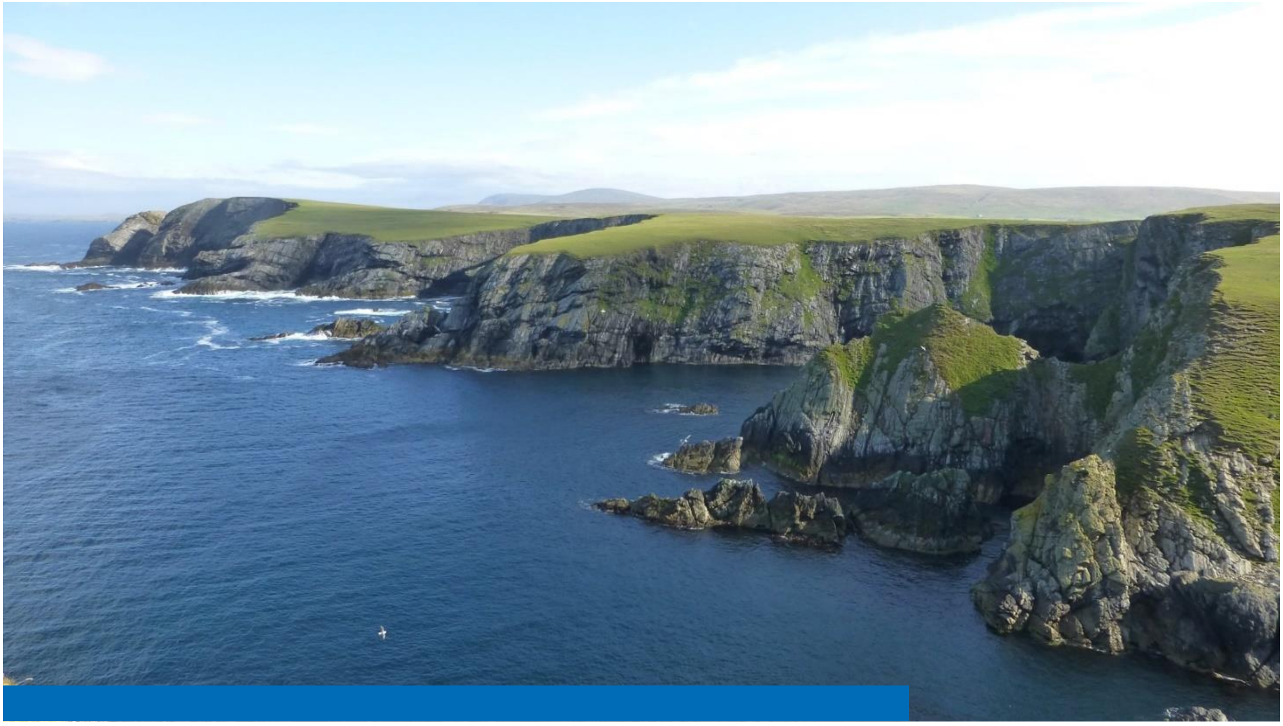
Creating a world fit for the future



A routemap for NHS Shetland to achieve Net-Zero by 2045

A report for NHS Shetland

NHS Shetland

ED14304 | Issue number 4 | Date 30th April 2021

Ricardo Confidential

Customer:

NHS National Services Scotland

Contact:

Lisa Groves, Gemini Building, Fermi Avenue, Harwell, Didcot, OX11 0QR, UK

T: +44 (0) 1235 753 032

E: lisa.groves@ricardo.com

Authors:

Ed Bovill, Lisa Groves, James Sharp, Fern Spencer, Rebecca Turner, Callum Forsyth, Stuart Ballinger, Jess Twemlow, Seamus Rooney, Warren Hicks, Tom Nokes, Charles Gaisford, Aaron Yule

Approved by:

John Murray

Date:

30th April 2021

Ref: ED14304

Ricardo is certified to ISO9001, ISO14001, ISO27001 and ISO45001

Front cover image credit: Visit Scotland

Executive summary

The Scottish Government and NHSScotland have committed to be net-zero for greenhouse gas (GHG) emissions by 2045. As a step towards this, NHSScotland nominated three of its boards to produce net-zero routemaps as part of a pilot project. NHS Shetland, NHS Ayrshire and Arran (NHSAA) and NHS Education Scotland (NES) were part of this pilot project and have worked with Ricardo Energy & Environment to develop the routemaps.

This report looks at the challenges and priorities facing NHS Shetland, the starting point in the Board's 2019/20 baseline emissions and charts realistic options to progress the strategic decarbonisation of the Board towards achieving net-zero by 2045.

The routemap for NHS Shetland has been developed by considering three possible futures for the Board in the form of pathways towards net-zero emissions by 2045. Each pathway involves different combinations of decarbonisation interventions, providing costed options and timings for deployment of measures under those pathways.

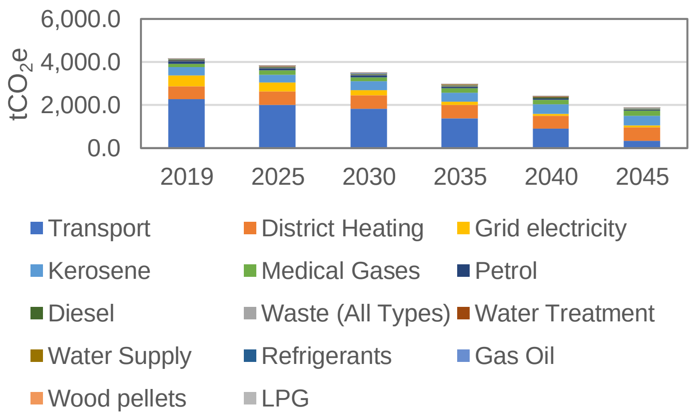
NHS Shetland is representative in many ways of the 3 island health boards. It includes a number of remote and rural islands, with a single, central acute hospital (Gilbert Bain Hospital) and a range of small island-based clinics, dental practices, nurses offices and staff accommodation.

Board-specific challenges for NHS Shetland that are covered in this routemap include:

- Re-confirming the scope and boundary for appropriate emissions reporting for the Board, particularly where location-based emissions would be significantly higher than market-based emissions, due to current fuel sources for both power and heat on Lerwick.
- Examining the impact of a 'Net-Zero' hospital as a major aspirational measure.
- Understanding whether the Board could achieve net-zero without moving to a new main hospital building, with restrictive caveats including 24/7 usage and significant seasonal variations in energy use.
- Exploring options that give NHS Shetland more control over their scope 3 emissions in their current and future travel policy and vehicle leases, as the level of control over significant travel-related emissions is limited.
- Understanding the costs of potential measures, in the context of limited capital and revenue resources, which has prevented previous capital projects from being developed.

We reviewed historical data for financial year 2019/20 to establish the emissions baseline for NHS Shetland and mapped the projected emissions against that baseline out to 2045, using our current understanding of planned NHS Shetland activities and the wider context of local, regional and national changes over that timescale.

Figure 1 – Business As Usual emissions by source



The emissions sources included in the baseline are fuels, electricity, district heating, refrigerant gases, medical gases, water supply and treatment, fleet vehicles, business travel, patient travel and waste.

> In 2019/20, NHS Shetland was responsible for **4,163 tCO2e**, with roughly 50% of these emissions being associated with patient transport. For emissions within the direct control of NHS Shetland, the 2019/20 baseline was **1,817 tCO2e.**

Through discussions with NHS Scotland and given the individual circumstances of NHS Shetland, it was agreed that three net-zero pathways would be modelled. These were:

Aspirational Pathway – assumes that significant resources and budget are made available to allow the rapid implementation of measures while taking account of current contractual constraints. Importantly, this approach collectively applied by the public sector can support the required market transformation of buildings and energy use across Scotland. This approach would also minimise carbon emissions which, in turn, will reduce the impact of climate change and the associated health implications on the global population. This pathway includes a new hospital.

Restricted Pathway – assumes that the resources and budget available to allow the implementation of low-carbon changes are significantly constrained. This restricts the scale of planned changes and substantially delays the timeframe for action however it could reduce the cost of action as legislation and technological improvements drive change in the marketplace.

Balanced Pathway – attempts to find a middle ground between the two previous scenarios. The scenario assumes some restrictions on resources but also seeks to implement changes at a point where costs and risks are minimised while also reducing carbon emissions as quickly as possible given the identified constraints. This pathway also includes a new hospital on Lerwick.

The figure below shows the emissions trajectory for all pathways.

Figure 2 - Pathway comparison

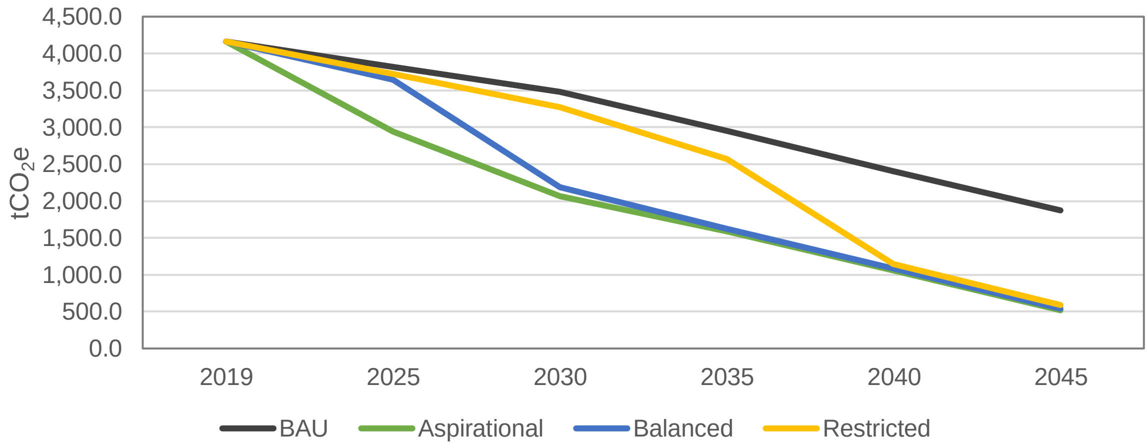
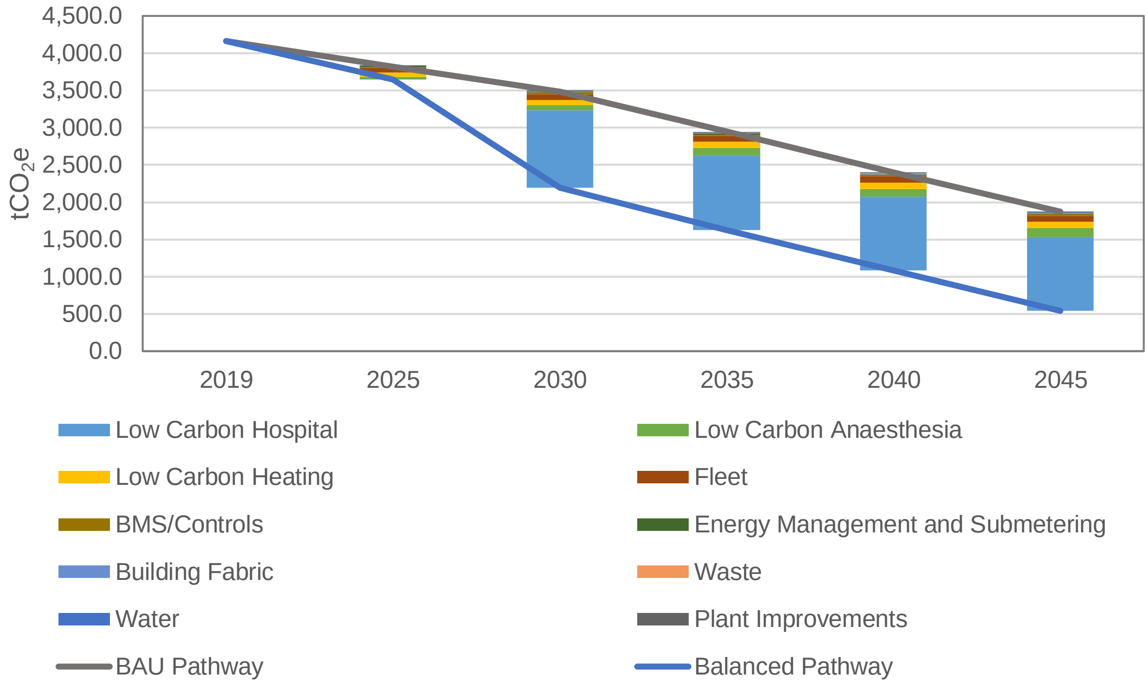


Figure 2 shows that all pathways ultimately lead to a reduction in baseline emissions in 2045 that is greater than the expected 55% under Business as Usual. The key differences are the *rate at which emissions are reduced*, which is greatest for the aspirational pathway and lowest for the restricted pathway. The pathways demonstrate the fact that NHS Shetland has a strong opportunity to achieve net-zero emissions by 2045, with significant options to implement measures to reduce the need for expensive off-setting requirements in the year 2044/45.

The recommended pathway for NHS Shetland to follow is the Balanced Pathway, which addresses the major emissions sources from the Gilbert Bain through investment in a new low carbon hospital by 2030, while implementing measures to reduce all other emission sources over a longer timescale to 2045 and achieving an 87% reduction in emissions from the 2019/20 baseline, as shown in Figure 3 below.

Figure 3 - Comparing the balanced pathway to business as usual



The reduction of emissions from the low carbon hospital is the most influential measure indicated, in terms of quantity of emissions reduced.

In spite of the risks outlined, it can be argued that the public sector has a duty to lead the way on investing in low and zero-carbon, provided that it is given the appropriate funding. Strong policy direction and clear requirements for future low carbon buildings will give the market confidence to develop solutions and generate efficiencies of scale, paving the way for the rest of society to follow.

Given Scotland's aging population, early investment to cut carbon emissions would also mean that as the pressure on budgets increases over time, NHS Shetland will already have made the investments necessary to transition to a low carbon solution and will be benefitting from the efficiencies it generates.

Most importantly, early adoption of low and zero-carbon solutions will lead to early cuts in carbon emissions which will have long term global health benefits. These benefits will be a direct result of NHS Shetland cutting its emissions and, just as significantly, through supporting market transformation.

NHS Shetland has a strong opportunity to achieve net-zero by 2045, with significant options to implement measures to reduce the need for expensive off-setting requirements in the year 2044/45.

