

Case Study

Kvitfjell Raudfjell Wind Farm





Industry
Wind energy
(onshore)



Chartering
Nine chartered
vessels



Volume
Over
290,000 FRT



Storage
Management
of 50,000 m²
storage yard



Cargo
Highlights
Over 800 OSHL
cargo units



Highlight
One of Europe's
largest onshore
wind farm
projects in 2019



50,000-square-meter storage area at the Grøtsund Terminal, managed by deugro and dteq

Case Study: Kvitfjell Raudfjell Wind Farm Project

As part of the Kvitfjell Raudfjell Wind Farm Project, deugro Danmark A/S successfully delivered 67 4.2-megawatt (MW) wind turbines with a volume of more than 290,000 freight tons originating from Morocco, Denmark and Indonesia to Norway. The cargo contained 800 oversized and heavy lift (OSHL) components including tower sections, nacelles, blades, generators and hubs plus more than 200 containers. The largest components were 28.3-metric-ton B63 blades with transport dimensions of 65 x 4.13 x 3.15 meters, and the heaviest were mid-towers with a weight of 80.24 metric tons each and measurements of 33.88 x 4.50 x 4.22 meters.

The Kvitfjell Raudfjell Wind Farm (Nordlys) Project was awarded by deugro's client Siemens Gamesa Renewable Energy. With over 290,000 freight tons, it was one of the largest onshore wind farm projects in Europe in 2019,

generating power supply for around 50,000 households.

The project sites were located west of the city of Tromsø in northern Norway, on the remote neighboring mountains Kvitfjell and Raudfjell,

and consisted of 67 hardstands with access roads inclining and declining at a grade of around 15% to 20%. Of the 67 wind turbines in total, 47 of them had to be installed on Kvitfjell and 20 on Raudfjell.

The only access for the OSHL cargo components was through a small 20-meter-wide jetty in Norfjorden, approximately 10 kilometers away from the construction sites.

Project preparation

Such a large-scale project requires precise planning, coordination and cooperation between all parties involved. To ensure the installation, commissioning and transportation of the 67 wind turbines remained on schedule, many different factors had to be considered and coordinated simultaneously during the preparation phase.

These included the identification of transport routes and the selection of suitable transport modes and equipment, while taking the cargo's

technical requirements, as well as the local infrastructure, weather conditions, restrictions and safety regulations, into account. Delivery sequences, cargo readiness, cargo collection, and the transport to the construction sites with interim storage at the Grøtsund Terminal at the Port of Tromsø, Norway, as well as the feeder vessel shuttling to the destination jetty, had to be carefully planned.

To move the cargo safely across all interfaces and to develop the suitable method statements, a variety of analyses, technical studies, simulations and calculations had to be prepared. Based on the weights and dimensions of the individual cargo units, these evaluations covered marine engineering, including stability and ballasting calculations, lifting and cargo securing calculations, a mooring analysis as well as RO/RO simulations and the identification of trailer configurations for the last mile up to delivery under hook of the installation cranes. Therefore, deugro engaged with



Discharge operations at the Grøtsund Terminal

dteq Transport Engineering Solutions, a company of the deugro group, who provided technical support and expertise on specific marine and land transportation requirements and who conducted various personal site visits and attended the trial run on site. For the trial run, the experts used an extended blade trailer to simulate the transport of B63 blades, the longest transport configuration, with the subcontractor Mar-Train.

Ocean freight and cargo collection

In the first step, the wind turbine components were shipped from Morocco, Denmark and Indonesia to the Grøtsund Terminal, Port of Tromsø, in Norway for interim storage. All shipments from the ports in Morocco and Denmark were executed and personally supervised by deugro, whereas the shipments from Indonesia were arranged by the tower supplier. For the shipments from the Port of Tangier, Morocco, deugro chartered

a total of four geared multi-purpose vessels with a combined lifting capacity of over 160 metric tons each, as well as two additional gearless general cargo vessels. For the gearless vessels, a 220- and a 160-metric-ton mobile crane had to be mobilized from Tromsø to the Grøtsund Terminal by the chartered feeder vessel because the mobile cranes exceeded the maximum permitted axle load for road transportation. Three further geared general cargo vessels with a combined lifting capacity of 170 metric tons each were chartered for the shipments from Denmark.

