POSITION PAPER

STAKE HOLDER CONSULTATION PROCESS OFFSHORE GRID NL	
Type:	Position paper
Work stream	Other
Topic:	O.2 Stranded Asset Mitigation
Filename	ONL 15-217 O2_Stranded asset mitigation_PP_v1
Version	1 Public release
Pages	8

QUALITY CONTROL		
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Release		

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1. Background material

Literature used:
• N.A.

2. Scope and considerations

The Figure 1 below shows a schematic cross section of the connection of an offshore wind farm to the onshore electricity grid. Wind turbines are connected through “inter-array” cables (in orange) to the offshore Connection Point (CP)[1] at the offshore substation, from which electricity is transported to shore. TenneT is responsible for the grid connection up to, and including, the offshore substation and will take care for the supply and installation.

The wind park, including the wind turbines and the inter-array cables, up to the offshore CP at the switchgear installation on the offshore substation of TenneT, is to be supplied and installed by the owner of the Power Park Module (PPM[2]).

TenneT intends to standardise the offshore transmission grid as much as possible for all five wind areas to be realised in the coming years in line with the Energy Agreement.

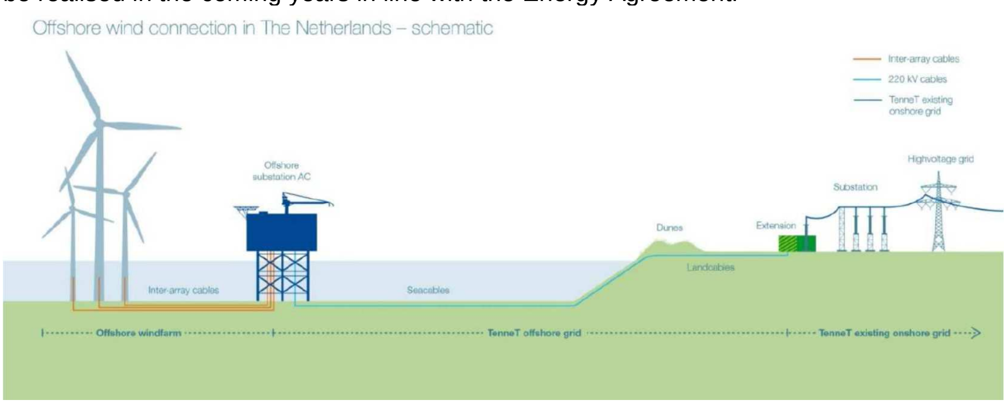

Figure 1 - Schematic of the offshore electrical grid. Source: TenneT

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[1] The connection point (CP) between the offshore power park module (PPM) and TenneT is specified [TenneT position paper ONL 15-061 T.3 Point of Common Coupling] at the cable termination of the inter-array cables and the switchgear installation on the platform.

[2] TenneT, position paper ONL 15-079 T.5 Operation of Bays

With respect to the interface between the offshore wind park owner (WPO) and TenneT the following risks have been identified:

- Commissioning of the offshore grid is delayed to an extent that start of operation of the PPM's is delayed resulting in loss of production of the PPM's;
- Outage in the offshore grid which will lead to loss of production of the PPM's.

In this position paper the view of TenneT on above risks and on how these risks could be mitigated is described. Apart from the loss of production also the loss of telecommunications is taken into account.

2.1 Installation delays

Planning

First of all, the risk of installation delays must be mitigated by aligning the installation planning of TenneT to the installation planning of the WPO's where certain milestones of TenneT (jacket installation, topside installation and energising of the offshore grid) are aligned to the foreseen installation periods of array cables, wind turbine generator (WTG) foundations and the WTG's itself.

The project planning is addressed to in [TenneT position paper [ONL 15-344 P1_Planning_PP].

Telecommunication

No wireless communication interface between offshore platform and onshore substation is foreseen as a standard back-up system to the communication system through fibre optic cables integrated in the export cables.

However, if a firm and significant delay is determined, TenneT will consider the installation of such a wireless communication interface in consultation with the WPO's. Therefore, such a system will be taken into account during the design, permitting and engineering process.