To achieve net zero through divestment from all fossil fuels, NHS Shetland needs to implement the following measures at a minimum when following the balanced pathway outlined in this document:

General

- Develop an action plan for the implementation of measures outlined in the balanced pathway, and set up strong internal governance by:
- Setting up a Net Zero taskforce within NHS Shetland that has responsibility for driving the implementation of the measures outlined in the balanced pathway, as well as monitoring the outcomes of these measures.
- Maintain the routemap as a live document, with regular reviews of the measures recommended within the report, in particular whenever there is a major investment decision that would have a significant impact on emissions and/or ahead of major milestones being reached, such as emissions calculations for 2029/30.

Buildings

- Replace the Gilbert Bain hospital with new low carbon hospital – this must have no fossil fuel consuming plant.
- District heating: As multiple properties (likely including the new low carbon hospital) are connected to the district heat network, the network needs to become zero carbon by divesting from using heavy fuel oil during fuel shortages or periods of high demand.
- Other properties: Replace fossil fuel heating systems with electric heating systems such as heat pumps or electric heaters.
- Source all electricity from renewable sources, either from on-site renewables, power purchase agreements, or green tariffs from energy suppliers.
- Improve waste segregation to increase proportion of recycled waste across all properties, and implement policies and awareness campaigns to reduce waste where possible.

Transport

- Continue with current plans to replace all fleet vehicles with low carbon models such as EVs or hydrogen fuel cell vehicles.
- Ensure there is sufficient charging infrastructure on NHS properties to enable the above.
- Work collaboratively with Shetland Islands Council on an EV infrastructure strategy that will cover grey fleet for the Board.
- Develop low carbon business and patient travel policies and reduce all travel by high carbon forms of transport (e.g. aircraft) where possible.
- Participate as an active stakeholder in promoting and supporting low carbon air and ferry transport to influence decision making across the region.

Other identified measures across all three potential pathways are aimed at reducing absolute emissions through efficiency improvements, better operating practices through implementation of policies, generating electricity from renewable sources, or replacement of existing equipment with high-efficiency models.

Table of Contents

1 Introduction

1.1 What is net-zero?

Achieving net-zero is about reducing your avoidable emissions as far as possible and then achieving zero-emissions by balancing your unavoidable use of fuels, energy, transport and processes that generate greenhouse gases with projects that ‘offset’ the equivalent amount.

While there is no official definition of net-zero, Ricardo Energy & Environment’s key working principals are to ‘balance greenhouse gas emissions through mitigation measures and removal from atmosphere, within your boundaries, over time’.

The definitions of Scope 1-3 emissions are provided below for reference. In principle, Scope 1 and Scope 2 should be absolute zero by 2045 (other than unavoidable emissions, such as those from anaesthetic gases when all options to phase in lower-carbon anaesthetic gases have been taken up) and net zero when including Scope 3 emissions.

Scope 1: from the activities of an organisation or under their control. Including fuel combustion on site such as gas boilers, fleet vehicles and air-conditioning leaks.

Scope 2: from electricity, steam and heat purchased and used by the organisation. Emissions are created during the production of the energy and eventually used by the organisation.

Scope 3: from activities of the organisation occurring from sources that they do not own or control, such as emissions associated with business travel, waste and water.

1.2 What is a net-zero routemap?

A net-zero routemap provides options for the strategic decarbonisation of an organisation, a public body, an industry sector or even entire regions over a set timescale.

This routemap for NHS Shetland has been developed by considering three possible futures for the Board in the form of pathways towards net-zero emissions by 2045 that involve different combinations of decarbonisation interventions. This will enable NHS Shetland to engage strategically with NHSScotland and the Health Facilities Scotland (HFS) team on their net-zero journey.

1.3 Why has NHS Shetland developed a net-zero routemap?

The Scottish Government and NHSScotland have committed to be net-zero for greenhouse gas (GHG) emissions by 2045. As a step towards this, NHSScotland nominated three of its boards to produce net-zero routemaps as part of a pilot project.

NHS Shetland was part of this pilot project and has worked with Ricardo Energy & Environment to develop its routemap.

Image - Gilbert Bain Hospital, Lerwick, Shetland Islands[1]

NHS Shetland is representative in many ways of the 3 island health boards. It includes a number of remote and rural islands, with a single central acute hospital (Gilbert Bain Hospital) and a range of small island-based clinics, dental practices, nurses offices and staff accommodation.

Board-specific challenges for NHS Shetland that are covered in this routemap include:

- Re-confirming the scope and boundary for appropriate emissions reporting for the Board, particularly where location-based emissions would be significantly higher than market-based emissions, due to current fuel sources for both power and heat on Lerwick;
- Examining the impact of a 'Net-Zero' hospital as a major aspirational measure;
- Understanding whether the Board could achieve net-zero without moving to a new main hospital building, with restrictive caveats including 24/7 usage and significant seasonal variations in energy use;
- Exploring options that give NHS Shetland more control over their scope 3 emissions in their current and future travel policy and vehicle leases, as the level of control over significant travel-related emissions is limited;
- Understanding the costs of potential measures, in the context of limited capital and revenue resources, which has prevented previous capital projects from being developed.

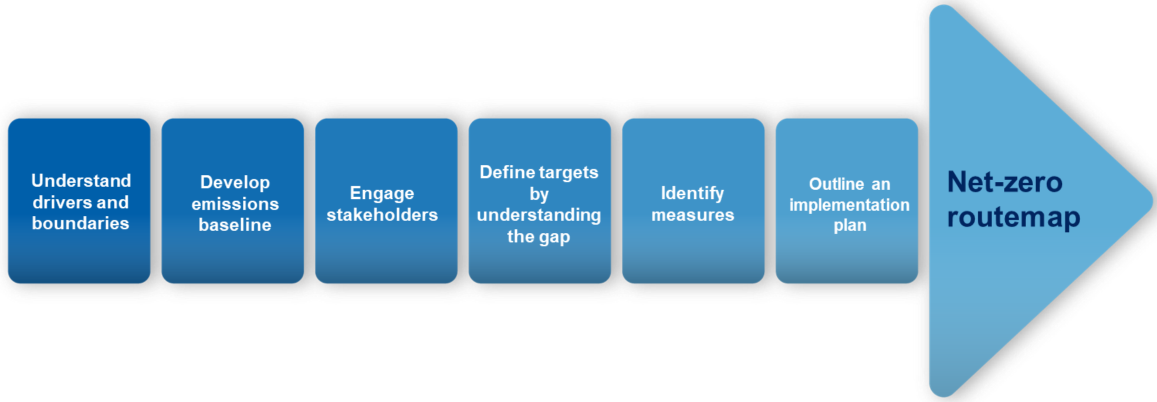
---

[1] https://www.neonataltransport.scot.nhs.uk/rural-and-remote-hospitals/remote-and-rural-units-north-area/gilber-gain-hospital-maternity-unit-shetland

2 What is included in the routemap?

The project workflow in developing the routemap is shown below in Figure 4.

Figure 4 - Key stages in defining and developing a net-zero routemap[2]



The routemap report itself covers four major steps:

1. Defining the 2019/20 emissions baseline for NHS Shetland.
2. Setting a 'Business As Usual' projection of those emissions to 2045, taking into account any known or planned interventions that will have an impact on emissions, including external factors outside the control of the Board.
3. Setting out pathways to net-zero that look at both technology and policy options to address the gap to net-zero.
4. Drawing conclusions from a comparison of the pathways and making recommendations for next steps.

At this stage, it is equally important to set out what the routemap **does *not* cover**, and why:

- *Carbon sequestration measures and other offsetting options* (such as greenhouse gas removal technologies) are not within the scope of work set out by NHSScotland. This limits the ability of all potential pathways to achieve net-zero as offsetting strategies are generally a core component of achieving net-zero, particularly for hard-to-treat emissions sources and scope 3 emissions. A separate project to calculate the carbon sequestration potential of the entirety of NHSScotland has been undertaken during 2020/21.
- *Staff commuting and patient travel* (separate to patient transport paid for by the Board) are not within the scope of work due to the lack of direct influence from the Board.
- *Supply chain and procurement* are also not in scope as efforts to reduce emissions from the NHSScotland supply chain are being coordinated through NHSScotland National Procurement.
- *Non-CAPEX and OPEX costs* of implementing measures are not included in the report, particularly in terms of staff resources for managing the implementation, procuring services to deliver the work, clearing out and/or moving of staff and equipment during the works etc. This 'unseen enabling cost' cannot be quantified at this level of granularity within the study. Where a measure is likely to incur significant disruption to normal operating procedures, this has been noted within the report.
- *Costs for backlog maintenance* are not in scope for this work as this is considered Business As Usual and does not impact on the additional emissions reduction measures modelled for NHS Shetland. It is recognised that the maintenance backlog could have both positive and negative emissions impacts once completed, that have not been quantified under Business As Usual, unless where already noted.
- Finally the routemap does not cover the *immediate impacts of COVID-19 on emissions* during 2020/21, primarily due to the gap between the 2019/20 baseline and the first modelling year of 2024/25 The NHS is currently operating in a Business 'Not as Usual' situation, and with the time

[2] Ricardo Energy & Environment 'How to achieve net-zero' webinar series 2020

boundary of emissions projections reaching to 2045, it is assumed a large amount of previous 'Business As Usual' behaviours and related emissions will restabilise.

3 Baseline and business as usual trajectory

The first stage in working towards net zero is to understand current emissions. This is the emissions baseline. The baseline emissions have then been projected out to 2045 using a 'business as usual' scenario in order to understand the scale of additional intervention that will be required to achieve net-zero. The following section outlines the emissions covered in NHS Shetland's baseline, the breakdown of where the key emissions contribution lies within the Board's operations, and how planned activities and other changes over the next 25 years will affect the projected emissions of the Board by 2045.

3.1 2019/20 baseline

Setting a baseline allows NHS Shetland to understand the position from which it is setting out on its net zero journey. The 2019/20 financial year has been selected as the baseline year for the routemap. This provides a recent picture of emissions that is relatively unaffected by the Covid-19 pandemic, and therefore reflects typical activity levels as closely as possible.

The **emissions sources** included in the 2019/20 baseline for NHS Shetland are as follows:

- Fuels (natural gas, gas oil, kerosene, biofuels, etc.)
- Electricity and transmission and distribution losses
- District heating
- Refrigerant gases
- Medical gases
- Water supply and treatment
- Fleet vehicles (NHS owned vehicles)
- Business travel (Grey fleet, public transport, flights)
- Patient travel (where costs are covered by the Board)
- Waste (disposal)

The operational boundary applicable to NHS Shetland is defined as all buildings and transport that constitute the operational activities of the Board. This includes all properties owned, leased or tenanted by NHS Shetland and their staff, and all transport resulting from the operations of the Board.

3.1.1 Baseline data, uncertainties and assumptions

We have reviewed historical data for financial year 2019/20 and established the emissions baseline for NHS Shetland.

In 2019/20, NHS Shetland was responsible for **4,163 tCO_2e**, with roughly 50% of these emissions being associated with patient transport. For emissions within the direct control of NHS Shetland, the 2019/20 baseline was **1,817 tCO_2e.**

The data requested, evidence received, and any estimations made to fill in data gaps has been detailed in a separate Business As Usual report for the Board. There were several instances where estimations needed to be made to cover data gaps. This is due to many of the properties not having robust data collection procedures in place due to their small scale - many of NHS Shetland's properties are located on small islands and are converted domestic properties. All estimations made were based on relevant data either from NHS Shetland's other properties for which data was available, comparison to Ayrshire & Arran properties, or from appropriate CIBSE Guide F benchmarks.

All emissions are reported using the location-based methodology as outlined in the GHG Protocol. Under this methodology, all emissions are reported using standard emissions factors as released by the UK Government annually.

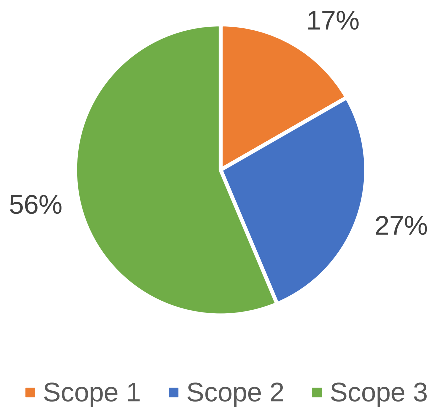
For electricity emissions, all electricity originating from the national grid (i.e. not on-site or direct wire renewables) are reported using the average grid factor for the whole of the UK (there are no official emissions factors available which are specific to just Scotland at this time). This means that procurement decisions (such as purchase of green electricity from energy suppliers) which would result in electricity being “zero carbon” are not reflected in this methodology. Any electricity sourced from on-site or direct wire renewables are still reported as zero carbon under this methodology.

This has been chosen as the reporting methodology as otherwise the impact of measures on electricity consumption will be obfuscated by the fact that all electricity emissions are reported as zero. Considering that electricity is a major source of emissions and a large number of measures target reductions in its use, this would reduce the apparent impact of these measures significantly.

3.1.2 Baseline results

The following diagrams give a breakdown of the 2019/20 emissions baseline by emissions scope, by area within the board, and by the emissions source, as each way of looking at the data shows a different factor to consider in the routemap. Figure 5 below for example shows that 56% of the total footprint for NHS Shetland relates to sources where the Board has very little control or influence over those emissions.

