Modeling of Operational Availability of Offshore Wind Turbines

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***Abstract*—Availability of offshore wind turbines is known as a key element to a profitable offshore wind project. Because of the poor accessibility, maintenance of offshore wind turbines dominates the availability problem. This paper presents a mathematical model for the operational availability of offshore wind turbines considering the maintenance issue and the offshore weather conditions. The model categorizes all the main issues varying the maintainability and then the outage time into several items that can be easily collected. The insufficiency of transfer vessels and the average operational availability of offshore WTs in a lager offshore wind farm are discussed. An example based on an offshore wind farm is used to demonstrate the application of the model. The results are compared and discussed with the field data. Sensitivity analysis forms the suggestion to allocate one vessel for every 15-20 offshore WTs in an offshore wind farm for the routine maintenance. It also provides some suggestions for the spare part management.**

Keywords—Availability, offshore wind turbine, downtime, transfer vessels

I. INTRODUCTION

Many offshore wind turbines (WTs) are undergoing extensive shutdowns due to the intensive met-ocean conditions. Offshore environment often boosts the failure rates of mechanical and electrical systems and reduces the utilization of WTs. The harsh weather often hampers the offshore maintenance, makes the downtime of faults everlasting. Since availability is a measure of both reliability and maintainability, it becomes a key factor of offshore wind projects.

Availability, which may be calculated as the ratio of Mean Time between Failure (MTBF) divided by the sum of MTBF and Mean Time to Repair (MTTR), has been widely used in generating system capacity evaluation. Sometimes it also can be calculated with failure rate (λ) and repair rate (μ) using the two-state reliability model [1]. Constant MTTR or repair rate from a long-run average value has been widely used in reliability evaluation. MTTR usually ignores standby and delays associated with the maintenance and logistics which is proved to be feasible in onshore systems. But these standby and delays are very considerable in offshore programs. According to [2], the downtime of offshore WT caused by logistics accounted for about 50% of all the shutdowns. Reference [3] confirms that besides the inherent, design- and quality-dependent reasons the maintenance plays an important role for availability of offshore WTs. Especially in the large offshore wind farms there are tens or hundreds of offshore WTs installed, which will certainly lead to maintenance resources insufficient problems. These delays associated with logistics are seldom considered in traditional reliability evaluation of power system.

Offshore weather condition is another reason that affects the availability of WTs. Nine aspects that highly influence the availability and reliability of offshore wind farm generation were highlighted in [4] including offshore environment and the unique installation area of wind farm. Reference [5] studied extreme weather impacts on offshore WTs. It showed that the spring and summer months are generally the only months during which vessels can perform O&M in the North Sea. The two-state weather model has been proposed to deal with the varying weather conditions where power system networks are exposing [6]. However, it mainly focuses on the impact that weather contributes to the failure rate. The impacts of weather conditions like wind speed and wave heights, and their effects on the offshore maintenance strategies are not involved.

This paper proposes an analytical model of operational availability (A_O) of offshore WTs which considers all downtime caused by maintenance issues and offshore weather conditions. First, the downtime of the offshore WTs and the procedure of the corrective maintenance are studied. Then maintenance of offshore WTs was classified into several categories by the components and their respective transfer vessels. Finally, the model for operational availability evaluation of offshore wind turbines is proposed. The model is suitable for the situation without operational experiences. The paper is structured in the following way. Section II describes the maintenance and the downtime of offshore WTs. Section III presents the A_O model of offshore WTs. The influences of environment conditions and fault moments are also discussed in this section. The central findings are summarized in Section VI.

II. DOWNTIME OF OFFSHORE WT

Operational availability (A_O) is defined as the probability that an item will operate satisfactorily at a given point in time

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when used in an actual or realistic operating and support environment. It includes logistics time, waiting time or administrative downtime, and both preventive and corrective maintenance downtime [1]. It reveals the real downtime of the products. The simplest representation is:

$$A_o = \frac{\Sigma[uptime]}{\Sigma[uptime] + \Sigma[downtime]} = 1 - \frac{downtime}{8760} \quad (1)$$

