From:	[redacted]
To:	SizewellC
Cc:	[redacted]
Subject:	Sizewell C and the requirement for an Acoustic Fish Deterrent - Fish Guidance Systems Submittal following the 1st Preliminary Meeting - FGS Reference 1688R0103
Date:	06 April 2021 14:16:41
Attachments:	Sizewell C and the AFD - Planning Inspectorate Briefing Note - FGS Reference 1688R0103.pdf

Good afternoon,

Following FGS's attendance at the first preliminary meeting for the Sizewell project, we have drawn up a document outlining why an Acoustic Fish Deterrent (AFD) should be installed at Sizewell C, and would be grateful if you can please forward the attached document to the inspectors for their review.

As we mentioned during the meeting, the AFD is currently NOT included in the mitigation measures proposed by EDF, and we would welcome the opportunity to discuss the requirement in more detail with the inspectors as part of the examination process.

If you have any questions, or require any further information, then please don't hesitate to contact me.

Yours faithfully,

David Lambert

Dr D R Lambert
Managing Director

Fish Guidance Systems

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Sizewell C Acoustic Fish Deterrent (AFD)

FGS Reference – 1688R0103

Executive Summary

Over the last 25 years Fish Guidance Systems Ltd (FGS) has researched, developed and innovated a unique solution for the deterrence of fish across a wide range of applications and in numerous locations. This experience puts FGS's scientists and engineers at the forefront of their industry, and their expertise enables FGS to provide educated, science-led advice in relation to the installation, maintenance and applicability of Acoustic Fish Deterrents (AFD).

This briefing note has been prepared by FGS for the Planning Inspectorate's review of the Development Consent Order (DCO) for a new nuclear power plant at Sizewell (Sizewell C, known as SZC).

As part of the DCO, EDF Energy (EDF) has outlined the mitigation measures it proposes to protect fish from the cooling water Intake Heads. However, EDF has chosen not to follow UK Best Practice, and while it originally proposed to include an Acoustic Fish Deterrent (AFD) system, EDF has subsequently excluded an AFD from its plans.

This document explains why an AFD is required at Sizewell by outlining the basis of the UK's Best Practice for the screening of cooling water intakes, as well as highlighting –

- 75% of the fish that are expected to be impinged will be sprat and herring, clupeid fish that are known to be 'fragile', and which will not survive passing through the proposed screening system.
- AFD systems are ideally suited to deflecting these fragile fish.
- Cefas has previously acknowledged that "*any mitigating effect of the low-velocity intake is only likely to be realised if it is combined with some form of artificial stimulus" and "low-velocity intake and AFD need to be considered as a combined mitigation measure"*
- SZC, along with all other existing east coast power plants, are prone to clupeid inundations that have previously disrupted generation at east coast power plants, which can
  - result in the loss of hundreds of tonnes of fish
  - impact on the integrity of the cooling water system
  - potentially compromise the safety of the plant

The briefing note also outlines the main components of an AFD, the latest developments in AFD technology, including –

- Active Pressure Compensation Systems for the Sound Projectors
- New Power and Communication Hubs
- Improved software and hardware providing greater monitoring and control over the systems.

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www.fgs.world/sizewell-c

The document confirms that an AFD system meeting all of the requirements set by EDF/NNB (New Nuclear Build Generation Company) for the HPC AFD is currently available, and in the absence of a specification for SZC, and the other same mitigation measures proposed for HPC being proposed by EDF for SZC, the same system should be suitable for SZC.

A detailed design process will be required to confirm the final specification for the AFD at SZC, and this should include a review of the deployment of the system, the use of ROVs for the maintenance work, required redundancy and the final configuration of the Sound Projectors, preferably adopting the recommended 'stadium' configuration.

Biographical Note: The response on the requirement for an AFD has been prepared by our external consultant, Dr Andrew Turnpenny. Andy has a detailed knowledge of the Sizewell site and the mitigation measures proposed for SZC, having been closely involved in the initial design of the mitigation measures for HPC, on which the SZC mitigation measured are based.

Andy started his professional career in 1976 as a Research Officer for the Central Electricity Research Laboratories Marine Biological Laboratory, where he specialized in research into the behavioural and physiological aspects of fish impingement and entrainment, and into methods of mitigation. He has written numerous scientific papers and reports on this subject and presented at many major international scientific conferences. He is a global pioneer in the development of AFD technologies and was a founding company director of Fish Guidance Systems Ltd. Andy has advised UK regulators and conservation bodies on Best Practice for fish protection at water intakes[1] and on international environmental practice in cooling water (CW) system design for large power stations[2]. Both publications have formed the basis of the fish protection strategy for SZC. He has undertaken fish studies at the Sizewell site since the late 1970s, leading up to the Sizewell B Public Inquiry and as part of the commissioning investigations for Sizewell B. Andy's involvement in the SZC project began in 2007 when he was invited to join the BEEMS Expert Panel (EP), on which he served until its disbandment in December 2017.

The EP comprised a group of industry experts, academics and regulators with particular experience of power stations and regulatory processes. Andy's particular role on the EP concerned biological issues relating to protection of fish and other biota, and he and other EP members gave scientific and regulatory guidance on how information presented in the Environment Agency reports[1,2] should be applied to SZC and other new nuclear power projects. From 2010 until recently he served as a director of THA Aquatic Ltd (formerly Turnpenny Horsfield Associates Ltd). He retired from the post in January 2010 and now acts as an independent consultant. During the course of the SZC development Andy provided consultancy advice to the Environment Agency (EA) on CW system design and was subsequently commissioned by the EDF Energy CWS design team to provide design advice to the SZC Fish Protection Working Group.

Andy has also been a key adviser on fish and shellfish protection on NNB's Hinkley Point C project, on the Bradwell HP1000 new nuclear project, as well as on energy schemes in Wales, including the Pembroke CCGT project, the Wylfa new nuclear project and the proposed Swansea Bay and Cardiff /Newport tidal lagoon projects.

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[1]Turnpenny, A.W.H &O'Keeffe, N. 2005. Screening for intake and outfalls: a Best Practice guide. Environment Agency. Science Report. SC030231.

[2]Turnpenny, A.W.H., Coughlan, J., Ng, B., Crews, P, Bamber, R & Rowles, P., 2010. Cooling Water Options for the New Generation of Nuclear Power Stations in the UK. SC070015/SR3, 214 pp.

1. The Current Status of AFD for Sizewell C (SZC)

1.1 Background

At Hinkley Point C Nuclear Power Plant EDF Energy (EDF) have submitted a formal application to the Environment Agency to vary its Water Discharge Activity (WDA) Permit No. EPR/HP3228XT to remove the need to install an Acoustic Fish Deterrent (AFD) system at the cooling water abstraction point in the Severn Estuary. This would overturn its commitment under the Development Consent Order (DCO#2013:SI2013:248) issued by the Planning Inspectorate (PINS) to provide one of the key environmental protection measures aimed at protecting fish within the Severn Estuary Special Area of Conservation. The attempt to abandon this key fish protection measure is a setback to the progress in the field made over the past two decades by the Environment Agency and the UK's other regulators and statutory conservation bodies, and not least by the industry itself. It also potentially undermines the case for optimal fish protection at other power stations and industrial facilities, including other new nuclear-build sites.

