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Sizewell C Project

Combustion Activity Permit Application Appendix H: Best Available Techniques Rationale

DOCUMENT CONTROL

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1 BEST AVAILABLE TECHNIQUES (BAT) RATIONALE

1.1 Purpose of the BAT Rationale Document

This Best Available Techniques (BAT) rationale document has been prepared to support the Sizewell C Ltd permit application for an installation activity environmental permit, Environmental Permitting (England and Wales) Regulations 2016, as amended (EPR) Schedule 1, Section 1.1A(1)(a): Burning of any fuel in an appliance with a rated thermal input of 50 megawatt (MW) or more (Ref 1).

The BAT rationale report details the considerations undertaken with regards the options available for supplying the electricity to the construction phase of Sizewell C (SZC) prior to electrification and demonstrates that the option chosen was the most appropriate.

1.2 Definitions

Term / Abbreviation	Definition
ACA	Ancillary Construction Area
BAT	Best Available Techniques
CCGT	Combined Cycle Gas Turbine
CES	Construction Electrification Supply
CO	Carbon Monoxide
EDRMS	Electronic Document and Records Management System
EPR	Environmental Permitting (England and Wales) Regulations 2016, as amended
GTL	Gas to Liquid
HC	Hydrocarbons
g/kWh	gram/kilowatt hour
HVO	Hydrotreated Vegetable Oil
KvA	Kilovolt Amp
kWe	Kilowatt electrical
KWth	Kilowatt Thermal
LPG	Liquid Petroleum Gas
MCA	Main Construction Area
MvA	Millivolt Amp
MW/MWth	Mega Watt/ Mega Watt Thermal
NH_3	Ammonia
NOx	Nitrogen Oxides
OCGT	Open Cycle Gas Turbine
PM	Particulate Matter
SO_2	Sulphur Dioxide
SZB	Sizewell B
SZC	Sizewell C

Term / Abbreviation	Definition
TCA	Temporary Construction Area

1.3 References

Ref	Title	Location	Document No.
1	EPR Schedule 1, Section 1.1A(1)(a): Burning of any fuel in an appliance with a rated thermal input of 50 MW or more.	Legislation	n/a
2	COMMISSION IMPLEMENTING DECISION (EU) 2021/2326 of 30 November 2021 establishing BAT conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants.	Legislation	n/a
3	DIRECTIVE (EU) 2015/2193 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants.	Legislation	n/a
4	REGULATION (EU) 2016/1628 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 September 2016 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery, amending Regulations (EU) No 1024/2012 and (EU) No 167/2013, and amending and repealing Directive 97/68/EC.	Legislation	n/a
5	INNIO(2021) INNIO Jenbacher Gas Engines Ready for Hydrogen. Available at: https://www.innio.com/en/news-media/press-releases/innio-jenbacher-gas-engines-ready-for-hydrogen (Accessed: 043/04/ 2024).	Website	n/a
6	Appendix L (of Supporting Information Document): Mitigation Strategy	EDRMS	101256949

2 BACKGROUND

Summary Description of the Proposed Combustion Activity

SZC's total combustion activity capacity using generators during the construction phase is anticipated to reach an aggregated thermal capacity input in excess of 50 megawatt thermal (MWth). Due to the potential for the threshold to be reached, it has been agreed with the Environment Agency to apply for the >50 MWth permit straight away rather than apply for a lower capacity Medium Combustion Plant permit. This approach will allow flexibility in the operating profile of the generators throughout the construction phase.

For a short period of 3 to 4 years during the early construction years of the power station there will be a need to use diesel generators. There will be an increasing generator use in 2024 and 2025. Currently it is estimated that the peak demand is for a 12-18 month period, starting in 2025. During this time, the Project is looking to utilise a number of 1250 kilovolt amp (KvA) (2,400 KWth) generators located around the construction site which are strategically positioned where the eventual connected electricity supply will become available. Presently it is not possible to profile the demand from these generators but the peak demand is estimated on a moderately conservative basis to be around 82 MWth. Ahead of the expected peak period in 2025/2026 the capacity of the generators would likely be below the 50 MWth threshold.

