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AN ANALYSIS OF ALTERNATIVES FOR THE DEVELOPMENT OF JONES ACT COMPLIANT WINDFARM CONSTRUCTION VESSEL FLEETS

Kenneth J. Maloney, PE
MiNO Marine, LLC
Jefferson, Louisiana, USA
maloney@minomarine.com

David M. Bourg, PhD, PE
MiNO Marine, LLC
Jefferson, Louisiana, USA
david@minomarine.com

Kenneth F. Humphreys, PE
MiNO Marine, LLC
Jefferson, Louisiana, USA
kenneth@minomarine.com

Christopher M. Townsend, PE
MiNO Marine, LLC
Jefferson, Louisiana, USA
chris@minomarine.com

ABSTRACT

The typical offshore wind turbine generator (WTG) currently being installed worldwide produces 6 to 8 megawatts of electrical power and stands more than 100 meters above the ocean surface. The next generation turbines will produce 12 megawatts or more. In the summer of 2016 five of these turbines were installed in the coastal waters of Rhode Island. They are representative of the latest in a constantly evolving series of WTGs. As manufacturers continue to develop more powerful turbines, larger and larger specialized vessels will be needed to lift the components at assembly sites offshore. The process these vessels use to build America's offshore windfarms will need to be different from the approach normally used at sites outside the U.S. This is due in part to regulatory restrictions imposed by the Merchant Marine Act of 1920, which is more commonly known as the Jones Act. As it pertains to offshore windfarm construction, the Jones Act prohibits foreign-flagged vessels, (vessels built outside the United States) from moving cargo between two U.S. ports. Under the law, an offshore windfarm within territorial waters is considered a U.S. port. Therefore, employing a foreign built windfarm construction vessel to transport components from a nearby port to the construction site, as it typically does, violates the Jones Act. Although the Jones Act might appear to be a deterrent to the development of offshore wind in the U.S., it is not. The developers of the Rhode Island's Block Island Wind Farm (BIWF) used a combination of U.S. and foreign-flagged vessels to construct BIWF, while remaining in compliance with the law. This paper reviews the approach used at Block Island and discusses how it can be applied to future projects. An analysis of alternatives for various vessel fleet combinations that can be used for this purpose is provided. The analysis is based on results produced by a throughput and scheduling model developed by the authors. The model leverages the experience gained during the construction of BIWF, and was validated with data collected during the project. The alternatives include scenarios utilizing existing vessels modified for windfarm construction service, foreign-flagged windfarm construction vessels, and new vessels specifically built for the U.S. market. The paper concludes with a review of the relative efficiencies of various fleet configurations while undertaking the construction of a notional windfarm located off the East Coast of the U.S.

INTRODUCTION

The state of the art offshore wind turbine generator (WTG) currently being installed worldwide produces 6 to 8 megawatts of electrical power and stands more than 100 meters above the ocean surface. Five of these turbines were installed in the coastal waters of Rhode Island in the summer of 2016. They represent the latest in a constantly evolving series of larger and larger WTGs. The major manufacturers of these units have announced plans to manufacture even larger generators that produce up to 12 megawatts. [1] With each evolutionary step, larger and larger specialized vessels are needed to lift the components at assembly sites offshore. Many of these components weigh hundreds of tons and must be handled with precision and great care.

Dozens of large wind turbine installation vessels (WTIVs) are currently working the growing wind farms of Europe and Asia. One of these vessels was employed during the construction of the Block Island Wind Farm (BIWF) mentioned above and is shown in Figure 1. These vessels have three common features that separate them from other marine construction vessels. First, they are able to jack themselves out of the water using a series of movable legs. For this reason, they are referred to as "jackups" or "liftboats". Second, they have large heavy lift cranes with extended booms for reaching the heights needed to install the upper components of a WTG. Finally, they have large cargo decks that are used to transport as many as a half dozen disassembled WTGs from staging ports to the offshore wind farms where they are erected.

FIGURE 1: MV BRAVE TERN INSTALLS A TURBINE BLADE AT BIWF, (PHOTO: DEEPWATER WIND, LLC)

The Brave Tern, supported by the liftboats LB Paul and LB Caitlin, assembled the turbines at BIWF over a three-week period in August 2016. The Brave Tern is a purpose-built WTIV that has been in service erecting WTGs primarily in the European market since 2011. The approach it used to build BIWF however was a departure from the process typically used. Normally, the WTIV would load one or more complete sets of WTG components at a staging port, sail to the wind farm, assemble the turbines, and return to port for another load. This was not the case at Block Island. For this job, the Brave Tern remained offshore and assembled turbine components delivered to it from the staging port, Providence, RI. One of the vessels that did this work is visible directly aft of the Brave Tern in Figure 1.

This departure from standard construction practices is due to the existence of a U.S. maritime statute known as the Jones Act. [2] The Jones Act was enacted in 1920, but similar statutes have regulated maritime trade in U.S. waters since the earliest days of the nation. For the purposes of this report, it is taken as a matter of fact that the offshore wind industry must comply with this requirement and it is not our intent to explain this law in detail, or argue its merits. However, some explanation of its impact on the development of offshore wind in the U.S. is necessary to provide context for the challenges facing the industry.