A. Downtimes description

Offshore WTs will be unavailable for two reasons: planned outage and unplanned outage. Planned outages are usually carried out when wind speed is low and the time schedules are much more manageable, so the downtime of planned outages donated by D_{PMs} usually can be easily predicted. Unplanned outage of offshore WT may be caused by power system or the WT itself. The former one will not affect the availability for the WT itself is in up-state. This paper mainly analyzed the downtime caused by Corrective Maintenances (CMs), which is donated by D_{CMs}. The downtime of the wind turbine can be calculated as:

$$downtime = D_{PMs} + D_{CMs} \quad (2)$$

D_{CMs} are very considerable in offshore wind farms. CMs of offshore WTs may not be executed immediately due to weather, logistics and some other reasons which may lead to a long waiting time. Even when a repair work starts, the work still may be interrupted or delayed for the weather or logistical reasons. A more intuitive description of a CM for offshore WT is shown in Fig.1.

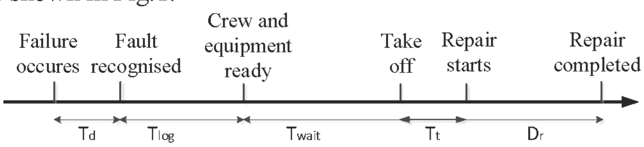

Fig.1 the process of corrective maintenance for offshore WT

The duration of a failure can be categorized into five parts and be calculated by Eq. (3).

$$D_{CM} = T_d + T_{\log} + T_{wait} + T_t + D_r \quad (3)$$

T_d is spent to find out the failed part or the reasons. For modern offshore WTs, faults can be detected by the intelligent fault diagnosis systems in a few minutes or seconds which means T_d is almost negligible comparing with the whole downtime.

$T_{\log}$ is for logistics preparing. It mainly depends on the O&M management and the failure. As the logistical works can be carried out simultaneously,

$$T_{\log} = \max\{T_{te}, T_{crew}, T_{sp}\} \quad (4)$$

where, T_{te} is the time for the arrangement of transportation and equipment. T_{crew} is for maintenance technicians, which is associated with working shifts. T_{sp} is for the needed spare part which is determined by stock policy.

T_{wait} is for the appropriate offshore weather condition.

T_t is spent to transport to the failed WT. It is mainly determined by the speed of the transfer vessel (v_{tr}) and the distance between the harbor and the WT (D_{WT}).

$$T_t = \frac{D_{WT}}{v_{tr}} \quad (5)$$

D_r is the downtime for the repair work. Note that if a maintenance activity requires more than one working day, it should be divided into sub-activities which can performed in several days because the night time is not suitable for offshore operations. Suppose that T_r is the real time spent on repairing or replacing the fault parts, then T_r can be described as

$$T_r = N_r * t_{wh} + t_{rest} \quad (6)$$

where, n is the minimum working days the repair work will be occupied. The working days the maintenance real take, which is donated by N_r, is variable with the accessibility of the wind farm. t_{rest} is the rest time which may be less than a whole working day. And D_r will be:

$$D_r = N_r * 24 + t_{rest} \quad (7)$$

These five time variables may be quite different for different subsystems and faults. Even in the same wind farm, these variables for different WTs may be unlike each other. So in order to gain the availability of WTs in an offshore wind farm with many wind turbines, the average values are what we expected. According to this category, the data of these time variables can be easily collected or estimated for a given offshore wind project, even a new one.

B. Definition of Normal weather and adverse weather

Weather condition is an important factor in availability evaluation of offshore programs. One situation is that the weather persisting not accessible to offshore WTs for quite a long time, such as ice season in North Sea. The other is that the weather is not suitable for offshore operations for a few hours or days, such as lighting storms, typhoons and nighttime. Considering that the lasting severe weather has obvious effect both for failure rate and the offshore repairs, This paper redefines the weather model based on IEEE Standard 346-1973 with their obstructions of the offshore maintenance. A period of time in a year which persists not suitable for offshore transportation and operation for quite a long time, such as ice season in North Sea and hurricane season in Pacific Ocean, is defined as adverse weather (AW). The rest is normal weather (NW). In normal weather days, the offshore operation may not be carried out either, because of the visual problems or wind speed and wave height. The weather in normal weather conditions which is suitable for offshore maintenance is called good weather (gW) and the one is not suitable is call bad weather (bW).

