reduce the amount of water withdrawn and thus reduce impingement and entrainment, they consume water and may also have a variety of adverse impacts. These impacts were studied in EPRI Report 1022760 Net Environmental and Social Effects of Retrofitting Power Plants with Once-Through Cooling to Closed-Cycle Cooling (EPRI 2011b) and include:

- Human health,
- Terrestrial resources,
- Water resources,
- Public safety and security, and
- Quality of life related to noise and visual impacts.

Because of evolving industry practices for compliance with the new § 316(b) regulations, developing a quantitative measure of the amount of cooling water reduction and existing cooling tower impacts, and then calculating the environmental benefit from that reduction, would be challenging. EPRI resources that could be consulted if a quantitative assessment were to be undertaken are listed below.

- Report 1022491: Closed-Cycle Retrofit Study (EPRI 2011c)
- Report 1022751: Evaluation of the National Financial and Economic Impacts of a Closed-Cycle Cooling Retrofit Requirement (EPRI 2011d)
- Report 1022760: Net Environmental and Social Effects of Retrofitting Power Plants with Once-Through Cooling to Closed-Cycle Cooling (EPRI 2011b)
- Report 1023174: Maintaining Electrical System Reliability Under a Closed-Cycle Cooling Retrofit Requirement (EPRI 2011e)
- Report 1023401: National Benefits of a Closed-Cycle Cooling Retrofit Requirement (EPRI 2011a)
- Report 1023453: Clean Water Act Section 316(b) Closed-Cycle Cooling Retrofit Research Program Results Summary (EPRI 2011f)
- Report 1025006: Program on Technology Innovation: Tradeoffs Between Once-Through Cooling and Closed-Cycle Cooling for Nuclear Power Plants (EPRI 2012)
- Report 1006786: Water and Sustainability (Volume 3): U.S. Water Consumption for Power Production—The Next Half Century (EPRI 2002)

In addition, information can be found in the documents that individual power plants file with regulators for compliance with the § 316(b) National Pollutant Discharge Elimination System permit renewal programs over the last two decades. Other resources to support this analysis are available from EPA, including a report on economic analyses, benefits analyses, the final regulations, and the fact sheet supporting the final regulations.

### 3.2.4 Waste Generation

Wastes can be produced by thermoelectric power plants from a variety of sources. The primary operational waste comes from the consumption of solid fuels (primarily coal) or the use of nuclear fuels and resulting production of ash or spent nuclear waste. Developing offshore wind energy would reduce hazardous, extremely hazardous, and nonhazardous waste generated during the construction, operation, and decommissioning of conventional thermoelectric projects.

Waste created by a typical coal plant includes more than 113,000 metric tons (125,000 short tons) of bottom ash and 175,000 metric tons (193,000 short tons) of fly ash from the smokestack scrubber each year. Nationally, at least 42 percent of coal combustion waste ponds and landfills are unlined (Union of Concerned Scientists 2016).

EPA's final rule on Disposal of Coal Combustion Residuals (CCR) from Electric Utilities was signed on December 19, 2014, and after public review, the final rule became effective on October 4, 2016. The result of the new rule was to establish technical requirements for managing CCR landfills and surface impoundments. One practical consequence of this and related regulatory efforts is additional pressure to reduce the production of CCR, primarily fly ash, and bottom ash by retiring coal-fueled power plants for natural gas or renewable energy generation facilities.

Analogously, a typical nuclear power plant produces approximately 27 metric tons (30 short tons) of used fuel (spent fuel) per year. Disposing of spent nuclear fuel is especially challenging because even after thousands of years, it is still radioactive. While substituting offshore wind for nuclear power generation would remove the problem of generating new spent nuclear fuel, both technologies produce little or no GHG during normal operations; therefore, there is no net benefit with respect to GHG reduction. On the other hand, as noted above, nuclear power is a substantial user of water in OTC systems with the associated impacts on impingement, entrainment, and water temperature.

Trying to quantitatively assess the benefit of offshore wind project in terms of waste reduction from onshore generators, especially coal and nuclear fuels, can be challenging because of the ongoing efforts to retire those facilities that are the largest generators of such wastes. The public pressure and regulatory drivers for waste reduction that are unrelated to offshore wind development should be acknowledged to avoid taking credit for multiple programs. This continuingly evolving baseline will require a review of which facilities should be included in the list of facilities being retired and include their current waste generation profiles.

Conducting an LCA can be useful in defining types and quantities of wastes that should be evaluated in a benefits analysis. As noted in Section 3.2.2, the scope of the LCA should include construction, operation, maintenance, and decommissioning of equipment and facilities. Wastes from offshore wind or other renewable generation sources would occur primarily during construction and decommissioning, while wastes from coal and nuclear would occur most during operation, which would include disposal.

Conducting an LCA for a coal or nuclear facility would require identifying the current wastes being generated and reported. That information is available in a number of data sources, in particular EIA's monthly and annual reports on environmental information (EIA 2016a). This database provides information on items such as fly ash and bottom ash production and disposal, as well as nuclear fuel consumed annually. These facilities may also generate other wastes, which should be noted in the LCA. It is possible that these other wastes could be similar to those generated by an offshore wind energy facility since both types of facilities would need to undergo regular maintenance. However, because of the much greater simplicity of the wind facility, it is likely that the wastes from that facility would be substantially less than for a more complex thermoelectric generation facility.

## 3.3 Socioeconomic Benefits

This section provides general guidance for conducting a socioeconomic assessment, with additional guidance on beneficial effects that could be attributed to offshore wind projects and a discussion on conducting an economic impact analysis. An overview of socioeconomic assessments is provided in Sections 3.3.1 and 3.3.2; Section 3.3.3 presents potential social benefits of offshore wind, Section 3.3.4 discusses potential economic benefits of offshore wind, and Section 3.3.5 describes tools available to conduct an economic impact analysis and explains the advantages and limitations.

### 3.3.1 Overview of Socioeconomic Analysis

Socioeconomic assessments are useful for understanding the social and economic consequences of projects, programs, and policies. Although NEPA does not specifically require a socioeconomic assessment, NEPA does require an integrated use of the social sciences to assess impacts on the human environment. According to 40 CFR 1508.14:

> *Human environment* shall be interpreted comprehensively to include the natural and physical environment and the relationship of people with that environment. This means that economic or social effects are not intended by themselves to require preparation of an environmental impact statement. When an environmental impact statement is prepared and economic and social and natural or physical environmental effects are interrelated, then the environmental impact statement will discuss all of these effects on the human environment.

Several Federal and State agencies have developed guidelines for conducting a socioeconomic assessment. Most of the guidance has been developed for transportation projects, and there is no official Federal or State guidance specific to renewable energy projects. **Table 3-8** presents a list of resources for conducting a socioeconomic assessment.

**Table 3-8. Existing Guidance for Conducting Socioeconomic Assessments**

| Title | Agency |
|---|---|
| Other Social Effects: A Primer (2013) | Institute for Water Resources |
| Guidelines and Principles for Social Impact Assessment (1994) | National Marine Fisheries Service |
| Guidance for Social Impact Assessment (2007) | National Marine Fisheries Service |
| Guidebook for Assessing the Social and Economic Effects of Transportation Projects (2001) | National Cooperative Highway Research Program |

| Title | Agency |
|---|---|
| Socioeconomic Guidance Manual, A Practitioner’s Guide (2010) | New Jersey Department of Transportation |
| Community Impact Assessment: A Quick Reference for Transportation (1996) | Federal Highway Administration |
| Environmental Manual – Chapter 458 (2016) | Washington State Department of Transportation |

### 3.3.2 Process for Conducting Socioeconomic Assessment

A socioeconomic assessment is helpful to understand how impacts from a project can affect a community. The socioeconomic assessment typically consists of a social benefit analysis and may incorporate an economic impact analysis.

An economic impact analysis focuses on how a particular economy is likely to change from a project (e.g., the investment in an offshore wind energy plant), whereas a social benefit analysis measures the wider benefits to society. An economic impact analysis is useful for demonstrating the economic benefits of the project. Economic impact analyses use the change in expenditures to estimate how the project would affect economic activity, measured as employment, labor income, value added, output, and tax revenues.

A social benefit analysis identifies potential impacts and benefits and evaluates the implications for demographic and community concerns. It considers the characteristics of the population and communities that would be affected by the project, and how they might be affected.

The socioeconomic assessment uses both components to determine if society would be better off with or without the offshore wind energy project.

The process for conducting a socioeconomic assessment includes the following steps:

1. Develop a baseline community profile,
2. Identify the socioeconomic impacts from the project,
3. Evaluate impacts, and
4. Assess the cumulative socioeconomic effects of the project.

#### *3.3.2.1 Develop a Baseline Community Profile*

To develop the baseline, it is important to delineate the study area and identify the population and community that would be affected by the project. The community may be local, regional, national, or international, depending on the particular social benefit being evaluated. The area and populations being considered for socioeconomic effects may extend beyond a specific region selected for an economic impact analysis. The 2012 BOEM report titled, *Atlantic Region Wind Energy Development: Recreation and Tourism Economic Baseline Development* should be referenced for additional guidance on creating a baseline community profile (BOEM 2012).

The baseline data collection exercise should focus on compiling information on factors that are likely to be affected by an offshore wind energy project. Typical factors to be considered are shown on **Figure 3-8** and listed below.

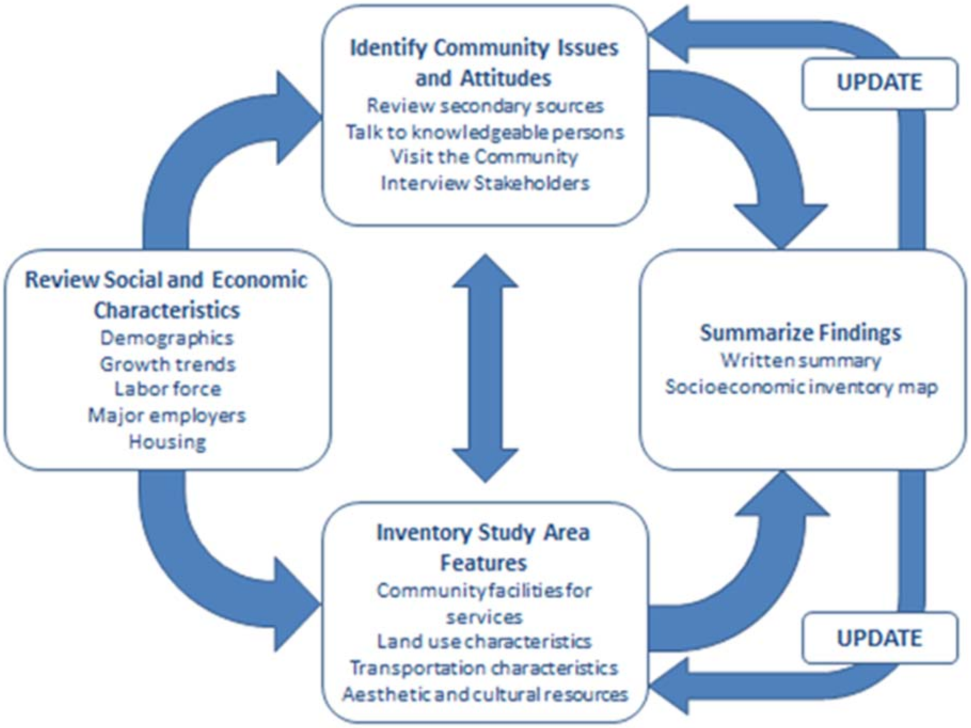


**Figure 3-8. Baseline Data Collection Factors**

*Source: Florida Department of Transportation*

Demographics

- Ethnicity and race
- Age
- Income levels (household, per capita, poverty)
- Labor status
- Special population subgroups (i.e., children, elderly, disabled)
- Households length of tenure
- Housing availability, age, and type; ownership versus rental
- Occupancy/vacancy rates

Economic Base

- Employment
- Businesses

- Property tax base

Community Facilities and Infrastructure

- Community centers/activity centers
- Infrastructure (e.g., roads, transit, and water and sewerage systems)
- Public services and facilities (e.g., schools, police stations, fire departments, libraries, and emergency medical services)
- Special areas, historic districts and parklands
- Focal points or informal meeting places (e.g., places of worship, playgrounds, and laundromats)

Information needed to profile the baseline conditions of the study area can be gathered from the U.S. Census Bureau, U.S. Bureau of Economic Analysis, U.S. Department of Education, State economic development agencies, local government agencies (e.g., planning departments), local chambers of commerce, local schools and libraries, and other public and private institutions that publish data on their communities. While reviewing the data, it may be possible to define measurable indicators of valued socioeconomic components, such as a particular industry that employs a majority of the community.