It is therefore concerning that at the proposed Sizewell C (SZC) Nuclear Power Plant EDF appears to be following a similar route. The Environment Agency (EA) response to the SZC Stage 3 Consultation[3] points out that EDF, having previously committed to installing AFD at its cooling water intake point in the Stage 2 consultation, has now withdrawn this key fish protection measure from the proposed development, falling back on fewer protection measures which have limited or no value for a high proportion of the expected fish intake. According to EDF projections, 75% of the fish entering the plant will be returned to the sea dead, something which could largely be mitigated using AFD technology.

Decisions at these two key new nuclear build sites will shape the future of aquatic biota protection at UK power stations for at least the next 60 years, and almost certainly beyond. Environment Agency (2010) evidence makes the case that European Best Available Technology (BAT) guidance favouring the use of direct, once-through cooling may only remain valid where available modern fish protection techniques are employed. Failure to include AFD measures in EDF Energy's two flagship UK new nuclear build projects, Hinkley Point C (HPC) and Sizewell C, (SZC) is likely to establish precedents that future developments at other potential UK new nuclear build sites such as Wylfa, Bradwell, Oldbury and Sellafield may seek to follow.

1.2 Environment Agency Best Practice Requirements

The origin of EA Best Practice

The need to include measures to prevent the accidental removal of fish incidental to seawater abstraction for steam turbine cooling has been recognized by the Environment Agency for many years. Its fish screening Best Practice guide, compiled in collaboration with other UK conservation bodies (Environment Agency, 2005), highlighted the risk of unacceptably high fish mortalities caused by large water abstractors such as power stations. It proposed the use of AFD systems as Best Practice at any such sites. Since that date, new seawater cooled power UK stations at Shoreham-on-Sea, Great Yarmouth, Marchwood and Pembroke have all integrated AFD technology into their cooling water designs in line with Best Practice. While all of these feature onshore cooling water intakes, the estuary-cooled nuclear plant at Doel (Maes *et al*., 2004) has operated AFD at an offshore-sited intake for more than 25 years, with excellent results.

[3] Environment Agency response to Sizewell C Development Consent Order Stage 3 Consultation (publishing.service.gov.uk)

Subsequently, the Environment Agency consolidated their position on AFD and other fish protection measures in a new Evidence Document (Environment Agency, 2010) focusing on protection of the marine environment at new nuclear build sites. The timing was not a coincidence. It was commissioned by the EA to inform discussions about the types of environmental protection measures that could reasonably be demanded of new nuclear build developers by the regulators based on examples of best international practice. Its content has therefore formed the basis of cooling water (CW) plant siting and design, both within each of the new nuclear build development companies, and in their negotiations with the regulators and conservation bodies (namely, The Environment Agency, The Countryside Council for Wales -CCW, Natural England -NE, The Marine Management Organisation -MMO). It is why fish protection measures such as AFD technology were included in the HPC Development Consent Order (DCO) in the first instance, and in the earlier SZC DCO application.

The Elements of Fish Protection Best Practice and Why they Need to Work Together
Impacts of CW abstraction on wildlife arise in the first instance from biota being unintentionally drawn into the station along with the cooling water. EA Best Practice guidance recognises three key elements to fish protection for large industrial cooling systems:

1. **Intake Siting**. The first Best Practice principle is to reduce the risk of fish entrapment/ entrainment by locating the intakes in an area of low fish abundance, taking account of fish species/ life stages that may be resident in an area, and those that may be brought through the area on the tidal stream. Thus, development should aim to avoid sensitive habitats such as spawning and areas, rock reef habitats etc., as well as parts of the water body known to act as migration corridors for diadromous species. This must be balanced with nuclear safety and operational imperatives which may rule out certain options.
2. **Controlled Intake Velocities and Fish Deterrence**. A second principle is to reduce the chances of any fish that enter the abstraction zone (i.e. the potential area of influence around the intakes) being drawn into the intakes against their volition. This requires consideration of what sensory cues might be available to warn fish against entering the intake, and avoiding high intake velocities and turbulence patterns that might confuse fish and increase their risk of entrapment/ entrainment. Best Practice requires that Intake Heads should be designed with low enough water velocities to allow fish the chance of escape. Intake designs should also aim to eliminate vertical current components which fish find difficult to avoid. The hydraulic design should be fully modelled as part of the design process (numerical or wet modelling as appropriate). Also, developers should make use of behavioural warning technologies (fish deterrents) to signal approaching danger. Thus, in a well-designed system fish approaching the intake in the tidal stream should be able to take evasive action and move into 'safe' hydraulic streamlines that pass around or above the Intake Heads.
3. **Fish Recovery and Return**. While it is axiomatic that it is better to prevent fish entering the intake in the first place, it is inevitable that weaker swimming fish or those insensitive or unable to react to warning signals will be drawn in. Best Practice requires that provision should be made to minimise in-plant handling stresses and to enable the return of any captured fish and other biota to the source water body. The return-too-sea point should be at a location which minimises the risk of re-entrainment. Some species are tougher that others, and while robust taxa such as eels, flatfish and other benthics/epibenthics may survive well, fragile species with deciduous scales such as sprat, herring, shad and salmonid smolts are unlikely to survive this process. It is also uncertain whether even the more robust species may be shaken up by the multiple within-plant handling process to the extent that they become more vulnerable to predation. This aspect has never been fully investigated.

It is a keystone of the Best Practice approach that ALL of these measures are used together to achieve optimum fish protection: controlled intake velocities may be ineffective in the absence of sensory warning cues; deterrent stimuli are of limited benefit when water velocities are too high to allow fish to avoid; fish that are insensitive to e.g. acoustic stimuli can be helped by implementing a well-designed FRR system. Serendipitously, fish species that are insensitive to sound include many of the more robust epibenthic taxa that survive better through FRR systems, while the more fragile pelagic taxa include many acoustically sensitive species that can be deterred efficiently by AFD systems. Omitting any one of these elements from a fish protection design therefore defeats the principles of Best Practice established through the many years of research, development and consultation between the power industry, regulators and statutory conservation bodies.

1.3 Brief Description of the Fish Protection Techniques

Low-Velocity Side-Entry (LVSE) Intakes

The increasing tendency of developers to site CW intakes for large CW systems offshore is driven by safety and engineering needs, essentially to ensure that the intake openings can be sufficiently submerged to avoid surface vortex formation and air entrainment into the tunnels. From a fish protection perspective this can be beneficial if it avoids drawing water draining sensitive intertidal habitat, provided that any sensitive offshore habitats are avoided. It unfortunately can make access to the Intake Heads for maintenance of any AFD or other electronic equipment more costly and more difficult. It also affects provision of any required deterrent system power and signal cabling back to the shore station.

