South East Strategic Reservoir Option (SESRO)

Supporting Document A-3:

Carbon Report

Notice

Position Statement

This document has been produced as the part of the process set out by RAPID for the development of the Strategic Resource Options (SROs). This is a regulatory gated process allowing there to be control and appropriate scrutiny on the activities that are undertaken by the water companies to investigate and develop efficient solutions on behalf of customers to meet future drought resilience challenges.

This report forms part of suite of documents that make up the 'Gate 2 submission.' That submission details all the work undertaken by Thames Water and Affinity Water in the ongoing development of the proposed SROs. The intention of this stage is to provide RAPID with an update on the concept design, feasibility, cost estimates and programme for the schemes, allowing decisions to be made on their progress and future funding requirements.

Should a scheme be selected and confirmed in the companies' final Water Resources Management Plan, in most cases it would need to enter a separate process to gain permission to build and run the final solution. That could be through either the Town and Country Planning Act 1990 or the Planning Act 2008 development consent order process. Both options require the designs to be fully appraised and in most cases an environmental statement to be produced. Where required that statement sets out the likely environmental impacts and what mitigation is required.

Community and stakeholder engagement is crucial to the development of the SROs. Some high level activity has been undertaken to date. Much more detailed community engagement and formal consultation is required on all the schemes at the appropriate point. Before applying for permission Thames Water and Affinity Water will need to demonstrate that they have presented information about the proposals to the community, gathered feedback and considered the views of stakeholders. We will have regard to that feedback and, where possible, make changes to the designs as a result.

The SROs are at a very early stage of development, despite some options having been considered for several years. The details set out in the Gate 2 documents are still at a formative stage and consideration should be given to that when reviewing the proposals. They are for the purposes of allocating further funding not seeking permission.

Disclaimer

This document has been written in line with the requirements of the RAPID Gate 2 Guidance and to comply with the regulatory process pursuant to Thames Water's and Affinity Water's statutory duties. The information presented relates to material or data which is still in the course of completion. Should the solution presented in this document be taken forward, Thames Water and Affinity Water will be subject to the statutory duties pursuant to the necessary consenting process, including environmental assessment and consultation as required. This document should be read with those duties in mind.

Contents

Figures and Tables

1. Introduction

1.1 In the final determination of the 2019 water industry price review (PR19) Ofwat set out a formal gated process and allocated funds to develop integrated strategic regional water resource solutions (SROs) during the 2020-2025 planning period (AMP7). The South East Strategic Reservoir Option (SESRO) / Abingdon Reservoir Option has been included in successive Water Resource Management Plans (WRMPs) developed by Thames Water and was selected in the Thames Water and Affinity Water WRMP19 preferred plans; therefore, the PR19 final determination allocated funds to these two water companies to develop SESRO through the Ofwat gated process.

1.2 This report provides an overview of the current carbon assessment for the scheme and supports the Gate 2 submission to the Regulators' Alliance for Progressing Infrastructure Development (RAPID), which includes Ofwat, the Environment Agency (EA) and the Drinking Water Inspectorate (DWI) [1].

1.1 Scheme Overview

1.3 SESRO would deliver a new reservoir to store water abstracted during periods of high flow in the River Thames for use during periods of low river flow or high demand for water. The reservoir could be used by the customers of multiple water companies across the South East of England. Further details of the scheme are provided in Supporting Document A1, Concept Design Report, with a summary of the key components provided below:

- Provision of a fully bunded reservoir in Oxfordshire, 5km south-west of Abingdon (with total storage capacity between 75 Mm^3 and 150 Mm^3) within the area bounded by the A34 and Steventon to the east; the Great Western Main Line (London to Bristol) to the south; the A338 and East Hanney to the west; and the River Ock to the north.
- Pumping station at the toe of the embankment (on the north-east side of the reservoir) containing pumps for filling the reservoir and turbines for energy recovery during periods when the reservoir releases water to the River Thames.
- 3.3 km long conveyance tunnel to transfer flows via the pumping station to and from an intake / outfall structure on the right bank of the River Thames near Culham.
- Raw water to be abstracted from the river when water levels are high, using pumps to fill the reservoir. The maximum quantity abstracted in any day would not exceed 1,000 Ml.
- Flows to be discharged into the river when the reservoir is releasing water via the energy recovery turbines (working assumption maximum rate of 600 Ml/d, but

[1] Strategic Regional Water Resource Solutions Guidance for Gate Two. RAPID, Ofwat, EA, DWI. April 2022. Strategic-regional-water-resource-solutions-guidance-for-gate-two_RAPID.pdf (ofwat.gov.uk)

typical release rate between ~165 Ml/d and ~320 Ml/d depending on the size of the reservoir selected).

- Auxiliary drawdown channel which would also form a rehabilitated, navigable section of the Wilts & Berks Canal, available to allow release of additional water from the reservoir in emergency scenarios. The Wilts & Berks Canal was taken out of operation ~100 years ago but may be reinstated in the future.
- Main access road (from A415) and diversion of the East Hanney to Steventon Road.
- Temporary rail siding to facilitate delivery of construction materials by freight train.
- Recreation facilities, public education facilities, landscaping and creation of aquatic / grassland habitats.
- Channel and floodplain construction as required to mitigate the impact of the reservoir on local watercourses and floodplains.

1.4 This report provides details on the carbon assessment at Gate 2 for the six SESRO variants. These include four single phase variants and two dual phase variants:

- 150Mm^3 capacity reservoir
- 125Mm^3 capacity reservoir
- 100Mm^3 capacity reservoir
- 75Mm^3 capacity reservoir
- 30+100Mm^3 capacity phased reservoir
- 80+42Mm^3 capacity phased reservoir

1.2 Carbon Overview

1.5 SESRO has the potential to deliver significant water security benefits but could also be a significant source of carbon emissions through its construction and operation.

1.6 To align with the latest RAPID Gate 2 guidance the carbon assessment is required to consider:

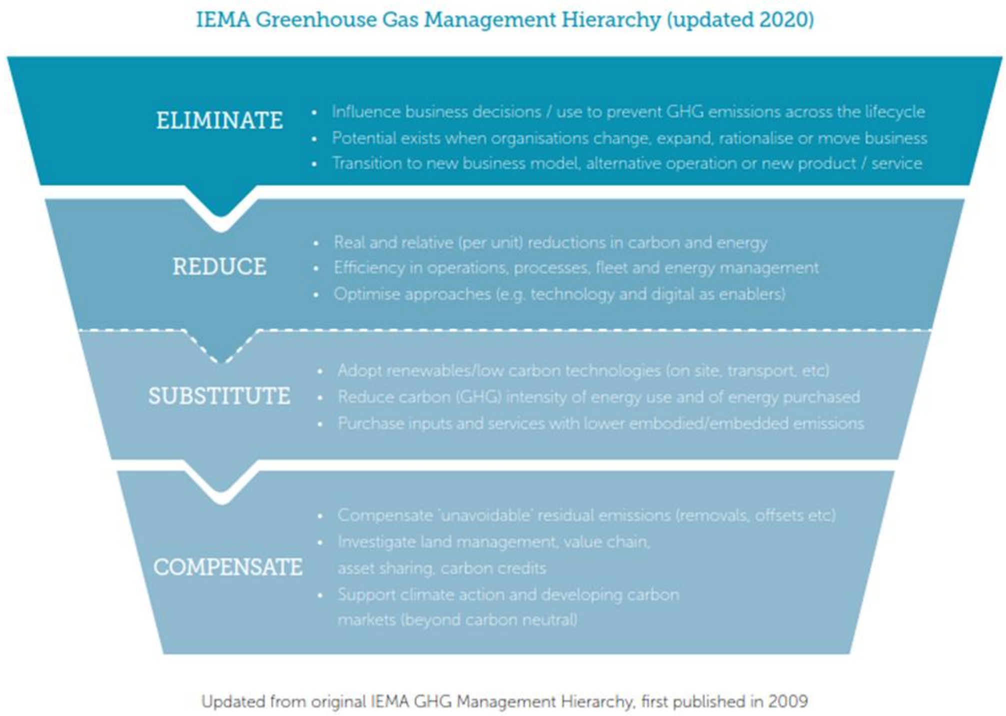
- Assessment of whole life carbon cost of the solution.
- Consideration and discussion of whole life carbon reduction including how carbon has been considered in the best value planning approaches, metrics and decision making with due consideration to the six main greenhouse gasses.
- Demonstration of use of relevant policy, frameworks and approaches to drive down carbon emissions.
- Assessment of key emission areas (scope 1, 2 and 3), considerations for reduction and inclusions of material selection choice (including explanation of where low carbon materials have been discounted).

- Consideration of the impact between cost and carbon reduction.

1.7 To respond to the above requirements, this report provides an overview of the current estimate for capital carbon (Section 2) and operational carbon (Section 3). These have subsequently been used to assess the whole-life carbon emissions of the scheme (Section 4). Aspects on which to focus mitigation measures as the scheme moves forward into the next stages of design have been considered in Section 5 and Section 6.[2]

1.8 The carbon assessment for SESRO has followed the IEMA emissions reduction hierarchy shown in Figure 1.1 to identify opportunities to mitigate carbon impacts of the scheme. This aligns well with the carbon reduction hierarchy from PAS2080 and helps focus efforts on reducing emissions rather than offsetting them.

Figure 1.1: IEMA Greenhouse Gas Management Hierarchy



Source: IEMA, 2020

1.9 It is acknowledged that a significant proportion of capital and operational carbon emissions associated with SESRO are considered Scope 3 emissions and outside of the direct control of the water companies and project team. However, it is also acknowledged that there are significant opportunities to work with the supply chain (prior to scheme delivery) to support accelerated decarbonisation of external systems and supply chains to help reduce the carbon impact. For example, the availability, at sufficient scale, of alternative fuels and construction plant for the earthworks and haulage activities associated with reservoir construction are a key

[2] The calculations provided in this report account for tCO2e (equivalent), accounting for wider GHG emissions. 'Carbon' is used as a shorthand to reference this value throughout the report

area for engagement to enable decarbonisation of the SESRO scheme.

1.10 The carbon emissions mitigation efforts have been split into two areas:

- Opportunities directly under the control of the project team, including areas which can reduce emissions through design decisions that can be embedded and costed into the scheme.
- Longer term opportunities where the scheme and sector can influence external systems and supply chains to decarbonise major components of the scheme. These longer-term mitigation opportunities have been covered by a collaborative project commissioned by the All Company Working Group (ACWG) which has identified a consistent view across SROs of how these external systems may decarbonise in the future. The ACWG study can therefore be used to inform future decarbonisation potential and engagement priorities for individual SROs.

1.11 The goal for SESRO carbon management is to:

- Establish a capital, operational and whole life carbon baseline assessment aligned to latest guidance and emissions factor sources quoted in the RAPID guidance. The aim is to ensure that the assessment transparently follows guidance on emissions factors, scope boundaries and use of assumptions to fill gaps.
- Draw insights from the baseline assessment to communicate major emissions hotspot sources with relevant stakeholders.
- Communicate actions that have already been incorporated into the design to mitigate emissions.
- Communicate future recommendations for design teams to further mitigate emissions at later stages.
- Establish a stakeholder engagement plan that demonstrates how the SESRO project (in future stages) could influence external systems to support carbon reduction ambitions, whilst acknowledging these will remain outside of the project team's control.
- Highlight uncertainties in decarbonisation potential and cost impacts of implementing decarbonisation technologies and how these uncertainties will be monitored over time.