Therefore, gW is the only condition that offshore maintenance can take place. It represents two meanings: the visual requirement specifies no rainy, no fog or no night time which narrows the visions; the wind speed and wave height requirements fit the transporting and lifting request. Some research have been made in NL3 [7] and found that a wave height limit is accompanied with a wind speed limit. The probability of the good weather can be presented as:

$$P_{gW} = P(gv)P(Hs,V) \tag{8}$$

where, $P(gv)$ is the probability of good vision days, and $P(Hs,V)$ is the percentage of time specified by the wind speed and wave height of the transfer vessels. P_{gW} is the average percentage of gW.

III. MATHEMATICAL MODEL

An offshore wind farm consists of N_{WT} WTs. Generally, there are N_{sub} subsystems of a WT including blades, generators, gear box, electrical systems, control, yaw system, pitch mechanism, shaft and bearing, inverter, brake, and parking brake, etc. Any faults of these subsystems will result an outage of the wind turbine. Reference [8] demonstrates the reliability and downtime of theses subassemblies.

For offshore wind farms, some transfer vessels and support equipment are needed to take the offshore maintenance works. Four maintenance categories of an offshore wind project are defined in [8] and the associated fault classifications for all subsystems of a WT is shown in Tab.1. From Tab.1, it is noticed that all of the offshore maintenance should be carried out with some kind of transportations. In other words, the transport vessel will be occupied when the failure is confirmed until the failure is fixed. It means that the downtime of an offshore WT is also the average occupation of all transporting vessels minus the time transferring back. As the maintenance categories are in series, the downtime of WT can be obtained by Eq.(9).

$$\mathrm{D}_{\mathrm{CMs}} = \sum_{i=1}^{N_{cat}} d_i - \sum_{i=1}^{N_{cat}} \lambda_i T_{t.i} \tag{9}$$

where, N_{cat} is the number of maintenance categories defined by the transportations, d_i and λ_i are the average holding time of and the utilization rate of the transportations i respectively. $T_{t.i}$ is the transportation time from the failed WT of the onshore accommodation with the transfer vessel i which can be calculated by Eq.(5).

Tab. 1 PROBABILITY OF OCCURRENCE FOR DIFFERENT COMPONENTS

Component	Cat_1	Cat_2	Cat 3	Cat 4
Shaft& bearing	90%			10%
Break			20%	80%
Generator		30%	20%	50%
Parking brake			100%	
Electrical system		2%	8%	90%
Blade	1%	59%	20%	20
Yaw System	1%		34%	65%
Pitch Mechanism			50%	50%
Gearbox		10%	5%	85%
Invertor			10%	90%
Control			50%	50%

In order to get d_i, the duration is divided into two parts: when the transportation system is sufficient, the transportation equipment is occupied when the CM is done and maintenance system gets back to the accommodation. When the transportation system is not sufficient, it is the queuing time and this backlog of maintenance is related to the number of failed WT and the average time it will take to get repaired.

A Markov chain as depicted in Fig.2 is introduced to represent the backlog of maintenance activities. The state numbers represents the number of WTs that are failed and queuing for the transportation i for the maintenance.

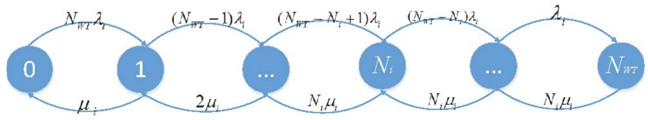

Fig.2 Markov diagram of the queuing model of transportations.

So,

$$d_i = d_i^e + \frac{1}{\lambda_i} \frac{\sum_{i_s > N_i} P(i_s)(i_s - N_i)}{\sum_{i_s} P(i_s)(N_{WT} - i_s)} \tag{10}$$

where, d_i^e is the average holding time of the transporting vessel i excluding the waiting in queuing.

