# Project Assessment Report

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**Project:** Heysham 2 power station – Gas Circulator Variable Frequency Converter replacement.

**Site:** Heysham

**Title:** NP/SC 7571 – Torness and Heysham 2 power stations Variable Frequency Converter (VFC) replacement – Stage Submission 2 (SS2) – EC 335635 rev 000 Proposal Version 002.

**Licence Instrument No:** 585 (Agreement)

**Nuclear Site Licence No:** 60

**Licence Condition:** 22(1)

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## Revision History

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¹ Acceptance of the PAR to allow release of LI
² Approval is for publication on ONR web-site, after redaction where relevant
## Circulation (latest issue)

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EDF ENERGY Nuclear generation Limited - Heysham 2 power station agreement to the replacement of Gas Circulator Variable Frequency Converters

NP/SC 7571 – Torness and Heysham 2 power stations Variable Frequency Converter (VFC) replacement – Stage Submission 2 (SS2) – EC 335635 rev 000 Proposal Version 002
EXECUTIVE SUMMARY

Title

EDF Energy Nuclear Generation Limited (EDFNGL) - Heysham 2 power station – Licence Instrument 585 – ONR agreement to NP/SC 7571 – Torness and Heysham 2 power stations Variable Frequency Converter (VFC) replacement – Stage Submission 2 (SS2) – EC 335635 rev 000 Proposal Version 002,

Permission Requested

EDFNGL, the owner and operator (licensee) of Heysham 2 power station, has requested that the Office for Nuclear Regulation (ONR) issue an agreement, under licence condition 22(1) arrangements, for a modification to replace 50% of the gas circulator VFCs with modern equivalent variable speed drives (VSDs) on each reactor at Heysham 2 power station.

Background

In the event of a reactor shutdown trip at Heysham 2 power station, the gas circulator motors, which are normally supplied with 11kV, are run instead by VFCs operating at 3.3kV. In October 2003, 3 out of 8 VFCs failed during a trip of Reactor 8 at Heysham 2 power station. EDFNGL responded by improving reliability through an on-going stabilisation project. However, the VFCs are obsolete and require specialist contract support for maintenance and spares. To address on-going reliability concerns, EDFNGL propose to replace 4 out of 8 of the VFCs in each reactor, in opposing quadrant pairs, with modern equivalent VSDs and continue with the stabilisation of the remaining VFCs on each reactor, with the VFCs replaced as a result of this modification providing a future source of spares for the retained units.

Assessment and inspection work carried out by ONR in consideration of this request

The Safety Case submission, NP/SC 7571, covering both Heysham2 (HYB) and Torness (TOR) has been assessed and a Licence Instrument (LI) 534 was issued for Torness Power Station on 5 December 2013. Three assessments were undertaken for Torness as follows:

- Electrical Engineering Assessment, ONR-CNRP-AR-13-067.
- Control and Instrumentation (C&I) Assessment, ONR-CNRP-AR-13-065.

Each of these assessments recognised that although TOR would be the first station to undergo the modification, HYB would follow. Each assessment made specific reference to HYB and stated that each assessor was content, with caveats covering any differences between the stations, for 50% of the VFCs at HYB to be replaced by VSDs. In addition, an assessment covering the differences between the stations, specifically Computer Based Systems Important to Safety (CBSIS) security, plant room heating, ventilating and air conditioning (HVAC); auxiliary supplies electrical loading and obsolescence at HYB has been completed and reported in assessment report ONR-CNRP-AR-14-087 which satisfactorily addressed the caveats previously raised.

Matters arising from ONR's work

The ONR C&I specialist inspector undertaking the HYB specific assessment was content with the main submission, NP/SC 7571. A separate CBSIS security case submission, “Heysham 2 Power Station Security Case for Gas Circulator Variable Speed Drive – HYB/REP/SEC/0019“ was also assessed. The ONR C&I specialist inspector considered that greater detail was required in certain supporting documents of the security case The C&I specialist inspector agreed actions with EDFNGL, which are captured in assessment report ONR-CNRP-AR-14-087 and tracked within the ONR issues database. The inspector considered that these actions
were associated with enhancing and/or updating documentation and procedures and have no physical impact on the installation and therefore will not prevent the installation from proceeding at this time.