1.12 In the next stages of design development for SESRO it would be necessary to continue to evaluate water sector and water company goals of achieving carbon reductions in line with sector and national net-zero commitments alongside the cost implications of decarbonisation.

1.3 Uncertainty within Carbon Estimates

1.13 There is inherent uncertainty in carbon estimating due to the developing maturity of carbon accounting practices and associated data. There is also additional uncertainty driven by scope uncertainty associated with level of design information available at given stages within the project lifecycle.

1.14 There is currently no standardised or established guidance to assess uncertainty in carbon estimates in a consistent way and directly applying the range of uncertainty associated with cost estimates and optimism bias would likely overstate the level of uncertainty associated with the Gate 2 carbon estimate.

1.15 Whilst further ongoing work is required at a carbon estimating and accounting discipline level and within the infrastructure sector to establish a more formalised approach to assessing carbon uncertainty, a range of +/-30% has been applied based on expert judgement for the Gate 2 estimate. This uncertainty range accounts for:

- Uncertainty in carbon factors related to the quality and representativeness of industry level emissions factors to the specific activities undertaken and materials used on the SESRO scheme.
- Scope uncertainty associated with ensuring the carbon estimate has captured all scope requirements to fully deliver the scheme.

1.16 These uncertainty estimates will be reviewed and refined at future stages of SESRO design development to build on any further industry wide efforts to assess uncertainty in carbon estimating.

2. Capital Carbon

2.1 Under the Greenhouse Gas Protocol, capital carbon emissions from construction are typically categorised as Scope 3 emissions of the sector/organisation. Capital carbon emissions from construction and maintenance activities are the result of materials (extraction and processing), manufacturing effort, transportation and any disposal of construction waste. The capital carbon assessments within this section cover lifecycle modules A1-A5 (as per PAS2080:2016) and are only associated with the embodied carbon of materials used and associated construction activities to get the reservoir up to commissioning stage. The assessments also considered a cradle-to-built asset boundary (as per UKWIR, 2012).

2.2 Asset construction will be a significant emissions source for most SROs and quantification of these emissions is a key element to identifying efficient mitigation opportunities. This section provides an overview of the capital carbon emissions estimate undertaken for SESRO and describes some of the key carbon hotspots.

2.1 Capital Carbon Components and Emissions Factors

2.3 A capital carbon assessment has been carried out using current design information alongside the breakdown of asset scope inputs used for the Gate 2 cost estimate. The asset information used for costing was aligned to carbon models developed based on industry standard data to enable an estimate of capital carbon. Assessments were completed for the four single-phase SESRO variants of capacity 150Mm^3, 125Mm^3, 100Mm^3 and 75Mm^3 capacity reservoir, as well as the two dual-phase variants of capacity 30+100Mm^3 and 80+42Mm^3.

2.4 The assessment for the reservoir construction activities has predominantly used emissions factor rates from Civil Engineering Standard Method of Measurement (CESMM4). These cover activities such as topsoil stripping, excavation, stockpiling and placing of excavated materials.

2.5 Additionally, carbon models have been used to determine capital carbon emissions for other types of asset that would be constructed as part of SESRO, such as models for site service roads and temporary fencing. These models have been developed using typical industry generic designs and supplier information for products and materials, alongside emissions factor data from the Inventory of Carbon and Energy (ICE).

2.6 Typically CESMM4 factors have been applied to construction activities and ICE database factors have been used for construction material carbon intensities. Table 2.1 summarises some of the key emission sources and model emission factors they are associated with.

2.7 Over time, as more detail is built into material specifications and specific locations of supply, it is expected that more supplier specific emissions data could be utilised in place of industry generic emissions inventories.

Table 2.1: Summary of Key Emission Quantities and Factors (150Mm³)

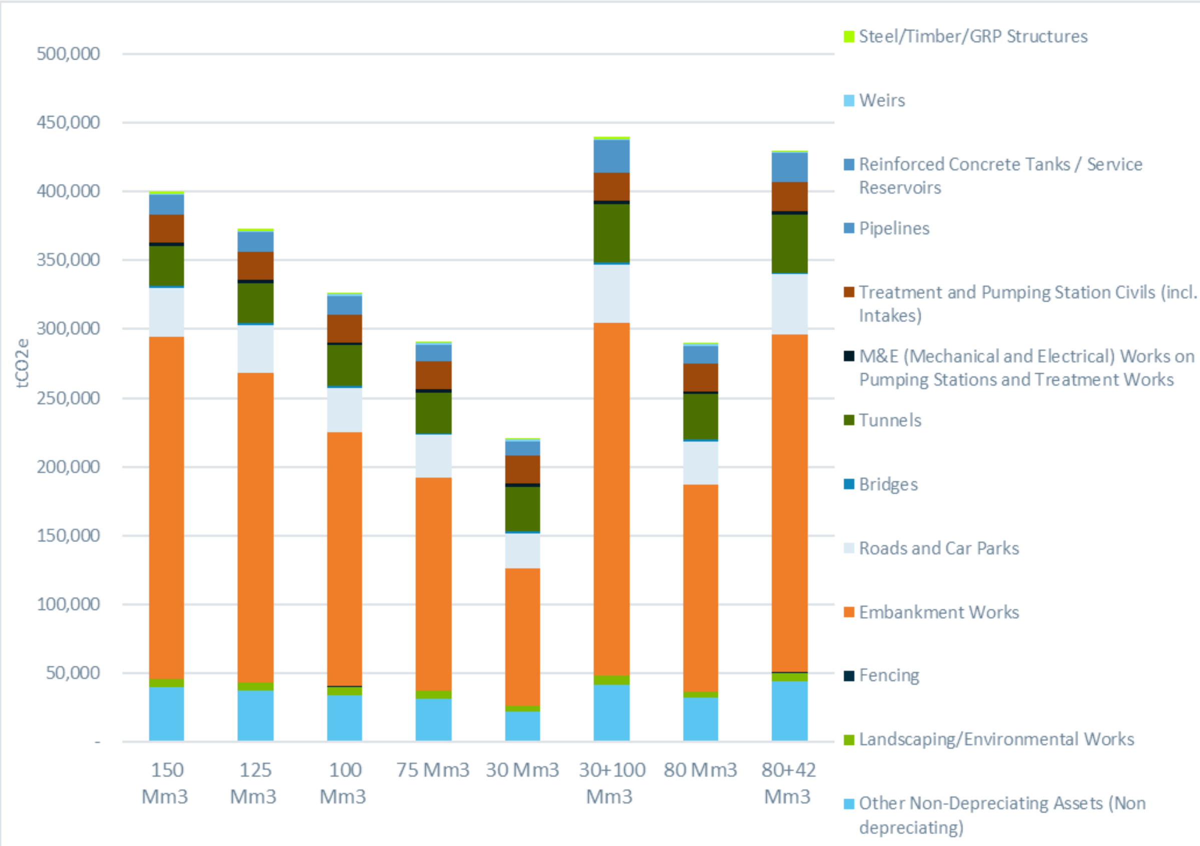
Item/Material	Emission Factor (kgCO2e/unit)	Modelled Capital Carbon for Initial Construction of 150Mm³ Variant (tCO2e)
Embankment Earthworks (Structural)	1.28 (Excavation) 1.698 (Handling) 1.46 (Filling)	125,580
Embankment Earthworks (Landscaping)	1.28 (Excavation) 1.698 (Handling) 1.46 (Filling)	79,450
Roads (assumed concrete)	121.59	61,090
Rip-rap	0.0132 (Shipping) 0.0278 (Rail) 10.837 (Place)	24,040
Concrete	278.693	21,330
Various steel items	6,142.28	13,770
Tunnel grout	6684.60	10,560
Excavation with TBM	148.28	9,760
Bedding & inner face protection (sand & gravel)	12.28 (Fill with imported material) 2.65 (Handling)	7,310
Site and embankment drainage (sand & gravel)	12.28 (Fill with imported material) 1.06 (Excavating trenches up to 5m below ground) 1.46 (Moving from stockpile to site)	4,720
Other	-	42,490

2.2 Summary of Capital Carbon Estimate

2.8 The capital carbon associated with the construction of each of the six SESRO variants is shown in Figure 2.1. As well as showing total capital carbon, Figure 2.1 also provides a breakdown into the ACWG asset life categories to help identify the aspects which contribute more significantly to higher emissions. See Supporting Document A2, Cost Report and Section 2.3 of this report for further details on the ACWG asset life categories.

2.9 The capital carbon emissions are higher for the larger reservoir capacity variants due to the increased amount of embankment works required.

Figure 2.1: Capital Carbon Estimate for SESRO Variants



2.2 Capital Carbon Hotspots

2.2.1 Embankment works

2.10 Across all options shown in Figure 2.1, the embankment works category is the largest carbon hotspot, accounting for between 39% and 55% of the total capital carbon. The aspects that are grouped into this category relate primarily to the construction of the reservoir borrow pit and the reservoir embankments; this includes:

- Excavation of the borrow pit at the SESRO site;
- Placement of the excavated material from the borrow pit to form the SESRO reservoir embankment;
- Importing and placing sand and gravel to create drainage layers within the SESRO reservoir embankment; and
- Importing and placing sand, gravel and riprap on the inner face of the SESRO reservoir embankment for protection against wave erosion.

2.11 The current design for the reservoir is based on achieving a balance between the volume of clay that would be excavated from the borrow pit and the volume of clay that is required to form the main reservoir embankment. It is also important to ensure that any other material excavated from the borrow pit can be used on the site, so as to remove the need for export and disposal off-site and associated emissions, and the Gate 2 concept design achieves this aim.

2.12 While the majority of the volume of material required for the reservoir embankment will be sourced from the borrow pit, some components of the embankment need to be formed of material that is not available at the site. The internal drainage layers within the reservoir embankment are to be formed from gravel and sand, and a layer of stone riprap is required on the inner face of the embankment. The current design includes for a temporary rail siding to allow this material to be transported to the site by freight trains. The supply emissions factor for riprap, sand, and gravel did not account for transport; therefore, a separate estimate for transport has been included using the estimated weight of those materials and the relevant BEIS/DEFRA 2021 carbon factor for transport.

2.2.2 Roads

2.13 Roads are another significant carbon hotspot for the scheme, accounting for between 14% and 19% of the overall capital carbon. The roads category includes:

- Permanent roads (A415 to SESRO access road, Steventon to East Hanney road diversion, and the river intake/outfall access road);
- Temporary haul roads (across the reservoir site including access to the rail siding and the associated materials handling area); and
- Bridges (associated with the new roads and for various watercourse crossings)

2.14 The current roads capital carbon emissions assume a concrete road construction, which is considered to be conservative. It is recommended to consider the construction method for paved and unpaved haul roads in further detail during the next stage of design development to identify whether an alternative carbon model would be more appropriate.