$$\begin{cases} P(i_s)(N_{WT} - i_s)\lambda_i = P(i_s+1)(i_s+2)\mu_i, \forall i_s < N_i \\ P(i_s)(N_{WT} - i_s)\lambda_i = P(i_s+1)N_i\mu_i, \forall i_s \ge N_i \\ \sum_{i_s} P(i_s) = 1 \end{cases} \tag{11}$$

where,

$$\begin{cases} P(0) = \dfrac{1}{1 + \sum\limits_{i_s=1}^{N_i} \dfrac{\lambda_i^{i_s} \prod_{j=0}^{i_s-1}(N_{WT}-j)}{\mu_i^{i_s}(i_s+1)!} + \sum\limits_{i_s=N_i+1}^{N_{WT}} \dfrac{\lambda_i^{i_s} \prod_{j=0}^{i_s-1}(N_{WT}-j)}{(N_i)^{i_s-N_i}(N_i+1)!\,\mu_i^{i_s}}} \\ P(i_s) = \dfrac{\lambda_i^{i_s} \prod_{j=0}^{i_s-1}(N_{WT}-j)}{\mu_i^{i_s}(i_s+1)!} P(0), i_s = 1,\ldots,N_i \\ P(i_s) = \dfrac{\lambda_i^{i_s} \prod_{j=0}^{i_s-1}(N_{WT}-j)}{(N_i)^{i_s-N_i}(N_i+1)!\,\mu_i^{i_s}} P(0), i_s = N_i+1,\ldots,N_{WT} \end{cases} \tag{12}$$

According to the normal weather and adverse weather defined before, there are two kinds of possibilities.

A. *Faults happen in adverse weather*

As adverse weather is not suitable for offshore operations, the fault happened in this time should wait until adverse weather ends. But the logistics and technicians can be arranged in advance. There are two situations.

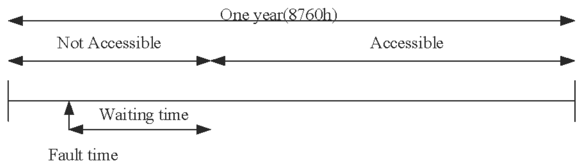

Fig.4 faults happen in adverse weather

When the waiting time is enough for preparing the logistics, which means the logistics are ready for the maintenance when the adverse weather ends which is shown in Fig.4. The repair work starts at $t=T_{AW}$. Repair work will take (n+1) days to get the component recovered which requires (n+1) days' good weather conditions. So when a fault happened at t, the average downtime will be:

$$\int_0^{T_{AW}-T_{\log i}} \frac{\lambda_i}{8760}\begin{bmatrix}(T_{AW}-t+2T_{si}+T_{ri})P_{gwi}^{n+1}\\ +(T_{AW}-t+2T_{si}+T_{ri}+24)(1-P_{gwi})P_{gwi}^{n+1}\\ +(T_{AW}-t+2T_{si}+T_{ri}+24*2)(1-P_{gwi})^2P_{gwi}^{n+1}\\ +\dots\\ +(T_{AW}-t+2T_{si}+T_{ri}+24*m)(1-P_{gwi})^m P_{gw.i}^{n+1}\\ +\dots\end{bmatrix}dt$$

$$=\frac{\lambda_iP_{gwi}^{n+1}}{8760}\left(\frac{A_i}{P_{gwi}}t+\frac{24}{P_{gwi}}t-\frac{t^2}{2P_{gwi}}\right)\Bigg|_0^{T_{AW}-T_{\log i}} \qquad (13)$$

where, $A_i = T_{AW} + 2T_{si} + T_{ri} + n_i * 24$.

When the waiting time is not enough for the preparation of the logistics, the logistics are unready when the adverse weather finished. At least ($T_{\log i} - T_{AW} + t$) is essential and waiting for a day time to take the repair works. Because of the non-attended situation, the repair work normally starts in the early morning, usually 6 a.m. in Donghai bridge offshore project. The average waiting time for the work shifts between 6 a.m.-6.pm is illustrated in Fig.5.

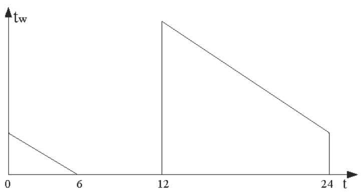

Fig.4 Average waiting time for the 6 a.m. to take off

The average downtime will be:

$$\int_0^{T_{\log i}} \frac{\lambda_i}{8760}\begin{bmatrix}(T_{\log i}+T_{avgi}+2T_{si}+T_{ri})P_{gw.i}^{n+1}\\ +(T_{\log i}+T_{avgi}+2T_{si}+T_{ri}+24)(1-P_{gw.i})P_{gw.i}^{n+1}\\ +(T_{\log i}+T_{avgi}+2T_{si}+T_{ri}+24*2)(1-P_{gw.i})^2P_{gw.i}^{n+1}\\ +\dots\\ +(T_{\log i}+T_{avgi}+2T_{si}+T_{ri}+24*m)(1-P_{gw.i})^m P_{gw.i}^{n+1}\\ +\dots\end{bmatrix}dt$$

$$=\frac{\lambda_iP_{gwi}^{n+1}}{8760}\left(\frac{B_i}{P_{gwi}}t+\frac{24t}{P_{gwi}}\right)\Bigg|_0^{T_{\log i}} \qquad (14)$$

where, $B_i = T_{\log i} + T_{avg} + 2T_{si} + T_{ri} + n_i * 24$ and the average waiting time $T_{avg} = 10.5h$.

B. Faults happen in normal weather

When the fault happens in normal weather, the waiting time may be much less than in adverse time. It just waits for the logistics and the suitable weather conditions to take off. It is shown in Fig.6. There are two possibilities.

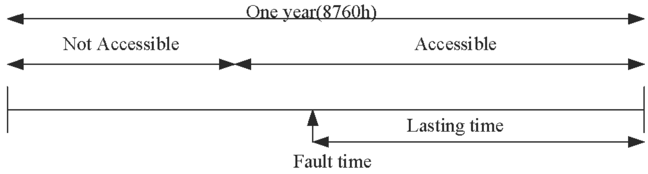

Fig.6 faults happen in normal weather

When lasting time is enough for the preparing and maintenance work, the average downtime is:

$$\int_{T_{AW}}^{8760-T_{\log.i}} \lambda_i\begin{bmatrix}(T_{\log.i}+T_{avg.i}+T_{t.i}+T_{r.i})P_{gw}^{n+1}\\ +(T_{\log.i}+T_{avg.i}+T_{t.i}+T_{r.i}+24)(1-P_{gw.i})P_{gw.i}^{n+1}\\ +(T_{\log.i}+T_{avg.i}+T_{t.i}+T_{r.i}+24*2)(1-P_{gw.i})^2P_{gw.i}^{n+1}\\ +\dots\\ +(T_{\log.i}+T_{avg.i}+T_{t.i}+T_{r.i}+24*m)(1-P_{gw.i})^m P_{gw.i}^{n+1}\\ +\dots\end{bmatrix}dt$$

$$=\lambda_iP_{gw.i}^{n+1}\left(\frac{B_i}{P_{gw.i}}t+\frac{24t}{P_{gw.i}}\right)\Bigg|_{T_{AW}}^{8760-T_{\log.i}} \qquad (15)$$

When $8760 - t < T_{\log.i}$, the maintenance will wait for the next year's normal weather. The downtime is:

$$\int_{8760-T_{\log.i}}^{8760} \lambda_i\begin{bmatrix}(T_{AW}-t+T_{t.i}+T_{r.i})P_{gw.i}^{n+1}\\ +(T_{AW}-t+T_{t.i}+T_{ri}+24)(1-P_{gw.i})P_{gw.i}^{n+1}\\ +(T_{AW}-t+T_{t.i}+T_{r.i}+24*2)(1-P_{gw.i})^2P_{gw.i}^{n+1}\\ +\dots\\ +(T_{AW}-t+T_{t.i}+T_{r.i}+24*m)(1-P_{gw.i})^m P_{gw.i}^{n+1}\\ +\dots\end{bmatrix}dt$$

$$=\lambda_iP_{gw.i}^{n+1}\left(\frac{A}{P_{gw.i\ i}}t+\frac{24}{P_{gw.i}}t-\frac{t^2}{2P_{gw.i}}\right)\Bigg|_{8760-T_{\log.i}}^{8760} \qquad (16)$$