#### *3.3.2.2 Identify the Socioeconomic Impacts of the Project*

Socioeconomic impacts can vary from desirable to unfavorable and can range in magnitude from temporary minor impacts to major impacts that have a significant and lasting impact on the community. Certain impacts may be prevalent only during the construction phase of a project and may no longer occur once the project progresses into its operational phase. It is also important to consider the distribution of impacts across different populations, especially vulnerable segments of the population.

To identify the socioeconomic impacts from the project, the baseline (no action alternative or without-project conditions) is compared to the conditions with the project in place. The incremental impacts are evaluated as either positive or negative benefits. For example, if the baseline is developing additional natural gas-fired electricity generation to meet energy needs, then the incremental impacts of developing an offshore wind energy project would be the difference between what would be expected from additional natural gas-fired electricity generation and the offshore wind energy project. Impacts may be measured along each segment of the value chain (i.e., project planning, manufacturing, installation, operation and maintenance, and decommissioning).

From a social perspective, the analysis should consider whether the project would separate or set apart groups or disrupt the community. The assessment will also draw upon the analysis of property acquisitions with due consideration given to whether neighborhoods may be directly or indirectly affected by displacement and relocation, if any, of residents or community facilities. Community outreach is helpful for identifying socioeconomic impacts and understanding the concerns and objectives of each community and how these may be affected by an offshore wind energy project. The significance of the social impacts is based on the estimated magnitude of impacts and importance to the affected communities. Community outreach can be conducted to engage local and regional agencies, officials, special interest groups, and private citizens.

#### 3.3.2.3 Evaluate Impacts

In general, comparing the socioeconomic data of the study area to the surrounding city or county and establishing a threshold or benchmark is a popular method of qualitatively assessing socioeconomic data. For example, if the poverty level within the study area is higher than levels in the county, then it could be reported that residents in the study area have lower incomes and higher poverty levels compared to residents in the surrounding region.

In many cases, it may not be possible to quantify a benefit because there are not sufficient data or the nature of the benefit may not lend well to quantification. For benefits that cannot be readily measured, a qualitative assessment can be useful. Qualitative assessments are focused on gaining an understanding of how a project, program, or policy affects a particular community and to uncover prevalent trends in opinions. They may also provide insights of underlying reasons and motivations. Qualitative assessments may include detailed descriptions of situations, interactions, and observed behaviors. Direct quotations may be used to demonstrate the experiences, attitudes, beliefs, and thoughts of the community. Assessing a benefit qualitatively may be based on interviews, community outreach, observations, or articles relevant to the project and the affected communities. The British Government developed a framework and quality indicators for qualitative research (HM Treasury 2012). The results of the qualitative assessment contribute to a greater understanding of the project, policy, or program for further decision making.

Some benefits of the project may be monetized using economic methods, such as revealed preference, stated preference, and benefits transfer approaches. It is important to avoid double-counting when assessing the value of a resource as there may be some cross-over. Tools and methods should be selected based on available data, resources, timeline, and financial limitations

#### 3.3.2.4 Assess the Cumulative Socioeconomic Effects of the Project

In addition to assessing the direct and indirect effects of a project, a robust socioeconomic assessment also warrants an examination of cumulative effects. Cumulative effects encompass all effects related to a project, both direct and indirect, as well as effects of any other actions that may affect the environment in the area under study. The cumulative effect of a project is defined as “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions” (40 CFR 1508.7). Actions to be considered in a cumulative effects assessment include not only previous or future actions of the agency sponsoring the project, but actions of other government agencies, private citizens, and corporations, which may be either related or unrelated to the proposed project.

Assessing the cumulative impacts would require developing a list of all other past, present, and future actions and identifying the impacts of each project, which is typically done in consultation with the project teams or the sponsoring agencies. The nature of impacts from the other projects are then documented and presented as part of the socioeconomic assessment report.

The results of the social benefit and economic impact analyses should be considered together to evaluate the overall implications of the findings. Each impact would be presented as an indication of the magnitude of the effect on social welfare and community cohesion.

The results may or may not support moving forward with the project, depending on what is in the best interest of the communities that would be affected. In the case of multiple alternatives being evaluated, the results may be used to support a particular alternative over the others.

### 3.3.3 Potential Social Benefits of Offshore Wind

Compared with traditional energy generation, renewable energy can have both positive and negative social benefits. In most cases, social benefits are described and assessed qualitatively. It is important to describe the specifics of how these benefits would relate to the community that would be affected. Quantifying and monetizing the social benefits of an offshore wind energy project can be complex. Knowledge of economics is useful for identifying appropriate methods, preparing robust modeling, and making suitable assumptions. When monetizing benefits, it is anticipated that certain variables will have a range of potential values. To account for this uncertainty, a probability function can be assigned, and Monte Carlo simulations can be performed. During each iteration of a simulation, a different value is assigned to each variable based on the respective probability distribution. The results provide decision-makers with information on the probability of obtaining a specific outcome. When a benefits transfer approach is employed, it is important to adapt the estimate of benefits from other contexts to the project and to ensure that the values are adjusted for inflation to current dollars. When appropriate, techniques for measurement, expressions of output, and data sources are provided.

#### *3.3.3.1 Energy Reliability*

Offshore wind energy resources provide greater energy independence from foreign nations, and can be a physical hedge against volatile and uncertain future fuel prices and changes in emissions policy. Thirteen out of 28 coastal states import electricity from out of state to support demand, and also have the highest electricity prices in the country (EIA 2016c). Offshore wind energy plants would allow these states to generate power internally and increase control over their energy supply. Moreover, renewable energy cannot be depleted, whereas conventional energy sources based on fossil fuels have a limited supply. As long as the wind is blowing and the turbines are in operation, energy is generated.

Scientists forecast that as climate change progresses, extreme weather events will be more likely to occur and/or more likely to be severe (EPA 2016b). Having a more decentralized energy system can provide greater resilience from natural disasters. Centralized energy grids are vulnerable to disruptions after a natural disaster. Decentralized energy creates redundancies in the power system that can disconnect from the grid experiencing an outage and provide energy until the main grid is back online. A decentralized system also offers the opportunity to provide power to designated critical infrastructure first, whereas with a centralized system, it is not possible to differentiate end users (Warner 2011). These capabilities also allow utility companies to be more strategic and efficient when deploying resources to repair and restore service (DeBlasio 2012).

#### *3.3.3.2 Transmission and Distribution*

Offshore wind plants lose less energy because they have greater transmission capacity and distribution efficiency than conventional electricity sources. Transmission losses can be less than 4 percent for offshore wind (Kilisek 2015), whereas conventional electricity generation has transmission and distribution losses of about 6 percent on average (EIA 2016b). This lower loss means that more of the power generated is ultimately delivered to the end user.

Locating offshore wind energy near highly populated coastal areas reduces grid congestion, and as an alternative to long-distance transmission, reduces the need to build new transmission lines. The capital costs for planning, constructing, and maintaining the transmission and distribution system contributes to the cost of electricity. According to EIA, about 25 percent of the average price of electricity is for distribution and 9 percent is for transmission (EIA 2015). Additionally, transmission and distribution lines create changes in the landscape, can restrict land use, and cause environmental impacts to plants and animals (EPA 2014). If a new transmission corridor were planned for a region and an offshore wind project would eliminate the need for the corridor, the avoided capital and socioeconomic costs of building the new transmission corridor would be a benefit of the project.

#### *3.3.3.3 Electricity Prices*

The Block Island Wind Farm, launched in December 2016, is the first offshore wind energy plant in the U.S. The 30-MW plant comprises five turbines and is located off the Rhode Island coast. Before the Block Island Wind Farm was built, there was no mainland cable connection, and Block Island was reliant on diesel-fueled generators for electricity (EIA 2016d). Increased summer demand coupled with high fuel prices had caused Block Island’s electricity costs to rise to almost six times the national average in the past (EIA 2016d). The Block Island Wind Farm is expected to reduce island electric rates by 40 percent (Deepwater Wind 2016).

Depending on a variety of factors, the incorporation of the energy from offshore wind project may affect electricity rates. Generally, coastal states pay higher electricity prices than inland states. According to EIA, the average electricity price for all sectors was 10.83 cents in August 2016; the average electricity prices for New England, Mid-Atlantic, Pacific contiguous, and Pacific noncontiguous states were all higher than the national average (EIA 2016e). Hawaii has the highest electricity price, followed by Alaska, California, Connecticut, Massachusetts, Rhode Island, New Hampshire, and New York. Offshore wind energy may become more cost-competitive in these coastal states with high electricity rates sooner than other areas. Based on the offshore wind energy cost analyses and projected deployment levels of offshore wind, it is expected that offshore wind energy could be cost-competitive in markets with relatively high electricity rates within a decade (DOE and DOI 2016).

Some utilities offer optional “green pricing,” which is a premium paid for electricity for the incremental cost of supplying additional renewable energy. The green pricing allows utilities to purchase or generate more power from renewable energy sources. This premium represents the attributes of renewable energy that incite some ratepayers to pay more for renewable energy development. According to DOE, EERE, nearly 850 utilities offer green pricing options (DOE, EERE 2015).

The impact of an offshore wind project on electricity prices should be considered in the socioeconomic assessment. The social benefit analysis evaluates the impact on society when electricity prices change. If electricity prices rise, it may affect low- and moderate-income households more because electricity is likely a higher percentage of household income, and these populations may not be able to sufficiently decrease electricity use or invest in more energy-efficiency measures to reduce electricity consumption. Conversely, if electricity prices decrease, this creates a benefit for the ratepayers.