2.2.3 Tunnels

2.15 The tunnels category accounts for between 6% and 12% of the total capital carbon for the scheme. This category includes the material and construction efforts for:

- A 3.5-4 km long, 4-4.5 m diameter, concrete lined tunnel, constructed by a Tunnel Boring Machine to connect the river intake/outfall and the pumping station.
- A 0.5 km long, 4.5-5 m diameter tunnel with a concrete lining to connect the pumping station with the main inlet/outlet tower in the reservoir.
- Shafts at the pumping station, river intake/outfall structure and main reservoir inlet/outlet tower.

2.16 The majority of carbon in this category is associated with the tunnel between the pumping station and the river intake/outfall.

2.2.4 Structures

2.17 The main structures required for SESRO are the river intake / outfall structure, the pumping station and the reservoir inlet / outlet towers. These have been assigned across the 'reinforced concrete tanks' and the 'pumping station civils' ACWG asset life categories. These two categories combined account for between 5% and 7% of the total capital carbon for the scheme.

2.2.5 Other Categories

2.18 Non-depreciating assets, which are those items not expected to require replacement (for example, temporary works) contribute up to 9% of capital carbon emissions.

2.19 All other categories in the capital carbon assessment contribute less than 5% of the total capital carbon emissions. While these are not identified as major hotspots within this report, their emissions impact would need to continue to be optimised during later stages of design development.

2.3 Replacement Capital Carbon

2.20 SESRO consists of a variety of different components. These components will be designed to different sets of standards, each with a typical design (or asset) life. There would be a need to replace certain components of the scheme at different times over the operating period of SESRO.

2.21 For use across all Strategic Resource Options (SROs), the ACWG has outlined a set of 'asset life categories' into which the components of the schemes are assigned. This is to allow for a more consistent assessment of the need to replace certain components at the end of their asset life. The categories that have been used for SESRO and their associated asset life are presented in Table 2.2. Assets are replaced at the end of their asset life and the initial modelled capital carbon for construction of that asset are repeated at that time.

Table 2.2: ACWG Asset Life Categories used for SESRO

ACWG Asset Life Category	Asset Life (years)
Embankment Works	250
Other Non-Depreciating Assets (Non depreciating)	n/a
Roads and Car Parks	60
Tunnels	100
Treatment and Pumping Station Civils (incl. Intakes)	60
Reinforced Concrete Tanks / Service Reservoirs	80
Landscaping/Environmental Works	30
Pipelines	100

M&E (Mechanical and Electrical) Works on Pumping Stations and Treatment Works	20
Bridges	40
Steel/Timber/GRP Structures	30
Weirs	100
Fencing	10
Land (Non depreciating)	-

3. Operational Carbon

3.1 An operational carbon assessment has been undertaken for the SESRO scheme. These emissions would be considered as Scope 1 and 2 emissions of an organisation under the GHG Protocol, which cover direct and indirect emissions, respectively. Direct emissions in the water sector result from treatment process emissions, fossil fuel use and owned or leased transport emissions. Indirect energy emissions are the product of purchase and use of grid electricity by water company assets notably for water and wastewater pumping and treatment as well as use in buildings. Under the PAS2080:2016 life cycle modules, the current assessment covers use stages B1-B6 modules.

3.2 For SESRO, the major operational emissions source is through maintenance activities and indirect emissions associated with grid power consumption.

3.1 Operational Carbon Estimate Components and Emissions Factors

3.3 The operational carbon assessment for SESRO is based on the power and maintenance requirements of the scheme and has been aligned to the inputs to the operating cost estimate. The following main aspects for operation of SESRO have been considered:

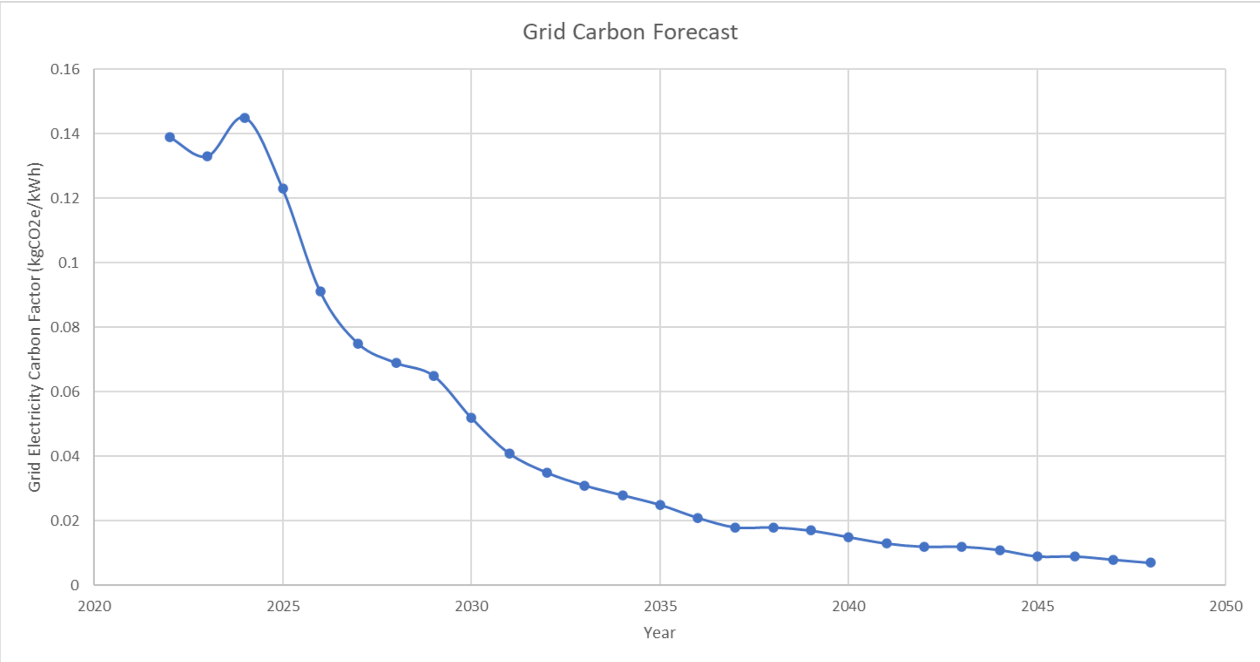
- Annual maintenance costs are based on 0.25% of the initial construction cost of the civil works components (excluding internal embankment works) and 1.5% of the initial cost of the E&M works. Consideration of the typical maintenance activities for reservoirs however indicates that the carbon intensity of these activities would be less than their cost intensity, as they would require relatively limited additional products, materials and operational consumables. Therefore, to estimate carbon emissions associated with maintenance activities an additional factor of 0.1 was applied. This assessment will be refined at future stages of design development with a bottom-up estimate to account for transport fuel as well as typical products and materials required for operational maintenance.
- Energy required to pump water from the River Thames into the reservoir during periods of high flow in the River Thames and when the reservoir is below top water level. This has been based on a 100% utilisation scenario, while it is anticipated that the average utilisation will be 38% (for further detail see Supporting Document A2, Cost Report).
- Energy generated through two energy recovery turbines when water is released from the reservoir to the River Thames.
- Operation of an air diffuser network to maintain reservoir water quality. Water quality modelling for the 150Mm^3 scheme has identified an annual energy requirement of 585MWh. The ratio of reservoir surface area has been used to estimate the equivalent energy requirement for the other SESRO variants.

- Operation of a sweetening flow pump during periods when water is neither being released from the reservoir or pumped into the reservoir. It was estimated that the pump would need to operate, on average, 3,900 hours per year. This results in an average annual energy requirement of approximately 234MWh.
- Miscellaneous energy requirements have been estimated as 7.5% of the annual maximum utilisation energy requirements.

3.4 Key emissions factors used for the operational carbon assessment are:

- Current year grid carbon intensity utilises DEFRA's 2021 grid emissions factor which allows for transmission and distribution losses[4].
- Forecast grid carbon intensity for future years utilises projected emissions factors from the BEIS Green Book Data Tables 1-19[5], using commercial/public sector values which are also shown on Figure 3.1.

Figure 3.1: BEIS Green Book – Forecast Grid Carbon Intensity



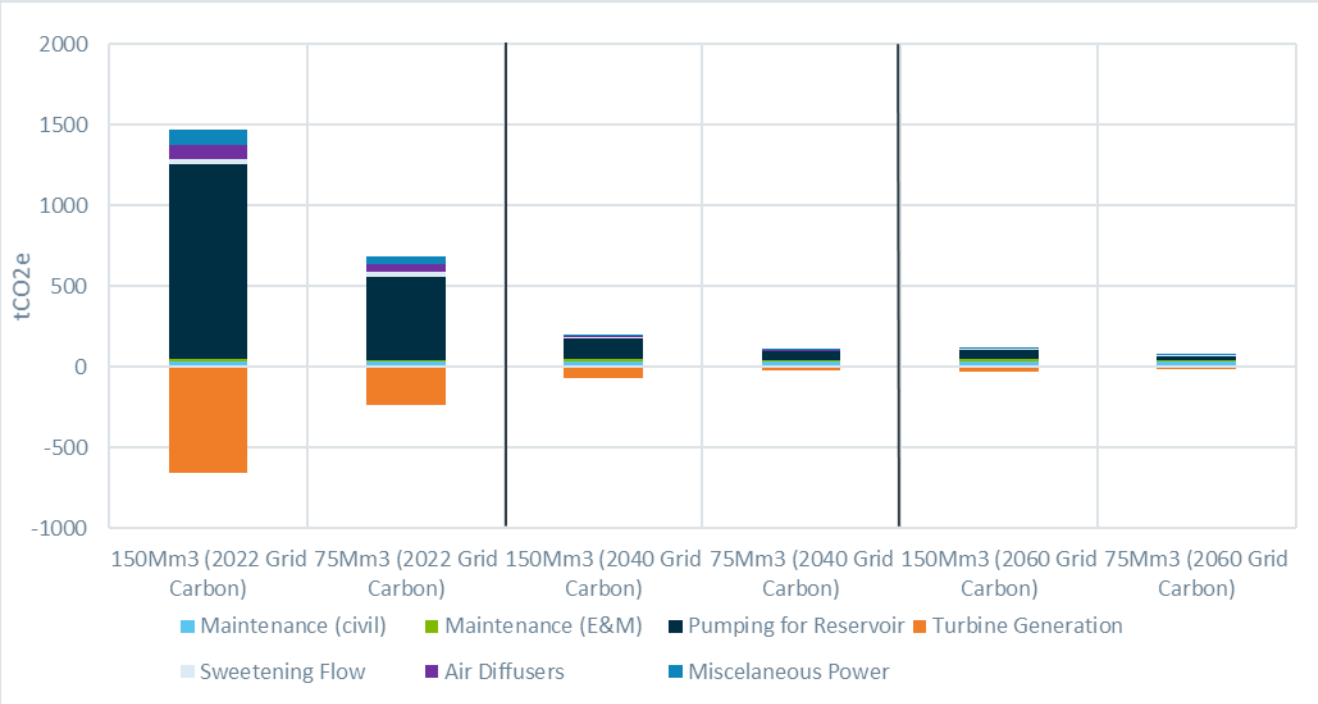
3.2 Summary of Operational Carbon Estimate