According to Eq.(14) – (17), the average downtime of component i without queuing is

$$\begin{aligned}d_i^e &= \lambda_iP_{gw.i}^{n+1}\left(\frac{A_i}{P_{gw.i}}t+\frac{24}{P_{gw.i}}t-\frac{t^2}{2P_{gw.i}}\right)\Bigg|_0^{T_{AW}-T_{\log.i}}\\ &+\lambda_iP_{gw.i}^{n+1}\left(\frac{B_i}{P_{gw.i}}t+\frac{24t}{P_{gw.i}}\right)\Bigg|_{T_{AW}-T_{\log.i}}^{T_{AW}}\\ &+\lambda_iP_{gw.i}^{n+1}\left(\frac{B_i}{P_{gw.i}}t+\frac{24t}{P_{gw.i}}\right)\Bigg|_{T_{AW}}^{8760-T_{\log.i}}\\ &+\lambda_iP_{gw.i}^{n+1}\left(\frac{A_i}{P_{gw.i}}t+\frac{24}{P_{gw.i}}t-\frac{t^2}{2P_{gw.i}}\right)\Bigg|_{8760-T_{\log.i}}^{8760}\end{aligned}$$

$$d_i^e = \lambda_iP_{gw.i}^{n}(A_iT_{AW}+8760B_i+210240-B_iT_{AW} -\frac{T_{AW}^{\ 2}}{2}+\frac{T_{AW}T_{\log.i}}{2}-\frac{8760T_{\log.i}}{2}) \qquad (17)$$

Based on Eq.(9-10,17), the downtimes caused by CMs of offshore WTs can be calculated. With Eq.(1), A_o of offshore WT will be obtained.

IV. CASE STUDY

The proposed model has been demonstrated by means of a case study of an offshore wind farm consisting 50 WTs located 15km from a harbor. The annual failure frequency per component and occurrence frequency of each maintenance category are based on real data from [8] which is presented in Tab.2 and Tab.3. The number of annual fog day and thunderstorm day are 23.2 and 20.2.

Tab. 2 ANNUAL FAILURE FREQUENCY OF EACH COMPONENT

Component	Annual Failure Frequency	Component	Annual Failure Frequency
Shaft &bearing	0.01	Yaw System	0.2
Break	0.05	Pitch Mechanism	0.15
Generator	0.13	Gearbox	0.25
Parking brake	0.01	Invertor	0.2
Electrical system	0.27	Control	0.21
Blade	0.07		

Tab. 3 OPERATION PARAMETERS OF MAINTENANCES

Type	Transportations	Spare parts description	Leading time	Repair time
M_1	Cat_1	Heavy component, external crane needed	500h	43h
M_2	Cat_2	Heavy component, build up internal crane	160h	53h
M_3	Cat_3	Small parts, permanent internal crane	48h	12.4h
M_4	Cat_4	Small or no parts, outside	8h	5h

A. *Availability Analysis and transporting vehicles*

According to Tab.1, the failure frequency of the offshore WT is 1.55 occ/yr. The availability of the offshore WT is about 0.9935 just considering the repair time. The availability decreases to 0.9579 considering the waiting time of offshore weather conditions and logistics. Involving the insufficiency of transporting vehicles, the availability decreases to 0.8815. The results show that weather conditions and logistical supports take considerable downtimes of offshore WTs.

As the transporting vehicles contribute not only to the availability but also to the maintenance budget, it is very important to find out the relations between A_o of offshore WT and the amount of transporting vehicles. The results presented in Fig.6 illustrate that the increment of transportations of Cat.1, Cat.2 and Cat.3 have small improvements to the availability. This means that one transporting vehicle of Cat.1, Cat.2 and Cat.3 each is enough for the maintenance of this offshore farm.

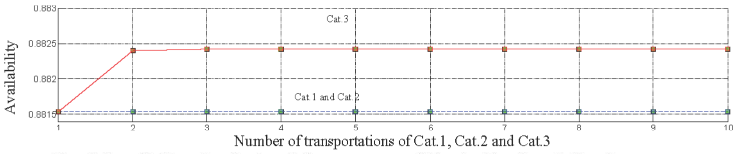

Fig.6 Sensibility Analysis of the amount of Cat.1, Cat.2 and Cat.3

Further study shows that one transporting vehicle of Cat.1, Cat.2 each is still enough for the offshore wind farm with 2000 WTs. When N_{WT} exceeds 300, more Cat.3 is needed.

The number of Cat.4 has significant influence on the availability for its higher frequency of use. Insufficient Cat.4 leads to a low availability and too many Cat.4s do not help too much to the availability as shown in Fig.7. For the given case with N_{WT} =50, three Cat.4s can achieve the availability of 0.9499 and more Cat.4s have limit effects on the availability.