An issue that began to be recognised in the CEGB (Central Electricity Generating Board) era when Sizewell B was under construction is that siting an Intake Head in a fast-flowing tidal stream could make it more difficult for fish to avoid entrapment. Ministry (MAFF) advice to the Sizewell B design team was that the intake approach velocity should be kept at or below 0.5 ms-1. However, this did not take account of the Intake Heads being open-all-round structures abstracting from fast tidal flows. Hydraulic modelling studies carried out subsequent to the Sizewell B design showed that the 0.5 ms-1 maximum would only be met under completely slack water conditions, and that the tidal stream velocity was more or less additive; hence at a CW pumping rate that would give a calculated average approach velocity of 0.5ms-1, in a 2 knot (~1 ms-1) tidal flow the effective approach velocity would in fact be close to 1.5ms-1. Flume experiments carried out by the Central Electricity Research Laboratories (CERL) tested designs which blocked the flow path along the tidal axis to reduce this effect (Turnpenny, 1988). This solution was presented in the Environment Agency (2005) Best Practice guide for intake and outfall screening[1] as the low-velocity side-entry (LVSE) design which formed the starting point for the Intake Head design now being adopted at HPC and SZC. Best Practice guidance indicated that the LVSE design was a lab-tested concept only at that stage and that it would require further validation by modelling and to be optimised for conditions at individual sites.

Behavioural Fish Deterrents

Studies of temporal fish impingement patterns at UK power stations sometimes reveal a strong diurnal pattern, often also overlain upon a tidal pattern. The diurnal component probably derives from visual perception of intakes being poorer at night. Examination of impingement patterns at the Hinkley Point site (Turnpenny, 1988) revealed no discernible difference between day and night impingement rates, which may be explained by the consistently high turbidities impeding visual detection even in daylight. In such situations behavioural fish deterrents can be used to provide warning signals to guide fish away from intake openings.

EA (2005) Best Practice guidance identifies several types of stimuli that can be used in different situations, acoustic, electric, strobe lighting and hydraulic. Of these, only acoustic and strobe-light based system have been used successfully in salt water applications, although hydraulic considerations have been paramount in developing the HPC and SZC designs, including the recommended use of a velocity cap. The type of AFD suitable for use in marine applications is known as a Sound Projector Array (SPA), in which multiple transducers (Sound Projectors) are used to generate a repellent acoustic field around the intake openings (Figures 1 & 2).

Key requirements for AFD to meet Best Practice are:

- Background noise levels should be measured to ensure the AFD signal is not masked and the volume level can be set to ensure this.
- For SPA systems, acoustic modelling (e.g. using FGS's proprietary PrISM model) is essential in design of the acoustic field to optimise fish guidance away from the intakes. Modelling should also be used to ensure that the spread of the sound field is not excessive, which might interfere with movements of migratory fish or cause local loss of habitat.
- Sound levels should also be measured at commissioning to validate predicted values.
- Diagnostic/monitoring systems should be fitted so that the performance of the underwater equipment can be monitored remotely e.g. from an onshore plant control room.
- Provision should be made for retrieving the underwater equipment (Sound Projectors and associated equipment) for servicing.
- Some redundancy (i.e. using more sound sources than are strictly needed) is desirable to allow for Sound Projector failures over time).

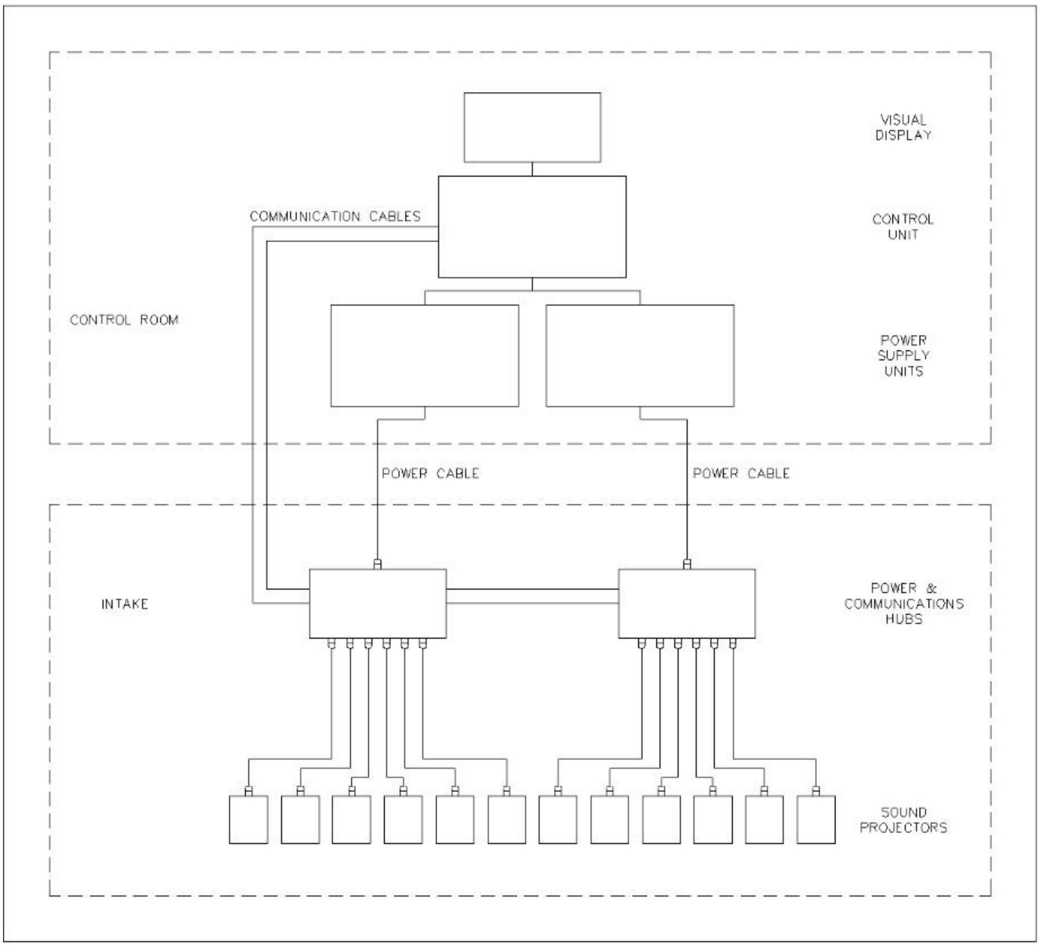

Figure 1 - Block diagram showing generic architecture for FGS's Sound Projector Array AFD system



Figure 2 - AFD system components: Control Equipment Enclosure (left), Underwater Hub (middle), Sound Projector Stacks at Pembroke CCGT (right)

Fish Recovery and Return (FRR) Systems

While the term 'Fish Recovery and Return' is widely used, it should more properly be called 'Biota Recovery and Return', as all manner of marine life filtered from the cooling water stream are put back to sea by these systems. However, the term 'FRR' will be used here to encompass all biota.