3.5 Figure 3.2 shows the annual operational carbon emissions for the largest (150Mm^3) and smallest (75Mm^3) single phase SESRO variants. The annual operational carbon emissions have been compared at three different timeframes using the BEIS grid carbon intensity forecast:

[4] Transmission and distribution losses would be accounted for as scope 3 emissions under the GHG protocol
[5] Electricity emissions factors to 2100, Department for Business, Energy & Industrial Strategy (data-tables-1-19.xlsx (live.com))

- 2022 using BEIS grid carbon intensity forecasts 0.139 $kgCO_2e/kWh$
- 2040 using BEIS grid carbon intensity forecasts 0.015 $kgCO_2e/kWh$
- 2060 using BEIS grid carbon intensity forecasts 0.007 $kgCO_2e/kWh$

Figure 3.2: Effect of Grid Decarbonisation on Whole Life Operational Carbon Emission

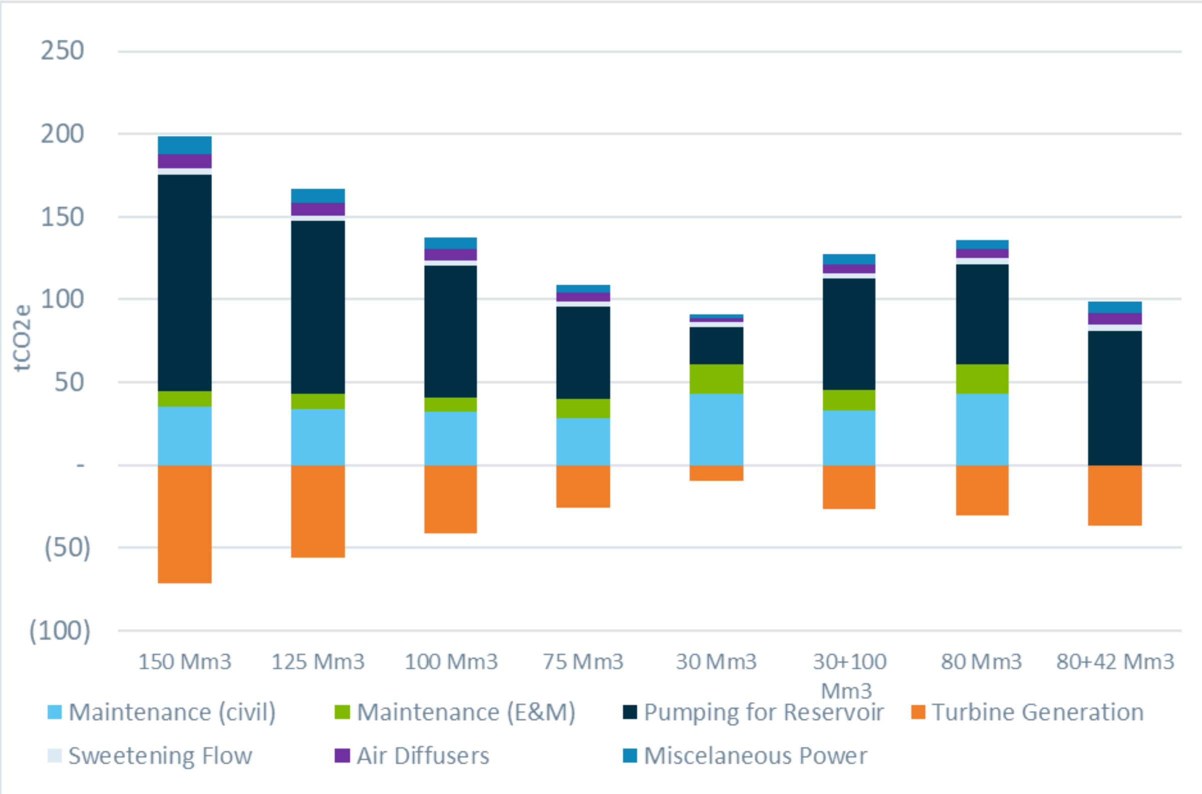


3.6 Figure 3.2 demonstrates the impact of the predicted grid decarbonisation on the carbon intensity of SESRO's anticipated power consumption. There is expected to be an 89% decrease in annual power carbon emissions between now (2022) and 2040 and it is predicted that the grid will have largely decarbonised by around 2050.

3.7 If SESRO were to be constructed, it would only be completed by the late 2030s at the earliest, meaning that the 2040 carbon intensity of power consumption would be more representative of SESRO's initial operational carbon. The Phase 2 component of the dual phase variants would come later in the assessment period. Therefore, Figure 3.3 uses:

- 2040 BEIS grid carbon intensity factor of 0.015kgCO2e/kWh for all single phase variants and the Phase 1 component of the dual phase variants.
- 2060 BEIS grid carbon intensity factor of 0.007kgCO2e/kWh for the Phase 2 component of the dual phase variants.

Figure 3.3: Annual Operational Carbon Estimate for SESRO Variants (BEIS grid carbon factor)



Note: 2040 BEIS grid carbon intensity factor of 0.015kgCO2e/kWh for single phase variant and the Phase 1 component of the dual phase variants. 2060 BEIS grid carbon intensity factor of 0.007kgCO2e/kWh for Phase 2 component of the dual phase variants.

3.3 Operational Carbon Hotspots

3.3.1 Grid Power Consumption

3.8 As noted in Section 3.1 and shown on Figure 3.2, over time, the significance of power related carbon emissions is expected to decrease as grid decarbonisation projects take effect. If the 150Mm^3 SESRO variant were to be constructed, the earliest first year of operation would be in the late 2030s. By this time it is expected that carbon emission intensity should be approximately 13% of its current level. Furthermore, by 2050 the forecast indicates a reduction to 5% of current levels.

3.9 Pumping water into the reservoir would be the largest use of power for the operation of SESRO, accounting for 66% of gross operational carbon emissions as presented in Figure 3.3, based on an operating year of 2040. Power for operating the sweetening flow pump and the air diffuser network alongside other miscellaneous power requirements contributes a further 3-5% to operational carbon emissions.

3.10 While the current SESRO design already incorporates hydropower turbines, there would be proactive steps required during subsequent design stages to improve the energy efficiency of the scheme. For example, there could be opportunities to generate more energy from other renewable sources such as wind turbines and solar photovoltaic plants, see Supporting Document A1, Concept Design Report for further details. It is recommended that further consideration is given to these additional renewable energy opportunities at the next stage of design development.

3.11 In the context of the Government 2050 Net Zero target, major infrastructure schemes, such as SESRO, will need to consider how they can generate a proportion of their own demand and continue to drive energy efficiency because the larger the national demand for power the more difficult it will be to generate enough renewables to substantially decarbonise the grid.

3.3.2 Maintenance

3.12 Maintenance associated with the reservoir accounts for 18% of gross operational carbon emissions for the 150Mm^3 variant as presented in Figure 3.3. The approach to estimating the carbon impact of maintenance is covered in Section 3.1. Some examples of the regular maintenance activities that would be required include:

- Valves (Greasing of spindles, ensure regular operation, Replacement of gland packing (occasional), Painting (occasional)
- Pro-active maintenance of M&E equipment, such as, pumps, blowers, generators, water mixing plant and Instrumentation (Check power connections, check for leakage/damage, greasing/oil)
- Turbines (inspection of electrical cabinet and gearbox, oil/lubrication, rotor blade servicing, alignment)
- Maintaining roads (e.g. resurfacing access roads as required)
- Landscape management
- Security fencing inspections

3.13 The activities above, while potentially labour / cost intensive, would have relatively limited consumables that would have a direct carbon impact. Furthermore, many of the products or consumables required would have already been accounted for in the replacement capital carbon. The additional operational maintenance carbon emissions are likely to be associated with:

- Transport fuel consumption for the maintenance visits.
- Embodied carbon associated with the limited amounts of grease and M&E replacement parts required.
- Fuel use for landscaping e.g. maintaining grass / vegetation on embankments.

3.14 The scale and frequency of each of the above activities would be reviewed in subsequent design stages to provide an improved granularity of annual operational carbon emissions.

4. Whole-Life Carbon

4.1 Whole-Life Carbon Estimate Components

4.1 The outputs from the capital and operational carbon assessments outlined above have been used to inform a whole-life carbon assessment.

4.2 In order to align with whole-life cost estimates, whole-life carbon for SESRO has been assessed over 80 years (from 2022/23 to 2101/02) with the following assumptions based on initial outputs from WRSE Emerging Regional Plan:

- A 6-year planning and development period (2022/23 – 2028/29) during which carbon emissions are assumed to be negligible.
- A 9-year construction period (2029/30 – 2037/38) during which the capital carbon emissions as described in Section 2 are applied. A reduction of 1 year in construction period is assumed for the smaller reservoir sizes.
- A 65-year operation period (2038/39 – 2101/02) during which the replacement capital carbon emissions as outlined in Section 2.3 are applied alongside the annual operational carbon emissions as described in Section 3, which conservatively use a 100% utilisation scenario.

4.3 Whilst capital carbon associated with replacements have been considered (see Section 2.3) the quantified assessment does not include for estimating the potential impact of decommissioning the scheme. The operational life is expected to be over 100 years and it is anticipated that the systems in place to re-use, recycle or dispose of assets would be substantially different to present day.

4.2 Summary of Whole-Life Carbon Estimate

4.4 A summary of estimated whole-life carbon emissions is presented annually in Figure 4.1 and Figure 4.2, for the 150Mm^3 and 75Mm^3 variants, respectively. A summary of estimated cumulative whole-life carbon emissions is presented annually in Figure 4.3 and Figure 4.4 for the same variants.

4.5 Table 4.1 provides a summary of the estimated whole life carbon results for all SESRO variants. The data in Table 4.2 shows the capital carbon emissions of the reservoir account for ~75-80% of emissions across the whole-life carbon estimate, with a further ~14-19% associated with capital replacements of the assets across the 80-year period.

4.6 The operational carbon emissions are associated with maintenance (non-power related) and power consumption (power related), these account for approximately 1.2% of the estimated whole-life carbon emissions.

4.7 The large capital replacement emissions in 2096-98 are associated with the replacement of large civil components, such as roads, the river intake / outfall structure and the pumping station, for which an asset life of 60 years is assumed.

