Ofgem

# Calculating Target Availability Figures for HVDC Interconnectors – IFA 2 Model

June 2018

# Table of contents



# Table index



# Figure index



# Appendices

# Disclaimer

This report has been prepared by GHD for Ofgem and may only be used and relied on by Ofgem for the purpose agreed between GHD and Ofgem.

GHD otherwise disclaims responsibility to any person other than Ofgem arising in connection with this report.  GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report.  GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report.  GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Ofgem and others, which GHD has not independently verified or checked beyond the agreed scope of work.  GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

# Executive Summary

Availability targets for the Ofgem Cap and Floor regulatory assessment framework have been based on an agreed methodology and model, developed in 2013 for the Nemo interconnector by Sinclair Knight Merz (SKM).

The SKM report made a recommendation to regularly update the model to ensure developments in VSC converter and HVDC cable technologies are captured.

GHD were engaged by Ofgem in 2016 to review update the SKM model, reflecting any new information that had become available since the original model was created in 2013, and then use this data to create a North Sea Link (NSL) model.

In 2018, GHD have again been engaged by Ofgem to create a 3rd version of the model, in order to create a model for the IFA2 project, whilst increasing usability of the model.

The GHD 2nd review concludes that adjustments can be made to the GHD 2016 second revision model taking into account:

- Reliability data (MTBF and MTTR) is predominantly unchanged, as no new data has been released by previous sources.
- Improved useability to reflect comments received on the model.

The revised GHD model has been used to evaluate the target availability for the IFA2 project.

Using the updated model, it is suggested that the target level availability for the IFA 2 project (utilising the project characteristics provided) would be in the range of 95.9% to 97.04% with a proposed base target level of 96.59%.

# 1. Aims

The Ofgem Cap and Floor assessment framework[1] for new electricity interconnectors includes three major stages, i.e. the Initial Project Assessment, Final Project Assessment (FPA) and Post-Construction Review.

Ofgem are currently undertaking the FPA stage for the Interconnexion France-Angleterre 2 (IFA2) project between the UK and France, which was approved in 2017.

One of the main deliverables of the FPA stage is a target for the availability incentive, which can increase or decrease the level of the cap on revenues.

The availability target is set based on an agreed methodology and model, developed in 2013 for the Nemo interconnector by SKM. This methodology[2] and spreadsheet tool[3] was made publically available by Ofgem so that the process for setting of targets was completely transparent.

The SKM report made a recommendation to regularly update the model to ensure developments in VSC converter and HVDC cable technologies are captured.

In 2016 the model was updated by GHD to reflect newly available data from CIGRE.

GHD have reviewed the model to make it more accessible and increase ease of use. The revised model has been used to determine a target availability for the IFA2 project

[1] https://www.ofgem.gov.uk/electricity/transmission-networks/electricity-interconnectors
[2] https://www.ofgem.gov.uk/ofgem-publications/59247/skm-report-calculating-target-availability-figures-hvdc-interconnectors.pdf
[3] https://www.ofgem.gov.uk/ofgem-publications/59248/skm-model-target-availability-model-hvdc-interconnectors.xlsx

# 2. IFA2 Project

The IFA2 (Interconnexion France Angleterre 2) interconnector project is being developed by National Grid and RTE. The IFA2 project is due for completion in 2020 and will provide an additional link between France and the UK[4].


Figure 1 IFA2 HVDC Interconnector project

In Great Britain, the connection point would be a new substation at an existing National Grid facility off Chilling Lane near Warsash, Hampshire. The connection substation does not form part of National Grid IFA2's planning application. The proposed converter station is on a site to the north east of Solent Airport at Daedalus.

The HVDC cables linking Great Britain and France will be routed through the Channel and into the Solent to a landfall at Monks Hill Beach, and then around Solent Airport to the Converter Station. HVAC cables will then connect the converter station to the substation at Chilling, routed underground around Solent Airport to the landfall, then subsea to a landfall near Chilling before being laid underground to the grid connection point substation.

The connection point for IFA2 in France will be at Tourbe 400 kV substation in Normandy, where there is also commercially available land for a converter station adjacent to the site.

[4] http://www.ifa2interconnector.com/about-ifa2/

# 3. Modelling Results

The model includes the target availability calculations for a single interconnector project as agreed with Ofgem, as well as an example project that is used as the basis for entering a new interconnector.

The project specific details for the IFA2 interconnector scheme are provided in section 3.1.

## 3.1 IFA 2 Model

The IFA2 interconnector project was modelled with the details provided in Table 1.