Overall, 10 vessels loaded with blades sailed from the ports of Tangier, Morocco and Aalborg, Denmark. From Esbjerg, Denmark, three vessels each shipped around 23 sets of main components, such as nacelles, hubs and generators, and containers. The tower sections were shipped on four heavy lift vessels from the Port of Ciwandan, Indonesia under control of the tower manufacturer.

i

The challenges

- Over 800 oversized and heavy lift components with lengths of up to 65 m and weights of up to 80.2 MT
- A small and narrow landing jetty with a width of only 20 m
- Management of the 50,000 m² storage yard, cargo treatment and feeder vessel shuttling to the destination jetty
- Sophisticated combination of lifting and RO/RO operations
- Challenging and daily changing weather conditions

Movement of a 65-meter-long blade at the Grøtsund Terminal





On-carriage to the construction site with access roads inclining and declining at a grade of around 15% to 20%

Discharge at Grøtsund Terminal and intermediate storage

The first vessel, loaded with tower sections, arrived on April 12, 2019. It took two days to remove the snow from the quay area and storage yard with a big wheel loader prior to the vessel's arrival and discharge operations.

The supervision and coordination at the Grøtsund Terminal, as well as the Norfjorden RO/RO jetty, were executed by dteq for the entire duration of all incoming shipments, as well as for all 34 feeder vessel shipments. This included the loading of equipment used at the terminal and various client equipment for return to Esbjerg, Denmark.

» Well-prepared stowage plans ensured the timely discharge of all incoming components. «

An essential part of deugro's logistics concept was the coordination and unloading of 17 vessels all together arriving at the Grøtsund Terminal from Morocco, Denmark and Indonesia; the interim storage of the various wind turbine components; and the subsequent onward transport by feeder vessel, shuttling between the Grøtsund Terminal and the destination jetty in Norfjorden.

Due to its remote location, approximately 20 kilometers from Tromsø, there was no port handling equipment at the Grøtsund Terminal prior to the start of the project. To have a fully functional terminal set-up for handling the individual transfers to and from the vessels, deugro, in cooperation with its subcontractor Mammoet, rented on long-term lease two specialized reach stackers, 80 and 50 metric tons respectively; a 16-metric-ton forklift; and a terminal tractor featuring a roll trailer and blade trailer.

For the storage of the individual components, approximately 20,000 square meters were initially planned; however due to changes in the schedule, a significant increase of storage space was required, which deugro flexibly managed to secure. The storage area used for the project finally amounted to approximately 50,000 square meters in total. The storage space and additional port activities were closely managed by deugro, and the supervision team was headed by

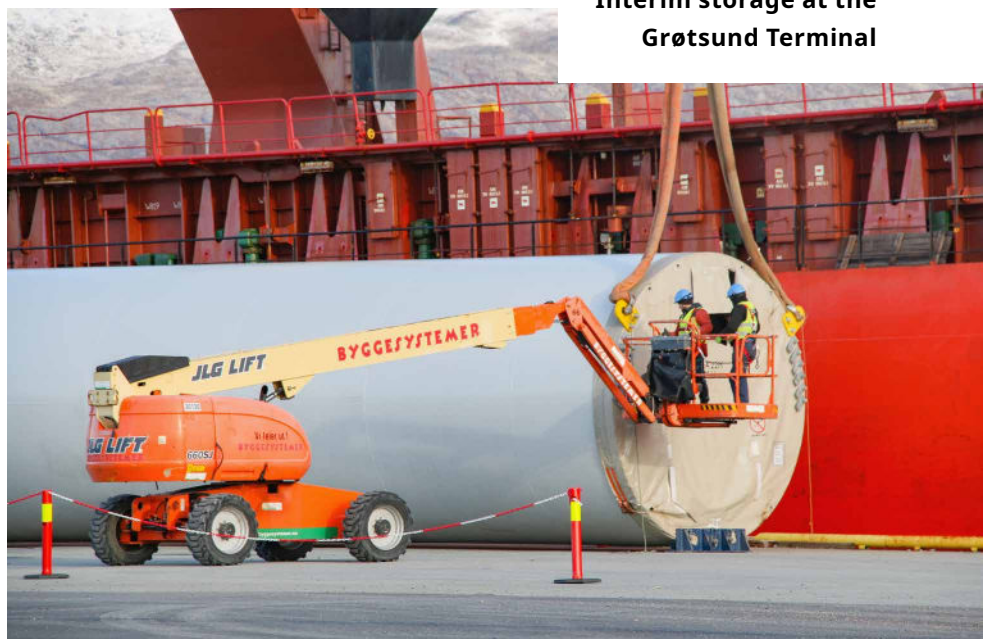
» The 50,000-square-meter storage space and port activities were closely managed by deugro and dteq. «

Peter Lorenzen from dteq. The main activities at the Grøtsund Terminal were the supervision and management of the discharge of incoming shipments, the individual transfers to and from the vessels as well as the handling of all lifting and transport equipment. This included

various activities at the storage yard—the connection to power for nacelles, generators and hubs; daily checks of the power supply; the dismantling of Liftra stacking frames from the tower sections and the mounting of Universal Tower Feet (UTF); and the cleaning of tower sections and blades prior to on-carriage.