Figure 4.1: SESRO 150Mm³ – Whole Life Emissions by Category (Annual)

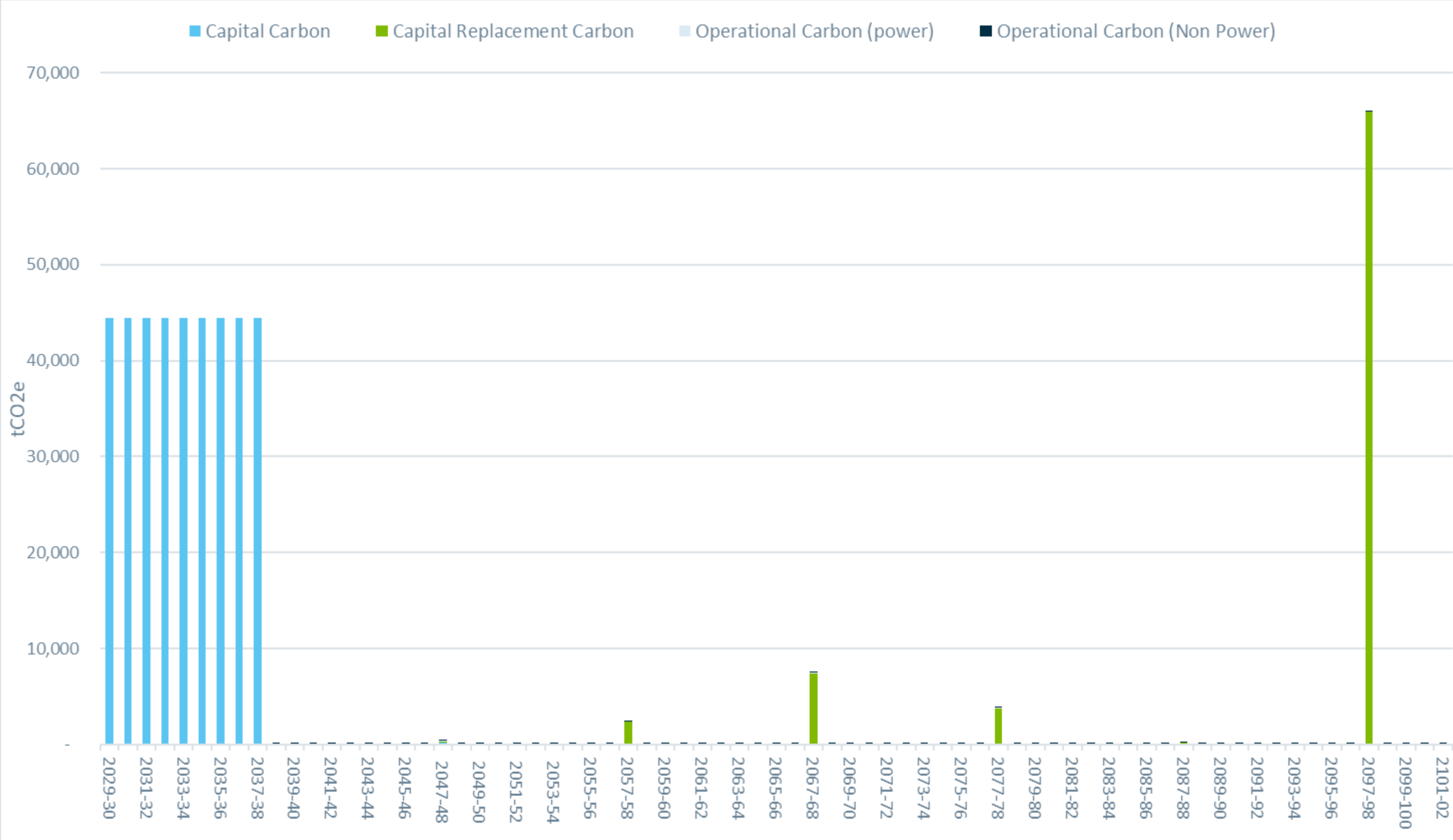


Figure 4.2: SESRO 75Mm³ – Whole Life Emissions by Category (Annual)

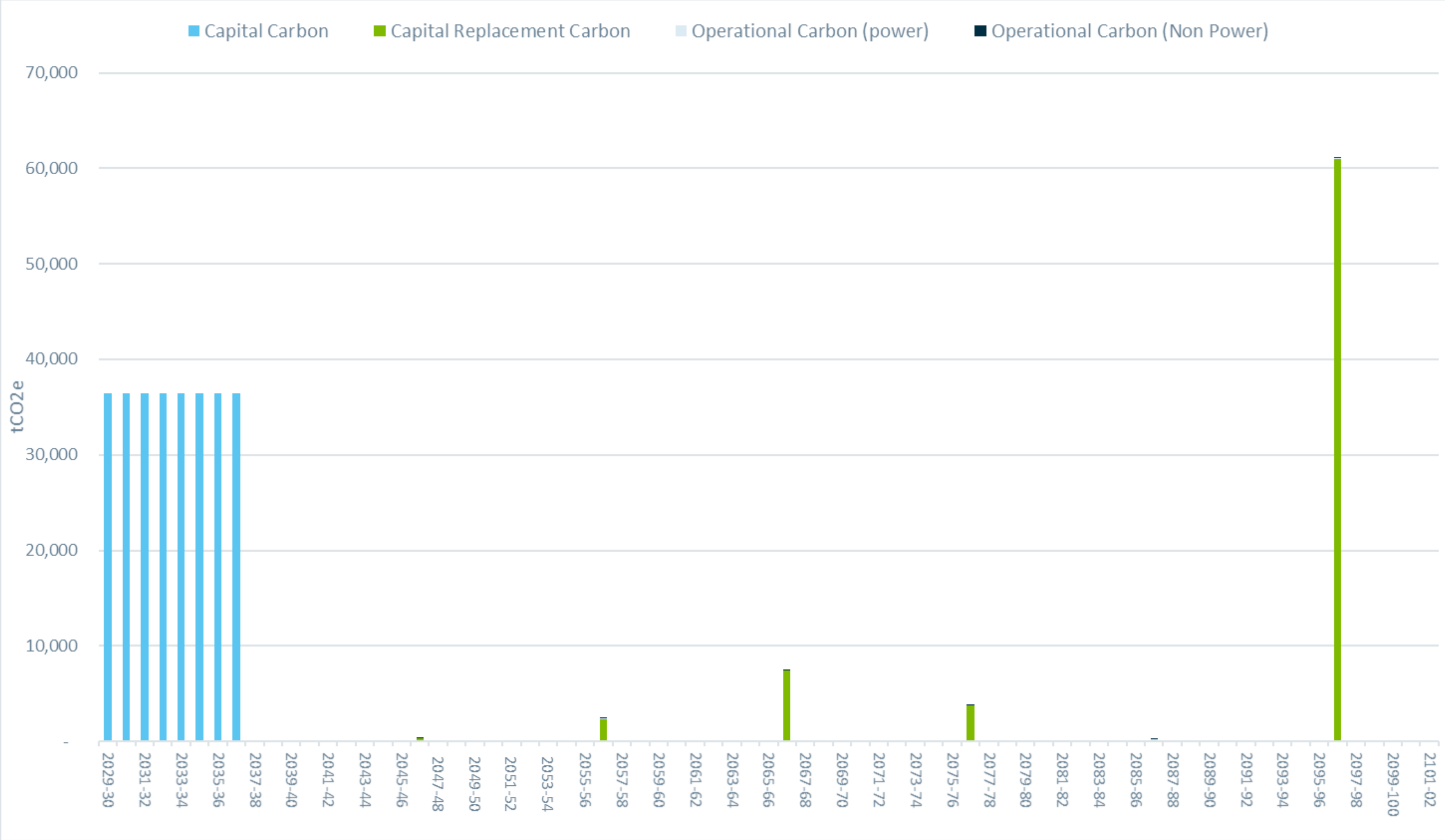


Figure 4.3: SESRO 150Mm³ – Whole Life Emissions by Category (Cumulative)

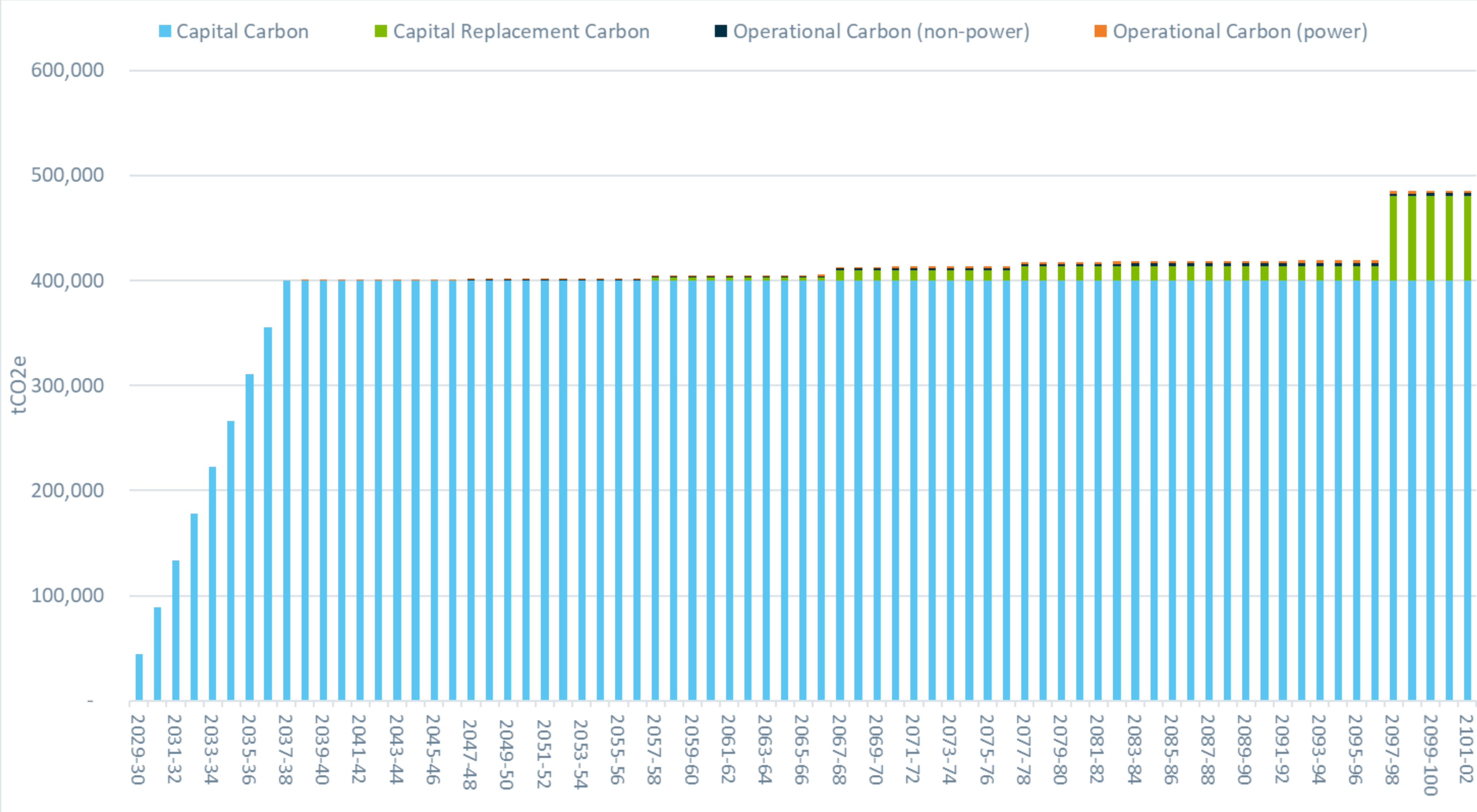


Figure 4.4: SESRO 75Mm^3 – Whole Life Emissions by Category (Cumulative)

