

Replacement of Transformers on Middelgrunden Offshore Wind Farm

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Abstract

Middelgrunden Offshore Wind Farm consists of 20 Bonus Energy turbines of 2 MW each, placed close to Copenhagen. Production started in 2001 and shortly after the first 30 kV transformer broke down due to a short circuit. Most of the transformers have been replaced on Middelgrunden Offshore Wind Farm because of short circuits in the period of 2001-2009. In order to reduce the downtime, many inventions have been made.

Methods and Results



Fig. 1 Installation of transformer by working vessels. The space is very limited in the tower and there is only 1 cm of free space along the transformer during the installation process.

The first transformers were replaced in 2001 by the manufacturer as a part of the product guaranty. In the following years, 16 out of 20 transformers have been replaced. As consultant we have helped the owner of the wind farm to optimize the cost spent on the replacement of defective transformers.

Replacing a transformer is a complex job involving different work teams, special equipments, boats, cranes etc. The weight of a transformer is 6.2 ton and it is placed on the 3. floor inside the tower, see fig. 2. The main manpower is provided to dismantle the floors inside the tower to make space for lifting the transformer and the installation, see fig. 3. The other main job is to deliver the transformer to the offshore foundation to the height of 4.5 meter above sea level, see fig. 1.

In order to reduce the downtime and cost many inventions have been made; acting fast, using alternative teams and finding other boats and using them optimally, and finally using local cranes with smaller mobilization costs and other cranes than are usually used for this kind of operation. The average installation cost after optimization is now reduced from 73,000 euros to 47,000 euros.

The optimal working period is achieved to be 11 working days, see figure 4. The cost of exchanging one transformer is stated in figure 5. This figures includes the cost of the transformer together with the production loss during the exchange process. The production loss has a big variation depending on the downtime of the turbine and wind energy in the exchange period, see figure 4. The maximum downtime in 2003 was 115 days. This was due to the discussions with the manufacturer and the lack of available transformers.

Average value of the production loss is calculated to be 40,000 euros. It should be noted that this cost is close to the installation cost and it shows how important the length of exchange process is.

Note: The breakdown of the transformers is still pending in a court case and is not treated here.

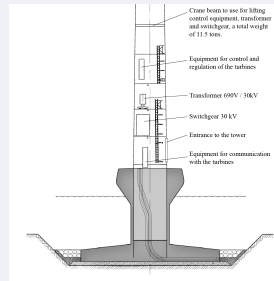


Fig. 2 Transformer is placed on the 3. floor in the turbine tower.



Fig. 3 Looking down at the transformer after dismantle of 3. floors inside the tower.

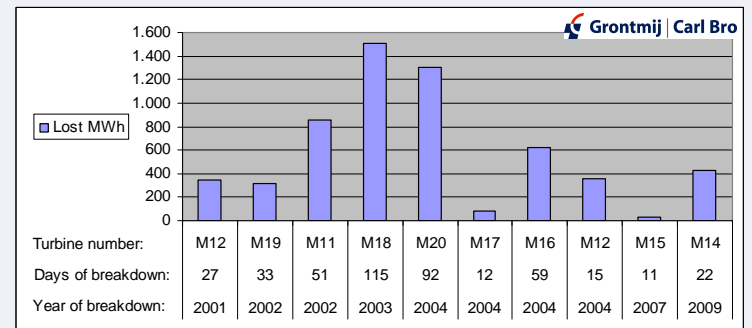


Fig. 4 Lost production after transformer breakdown. Days of breakdown before new transformer was installed, turbine number and year of breakdown is stated beneath the figure.

Cost elements	Euro	%
Manpower	19,000	16
Offshore Crane	8,000	7
Support boats	8,000	7
Other equipment	4,000	4
Other cost (procurement, coordination, turbine service)	4,000	4
Insurance	4,000	4
Total installation cost	47,000	41
Transformer	28,000	24
Lost production, average 585 MWh * 68 euro/MWh	40,000	35
Total cost	115,000	100

Fig. 5. Cost from an optimized exchange of transformer. Note: In 2007, the cost of the transformer raised to 52,000 euros.

Conclusions

In order to reduce the downtime, after transformer breakdown, many inventions have been made. Cost reduction has been achieved by planning the exchange fast, using alternative teams and finding other boats and using them optimally, and finally using local cranes with smaller mobilization costs. Because of this flexible approach, the owner has been able to reduce the optimal time for replacement to 11 working days and the installation cost of replacing a transformer is reduced from 73,000 euros to 47,000 euros.