Conclusions

NP/SC 7571 Stage Submission 2 has been assessed by ONR and, as a result, there are no technical or regulatory reasons to prevent ONR from giving permission to a modification to replace of 50% of the VFCs at Heysham 2 power station.

Recommendation

It is recommended that ONR should give Agreement to a modification to replace 50% of the VFCs at Heysham 2 in accordance with NP/SC 7571 Stage Submission 2 by issuing Licence Instrument 585.

During completion of the technical assessment work in support of this PAR, the ONR Inspector raised the following issue:

- ONR issue number 3069 - ONR should review the final Response to Residual Risks, Action Plan and Accepted Risks, HYB/REP/SEC/0030/R [Ref. 11] and the Generic SyOps including Appendix P ‘HB/SDI/000/006’ [Ref. 10].
## LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>ALARP</td>
<td>As low as reasonably practicable</td>
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<tr>
<td>C&amp;I</td>
<td>Control and Instrumentation</td>
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<td>CBSIS</td>
<td>Computer Based Systems Important to safety</td>
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<td>CCF</td>
<td>Common Cause Failure</td>
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<td>EC</td>
<td>Engineering Change</td>
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<td>EDFNGL</td>
<td>EDF Nuclear Generation Ltd</td>
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<tr>
<td>HVAC</td>
<td>Heating, ventilation and air conditioning</td>
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<td>HYB</td>
<td>Heysham 2 power station</td>
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<td>ONR</td>
<td>Office for Nuclear Regulation (an agency of HSE)</td>
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<td>PAR</td>
<td>Project Assessment Report</td>
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<tr>
<td>PSA</td>
<td>Probabilistic Safety Assessment</td>
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<td>SAP</td>
<td>Safety Assessment Principle(s) (HSE)</td>
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<td>SyOps</td>
<td>Security Operating Procedure</td>
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<td>TOR</td>
<td>Torness power station</td>
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<td>VFC</td>
<td>Variable Frequency Converter</td>
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<td>VSD</td>
<td>Variable Speed Drive</td>
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1 PERMISSION REQUESTED

EDFNGL, the licensee for Heysham 2 (HYB) power station, has requested [Ref. 3] that the Office for Nuclear Regulation (ONR) issues an Agreement, in accordance with its licence condition 22(1) arrangements, to a modification associated with the replacement of 50% of the variable frequency converters (VFC) associated with the gas circulator motors on each reactor at HYB power station.

2 BACKGROUND

3 The existing VFCs at both Torness (TOR) and HYB are used to provide variable voltage, variable frequency electrical supplies to support variable speed operation of the gas circulators when the reactors are not at power. Operation of the VFCs supports forced post-trip cooling, for both pressurised and depressurised reactor conditions, as well as shutdown cooling.

4 The safety implications of VFC failures were highlighted following the Reactor 8 trip at HYB on 2 October 2003, in which three out of the eight VFCs failed. The licensee reviewed the adequacy of the safety case and concluded that whilst the failures represented a significant challenge the deterministic analysis remained sufficiently robust and that the risk associated with the apparent decrease in VFC reliability remained acceptable. However, in order to sustain the requirement that the risk was also as low as reasonably practicable (ALARP), remedial work to the VFCs was required.

5 The remedial work resulting from this has evolved into an on-going VFC stabilisation programme, which involves scheduled component replacement (such as relays, capacitors and contactors) together with re-engineering and replacement of the numerous control circuit boards within the VFCs. This work has stabilised the reliability of the VFCs as well as extending their service life (the original manufacturer has not supported the equipment for a number of years); however failures have not been eliminated.