The overall impact of a price change can be measured by forecasting the current electricity prices over the life of the offshore wind project (20 to 25 years) and comparing these prices with the electricity prices projected with the offshore wind project. The project may supply an entire region or may be distributed directly to end users. The prices that the ratepayers would pay and the number of ratepayers that would be affected by the price change would be used to estimate the price effect. EIA publishes an *Annual Energy Outlook* report each year that forecasts electricity prices 25 years into the future by sector and region. This report can be used to develop the baseline of electricity prices. The forecasted prices with the offshore wind energy project depends on the size of the offshore wind energy plant, where the electricity would be delivered, the owner of the project (e.g., utility, local government, private developer), who is purchasing the power, and the wholesale price. The incremental increase/decrease in electricity prices would be estimated over the project life and multiplied by the estimated number of ratepayers for each corresponding year. The number of ratepayers is likely to cover a much larger area than the immediate region surrounding the project being considered for an economic impact analysis. Each year would be discounted to obtain the present value of the electricity price change.

#### 3.3.3.4 Human Resource Development

The European Wind Energy Association (EWEA) estimates that the offshore wind energy sector in Europe will create 134,000 direct and 169,500 indirect jobs by 2020, leading to a demand for appropriately skilled workers (EWEA 2011). The offshore wind industry in Europe is expecting a shortage of engineers, operation and maintenance technicians, and project managers (EWEA 2011). As the offshore wind industry develops in the U.S., the need for more skilled workers will expand. This increase in demand will present an opportunity to develop human resources that may lead to new college course offerings, apprenticeships, and specialized academic and industrial training programs, similar to what happened in Europe. DOE indicates that many of the jobs will potentially be located in economically depressed ports and shipyards (DOE, EERE 2012). There is also potential growth in the shipbuilding industry as the need for specialized offshore wind vessels increases. The opportunity for workers to gain specialized skills can lead to higher incomes, and as the labor force quality improves, economic growth will ensue.

#### 3.3.3.5 Community Investment Programs

Offshore wind developers may consider offering community benefits beyond clean power and tax revenues to facilitate public acceptance of a project and create a perception of equity. The community may be offered the opportunity to invest in an offshore wind energy plant and share in the proceeds. Compensation may be offered to fisherman to offset potential or perceived losses. A fund may be established for community groups, activities, or infrastructure. The magnitude of the community investment program benefit will depend on the scope of the program.

#### 3.3.3.6 Property Values

Coastal property values in the viewshed of an offshore wind energy plant may experience an increase, decrease, or no change. Changes to property values also change the associated property taxes, which would have implications for the local government that relies on taxes and other revenues to maintain government services. The hedonic price method can be used to estimate the value of a property that could be attributed to an offshore wind project. A more detailed explanation for how to conduct a hedonic pricing analysis with case studies is available from Cornell University (Monson 2009). The estimated change in property values and the number of houses affected can be used to estimate the total impact on the community. If property values increase or decrease, the change in property taxes can be estimated using the local property tax rate.

#### *3.3.3.7 Visual Amenity*

In the viewshed of the offshore wind project, some may interpret the visual changes of adding an offshore wind energy plant positively, negatively, or indifferently. Visual amenity is subjective. Contingent valuation can be used to monetize the visual amenity loss or gain. The economic value of the visual amenity is a measure of an individual’s preferences, expressed as either their willingness to pay for an improvement or to avoid a loss or their willingness to accept compensation to forgo an improvement or tolerate a loss. An unbiased questionnaire would be designed to survey a random sample of individuals or households in the community where the project would be located. Respondents would be asked about their willingness to pay for (or willingness to accept) a hypothetical change in visual amenity (pertaining to the offshore wind project). For waterfront properties in the viewshed, any visual amenity loss would be captured by performing a hedonic price method analysis. Thus, it is important to avoid double-counting when assessing property values and visual amenity separately. For more information on contingent valuation, see *Contingent Valuation: A User’s Guide* written by Richard T. Carson (2000).

#### *3.3.3.8 Environmental Externalities*

Externalities are consequences of activities that affect other parties and are not accounted for in the cost of the goods or services produced. For example, conventional electricity generation from fossil fuels produces more air pollution than any other industry. The air pollution is an environmental externality that is not accounted for in the cost of the electricity. Offshore wind can reduce negative environmental externalities associated with conventional electricity generation. Sulfur dioxide emissions contribute to acid rain, nitrous oxides emissions contribute to urban smog, and carbon dioxide emissions and other greenhouse gases contribute to climate change. Nitrous oxides emissions also contribute to ground-level ozone and particulate matter. Ozone can cause agricultural damage and adverse health effects. Ozone and particulate matter from conventional electricity generation can also cause illness and premature deaths, particularly for the elderly and children. DOE is working to rigorously quantify the health benefits associated with developing offshore wind energy instead of conventional energy sources for various development scenarios, and possibly a variety of relevant spatial and temporal scales (DOE and DOI 2016). Each of these environmental externalities can be measured and monetized.

The National Ambient Air Quality Standards (NAAQS) for six of the most common air pollutants – namely ground-level ozone, particulate matter , sulfur dioxide, nitrogen dioxide, carbon monoxide, and lead – are not set at a zero risk level, but at a level that reduces risk to human health and welfare with an adequate margin of safety (EPA 2015).

EPA raised standards for ground-level ozone to 70 parts per billion averaged over 8 hours. As of February 13, 2017, many of the counties in California and the East Coast from Massachusetts to

Maryland do not meet the 2015 Ozone Standard (EPA 2017). These areas are also relatively near offshore wind resources. Improvements in air quality by shifting from high-emission energy sources (such as coal) to offshore wind can assist in meeting NAAQS requirements and reducing health implications.

The amount of electricity generated by the offshore wind project would offset electricity generation from a particular resource that would be built alternatively to add supply to the overall system. Depending on what the alternative energy source would be, the emissions profile from that alternative source would be used to determine the quantity of emissions that would be offset. Because offshore wind is a zero-emission electricity source, all of the emissions from the alternative source would be offset. These offset can be estimated annually over the life of the project (20 to 25 years).

Many resources are available to assist with monetizing the social costs of the air emissions that would be avoided. For the social cost of carbon dioxide, the U.S. Government Interagency Working Group on Social Cost of Carbon provides guidance and monetized values by year in the technical support document (revised July 2015) (Interagency Working Group on Social Cost of Carbon, United States Government 2015).

Another user-friendly resource is the Muller and Mendelsohn article, “Weighing the Value of a Ton of Pollution,” which provides the marginal damage cost of sulfur dioxide, nitrogen oxides, and particulate matter emissions by quantile, along with maps of the U.S. depicting the distribution of marginal damage for fine particulate matter and sulfur dioxide for emissions from ground-level sources. The map can be used to understand where lower and higher sources are located. As expected, sources in the lower percentiles of the distribution are in rural areas in the western U.S., and sources whose emissions produce the largest marginal damage are located in the largest metropolitan areas. Although the document is intended for a market-based regulatory system, it can be used to monetize the social cost of air emissions (Muller and Mendelsohn 2010).

Each year, the U.S. Department of Transportation provides guidance for monetizing social values related to transportation projects. This guidance is related to the Transportation Investment Generating Economic Recovery grant program, and the most recent guidance for monetizing air emissions was updated in February 2015.

Another environmental externality to consider is the avoidance of potential hazardous spills. Compared with conventional energy generation, offshore wind energy plants are less prone to accidents. For example, if a tsunami or earthquake would occur, offshore wind energy would not cause oil spills or radioactive waste spills. This avoidance could be a project benefit, depending on the baseline electricity generation source that would be replaced or developed.

#### *3.3.3.9 Commercial Fishing*

Commercial fishermen may be concerned that an offshore wind energy project may impact fishing reserves. Engagement, consultation, and coordination with the commercial fishermen that may be affected by the project are imperative for identifying concerns and working together to establish a mutually beneficial plan. Mitigation options may include fisheries resource enhancement, business improvements (e.g., capital investments and other opportunities for fishermen), and financial compensation for lost access and/or habitat impacts (Moura et al. 2015). Commercial fishing impacts are specific to the location of the offshore wind energy project and the commercial fishing industry that operates in that area.

#### *3.3.3.10 Tourism, Recreation, and Navigation*

Although some people may fear that an offshore wind energy project would reduce tourism, representative studies have shown no decrease in the number of tourists after construction of an offshore wind energy plant (Benkenstein et al. 2003). It is actually possible that an offshore wind energy plant may attract tourism and become a differentiator from other beach destinations. Many offshore wind sites in Europe have already capitalized on using wind energy plants as a tourist attraction by creating offshore information centers with exhibitions, lectures, and traveling exhibitions via boat, viewing platforms with telescopes, information boards, boat tours, sightseeing flights, routes for motor and sail boats to view the wind energy plant, and offshore restaurants and merchandising products (South Baltic Programme 2013).

#### *3.3.3.11 Cultural Resources*

A cultural resource study would be helpful for understanding the magnitude of the potential impact of the offshore wind energy project on cultural and historic resources. Historical preservationists may be concerned about historic properties that could be hindered by an offshore wind energy project. BOEM created a Microsoft Access database and an ArcGIS geodatabase of known cultural resources and historic properties that could be impaired by the introduction of an offshore wind energy plant along the East Coast of the U.S. (Klein et al. 2012).

The offshore wind energy project may impact a tribal cultural landscape. BOEM provides guidance for characterizing tribal cultural landscapes (BOEM 2016b).

### 3.3.4 Potential Economic Benefits of Offshore Wind

At each phase of offshore wind energy development, there is the potential to generate economic benefits locally, regionally, nationally, and/or internationally, depending on the extent to which these geographic areas can deliver the materials and skills necessary to develop offshore wind energy. Imported materials and services into the particular region being assessed represent lost opportunities for local production and employment. As the offshore wind energy industry advances in the U.S., more opportunities for domestic value can be created along the value chain and for supporting services. Supporting services may include consulting services, financial services, education and training, and research and development. Economic benefits can be measured from project planning, manufacturing, installation, operation and maintenance, and decommissioning of wind turbines.

#### *3.3.4.1 Project Planning*

Project planning is the first step for an offshore wind project. Planning is a process of gathering information, analyzing the information, making decisions for the project, and managing risk. Project planning typically includes resource assessments, siting, permitting, community engagement, financing, and concept engineering. Project planning may include consulting services and financial services outside of the project team. Procured services and materials create economic impacts.

### 3.3.4.2 Manufacturing and Supply Chain

The manufacturing process, from raw materials to rotor blades, towers, and nacelles, can generate value nationally, or internationally if the materials are imported. At this time, Europe leads the world in offshore wind installations, and the top offshore wind turbine manufacturers are Siemens (global company based in Germany), Adwen (global company based in Europe), Vestas (global company based in Denmark), and Senvion (global company based in Germany) (EWEA 2016). However, it is worth noting that the wind turbines for the Block Island project were made by Alstom which has been acquired by GE Renewable Energy.