In brief, the Jones Act prohibits foreign-flagged vessels, or vessels built outside the United States, from moving merchandise (cargo) between two U.S. ports. This means that foreign vessels are prohibited from loading cargo in one U.S. port and offloading it at another U.S. port. In this case, the ports were Providence and the Block Island Wind Farm. Since the Brave Tern (a foreign-flagged vessel) was prohibited from transporting turbine components out to the wind farm site, that job was done by U.S. flagged vessels.

Although this is not the typical mode of operations for assembling wind farms outside the U.S., it worked at Block Island and it will likely be the only approach that is economically feasible for constructing the first wave of offshore wind farms here, simply because there are no U.S. flagged WTIVs. It is also a distinct possibility that there may never be a U.S. flagged WTIV. These vessels typically cost in excess of $200 million when built overseas and one constructed in the U.S. would cost in excess of 20% more due to the higher wages paid in U.S. shipyards.[3] Given the current uncertainty in support for the development of offshore wind in the U.S., investors are hesitant when it comes to financing the construction of one of these vessels without a lengthy charter agreement in place.

BACKGROUND

The Bureau of Ocean Energy Management, an agency of the Department of the Interior, is responsible for the oversight of wind energy lease sites beyond state territorial limits. Currently offshore leases for sites between Massachusetts and Virginia are held by less than a dozen companies. Figure 2 shows a map of the offshore blocks that have been leased to date. [4]

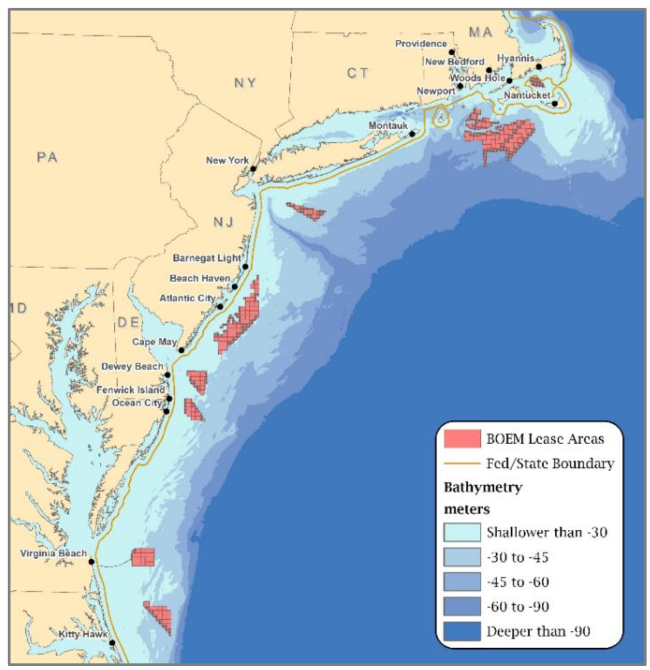

FIGURE 2: ATLANTIC OCS RENEWABLE ENERGY LEASE AREAS

The East Coast of the United States has some of the best locations for offshore wind development in the country. The water depths are reasonable for foundation installations and the wind resource ranges from good to excellent. The farther north one goes along the East Coast, the better the resource gets. The availability of that resource combined with a large coastal population are the main reasons why offshore wind is developing in this area first. The most active area of development is currently located off the coasts of Rhode Island and Massachusetts, where a handful of companies are working to get the industry rolling. This area also includes the Block Island Wind Farm (BIWF).

The typical wind farm is not constructed by the wind farm operator. It is constructed by contractors. Of particular interest for this paper are the subset of these contractors who are vessel operators. As noted previously, the vessels needed for this work are highly specialized and their availability and potential impact on plans for developing offshore wind farms in the U.S. have been discussed by several authors. [5, 6, 7] This study addresses this concern by investigating alternative approaches that can be used to avoid large capital investments in new vessels before starting offshore wind farm development here.

WIND TURBINE INSTALLATION VESSELS

Wind turbine installation vessels play two primary roles in the construction of an offshore wind farm. They transport the WTG component kits from a staging port to the offshore windfarm, and then they assemble those components on previously installed foundations. As these ships have deadweight limits that restrict the number of WTGs that can be transported at one time, it takes numerous voyage cycles to build a windfarm. A typical voyage cycle would include the following sequence of events:

1. Arrive at the staging port
2. Load and secure WTG component kits
3. Transit to the wind farm
4. Erect the loaded WTG component kits
5. Return to port and repeat the cycle

This process has been refined during the growth of Europe's windfarms and many vessels have been built to meet these requirements. WTIVs are meeting the demands for construction in many locations around the world and the capabilities of these vessels have had to keep pace with the development each new generation of WTGs as well. The first WTIVs to enter service normally transported and erected 3-4 megawatt turbines. Currently, 6-8 megawatt turbines are the norm and 12 megawatt turbines should be available by 2025. The increases in WTG power outputs drive the requirement for cranes with greater load and reach capacities and ships with larger decks and higher jacking capacities.

WIND FARM FEEDER VESSELS

The wind farm feeder vessel (WFFV) concept provides an alternate approach for assembling offshore wind farms. WFFVs are liftboats that are used to transport WTG components from the staging port to a WTIV located offshore. The WTIV then assembles components brought to the site by the feeder vessels. In this operational model, the feeder vessels "feed" the installation vessel a continuous supply of turbine components for assembly. This allows the WTIV to maximize utilization of one of its most valuable assets, its heavy lift crane.