Figure 5 - 2019/20 baseline footprint by scope



Scope	Emissions (tCO_2e)	% of Total
Scope 1	695.3	16.7%
Scope 2	1,121.6	26.9%
Scope 3	2,345.5	56.3%
Total	4,162.5	100.0%

Figure 6 - 2019/20 baseline footprint summary by area and scope

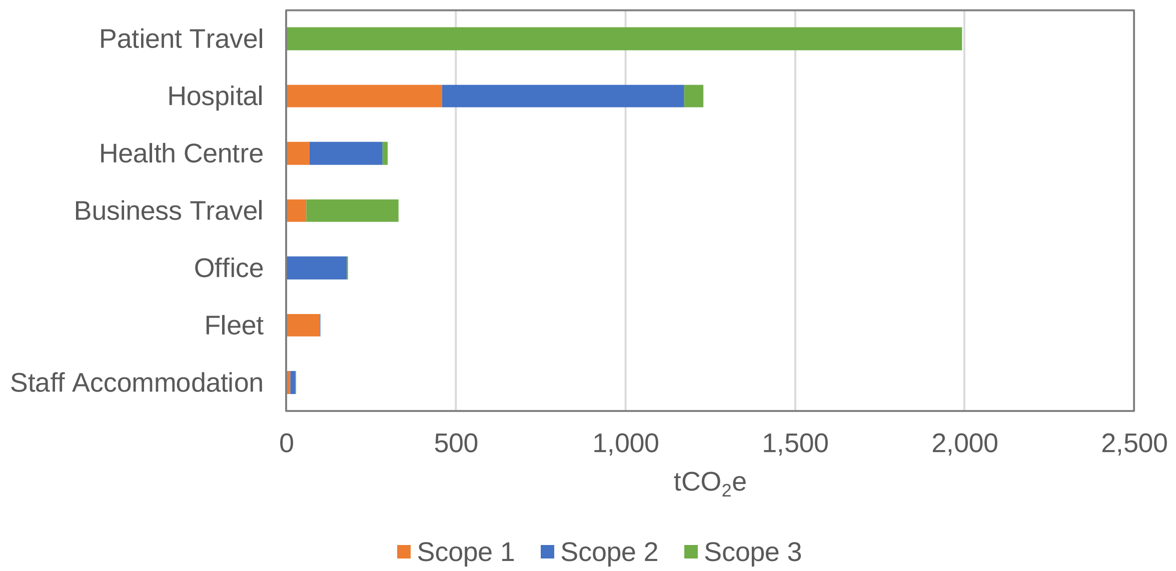
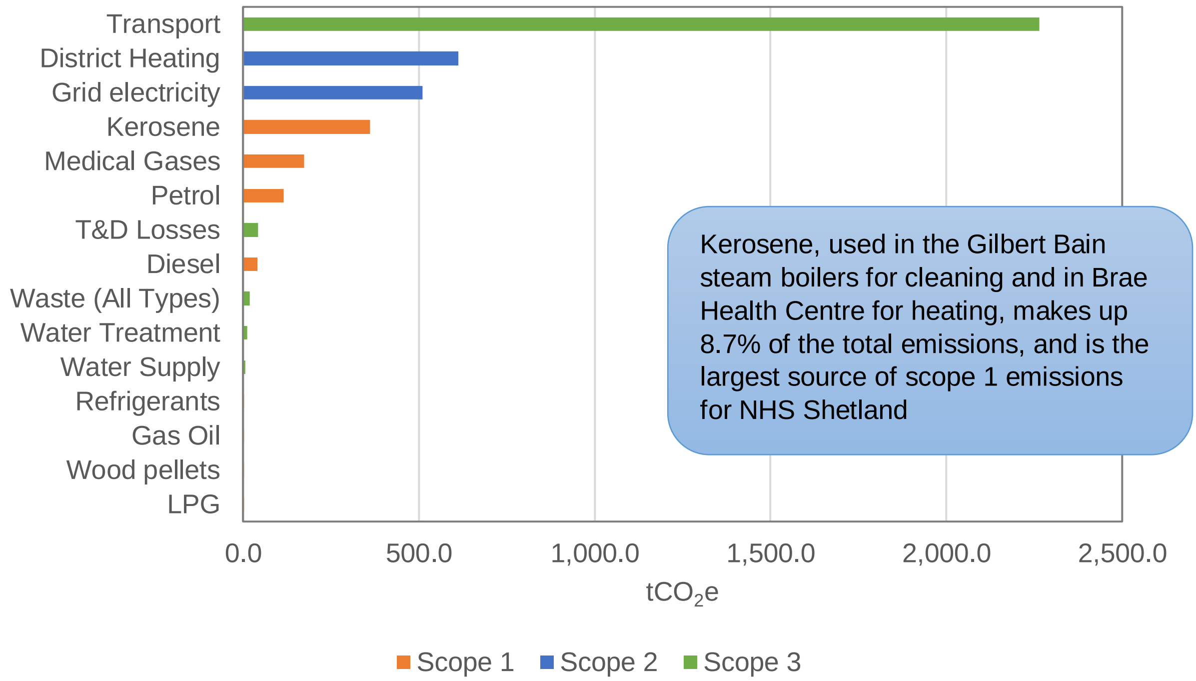


Figure 6 shows how patient travel is the single largest emissions source for NHS Shetland, representing 47.9% of the total baseline footprint. This is due to the number of flights undertaken by patients to the mainland for treatment: 8,870 to Aberdeen, 747 to Glasgow, 211 to Edinburgh, 20 to Inverness and 31 to Kirkwall. Inter-island flights also contributed to this emissions source, including 58 flights to Fair Isle and 12 to Foula. Figure 6 also shows that the Gilbert Bain Hospital is the second largest emissions area for NHS Shetland, with 29.6% of the total emissions share, with far more of the emissions being under scope 1 and 2 and therefore with higher potential for NHS Shetland to decide and/or influence the future emissions levels from these sources.

Figure 7 - 2019/20 baseline summary by emissions source and scope



Note that all business travel and patient travel have been combined together as “Transport” in Figure 7, and make up 54.4% of the total baseline footprint. District heating and electricity are the second and third largest emissions sources, with 14.7% and 12.3% respectively.

3.2 Business as usual trajectory to 2045

Projecting the baseline emissions to 2045 in line with the predicted business as usual (BAU) scenario provides an assessment of the gap compared to a net-zero scenario. This gap shows the scale of the intervention(s) required to achieve net-zero. It should be noted that this scenario only accounts for activities and events that are planned and are highly probable to occur.

As part of the BAU modelling, we looked to capture any information that will affect NHS Shetland’s carbon emissions under business as usual conditions. This includes known plans for building stock, projects confirmed and in the pipeline that will affect the emissions sources included within the baseline as well as growth in emissions sources due to external factors (such as population growth) and efficiency trends. These are summarised below:

- **Known internal factors**: Known internal factors/changes that will impact on the baseline emissions, e.g. confirmed plans to demolish a hospital and replace it with a new one.
- **Known external factors**: Known external factors/changes that will impact on the baseline emissions, e.g. ongoing decarbonisation of the national grid, Scottish Government policy on sales of fossil fuel cars after 2030, and plans to decarbonise local flights by 2040.
- **Confirmed pipeline projects**: Projects that impact emissions that have been signed off on or are very close to being given the go-ahead, e.g. plans to install cavity wall insulation at all 1950s or older buildings that have no insulation currently.

- **Growth rate**: This growth rate will be used by the model to indicate how emissions will grow year-on-year due to multiple affects. E.g. UK population growth (0.2%/year[3]) will mean more waste is produced annually within the NHS board.
- **Efficiency rate**: This rate counteracts the growth rate and is due to ongoing improvements in efficiency (energy/utility use) in the way the NHS is run. E.g. vehicle fleet will become more fuel efficient with time as vehicles are replaced with modern variants.

The outcomes of the BAU meetings held with NHS Shetland, and the resulting measures and emissions impacts used in the BAU projection to 2045 are detailed in Appendix A1.

3.2.1 BAU modelling results

The output of the BAU modelling is shown below in

Figure **8**,

Figure **9** and

Figure **10**.

The main factors already committed to by NHS Shetland that will contribute to the projected emissions under the BAU are:

1. An MRI scanner is due to be installed in the Gilbert Bain Hospital by 2022. This has been modelled to increase the annual consumption by 28,000kWh - based on 19.9kWh per scan[4] and 650 scans/year plus 15,000kWh for cooling systems.
   The new MRI scanner will reduce number of journeys to Aberdeen by 1300/year from 2022 (650 scans now carried out in Shetland instead of Aberdeen, modelled as 2 journeys per MRI scan to reflect that multiple journeys are taken for follow up consultations.) 75% of these journeys are modelled as flights due to proportion of patient journeys flying vs taking a ferry from 2019/20 patient travel data.
2. A New CT scanner is going to be installed that will increase scans within the Gilbert Bain by 10% (150/year). This will increase annual consumption by 180kWh based on 1.2kWh/patient[5]. The planned new CT scanner will reduce the number of flights by 150/year from 2021 due to 10% additional CT scans being carried out in the GB Hospital. 75% of these journeys are modelled as flights due to proportion of patient journeys flying vs taking a ferry.

Modelling shows that under a BAU scenario, total emissions will decrease by around 55% by 2045 without any further intervention from NHS Shetland. The remaining emissions gap that will need to be addressed to achieve net-zero in 2045 is **1,873 tCO2e**.

[3] https://www.gov.scot/news/scotlands-population-at-record-high-but-population-growth-has-slowed/#:~:text=The%20figures%20published%20in%20the,year%20to%2030%20June%202018.

[4] https://pubs.rsna.org/doi/10.1148/radiol.2020192084

[5] https://pubs.rsna.org/doi/10.1148/radiol.2020192084

Figure 8 - BAU emissions by scope 2019-2045

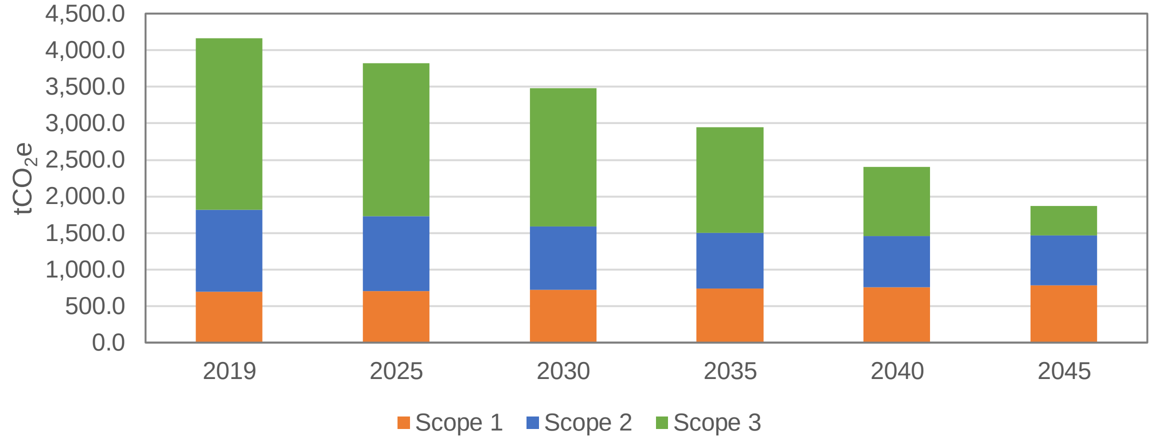


Figure 9 - BAU emissions by area, 2019-2045

Under the business as usual scenario, the Gilbert Bain Hospital is projected to be largest emission source in 2045, having only reduced its emissions slightly.

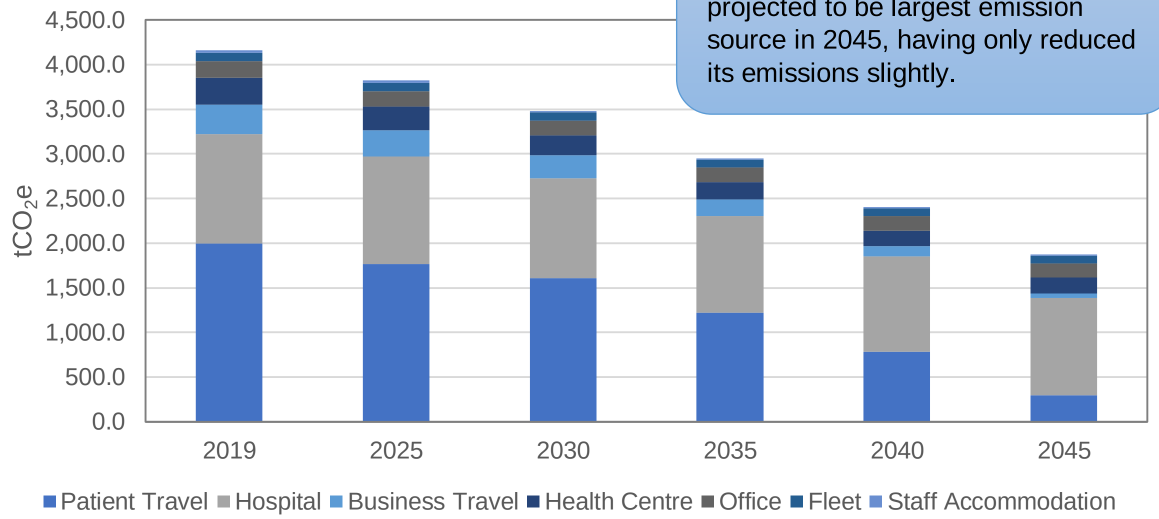
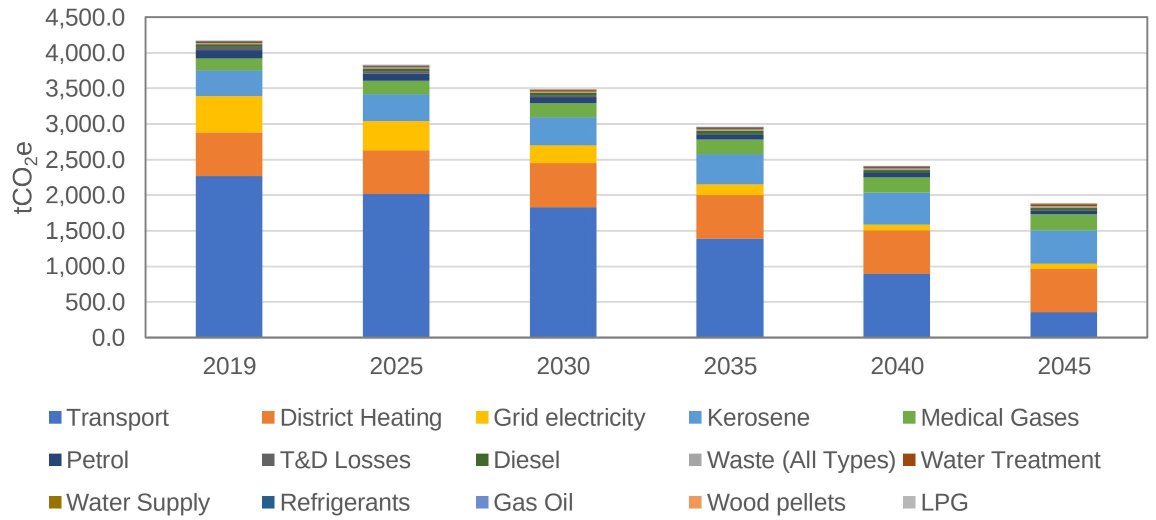


Figure 10 - BAU emissions by source, 2019-2045



Due to the planned repatriation of services to Gilbert Bain hospital, and the Scottish Government's wider decarbonisation commitments for transport, NHS Shetland's transport emissions are expected to fall year-on-year. The grid electricity emission reduction is modelled primarily to reflect the decarbonisation of the national grid as the contribution from renewable generation increases.

Kerosene, Medical Gases, Waste (All Types), Water Treatment and Water Supply all experience a slight increase in emissions as a growth in the demand for NHS services has been taken into account. All other emissions factors remain static across the modelled period, and as such any changes reflect growth and efficiency rates as well as any modelled BAU changes.