The nascent offshore wind energy market in the U.S. has the potential to expand the manufacturing capabilities and economic activity from domestic supply chains and create new manufacturing jobs in the U.S. to support offshore wind energy. Land-based wind turbines were initially adapted for early offshore wind energy installations. The turbine, tower, and blades of offshore turbines are generally similar to onshore turbines, but the substructure and foundation systems are quite different (BOEM 2016c). A limiting factor is how the wind turbine components would be transported overland to ports, since these components are much larger than onshore wind turbines (DOE 2013). Currently, there are over 500 manufacturing facilities in 43 states producing over 8,000 components for wind turbines, including eight utility-scale blade factories, nine tower facilities, and four turbine nacelle assembly facilities across 15 states (AWEA 2016). In 2015, 88 percent of the land-based wind energy capacity installed domestically used a turbine manufacturer with at least one U.S. manufacturing facility (AWEA 2016). The top land-based wind turbine manufacturers in the U.S. are GE Renewable Energy, Vestas, and Siemens (AWEA 2016).

The offshore drilling industry for oil and gas also has the potential to transfer skills to offshore wind development. For example, Gulf Island Fabrication, Inc., based in Houma, Louisiana was contracted for the fabrication of five jacket/piles for the Block Island Wind Farm. Gulf Island Fabrication, Inc. is a leading fabricator of offshore drilling and production platforms and other structures used in the development and production of offshore oil and gas reserves (4COffshore 2014). As more projects come online, the U.S. offshore wind market will accelerate to accommodate the demand. Innovation and design continue to evolve for the current offshore wind turbine industry, and the opportunity to reduce costs is significant. The offshore turbine market and the timing of an offshore wind project, in addition to the location, scale, financing, and associated partners, will contribute to determining how and where offshore wind turbines and other components will be procured.

### 3.3.4.3 Installation

Installation and grid connection requires civil engineering, site preparation, foundation installation, assembly, cabling, and skilled grid operators, potentially upgrading grid infrastructure. Foundations and cables are typically installed the first year of construction, and then installation and commissioning of turbines occurs the following year; however, the length of the construction period may be shorter or longer depending on the size and complexities of the wind energy plant (Renewable UK 2014). Installation of the cable connecting the onshore and offshore substations is considered a significant constraint because there is currently a limited supply of vessels available and few companies with the expertise required (The Crown Estate 2015). A construction port is necessary for an offshore wind energy plant for pre-assembly and construction. Location and size of the construction port dictate the size of the turbines that can be accommodated, shipment time, and sensitivity to weather windows (The Crown Estate 2015). While many of the resources required for installation and grid connection may be sourced near the site of the offshore wind energy plant, specialized equipment and expertise would be required from outside of the immediate region until increasing demand leads to the creation of more local expertise and resources, such as specialized vessels, for the offshore wind energy industry.

#### 3.3.4.4 O&M

O&M activities continue throughout the lifespan of the project, creating long-term jobs for remote monitoring, inspections, and repair services. Maintenance activities include visual inspections, hydraulic checking of key bolted joints, lubrication, end-to-end checks on proper operation of the safety and emergency systems, replacement of consumable parts, and cleaning. A port facility (either onshore or offshore, depending on the distance of the turbines from shore) is necessary to accommodate offshore wind operation and monitoring personnel and local services for fuel and vessels. The nearest port that meets the needs of the wind energy plant would be used to minimize the delay in responding to operation and repair needs. A 500-MW wind farm may employ up to 100 people and require around seven vessels, depending on the distance to shore (The Crown Estate 2015). An offshore facility for technicians would reduce transit time significantly, and may be more cost effective, depending on the distance to shore or the nearest suitable port facility. Offshore facilities for a 500-MW wind farm may employ around 30 technicians (The Crown Estate 2015).

Wind turbines are typically under warranty for the first 5 years, and the manufacturers would undertake the O&M activities during this period. Major repairs may be procured from the wind turbine manufacturer after the warranty period expires. The number of staff and number and size of vessels required for a maintenance crew depends on the size and requirements of the wind energy plant. A 500-MW wind energy plant may employ up to 100 people and require seven vessels, depending on the distance to shore (The Crown Estate 2015). There are presently training programs at local community colleges and universities in Massachusetts, Delaware, and Maryland to teach workers the skills necessary to work in the offshore wind industry. The Block Island Wind Farm attracted funding to support the Building Futures Energy Training Partnership to train and develop the local workforce to place entry-level and dislocated workers into wind energy careers (Rhode Island Economic Development Corporation [RIEDC] 2010).

#### 3.3.4.5 Decommissioning

Offshore wind turbines are designed to operate for 20 to 25 years. At the end of the lifespan, the components of the offshore wind energy facility need to be deconstructed (essentially the reverse of construction activities), and may be resold, recycled, and/or disposed. The first decommissioning of an offshore wind plant occurred in 2016 in Kalmar Sound, Sweden. For this particular wind energy plant consisting of five NEG Micon 2-MW turbines, decommissioning took 2 months (Hassel 2016). Decommissioning costs (excluding transmission assets) vary widely depending on the foundation technology deployed, and are estimated to be roughly half of installation costs, or between $100,000 and $160,000 per MW in 2010 dollar terms (Kaiser and Snyder 2010).

#### *3.3.4.6 Block Island Wind Farm Example*

It was estimated that approximately 22 percent of the total capital costs for the Block Island Wind Farm would be invested in Rhode Island: 10 percent of the engineering design, 12 percent of the fabrication and supply, 60 percent of the offshore installation costs, 75 percent for project management and inspection, and 90 percent for development (RIEDC 2010). The Block Island Wind Farm was estimated to produce direct economic benefits to Rhode Island of $107 million in constant 2010 dollar terms and $92 million in net present value terms (RIEDC 2010).

### 3.3.5 Tools for Assessing Economic Impacts

Economic impact analyses assess how the economy (e.g., local, regional, national) is likely to change as a result of the project (e.g., jobs, output, income, tax revenue). Offshore wind energy projects funnel direct benefits to local economies through hiring labor and expenditures on goods and services. Data on these direct impacts can typically be collected from the developer's project cost estimates, or the magnitude of the investment can be estimated based on the size and quantity of wind turbines specified for a proposed project. Examples of direct impacts include investments in specialized vessels for offshore wind development and port development.

Offshore wind energy projects also create indirect and induced benefits. Indirect benefits include the benefits arising from the wages and expenditures created in supplier businesses as a result of project expenditures. Induced benefits are changes in sales, income, or jobs created by changes in household spending, business spending, or government spending. Examples of possible direct, indirect, and induced jobs created by an offshore wind project are presented in **Table 3-9**.

**Table 3-9. Examples of Potential Jobs Created by an Offshore Wind Project**

| Type of Economic Impact | Examples of Potential Jobs |
|---|---|
| Direct Impact | Construction, operations, and maintenance of the project |
| Indirect Impact | Turbine manufacturing jobs, steel mill jobs, and parts manufacturers |
| Induced Impact | Jobs at retail establishments, restaurants, childcare facilities, and hotels |

A simplified diagram of a regional economy is displayed in **Figure 3-9** below. The regional economy being demonstrated is captured within the blue circle. The regional economy is composed of local businesses and the local population. There are flows and exchanges inside and outside of the regional economy. An offshore wind energy project begins with an investment that creates business activity in the regional economy. An economic impact analysis would evaluate impacts within the regional economy and would not include leakages or expenditures outside of the region.

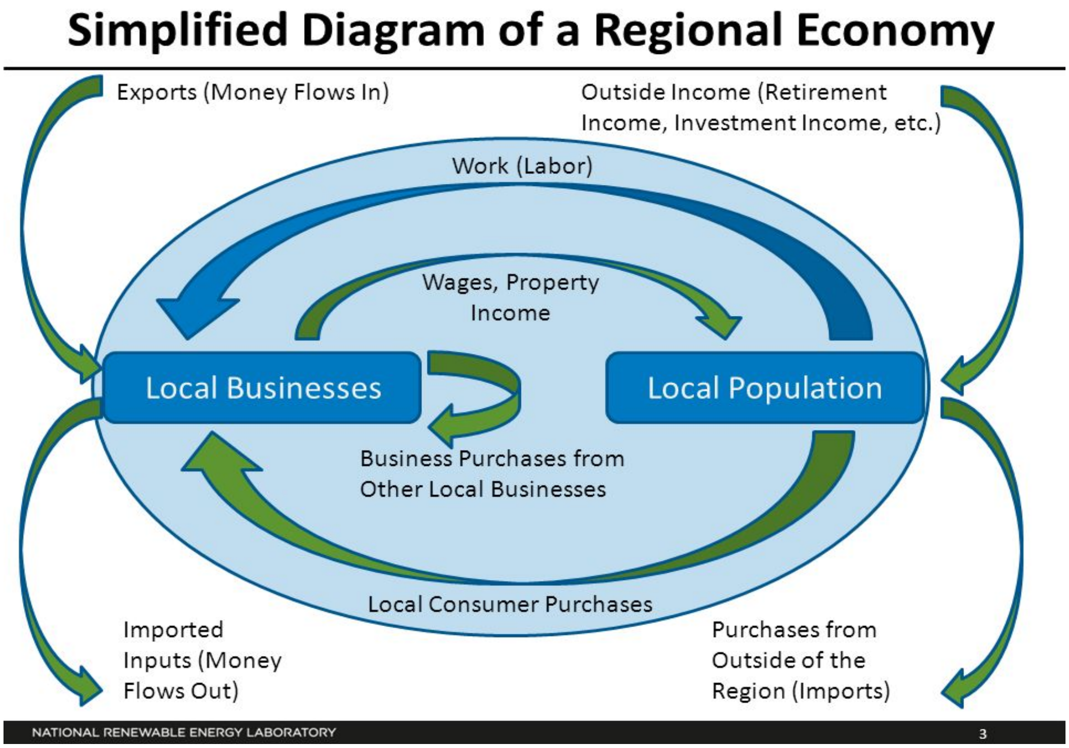


**Figure 3-9. Simplified Diagram of a Regional Economy**

*Source: National Renewable Energy Laboratory*

During each phase of offshore wind development, there is the possibility of utilizing local resources. This generates new business, which can lead to more employment; these are considered the direct benefits of the project. The new business, depending on the industry, may increase sales for local businesses in the supply chain, leading to more employment; these are the indirect benefits of the project. When local households or construction workers that are temporarily working in the region spend their income from the project in the local economy, these are induced benefits. Induced benefits can also increase employment as demand increases.

The direct, indirect, and induced benefits from the project can be measured as the amount of employment, labor income, value added, and output created by the project for each of these categories. The value added is the difference between total output and the cost of the intermediate inputs, such as taxes and employee compensation. Output is a measure of the value of industry production, such as sales or gross margin.

The most appropriate method for an economic impact analysis depends on the selected variables, available inputs, and the outputs produced by the tool. Inputs may include the capacity and generation of the offshore wind energy project, project costs, and cost structures. Results of economic impact analyses generally include employment and economic output. Some commonly used economic impact analysis methods and models include employment factors, Regional Input-Output Modeling System (RIMS II), the Jobs and Economic Development Impact (JEDI) model, and Impact Analysis for Planning (IMPLAN). The order listed above ranges from the simplest to most complex. The accuracy of the results is dependent on the quality of the inputs and understanding the limitations of the analysis. BOEM publishes competed economic impact studies that can be referenced for additional guidance (BOEM 2016a).