The HVDC offshore cable is 204 km of bundled HVDC subsea XLPE cable with 5.4 km of unbundled twin circuit HVAC offshore cable.

The onshore cables of the IFA2 project are 26.3 km of HVDC onshore XLPE cable and 4.7 km of HVAC onshore XLPE cable.

The unavailability of the VSC converter transformers was applied within the model based on a single transformer but with a spare phase arrangement, which takes two days to establish, thus providing a 99.45% availability (two days out of 365 lost).

Two circuits of HVAC cabling, each with a 50% rating, the time taken to isolate a faulted cable and return to service is assumed to be two days, hence availability assumed is 49.75%.

MTTR for an external fault on the HVDC cable was assumed as 90 days in normal weather and 115 days during restricted access.

Table 1: IFA2 Project Model Details

| Project Detail | Value/Technology | Unit |
|---|---|---|
| Rated Capacity | 1000 | MW |
| Rated Voltage HVDC | 320 | kV |
| Nominal System Voltage HVAC | 420 | kV |
| Converter Technology | VSC, Symmetrical Monopole | |
| Converter Transformer Arrangement | Single transformer (Three single phase units + spare) | |
| Cable Technology Onshore | HVDC XLPE<br>HVAC XLPE | |
| Cable Technology Offshore | HVDC XLPE Bundled<br>HVAC XLPE Single Core | |
| Offshore HVDC Cable Length | 204 | km |
| Onshore HVDC Cable Length | 26.3 | km |
| Onshore HVAC Cable Length | 4.7 | km |
| Offshore HVAC Cable Length | 5.4 | km |

Appendix A shows a screen shot of the IFA2 model data as input into the Project Sheet within the Excel model.

## 3.2 IFA2 Target availability using GHD model

The system availability of the IFA2 project was calculated within the GHD model using the average sensitivities for weather, maintenance and converter outages. The results for the base case are provided in Table 2.

### Table 2: Base System Availability in GHD model

| Project | Overall System Availability (%) |
|---|---|
| IFA2 | 96.59 |

The IFA2 system base case target availability was calculated to be 96.59% with the updated GHD model.

The cable fault unavailability was found to be most significant in determination of the overall system availability figures. The proposed cable length of the IFA2 project (204 km) will be relatively long compared to some projects e.g. Nemo (110 km) whilst shorter than NSL (714 km) which will become the longest subsea interconnector in the world, hence the mid-range value of cable fault unavailability and results in system availability between that determined for the previous Nemo and NSL projects.

The symmetrical monopole converter configuration for IFA2 project provides a reduced availability compared to NSL which is a Bipole arrangement but comparable to the symmetrical monopole topology used in the Nemo project.

## 3.3 Sensitivity Analysis

Sensitivity analysis was performed to determine how much the system unavailability of the IFA2 project would deviate from the base case of 96.59%, taking into account the range of MTBF and MTTR factors included within the model.

SKM suggested the reliability data associated with HVDC converters suffered from the most uncertainty due to limited data on reliability performance and new developments in technology.

A best and worst case assumption of 1 and 3 converter outages per year as shown in Table 3, was included in the model; a sensitivity study was performed and the results are shown in Table 4.

Table 3: Unplanned Unavailability Range for HVDC Converters in GHD Model

| Scenario/Range for MTBF | MTBF (Faults/Year) | MTTR (hours) | Total Annual Outage (hours) | Total Annual Outage (days) | Unavailability % |
|---|---|---|---|---|---|
| Base Case | 2 | 13.8 | 27.5 | 1.146 | 0.314 |
| Best Case | 1 | 13.8 | 13.8 | 0.575 | 0.158 |
| Worst Case | 3 | 13.8 | 41.3 | 1.721 | 0.471 |

An average MTTR figure for cable failures was assumed to be 65 days for offshore cables with a worst case assumption of 90 days due to weather conditions. The system availability figures whilst considering the worst case cable MTTR are provided in Table 4.

The planned unavailability due to scheduled maintenance could vary dependent upon the project maintenance plan and required outage time. The model allows the system availability to be calculated using a range of scheduled maintenance from more frequent (3 days per year) to less frequent (1.5 days per year).

Table 4: Sensitivity Analysis in GHD Availability Model

| Project | Overall System Availability (%) | | | | |
|---|---|---|---|---|---|
| | Worst Case Converter MTBF | Best Case Converter MTBF | Worst Case Cable MTTR | Most Frequent Maintenance | Least Frequent Maintenance |
| **IFA2** | 96.27 | 97.04 | 95.90 | 96.00 | 97.04 |

# 4. Conclusions

Using the updated model, it is suggested that the target level availability for the IFA 2 project utilising the project characteristics provided, would be in the range of 95.9% to 97.04% with a proposed base target level of 96.59%.