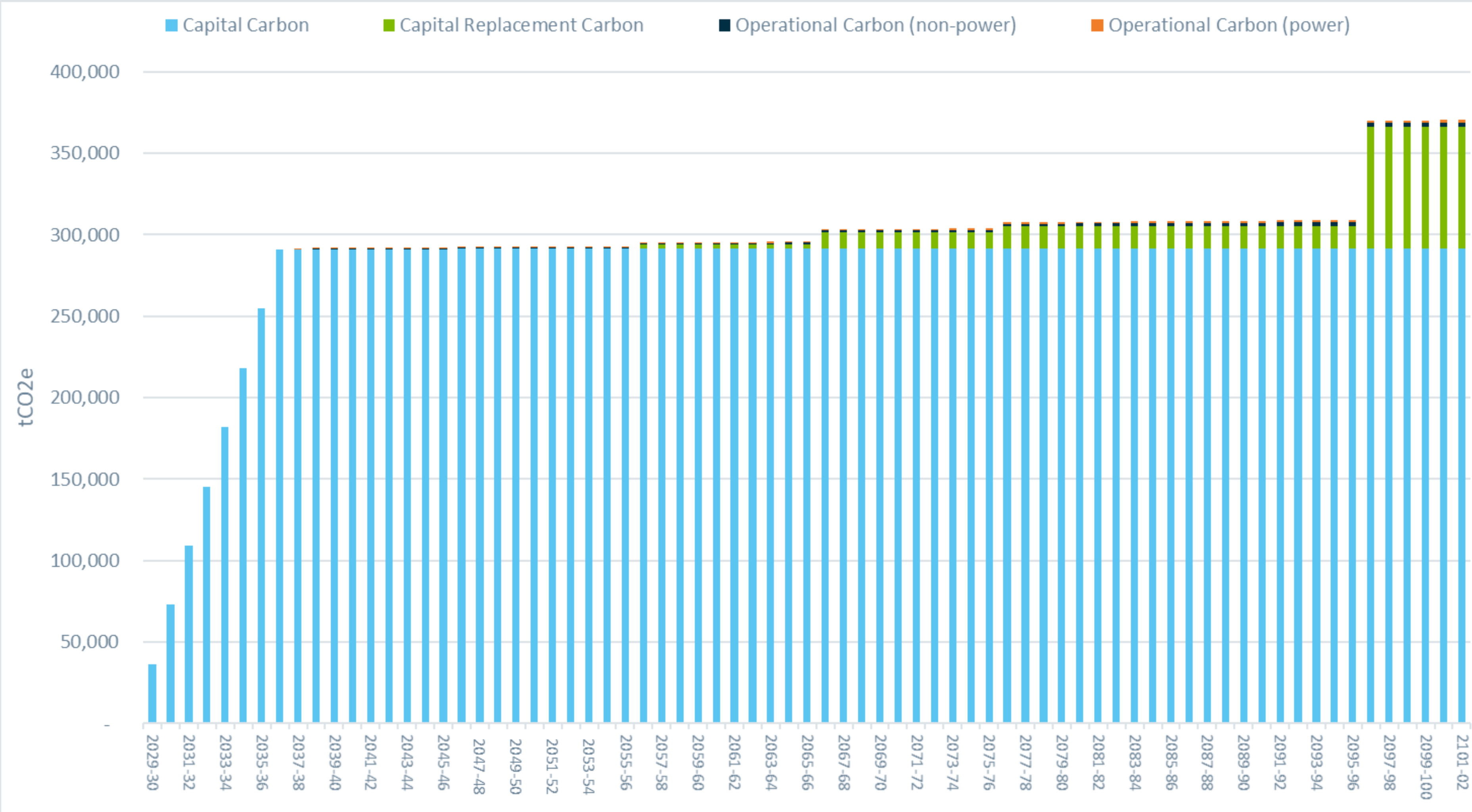


Table 4.1: Summary of Whole Life Carbon Assessment Results for all SESRO Variants

Aspect			150	125	100	75	30	30+100	80	80+42
Capital Carbon	tCO2e	a	400,119	372,911	326,769	291,193	221,008	439,818	290,298	430,300
Capital Replacement Carbon	tCO2e	b	79,820	78,467	76,383	74,842	64,754	67,595	71,924	74,447
Annual Operational (non-power)	tCO2e	u	46	45	43	41	40	61	45	61
Annual Fixed Power	MWh	v	1,533	1,332	1,133	921	512	1,486	958	1,414
Annual Variable Pumping (100% utilisation)	MWh	w	8,713	6,958	5,308	3,697	1,488	7,904	4,035	6,959
Annual Variable Turbine (100% utilisation)	MWh	x	4,751	3,728	2,748	1,713	631	3,034	2,007	2,895
First year operation		s	2039	2039	2038	2038	2038	2056	2038	2055
Last year operation		l	2102	2102	2102	2102	2102	2102	2102	2102
Years of operation	years	y = l-s	64	64	65	65	65	47	65	48
Average grid electricity carbon factor over operation period	$kgCO_2e/kWh$	z	0.00767	0.00767	0.00783	0.00783	0.00783	0.00700	0.00783	0.00700
Whole-life operational (non-power - fixed)	tCO2e	c = u * y	2,926	2,863	2,784	2,635	2,589	3,575	2,945	3,700
Whole-life operation (power - fixed)	tCO2e	d = v * y * z	753	654	577	469	261	320	487	153
Whole-life operation (power - variable) (100% utilisation)	tCO2e	e = (w - x) * y * z	1,945	1,586	1,303	1,010	436	1,320	1,032	684
Whole-life operation (power)	tCO2e	f = d + e	2,698	2,240	1,880	1,479	697	2,338	1,519	2,357
Whole-life carbon (100% utilisation)	tCO2e	$g^{100} = a + b + c + f$	485,563	456,482	407,816	370,148	289,048	513,325	366,686	510,804
Whole-life carbon (38% utilisation)	tCO2e	$g^{38} = a + b + c + d + 0.38(e)$	484,356	455,498	407,008	369,522	288,777	511,810	366,046	508,860

Table 4.2: Breakdown of Whole Life Carbon Assessment Results for all SESRO Variants

Aspect		150	125	100	75	30	30+100	80	80+42
Capital Carbon	a / g	82.4%	81.7%	80.1%	78.7%	76.5%	85.7%	79.2%	84.2%
Capital Replacement Carbon	b / g	16.4%	17.2%	18.7%	20.2%	22.4%	13.2%	19.6%	14.6%
Whole life Operational (non-power)	c / g	0.6%	0.6%	0.7%	0.7%	0.9%	0.7%	0.8%	0.7%
Whole life Operational (power)	f / g	0.6%	0.5%	0.5%	0.4%	0.2%	0.5%	0.4%	0.5%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

4.3 Whole-Life Carbon Cost – Net Present Value (NPV)

4.8 Whole life carbon emissions have also been monetised using BEIS Green Book Data Tables 1-19[6], Table 3. The monetisation of carbon has been built into the regional planning appraisal approach to account for the carbon impact of different schemes. summarises the whole life carbon NPV over 80 years of each of the option sizes.

4.9 The NPV has been calculated by multiplying the estimated emissions in each year by the carbon cost in each year and applying the green book standard discount rate, the sum of these values then provides the carbon NPV over 80 years. Table 4.3 summarises the carbon cost under the low, central, and high values. The central values have been used in the regional planning appraisal process.

4.10 Power consumption will vary from year to year depending on utilisation of the scheme. Operational carbon and therefore the estimated Whole Life Carbon Cost NPV will be lower for the 38% anticipated utilisation scenario when compared to the 100% utilisation scenario. However, as shown in Table 4.2, power consumption only accounts for 0.6% of the overall whole life carbon of the scheme, and therefore there is relatively little difference in the Whole Life Carbon NPV estimate based on 100% utilisation and that based on 38% utilisation, as presented in Table 4.3 and Table 4.4.

Table 4.3: Whole Life Carbon Cost NPV for all SESRO Variants (100% Utilisation)

	Carbon Emission Net Present Value (£000s)		
Option	**Low Carbon Cost**	**Central Carbon Cost**	**High Carbon Cost**
150Mm^3	43,690	87,390	131,080
125Mm^3	40,880	81,760	122,630
100Mm^3	36,500	72,990	109,490
75Mm^3	32,790	65,590	98,380
30Mm^3	25,210	50,420	75,630
80Mm^3	32,580	65,150	97,730
30+100Mm^3	41,150	82,300	123,450
80+42Mm^3	42,890	85,780	128,670

Table 4.4: Whole Life Carbon Cost NPV for all SESRO Variants (38% Utilisation)

	Carbon Emission Net Present Value (£000s)		
Option	**Low Carbon Cost**	**Central Carbon Cost**	**High Carbon Cost**
150Mm^3	43,620	87,240	130,870
125Mm^3	40,820	81,640	122,460
100Mm^3	36,450	72,890	109,340

[6] Electricity emissions factors to 2100, Department for Business, Energy & Industrial Strategy (data-tables-1-19.xlsx (live.com))

75Mm³	32,760	65,510	98,270
30Mm³	25,190	50,390	75,580
80Mm³	32,540	65,080	97,610
30+100Mm³	41,090	82,190	123,280
80+42Mm³	42,830	85,660	128,490

5. ACWG Carbon Mitigation Reservoir Assessment

5.1 The All Company Working Group (ACWG) have commissioned a study to identify potential decarbonisation opportunities for the different types of SROs with a focus on 'build clever' and 'build efficiently' measures. 'Build-nothing' and 'build less' measures in the PAS 2080 carbon reduction hierarchy (or 'eliminate' and 'reduce' measures as noted in the IEMA framework shown in Figure 1.1) are site specific and will have been considered through regional planning and earlier design development stages.

5.2 The ACWG study identified that, for reservoirs, the majority of carbon emissions would be associated with: on-site excavation, production of quarried material off-site, transporting materials to and from site, and the construction plant on site. This aligns with the assessment for SESRO outlined in the previous sections of this report.

5.3 The majority of carbon emissions arising from SESRO would be associated with initial construction, particularly earthworks activities including importing material to site; excavating material from the borrow pit; and moving / placing material on site. The SESRO concept design has already mitigated some of the associated emissions by, for example, sourcing clay from the borrow pit on site, as opposed to importing clay from elsewhere. However, there are further opportunities to further drive down emissions, such as substituting diesel for lower carbon fuels.

5.1 Mitigation Options Identified by ACWG Study

5.4 The ACWG study considered low carbon alternative fuels as a way of mitigating emissions. Some of these are readily available on the market and already in use, while others are theoretically possible but yet to be proven in industry. Table 5.1 is reproduced from the ACWG study to show the possible carbon savings for reservoir SROs.

Table 5.1: ACWG Study - Alternative Fuel Carbon Saving Estimates

Fuel Type	Vehicle Type	'Well to wheel' carbon savings	Availability
Diesel	Conventional	0%	Industry standard
Diesel	Hybrid	20%	Widely used up to 21 tonnes
Hydrotreated vegetable oil (HVO)	Conventional	92%	HVO only available in limited supply. Vehicles available.
HVO	Hybrid	94%	
Green hydrogen	Hydrogen powered	100%	Green hydrogen not currently available on the market. Vehicles not currently available.