#### *3.3.5.1 Employment Factors*

Employment factors can be used to perform the most simplified analysis of the direct employment effects of offshore wind energy development. Employment factors may be associated with the total installed capacity (nameplate capacity) of offshore wind energy or the amount of expenditures in related industries. For example, NREL estimates that more than 20 direct jobs would be created for each installed MW of capacity of new offshore wind in the U.S. (NREL 2010b). Employment may be assessed for each segment of the value chain. Long-term activities (e.g., operation and maintenance) are defined as full-time equivalent jobs. Each full-time equivalent job implies 40 hours per week, year-round, for a total of 2,080 hours. Temporary activities are expressed as job-years. For example, 10 job-years can mean a job that lasts for 10 years or 10 jobs that last for 1 year. These factors are limited to describing how employment could be generated by an offshore wind project and do not include other aspects of socioeconomic benefits.

#### *3.3.5.2 RIMS II*

RIMS II was developed by the Bureau of Economic Analysis and consists of a set of multipliers specific to a region that need to be applied manually by the user. The multipliers would only be used for direct local purchases, not purchases outside of the region being evaluated. One set of multipliers would be used for the direct economic impacts, and separate sets of multipliers would be applied to yield the indirect versus induced impacts. The multipliers do not include taxes. The results are the total economic impact, but the breakdown by industry is not provided. There is a cost to purchase the RIMS II multipliers.

#### *3.3.5.3 JEDI*

NREL developed the JEDI offshore wind model. JEDI is an input-output, bottom-up, spreadsheet-based model that is publically accessible and available free of charge from NREL. JEDI estimates the jobs, income, and economic output that would accrue to the state, county, or region that is being analyzed. JEDI uses state-specific multipliers for employment, earnings, and output (economic activity) from IMPLAN (discussed below) to estimate direct, indirect, and induced economic impacts. Multipliers are ratios of total changes to initial changes in regional economic activity. Changes in expenditures from the project are matched with the appropriate multipliers for each sector affected by the change in expenditure.

Economic impacts are categorized into project development and on-site labor impacts (direct), turbine and supply chain impacts (indirect), and induced impacts. Induced impacts are the effects created by expenditures of household earnings from the project (from both the direct and indirect sources). The results depend on how much of the project-related expenditures are spent locally and the structure of the local economy.

Users are required to enter basic information about the offshore wind energy project, such as the location (e.g., state), year of construction, and nameplate capacity. The user can input project capital costs, annual operating costs, other costs, and financing parameters, or can use the cost estimates generated by JEDI. If specific project values are available, users can enter the number of jobs and earnings expected to accrue to the region being analyzed. The default values are specific to offshore wind energy development and are based on extensive interviews with power generation project developers, State tax representatives, and other industry representatives. The default values represent an offshore wind energy project constructed in water with an average depth of 25 meters (82 feet) and no farther than 185 km (100 nautical miles) from a port. The user can replace default values with project-specific information.

JEDI reports economic impact results for two phases: construction and operating. The construction phase results are cumulative totals over the entire construction period and are categorized as project development and on-site employment, turbine and supply chain impacts, and induced impacts. The project development and on-site employment are composed of construction and interconnection labor, and construction-related services. The operating phase results are categorized as on-site employment, local revenue and supply chain impacts, and induced impacts. Operating phase results are annual results that may be expected over the operating life of the project. JEDI does not include any assumptions about the operating life of an offshore wind project or the amount of time necessary for construction. Impacts from decommissioning the wind energy project are not represented in the results.

The results include the direct, indirect, and induced macroeconomic effects from the project expenditures. There are four metrics for each type of outcome: jobs, earnings, gross outputs, and value added. Outputs are presented as aggregate impacts (the sum of all expenditures) without sector specificity. The series of effects generated by expenditures are summed to arrive at the gross output. Value added includes all personal income, estimated returns to investors, and indirect business taxes paid to State and local governments. The value added is basically the income that accumulates to individuals and governments as a result of industrial activity in the defined economy. The model also computes the portion of spending assumed to occur locally, local spending on debt and equity payments, property taxes, and land lease payments, if applicable.

**Tables 3-10** and **3-11** demonstrate an example of "simple" model analysis results using a limited number of inputs and the JEDI default values. **Table 3-10** displays the only inputs used for the example, and **Table 3-11** shows the results JEDI generated from the limited inputs. JEDI can estimate the investment cost for an offshore wind project based on the nameplate capacity, and then use the estimated cost and project location to evaluate the economic impacts. JEDI relies on historical cost data from Europe and reasonable cost estimates for the U.S.

**Table 3-10. JEDI Example Inputs**

| **Inputs** | |
|---|---|
| Project Location (i.e., nearest state) | Massachusetts |
| Year Construction Starts | 2018 |
| Total Project Size – Nameplate Capacity (MW) | 765 |

**Table 3-11. JEDI Example Outputs**

| | Jobs | Earnings | Output | Value Added |
|---|---|---|---|---|
| During Construction Period | | | | |
| Project Development and Onsite Labor Impacts | | | | |
| Construction and Interconnection Labor | 619 | $11.6 | | |
| Construction Related Services | 631 | $72.2 | | |
| Subtotal Project Development and Onsite Labor Impacts | 1,251 | $83.8 | $219.2 | $113.9 |
| Turbine and Supply Chain Impacts | 1,473 | $116.4 | $341.7 | $172.0 |
| Induced Impacts | 1,301 | $77.3 | $187.7 | $124.7 |
| **Total Impacts** | **4,025** | **$277.5** | **$748.6** | **$410.7** |
| During Operating Years (annual) | | | | |
| Onsite Labor Impacts | 45 | $4.6 | $4.6 | $4.6 |
| Local Revenue and Supply Chain Impacts | 178 | $13.2 | $37.8 | $19.3 |
| Induced Impacts | 74 | $4.5 | $11.0 | $7.3 |
| **Total Impacts** | **297** | **$22.3** | **$53.5** | **$31.2** |

Note: Earnings, Output, and Value Added values are millions of dollars in year 2012 dollars.

The results are not precise and should be considered an indication of the magnitude of potential economic development impacts. The results are the gross estimates, not net. It is important to interpret the gross results carefully. For example, the gross economic value is the total value added within an economy, without considering the possible negative effects on other economic sectors. The gross results do not include consideration of the opportunity costs of the investment used for the offshore wind energy facility or the consequences of displacing other power generation alternatives.

JEDI results are based on the estimated demand created by project expenditures and the economic activities that would be supported by that demand. Supply-side changes such as production price changes, utility rate changes, subsidies, and changes in taxes are not considered in the model.

The model does not reflect alternative uses of the investment required for the project. The analysis assumes power purchase agreements would be in place to cover equity and debt repayment and annual operating expenditures. Additional revenues (i.e., tax incentives and profits above costs) are excluded from the JEDI analysis.

### *3.3.5.4 IMPLAN*

The Minnesota IMPLAN Group IMPLAN software is an input-output model that can be used to analyze the direct, indirect, and induced effects of a change on the local, regional, or national economy. The direct impacts are a result of the direct investment expenditures for the project. The impact of industries buying goods and services from other industries is considered an indirect effect. Induced effects are the response to a direct effect that occurs when a change in income causes spending. IMPLAN can be used to analyze the economic impacts on a national, state, county, or zip code level. The study area can be any grouping of counties, states, or both.

IMPLAN has multipliers for all the industrial and household sectors in a defined area. These multipliers are used to estimate the regional impacts resulting from a change in final demand. The higher the multiplier, the more the specified economy is capable of supplying inputs to production without leakage from the region. Thus, the multiplier effects are greater in larger regions with more participating economic sectors. Suppliers to primary industries are measured by indirect multipliers. Induced multipliers are used for household impacts. Jobs needed to support the level of impact are also estimated using multipliers. Job estimates from IMPLAN represent both full-time and part-time jobs.

Expenditures are allocated to specific industries in IMPLAN. IMPLAN contains 528 standard industrial classifications. Offshore wind energy generation would be part of the IMPLAN industry sector "electric power generation, transmission, and distribution." The production function for this general IMPLAN industry sector does not exactly align with the production function specific to offshore wind energy generation. A custom production function specific to offshore wind energy generation can be created in IMPLAN.

IMPLAN results include total output, personal income, value added, and jobs. Total output for most industries can be defined as gross sales. Personal income includes salaries of employees (including all compensation) and normal proprietor profits. Value added includes all personal income, estimated returns to investors, and indirect business taxes paid to State and local governments. The value added is basically the income that accumulates to individuals and governments as a result of industrial activity in the defined economy. Jobs represent the number of positions in the economy and not necessarily the number of people employed.

IMPLAN calculates the number of jobs and output needed to support a given level of expenditure. A limitation of the model is determining whether the jobs and output are new or reallocations from other uses. IMPLAN also assumes a limitless supply of the factors of production, and that the relationship between industries is constant. The model also simplifies geographical differences by using national data that assumes products are produced exactly the same in all areas, and ignores potential regional differences in production inputs.

#### *3.3.5.5 Advantages and Limitations of Economic Impact Analysis Tools*

All of the tools presented are static examples of the estimated economic effects at a single point in time, and results from these tools should not be interpreted as forecasts. These tools do not include externalities or non-market goods and services. One or more economic impact analysis tools can be used to compare the results and perform sensitivity analyses.

The JEDI and IMPLAN input-output models rely on inter-industry relationships and personal consumption patterns existing the year the multipliers were created. Therefore, they do not account for any shifts in industry inputs or changes in consumption patterns that could result in price changes. The input-output models do not account for changes in industry productivity that may occur over time. The multipliers also introduce the assumption that the inter-industry relationships are constant. The input-output models assume unlimited factors of production are available to meet demand identified by the models.

The results from these economic impact analysis tools should be interpreted carefully. If the number of jobs is disproportionate to the labor market of the area analyzed, more complex modeling may be necessary to determine where the jobs would be coming from. The estimated change in economic activity should also be assessed relative to overall economic activity in the region to confirm whether the results are reasonable. The advantages and limitations of the economic impact tools reviewed are described in **Table 3-12**.