6 To address the on-going reliability and obsolescence concerns, the licensee developed the longer term strategy to stabilise 50% of the existing VFCs on each reactor and to replace the remaining 50% by modern software-based variable speed drives3 (VSDs) with the replaced VFCs providing a future source of spares for the retained units. This strategy was determined by an optioneering study, discussed by the licensee in Paper of Principle NP/SC 7510 [Ref. 13]. The option to refurbish 50% of the existing VFCs on each reactor and replace the remaining 50% in diametrically opposed quadrant pairs on either side of the secondary barrier was identified as the preferred choice. This was considered to allow the benefits associated with modern equipment to be realised without introducing significant difficulties in retaining a satisfactory safety case due to issues associated with software-related common cause failures.

7 The Safety Case submission [Ref. 2] covering both HYB and TOR has been assessed and a Licence Instrument (LI) issued for Torness Power Station [Ref. 3] on 5 December 2013.

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3 Variable frequency converters (VFCs) and variable frequency drives (VSDs) are in essence the same equipment, providing a fixed or variable frequency output allowing the speed control of any connected motor driven pumps or fans independent of input supply.
Engineering Assessment [Ref.4]; Control and Instrumentation (C&I) Assessment [Ref. 5] and Probabilistic Safety Analysis Assessment [Ref. 6].

8. It is noted that the physical replacement of each VFC quadrant pair will be substantiated in individual appropriately categorised Engineering Change (EC) papers.

3 ASSESSMENT AND INSPECTION WORK CARRIED OUT BY ONR IN CONSIDERATION OF THIS REQUEST

9. This assessment has been carried out in accordance with HOW2 guide NS-PER-GD-014, “Purpose and Scope of Permissioning” [Ref. 1].

10. As stated above three assessments were undertaken for TOR as follows:

- Electrical Engineering Assessment [Ref.4]
- Control and Instrumentation (C&I) Assessment [Ref. 5]
- Probabilistic Safety Analysis Assessment [Ref. 6]

11. Each of these assessments recognised that although TOR would be the first station to undergo the modification, HYB would follow. Each assessment made specific reference to HYB and stated that each assessor was content, with caveats covering any differences between the stations, for 50% of the VFCs at HYB to be replaced by VSDs. In addition, an assessment covering the differences between the stations, specifically Computer Based Systems Important to Safety (CBSIS) security, plant room heating, ventilating and air conditioning (HVAC); auxiliary supplies electrical loading and obsolescence at HYB has been completed [Ref. 9].

12. I consider that these areas adequately address the significant aspects of the VFC replacement safety case.

13. Although the safety case submission [Ref. 2] did not assign a safety function category to the VFCs/VSDs, ONR have assessed the categorisation in accordance with BS EN 61226 [Ref. 15] and BS IEC 61513 [Ref. 16] and consider that the combined VFC/VFD system performs a Category A function. This categorisation also affects the security case and the robustness applied to the security assessment. The licensee has accepted the VFCs/VSDs perform a Category A function in an email [Ref. 17].

14. ONR, consider, based on the assessments undertaken [Refs. 4, 5, 6, & 9], that the combined VFC/VFD system meets its regulatory expectations for a system performing a Category A function. It is evident that in NP/SC 7571 [Ref. 2] the licensee has made all reasonably practicable efforts toward achieving compliance with modern standards albeit that this requires a combination of existing VFCs and modern VSDs. All ONR reports on this subject have highlighted that as a consequence the licensee should carefully consider any future proposal to replace the remaining VFCs so as not to compromise reliability of the system or diversity in its implementation.

3.1 ELECTRICAL ENGINEERING ASSESSMENT

15. The assessment by the specialist electrical engineering inspector is reported in Ref. 4. The inspector was satisfied that the licensee had adequately considered the potential challenges to the main safety-related functions within the safety submission [Ref. 2] and that the key electrical engineering aspects were related to the ability of the VSDs to deliver the function required in all modes of operation, ensuring that the new VSDs do not compromise the integrity of the essential electrical system and that the new VSDs perform their safety function in parallel with the existing VFCs.