# Appendices

# Appendix A – IFA 2 Model Data Input

| | |
|---|---|
| Project: | IFA2 (Interconnexion French Angleterre 2) |
| Size: | 1000.0 MW |
| Timing: | 2020 |
| Locatior | UK-France |

| | |
|---|---|
| Total availability of IFA2 (Interconnexion French Angleterre 2) | 96.59% |

**Availability Calculation - Unplanned Outages**

| Input | | | | Calculation | | | | Output | |
|---|---|---|---|---|---|---|---|---|---|
| Units | Class | Circuit Length (km) | Equipment | Failure Rate (PA) | MTBF (Years) | MTTR (Days) | Available Capacity % | Unavailability (%) | % Total |
| 2 | Cables | 4.2 | IFA2 - UK AC Onshore Cable | 0.007 | 135.28 | 20.00 | 49.8% | 0.0204% | 1% |
| 2 | Cables | 5.4 | IFA2 - UK AC Subsea Cable | 0.005 | 192.90 | 65.00 | 49.8% | 0.0464% | 1% |
| 2 | Cables | 0.5 | IFA2 - French AC onshore Cable | 0.001 | 1136.36 | 20.00 | 49.8% | 0.0024% | 0% |
| 1 | Cables | 24 | IFA2 - French HVDC Onshore Cable | 0.021 | 47.35 | 20.00 | 0.0% | 0.1157% | 3% |
| 1 | Cables | 2.3 | IFA2 - UK HVDC Onshore Cable | 0.002 | 494.07 | 20.00 | 0.0% | 0.0111% | 0% |
| 1 | Cables | 204 | IFA2 - Offshore HVDC Cable | 0.098 | 10.21 | 75.94 | 0.0% | 2.0372% | 60% |
| 2 | Other | | VSC Converter Transformer | 0.008 | 125.00 | 32.25 | 99.5% | 0.0004% | 0% |
| 2 | Converter | | Symmetrical Monopole (Onshore) | 4.000 | 0.25 | 0.58 | 0.0% | 0.6301% | 18% |
| | | | | - | - | - | - | 0.0000% | 0% |
| | | | | - | - | - | - | 0.0000% | 0% |
| | | | | - | - | - | - | 0.0000% | 0% |
| | | | | - | - | - | - | 0.0000% | 0% |
| | | | | - | - | - | - | 0.0000% | 0% |
| | | | | - | - | - | - | 0.0000% | 0% |
| | | | | - | - | - | - | 0.0000% | 0% |
| | | | | - | - | - | - | 0.0000% | 0% |
| | | | | - | - | - | - | 0.0000% | 0% |
| | | | | - | - | - | - | 0.0000% | 0% |
| | | | | - | - | - | - | 0.0000% | 0% |
| | | | | - | - | - | - | 0.0000% | 0% |
| | | | | - | - | - | - | 0.0000% | 0% |
| | | | | - | - | - | - | 0.0000% | 0% |

Total Unavailability Due to Scheduled unplanned outages 2.8637%

**Availability Calculation - Scheduled Maintenance/Planned outages**

| Units | Class | | Maintenance Case (H/M/L) | Maintenance Rate/year | Maintenance Period (Years) | Maintenance Duration (Days) | Available Capacity % | Unavailability (%) | % Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Other | | Scheduled Maintenance Medium Case (1) | 1.00 | 1.00 | 2.00 | 0.00 | 0.5479% | 16% |

Total Unavailability Due to Scheduled Maintenance/Planned outages 0.5479%

| | |
|---|---|
| **Total unavailability** | **3.41%** |
| **Overall availability** | **96.59%** |

GHD

1st Floor 41-51, Grey Street
Newcastle-Upon-Tyne, Tyne & Wear, UK, NE1 6EE
T: +44 191 731 6120   F: 44 1904 431 590   E: newcastle@ghd.com



Ofgem - Availability Model  Rev 1 IFA2  01062018

Document Status

| Revision | Author | Reviewer | | Approved for Issue | | |
|---|---|---|---|---|---|---|
| | | Name | Signature | Name | Signature | Date |
| Rev 0 | Kieran Davis | CJ Jones | | G Skelly | | 13/04/2018 |
| Rev 1 | Kieran Davis | CJ Jones | | G Skelly | | 01/06/2018 |

www.ghd.com