A Construction Electrification Supply (CES) will be provided as soon as practicable, scheduled to be commissioned in 2027. Stage V emission generators with hybrid batteries are a key requirement of the Project and wherever possible will be used to bridge the gap through the early years of the construction prior to installation of the CES. During this time, the generators are there to provide power to support construction activities and to create a safe working environment for people working on the site, including welfare buildings, heating and lighting.

There is the potential that the CES may be available prior to the site demand exceeding 50 MWth. After installation of the CES, it is expected that where practicable the power demand will use this CES, however there may be a small number of generators needed. In addition to the CES, SZC is seeking to utilise power through an early electrical connection from Sizewell B (SZB) which will significantly reduce the power demand from generators in the first 2-3 years. This supply may not always be 100% available and there may be times where SZB require the power to support its operation or in shutdown/maintenance scenarios.

The proposed activity scenario, which the air quality modelling has been based upon, to support this permit application is considered to be moderately conservative, based on estimates of the installed capacity and it allows some headroom for the site's evolving requirements. The conservatism is based upon:

- Being based on the best available information for the early works power needs (2024) and the current estimates based on the peak generator power year in 2025/2026 ahead of the CES becoming available;
- Potential for early CES availability;
- Potential SZB connection; and
- Overall duration over which the generators will be operational, between the start of construction and CES connection. This will be short in comparison to the overall construction period of the build.

2.1 Applicable BAT

The most appropriate BAT associated with the generation of electricity from combustion are detailed below:

- COMMISSION IMPLEMENTING DECISION (EU) 2021/2326 of 30 November 2021 establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants (Ref 2);
- DIRECTIVE (EU) 2015/2193 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants (Ref 3); and
- REGULATION (EU) 2016/1628 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 September 2016 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery, amending Regulations (EU) No 1024/2012 and (EU) No 167/2013, and amending and repealing Directive 97/68/EC (Ref 4).

2.2 Methodology

For each of the potential technologies that could be used to fulfil the electricity requirements for the construction phase of SZC, a range of criteria were considered to help identify which of the technologies could be considered to be BAT. These criteria are:

- Technological; and
- Environmental.

The first step is to undertake a technological assessment to identify whether the available technologies appropriate for the generation of electricity are capable of being used for the task of supplying electricity in the manner required by the Project for the construction phase. Each technology will have either infrastructure or implementation requirements. Any technologies that are not suitable from a technological perspective will be discounted at this step of the assessment and those technologies taken forward will be further considered for their environmental cross-media impacts with respect to emissions, water use, waste generation, energy efficiency, wastewater discharge.

The technologies to be considered are:

- Combined cycle gas turbine;
- Open cycle gas turbine;
- Open cycle gas turbine operated on gas oil;
- Gas engines;
- Diesel engines;
- Engines (alternative fuels);
- Electrical renewables; and
- Micro-turbines.

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3 BAT OPTIONS APPROACH

As detailed in Section 1.5 above the methodology for considering whether a technology was appropriate for consideration with regards to BAT for the electrical supply to the Project were considered against Technological and Environmental criteria which are discussed in turn below.

3.1 Technological Considerations

Table 1 below details the considerations with regards to whether each of the identified technologies above is appropriate for the supply of electricity to the construction phase and is therefore be taken forward for further consideration as to its cross media environmental impacts.