16. The specialist electrical engineering inspector noted that the electrical loading studies showed no risk of overload of the diesel generators at HYB. With this consideration he
indicated that he was content that, from an electrical perspective, the conclusions reached within his assessment were applicable to HYB. The electrical inspector raised one caveat, that a review of the electrical loading of the auxiliary supplies at HYB should be undertaken. This was addressed in a specific HYB assessment [Ref. 9] and considered acceptable.

3.2 PROBABILISTIC SAFETY ANALYSIS (PSA) ASSESSMENT.

17. The assessment [Ref. 6] by the specialist PSA inspector focused on the claim that the risk associated with replacement of up to 50% of the VFCs with the new VSDs reduces risk to be as low as reasonably practicable (ALARP), and that common cause failures (CCF) have been adequately considered.

18. The PSA inspector considered the following aspects in the PSA assessment:
   - adequacy of the scope of the PSA sensitivity studies to support NGL’s safety case claims;
   - adequacy of the PSA model used in the sensitivity studies;
   - adequacy of representation of the VSDs in the PSA sensitivity studies;
   - adequacy of consideration of CCFs; and
   - whether risk has been reduced ALARP

19. Based on an assessment of these aspects, the PSA inspector was satisfied with the claims, arguments and evidence relevant to PSA presented within the licensee’s safety case, supporting documentation and the response to queries.

20. The specialist PSA assessor further noted that the safety case submitted [Ref. 2] was a joint safety case for TOR and HYB power stations and in terms of the claims arguments and evidence assessed, in relation to PSA, the inspector considered the conclusions reached were also applicable to HYB.

3.3 CONTROL AND INSTRUMENTATION (C&I) ASSESSMENT FOR REPLACEMENT OF 50% OF VFCs AT TOR

21. The assessment of the safety case by the specialist C&I inspector is reported in reference 5. This assessment focused on the licensee’s justification that the computer-based system development and testing of the VSDs is sufficient to satisfy the integrity claimed in the safety case. In achieving this, the inspector considered the adequacy of the licensee’s demonstration of production excellence and independence confidence building with reference to the approach of safety assessment principle (SAP) ESS.27 [Ref. 14] and the licensee’s own internal guidance.

22. The specialist C&I inspector reported [Ref. 5] that the licensee had indicated that the programmable electronic aspects of the VSD applications at TOR and HYB were identical and was therefore of the opinion that the conclusions of the TOR assessment could be applied to HYB.

23. The specialist C&I inspector raised two recommendations, one in relation to the obsolescence strategy and the second in respect of the CBSIS security case. These have both been addressed by the HYB specific assessment (see below).

3.4 HYB SPECIFIC ASSESSMENT

24. This assessment was undertaken by a specialist C&I inspector on the basis the most significant differences between TOR and HYB were considered to relate to C&I aspects of the modification. The specific areas assessed were CBSIS security, plant
room heating, ventilating and air conditioning (HVAC); auxiliary supplies electrical loading and obsolescence.

25. The licensee informed the specialist C&I inspector that the modification to the HVAC system was covered under a separate Category 2 EC 352535. The specialist inspector noted that expert HVAC contractors had undertaken the revised design and that this design had gone through the licensees’ verification process. The specialist C&I inspector was content that the licensee had followed an appropriate process and engaged with appropriate experts in the field to address the HVAC requirements. In addition, electrical loading aspects of the auxiliary supplies had been separately considered under EC 352534. The licensee states that this report reviews the impact of replacing the VFCs with VSDs on the existing 240V and 110V AC auxiliary and control supplies and concludes that there is will be no detrimental impact on the existing loading, protection and supply cable. [Ref. 18]. The issue of spares and obsolescence was addressed by the licensee for TOR by the production of Gas Circulator Variable Speed Drive Replacement, Through Life Management Strategy [Ref. 8]. The specialist inspector has reviewed this document and was satisfied it adequately addressed through life spares and obsolescence. The licensee, at a level 4 meeting, stated that a similar strategy and document will be produced for HYB.