**Table 3-12. Advantages and Limitations of Economic Impact Tools**

| Economic Impact Tool | Advantages | Limitations |
|---|---|---|
| Employment Factors | • Requires minimal inputs, time, and technical expertise.<br>• Inexpensive or possibly available free of charge.<br>• Transparent analysis. | • Overly simplified assumptions.<br>• Results are approximate gross impacts, meaning jobs that would be lost in other industries or transferred from other industries are not considered.<br>• Only considers potential increases in employment.<br>• May not consider regional differences in cost and labor availability. |
| RIMS II | • Transparent.<br>• Inexpensive to purchase.<br>• More specific to a region than using general employment factors. | • No user-friendly interface.<br>• Results do not break down impacts by industry.<br>• User cannot modify industry production functions or trade flow assumptions to reflect a particular industry, such as offshore wind.<br>• Multipliers do not account for price elasticities and changes in consumer/industry behavior over time in response to direct effects.<br>• Fiscal impacts are not assessed.<br>• Single region modeling that does not consider exchanges between multiple regions.<br>• The time for economic impacts to be realized is not specified. |
| JEDI | • User friendly.<br>• Default values are specific to offshore wind energy development.<br>• Requires minimal inputs, time, and technical expertise.<br>• Available to use free of charge.<br>• Useful for general estimates. | • Based on representative or typical offshore wind energy plant.<br>• Results are estimated gross impacts, not net impacts.<br>• Does not consider potential increases/decreases in electricity rates.<br>• Economic development losses associated with possible displacement of other energy sources.<br>• Displacement of other economic activity not considered.<br>• Static model that cannot assess future |

| Economic Impact Tool | Advantages | Limitations |
|---|---|---|
| | | changes or patterns over time.<br>• Does not consider taxes and subsidies. |
| IMPLAN | • More robust analysis and results than RIMS II.<br>• Provides detailed results.<br>• Can account for dynamic interactions within the state or regional economy.<br>• User can modify production functions and trade flow assumptions.<br>• New industries can be introduced into the region being analyzed.<br>• Allows for multi-region modeling.<br>• Includes fiscal impact function.<br>• Detailed analysis down to the zip code level, not just counties or states.<br>• Impacts are broken down by industry and direct, indirect, and induced impacts. | • Requires detailed assumptions that can significantly influence results.<br>• Software licensing costs for use (more expensive than RIMS II).<br>• May require extensive inputs, time, and technical expertise.<br>• Less transparent than spreadsheet methods.<br>• Static model that cannot assess future changes or patterns over time. |

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[2] BOEM is undertaking a separate, focused assessment of the environmental benefits that could result from reduced air emissions including emissions of GHGs from offshore alternative energy production.

# 4 BENEFITS ASSESSMENT APPROACH FOR USE IN NEPA ANALYSES

The previous section discussed methodologies and resources to use in preparing a benefits assessment. This section provides information on when and where to incorporate a benefits assessment into the NEPA process, and presents a semi-quantitative method for incorporating a more rigorous benefits assessment into a NEPA document.

While it is important to clearly state the anticipated benefits of a proposed action, it is also important to avoid having the document appear as if it is advocating for the proposed action. Properly stating the anticipated benefits is critically important in developing a balanced document since the potential benefits that could result from the proposed action are often not included in EISs.

## 4.1 Where to Include the Benefits Assessment

The benefits of offshore wind energy projects should be considered in the NEPA environmental review process at the construction and operations phase of BOEM’s Wind Authorization Process. At this stage BOEM will prepare a site-specific environmental review that will likely take the form of an EIS, however, BOEM could prepare an EA based on the scale and complexity of the proposal; level of public controversy; and number of environmental and socioeconomic issues. If BOEM were to prepare an EA, and there are no significant environmental impacts or all significant impacts can be mitigated to a level of insignificance, then BOEM prepares a Finding of No Significant Impact (FONSI) or a Mitigated FONSI, and the NEPA environmental review process is complete. If, however, there is the potential for significant, unmitigable environmental impacts from the proposed action, BOEM must prepare an EIS. Because both EAs and EISs are public documents, including information about the benefits of the project in these documents allows stakeholders to evaluate the relative merits and costs of the project.

### 4.1.1 EAs

There are a number of places in an EA (and EIS) where the benefits of a project can be considered. An EA (and EIS) includes a statement of the purpose and need for the proposed action. In the Purpose and Need statement the anticipated benefits that should accrue from the implementation of the proposed action may be mentioned. These two sets of discussions are the basis for the commitment of resources and the justification for the allowance of potential environmental impacts. They also set the basis for the identification of feasible alternatives for evaluation in the document. As a regulatory agency, BOEM's purpose and need may not have anything to do with the potential benefits of the project so it may not be appropriate to include benefits in the purpose and need. This determination would have to be made on a case by case basis.

On the other hand, including a discussion in the project description of benefits of the proposed action would be less appropriate. The project description should be a neutral statement about how the project is being proposed to be constructed, operated, and decommissioned. Different construction, operation, and/or decommissioning methods could be considered in the alternatives analysis, or changes to these methods could be included as mitigation measures following the impacts analyses, but focusing the project description on the proposed actions is best.

The effects assessment in an EA (and EIS) begins with a description of the Affected Environment within which the proposed action will be implemented. The Affected Environment is described with regard to the existing (baseline) environmental and socioeconomic conditions within the project study area. Included in the characterization of the Affected Environment are projections of future conditions in the absence of the proposed action. Impacts are identified by comparing the baseline conditions and the conditions with the project. So, while properly describing the Affected Environment is critical to an effective EA (or EIS), this section does not readily lend itself to a discussion of benefits.

The main focus of an EA (and EIS) is the impact assessment. To provide a balanced picture of the effects of the project, it is important that the effects assessment include the evaluation of the project's benefits as well as its impacts. If appropriate, a benefits assessment should be included in each of the issue areas evaluated in the impacts assessment. However, as discussed in Section 2, there may not be beneficial effects derived from a proposed action in each of the issue areas, so incorporating them in an individual issue area requires good judgment by the author of the EA (or EIS). In addition, because benefits may accrue from a proposed action only if other actions may occur as well, it is critically important to explain the context of how the benefit has been identified. It is important to note that in some cases the benefit may occur outside of the project area or the impact assessment area. For example, the reduction of solid wastes generated at a coal-fired power plant if it were to be replaced by an offshore wind generating station. The reduction in waste occurs only if the coal-fired power plant operates less as a direct result of an offshore wind generating station. However because changes to coal-fired power plants are not likely to be linked directly to offshore wind projects, taking credit for the reduced waste benefit may not be justified.

An EA may also evaluate impacts of alternatives to the proposed action that meet the stated purpose and need of the proposed action, although review of alternatives in an EA is not required to the same level of detail as in an EIS. To the extent that alternatives are included in an EA, the relative benefits of the alternatives should be identified and evaluated concurrent with the evaluation of relative potential adverse effects. An EA also needs to consider how the proposed action fits with other past, present, and reasonably foreseeable future projects and could lead to cumulative impacts. Importantly, a benefits analysis in the cumulative impacts assessment provides the decision maker with a more complete understanding of the overall effects of the project, both positive and negative.

### 4.1.2 EISs

If there is the potential for significant, unmitigable environmental impacts from the proposed action, BOEM must prepare an EIS. The EIS will include a more detailed and quantitative impacts analysis of the proposed action and will also contain an analysis of the impacts from a range of alternatives. Discussion of benefits in an EIS would be appropriate in the same locations as discussed above for EAs, such as in the purpose and need statement, proposed action description, alternatives description, and discipline-specific direct, indirect, and cumulative impacts assessments.

## 4.2 Risk-based Benefits Assessments

Assessing beneficial effects and comparing them with adverse effects is a good way to more fully evaluate the overall consequences of a proposed project and select a preferred alternative. The use of risk analysis to evaluate the effects of an action or a project is a well-established risk management tool that can provide a semi-quantitative measure of the consequences (both positive and negative) of undertaking a project.

A simple risk analysis considers consequences of the effect, if it occurs, and the likelihood of that effect occurring. These two parameters are assigned numeric values and are plotted in a matrix to develop a semi-quantitative risk number. The risk number is a measure of the magnitude of the risk. This simple assessment of the magnitude of an effect can be extended by also considering the extent, duration, reversibility, and recoverability of the effect.

### 4.2.1 Magnitude of Impacts and Benefits

Two parameters are required to assess the magnitude of impacts or benefits, consequences and likelihood. As presented in **Table 2-1**, the MMS programmatic EIS (2007b) characterized the consequences of potential impacts as falling into one of four categories, negligible, minor, moderate, or major. These categories can be assigned numeric values corresponding to their rank. **Table 4-1** presents the same environmental impact level definitions, as in **Table 2-1** but uses proposed definitions and numeric rankings of the analogous relative levels of beneficial effects. **Table 4-2** provides five categories to capture the likelihood of an event occurring.

The ranking values from **Table 4-1**, consequences, and **Table 4-2**, likelihood, can be placed on the axes of **Table 4-3**, and the numeric values at the intersections of the two axes can be multiplied to yield a comparative risk or benefit value. The higher the numeric value means the higher the magnitude of an adverse impact or beneficial effect.

**Table 4-1. Consequences of Adverse or Beneficial Effects**

| **Beneficial Effects** | | | |
|---|---|---|---|
| **Benefit Level** | **Rank** | **Biological and Physical Resources** | **Societal Issues** |
| Negligible | 1 | • Slight improvement in the health of local ecosystem, but not enough to detect a measurable difference<br>• Minimal increase in the extent and quality of habitat both for special-status species and species common to the area<br>• Slight increase in species richness or abundance of species common to the area<br>• Slight measurable improvement in air and/or water quality | • Minimal improvement to human health or well-being, but not sufficient to detect a significant difference for the community as a whole<br>• Minimal benefits for some individuals or communities (e.g., small number of additional employment opportunities)<br>• Some minimal improvements to facilities services in the community<br>• Slight impact on the overall economy (limited local procurement)<br>• Slight impact on the tourism sector or regional or local cultural resources |

| Beneficial Effects | | | |
|---|---|---|---|
| **Benefit Level** | **Rank** | **Biological and Physical Resources** | **Societal Issues** |
| Minor | 2 | • Minor but measureable improvement in the health of local ecosystem<br>• Measurable increase in the extent and quality of habitat for both special-status species and species common to the project area<br>• Measureable increase in populations of species common to the project area<br>• Measurable improvement in air and/or water quality | • Some minor improvement with regards to human health<br>• Benefits for local employment<br>• Improvements to infrastructure and community services<br>• Moderate benefit to the overall economy (local suppliers)<br>• Minimal economic improvement<br>• Moderate benefits for tourism or local/regional cultural resources |
| Moderate | 3 | • Moderate improvement in the health of local ecosystem<br>• Moderate increase in the extent and quality of habitat for both special-status species and species common to the project area<br>• Moderate increase in populations of species common to the project area<br>• Measurable moderate improvement in air and/or water quality | • Moderate benefits to human health<br>• Benefits to employment on a regional scale<br>• Moderate improvements to facilities and community services<br>• Significant improvement in the local economy<br>• Moderate economic improvement<br>• Significant benefits for tourism or local/regional cultural resources |
| Major | 4 | • Major improvement in the health of ecosystems regionally<br>• Major increase in the extent and quality of habitat for both special-status and commonly occurring species on a regional scale<br>• Significant improvement in air and/or water quality on a regional scale | • Major benefits to human health<br>• Benefits to employment on a regional scale<br>• Notable improvements to facilities and community services<br>• Major improvement in the regional economy<br>• Significant economic improvement<br>• Substantial impact to tourism or local/regional cultural resources (many achievements in regard to cultural heritage, for example shipwrecked boats) |

**Table 4-2. Risk Analysis Framework Likelihood Levels**

| Likelihood of Impact or Benefit to Natural or Cultural Resources | | | | |
|---|---|---|---|---|
| **Rare** | **Unlikely** | **Likely** | **Almost Certain** | **Certain** |
| Highly unlikely to occur but theoretically possible | May occur within the life of the project or activity | Likely to occur more than once during the life of the project or activity | Very likely to occur during the life of the project or activity | Will occur as a result of the project or activity |

**Table 4-3. Magnitude of Impact Risks or Beneficial Outcomes**

| | Rare 1 | Unlikely 2 | Likely 3 | Almost Certain 4 | Certain 5 |
|---|---|---|---|---|---|
| Negligible – 1 | 1 | 2 | 3 | 4 | 5 |
| Minor – 2 | 2 | 4 | 6 | 8 | 10 |
| Moderate – 3 | 3 | 6 | 9 | 12 | 15 |
| Major – 4 | 4 | 8 | 12 | 16 | 20 |

Values between 1 and 4 indicate that the project would result in few or no impacts or would provide little or no benefits; values between 5 and 8 would result in modest impacts or provide modest benefits; values between 9 and 12 would result in moderate impacts or provide moderate benefits; while values 15 or above would result in high impacts or provide high benefits from a project.