In a traditional CEGB-era UK power station, biota and other debris present in the CW stream is filtered by drum- or band-screens with 8-10 mm mesh openings; this is more commonly reduced to 5 mm in modern designs, although SZC proposes to retain a 10 mm mesh to reduce risk of seasonal blockage by ctenophores[4]. Their original purpose was solely to protect the turbine heat-exchange condensers, which have small-bore pipes through which the seawater runs to condense turbine exhaust steam, and the screens had no fish protection function. More recent designs have been modified so that mesh surfaces are smooth, fish collecting on the screens are kept wet and lifted out in purpose-designed fish buckets, from which they are flushed out with low-pressure water jets. From there they are washed into launder channels, into which additional flushing water is pumped so that they can be washed back to sea. In some cases open launder channels are used throughout, in others tunnels or pipelines may be needed to traverse sea walls and site topography, as will be the case at SZC3. Depending on the length and slope of these conduits, the journey back to sea may typically take minutes or tens of minutes. While a well-designed system will minimise turbulence and abrasion, some stresses are inevitable and good FRR performance requires that conduits are kept clear of weed and other debris at all times. Automatically raked trash racks may be needed within the launder system to prevent blockage further downstream, and these represent a further hazard to fish.

In new nuclear build stations, CW drum screens are safety-critical and need trash-rack screens (typically 50-100 mm spacings: 75 mm for SZC3) located upstream to ensure that larger items such as tree branches fishing gear and oil drums cannot damage the screens. These may also prevent the passage of some larger fish such as adult salmon, sea trout, dogfish, cod, etc., which would otherwise be removed to the FRR system by the drum screens. Fish large enough to collect against the trash rack bars will not normally survive.

Finally, the point of FRR discharge must be carefully selected to ensure firstly that fish are returned below the lowest astronomical tide mark, and secondly that tidal advection will not

[4] Bk6_ES_V2_Ch22_Marine_Ecology_Appx22I_Impingement_Predictions.pdf

carry them straight back to the intake. Hydrodynamic particle track modelling can be used to achieve this.

1.4 Sizewell C: Importance of Acoustic Fish Deterrents

The Fish Impingement Issue at Sizewell

The expansion of nuclear power generation at the Sizewell site has raised concerns over potential impacts on fish and fisheries ever since the proposed B-station development of the 1980s. At that time extensive work was carried out by the CEGB in collaboration with the MAFF Lowestoft Fisheries Laboratory (now part of Cefas). Surveys of fish killed in the cooling water system of the now-decommissioned Sizewell A carried out in preparation for the B-station public inquiry estimated an annual kill of 33 tonnes of sprat (the most abundant species), 3.6 tonnes of whiting and 0.53 tonnes of herring, along with catches of 70 other finfish species (Turnpenny *et al.,* 1988). The average cooling water flow rate was 26 cumecs ($m^3 s^{-1}$), compared with a figure more than five times higher for the proposed C station (132 cumecs). Some differences in intake design (but no AFD) did reveal the later B -station to catch less fish per unit of cooling water flow (between one-and two thirds less: Turnpenny and Taylor, 2002) but substantial further improvements could have been achieved if AFD had been available and fitted at that time. **AFD could still be retrofitted to Sizewell B to reduce the overall impact of the combined B & C sites**. Large volumes of fish such as sprat, Atlantic herring, sole, herring, bass and skate as well as coastal shellfish, are present in the area, and an acoustic fish deterrent is key to the protection of important finfish species from the station's cooling water intakes.

Coastal fisheries pursued by UK vessels has declined in recent years but East Coast fishers see new possibilities as a result of BREXIT. According to a recent study by REAF (Renaissaance of East Anglian Fisheries)[5] "*The opportunity is remarkable. The UK's departure from the EU's Common Fisheries Policy could, if accompanied by well-designed national policy and regulation, increase UK vessel quota catch in the Southern North Sea by seven times its value and UK vessel non-quota catch by 25%, together adding 25 or more vessels to the UK fleet in the Southern North Sea, creating corresponding offshore and onshore jobs".*

Based on fish impingement estimates for the C-station published by EDF Energy (Cefas TR345 and TR406), the fish situation at Sizewell now remains broadly similar, except that the herring, at an all-time stock low when surveyed during the early 1980s, have increased in importance. Cefas TR406 estimates herring impingement catches equating to 15.6% of total annual numerical catch, about one-third that of the sprat catch, compared with 0.003% of the sprat catch by number from the early 1980s. Unmitigated C-station predictions of over 2.5 million herring per year are 146 times larger than were reported for the A-station in CEGB/MAFF surveys from the early 1980s (Turnpenny *et al*, 1982). This vast change highlights the danger of viewing data for a period of only a few years (Cefas surveys focus on the years 2009-17) when looking at operations that will impact the marine environment for at least six decades.

Overall predictions of impingement mortalities for SZC are shown in the table below (shown as Table 2, extracted from Cefas TR406), predicted catches with no mitigation totalling around 13 million fish annually. Figure 3 of TR406 indicates peak seasonal impingement catches on the B-station (maximum cooling water demand = 50 cumecs) reaching in excess of 2.5 tonnes per day in three consecutive years, which scaled up for flow at SZC would amount to 6.5 tonnes per day, unmitigated.

[5]https://eastsuffolkmeansbusiness.co.uk/wp-content/uploads/2019/10/REAF-Report-2019-Digital.pdf

Table 2 Annual mean SZC predictions of impingement for the 24 key species **with the proposed LVSE intake heads and FRR systems fitted and the corrections to bass and thin lipped grey mullet assessments incorporated as per Section 7.5.** Losses have been converted to adult equivalent (EAV) numbers and weights (t) and calculated as a percentage of the mean stock SSB (t) or, if this is not available, mean international landings (t). Species where the impingement weight > 1 % of the relevant stock comparator (given in bold) would be shaded red (there are none). Note, values in red font are estimates of the population numbers (e.g. sand goby) or reported catch numbers (salmon & sea trout)

Species	Mean SZC prediction (No mitigation)	SZC prediction with LVSE intakes	FRR mortality	EAV number	EAV weight (t)	mean SSB	% of SSB	Mean landings (t)	% of landings
Sprat	7,125,393	2,729,025	2,729,025	2,050,190	21.53	220,757	**0.01**	151,322	0.01
Herring	2,555,783	978,865	978,865	700,103	132.08	2,198,449	**0.01**	400,244	0.03
Whiting	1,865,492	714,484	393,295	140,044	40.03	151,881	**0.03**	17,570	0.23
Bass	57,537	22,037	12,133	2,717	4.16	14,897	**0.03**	3,051	0.14
Sand goby	381,612	146,157	30,108	30,108	0.06	205,882,353	**0.01**	NA	NA
Sole	250,059	95,773	19,729	4,200	0.90	43,770	**0.00**	12,800	0.01
Dab	148,921	57,037	30,715	13,656	0.56	NA	NA	6,135	**0.01**
Anchovy	73,865	28,290	28,290	27,558	0.57	NA	NA	1,625	**0.04**
Thin-lipped grey mullet	67,684	25,923	14,273	1,190	0.62	600	**0.10**	120	0.52
Flounder	38,180	14,623	3,377	1,559	0.13	NA	NA	2,309	**0.01**
Plaice	25,288	9,685	1,995	689	0.17	690,912	**0.00**	80,367	0.00
Smelt	23,863	9,139	9,139	6,959	0.12	105,733,825	**0.01**	8	1.36
Cod	16,845	6,451	3,884	1,395	3.63	103,025	**0.00**	34,701	0.01
Thornback ray	10,802	4,137	852	164	0.52	NA	NA	1,573	**0.03**
River lamprey	6,720	2,574	530	530	0.04	62	**0.07**	1	3.76
Eel	4,516	1,730	356	356	0.12	79	**0.15**	14	0.84
Twaite shad	3,601	1,379	1,379	1,379	0.43	7,519,986	**0.02**	1	32.40
Horse mackerel	4,077	1,561	1,561	1,561	0.22	NA	NA	20,798	**0.00**
Mackerel	628	241	241	241	0.08	3,888,854	**0.00**	1,026,828	0.00
Tope	64	24	5	5	0.03	NA	NA	498	**0.01**
Sea trout	10	4	4	4	0.01	NA	NA	39,795	**0.01**
Allis shad	5	2	2	2	0.00	27,397	**0.01**	0	0.68
Sea lamprey	5	2	0	0	0.00	NA	NA	NA	NA
Salmon	0	0	0	0	0.00	NA	NA	38,456	**0.00**