Table 1 Technological considerations

Technology	Infrastructure Requirements	Limitations	Comment
Combined cycle gas turbine (CCGT)	Engineered infrastructure to include concrete platform for units, buildings, stack, chemical storage facilities and water and wastewater infrastructure. Electrical distribution network. Gas supply. Dedicated road network.	The construction area is spread over 3 zones: Main Construction Area (MCA), Temporary Construction Area (TCA) and Ancillary Construction Area (ACA). There is no gas supply to each of the construction zones. The timescales for the implementation of a CCGT plant would be in excess of 32 months.	The permanence of this technology, the infrastructure requirements and need for a dedicated gas and water supply, installation of an electrical distribution network from a central point, as well as wastewater discharge infrastructure means that this technology is not appropriate for the construction activity given that it would not be in place in time prior to site electrification. **Not considered further.**
Open cycle gas turbine (OCGT)	Engineered infrastructure to include concrete platform for units, stack, chemical and oil storage facilities. Electrical distribution network. Gas supply. Dedicated road network.	The construction area is spread over 3 zones: MCA, TCA and ACA. There is no gas supply to each of the construction zones. The timescales for the implementation of a OCGT plant would be approximately 18-21 months.	The semi-permanence of this technology and need for a dedicated gas supply and installation of an electrical distribution network from a central point means that this technology is not appropriate for the construction activity given that it would not be in place in time prior to site electrification. **Not considered further.**

Technology	Infrastructure Requirements	Limitations	Comment
Open cycle turbine operated on gas oil	Engineered infrastructure to include concrete platform for units, stack, chemical and oil storage facilities. Fuel supply. Electrical distribution network. Dedicated road network.	The construction area is spread over 3 zones: MCA, TCA and ACA. The timescales for the implementation of a OCGT plant would be approximately 18-21 months.	Given the semi-permanence of this technology and need for the installation of an electrical distribution network from a central point it is not appropriate for the construction activity given that it would not be in place in time prior to site electrification. **Not considered further.**
Gas engines	Gas supply. Dedicated road network.	The construction area is spread over 3 zones: MCA, TCA and ACA. There is no gas supply to each of the construction zones. This would take in excess of 2 years given the time for the infrastructure to go through planning and construction.	The need for a dedicated gas supply means that this technology is not appropriate for the construction activity given that it would not be in place in time prior to site electrification. **Not considered further.**
Diesel engines	Diesel supply. Dedicated road network.	None- a dedicated road network as supplied by the Project will be built to ensure the engines can be serviced and fuel supplied.	This option is considered to be flexible enough to accommodate the requirements associated with the construction phase at point of use and **is considered further**.
Engines (alternative fuels)	Fuel supply. Dedicated road network.	None- a dedicated road network as supplied by the Project will be built to ensure the engines can be serviced and fuel supplied.	This option is considered to be flexible enough to accommodate the requirements associated with the construction phase at the point of use and **is considered further.**
Electrical renewables	Dedicated road network. Electrical distribution network.	The construction area is spread over 3 Main zones: MCA, TCA and ACA. Intermittency of the electrical generation. In 2022 onshore wind had a load factor of 27.4% and solar 11%.	The need for a dedicated electrical supply network from a central source, the timescales to install and operate, intermittent nature of renewables having a lower actual delivered load factor than nameplate capacity (e.g.

Technology	Infrastructure Requirements	Limitations	Comment
		Need for back-up supply during periods of low electrical generation.	the installed capacity would need to be significantly higher than Projects demand to meet supply) and need for back-up supply during periods of low generation means that this technology is not appropriate for the construction activity. **Not considered further with regards to supply across the whole construction area given the load factor for solar or microturbines but can be considered for localised usage and is discussed in further detail within Appendix L Mitigation Strategy.**
Micro-turbines	Dedicated road network. Electrical Supply.	Micro-turbine technology fuelled using gaseous, renewable and liquid fuels are available in units from 65KvA to 10 millivolt amp (MvA) are available on the market for the provision of low NOx power. It is understood from discussions with providers and information available on the market that these units require a small amount of electricity for start-up and have a small parasitic load in terms of powering the individual units.	Due to the power demands and need for an electrical supply, this technology is not appropriate for the construction activity. **Not considered further.**

3.2 Discussion of Environmental and Cost Considerations

As can be seen from Table 1 above the only technologies that have been taken forward for further consideration are:

- Diesel engines; and
- Engines (other fuel).

The other potential fuels that could be utilised in engines as alternatives to diesel are discussed below as to their potential suitability for the Project.