In order to keep the WTIV working continuously, the WFFVs supporting the project must be able to keep pace with construction. To do this, it takes a minimum of two WFFVs. While one is offshore feeding WTG components to the WTIV, the other must be on its way to resupply. That resupply voyage needs to be completed before the WTIV finishes its work and moves to the next WTG foundation.

The WFFV mission can be done with two different approaches. One approach uses vessels that are capable of transporting at least one complete WTG component kit at time. These are identified as *whole* feeders. The other approach uses several vessels to transport one or more of the components in a WTG component kit. These vessels are identified as *partial* feeders. Partial feeder vessels will generally be smaller than whole feeder vessels and may require specific modifications to transport specific WTG components. Two partial feeder vessels like these were used effectively to support the work done by a WTIV during the construction of the Block Island Wind Farm. Figure 3 shows both of these vessels loaded with WTG components and bound for BIWF.

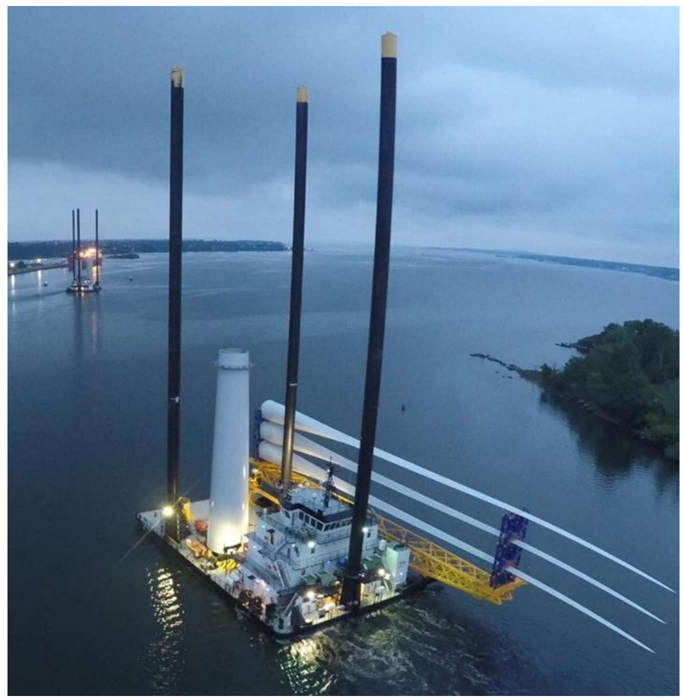

FIGURE 3: LB CAITLIN (FOREGROUND) AND LB PAUL (UPPER LEFT) LOADED WITH BIWF WTG COMPONENTS (PHOTO: KERRY L. SIMMONS, BLUE WATER SHIPPING)

WIND FARM CONSTRUCTION MODEL

Early in 2016, MiNO Marine developed an operations analysis model that was intended to test the various factors that could drive design requirements for new wind turbine installation vessels. The goal of building this model was to have a tool that could be used to provide clients with the best solutions for wind farm construction in the U.S. In order to do this, the model needed to be able to provide performance analysis results of WTIVs working alone and with feeder vessels. To accomplish this, the model used a combination of spreadsheets and critical path scheduling software. The spreadsheet was used to make detailed event duration calculations and critical path scheduling software was used to build the event sequences needed to determine total durations. A typical installation schedule for one of these WTGs is shown in Figure 4.

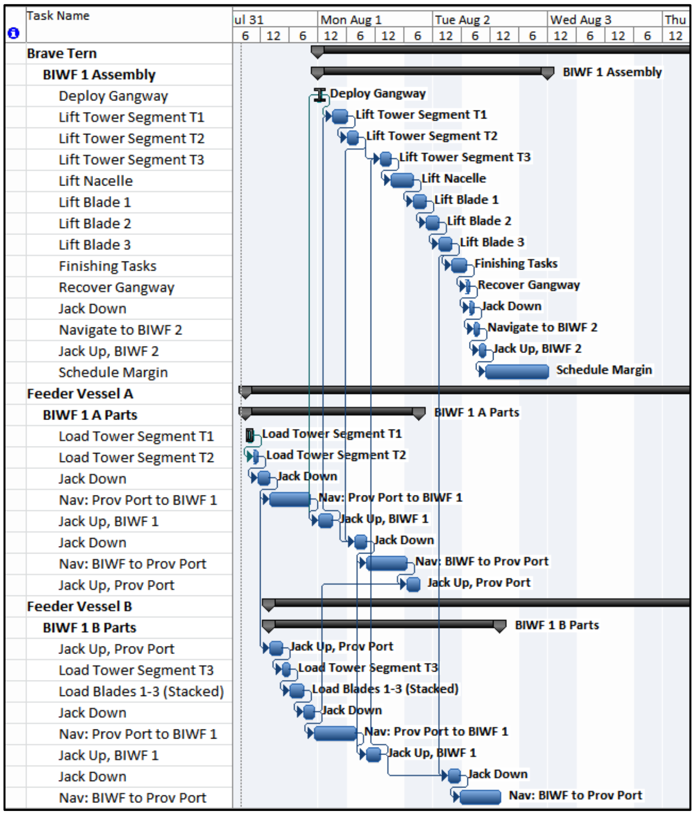

FIGURE 4: BIWF WTG 1 VESSEL SCHEDULE

The method used to estimate time durations for various tasks in the example shown in Figure 4 is typical of the approach used throughout the model. Each schedule event was first broken down into a sequence of tasks. For each task, an independent variable was identified. Time estimating factors either were obtained from public domain sources or were estimated. Task durations were then computed by multiplying the independent/key variable by the time estimating factor. The total time for the event was then sequenced into the critical path schedule.