TR406 Impingement predictions NOT PROTECTIVELY MARKED Page 16 of 132

Table 1 – Table 2 from Cefas Document TR406

Proposed Embedded Mitigation for SZC

The EDF propose that embedded mitigation to relieve these potential impacts on fish will comprise two key elements:

1. The installation of Intake Heads (4 off) modelled on the LVSE design developed for HPC, aligned with long axis along the tidal path and with target maximum velocities at the intake openings of 0.3 ms-1;
2. Return of entrapped fish to sea via unchlorinated FRR systems (2 off).

The third strand of embedded mitigation identified as Best Practice has been ruled out in the Optioneering (reported in Section 3.2 of TR406) with the following statement:

"Conclusion: Logistical and safety considerations preclude the use of AFDs at Sizewell C."

The box below from Section 3.3 of Cefas TR406 lists five tests that EDF have applied in the optioneering process. A point worthy of note is the third bullet concerning "proven operational experience in a similar environment", which is used to downgrade the suitability of AFD. It appears that the same test was not applied to the LVSE intake design, accepted by EDF for both the HPC and SZC sites. The LVSE design has only thus far progressed as far as a lab-tested concept, whereas there is over 25 years' experience of operating and maintaining AFDs in an offshore (albeit less distant) salt water environment (Doel Nuclear Station, Belgium).

- Compatible with nuclear safety requirements for an uninterrupted supply of cooling water for the 60-year operational life of the station. This implies the use of systems that are highly resistant to damage or blockage and that are readily maintainable in all weather conditions, all year round.
- Operation and maintenance compatible with the EDF Energy's zero harm safety policy for staff and contractors. i.e. no requirement for activities judged hazardous to human life.
- Proven operational experience in a similar environment that demonstrates reliable delivery of effective environmental mitigation.
- Due to the offshore environment any system should preferably use entirely passive technology e.g. requiring no power, chemical supplies or compressed air systems that could compromise reliability and hence nuclear safety and environmental effectiveness.
- System operational maintenance requirements must be compatible with high power plant availability.

Table 2 – Excerpt from Section 3.3, Cefas TR406 Document

Uncertainty in the Cefas Assessment of the LVSE Benefit

Cefas's assessment summarised in their TR406 Table 2 above rightly assumes zero FRR survival of the more fragile pelagic species, including shads, mackerels, herring and sprat (the last two of which account for around 75% of the raw numbers predicted to be impinged) but appears to make untested and untestable assumptions about the benefits of the LVSE intake on entrapment rates of these and other species. In the Cefas assessment, all of the unmitigated catch figures have been scaled down by a uniform factor of 0.383 to reflect the anticipated benefit of the LVSE intake over the SZB velocity-capped intake design. The derivation of this factor is not explained in the ES but refers to BEEMS Scientific Position Paper SPP099, which does not appear to be publicly accessible for critical review. At present the validity of this figure, which has a major downward influence on the overall impact assessment, cannot be confirmed. A major flaw would appear to be the assumption that the benefits of the lower intake velocities associated with the LVSE design will translate to reductions in fish entrapment. Given the "highly turbid coastal environment" at SZC (mentioned several times in the ES), there is a high risk that for a significant proportion of the time (during periods of high turbidity and at night), fish would not benefit from visual cues at the intake. The Best Practice solution of using an LVSE design in combination with AFD or other warning /deterrent system is intended to obviate or reduce this risk but will not be installed at SZC under current proposals.

Cefas document TR148 relates to its assessment of impingement and entrainment predictions at Hinkley Point C, and confirms this conclusion in Section 3.1, stating

"The key to reducing fish impingement is to design the cooling-water intake structures for a maximum intake velocity that will allow most fish to escape, and the Hinkley Point C project has a design target of ≤0.3 m s^{-1}. Earlier studies (O'Keeffe and Turnpenny, 2005) showed that this would allow larger individuals of most coastal fish species to avoid entrapment, provided that they also have appropriate sensory cues to encourage avoidance behaviour.

Because of the usual high water turbidity at Hinkley Point and the consequent absence of visual clues, ***any mitigating effect of the low-velocity intake is only likely to be realised if it is combined with some form of artificial stimulus*** *(e.g. an acoustic fish deterrent) to induce fish to swim away from the intake structure. Equally however, an acoustic fish deterrent is unlikely to be fully effective on its own if the intake velocity exceeds the swimming capabilities of the fish.* ***For these reasons low-velocity intake and AFD need to be considered as a combined mitigation measure."***

What fish would benefit most from AFD at Sizewell?
A fish characterization study based on B-station impingement surveys and multi-method sampling of the sea area around the proposed Sizewell C site identified a total of 88 fish species, many of which are sensitive to sound. Species that would benefit most from AFD are the fragile Clupeiform species, the most common of which are sprat (~55% of predicted total) and herring (~20%). Trials of the AFD system installed at the Doel nuclear station achieved catch reductions of 88% and 95% respectively (Maes *et* al., 2004) for these species. It is clear therefore that the bulk of the fish impingement could be prevented by using a correctly specified and installed AFD system. Other species, such as the Twaite shad (0.02%), are not numerically abundant but are of high conservation value.

These are not the only fish that would benefit from AFD. The study by Maes *et al.* (2004) reported a 60% reduction across all 41 fish species recorded. While various studies (Environment Agency 2005) have shown less dramatic reductions amongst demersal species, statistically significant reductions of around 37-55% have been reported for other species, including common and sand gobies, flounder and Dover sole. Fish with very low hearing sensitivity, e.g. European eel and lamprey species are not likely to benefit from AFD but these can be handled and returned with minimal damage by FRR facilities. That is why it is important that the full suite of Best Practice fish protection measures are installed and operated together.

As a point of environmental principle, it would be difficult to argue that fish returned to sea after passing through the 3 km, deeply submerged seawater tunnels, pumping station forebay and handling within an FRR system would fare as well as fish that were excluded at the point of water abstraction. Hence, EDF's argument that sufficient fish protection is provided simply by the combination of LVSE and FRR techniques is flawed. The only thing that can be said for fragile pelagic fish such as sprat, herring is that returning the dead fish will return some nutrient value to the receiving water.