After accounting for planned Business As Usual activities and changes, the largest challenges for NHS Shetland to address by 2045 if the Board is to achieve net-zero are:

1. Divesting from all fossil fuel use across all sites
2. Emissions from the Gilbert Bain Hospital (responsible for 58% of remaining emissions)
3. The use of kerosene at the Gilbert Bain and Brae Health Centre (60% of NHS Shetland's scope 1 emissions in 2045)
4. Emissions related to district heating
5. Emissions related to medical gases

The next chapter of this report looks at options to address all five of these challenges and examines how those options could be applied to NHS Shetland.

4 Defining the pathways to net-zero

4.1 Approach

Through discussions with NHSScotland and given the individual circumstances of NHS Shetland, it was agreed that three net-zero pathways would be modelled. These were:

Aspirational Pathway – assumes that significant resources and budget are made available to allow the rapid implementation of measures while taking account of current contractual constraints. Importantly, this approach collectively applied by the public sector can support the required market transformation of buildings and energy use across Scotland. This approach would also minimise carbon emissions which, in turn, will reduce the impact of climate change and the associated health implications on the global population.

Restricted Pathway – which assumes that the resources and budget available to allow the implementation of low-carbon changes are significantly constrained. This restricts the scale of planned changes and delays the timeframe for action however it could reduce the cost of action as legislation and technological improvements drive change in the marketplace.

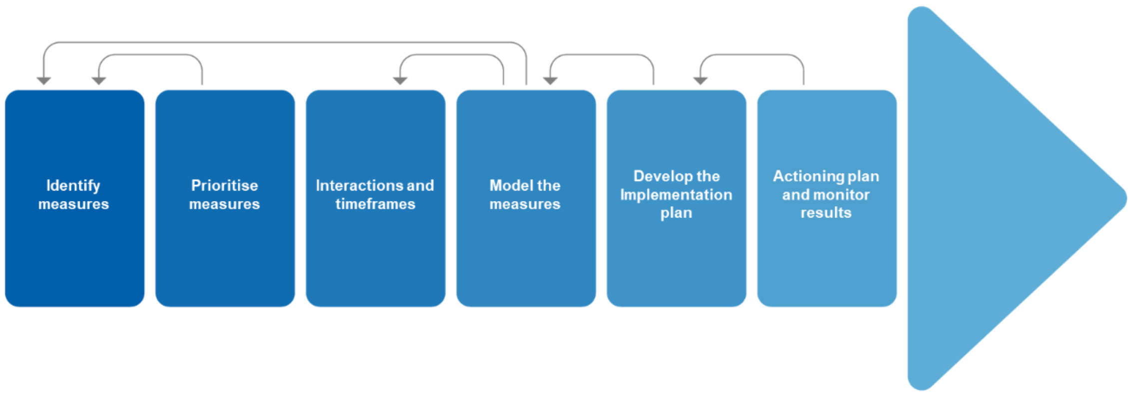
Balanced Pathway – attempts to find a middle ground between the two previous scenarios. The scenario assumes some restrictions on resources but also seeks to implement changes at a point where costs and risks are minimised while also reducing carbon emissions as quickly as possible given the identified constraints.

To translate the net-zero carbon definition into a framework for exploring these emissions pathways to 2045, a set of overarching parameters were established to define the pathways. These were used to ensure the proposed mitigation measures were established on a solid foundation and that the three Boards in the net-zero routemap pilot utilised a consistent framework. The table in Appendix A2 of this report describes the scenario parameters that were treated as maximum boundaries when setting the modelling assumptions for NHS Shetland within each pathway.

4.2 Decarbonisation interventions

Identifying decarbonisation interventions and developing emissions reduction plans is an iterative process that has generated a live document for NHS Shetland that will evolve over time. The feedback loops are shown in Figure 11 below, and the following chapters reflect some of the identification, prioritisation, interactions and modelling loops that took place during the project.

Figure 11 - Workflow to develop decarbonisation interventions



A long list of measures was identified by the Ricardo technical leads across the following categories:

- Energy efficiency and energy management.
- Electricity supply.
- Heat supply.
- Transport.
- Non-CO_2 gases.
- Waste.
- Water.

The measures were entered into a detailed measures template, taking account of factors such as:

- Fuel type and kWh (before and after each measure is implemented).
- Investment required.
- Which year the measure is undertaken, and the number of years needed to implement.

It is important to note that costs indicated are based on a high-level desk-based assessment of potential measures, with all information on current systems and practices provided by NHS Shetland. As such, full financial and technical feasibility studies would need to be carried out before measures were implemented.

A workshop and subsequent follow-on clarification sessions were then held with NHS Shetland to review the proposed measures and determine how likely it might be for NHS Shetland to adopt these measures. Minutes from this workshop are attached as Appendix A3 of this report. The output of the workshop was a Red/Amber/Green (RAG) rating for each proposed measure, considering factors around site suitability, technical feasibility and financial feasibility to inform the modelling of those measures within each of the three scenarios. Importantly, of the suggested measures for waste management, most were rated as Red for NHS Shetland and were not taken forward into the model as the Board felt there weren't any further actions they could take above and beyond their current level of management. It was noted that all measures will need to be installed in compliance with standard NHS operating procedures and health standards.

A description of each short-listed measure has been provided in Appendix A4 of this report, including details of the indicative costs for each measure, while the diagram below provides an overview of the measures applied within the three different pathways. Note that although the same measure may be applied across multiple pathways, the scale, scope and timeline of implementation for each measure varies between pathways.

Figure 12 – Short-listed measures for NHS Shetland, including an indication of relevance to each pathway

Short-listed measures	Aspirational pathway	Restricted pathway	Balanced pathway
A new low carbon hospital on Lerwick	✓	×	✓
A shift to electric vehicles	✓	✓	✓
Installing Air Source Heat Pumps (ASHP) – Air-to-Water and/or Air-to-Air, or Ground Source Heat pumps (GSHP)	✓	✓	✓
Increasing utilisation of the heat network	✓	✓	✓
Improving energy management and controls	✓	✓	✓
Improving the building envelopes	✓	×	✓
Modernising existing or upgrading plant	✓	✓	✓
Installing new renewable wind turbines	✓	×	×
Installing new ground-mounted solar photovoltaics	✓	✓	×
Installing new roof-mounted solar photovoltaics	✓	✓	×

Short-listed measures	Aspirational pathway	Restricted pathway	Balanced pathway
Installing new carpark solar photovoltaics	✓	✓	×
Improving water measurement and monitoring	✓	✓	✓
Reducing water consumption in building plant and equipment	✓	✓	✓
Reducing water used for sanitary/domestic purposes	✓	✓	✓
Reducing water consumption for medical activities	✓	✓	✓
Improved waste segregation	✓	✓	✓
Phasing out higher-carbon anaesthetic gases	✓	✓	✓

The following section details how the identified decarbonisation measures were modelled under each net-zero pathway and shows the resulting emissions savings from the interaction of those measures, in tonnes of carbon equivalent over time.

4.2.1 Impact of a new low carbon hospital on Lerwick

During the discussion of measures appropriate to each pathway, it was agreed with NHS Shetland to model a brand-new low carbon hospital to replace the Gilbert Bain Hospital in both the Aspirational and the Balanced pathways. This reflects the current direction of travel for the Board, and the wider need to upgrade the hospital building within the next 10 years. Only the Restricted pathway assumes a new hospital is too costly and examines the other measures that could feasibly be applied to reduce emissions from the existing hospital.

To further support the modelling assumptions regarding where the emissions impacts would be appropriately allocated for a low carbon hospital on Lerwick, we utilised the available information on a low carbon new-build hospital on Orkney, which is of a similar size and scale to the Gilbert Bain Hospital.

Case study: Balfour Hospital, Orkney

The brand new Balfour Hospital is a rural general hospital in Kirkwall, Orkney, which is managed by NHS Orkney. NHS Orkney serves a population of approximately 21,300 people distributed across three distinct regions – the North Isles, the South Isles, and the Mainland, which collectively consist of 17 inhabited islands, the largest of which is the Mainland.

Image source: https://www.ohb.scot.nhs.uk/design-gallery

The Balfour Hospital[6] was established in 2019 as an improved replacement for a previous mainland hospital with the same name. It was replaced as part of a business case for reshaping and investing in health services across NHS Orkney as part of whole system health and care redesign, at a reported cost of £64million[7]. One of the key drivers for the replacement of the hospital included the 'environmental performance' of the building, since the hospital was largely deemed no longer fit for purpose in terms of high carbon emissions and was considered 'costly' to run. Key areas of improvement that were identified within the business case included: a focus around carbon, such as the overall NHS target for low/net zero carbon buildings; resource efficiency relating to materials and waste; and encouraging physical activity and use of public transport to access the hospital and reduce emissions from transport.

The new Balfour hospital was developed to address many of these issues. For example:

- The hospital site strategy and traffic plan prioritise pedestrians and cyclists over cars.
- Facilities management (FM) services provided by Orkney include domestic, portering, stores, grounds maintenance, waste collection, medical physics, laundry, and other in-house FM services. All of which are provided and managed from FM offices within the FM suite on the ground floor of the building.
- The hospital includes an Energy Centre external to the main building. The primary power source for the new facilities is electricity, which powers heat pumps, with an oil-fired boiler plant as the backup system to provide resilience and to ease any operational spikes. The main plant is twin air to water heat pumps, which are externally mounted and in essence extract heat from the air and, using electrical heat pump technology, transfer that heat to circulating water. Each of the external units is connected to internally mounted water to water heat pumps, which distributes the heated water through a second heat pump cycle. This increases the temperature of the circulating water to normal heating system levels, which then feeds the heating and hot water demands of the building.

Unfortunately, due to the new Balfour Hospital only being built in 2019, publicly available data relating to energy and carbon at the site are currently limited and unlikely to be published within the timeframe of this project. Instead, the most readily available information relates to high-level content[8] published by NHS Orkney, such as the bullet points above. This means that the hospital will feed into the board level reports rather than be wrapped into site level, due to the lack of granularity of data for modelling purposes.

Looking wider at the NHS across the UK, the recently published NHS England 'Delivering A Net Zero Health Service' report[9] commits to creating 40 new 'net zero hospitals' as part of the government's Health Infrastructure Plan with a new Net Zero Carbon Hospital Standard available from spring 2021. This should provide useful reference information in further developing feasibility and business case planning for a new hospital on Lerwick.

[6] https://www.keppiedesign.co.uk/project/balfour-hospital-orkney/

[7] https://www.orkney.gov.uk/Files/Community-Life-and-Leisure/Arts/2018/Integrated_Artwork_Commission.pdf

[8] https://www.ohb.scot.nhs.uk/design-gallery

[9] https://www.england.nhs.uk/greenernhs/wp-content/uploads/sites/51/2020/10/delivering-a-net-zero-national-health-service.pdf

4.3 The three net-zero pathways

Each of the net-zero pathways were modelled to include the decarbonisation measures agreed with NHS Shetland. This section covers the results of this modelling and sets out a narrative and graphical explanation of what each of the pathways could look like. The following appendices provide detailed information that underpin this entire section:

- Appendix A4: A detailed description of each measure
- Appendix A5: Indicative cost breakdown for each modelled measure
- Appendix A6: Assumptions and modelled factors for each pathway

4.3.1 The Aspirational pathway

4.3.1.1 Overview

Aspirational Pathway – assumes that significant resources and budget are made available to allow the rapid implementation of measures while taking account of current contractual constraints. Importantly, this approach collectively applied by the public sector can support the required market transformation of buildings and energy use across Scotland. This approach would also minimise carbon emissions which, in turn, will reduce the impact of climate change and the associated health implications on the global population.

The premise of the aspirational pathway model is that NHS Shetland is supported by the Scottish Government to prioritise the reduction of carbon emissions ahead of cost implications, primarily through the establishment of a new net-zero hospital to replace the Gilbert Bain Hospital. The model assumes that budget could be secured to allow rapid investment in measures that reduce carbon emissions. This early prioritisation of low and zero-carbon infrastructure, procurement and operations is likely to have negative cost implications. Early adoption of low and zero-emission practices could lead to efficiency savings however it is likely that a premium will be paid as a result of early adoption of these solutions before market forces drive down costs. There is also a risk that NHS Shetland could invest in solutions which are made redundant by later technological developments.

Importantly this proactive approach could avoid a situation where NHS Shetland finds itself approaching the 2045 deadline and is having to pay a premium for low-carbon solutions because demand exceeds availability. Any increased costs generated by a high demand for suppliers could be exacerbated for NHS Shetland and other island-based organisations. This situation could be exacerbated by a late rush to adapt by the private sector, facing punitive legislation, which ultimately could lead to NHS Shetland missing the 2045 deadline.

4.3.1.2 Pathway intervention measures

The modelled aspects of the aspirational pathway are set out below in Table 1.

Table 1 Aspirational pathway, modelled measures

Site/Site Category	Emissions Source	Modelled measures
Gilbert Bain Hospital	Electricity	A new "Low Carbon" hospital replaces the Gilbert Bain in 2025-2026 in this pathway. Montfield HQ and Breiwick House are consolidated into the hospital at this date and existing sites are decommissioned.
	Heating systems	The new hospital sources all its electricity from zero carbon sources - either on-site renewables or local renewables with a PPA (power purchase agreement).
	Steam (Kerosene)	The hospital retains a district heating connection for heating, hot water and steam generation, but the network is zero carbon by the time the new hospital is built and connected.
	Water supply and treatment	Steam use on site is minimised - all hot water from laundry equipment is generated from the district heat network, and local electric steam generation is only used where absolutely necessary. Water use and wastewater is minimized in the new hospital during the design phase. Cooling systems are all closed loop, and all fixtures and fitting are ultra-low flow. Submetering is designed into the hospital from the ground up to allow for in-depth monitoring of energy use throughout - *supports energy management measure outlined in more detail in the Health Centres section of this table.*
	Medical gases	Emissions from medical gasses are reduced by 50%, phased from 2021 to 2030. This is through use of lower carbon impact gasses and rationalizing use of such gasses within the hospital. It is also expected that advancements in technology utilised in the new hospital will aid this reduction.
	Waste	Through improved waste segregation practices, a 50% reduction in waste in the orange stream and 30% in municipal waste are achieved by 2040 (phased from 2030).
Health Centres, Staff Accommodation and Offices	Electricity	BMS systems are updated and expanded in 2022 to allow for improved monitoring and remote control in Brae Health Centre and Bixter Health Centre. Through more effective monitoring, rationalization of set points and improved control (with installation of comprehensive control points), 12% savings across electricity and heating energy use in all connected systems is achieved. Note: Montfield HQ and Breiwick House have BMS systems but are excluded as they are to be consolidated into the new hospital before reasonable payback of the upgrades can be achieved. Energy management & submetering: 7% savings for all electricity, heating fuels and water from 2022. Achieved through: Setting up green teams with local responsibility for energy use, allocating an energy manager to monitor and take actions on collected data, setting site-by-site benchmarks and targets, conforming to and obtaining certification for ISO 50001, carrying out regular staff energy awareness training, installing smart fiscal meters on all properties (electricity and water), and submetering of major plant in largest sites (excluding hospital).