5.5 In the ACWG study, three different scenarios were considered (worst, middle, and best case), across three timeframes for when construction could occur. If SESRO were to be constructed before 2040 (as is indicated in the WRSE Emerging Regional Plan) construction would fall within the first timeframe, with Table 5.2 providing a summary of the mitigation options that could be available. If the regional planning were to be updated and the scheme was selected later in the planning period, focus could be shifted to other technologies likely to become more viable post-2040.

Table 5.2: ACWG Study – Potential Capital Carbon Savings for Reservoir SROs

Scenario	Fuel Mix	Capital carbon savings (from ACWG report)	Comments
Worst case	100% Diesel	0%	Baseline scenario, business as usual
Middle case	50% Diesel -electric hybrid 50% HVO	62%	Use of diesel electric hybrid vehicles for construction and haulage. Proactive engagement with HVO suppliers results in sufficient HVO being available.
Best case	100% Hydrogen	96%	Use of green hydrogen only.

5.6 The capital carbon savings from the ACWG study were estimated for a typical non-impounding reservoir of embankment construction. Of course there is a large degree of uncertainty when using any of these carbon saving potentials, as each reservoir scheme will have site specific design differences such as:

- The cut-fill balance as well as the required volume of imported material.
- The scale of other structures required to facilitate the reservoir (e.g. intakes, tunnels, roads, etc) in relation to the volume of earthworks required.
- The site specific ground conditions which would dictate compaction effort and therefore fuel consumption for earth placement.
- The embodied carbon of HVO fuel, type of hydrogen used, and vehicle fuel efficiency are likely to vary depending on the period for construction.

5.7 A specific number is difficult to quantify without reviewing each individual scheme assumption against those used as an example within the ACWG study. For simplicity a range of plus or minus 30% has therefore been assumed at this stage. The current assessment provides an indication of future focus areas for emissions reductions efforts and to inform future supply chain engagement to support decarbonisation efforts.

5.2 Potential Mitigation Measures

5.2.1 Key Findings and Recommendations from the ACWG Study

5.8 If the reservoir SROs are to progress to the next stage of design development the ACWG study has recommended that engagement with contractors and HVO suppliers should take place to address constraints within the UK market for HVO.

Contractors could help to improve estimates of fuel required for the key construction activities, which the Water Companies could then use in engagement with market suppliers of HVO. This engagement could provide confidence for HVO suppliers to invest in increased production.

5.9 If construction of any of the reservoir SROs were to proceed during the 2030s pursuing a 100% hydrogen solution (ACWG best case) is not considered feasible. However, given the scale of the reservoir SROs, they would offer the opportunity to pilot new construction plant as a model to the construction industry of what is achievable. To that end, it would be recommended that a proportion of the construction plant (10% - 20%) be hydrogen powered to promote wider industry benefits.

5.10 Hydrogen faces two key challenges: fuel availability and plant availability. The ACWG study identified that hydrogen powered construction plant is only at prototype development stage. Similarly, most hydrogen produced today is grey hydrogen, which does not offer the same carbon savings as HVO or green hydrogen. Engagement with the supply chain could see the use of prototype construction plant and delivery mechanisms for hydrogen put in place for a small proportion of the project, so that the reservoir SROs could be used as a flagship projects to demonstrate technical viability of hydrogen powered vehicles in construction.

5.2.2 Potential Scale of Mitigation for SESRO

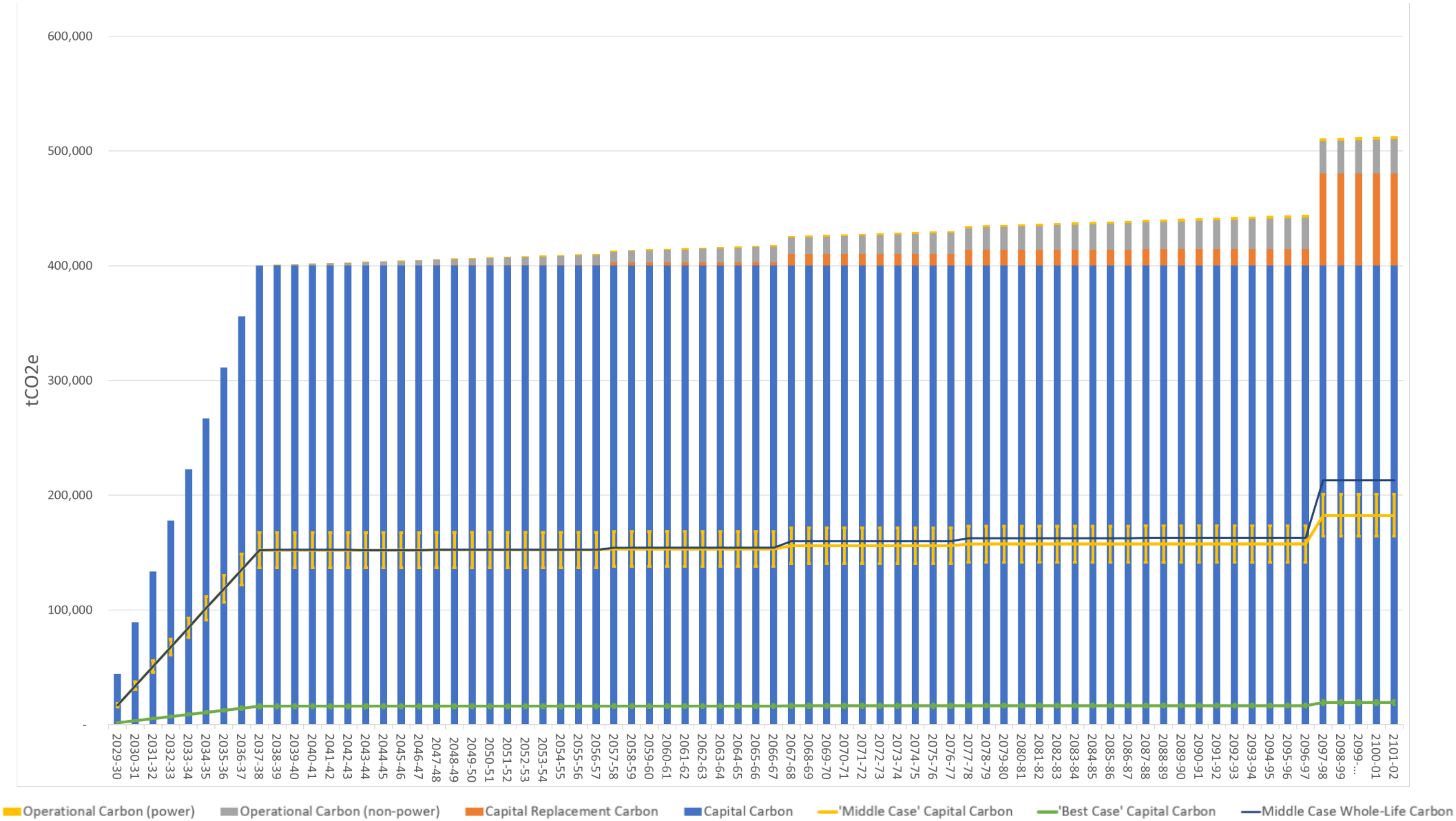
5.11 Given the recommendations outlined from the ACWG study and the potential capital carbon savings related to alternative fuels presented in Table 5.2 an assessment has been carried out to estimate the potential emission savings for SESRO. Figure 5.1 shows the savings that could be achieved when using the middle and best case approach:

- The yellow capital carbon line shows the potential scale of capital carbon emissions if the middle case scenario.
- The green line demonstrates the potential capital carbon emissions if the best-case scenario was possible to implement.

5.12 Both scenarios are indicative and have uncertainties associated with the actual scale of emissions reductions available and, therefore, the assessment would need to be refined further in subsequent design stages as discussed in Section 6.3.

5.13 To achieve the ‘middle case’ scenario requires overcoming supply chain challenges over the next 6-8 years if SESRO were to be constructed before 2040.

Figure 5.1: Emission Savings if ACWG Study Factors Applied (150Mm³ Variant)



6. SESRO Carbon Mitigation Strategy

6.1 The carbon assessment and analysis presented above has been used to inform focus areas for carbon mitigation efforts. Some of these have already been implemented as part of the development of the Gate 2 design, while others are identified as future strategic priorities. If SESRO is to continue to the next stage of design development, the carbon mitigation strategy will also need to advance. This would involve acting on recommendations from the ACWG study (discussed in Section 5) including engagement with relevant external stakeholders.

6.2 Section 6.1 below summarises capital carbon mitigation measures already considered as well as those identified for assessment at the next stage of design development. Mitigation measures are presented for operational carbon in Section 6.2. The estimated potential savings and targets for the next stage of design development, are then summarised in Section 6.3. An initial stakeholder engagement plan is outlined in Section 6.4 which, if implemented, could help broaden the dialogue and promote early collaboration to drive emissions reductions.

6.1 Capital Carbon

6.1.1 Capital Carbon Mitigation Incorporated into Current Design

6.3 The following aspects have already been identified for their carbon saving potential and included in the current design (terminology in [] demonstrates the IEMA step applied):

- **[Reduce] Cut and fill balance** – As discussed in Section 2.2.1, the Gate 2 concept for the SESRO reservoir has been designed to have a balance between the volume of clay that would be excavated from the borrow pit and the volume of clay that is required to form the main reservoir embankment. Remaining material excavated from the borrow pit would be used for landscaping. This is a key feature of the design which needs to be maintained throughout future development stages because it avoids the carbon which would be emitted if clay needed to be imported or exported from the site.
- **[Substitute] Import of construction material by freight trains:** As mentioned in Section 2.2.1, there would be a requirement for significant quantities of sand, gravel and riprap to be imported to the site for use in the reservoir construction. Due to the site's close proximity to the Great Western Mainline Railway (London to Bristol) the Gate 2 design includes for a temporary railway siding to allow this material to be brought to the site by train rather than Heavy Goods Vehicles.

6.1.2 Capital Carbon Mitigation Opportunities

6.4 Carbon mitigation opportunities have been identified during Gate 1 and Gate 2 for 'build clever' and 'build efficiently' stages in the carbon reduction hierarchy, these range in potential impact and feasibility with some being relatively easy to implement, and others requiring further work to understand their feasibility. The following areas will continue to be explored as part of the carbon mitigation strategy for SESRO:

- **[Substitute] Electric / hydrogen / biodiesel / hybrid powered plant** – As discussed above, use of alternative construction plant could significantly reduce the fossil fuel emissions for construction. There may also be opportunities to consider shared use of this plant with other infrastructure schemes.
- **[Reduce] Automated plant** – Maximise use of automation to increase the efficiency of earth movement and therefore reduce associated carbon emissions.
- **[Reduce] Reuse of materials from site clearance** – For example, the existing Steventon Road and East Hanney Road will need to be demolished, and the material could be reused within the site for temporary haul roads.
- **[Reduce] Reuse of existing solar panels** – The construction of SESRO would require removal of solar farms that are currently located at the site. There may be an opportunity for the panels to be moved to a new location. The remaining design life of the solar panels would need to be taken into consideration.
- **[Substitute] Low carbon construction materials** – Low carbon concrete and steel, and sewage sludge ash to make low carbon aggregate. This opportunity is considered as a high impact option, however the feasibility of these materials in different parts of the construction should be further assessed.
- **[Reduce] Dual purpose infrastructure** – There is a potential opportunity for the A415 to SESRO access road to also be used as an embankment for a Flood Storage Reservoir.