On an operational front, Clupeid inundations (sprat and herring) have previously disrupted generation at the existing east coast plants, creating risks not only for the fish, but also to the safety of the plant due to the potential impact on the integrity of the cooling water intakes. Hundreds of tonnes of fish can be killed during these infrequent events (Turnpenny & Coughlan, 1992, 2003). AFD would be beneficial in limiting this risk also and avoid the associated massive fish kills.

1.5 References

Environment Agency (2005).
Screening for Intake and Outfalls: a best practice guide. Science Report SC030231 for the Environment Agency, Bristol, UK. [Authors: Turnpenny, A.W.H., and O'Keeffe, N.].

Environment Agency (2010).
Cooling water options for the new generation of nuclear power stations in the UK. Science Report SC070015/SR3 for the Environment Agency, Bristol, UK. [Authors: Turnpenny, A.W.H., Coughlan, J., Ng, B., Crews, P., Bamber, R.N., Rowles, P.]

Maes, J., Turnpenny, A.W.H., Lambert, D.R., Nedwell, J.R., Parmentiers, A., and Ollevier, F. (2004).
Field evaluation of a sound system to reduce estuarine fish intake rates at a power plant cooling water inlet, *Journal of Fish Biology*, **64**, 938-946.

Pawson, M. G. (1992).
Climatic influences on the spawning success, growth and recruitment of bass (*Dicentrarchus labrax* L.) in British waters. *ICES Marine Science Symposia*, **195**: 388 –392.

Turnpenny, A.W.H., Utting, N.J., Milner, R.S. and Riley, J.D., 1988.
The effect of fish impingement at Sizewell 'A' Power Station, Suffolk, on the North Sea fish stocks, Central Electricity Generating Board. Report. No. TPRD/L/3270/R88.

Turnpenny, A.W.H., 1988.
The behavioural basis of fish exclusion from coastal power station cooling water intakes. Central Electricity Generating Board. Report No. RD/L/3301/R88.

Turnpenny, A.W.H. & Taylor, C.J.L., 2000.
An assessment of the effect of the Sizewell power stations on fish populations. *Hydroécol. Appl.*, **12**, pp.87–134.

Turnpenny, A.W.H. and Coughlan, J., 1992.
Power generation on the British coast: thirty years of marine biological research. *Hydroécol. Appl.* **4**(1), 1-11.

Turnpenny, A.W.H. and Coughlan, J., 2003.
Using Water Well: Studies of Power Stations and the Aquatic Environment. Monograph, Innogy plc, Swindon, UK, 142 pp.

2. AFD Systems

There are a number of components that make up an AFD system, and FGS is committed to the continual improvement and upgrade of the components. The current status of the AFD system available from FGS meets all the requirements EDF has published for the Hinkley Point C project. Since EDF has excluded the AFD from the proposed mitigation measures at SZC there is no specification available for SZC, but we assume that since EDF has transferred the same other mitigation measures from Hinkley to Sizewell, the current system available from FGS would meet the requirements for Sizewell. The main components of an AFD system are outlined below, along with the most recent developments that have been incorporated into the design.

2.1 Control Equipment and Software

The software to control the system has been completely rewritten over the last year, but retains the standard inbuilt diagnostics in both the Sound Projectors as well as the Underwater Hubs that is capable of monitoring over 10 different parameters.

The diagnostics enable continuous real time monitoring of the system, both from site and remotely. The status of the system is displayed with traffic light coloured icons to easily see when each component is operating correctly (green), when one of the monitored parameters is outside the normal limits (yellow), and when there is a fault (red).

The software now also provides –

- a more flexible graphic user interface (GUI) that can be set up to provide an individual site-specific schematic of the layout of the system.
- if required, the ability to incorporate an unlimited number of Hubs, and associated components, into the system.
- the ability to integrate different types of transducers into the same system. This enables High Frequency transducers to be incorporated into the ‘standard’ Sound Projector Array. These offer the potential of providing an additional deterrent for specific key fish, such as shad.
- While less related to SZC, the software now also enables the integration of other components into the system, associated with air flow systems, including a compressor, mass air flow controllers, pressure gauges, solenoids and ball valves.
- The extension of the event controller, enabling actions to specific devices based upon a change of state (going from green to yellow or red); an input from an external device, such as depth sensor or fish sensor; a time based event; or a system event, such as a power loss.
- The ability to incorporate multi-signal units, with the signals being changed remotely. This means that if better signals are developed, the system can be upgraded without loss of continuity. It also allows the possibility of varying the signal according to season and fish species present.
- the remote operation and monitoring of the system via a broadband connection. This enables the system to be monitored (and if required operated) remotely via the internet, irrespective of the user’s location, so the site operators can operate and monitor the system from their Control Room on site, FGS can provide supporting operation and monitoring of systems from its offices, and if required the Regulator is able to monitor the operation of the system from its own facilities. The level of operation and monitoring access can be controlled for different users.
- daily emails to report on the condition of the system.
- if required, immediate feedback is available via an SMS texting unit.

As noted above, the new software would enable one AFD system to be installed across all four Intake Heads, but since the AFD system is modular we would propose four separate systems be installed, with a central control unit to coordinate the operation across the four Intake Heads. The software would be similar to that which has been used by FGS over the last 10 years to control the similar sized system installed at Pembroke Power Station. As a result, the AFD at SZC would represent four separate systems the size of Pembroke, not one system four times the size of Pembroke. The distinction is important, as SZC should not be viewed as a much larger and more complex system due to its size.

2.2 Underwater Power and Communication Hubs

The existing Underwater Power and Communication Hubs provide the network 'nodes' for a system, linking the individual Sound Projectors to the Control Equipment. The internal PCB monitors and controls the communications within the system, and the unit also distributes the power to the Sound Projectors.

While FGS's original Underwater Hubs could be deployed at SZC, FGS has updated the units to make them more suitable where there is a greater distance between the Hub and the Control Equipment. The new Hubs have the following advantages

- They incorporate an internal Power Supply, which -
  - reduces the size of the power cables required between the Control Equipment and the Sound Projectors, reducing installation costs and making the connections more flexible.
  - enables the projectors to be located at greater distances from the Control Equipment without any significant drop in power.
- The Hub PCB has an improved communication system, enabling –
  - increased amounts of data to be handled by the PCB.
  - more parameters to be monitored in the individual components.
  - larger systems to be deployed.
  - improved reliability in the comms system.
- If required, the Hubs can incorporate 100% redundancy, so in the event of a failure in one of the components there is an inbuilt back up to ensure the continued operation of the system.
- If required, the Hub PCB can now connect to up to eight Sound Projectors, instead of the original six projectors, enabling larger systems to be deployed.
- The Hub PCB is also designed for fibre optic connections, enabling comms data to be sent over much longer distances, which will ensure the systems can be monitored and controlled from shore, even when deployed 3.5 km from shore.

2.3 Sound Projectors

The Sound Projectors form the heart of an AFD system, providing the acoustic deterrent signal required to deter fish from an intake. FGS's Sound Projectors are based upon over 25 years research and experience of deploying, operating and maintaining the units.