Auxiliary power

Apart from loss of production, a second consequence of delay of installation of the grid connection is that the first WTGs that are installed require auxiliary power which can't be provided through the grid. This risk can be mitigated in three ways:

- Install WTGs with a diesel engine powered generator (DG-set) to provide auxiliary power;
- Install a diesel engine powered generator plant (DG-plant) on the offshore platform;
- Delay of installation of the WTGs.

In Annex A, a comparison is made between the first two options: providing auxiliary power by small DG-sets per WTG or by a DG-plant on the offshore platform. This comparison shows that provisions for a DG-plant on the offshore platform (to be able to bear the weight of at least 200 MT of the DG-plant) will have a significant impact on CAPEX whereas small DG-sets per WTG require no provisions and as such have no impact on CAPEX. The operational costs (installation temporary equipment and refuelling) for both options are estimated to be equal.

2.2 Offshore grid outage

As each offshore platform will be connected with two circuits, a loss of one component (export cable or transformer) will lead to power curtailment but the platform and all WTG's will stay energized and communication will be fully functioning. Reference is made to [ONL 15-216-T12_Redudancy_availability_PP] for a further information on redundancy.

The risk that during the repair time of a major failure (cable fault or major transformer fault) a second failure occurs in the other circuit has not been assessed in T.12, but with an availability of energy of 98,7% for a single transmission system (taken from T.12), the availability of one of the two transmission systems will be 99,983%. The resulting risk of the unavailability of both transmission systems is to be considered so low (average of 1,5 hours / year), that investing in mitigation measures described in paragraph 2.1 (wireless offshore to onshore communication system and provisions for a DG-plant on the offshore platform for providing auxiliary power for the WTGs) will not weigh up to this risk. In line with the previous chapter, also in this situation, small DG-sets per WTG are considered to be a better mitigation measure than a large DG-plant (see Annex A), from a LCoE perspective.

For the risk of loss of communication only the export cable should be considered. Therefore, the availability of the telecommunication is higher than the transmission system. This risk is even lower than the figures given above (less than one hour / year).

3. Position of TenneT

Above considerations lead TenneT to the following position:

TenneT is inclined towards (i) not installing, nor make provisions for, a (diesel engine powered) back-up generator plant on the offshore platform to provide auxiliary power for the WTGs; and (ii) installing a wireless communication interface (emergency facility) between in the offshore platform and onshore substation, only in case a firm and significant delay in realisation of such communication through the export cable fibres.

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4. Topic consultation

The expert meeting of 2-3 July, 2015 gives TenneT the opportunity to get feedback from developers on their position regarding overplanting. The main goal of this meeting will be to assess whether TenneT’s views as documented within this position paper, and background data above, are shared by the industry.

5. Impact on cost

In the table below a summary is presented of the impact of preparing the TenneT platform in advance for possible location of back-up generation capacity on the platform on the TenneT platform on the Levelised Cost of Energy (LCoE). This preparation leads to an additonal investment in CAPEX, leading in turn to an extra investment - relative to the base case and hence to an increase in LCoE. Note that the OPEX during the "black out" is not considered here, as this is expected to approximately equal for either developer or TenneT depending on the execution scenario.

Cost impact: high level breakdown

Quantitative	LCoE Impact	Uncertainty	Comment
Cost element TenneT			
Substation: Platform	0.1%	Low	Increase in platform cost of 4% due to preparation for backup generation capacity (1)(2).
Society			
Borssele Alpha LCoE impact	*0.1%*	Medium	Combination of the LCoE impact from separate items above (1)(2).
Impact future years	*0.1%*	Medium	Impact for future years remains 0.1%, CAPEX impact is not expected to decrease for projects in future years.

Qualitative	LCoE Impact	Uncertainty	Comment
Technical	none	Medium	Installation and rental of generators and consumables, are comparable for both cases (back up supplied by Developer or TenneT) and are not taken into account in the LCoE calcuation (1).

References: TenneT internal (1), Ecofys internal (2)

6. Annex A – Qualitative comparison between WTG auxiliary power solutions

This Annex describes the possible options for temporary power supply to the WTG's in case of long term unavailability of the grid connection.

Two ways of providing (temporary) auxiliary power to the WTG's in case of long term unavailability of the grid connection are:

- Install WTGs with a diesel engine powered generator (DG-set) to provide auxiliary power;
- Install a diesel engine powered generator plant (DG-plant) on the offshore platform.