Diesel alternatives: The use of alternative fuels is considered an option available to the SZC construction site for fuelling various plant and equipment on site. Two such fuels that could be considered for use on site are Gas to Liquid (GTL) fuel and Hydrotreated Vegetable Oil (HVO), which are both 'drop in fuels' that provide direct replacement for conventional diesel fuels. These alternative fuels provide a number of benefits including a reduction in both Particulate Matter (PM) and Nitrogen oxides (NOx) emissions to a varying degree depending on appliance and engine type.

Independent testing on the efficacy of the two fuels to reduce emission levels versus conventional diesel was commissioned by one of the main suppliers of generators, the tests were conducted to ISO8178 D2 Cycle (constant speed engine) on all three fuels, EN590 Diesel, Green D+ (HVO) and GTL. The fleet used were all 'In Service' generators ranging in lifetime running hours between 9,000 to 12,000 that had been fully serviced and load tested prior to the emission test. The engines used had different internal designs to achieve their initial Stage IIIA classification to offer a broader picture of how the alternative fuels would perform across a diverse fleet.

The reduction in emissions recorded can be up to 20% for hydrocarbons (HC) and NOx combined for generator sets, although the study was for smaller models than the ones to be used at SZC because of the larger gensets to be used because of the hybridisation model. Both fuels had a fuel penalty due to the lower calorific values of the green fuels, these range between 0.1% - 2.9% for HVO fuels and 0.8% - 4.9% for the GTL. Therefore, a greater volume of fuel would be required to deliver the same electrical output as diesel given the fuel penalty meaning there is only a small benefit of using HVO when compared to diesel with regards to potential emissions.

The use of HVO is likely to be limited to areas where there are specific considerations to take into account such as proximity to ecological habitats given that HVO is typically about 10% more expensive than diesel. Currently, some of the site generators used for the early welfare are powered by HVO. This trial will monitor the use, fuel consumption and electricity provided to assess the potential benefits of using HVO. Given the higher fuel penalty for GTL compared to HVO this is not currently being considered but if this position changes the Environment Agency will be notified.

Hydrogen: Hydrogen is an alternative lower carbon fuel than diesel where it is produced from green energy and not through steam methane reforming which would have a similar or greater carbon footprint than diesel.

Whilst the use of hydrogen would provide some emission benefits with regards to particulates or sulphur compounds when compared to diesel, because of the higher temperature which hydrogen burns at it would generate greater thermal NOx than diesel engines.

Also, the low volumetric energy density of hydrogen requires a significant number of storage vessels which would require to be ATEX/DSEAR zoned to prevent explosion risk.

Typically, most gas engines are currently able to operate on a blend of hydrogen with natural gas. There are some manufacturers which have developed 100% hydrogen ready models such as Jenbacher, but even as part of their advertisement of this fact, Jenbacher (*https://www.innio.com/en/news-media/press-releases/innio-jenbacher-gas-engines-ready-for-hydrogen*) state that *"gas engines running on natural gas today can be converted to H2 operation when hydrogen becomes more readily available"* (Ref 5). Given the lower energy density of hydrogen and the fact that it would need to be a blended mix with natural gas or has availability issues if used at 100% it is not considered appropriate currently given the short timescale for operation of the permit until CES occurs.

Liquid Petroleum Gas (LPG): LPG is an alternative also but would suffer from the same issues as hydrogen with regards to a much lower energy density than diesel which would require a larger number of tanks with specific handling issues and have ATEX/DSEAR zones which would lead to a higher explosion risk.

From the above we can see that the only alternatively fuelled engine which is suitable for consideration are the diesel alternative fuels.