For an EA where a qualitative assessment of benefits would be appropriate, a statement of the relative benefits of each identified potential impact or benefit would be appropriate. For an EIS where a more quantitative presentation of the benefits would be appropriate, the values from **Table 4-3** can be used for a more in-depth assessment.

### 4.2.2 Semi-quantitative Determination of Impacts and Benefits

To provide the more quantitative assessment of impacts or benefits, as appropriate for an EIS, the magnitude of the impact or benefit can be refined by considering three other factors. **Table 4-4** identifies four factors that can contribute to the significance level of a benefit (or impact). The first factor, magnitude, is the quantity resulting from **Table 4-3**. The definitions for the other three factors are presented in **Tables 4-5** through **4-7**.

### Table 4-4. Significance Indicator Definitions

| Significance Indicator | Definition |
|---|---|
| Magnitude | The degree to which the impact will be felt by the receiving environment |
| Extent | The geographic extent at which the impact is likely to be felt |
| Duration | The time (or temporal extent) the impact is anticipated to be experienced (e.g. during construction only or over the life of the project) |
| Reversibility | Whether or not the receiving environment will return to its pre-project state following the end of the project |

### Table 4-5. Definitions and Ranking Values of Significance Indicators - Extent of Impact

| Criterion | Ranking | Environmental | Socioeconomic |
|---|---|---|---|
| Localized | 1 | The benefit is localized in a small space within the area of influence | The benefits affect a small number of individuals |
| Local | 2 | The benefit is manifested within the area of influence without extending to a wider area | The benefits affect several individuals or a small number of individuals within a local community |
| Regional (offshore marine waters) | 3 | The benefit extends to marine waters outside the area of influence | The benefits affect individuals and businesses within a region of the U.S. |
| National (including onshore and/or coastal areas) | 4 | The benefit has extended to marine waters and coastal/onshore areas outside the area of influence and within U.S. waters | The benefits extend to several economies within the U.S. |

### Table 4-6. Definitions and Ranking Values of Significance Indicators - Duration of impact

| Criterion | Ranking | Environmental | Socioeconomic |
|---|---|---|---|
| Passing | 0 | The benefit lasts less than 1 day | The benefit lasts less than 1 day |
| Brief | 1 | The benefit lasts less than 1 month | The benefit lasts less than 1 month |
| Temporary | 2 | The benefits are expected to last between 1 month and 12 months | The benefits are expected to last between 1 month and 12 months |
| Prolonged | 3 | The benefits are expected to last between 1 year and 5 years | The benefits are expected to last between 1 year and 5 years |
| Semi-permanent | 4 | The benefits are expected to last between 5 and 10 years | The benefits are expected to last between 5 and 10 years |
| Permanent | 5 | The benefits are expected to last longer than 10 years | The benefits remain for longer than 10 years |

**Table 4-7. Definitions and Ranking Values of Significance Indicators - Reversibility of impact**

| Criterion | Ranking | Environmental | Socioeconomic |
|---|---|---|---|
| Immediate | 0 | Beneficial impact anticipated to last less than 1 month | Beneficial impact anticipated to last less than 1 month |
| Short term | 1 | Beneficial impact anticipated to last less than 1 year | Beneficial impact anticipated to last less than 1 year |
| Medium-term | 2 | Beneficial impact anticipated to last between 1 and 5 years | Beneficial impact anticipated to last between 1 and 5 years |
| Long-term | 3 | Beneficial impact anticipated to last between 5 and 10 years | Beneficial impact anticipated to last between 5 and 10 years |
| Extensive | 4 | Beneficial impact anticipated to last longer than 10 years | Beneficial impact anticipated to last longer than 10 years |
| Ongoing | 5 | Beneficial impact anticipated to last many generations | Beneficial impact anticipated to last many generations |

To determine the significance of the impact or benefit from each identified potential impact or benefit, the sum of the corresponding rank numbers for each variable (magnitude, extent, duration, reversibility, and recoverability) would be calculated and divided by the total number of variables assessed.

$$\text{Significance} = \frac{(\text{Magnitude} + \text{Extent} + \text{Duration} + \text{Reversibility})}{4}$$

Variables determined to be “not applicable” would be assigned a zero rank and not included in the determination of denominator. The magnitude of impact or benefit would be based on the methods discussed in Section 3 and ranked as defined in **Table 4.1**.

Utilizing the result of the significance calculation, a rank number and associated description can be assigned using the ranking framework as detailed in **Table 4-8**.

**Table 4-8. Significance Ranking for Net Impacts and Benefits**

| Significance Rank | Description |
|---|---|
| < 1.5 | Negligible |
| 1.5 to < 2.5 | Minor |
| 2.5 to < 3.5 | Moderate |
| 3.5 to < 4.5 | Major |
| > 4.5 | Extreme (impacts) or Dramatic (benefits) |

< = less than; > = greater than

Using this semi-quantitative approach in an EIS will promote consistency among subject matter experts in the assessment of potential project impacts and benefits.

## 4.3 How to Include the Benefits Assessment

Section 4.1 discusses where benefits could be included in an EA or EIS. The discussion in this section focuses on how to include the semi-quantitative benefit assessment in the effects assessment of an EA and EIS. NEPA requires the discussion of direct, indirect, and cumulative impacts. The consideration of benefits should also consider these three categories.

### 4.3.1 Direct Benefits

Direct effects are caused by the proposed action and occur at the same time and place. When considering the direct consequences of most development projects, there are relatively few direct benefits unless the action includes environmental enhancement or restoration. For offshore wind projects, an example of a direct benefit is the new hard bottom substrate provided by the foundations supporting the turbines. This new substrate can increase available settling areas for sessile organisms, which can then be the basis for a complex community that did not occur in the area originally. However, these direct benefits will likely result in other environmental changes that grade into indirect benefits, such as increased fish biomass that can then have associated effects.

### 4.3.2 Indirect Benefits

Indirect effects are caused by the proposed action but are later in time or distance but are reasonably foreseeable. Indirect benefits would be those not immediately related to the proposed action but resulting from a change to the environment directly attributable to the proposed action. The direct changes may be negative or positive, but the indirect effects would need to be positive to be considered as indirect benefits.

### 4.3.3 Cumulative Benefits

Cumulative effects are those that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Cumulative benefits would capture positive environmental changes associated with many related or seemingly unrelated projects. For example, offshore wind energy production may contribute to the retirement of onshore power plants, some of which may be coal fired while others may be petroleum or natural gas. However, while the addition of more energy sources can allow for the retirement of other, older or less environmentally friendly energy production facilities, there is typically no certainty that with the activation of one set of projects other projects will be retired. Further, the addition of offshore wind could displace onshore wind, hydro, or solar energy production if there are factors that make those energy production facilities less attractive than conventional energy production facilities. Under this scenario, larger trends would need to be considered; the benefits of a specific offshore wind project would typically not be able to be connected to specific onshore power projects. However, when general, non-specific trends are considered when identifying benefits, care must be exercised to avoid taking credit several times over by different alternative energy projects for the retirement of conventional power plants.

Initial benefits from early projects will result in changes in infrastructure including energy distribution systems, construction and port facilities, educational opportunities to create a skilled work force, and other areas. As successive projects come on line, the incremental costs of and benefits from subsequent projects may drop. Properly capturing these thresholds and presenting them in a NEPA document will be critical to presenting the overall benefits of the specific project as well as associated existing, proposed, and future projects.

### 4.3.4 Monetizing Benefits

Converting impacts or benefits into financial terms can allow for a comparison of different types of effects independent of the discipline being considered, which can lead to a more independent overall assessment. For some disciplines such as economics or system optimization, the monetization of various parameters is routine. For other disciplines such as natural resources, there are some situations where the impacts to environmental resources can be monetized such as with Natural Resources Damages Assessments; however, this methodology is not typically used in a NEPA assessment.

NEPA documents do not typically include detailed economic analyses. The key driver for a NEPA analysis is environmental impacts. Methods for determining monetary values for environmental resource areas have not been widely used outside of Natural Resources Damages Assessments and those actions have much different objectives than do the preparation of an EIS. As a consequence, a NEPA author should be careful when trying to monetize environmental benefits (and impacts) in an EIS.

## 4.4 Conclusions

A NEPA author should weave the description of beneficial effects from a project throughout the EA or EIS. The greatest emphasis on benefits should be in the impacts assessment section of an EA (describing the magnitude of the benefits) or an EIS (presenting a semi-quantitative description of the benefits), but discussing benefits in other areas will be appropriate as well. Setting out benefits in the project objectives establishes a basis for evaluating how successful different alternatives would be in meeting those objectives. In addition, explaining expected baseline conditions without the project will allow for a clear evaluation of how the environmental changes from a project may provide beneficial changes to the different environmental resources.

Using the semi-quantitative approach of risk analysis in an EIS will promote consistency among subject matter experts in the assessment of potential Project impacts and benefits. A simplified risk analysis considers consequences of the effect, if it occurs, and the likelihood of that event occurring. These two parameters are assigned numeric values and are plotted in a matrix to develop a semi-quantitative risk number. The risk number is a measure of the magnitude of the risk. This approach to assessing the magnitude of an effect can be further quantified by also considering the extent, duration, reversibility, and recoverability of the effect.

Consideration of not only direct benefits of a project but also indirect and cumulative benefits of the project is important, and may be critical. A proper characterization of the benefits that may result from a project may be strongly affected or fully dependent on actions that are unrelated to and independent of the proposed action. Thus, the incorporation of the indirect and cumulative benefits of a project into the EA or EIS can provide the reviewer with a more complete picture of the effects (both positive and negative) of a project. However, care must be taken to properly frame the anticipated (or required) associated actions that are needed for the benefits to occur and to avoid double-counting benefits from unconnected and unrelated projects to overstate the benefits.

Finally, because a benefits analysis is strongly affected by context and the criteria for significance of benefits differs from those of impacts, it is important to explain how the benefits are being evaluated. In addition, because there are different perspectives of benefits based on the technical area being reviewed (e.g. system benefits, environmental benefits, or socio-economic benefits), the methods used to determine the benefits need to be tailored to that technical area and consistent with current best practices used in that technical area. This requirement will necessitate the use of substantially different methodologies in determining benefits. Also, care must be exercised if an attempt is made to express the benefits monetarily.