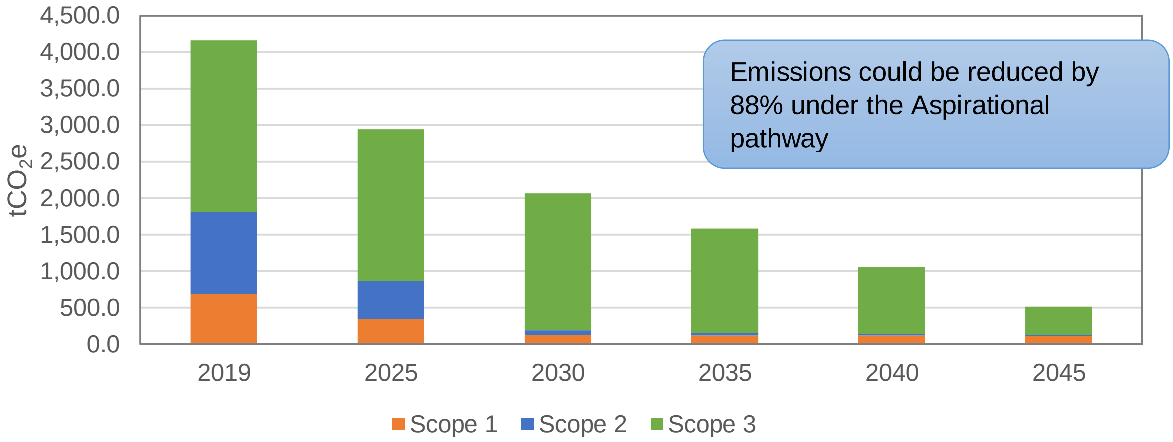
		Potential for renewable installations has been identified on health centre roofs as well as car parks. These installations are modelled to be installed from 2022-24 and could generate up to 475,000kWh/year - reducing the amount of electricity purchased from the grid.
	Heating systems	Smart heating controls to be installed in all properties that do not have a BMS system. This includes properties that have kerosene boilers or storage heaters. Both heating systems can be controlled by smart control systems that would reduce their energy consumption through better control and response to external temperatures. Savings of 12% can be achieved and new controls are installed in all properties in 2022 in this pathway. Improving the insulation levels in all properties would reduce the thermal losses through building fabric and therefore reduce heating system energy use. Many of the properties in Shetland have un-filled cavity walls, with four properties having solid walls due to their age. All wall cavities are filled and external wall insulation installed in this pathway, with the works being carried out from 2022-2027. All properties have had roof insulation upgraded within the last 10 years, and all windows and doors are double-glazed or well insulated and air-tight and are therefore not due for an upgrade. 5% heating energy savings can be achieved through this measure. For all properties with a fossil fuel heating system, air-to-water heat pumps are installed in this pathway and are sized to the heat demand of the property (taking into account other measures that impact heat demand). Five properties fall under this category, and these new heating systems are all installed in 2022 under this pathway. Generally, air-to-water heat pump systems can achieve a COP of 2.5 to 3, and by installing these systems the sites would divest themselves of fossil fuel use. For all properties with a BMS system that are heated using AHUs (air handling units), upgrades of AHU fans, motors and circulation pumps to the highest standard are included, as well as installation of heat recovery. Savings of 5% on electricity use in these systems can be achieved by implementing this measure.
	Water supply and treatment	Water use and wastewater use in sanitary, domestic, laundry and kitchens are minimized by installing ultra-low flow fixtures for toilets, taps and showers. Under this pathway, works to upgrade the fixtures are carried out in 2022-2024 and can achieve water savings of 40%.
	Waste	Through improved waste segregation practices, a 50% reduction in waste in the orange stream and 30% in municipal waste are achieved by 2040 (phased from 2030)
Fleet (Cars)	Fuel	All fleet cars are modelled as being replaced with EVs in 2021 as step change in fleet.
Fleet (Vans)	Fuel	All vans are modelled as being replaced with EVs by end of 2030. Modelled as gradual change in fleet over next 10 years.
Grey fleet (personal cars)	Mileage	No additional measures have been modelled under the pathways for grey fleet, business travel or patient travel. All modelled measures are covered under BAU.

Business travel (flights)	Flight distance	For business and patient travel, no further measures have been modelled as the NHS has no direct control over these transport modes.
Business travel (ferries)	Distance travelled	
Business travel (Busses)	Mileage	
Patient travel (flights)	Flight distance	
Patient travel (ferries)	Distance travelled	
Patient travel (Busses)	Mileage	

4.3.1.3 Pathway mitigation potential

The following charts illustrate the mitigation potential for the Aspirational pathway.

Figure 13 - Impact of the aspirational pathway split by emissions scope



	2019	2025	2030	2035	2040	2045
Scope 1 (tCO_2e)	695.3	346.8	131.5	125.4	119.6	116.3
Scope 2 (tCO_2e)	1,121.6	518.0	61.0	35.5	20.6	17.7
Scope 3 (tCO_2e)	2,345.5	2,075.1	1,871.7	1,425.8	922.5	384.6
Total (tCO_2e)	**4,162.5**	**2,939.9**	**2,064.2**	**1,586.6**	**1,062.7**	**518.6**
% change	**0.0%**	**-29.4%**	**-50.4%**	**-61.9%**	**-74.5%**	**-87.5%**

Figure 13 shows the impact of the aspirational pathway on total baseline emissions, as well as each individual emissions scope. The overall reduction in emissions seen between 2019 and 2045 is 87.5%. The residual emissions in 2045 are 74.2% attributed to scope 3, 3.4% to Scope 2, with the remaining 22.4% in Scope 1.

The effect of prioritising early intervention can be clearly seen through a 29.4% fall in emissions between 2019 and 2025. Scope 1, 2 and 3 emissions are then significantly reduced respectively by 2045, with Scope 1 reducing 96.8%, Scope 2 reducing 99.7%, and Scope 3 reducing 96.8% by 2045.

Figure 14 - Impact of the aspirational pathway split by emissions source

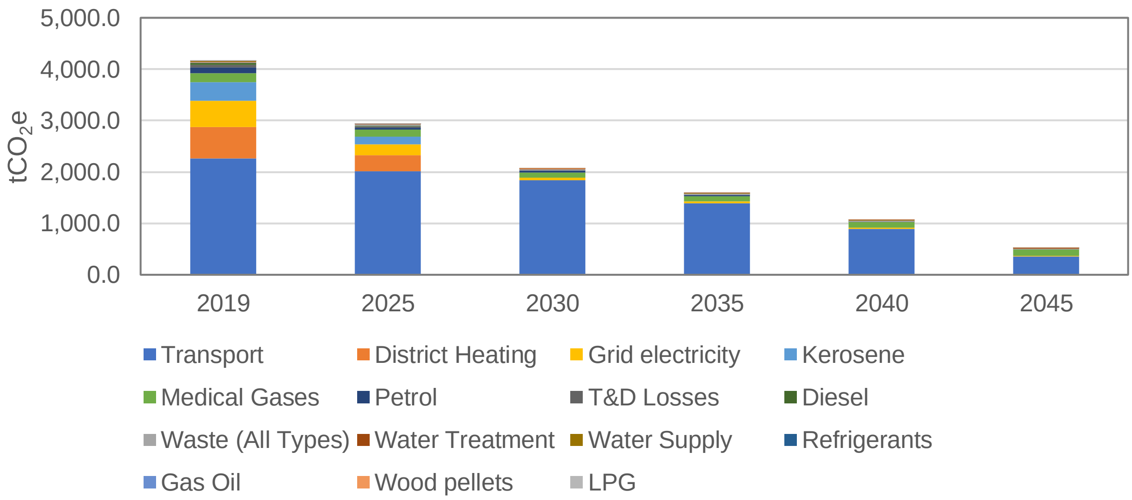


Figure 14 shows how the aspirational pathway impacts each of the emissions sources that contribute to the total footprint. The impact of early investment can again be seen, with emissions associated with district heating, kerosene, diesel, gas oil, and LPG reaching net-zero by 2030. In 2045 the residual emissions are attributed primarily to transport and medical gases, with small contributions from grid electricity transmission and distribution losses, waste, water supply and treatment, and refrigerants and wood pellets.

Figure 15 - Impact of the aspirational pathway split by activity area

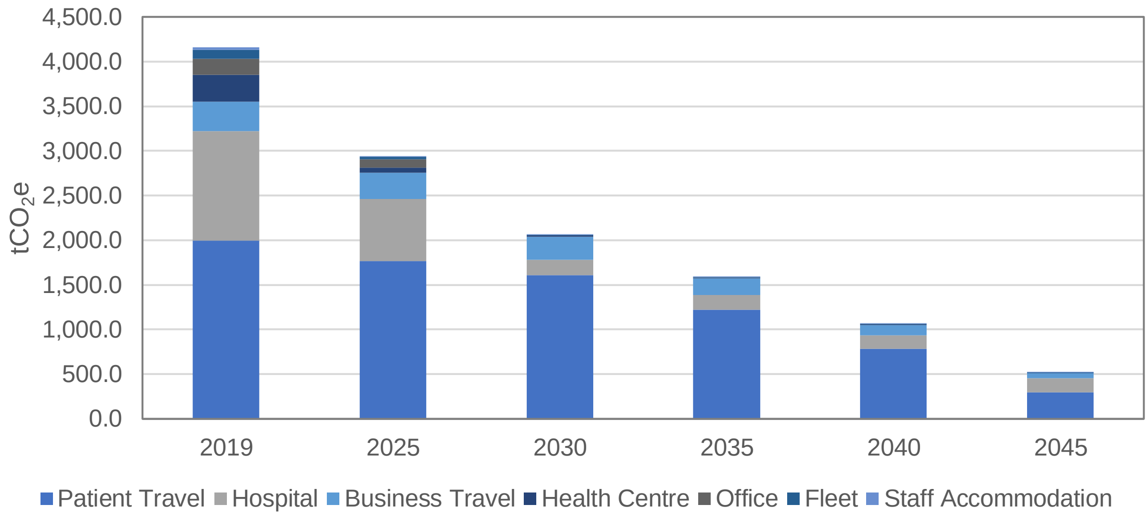
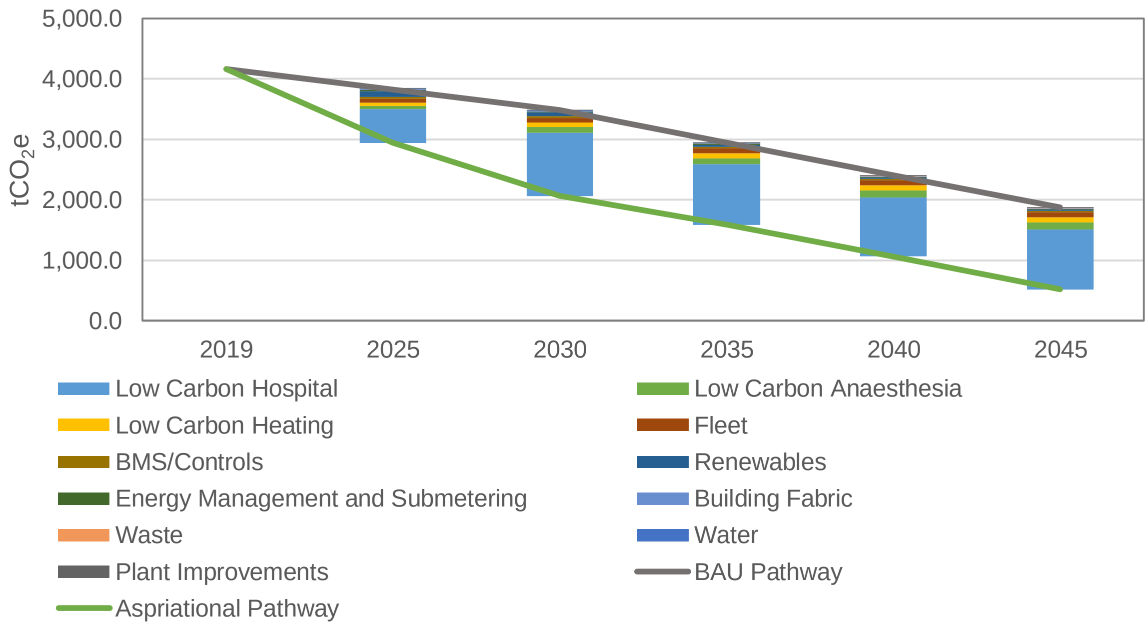


Figure 15 shows how the aspirational pathway impacts each of NHS Shetland's areas of activity. This shows that the substantial early reduction in emissions is heavily influenced by the move towards low/zero emissions buildings, such as the replacement of the Gilbert Bain hospital and retrofitting of health centres. There is also a significant drop in emissions from patient travel due to the repatriation of services.

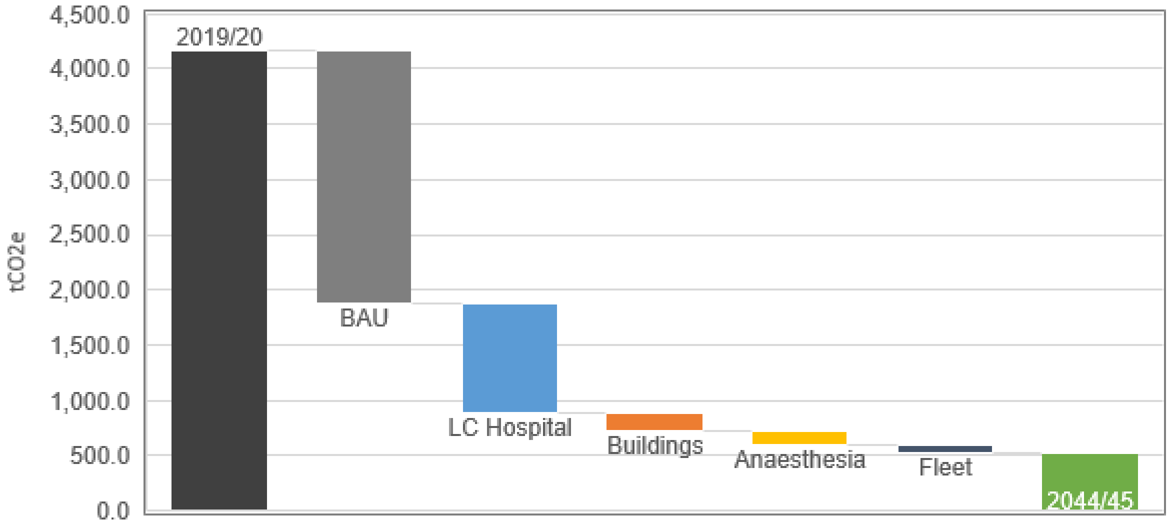
Reductions in emissions associated with business travel and fleet are primarily associated with the projected electrification of the transport sector, although by 2045 most residual emissions (57.3%) are still associated with patient travel to and from Shetland

Figure 16 - Comparing the aspirational pathway to business as usual



Under the aspirational pathway baseline emissions are reduced by 87.5% compared to 55% under a business as usual scenario. Figure 16 shows the contribution of groups of measures to the significantly reduced emissions profile of the aspirational pathway, which is shown as a waterfall diagram in Figure 17 below. This highlights the substantial opportunity available through low or zero emissions properties to significantly address NHS Shetland's primary source of emissions.