Along with the Hub PCBs, FGS has recently updated the Sound Projector PCB. The improvements include –

- an improved microprocessor capable of handling increased data.
- monitoring more parameters associated with the operation of the Sound Projector.
- the option of increased sound output, which can

  - be implemented when there is a danger of sprat of herring inundation.
  - provide increased output in the event of an adjacent projector failing, providing greater resilience in the system.
- operation of connected components, including High Intensity Lights, when installed, and the Active Pressure Compensation System

2.4 Active Pressure Compensation System (APCS)

Sizewell is one of a number of sites where the Sound Projectors are less accessible, and as a result FGS has developed an Active Pressure Compensation System (APCS). This system replaces the standard 'airbag' of the Passive Pressure Compensation System, and:

- provides continuous monitoring and adjustment of the compensating pressure in the Sound Projector housing.
- removes all of the operational, maintenance and reliability issues associated with the older passive pressure compensation system.
- extends the service interval of the Sound Projectors out to a minimum of 18 months, with the option of longer service intervals, if required.
- enables pressure compensation over any range that is required, with the current system designed for tidal ranges up to 30 m.
- offers a number of different configurations with Sound Projectors, so can be configured to fit with a number of different possible deployment systems at SZC.

The APCS system has undergone significant in-house testing, simulating the tidal changes over three full years without any faults, and the system has recently been supplied to the US Fisheries and Wildlife Service (USFWS) and deployed at Barkley Lock in Kentucky, USA.

Plate 1 – Low Profile MkIV 30-600 Sound Projector with APCS fitted for deployment at Barkley Lock, USA (access side panel removed for photograph)

2.5 Deployment Frames

The Sound Projectors and Hubs are typically located on Deployment Frames, which are designed for each individual application. EDF carried out the initial design of the frames for HPC, and we assume at this stage that something similar would be incorporated in SZC.

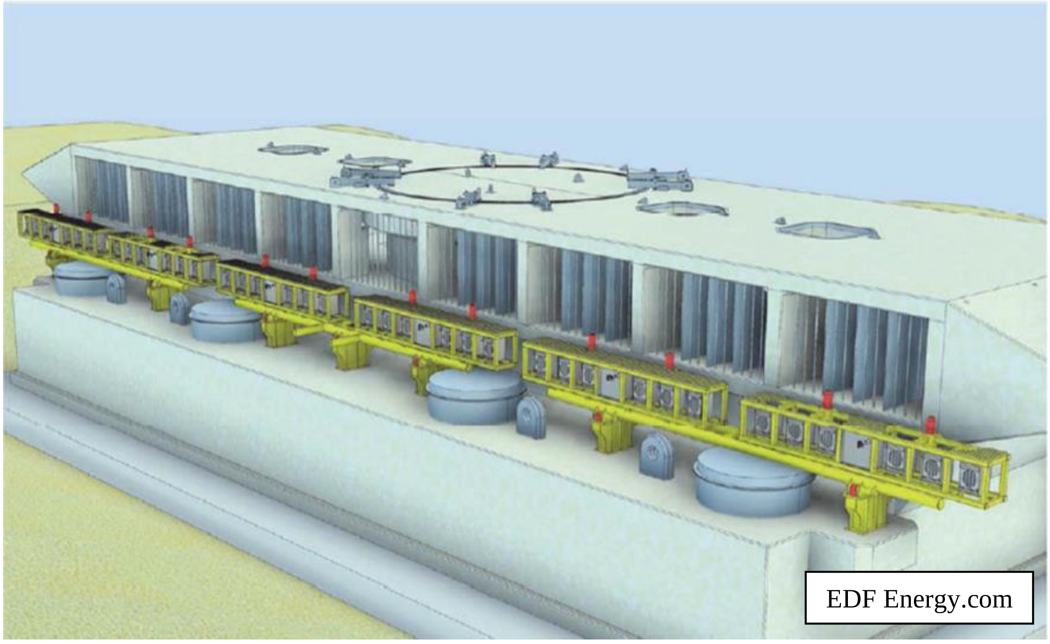

Figure 3 - EDF preferred design for AFD SPA system at HPC, with Sound Projectors mounted off-structure along the sides and below the intake opening.

The yellow Deployment Frames each contain two Hubs a total of 12 Sound Projectors. Due to the absence of any vertical superstructure in the EDF design that would enable to projectors to be raised up to the surface on a rail, there will be a need for divers or a remotely-operated vehicle (ROV) to connect / disconnect the cables that would connect to the Deployment Frames.

2.6 Cabling and Connectors

The system will require a number of power and communication cables. The architecture for the power distribution is typically determined as part of the detailed design of an AFD, but with the development of the new Underwater Power and Communication Hubs incorporating localised Power Supply Units the number and size of power cables has potentially reduced.

All FGS systems use underwater mateable connectors, albeit that the majority of the cables run between the Hubs and the Sound Projectors, which will be located on the Deployment Frames. As a result, most of the connections will only be disconnected/mated once the frames have been brought to the surface and are located on the deck of the service vessel / on shore. The possible use of Remote Operated Vehicles (ROV)s to service the system may require the use of specialist ROV connectors, but this is standard technology available from a number of suppliers, having been used extensively around the world in the oil and gas industry for many years.

We assume the final design for the deployment, and associated connectors, can be determined as part of the detailed design of the system, which can take place as required by EDF over the next five years, if not longer, before a system is required to be installed on the Intake Heads.

3. Required System Specification

3.1 Current Specification

In addition to the existing capabilities, the current AFD system available from FGS already meets all of the key HPC requirements specified by EDF:

- The AFD system is based upon proven technology.
- The Sound Projectors generate a sound level in excess of 160 dB re 1µPa.
- The Sound Projectors are programmable and can store and produce multiple signals in the required range of 30-2000Hz.
- The current FGS MkIV 30-600 Sound Projector with optional Active Pressure Compensation System (APCS) is suitable for deployment in tidal locations of 25m in depth, and current speeds between 0 – 1.8 m/s.
- The Service Interval of the FGS MkIV 30-600 Sound Projector is 18 months, so the system can be maintained on an 18-month replacement cycle for the Sound Projectors.
- Acoustic modelling using FGS's proprietary model, PrISM, has demonstrated –
    - a system can be installed that will provide the required sound pressure level of 160 dB re 1µPa across the whole surface of the intake screens (at the entrance to the Intake Heads) with minimal interference and acoustic nulls.
    - the sound field generated by the system produces a strong acoustic gradient, with the sound pressure level reducing with distance from the Intake Heads.
    - the sound pressure level can be maintained for all states of tide.
- The system is capable of being powered from onshore via submarine cable(s).
- The following items can be incorporated into the system, but will need to be finalised as part of the detailed design of the Deployment System –
    - Maintenance activities of the AFD systems and associated mechanical and electrical power supply infrastructure, so that it does not interfere with, or risk damage to, the cooling water intake structures.
    - A Deployment Design to minimise diving activities.
    - Compliance of the Deployment Structure with a SC2 seismic requirement.
- The requirement for the system to meet a minimum availability of 90%, including downtime for both planned and unplanned maintenance can be incorporated into the final design of the system, including any additional redundancy that may be required to meet this requirement. We assume the Environment Agency will also specify what redundancy it requires, which can also be incorporated into the final design.