# 5 SUMMARY

BOEM has regulatory authority over offshore wind energy development including conventional oil and gas exploration and production, and renewable energy production from wind, waves, and currents. In this regulatory capacity, BOEM must comply with NEPA prior to approving a lessee's construction and operation plan for wind or other renewable energy production projects on the OCS. EAs and EISs focus on adverse impacts to the environment. However, NEPA analyses also need to discuss environmental and socioeconomic benefits. This white paper identifies resources and describes technical approaches that can be used by authors of EAs and EISs to capture the beneficial effects that can accrue from the development of renewable energy sources on the OCS.

A considerable body of knowledge and standards of practice have been developed to assess environmental impacts from development projects, but less effort has been invested in defining ways to determine beneficial effects of those projects. Three factors that need to be considered in developing a benefits analysis for a NEPA document are significance, and discipline-specificity.

While an environmental restoration or enhancement project may have clear, direct benefits to the environment, the direct environmental benefits resulting from most development projects are less clear. Constructing an offshore wind turbine will directly affect local habitats by increasing the amount of hard substrate locally. Indirect effects may include an increase in boat traffic to the area by people fishing around the new substrate. These direct and indirect effects may be beneficial but typically need to be viewed in a fuller context. Consideration of cumulative effects may be where the environmental benefits of offshore wind projects are most appropriate. However, setting the boundaries for inclusion of potential cumulative projects is key to an effective cumulative effects assessment.

To capture the potential benefits of an environmentally positive project such as an offshore wind farm, the potential benefits need to be put into a context because many beneficial outcomes are predicated on other actions occurring sometime within but frequently external to a proposed project. Such actions may be under the control of the project applicant, but will more likely be independent of the proposed project. As such, it will be important for a NEPA author to provide an appropriate context for the analysis so the reader understands the direct, indirect, and cumulative benefits, and the degree to which the project can ensure the identified benefits will occur.

An EA or EIS for an offshore wind energy facility determines which impacts from a project, if any, are significant. Identifying whether a benefit is significant is often more complex than identifying significant environmental impacts. The approach of substituting a positive outcome measure in place of the negative impact criteria does not work effectively. Rather, a separate but analogous set of significance criteria must be developed and applied.

The process for developing a benefits analysis is fairly well defined in some disciplines, e.g., economics, but is not so well defined in others, e.g. environmental. As such, the methods for completing a benefits analysis will need to be tailored to the discipline being evaluated.

To support the broader perspective of a NEPA benefits analysis, it will be important to establish a credible baseline. The baseline will capture actions and projects that are occurring concurrently with the proposed action. Some actions, such as phasing out of coal fired power plants or reducing OTC, may be driven by factors independent of an offshore wind project. Taking credit for the environmental benefits of those other changes would need to be justified. The overall benefits may best be discussed on a system-wide basis or in a cumulative impacts and benefits assessment.

### System Benefits

The addition of offshore wind power generation can provide specific system benefits when properly incorporated into the existing generation and distribution infrastructure. The U.S. offshore wind resource is abundant and the wind pattern closely resembles electricity demand, peaking in the afternoon and evening hours. Wind conditions near major load centers are much stronger offshore than on land. These windy offshore areas are a relatively short interconnection distance from electrical grids in densely populated areas.

The relative value, and thus the benefit, from offshore wind energy production will be strongly affected by the ability to site the facilities near existing population centers and by the onshore system in place to distribute that energy to the areas where it is needed.

The incorporation of offshore wind energy into an overloaded onshore grid system could provide a benefit to local transmission infrastructure by bypassing or reducing the distant, onshore constraints. Power is moved from generator to load center, often across long distances, between states and regions to address and supplement demand. There are daily and seasonal fluctuations yet the current transmission infrastructure is often not capable of adequately supplying power where it is needed when it is needed. Developing offshore wind generation relatively close to major load centers and metropolitan areas would reduce demand for transmission system upgrades along existing transmission corridors.

The addition of offshore wind may also provide greater flexibility to system operators by decentralizing the system if the current system generation is transmitted from generators far from load centers.

### Environmental Benefits[3]

Offshore wind power result in few or no environmental impacts in specific areas such as emissions of carbon dioxide, mercury, nitrous oxides, and sulfur oxides compared to conventional electrical power generation. Being able to reduce or eliminate those emissions would be a clear environmental benefit. However, these benefits are typically indirect or cumulative and cannot be guaranteed if the projects are not connected actions in some formal way.

Over half of all water withdrawn in the U.S. each year is for cooling purposes, with power generation the largest user of cooling water. An offshore wind project that allows for the elimination of OTC or wet cooling would remove impacts to plankton or eliminate brine discharges. However other factors are driving facilities to reduce or eliminate OTC and reduce or eliminate brine discharges. EAs or EISs that identify these changes as benefits from a project need to fully characterize these other drivers to put these benefits into the proper context.

The primary operational waste from thermoelectric power plants is either from the consumption of solid fuels (primarily coal) and the resulting production of ash or the use of nuclear fuels and the resulting production of spent nuclear waste. Developing offshore wind energy would reduce hazardous, extremely hazardous, and nonhazardous waste generated during the construction, operation, and decommissioning of conventional thermoelectric projects.

Some changes can be both positive and negative, depending on the perspective of the examiner. For example reducing the burning of coal in power plants would reduce the production of fly ash. Less fly ash could be beneficial in several ways, including less use of landfill space for disposal and a reduced potential for spills from impoundments containing the fly ash. However, because fly ash is often used as an additive when grinding clinker to make Portland cement, the reduced availability could result in indirect impacts from the procurement of a replacement component. Thus, the benefits of reduced fly ash production and disposal may be offset by the adverse impacts to cement quality and environmental resources.

Because of the need for a broader look at factors affecting whether an effect is positive or negative, a limited and focused LCA may be a useful tool for identifying the different effects and determining the likely magnitude of an overall benefit. The most critical element of an LCA is the initial definition of its goals and scope, including the definition of the LCA boundary. An author needs to start far enough upstream of the specific project to capture meaningful inputs and continue far enough downstream of the specific project to consider meaningful impacts but without being so far upstream or downstream so as to be highly speculative.

### Socioeconomic Benefits

Socioeconomic assessments are useful for understanding the social and economic consequences of projects, programs, and policies. Although NEPA does not specifically require a socioeconomic assessment, NEPA does require an integrated use of the social sciences to assess impacts on the human environment. A socioeconomic assessment typically consists of a social benefit analysis and may incorporate an economic impact analysis. An economic impact analysis focuses on how a particular economy is likely to change from a project (e.g., the investment in an offshore wind energy plant), whereas a social benefit analysis measures the wider benefits to society. The socioeconomic assessment uses both components to determine if society would be better off with or without the offshore wind energy project.

Social benefits considered in a socioeconomic assessment of an offshore wind energy project may include:

- Energy reliability,
- Transmission and distribution,
- Electricity prices,
- Human resource development,
- Community investment programs,
- Property values,
- Visual amenity,
- Environmental externalities,
- Commercial fishing,
- Tourism,
- Recreation,
- Navigation, and
- Cultural resources.

At each phase of offshore wind energy development, there is the potential to generate economic benefits locally, regionally, nationally, or internationally, depending on the extent to which these geographic areas can deliver the materials and skills necessary to develop offshore wind energy. Economic benefits can be measured from project planning, manufacturing, installation, operation and maintenance, and decommissioning of wind turbines.

Economic impact analyses assess how the economy (e.g., local, regional, national) is likely to change as a result of the project (e.g., jobs, output, income, tax revenue). Offshore wind energy projects funnel direct benefits to local economies through hiring labor and expenditures on goods and services. Offshore wind energy projects also create indirect and induced benefits. Indirect benefits include the benefits arising from the wages and expenditures created in supplier businesses as a result of project expenditures. Induced benefits are changes in sales, income, or jobs created by changes in household spending, business spending, or government spending.

The most appropriate method for an economic impact analysis depends on the selected variables, available inputs, and the outputs produced by the tool. Some commonly used economic impact analysis methods and models include employment factors, RIMS II, the JEDI model, and IMPLAN. The order listed above ranges from the simplest to most complex. The accuracy of the results is dependent on the quality of the inputs and understanding the limitations of the analysis.

### How and Where to Include Benefits in NEPA Documents

The benefits of offshore wind energy projects should be considered in the NEPA environmental review process at the EA stage and, if undertaken, at the EIS stage. Generally, EAs provide a more qualitative review of impacts while EISs provide a more quantitative analysis, although this generalization varies widely across agencies, programs, and projects.

There are a number of places in an EA or EIS where the benefits of a project can be considered. An EA or EIS includes a statement of the purpose and need for the proposed action. In this discussion the anticipated benefits that should accrue from the implementation of the proposed action should be mentioned. This discussion is the basis for the commitment of resources and the justification to allow residual environmental impacts. It also sets the basis for the identification of feasible alternatives for evaluation in the document.

The Affected Environment section describes the existing baseline environmental and socioeconomic conditions within the project study area in the absence of the proposed action. Establishing a credible baseline allows for a description of the benefits and impacts from a project that are projected to occur with the implementation of the project. A key component of the baseline is a description of other associated but not directly related activities that could beneficially affect or be beneficially affected by the project. It is important to indicate which of these positive changes will occur, independent of the proposed actions. It would be inappropriate to claim credit for beneficial changes that were happening irrespective of the proposed action.

The main focus of an EA or EIS is the effects assessment. As there may not be benefits in all issue areas, the benefits assessment needs to be tailored to those that would occur rather than attempt to include a benefits assessment in all issue areas evaluated in the effects assessment.

A key component of an EA or EIS is the analysis of alternatives to the proposed action that meet the stated purpose and need of the proposed action. The relative benefits of the alternatives should be identified and evaluated concurrent with the evaluation of relative potentially adverse effects.

A good approach to provide at least a semi-quantitative measure of the benefits in an EA or EIS is the use of a risk analysis tool. Risk analysis can be used to evaluate the magnitude and significance of the effects of a project. Two parameters are required for the assessment of magnitude of impacts or benefits - consequences and likelihood. Each potential aspect is given numeric scores for these two parameters, and these parameters are then combined using a risk matrix to calculate the magnitude of an effect.

The analysis can be extended further by considering other factors such as extent, duration, and reversibility. From consideration of these parameters, a value can be calculated that can then be used to characterize significance. Using this semi-quantitative approach of risk analysis in an EA or EIS will promote consistency among subject matter experts in the assessment of potential project impacts and benefits.

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[3] Consideration of benefits to Air Quality/GHG and from newly available substrates are the subjects of two separate BOEM-sponsored analyses and are not discussed in the current white paper.

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## The Department of the Interior Mission

As the Nation’s principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the sound use of our land and water resources, protecting our fish, wildlife and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island communities.

## The Bureau of Ocean Energy Management

The Bureau of Ocean Energy Management (BOEM) works to manage the exploration and development of the nation’s offshore resources in a way that appropriately balances economic development, energy independence, and environmental protection through oil and gas leases, renewable energy development and environmental reviews and studies.

**www.boem.gov**