The first version of the operations analysis model was finished by the summer of 2016. As a benchmark test, a model of the Block Island Wind Farm project was set up. This was done in advance of the start of construction so that events could be monitored to see how well the model matched real world events. After the first round of turbine components were delivered to Block Island, the pace of the feeder vessels was significantly ahead of the prediction. One cause of this turned out to be a time saving step taken by the shore crew in Providence. It is also an example of how human learning and innovation can improve a process in unanticipated ways. The model presumed that the shore crew would not begin moving a component to dockside until the receiving feeder vessel had arrived and was in position to receive the component. The shore crew was able to assess each vessel's progress on the return voyage and would have the next component scheduled for delivery rigged and awaiting loadout at dockside when the vessel arrived. This trimmed hours from the estimated turnaround times in port.

With information provided by Montco Offshore, MiNO was able to reconcile other differences between the predicted and actual progress at the site. The main cause of discrepancies between the model and the real world however, was due to the impact of weather delays. In an effort to simplify the model, weather delays were not incorporated into it. This was done because many of the evolutions involved with erecting a WTG are constrained by strict wind limits and wind events caused numerous delays at BIWF. Based on feedback from Montco Offshore obtained during this project, the throughput model and scheduling process were refined to a point where it could be used to evaluate the performance of various types of vessels and fleets of vessels. The resulting modeling approach was then used to perform the analysis presented in this report.

ANALYSIS OF ALTERNATIVES

The purpose of this report is to present the performance of various combinations of vessels that could be used to build the next wind farms in the waters of the U.S. In order to establish a level playing field for all of the scenarios that are tested some simplifying assumptions or global ground rules for the analysis need to be established. Therefore, we need to make decisions about the common factors involved with the analysis. These factors will be constant across all scenarios and include things like the type of turbine, the locations of the staging area and wind farm, the size of the project and so on. The identification of these common factors and a brief explanation for why they were selected for use in the analysis are provided below. It should be noted that changing any of these constraints would influence all of the scenarios equally, but not change the relative results of the analysis.

Project – South Fork Wind Farm, a 90 megawatt windfarm consisting of 15 six megawatt WTGs. [8] This project will likely start construction in 2019 [9] and is a practical near-term example for scenarios.

Staging Port – A port with unobstructed deep draft access located approximately 55 nautical miles from wind farm.

Environment – Calm for all operations.

Turbines – Nominal 6 megawatt WTGs similar to those installed at BIWF.

WTG Assembly – The performance of the WTIV for all assembly tasks is modeled as a constant. For example, the time it takes the WTIV to install one turbine blade is modeled with a duration of 2.9 hours in every scenario and for every turbine.

Vessels – Vessels use identical performance characteristics and project constraints. Ship's speeds for similar situations and transit distances for WFFVs were held constant. The transit from port to the wind farm is always 55 nmi and the transit between WTG foundations is always 0.5 nmi. Water depths for jacking tasks were also held constant at 40 meters.

The selection of these constraints for the AoA imposes some limits on the applicability of the results. For instance, the combination of selecting a staging port and a wind farm site introduces a fixed navigational distance for the movement of turbine components. Changing that distance by selecting different locations would change the transit durations. With higher transit durations, additional feeder vessels would be needed. Increasing the number of feeders increases the amount of time available for the round trip.

In order to test the hypothesis that offshore wind farm construction can proceed in the U.S. without first building new Jones Act compliant vessels, four scenarios were analyzed. These include the following baseline, noncompliant scenario, and three compliant, alternative scenarios:

1. WTIV – This scenario utilizes a single WTIV to transport and assemble all WTGs as if the Jones Act were not being enforced. This is the baseline case.
2. Whole WFFV – This scenario utilizes two (2) whole WFFVs to transport components to a WTIV that remains stationed offshore throughout the project.
3. Partial WFFV (Pair) – The scenario utilizes two (2) partial WFFVS to transport components to a WTIV that remains stationed offshore throughout the project.
4. Partial WFFV (Trio) – The scenario utilizes three (3) partial WFFVS to transport components to a WTIV that remains stationed offshore throughout the project.

In scenarios 2 through 4, the notional vessels used as whole and partial feeders are based on existing US-flagged liftboats. Liftboats are typically described by their leg length – a “235-class” vessel has legs that are 235 feet long. This class represents medium-sized liftboats like the LB Paul and LB Caitlin. Liftboats with legs in excess of 300 feet are considered large liftboats. Vessels like the LB Jill and LB Robert are “335-class” liftboats and representative of this class. In addition to being able to jack up in deeper waters, the 335-class can also lift significantly higher deck loads.