The final 12 blades arrived in Orion frames instead of Bluetec frames. Therefore, they had to be turned 90 degrees at the storage yard before being loaded and shipped on the feeder vessel. Because the blade tips point down in Orion frames, instead of up in Bluetec frames, the stowage plan for the main deck had to be mirrored and modifications on board had to be made to accommodate the blades without touching the ramp area. Furthermore, the upper part of the second-tier Orion frame had to be taken off in order to fit under the forward hatch cover.

Interim storage at the Grøtsund Terminal





Ten-kilometer on-carriage from the Norfjorden jetty to the job site

Feeder vessel shuttling between the Grøtsund Terminal and the Norfjorden jetty

The onward transportation of the cargo units, from the storage yard to the destination jetty in Norfjorden by feeder vessel, was precisely planned and executed according to schedule, in line with the requirements of the construction site and the predefined loading sequences.

The biggest challenge was the quay in Norfjorden—a small and narrow jetty with a width of only 20 meters. The only possible solution for moving the components off the vessel was driving them out by trucking equipment using the vessel's RO/RO ramp.

To ensure the most optimal set-up, this required intense preplanning of the stowage plans in close cooperation with dteq, minimizing the number of sailings by optimizing the vessel. The vessel's cranes were fully used to move around with cargo—from the weather deck to the RO/RO deck and from the lower hold to the RO/RO deck.

Each feeder vessel voyage had to carry two complete sets of components. These consisted of two base, mid and top towers; two sets of three blades; and two nacelles, hubs and generators. To enable a delivery of one complete set on day one of discharge, the roll-off from the Norfjorden jetty to the site, and one complete set on day two, all components had to be loaded in the predefined sequence.

The loading operations of the feeder vessel at the Grøtsund Terminal and the discharge operations, the loading onto the trailer and the clamping of the tower parts in the feeder vessel, as well as the subsequent roll-off over the stern ramp at the jetty in Norfjorden, were supervised and managed by dteq.

For the loading operations inside the feeder vessel, the roll-off over the stern ramp and the subsequent delivery to the job site, a variety of equipment was used. For the mid

and base tower sections, clamp trailers were used. The top tower sections were moved by clamp trailer at the end with the larger diameter and by dolly with a cradle on the turntable at the smaller end. Extendable blade trailers were used for the B63 blades, and lowbed trailers for the nacelles, hubs and generators.

On-carriage

To deliver one complete set of components per day and to ensure the safe transportation of all oversized components to the construction sites, five escort vehicles were used—one in front of the convoy consisting of a three truck-trailer configuration, one to close the public road at the start of the site access road, and one behind each of the three trailers carrying the steersman as well.

Due to an approximately 135-degree turn, the blade and tower transports had to drive past the start of the access road and then reverse up the access road about 500 meters until a specially built turning area, before they could drive forward on the remaining access road. To pull up the tower and generator transports, tow trucks were required on site.

The project involved a total of 603 truck-trailer loads from the feeder vessel at Norfjorden jetty to the job sites as well as numerous standard truckloads of power transformer units and containers from the Grøtsund Terminal to the job sites. The final feeder vessel was discharged on October 30, 2019, in heavy snowfall, as on the two previous voyages, and the deliveries from Norfjorden to the job site were placed on standby in some cases due to adverse weather conditions resulting in unsafe transit roads to and within the job site. Nevertheless, the final components were delivered to the site within schedule upon acceptable safety approvals from the project QHSES teams.

On November 5, 2019, the feeder vessel completed the loading of

cargo to be returned, such as reach stackers, forklifts, the tug master, the roll and blade trailers as well as various equipment from the client at the Grøtsund Terminal in heavy snowfall.

The safe and successful execution of one of the largest onshore wind farm projects in Europe in 2019 marks another milestone in deugro's long and successful history in the execution of wind farm projects. deugro's experienced and dedicated team, as well as deugro's and dteq's close and excellent cooperation with the client and all subcontractors, led this exceptional project to a successful completion—from preparation to execution.



Discharge operations at the 20-meter-wide jetty in Norfjorden