Table 2 Environmental Considerations

Environmental Parameters	**Diesel Engines (Stage V)**	**Alternatively fuelled engines (Stage V)**	**Comment**
Emissions to air	Generate emissions such as NOx, Sulphur Dioxide (SO_2), PM and ammonia (NH_3).	A study undertaken by the generator supplier found that the reductions in emissions recorded can be up to 20% for HC and NOx combined for gensets, although this was for smaller models than the ones to be used at SZC.	**Alternatively fuelled engines can have better emission performance.**
Emissions to water	No emissions to water.	No emissions to water.	**No difference between each option with regards to emissions to water.**
Energy efficiency	Typically,38-44.5% energy efficiency level when running on gas oil.	Both fuels have a fuel penalty due to the lower calorific values of the green fuels, these range between 0.1% - 2.9% for HVO fuels and 0.8% - 4.9% for the GTL fuel.	**Conventional diesel engines would have a higher energy efficiency than those on alternative fuels.**
Noise	Can generate noise during operation. This is partially offset by having containerised packages.	Can generate noise during operation. This is partially offset by having containerised packages.	**No difference between each option with regards to noise profile.**
Waste Generation	Only waste oils and consumables as part of the servicing of the engine every 500 operational hours.	Only waste oils and consumables as part of the servicing of the engine every 500 operational hours.	**No difference between each option with regards to waste generation.**
Water use	No water requirement.	No water requirement.	**No difference between each option with regards to water use.**

From Table 2 above we can see that engines operated on either diesel or diesel alternative fuels perform similarly with regards to most environmental parameters with the exception of emissions to air and energy efficiency. For emissions to air, the diesel alternative fuel will have lower emissions but the difference will be lower than detailed above as the study undertaken by the generator supplier was on smaller models. However, this is off-set by the diesel engines having a lower fuel consumption of up to 3-5%, dependent on the alternate fuel, which would off-set the generation of any emissions due to lower fuel consumption.

The generators proposed are to be Stage V compliant to Carbon Monoxide (CO) 3.50 grams/kilowatt hour (g/kWh), HC 0.19 g/kWh, NOx 0.67 g/kWh and PM 0.035 g/kWh. These emissions are similar to those for Stage IIIb except the PM emissions for stage IIIb are 0.025 g/kWh and NOx are 2 g/kWh. This means that the proposed Stage V generators would have emissions roughly one third of equivalent Stage IIIb generators for NOx, although it should be acknowledged that the emission standards are for less than 560 kilowatt electrical (kWe) for Stage IIIb and over 560 kWe for the Stage V generators.

There are also other technological options which are discussed within the Mitigation Strategy (Appendix L of Supporting Information Document) (Ref 6).

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4 CONCLUSIONS

The proposed technology to be used during the construction phase for SZC is to be diesel Stage V engines as they have the following benefits:

- They are a flexible source of energy generation which is capable of supplying a varying demand. This includes the ability for individual units to be taken out of use when not required, whereas other technologies would have to operate at lower load which would be significantly less efficient in terms of fuel use and emissions;
- The generators can be installed at point of use quickly to help deliver an efficient construction programme;
- The energy density of the fuel is such that it allows easy use and refuelling;
- The generators can be dispersed across all 3 zones within the construction area to the point of use more easily than the other technologies; and
- As soon as construction activities within the programme are completed the generators can be easily decommissioned and removed off-site without any remediation works.

The Mitigation Strategy (Appendix L of Supporting Information Document) (Ref 6) details a number of operational and technological measures which have and can be adopted by the Project to lessen the environmental impact of emissions from the chosen technology. Those that have been adopted include use of hybrid (diesel/battery) for some of the larger generators, fitting of selective catalytic reduction to some of the larger generators, increased stack height for more effective dispersion of some of the generators in addition to looking at trialling of HVO to demonstrate its effectiveness and suitability for use. There is also the potential to use solar, microturbines and batteries for small, localised generation of electricity.

Currently there are some hybrid generators on site to run the main office and welfare units. Live trials are ongoing with suppliers to optimise the hybrid configurations to meet site operational requirements. The output of the trials will inform specifications for hybrid generator deployment for upcoming works.

When the Project's electrical demand and frequent peaks are fully defined, Stage V generators with a Hybrid (Peak Lopping) setup will endeavour to be used where suitable.

At this point in time, some of the site generators used for the Early welfare are powered by HVO. This trial will monitor the use, fuel consumption and electricity provided to assess the potential benefits of using HVO and its suitability for a wider deployment within the Project.