SCENARIO 1: WTIV (BASELINE)

The baseline throughput scenario for the AoA uses a single WTIV to transport turbine components and install them offshore. The vessel selected for this role is capable of transporting four complete turbine assembly kits and all of the tooling and lifting fixtures needed to erect a turbine. This scenario begins with the WTIV stationed at the staging port in an elevated position and ready to receive components. Four turbine kits are loaded on the WTIV before it departs for the wind farm to begin a construction cycle. The cycle ends after the WTIV has erected the four turbines, returned to port and discharged all empty turbine component transport fixtures. It takes the WTIV four cycles to install all the wind turbines.

The project schedule ends when the WTIV finishes discharging the last batch of empty turbine component transport fixtures back at the staging port. The total time required to install all 15 turbines, excluding delays, is approximately 37 days (881 hours). For each installation cycle, the uninterrupted time required by the WTIV to load, transport and erect four turbines is 235 hours. This includes an average assembly time of approximately 40 hours per turbine. With this loadout configuration, the WTIV will spend approximately 30% of its time in transit or in port, and the balance offshore erecting turbines. A summary project schedule for this scenario is shown in Figure 5.

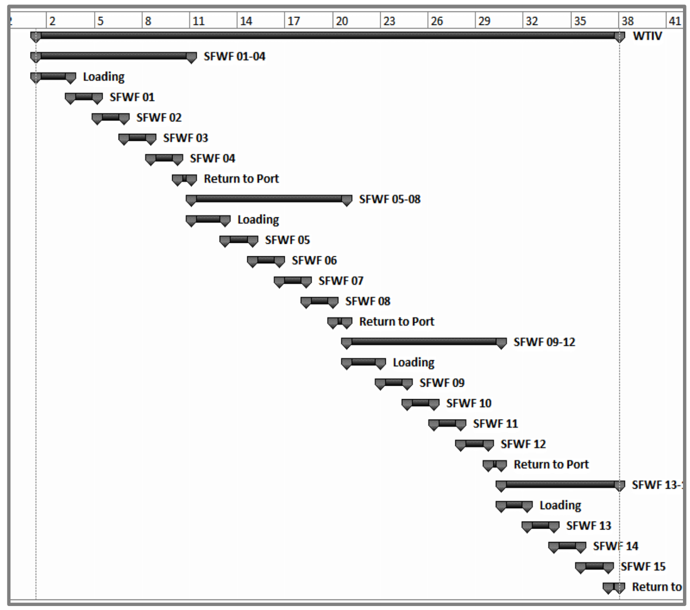

FIGURE 5: SINGLE WTIV PROJECT SCHEDULE

SCENARIO 2: WHOLE WFFV

When evaluating the feasibility of using existing US-flagged liftboats for whole WFFV service, the overall lift capacity of the vessel and cargo weights and centers of gravity were considered in arranging components and in determining whether baseline vessel modifications would be needed. The primary modification required for these vessels was the removal of their cranes. This increased the vessel’s variable load lifting capacity and available deck area. For vessels transporting turbine blades, side cantilever supports were used. Cargo positions and ballast levels were also adjusted to produce arrangements that satisfied all operational safety requirements. These included making sure that loaded vessels were within the permissible zone of the stability curve in both fully fueled and low fuel conditions. All of the feeder vessel configurations presented in these scenarios met these stability requirements.

Two whole WFFVs are used to transport WTG components to the WTIV for assembly under this scenario. These vessels would be 335-class liftboats similar to the LB Robert, which is shown in Figure 6. A single vessel could be used for this purpose, but the resulting WTIV idle time makes that case an impractical one from a cost effectiveness standpoint. In order to eliminate that idle time, two WFFVs were utilized. Each WFFV transits from the staging port directly to the next WTG site. This sets up a leapfrog process where the first vessel, designated F1, transports complete WTG kits to the odd numbered turbine sites while the second WFFV, designated F2, serves the even numbered sites. This also avoids interferences at the installation sites and in port.

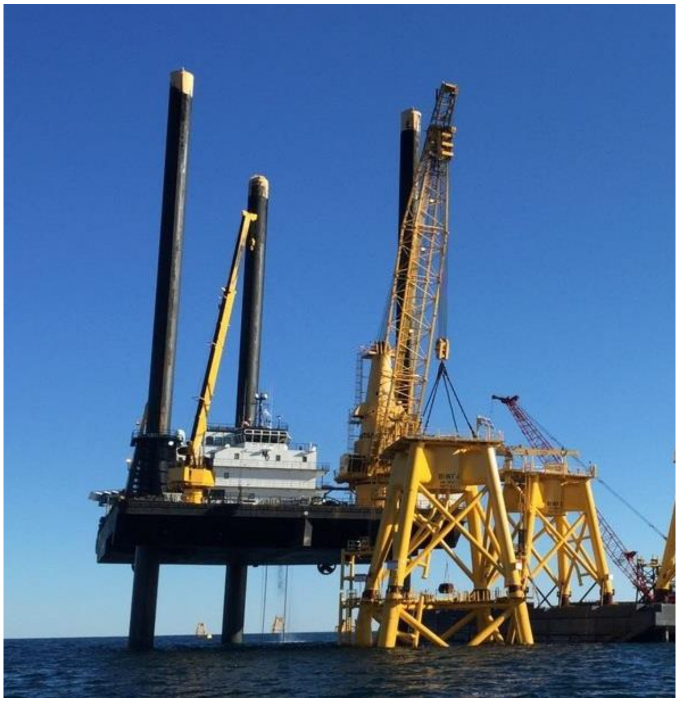

FIGURE 6: LIFTBOAT LB ROBERT INSTALLING A WTG FOUNDATION JACKET AT BIWF (PHOTO MONTCO OFFSHORE)