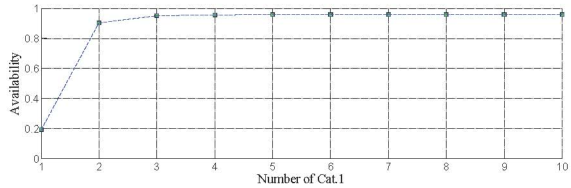

Fig.7 Sensibility Analysis of the amount of Cat.4

Further study for the appropriate number of Cat.4 for offshore wind farms is shown in Fig.8 with $A_O \geqslant 0.95$. It is suggested to allocate one vehicle of Cat.4 for about 15-20 offshore WTs.

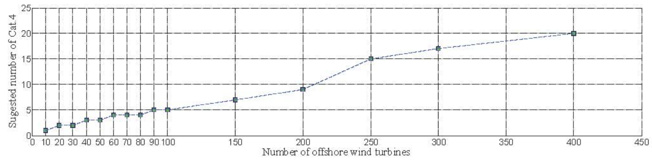

Fig.8 Appropriate number of Cat.4 for different scale offshore wind farms

B. *Sensibility Analysis*

In order to find out the reliability of component and the availability of offshore WT, sensibility analysis of failure frequency is carried out and shown in Fig.9.According to Fig.9, availability of offshore WT is more sensitive to the reliability of invertor, gear box and electrical system. It suggests using more reliable electrical systems, gear boxes and invertors to improve the availability of offshore WT.

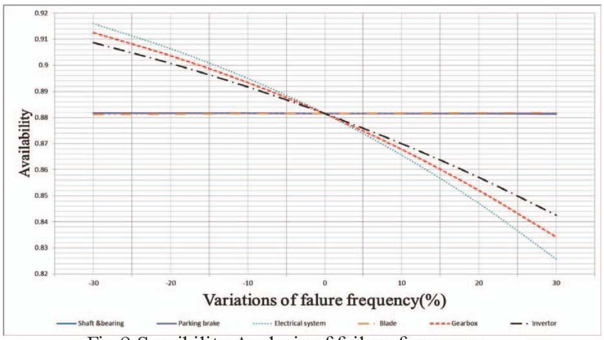

Fig.9 Sensibility Analysis of failure frequency

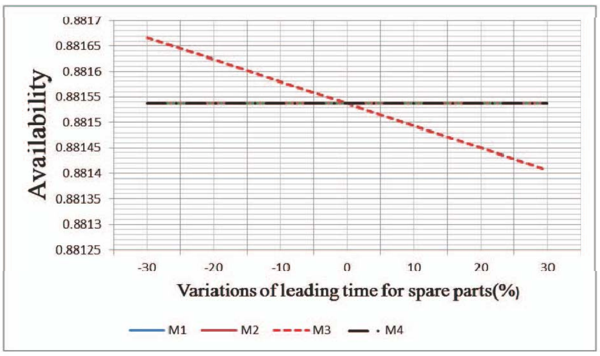

Fig.10 Sensibility Analysis of leading time for spare parts

Spare parts management is also an important part of the offshore wind farm O&M. It affects the availability and also the cost of spare parts system. This study aims to find out the necessity of modifying the stock size. Variations of leading time for M_1, M_2, M_3 and M_4 from -30% to +30% are introduced. Results show that the availability of offshore WTs is more sensitive to M_3 as shown in Fig.10. It is suggested that increment of M_3 in stock size can improve the availability.

V. CONCLUSION

This paper investigates several aspects contributing to the downtime of offshore WTs. A model is proposed to evaluate the operational availability of offshore WTs considering marine weather conditions and O&M strategies. The model was demonstrated by means of a case study of a 50 WTs wind farm located 15km from shore. The results of the case study show that the vessels for the large and heavy components are occupied occasionally and one vessel is usually sufficient. But the boats for the maintenance of small and light components and ordinary inspections will vary A_O significantly. Further studies show that it is better to allocate one boat for every 15-20 WTs in an offshore wind farm to maintain $A_O \geq 0.95$. Sensibility analysis suggests that improving the reliability of electrical system, gear box and invertor and keeping more M_3 in stock size will help to obtain a higher operational availability.

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