Figure 17 - Carbon savings by measure for the Aspirational pathway, cumulative from 2019/20 baseline to 2044/45



Note In Figure 17 LC Hospital is shorthand for Low Carbon Hospital.

4.3.1.4 Indicative investment costs and potential cost savings

Figure 18 shows the estimated capital investment costs for all decarbonisation measures and fuel cost savings that NHS Shetland can expect to see when following the aspirational pathway capital expenditure schedule, excluding the cost of constructing the new hospital.

By prioritising early investment, it is expected that capital expenditure will peak at just over £600,000 in both 2022 and 2024 but after this investment will remain below this level. This early investment, though the highest initial expense of all pathways, allows for greater fuel cost savings to be made much more quickly. The jump in fuel savings from 2026 is due to the new low carbon hospital that has been modelled for this pathway. Fuel savings from this measure alone account for ~75% of fuel savings from 2026 onwards.

The investment in renewables is responsible for most of the capital expenditure modelled (~£1.4 million) but delivers the most cost savings by delivering a total of £2.8 million of cumulative savings by 2045, with renewable energy coming online by 2026.

Figure 18 – Estimated annual investment costs and cost savings for the aspirational pathway

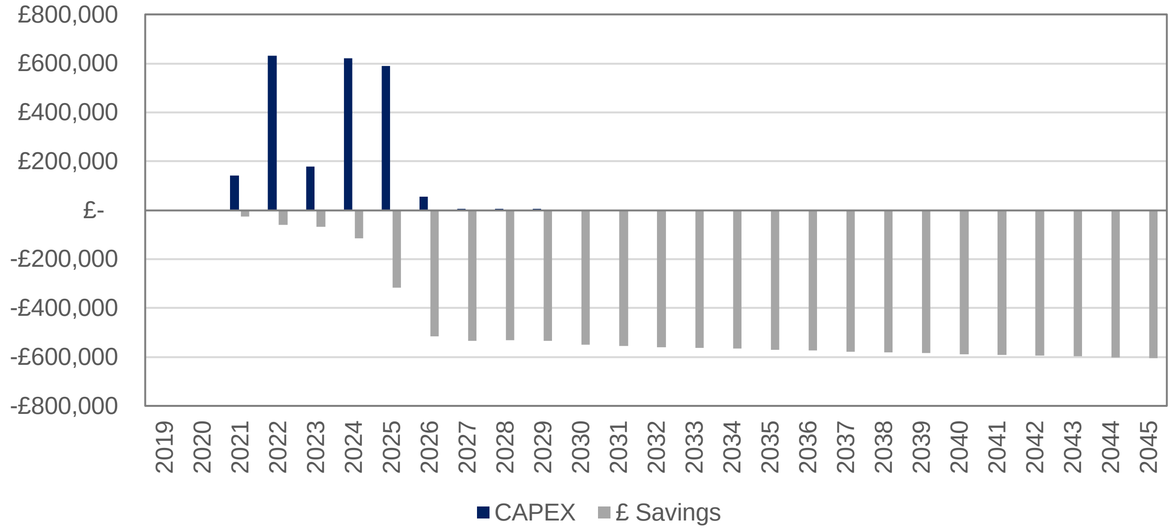
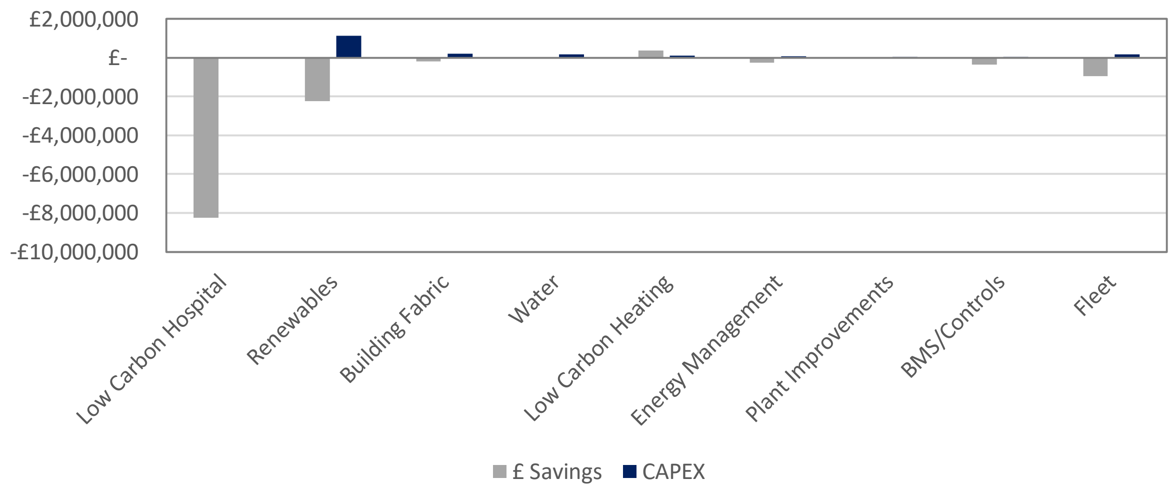


Figure 19 shows the cumulative total estimated CAPEX cost and fuel savings for all measures from 2021-2045. It can be seen that the low carbon hospital realises fuel savings of over £8.2 million from the date of implementation (2026) to 2045, though it will likely require significant investment during its construction. The installation of renewables at non-hospital sites is the second largest source of fuel savings, followed by replacement of the current vehicle fleet with EVs.

It is worth noting that the "fuel savings" for low carbon heating systems are negative - i.e. fuel costs will increase with the installation of these systems. This is because of the high fuel cost of low carbon heating measures compared to liquid fuels, but it is important to note is that the price differential between low carbon fuels and traditional heating fuels may change from those currently predicted in the future as Government policy drives a move away from fossil fuel use.

Figure 19 – Estimated investment costs and cost savings for each measure in the aspirational pathway



In summary, the Aspirational pathway shows the fastest pathway to reducing emissions for NHS Shetland and could achieve an 88% reduction on 2019/20 emissions before considering offsetting or other measures to remove carbon. Patient transport and medical gases are key unavoidable emission sources in 2045 even under the Aspirational pathway. This is a high investment pathway, assuming all measures are implemented as early as technically feasible.

4.3.2 Restricted pathway

4.3.2.1 Overview

Restricted Pathway – which assumes that the resources and budget available to allow the implementation of low-carbon changes are significantly constrained. This restricts the scale of planned changes and delays the timeframe for action however it could reduce the cost of action as legislation and technological improvements drive change in the marketplace.

The premise of the restricted pathway model is that NHS Shetland could find itself in a position where available resources and budget are constrained, and therefore it is not possible to fund the establishment of a new low carbon hospital on Lerwick. This could in part occur because of an aging population in Scotland which requires higher levels of care. This situation could be exacerbated by a prolonged and complicated global recovery from Covid-19. The model therefore assumes a limited scope in the changes made and a delayed timeframe for them being implemented.

While a slow rate of implementation is not ideal, a potential advantage of this is that legislation, improved manufacturing efficiencies and technological advances could reduce the cost and risks associated with these changes. This could maximise the positive impact of constrained budgets and avoid investment in solutions which are found to be ineffective or are surpassed by technology advancements.

The expectation that solution costs will reduce over time has been seen in low-carbon solutions such as LED lightbulbs and photovoltaics, however there can be exceptions to this. Between now and 2045 it is possible that energy and technology costs could increase due to the requirement for both to be decarbonised and the investment needed to achieve this. The cost of electricity has risen over the last decade and, as energy decarbonises, it is likely that this will continue.

Energy, transport and low carbon technology costs are significant factors in the transition to net-zero that NHS Shetland would like to make.

4.3.2.2 Pathway intervention measures

The modelled aspects of the restricted pathway are set out below in Table 2.

Table 2 Restricted pathway, modelled measures

Site/Site Category	Emissions Source	Modelled measures
Gilbert Bain Hospital	Electricity	The current BMS system is updated in 2025-35 to allow for improved monitoring and remote control. Through more effective monitoring and rationalization of set points (no additional hardware is included in this pathway due to the cost), 5% savings across electricity and heating energy use in all connected systems is achieved. Energy management & submetering: 3% savings for all electricity, heating fuels and water from 2025-2035. Achieved through: Setting up green teams with local responsibility for energy use, allocating an energy manager to monitor and take actions on collected data, setting site-by-site benchmarks and targets, carrying out regular staff energy awareness training, and installing smart fiscal meters on all properties (electricity and water). Due to the high cost of on-balance sheet renewables these have not been considered as part of this pathway. There would be potential to set up PPA agreement with local renewable installations but these have not been included within the modelling for this pathway.
	Heating systems	Heating systems at the Gilbert Bain are fed by the district heating network, and so no changes to the heating systems energy source is suggested. However, the district heating network is assumed to transition to a zero-carbon energy source by 2040.
	Steam (Kerosene)	The steam system at the Gilbert Bain is a significant source of carbon emissions at present, and will continue to be so until the system moves away from using Kerosene. Due to the age of the current plant (<5 years old), the system will not be cost-effective to replace until 2030 and there will be challenges to do so. The laundry will need to be moved away from using steam, and hot water for laundry equipment can be raised using the district heating system as the heat source. Clinical uses for steam (e.g. sterilisation) could be met with local electric steam generation, though the running costs of these systems are high so moving away from using steam altogether is a better option if possible. Under this pathway, kerosene use in the Gilbert Bain is replaced with district heating and electric steam/hot water generation, phased from 2035-2040.
	Water supply and treatment	Water use and wastewater use in sanitary, domestic, laundry and kitchens are minimized by installing low flow fixtures for toilets (via cistern water savers), taps and showers. Under this pathway, works to upgrade the fixtures are carried out in 2025-2035 on a maintenance replacement basis and can achieve water savings of 20%. Maintenance of current water distribution pipework will reduce water losses by 5% and is modelled as occurring annually from 2025.
	Medical gases	Emissions from medical gasses are reduced by 50%, phased from 2021 to 2040. This is through use of lower carbon impact gasses and rationalizing use of such gasses within the hospital. It is also expected that advancements in technology utilised in the new hospital will aid this reduction.

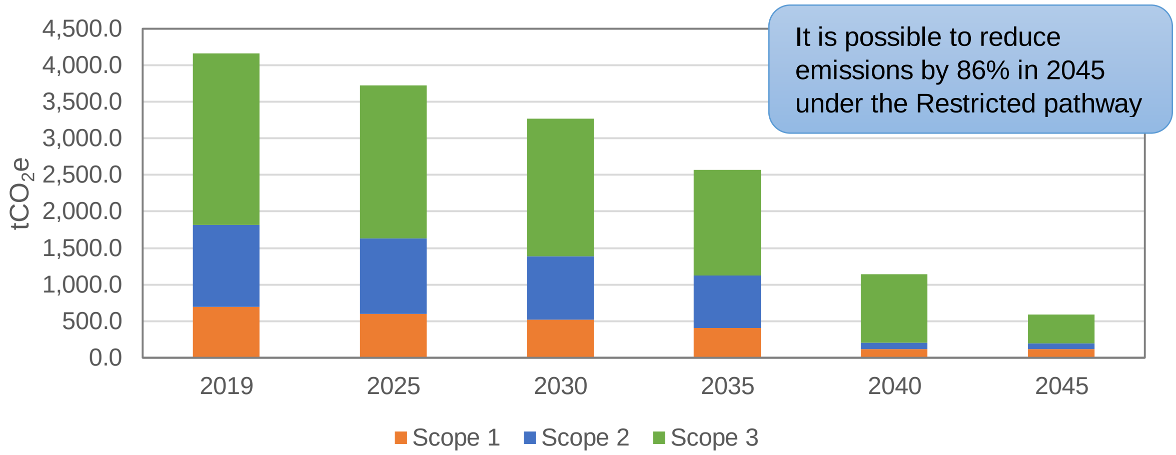
	Waste	Through improved waste segregation practices, a 50% reduction in waste in the orange stream and 30% in municipal waste are achieved by 2040 (phased from 2030)
Health Centres, Staff Accommodation and Offices	Electricity	BMS systems are updated and expanded in 2030-2035 to allow for improved monitoring and remote control in Brae Health Centre, Bixter Health Centre, Montfield HQ and Breiwick House. Through more effective monitoring and rationalization of set points (no additional hardware is included in this pathway due to the cost), 5% savings across electricity and heating energy use in all connected systems is achieved. Energy management & submetering: *As with Hospital section above* Due to the high cost of on-balance sheet renewables these have not been considered as part of this pathway. There would be potential to set up PPA agreement with local renewable installations but these have not been included within the modelling for this pathway.
	Heating systems	Rationalising heating set point temperatures through introduction of an NHS policy should reduce energy use in heating systems across the property portfolio by 5%. No new control hardware is included within this pathway. Due to the cost of installing cavity wall insulation this has not been included within this pathway. For all properties with a fossil fuel heating system, air-to-water heat pumps are installed in this pathway and are sized to the heat demand of the property taking into account other measures that impact heat demand. Five properties fall under this category, and these new heating systems are all installed in 2025-2035 under this pathway. Generally, air-to-water heat pump systems can achieve a COP of 2.5 to 3, and by installing these systems the sites would divest themselves of fossil fuel use. Despite the cost of these measure, this is still included due to the commitment to be fossil fuel free by 2045. For all properties with a BMS system that are heated using AHUs (air handling units), maintenance replacement of AHU fans, motors and circulation pumps to the highest standard are included. Savings of 3% on electricity use in these systems can be achieved by implementing this measure from 2030-2040.
	Water supply and treatment	Water use and wastewater use in sanitary, domestic, laundry and kitchens are minimized by installing low flow fixtures for toilets (via cistern water savers), taps and showers. Under this pathway, works to upgrade the fixtures are carried out in 2025-2035 on a maintenance replacement basis and can achieve water savings of 20%.
	Waste	Through improved waste segregation practices, a 50% reduction in waste in the orange stream and 30% in municipal waste are achieved by 2040 (phased from 2030)
Fleet (Cars)	Fuel	All fleet cars are modelled as being replaced with EVs in 2021 as step change in fleet.
Fleet (Vans)	Fuel	All vans are modelled as being replaced with EVs by end of 2030. Modelled as gradual change in fleet over next 10 years.