The complete project schedule is provided in Figure 7. The time scale for this schedule is in days from the start of the project. The total time required to complete the project is approximately 26 days. The average time needed to assemble a turbine in this scenario is approximately 40 hours. Of those 40 hours, the WFFV must be on station at the assembly site for a minimum of approximately 22 hours while the WTIV erects WTG components. For safety reasons, the feeder vessel must remain on station as long as there is a possibility that a component installation could be canceled. In that case, the WTIV would have to return the component to its foundation on the WFFV until whatever caused the installation issue is resolved. In the absence of delays of this nature, each WFFV has approximately 58 hours to make a round trip for more WTG components. With the transit distance used in the AoA (55 nautical miles), the WFFVs can complete a resupply cycle in approximately 33 hours. Adding time for precision navigation and jacking at the assembly site brings the total cycle time to 56 hours, which is well under the WTIV's two-turbine cycle time of 80 hours. This shows up in the schedule as 24 hours of free slack time for each turbine installation.

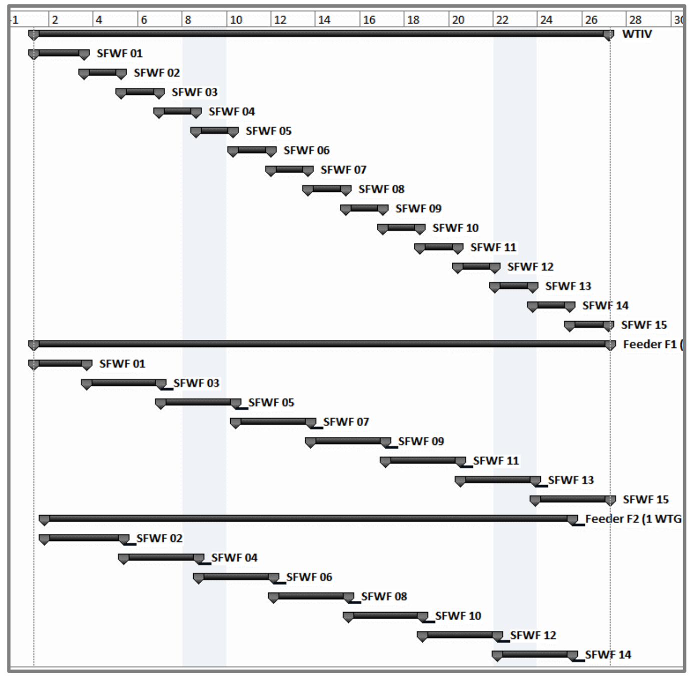

FIGURE 7: WHOLE WFFV PROJECT SCHEDULE

SCENARIO 3: PARTIAL WFFV (PAIR)

Partial feeder operations involve the transport of some, but not all of the components for a single WTG. When selecting vessels for partial feeder operations, it is important to consider transport capabilities as well as the amount of time needed to load and offload the components. The time each boat spends on station at the WTIV needs to be close to equal, even if the deadweight of the WTG component parts carried by each is not. The parts are also erected in a sequence, therefore, they need to arrive in that same sequence on each cycle.

The vessels used in this scenario were also used in the whole WFFV scenario. For this pair of vessels, being of equal size, the division of components is relatively simple. The first feeder, designated Feeder D, transports the three tower segments. The second, designated Feeder E, transports the nacelle and turbine blades. Although this represents a relatively equal division of the mass of the components, it does not result in an equal split in time spent offloading them at the WTIV. The overall project schedule for the partial feeder (Pair) scenario is shown in Figure 8.

As with the previous alternatives, the WTIV is presumed to begin the project near the first installation site. Both of the feeders begin the project jacked up in port and ready to receive components. Feeder D is loaded first and Feeder E starts receiving components as soon as Tower Segment 3 is loaded. With this combination of vessels, the project takes approximately 28 days to complete. The overall project time is longer than the whole WFFV scenario for two reasons. First, the WTIV experiences an idle time after tower segment T3 is erected while the WFFVs are exchanged. This adds about 3 hours to the assembly time required for each turbine. In spite of this added time, the project is completed well under the time needed for the single WTIV scenario.