26. The licensee has submitted a HYB VSD Security Case [Ref. 7] and supporting documentation. The C&I specialist inspector reviewed the HYB security case and supporting documentation and was satisfied that the security case has been adequately constructed and the identified risks were being appropriately managed. The inspector had raised issues in respect of the content of two items of the documentation and these are reported in section 4, below.

27. In addition the C&I inspector was content that the differences between the two stations have been adequately addressed and HYB have provided the claims, arguments and evidence to support this.

4 MATTERS ARISING FROM ONR’S WORK

28. The ONR C&I specialist inspector undertaking the HYB specific assessment was content with the main submission [Ref. 2]. In addition, the inspector also assessed the separate CBSIS security case submission [Ref. 7]. The ONR specialist inspector considered that greater detail was required in certain areas of Appendix P of the Security Operating Procedure (SyOps) [Ref. 10] and, in addition, there were a number of points raised against the Response to Residual Risks, Action Plan and Accepted Risks, HYB/REP/SEC/0030/R [Ref. 11] that need to be addressed. The specialist inspector agreed actions with the licensee, which are captured in assessment report ONR-CNRP-AR-14-087 [Ref. 9] and tracked within the ONR issues database. The inspector considered that these actions were associated with enhancing and/or updating documentation and procedures and have no physical impact on the installation and therefore will not prevent the installation proceeding.

5 CONCLUSIONS

29. This report presents the findings of ONR’s assessment of the licensee’s submission supporting a modification to replace 50% of the VFCs at HYB power station to address the on-going reliability and obsolescence concerns. The assessment of the submission has been performed by appropriate ONR assessors and has concluded that the submission is acceptable.

30. I conclude, therefore, that ONR should give permission for a modification to replace 50% of the VFCs at HYB power station in accordance with NP/SC 7571 Stage Submission 2: VFC Replacement.
6 RECOMMENDATIONS

31. I recommend that:
   
   - Licence Instrument No 585x [Ref. 12] is issued to provide ONR Agreement to a modification to replace 50% of the Variable Frequency Converters at HYB power station as requested in Ref. 2.
   
   - The following ONR issue identified during the technical assessment work in support of this PAR, which can be found on the ONR Issues Database as a Category 4 issue, should be brought to a satisfactory resolution through routine ONR interactions with the licensee:
     
     ONR Issue number 3069 - ONR should review the final Response to Residual Risks, Action Plan and Accepted Risks, HYB/REP/SEC/0030/R [Ref. 11] and the updated Generic SyOps inc Appendix P ‘HB/SDI/000/006’ [Ref. 10].
7 REFERENCES


3. Licence Instrument 534, Office for Nuclear Regulation, November 2013 (TRIM 2013/436308)


5. ONR-CNRP-AR-13-065 Rev 0 – Assessment of programmable electronic aspects of the replacement VSDs. Trim Ref. 2013/389861


8. Torness Power Station – Gas Circulator Variable Speed Drive Replacement Through Life Management Strategy - 4-A408/4-A649 Trim 2014/451525


10. Heysham 2 Power Station Departmental Instruction, Generic Security Operating Procedure (SyOps) for Computer Based Systems Important to Safety HB/SDI/000/006 Rev 0.2 inc. Appendix P Gas Circulator VSD specific SyOps. Trim 2014/452065


12. Licence Instrument 585, Office for Nuclear Regulation, November 2013 (TRIM 2014/462872)


15. BS EN 61226:2010 Nuclear Power Plants – Instrumentation and control important to safety – Classification of instrumentation and control functions.

16. BS IEC 61513 – Nuclear Power Plants – Instrumentation and control systems important to safety – General requirements for systems.

17. EDFNGL email to [redacted] 31 October 2013. Acceptance that the VSDs perform a category A function. Trim 2013/401180

18. Email – [redacted] (EDFNGL) / [redacted] (ONR), 30 September 2014,Trim 2014/451526