3.2 Final Design of the AFD System

The final design of an AFD will need to consider a number of points, which include –

Failures

Occasional failures do occur and can be due to a number of different reasons, but these are typically dealt with as part of a routine service contract provided by FGS, as the inclusion of additional redundancy enables failures to occur without adversely impacting the performance of the system. The development of the APCS has eliminated the potential issue of the failure associated with the passive pressure compensation system. FGS continually reviews the performance of all of the components, and will continue to incorporate any possible advances into the system for SZC.

Accessibility - While the current MkIV 30-600 Sound Projector based AFD system available from FGS meets the requirements of the project specification, EDF has highlighted that the design of the Intake Heads at SZC, and their lack of accessibility, has made the servicing of the AFD system more of a challenge. However, as already noted, the 18-month service interval of the MkIV Sound Projectors meets the required specification.

It has been stated by EDF that the system will need to be maintained by divers however, following personal conversations with an ROV company we understand that ROVs should be able to carry out the required work, and even if there is not one available at this moment in time, we assume if it wishes EDF can engage with ROV suppliers to develop a suitable unit. We also understand that EDF declined to start this process as part of the AFD 'Optioneering' phase it conducted in 2017 for HPC. If EDF does not wish to develop the required ROV then FGS would be willing to do so as part of the detailed design contract for an AFD for both SZC and HPC.

Diving Times

Associated with the accessibility of the projectors, EDF has previously employed a diving contractor to assess the time it will take to carry out the maintenance work underwater, and these assumptions have been used as the basis for the overall assessment of the practicality of maintaining the system.

FGS has been involved in the maintenance of its systems using divers for over 25 years and over this period of time it has built up significant experience in working with divers, and diving operations. As a result, it is possible to note that the assessment does not take into account that times will be reduced as divers become familiar with the required operations, nor has it allowed for any efficiencies that will be introduced by carrying our more than one task at a time when a diver is underwater. Efficiencies could be created in a number of ways, including:

- by potentially increasing the number of projectors per cluster, thereby reducing the number of clusters that require replacing.
- having the divers work more efficiently, prepping for more than one cluster exchange on an Intake Head at a time.
- Increasing the redundancy in the system, and thereby allowing the service interval to extend beyond 18 months per projector.

In addition, we would note that the intake velocity into the Intake Head has been designed to be below 0.3 ms^{-1}, and therefore the risk of a diver or their umbilical becoming entrained is very low.

As a result, the conclusions made must be read on the assumption that the aim of the diving assessment was to paint a worst-case picture, and in reality, the time required to carry out the work will be less than that stated.

Sound Projector Configuration

Acoustic (PrISM) modelling was carried out by FGS as part of the HPC AFD 'Optioneering' phase of the project, and it should be noted that while the projector configuration selected by EDF at HPC will protect the intake in accordance with EDF's specification, this was not the optimum solution, as it reduces the warning signal that could be generated by a 'stadium' configuration, with Sound Projectors located at the ends of the Intake Heads as well as along the face of the intakes. If the system at SZC is to be optimised following installation then the option for Sound Projectors being located at the ends of the Intake Heads will need to be included into the design of the Deployment Systems.

Sound Projector Deployment System - A number of Deployment Options have been considered by EDF, and we assume the AFD supplier will be involved with the final design of the Deployment System, to enable the maintenance task to be as efficient as possible.

As identified above, there are other areas that will also need to be considered, and so we assume this will include –

- Agreement on required redundancy.
- Changes in existing system to meet redundancy requirements.
- Confirmation of final system specification, including Control Software requirements.
- Confirmation of proposed maintenance regime.
- Confirmation of optimum sound field and location and number of required Sound Projectors.
- Design of suitable Deployment System to minimise diver time.
- Associated with this, work with a ROV manufacturer to enhance an existing design and / or design a new ROV to meet the project requirements.
- Incorporation of ROV-type connectors into the Underwater Power and Communication Hubs.
- Review maintenance activities of the AFD systems and associated mechanical and electrical power supply infrastructure, so that it does not interfere with, or risk damage to, the cooling water intake structures.
- Compliance of the Deployment Structure with a SC2 seismic requirement

Dated: 6th April, 2021

Glossary & list of Abbreviations

The following are taken from Environment Agency guidance[1], along with other additions as required to provide a complete list of acronyms in this document.

AFD: Acoustic fish deterrent: propagation of underwater sounds to deflect fish from water intakes.
APCS: Active Pressure Compensation System, a system for maintaining the correct pressure within a Sound Projector.
Approach velocity: Water velocity just upstream of a screen or water intake.
Band screen: Type of rotating fine filter screen, usually of 3-10 mm mesh, installed upstream of cooling water pumps and condensers to exclude marine detritus. Mesh is formed as 'conveyor' belt that rotates and is continuously backwashed to keep it clean.
BAT: Best Available Technology, as required under European Integrated Pollution Prevention and Control (IPPC) regulations.
BEEMS: British Energy Estuarine & Marine Studies. The BEEMS programme was set up by EFD Energy for Cefas to implement a multi-disciplinary programme of marine studies to support new-build power stations in the UK.
CCGT: Combined Cycle Gas Turbine, is a form of highly efficient energy generation technology that combines a gas-fired turbine with a steam turbine.
CCW: Countryside Council for Wales.
CEGB: Central Electricity Generating Board, The CEGB was responsible for electricity generation and supply in England and Wales from 1958 until privatisation of the electricity industry in the 1990s.
CW: Cooling water/circulating water. Latter used mainly with tower cooling.
DCO: Development Consent Order.
Drum screen: Type of rotating fine filter screen, usually of 3-10 mm mesh, installed upstream of cooling water pumps and condensers to exclude marine detritus. Mesh is formed as drum that rotates and is continuously backwashed to keep it clean.
EA: Environment Agency
EAV: Equivalent adult value: accounting method used in fish population dynamics, whereby the population value of a fish egg or juvenile is represented in terms of its probability of reaching adulthood.
EDF: EDF Energy
Entrainment: Passage of entrapped organisms that penetrate CW screens (typically zooplankton including ichthyoplankton and phytoplankton), via pumps, heat exchangers and other components of the CW circuit and back to the receiving water.
Entrapment: Inadvertent entry into the CW system of aquatic organisms caused by the ingress of water.
FGS: Fish Guidance Systems Ltd.
Fish bucket: Modified band or drum screen elevator within an FRR system.
FRR: Fish recovery and return: system using band or drum screens modified for safe fish handling, including their return to the source water body.
HPC: Hinkley Point C.
Ichthyoplankton: Early life-stages of fish contained within marine plankton.
Impingement: Retention of entrapped organisms on CW intake screens employed to prevent debris entering the CW heat exchangers.
Launder: Troughs, channels or pipes used to carry trash that has been backwashed from the fine screens.
LVSE: Low-Velocity Side-Entry, the design of Intake Head being installed at Hinkley Point C.
MMO: The Marine Management Organisation.
NE: Natural England.
NNB: Nuclear New Build Generation Company; NNB is a subsidiary created by EDF Energy to build and then operate Sizewell C
ROV: Remote Operated Vehicle
SPA: Sound Projector Array, a low frequency underwater transducer manufactured by FGS.
SZC: Sizewell C