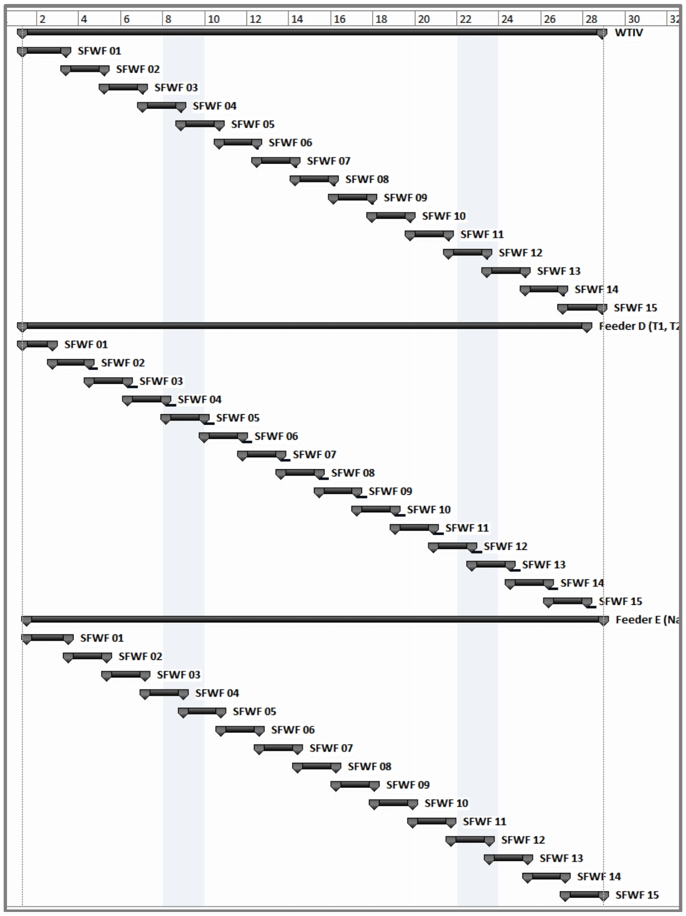

FIGURE 8: PARTIAL WFFV (PAIR) PROJECT SCHEDULE

SCENARIO 4: PARTIAL WFFV (TRIO)

The main objective in examining the performance of a trio of feeder vessels was to see if the addition of a third vessel would remove the feeders from the critical path. With three vessels available, both mass and time spend offloading could be more equitably distributed. Feeder vessel A in this scenario is a 235-class liftboat. It transports tower segments 1 and 2, which are arranged on the cargo deck in a staggered pattern on either side of the centerline. Additionally some deck equipment would be removed to reduce weight and enable the boat to meet stability requirements. Tower segment 3 and the nacelle are transported by a 335-class liftboat (Feeder B), which is capable of performing this mission without modifications. The final vessel in the Trio is another 235-class liftboat (Feeder C). It would need be configured like the vessel used to transport blades to BIWF by adding cantilevers and a blade transport fixture (CSF).

The overall project schedule for the partial feeder (trio) scenario is shown in Figure 9. As with the previous alternatives, the WTIV is presumed to begin the project near the first turbine's installation site. All of the feeders begin the project jacked up in port and ready to receive components. Feeder A is loaded first and Feeder B starts receiving components as soon as Tower Segment 2 is loaded. Feeder C begins its loadout after the nacelle is secured on Feeder B. With this combination of vessels, the project takes approximately 28 days to complete. The overall project time is approximately equal to the partial WFFV (Pair) scenario. Even though this project model triggers two feeder vessel exchange delays for the WTIV, they are offset by the reductions in time spent loading and unloading components. The only instances where the WTIV is not working on the critical path occur when the feeder vessels are being exchanged.