Grey fleet (personal cars)	Mileage	No additional measures have been modelled under the pathways for grey fleet, business travel or patient travel. All modelled measures are covered under BAU. For business and patient travel, no further measures have been modelled as the NHS has no direct control over these transport modes.
Business travel (flights)	Flight distance	
Business travel (ferries)	Distance travelled	
Business travel (Busses)	Mileage	
Patient travel (flights)	Flight distance	
Patient travel (ferries)	Distance travelled	
Patient travel (Busses)	Mileage	

4.3.2.3 Pathway mitigation potential

The following charts illustrate the mitigation potential for the restricted pathway.

Figure 20 - Impact of the restricted pathway split by emissions scope



	2019	2025	2030	2035	2040	2045
Scope 1 (tCO_2e)	695.3	595.6	523.2	406.3	119.9	116.6
Scope 2 (tCO_2e)	1,121.6	1,037.0	859.1	720.8	88.3	76.8
Scope 3 (tCO_2e)	2,345.5	2,090.4	1,889.8	1,438.7	934.6	396.4
Total	**4,162.5**	**3,723.0**	**3,272.0**	**2,565.8**	**1,142.8**	**589.9**
% change	**0.0%**	**-10.6%**	**-21.4%**	**-38.4%**	**-72.5%**	**-85.8%**

Figure 20 shows the impact of the restricted pathway on total emissions, as well as each individual emissions scope. This pathway demonstrates an 85.8% reduction in baseline emissions seen between 2019 and 2045 compared to an 87.5% reduction for the aspirational pathway. However, even with the similarity, the majority of the intervention measures impact much later, due to the restrictions in available budget. The residual emissions in 2045 are 67.2% attributed to scope 3, 13% to scope 2, with the remaining 19.8% in scope 1.

Figure 21 - Impact of the restricted pathway split by emissions source

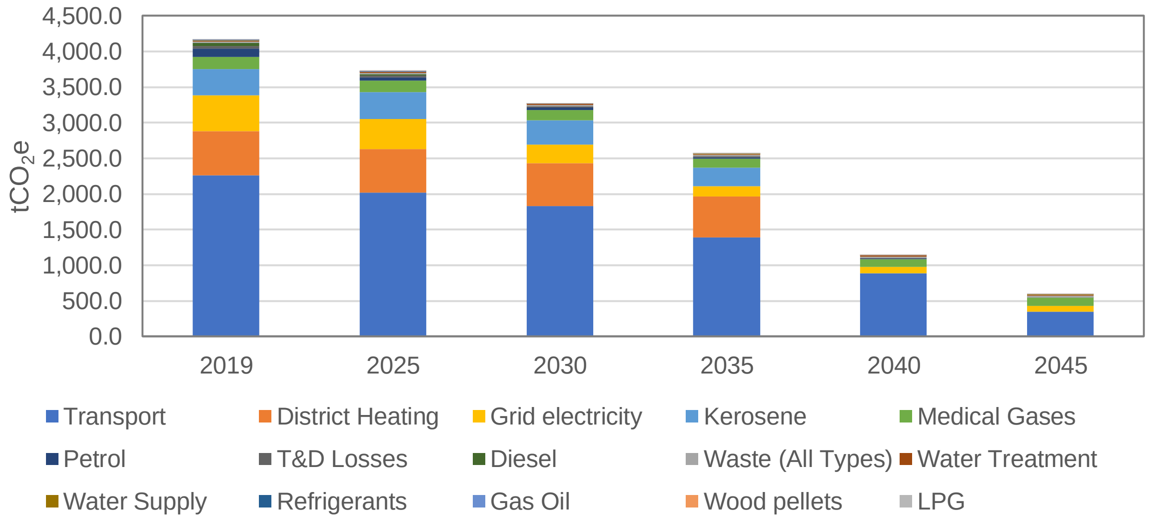


Figure 21 shows how the restricted pathway impacts each of the emissions sources that contribute to the total footprint. The impact of delayed investment can be seen, with emissions associated with diesel reaching net zero by 2030, gas oil by 2035, and district heating and kerosene reaching net-zero ten years later than under the aspirational pathway. In 2045 the residual emissions are attributed primarily to transport. However, grid electricity, and medical gases still contribute a considerable amount to emissions, with small contributions from transmission and distribution losses, waste, water supply and treatment, refrigerants, wood pellets, and LPG.

Figure 22 - Impact of the restricted pathway split by activity area

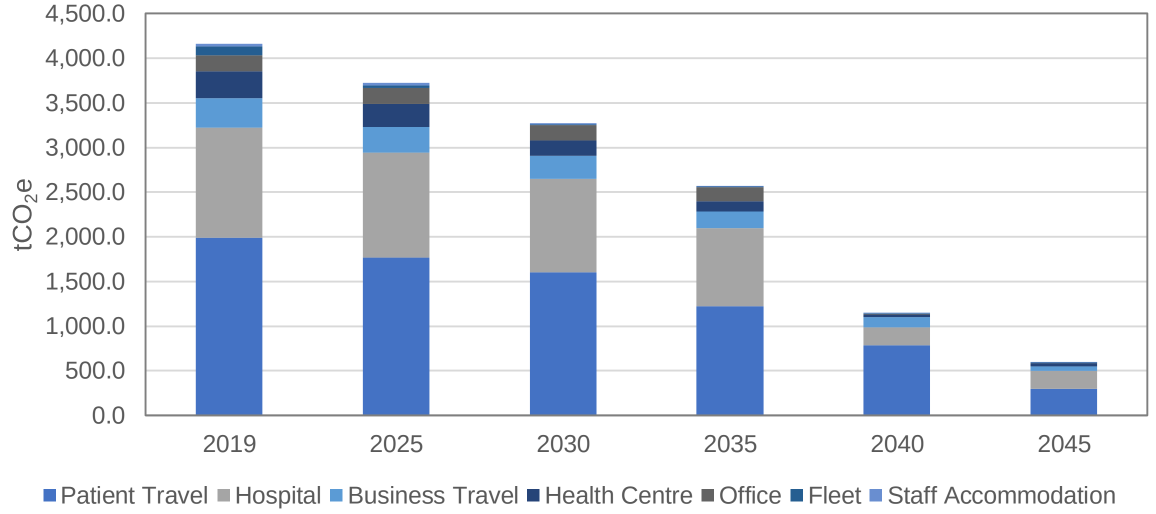
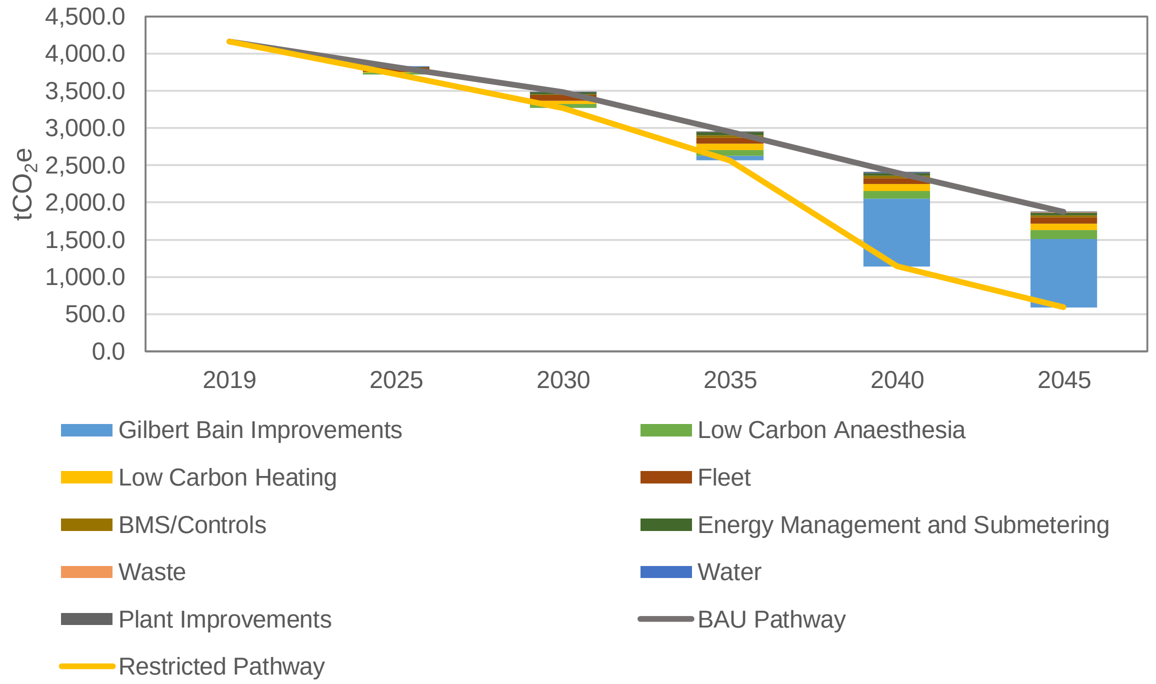


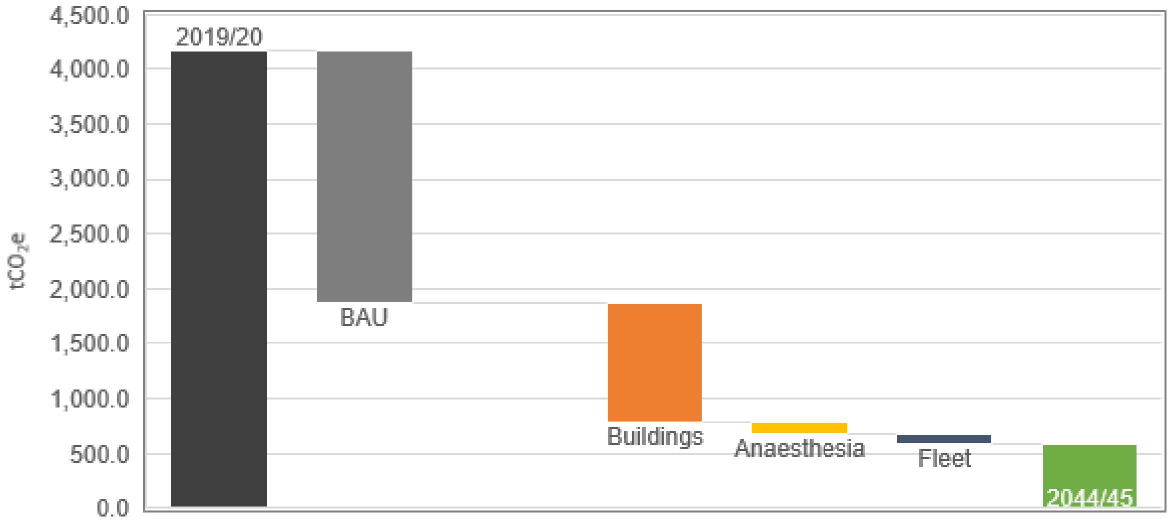
Figure 22 shows how the restricted pathway impacts each of NHS Shetland's areas of activity. The reduction of emissions from patient travel due to the repatriation of services is the most influential measure indicated, in terms of quantity of emissions reduced. This is then followed by the move towards tackling emissions via improvements to the Gilbert Bain Hospital.

Figure 23 - Comparing the restricted pathway to business as usual



Under the restricted pathway baseline emissions are reduced by 85.8% compared to 55% under a business as usual scenario. Although this is a relatively similar outcome as the aspirational scenario, the benefits realised along the way will be less, due to the relative delay in investment. Figure 23 shows the overall contribution of groups of measures to the emissions profile of the restricted pathway, which is shown as a waterfall diagram in Figure 24 below. Again, this highlights the substantial opportunity available through the move towards low or zero emission buildings through retrofitting and upgrade of the existing building stock even when a new hospital building is not an option.

Figure 24 - Carbon savings by measure for the Restricted pathway, cumulative from 2019/20 baseline to 2044/45

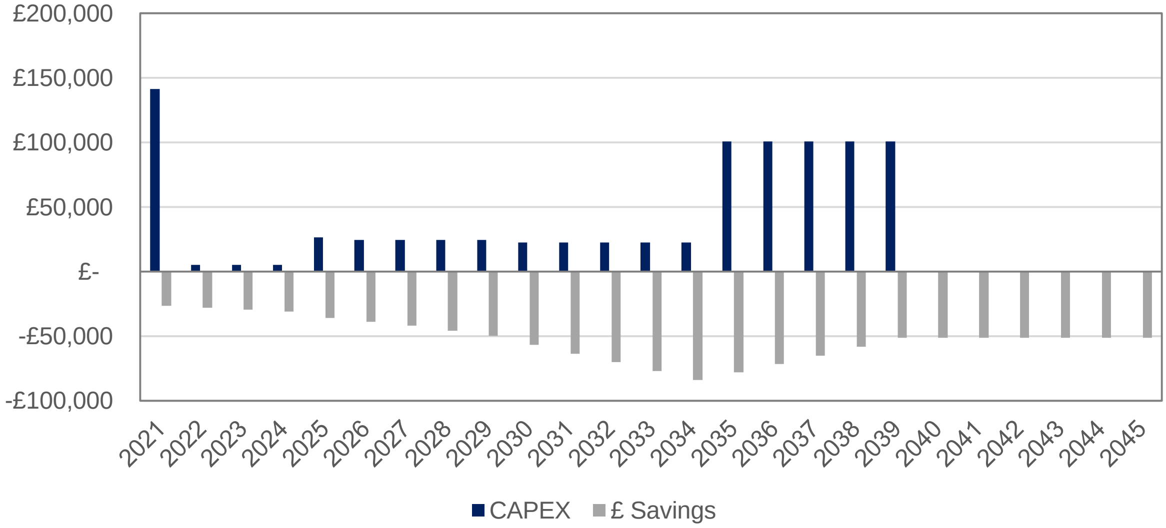


Note: In Figure 24 all measures that impact the Gilbert Bain hospital have been included under the Buildings category.

4.3.2.4 Indicative investment costs and potential cost savings

Figure 25 shows the estimated capital investment costs and fuel cost savings that NHS Shetland can expect to see when following the restricted pathway capital expenditure schedule. Unlike the aspirational pathway which requires no more investment from 2026 onwards, the restricted pathway requires consistent investment until 2039, including an initial investment in 2021 to install EV chargers and replace much of the car fleet with EVs.