6.2 Operational Carbon

6.2.1 Operational Carbon Mitigation Incorporated into Current Design

6.5 The following aspects have already been identified for their operational carbon saving potential and included in the current design:

- **Hydropower turbines:** As discussed in Section 3.1, the Gate 2 design includes for two hydropower turbines for renewable energy generation during periods when water is released from the reservoir to the River Thames. Energy generation has been estimated based on water resource modelling outputs.
- **Pump sizing:** The initial sizing of intake pumps has been set to allow them to operate as efficiently as possible given their expected use.

6.2.2 Operational Carbon Mitigation Opportunities

6.6 The main sources of operational carbon for SESRO are associated with maintenance activities and power consumption. Further work is required to better understand maintenance activities during the next stage of design development. The following areas will continue to be explored as part of the carbon mitigation strategy for SESRO:

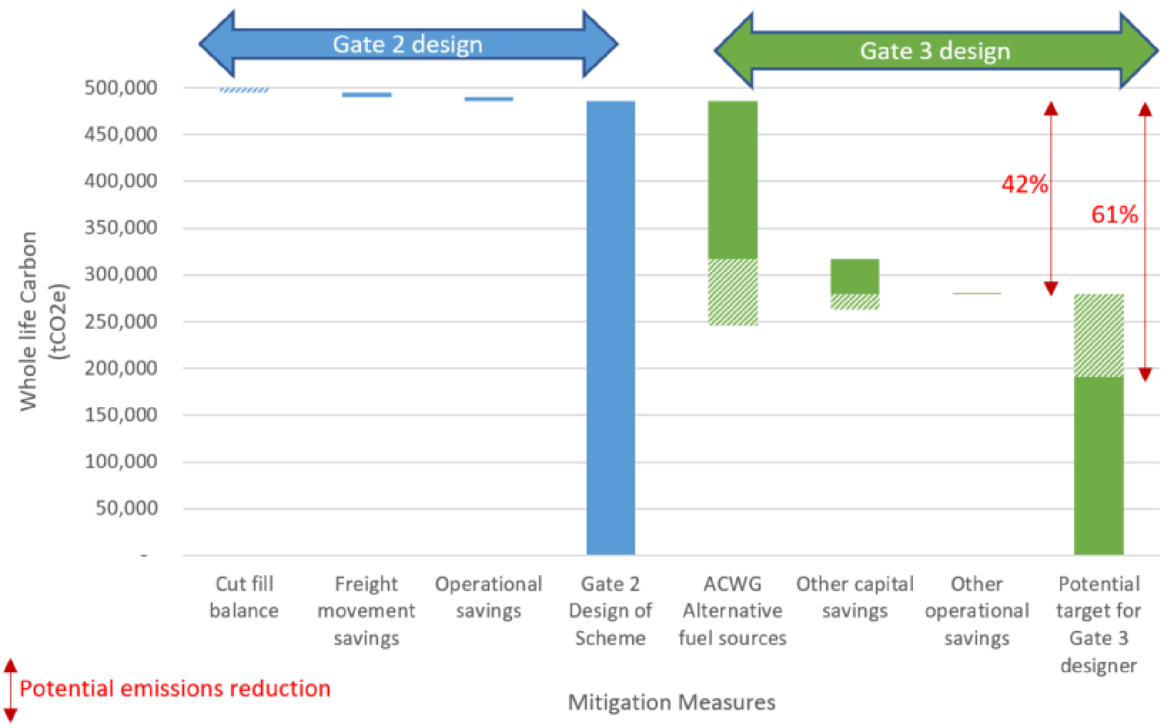
- **Inclusion of further renewable energy generation** – Hydropower turbines are incorporated into the Gate 2 design; however, there is also potential for other renewable energy generation. Initial consideration has been given to the feasibility of installing wind turbines and / or some floating solar panels. However, there are several aspects that require more detailed consideration before deciding if these can be incorporated, as highlighted in Supporting Document A1, Concept Design Report. If incorporated, these would help reduce the carbon intensity of power required during operation of the reservoir, as despite the significant amount of renewable energy generation potential from the hydropower turbines this power will not be able to be fully utilised by the scheme itself and will need to be exported to other end-users.

- **Water quality monitoring** – Real time water quality modelling could be used to optimize the use of the air diffuser network and the sweetening flow pump.
- **Low carbon power and decarbonised electricity procurement** – Organisations can also procure green electricity through their suppliers which, when market-based reporting, can be used to zero out the power generation emissions of grid electricity. This requires the purchase of Renewable Energy Guarantees of Origin (REGO) certificates and comes at a premium over standard electricity tariffs in most cases.
- **Making some provision for EV charging** at the visitor centre and main car parks to enable EV use for visitors and staff.
- **Self-sufficient visitor and education centres,** which are designed with net zero carbon objectives.
- **Planting and nature based solutions providing carbon sequestration** – SESRO requires land use change around the site, some of which will provide some carbon sequestration. An initial estimate of the impact of land-use change has been considered in the natural capital assessment provided in Chapter 9 of Supporting Document B2, Environmental Appraisal Report (terrestrial). A more detailed assessment would be undertaken at the next stage of design development.

6.3 Whole Life Carbon Mitigation

6.7 Figure 6.1 provides a conceptual view of the potential scale of emissions reductions opportunities available for the SESRO scheme. These consider the design activities already undertaken, the focus areas for emissions mitigation activities during future design stages and the external sector impacts that could support further decarbonisation of the scheme. These estimates are indicative, with an expectation that more detailed analysis would take place during later stages to develop more accurate emissions reduction potential values and assess which measures should be embedded within the base scheme design. The primary message from the below figure is the scale of whole life carbon savings available, and what the future scheme design and delivery should strive to achieve through collaboratively working with the supply chain and key stakeholders, as highlighted in Table 6.1.

Figure 6.1: Whole-life Carbon Mitigation Measures Estimate (150Mm³ Variant)



Notes: The above illustrative example is for the 150Mm³ reservoir option. Hatched bars represent a degree of uncertainty with carbon reductions.
'Cut fill balance' savings calculated by assuming 5% of clay now sourced locally (26Mm³), would have been imported from a site 50km away. 'Freight movement savings' calculated by assuming 100% of rip rap needed were transported by HGVs instead of train. 'Hydropower operational savings' assumes turbines account for 59% savings of pumping energy multiplied by the grid factor in future years for every year of operation. 'ACWG alternative fuel sources' savings utilise ACWG report savings of 62% of whole scheme carbon. 'Other capital carbon savings' estimated based on 25% reduction of non-earthworks carbon categories, based on assumed low carbon tanks, buildings and piling emission savings from the desalination section of ACWG report, multiplied by 1.5 to account for other measures. 'Other operational savings' estimated based on 60MWh solar energy produced from floating photovoltaics, multiplied by the grid factor in future years for every year of operation, multiplied by 1.5 to account for other measures. Embodied carbon of new plant required to deliver these savings (such as PV panels) is not included in the above assessment. Uncertainty bars have been assessed to be 30% of the mitigation measures, and are shown in a hatched pattern.

6.8 The potential carbon savings presented above are equivalent to a net present value of £67M in terms of carbon costs[7]. In future stages of design development, the capital costs of delivering mitigation measures should be compared against the resulting carbon cost savings, helping determine which measures provide cost-efficient carbon reductions and which would require further engagement to improve the cost-effectiveness of implementation. This assessment would require stakeholder engagement, further described Section 6.4.

6.9 In some instances carbon mitigation measures would increase the financial cost of the scheme. Agreement from multiple parties would be needed to ensure carbon savings opportunities are not missed during efforts to reduce capital costs and to identify how net-zero alignment could be best funded.

[7] Calculated by multiplying the estimated emission reduction in each year by the BEIS Green Book central estimate for carbon cost in each year and applying the green book standard discount rate.

6.4 Stakeholder Engagement Plan

6.10 Mitigation of carbon emissions requires continued movement away from the business as usual approach to delivering infrastructure. This will require engagement with a wide range of stakeholders, both to generate new ideas and to overcome the barriers to mitigation measures. Table 6.1 provides an initial overview of key stakeholders.

Table 6.1: Stakeholder Engagement Matrix

Mitigation measure	Accountable[1]	Wider stakeholders
Low carbon construction plant	Contractor	Equipment manufacturers HVO suppliers: Hydrogen suppliers: Other asset owners: Highways England, Defra, EA Other water companies delivering similar schemes
Low carbon construction materials	Client / Gate 3 designer	Contractors Concrete suppliers Structural steel suppliers
Automated plant	Contractor	
Reuse of materials from site clearance	Client / Gate 3 designer	Contractor
Reuse of solar panels	Client / Gate 3 designer	Contractor, solar farm operator, local stakeholders and planning consultees
Dual purpose infrastructure	Client / Gate 3 designer	Local authority
Further renewable energy generation	Client / Gate 3 designer	Local stakeholders and planning consultees
Water quality monitoring	Client / Gate 3 designer	
Planting and nature based solutions	Client / Gate 3 designer	Local stakeholders and planning consultees

6.11 As stated in the ACWG study, the use of low carbon fuel for construction will require early and meaningful engagement with the supply chain. Suppliers of construction plant are wary to invest heavily in alternative fuel plant until there is a clear demand for their use as well as a secured availability of alternative fuels.

6.12 In this regard a commitment to use low carbon earth moving equipment for the duration of construction provides a stronger business case for manufacturers to invest in lower carbon vehicles and plant. The Water Companies could also seek collaboration across the SRO programme and with other infrastructure heavy sectors, such as Highways England or the EA, as the same vehicle and plant types used on SESRO could also be used to build a motorway or flood defence assets.

6.13 As noted in the ACWG report, fuel supplies are also a constraint. HVO is not produced in reliable enough supplies nor is green hydrogen readily available on the market. Again, a commitment to purchase sizeable volumes across a 8-9 year construction programme could provide the economic stimulus for suppliers to meet demand, but requires engagement well in advance of construction start. A scheme of this size could also be seen as an opportunity to test a sample size of alternative vehicles, if full deployment does not become technically or commercially feasible at the point of construction start to deliver lessons learnt for future schemes.

6.14 Low carbon construction materials – such as steel for piling, structural steel for buildings, and cement – will also require early engagement with suppliers. As is similar for alternative fuel types, suppliers of construction materials will want confidence that contractors will approach them during bidding stage to procure low carbon materials. Contract preparation is likely to be a strong vehicle for creating the right market incentives for prospective contractors to engage with their suppliers to source low carbon alternatives.

6.15 Overall, engagement with the supply chain and policy makers to help develop an environment and marketplace where low carbon alternatives are prioritised; and collaborative efforts are made to ensure the implementation of these alternatives are cost-effective. This engagement will be an important focus of the SESRO mitigation strategy and will need to be undertaken alongside the broader water sector and SRO programme.

6.16 The development of detail on procurement route and timeframes where engagement with the supply chain is appropriate is also a key area the sector need to focus on to help ensure maximum value can be driven through engagement activities with the wider supply chain.

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