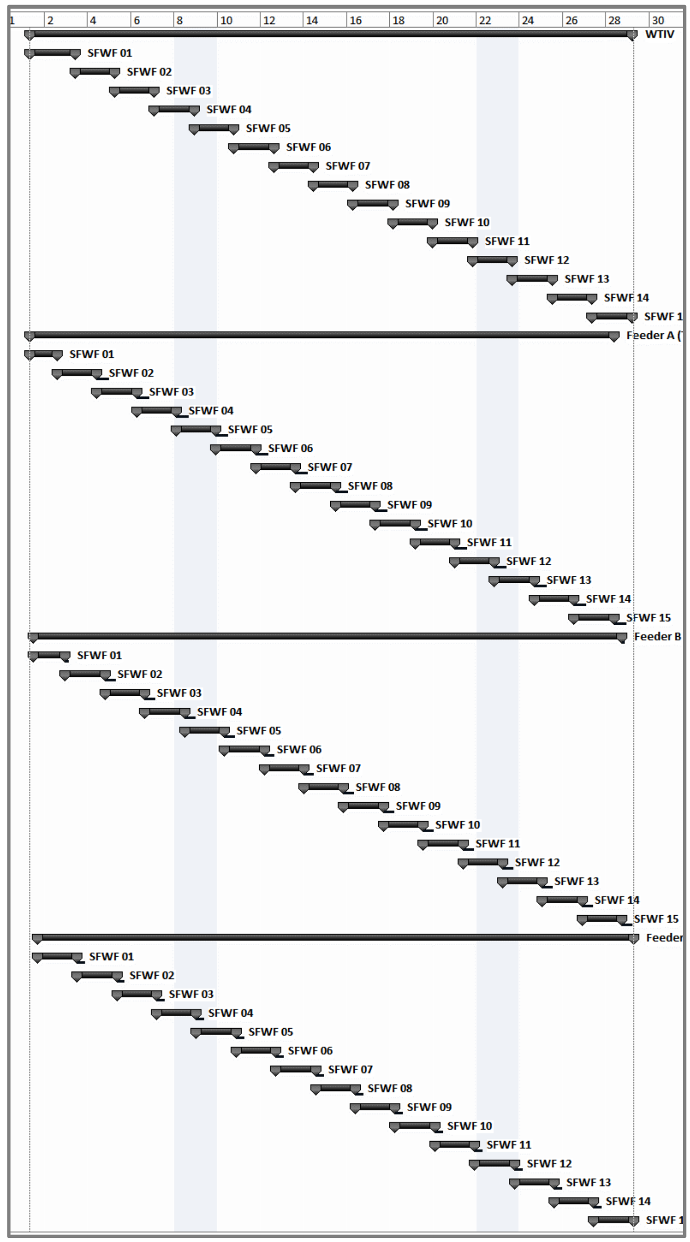

FIGURE 9: PARTIAL WFFV (TRIO) PROJECT SCHEDULE

SCENARIO PERFORMANCE COMPARISON

All of the feeder vessel scenarios modeled for this analysis of alternatives completed the project in less time than the single WTIV working alone. Key performance metrics for each of the AoA scenarios are presented in Table 1. The baseline WTIV project was completed in 37 days. Project durations for the feeder vessel scenarios ranged from 26 to 28 days.

TABLE 1: SCENARIO PERFORMANCE RESULTS

	1. WTIV	2. Whole WFFV	3. Partial WFFV	4. Partial WFFV
Vessels (WTIV + WFFVs)	1	3	3	4
Project Duration	37 days	26 days	28 days	28 days
Baseline Slack	-	11 days	9 days	9 days
Average Time	59 hrs	40 hrs	44 hrs	45 hrs
Slack	-	24 hrs	0 hrs	9 hrs

The analysis illustrates that a WTIV working with an appropriate fleet of feeder vessels can complete a project up to 30% faster than an equivalent WTIV working alone. The feeder vessel fleets tested in this AoA all outperformed the single WTIV. Both of the partial feeder fleets were adequate for this particular project but provided little or no margin for delays. The whole vessel feeder fleet provided the best capability, with significant schedule margins.

The analysis also showed that the feeder vessel fleet needs to be sized to keep the WTIV continuously working. In this analysis, a 40-hour cycle time was the objective and an appropriate fleet of feeder vessels would need to be able to achieve a resupply cycle time less than this to avoid delays. It also shows that there is a practical limit to the number of partial feeders that can be used during a project. The analysis indicates that three partial feeders are probably the limit when it comes to minimizing the overall project timeline. Dividing the WTG components up among four partial feeders would also be possible. To be effective however, components would still need to be allocated to the fleet so that each vessel spends nearly equal amounts of time on station at the WTIV.

CONCLUSIONS

The objective of this study was to show that solutions exist for supporting the construction of offshore wind farms in U.S. territorial waters, without first building new, specialized vessels. The analysis shows that existing U.S. flagged vessels designed for work in the offshore oil industry can be utilized to build offshore wind farms in the U.S. with minimal or no modifications. The analysis used actual vessels, components and locations to validate these capabilities. Fleets of feeder vessels tested in the analysis were made up of both small and large liftboats that are currently in service.

Although the amount of time needed to prepare and mobilize the vessels used in this AoA is not insignificant, it is small when compared to the time needed to design and build a new vessel for offshore wind service. The same comparison applies to the cost for each. Activities in the Gulf of Mexico’s oil fields have been depressed for several years and vessels similar to the ones used in this analysis might be available for this work on short notice. Identifying appropriate vessels and engineering the modifications needed would require several months to complete. The time needed to implement those modifications would depend on their extent and the availability of materials. Again, this would involve a matter of months, but not the years needed for new construction.

Fundamentally, the lack of a U.S. flagged, Jones Act compliant, wind turbine installation vessel should not deter or impede the progress of plans to develop offshore wind projects here. Existing Jones Act compliant vessels can be used as feeder vessels to transport turbine components to any offshore site between Maine and North Carolina. WTG assembly work would still need to be performed by an existing foreign-flagged WTIV, but this has been demonstrated to be in compliance with the Jones Act. This may not be the least expensive way to build an offshore wind farm, but it is the most expedient and practical way to do it in U.S. waters for now.

The analysis did not attempt to compare the cost of utilizing feeder vessels to the cost of WTIVs working alone. This is due to the highly variable nature of vessel day rates and the general reluctance of fleet operators to share competition sensitive pricing information. Even without that information, historical records of day rates indicate that the total cost to have a WTIV operating with a feeder vessel fleet would be higher than that of a WTIV working alone. In the short term however, this added expense pales when compared to the price of a new vessel and it may be worth the added expense if the result is that the WTGs are brought online sooner.

It can take two to three years to design and build a new WTIV. To justify taking on the financial risk associated with a venture like this, vessel operators typically need to demonstrate that the vessel can work continuously for years after it is delivered before financing institutions will back a construction project.

The development of purpose-built U.S. flagged offshore wind farm construction vessels depends on a number of factors, but none is more important than the demand for their services. In the early stages of the offshore wind industry here, the combination of foreign flagged WTIVs working with domestic, converted feeder vessels may be the only practical solution. Until a steady pipeline of projects develops, this approach may continue to be the norm for quite some time.

NOMENCLATURE

AoA Analysis of alternatives
BIWF Block Island Wind Farm
CSF Turbine blade cantilever support fixture
SFWF South Fork Wind Farm
WTG Wind turbine generator
WFFV Wind farm feeder vessel
WTIV Wind turbine installation vessel

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Bryan Bywalec, PE, Falcon Global, LLC

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