Both systems are described briefly and compared on feasibility

6.1 Assumptions

In this section the assumptions used for the comparison of the different options are presented.

WTG

Since the impact of a power outage will mainly be influenced by the number of turbines the following assumptions are used for the WTGs:

- Number of WTG's (2 OWF) 100
- Nominal Power ~7 MW
- Simultaneously factor own Consumption: 50%
- Consumption for heating/hydraulics in stand-still mode: 50kW
- Consumption for heating/hydraulics in pause mode: 100-150 kW

Infield cables

The infield cables will produce reactive power which will need to be compensated by the DG-plant. Following assumptions are used for the infield cables:

- Number of strings 10
- Reactive power production of 1 string ~7 Mvar
- Reactive power production of 10 strings ~70 Mvar

6.2 Description and comparison of the two auxiliary power options

Individual generator sets

This measure comprises the placement of – rental – GenSets of 50kVA at each WTG. These GenSets will be connected to the low voltage auxiliary system of the turbine. At each location an additional – rental – fuel tank of 1000 litre will be placed to limit the number of refuelling actions. The operational time without refuelling of a location will be about 3 days (based on a fuel consumption of 16ltr/h). In order to limit the amount of fuelling operations per location it might be considered to have the generators refuelled on a less frequent interval which means that the turbines are not energised on a continuous basis.

Diesel generator plant on offshore platform

This measure comprises the temporary placement of a number of – rental – GenSets of 1000-1250kVA at the OHVS. These GenSets will be coupled via a MV or LV board onto a temporary – rental – 66kV/0,4kV or 66kV / 10kV step-up transformer to energise the turbines over the 66kV infield grid.

Since the turbines are now energized through the 66kV grid, the turbines will be working in “pause-mode” and the average consumption is for this mode estimated to be around 100-150kW per turbine.

Due to the capacitive behaviour of the infield cables and the fact that the generator sets will have to operate with an inductive load, an additional inductive load bank is required to balance the capacitive charging current of the infield cables in the system. Such a – rental – load bank would most logically be connected on the 400V LV board of the GenSets.

Based on the cable lengths and types the total reactive power produced by the all infield cables would be approximately 70 Mvar. A load bank for this power rating will have a large space and weight impact on the OHSV and requires a step-up transformer of at least a 75 MVA. This system is considered not to be technically feasible.

Therefore it is suggested to energise the strings of turbines in a rotating way, keeping them energised for a period of time and de-energized while energizing the next string(s). This will reduce the required reactive power compensation to approximately 15 Mvar and active power to 2-3 MW (for 2 strings). Rotational energising of each pair of string(s) can be established automatically through the SCADA system. A satellite or line of sight communication would be required to allow for remote monitoring of the GenSets and the SCADA system.

The temporary GenSets shall be equipped with additional fuel tanks of 20.000 litre. With an active power consumption of 2 MW the daily fuel consumption (5kWh / litre) will be 10.000 litre. With a refuelling operation each 5 days this will lead to 3 tanks. All equipment will be placed in separate 20’’ containers to allow more easy placing at and removing from the offshore platform top deck.

Based on the above the following estimation of weight of equipment needed is made:

Item	Number	Capacity	Weight	Total Weight
Generator Set	3	1250kVA	20 Ton	60 Ton
Fuel tank	3	20.000 l	25 Ton	75 Ton
Transformer	1	17 MVA	30 Ton	30 Ton
Load bank	1	15 Mvar	60 Ton	60 Ton
			Subtotal equipment	225 Ton
Extra steel needed in offshore platform constructional steel				225 Ton
Total increase of weight				**450 Ton**

Comparison of the two options

It is assumed that the individual GenSets will require no upfront provisions (and therefore no pre-invested CAPEX).

A DG-plant will require additional construction steel of 225 ton. This will lead to a major increase of CAPEX. Apart from the addition steel, it should be investigated if the inductive load bank and step-up transformer of the required dimensions are available on the rental market. If not, these items have to be procured in advance which will further increase CAPEX.

For installation costs and refuelling costs it is assumed that both options have about the same impact provided that the individual GenSets will be operated in a start/stop operation (1 day on / 3 days off) to limit refuelling operations and fuel costs. But due to the very low chance such an operation will take place during the lifetime of the wind farms, these costs were not studied any further.