Figure 25 – Estimated annual investment costs and cost savings for the Restricted pathway



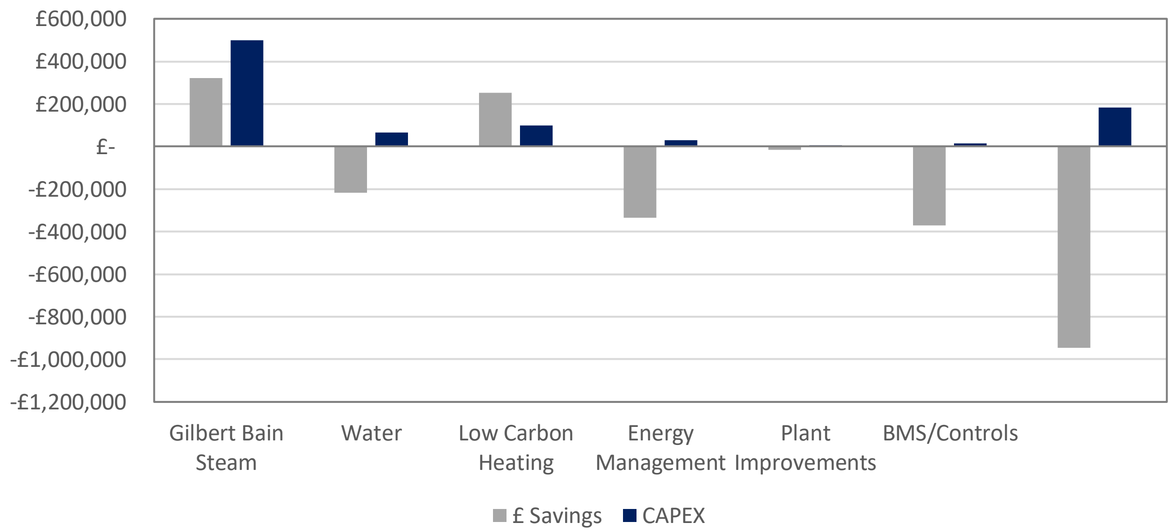
Low levels of investment are required from 2025-2034, but then investment increases significantly from 2035-2039 due to the replacement of the steam system in the Gilbert Bain hospital.

Due to the smaller and more delayed investment, fuel cost savings will peak at around £84,000 in 2034 after consistently growing annually from 2022. After 2032 the cost savings decline and eventually become negative in 2038. This is because of the high fuel cost of low carbon heating measures compared to liquid fuels, but what is important to note is that the price differential between low carbon fuels and traditional heating fuels may change from those currently predicted in the future as Government policy drives a move away from fossil fuel use.

Figure 26 shows the cumulative total estimated CAPEX cost and fuel savings for all measures from 2021-2045. The replacement of the current vehicle fleet with EVs is the second largest source of fuel savings, followed by improving building BMS and controls.

It is worth noting that the "fuel savings" for low carbon heating systems and the Gilbert Bain steam replacement system are negative - i.e. fuel costs will increase with the installation of these systems. However, this is because of the high fuel cost of low carbon heating measures compared to liquid fuels, but it is important to note is that the price differential between low carbon fuels and traditional heating fuels may change from those currently predicted in the future as Government policy drives a move away from fossil fuel use.

Figure 26 – Estimated total investment costs and fuel cost savings for each measure in the restricted pathway (2021-2045)



In summary, the Restricted pathway shows that it is possible for NHS Shetland to make significant emissions savings by 2045 (around 86% compared to the 2019/20 baseline) without replacing the Gilbert Bain Hospital. However, the actual emissions reductions would not be realised until at least 2040, and any fuel cost savings will become negative by 2038.

Patient transport and medical gases remain key unavoidable emission sources in 2045 under the Restricted pathway.

4.3.3 Balanced pathway

4.3.3.1 Overview

Balanced Pathway – attempts to find a middle ground between the two previous scenarios. The scenario assumes some restrictions on resources but also seeks to implement changes at a point where costs and risks are minimised while also reducing carbon emissions as quickly as possible given the identified constraints.

The balanced pathway model aims to find a compromise between the two previous models and recognises that there are likely to be budgetary restrictions and potentially also technological and capacity benefits from a more balanced, planned rate of implementation of some solutions. Equally, NHS Shetland will want to avoid late adoption of measures primarily because of the carbon emissions and the resulting environmental implications, but also because demand could impact on the cost of supply as the 2045 deadline approaches and public and private sectors are potentially legislated to take action.

We have therefore looked to the Balanced pathway as a route to achieving net-zero that is focussed on the 2045 deadline with the benefit of the establishment of a new low carbon hospital within the next 10 years. Certain measures are also more expansive and ambitious than the Restricted pathway. E.g. BMS/Controls measure - looking at improving/replacing existing control points vs setting implementing policies on set point temperatures, and with other supplementary measures pushed back closer to 2045.

4.3.3.2 Pathway intervention measures

The modelled aspects of the balanced pathway are set out below in Table 3.

Table 3 Balanced pathway, modelled measures

Site/Site Category	Emissions Source	Modelled measures
Gilbert Bain Hospital	Electricity	A new "Low Carbon" hospital replaces the Gilbert Bain in 2029-2030 in this pathway. Montfield HQ and Breiwick House are consolidated into the hospital at this date and existing sites are decommissioned. The new hospital sources all its electricity from zero carbon sources - either on-site renewables or local renewables with a PPA (power purchase agreement).
	Heating systems	The hospital retains a district heating connection for heating, hot water and steam generation, but the network is zero carbon by the time the new hospital is built and connected.
	Steam (Kerosene)	Steam use on site is minimised - all hot water from laundry equipment is generated from the district heat network, and local electric steam generation is only used where absolutely necessary.
	Water supply and treatment	Water use and wastewater is minimized in the new hospital during the design phase. Cooling systems are all closed loop, and all fixtures and fitting are ultra-low flow. Submetering is designed into the hospital from the ground up to allow for in-depth monitoring of energy use throughout - *supports energy management measure outlined in more detail in the Health Centres section of this table.*
	Medical gases	Emissions from medical gasses are reduced by 50%, phased from 2021 to 2030. This is through use of lower carbon impact gasses and rationalizing use of such gasses within the hospital. It is also expected that advancements in technology utilised in the new hospital will aid this reduction.
	Waste	Through improved waste segregation practices, a 50% reduction in waste in the orange stream and 30% in municipal waste are achieved by 2040 (phased from 2030)
Health Centres, Staff Accommodation and Offices	Electricity	BMS systems are updated and expanded in 2025-2028 to allow for improved monitoring and remote control in Brae Health Centre, Bixter Health Centre, Montfield HQ and Breiwick House. Through more effective monitoring, rationalization of set points and improved control (with installation of limited control points), 10% savings across electricity and heating energy use in all connected systems is achieved. Energy management & submetering: *As with Hospital section above* Due to the high cost of on-balance sheet renewables these have not been considered as part of this pathway. There would be potential to set up PPA agreement with local renewable installations but these have not been included within the modelling for this pathway.
	Heating systems	Smart heating controls to be installed in all properties that do not have a BMS system. This includes properties that have kerosene boilers or storage heaters. Both heating systems can be controlled by smart control systems that would reduce their energy consumption through better control and

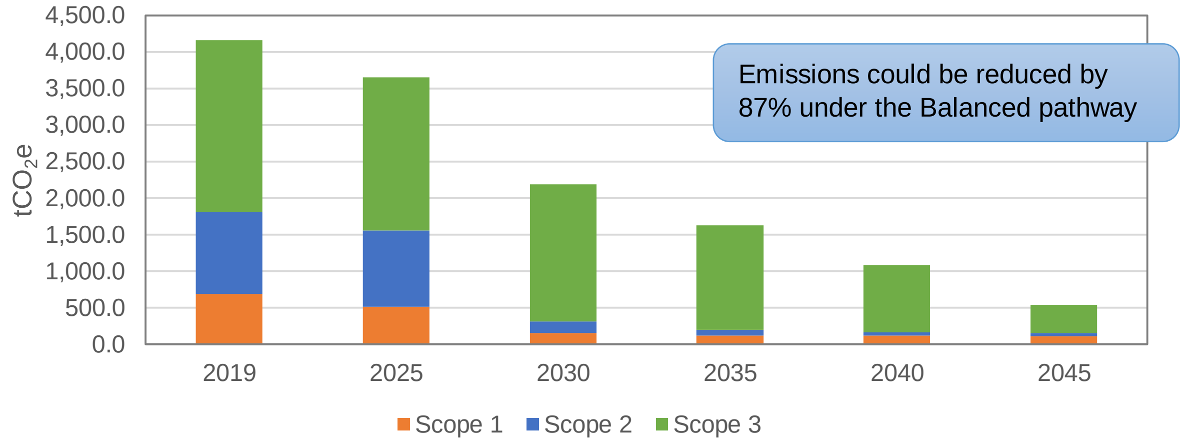
		response to external temperatures. Savings of 12% can be achieved and new controls are installed in all properties in 2025-2028 in this pathway. Improving the insulation levels in all properties would reduce the thermal losses through building fabric and therefore reduce heating system energy use. Many of the properties in Shetland have un-filled cavity walls, with four properties having solid walls due to their age. All wall cavities are filled in this pathway, with the works being carried out from 2025-2035. No external wall insulation is suggested in this pathway due to the high cost of this measure. All properties have had roof insulation upgraded within the last 10 years, and all windows and doors are double-glazed or well insulated and air-tight and are therefore not due for an upgrade. 5% heating energy savings can be achieved through this measure. For all properties with a fossil fuel heating system, air-to-water heat pumps are installed in this pathway and are sized to the heat demand of the property (taking into account other measures that impact heat demand). Five properties fall under this category, and these new heating systems are all installed in 2025-2028 under this pathway. Generally, air-to-water heat pump systems can achieve a COP of 2.5 to 3, and by installing these systems the sites would divest themselves of fossil fuel use. For all properties with a BMS system that are heated using AHUs (air handling units), upgrades of AHU fans, motors and circulation pumps to the highest standard are included. Savings of 3% on electricity use in these systems can be achieved by implementing this measure.
	Water supply and treatment	Water use and wastewater use in sanitary, domestic, laundry and kitchens are minimised by installing ultra-low flow fixtures for toilets, taps and showers. Under this pathway, works to upgrade the fixtures are carried out in 2022-2024 and can achieve water savings of 30%.
	Waste	Through improved waste segregation practices, a 50% reduction in waste in the orange stream and 30% in municipal waste are achieved by 2040 (phased from 2030)
Fleet (Cars)	Fuel	All fleet cars are modelled as being replaced with EVs in 2021 as step change in fleet.
Fleet (Vans)	Fuel	All vans are modelled as being replaced with EVs by end of 2030. Modelled as gradual change in fleet over next 10 years.
Grey fleet (personal cars)	Mileage	No additional measures have been modelled under the pathways for grey fleet, business travel or patient travel. All modelled measures are covered under BAU. For business and patient travel, no further measures have been modelled as the NHS has no direct control over these transport modes.
Business travel (flights)	Flight distance	
Business travel (ferries)	Distance travelled	
Business travel (Busses)	Mileage	
Patient travel (flights)	Flight distance	

Patient travel (ferries)	Distance travelled	
Patient travel (Busses)	Mileage	

4.3.3.3 Pathway mitigation potential

The following charts illustrate the mitigation potential for the balanced pathway.

Figure 27 - Impact of the balanced pathway split by emissions scope



	2019	2025	2030	2035	2040	2045
Scope 1 (tCO_2e)	695.3	517.4	159.7	125.4	119.6	116.3
Scope 2 (tCO_2e)	1,121.6	1,040.1	157.5	73.5	43.0	37.3
Scope 3 (tCO_2e)	2,345.5	2,090.6	1,872.5	1,427.5	925.2	387.3
Total (tCO_2e)	**4,162.5**	**3,648.0**	**2,189.7**	**1,626.4**	**1,087.8**	**541.0**
% Change	**0.0%**	**-12.4%**	**-47.4%**	**-60.9%**	**-73.9%**	**-87.0%**

Figure 27 shows the impact of the balanced pathway on total emissions, as well as each individual emissions scope. The overall reduction in emissions seen between 2019 and 2045 is 87%. As would be expected, the rate of reduction falls between the restricted and aspirational pathways, although it is relatively similar in both restricted and balanced pathways by 2045. The residual emissions in 2045 are 71.6% attributed to scope 3, 6.9% attributed to Scope 2, with the remaining 21.5% in scope 1.

Figure 28 - Impact of the balanced pathway split by emissions source

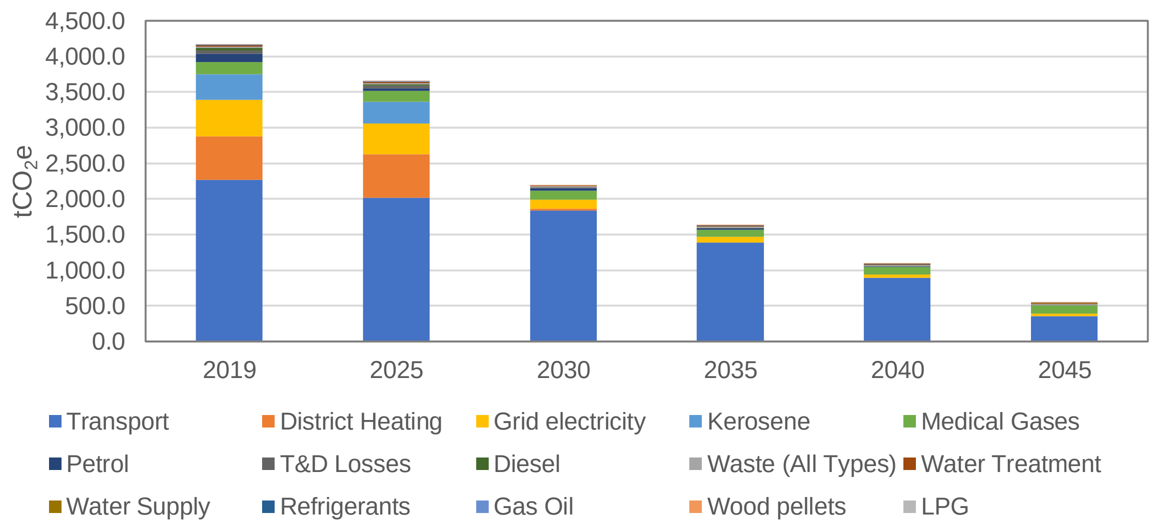


Figure 28 shows how the balanced pathway impacts each of the emissions sources that contribute to the total footprint. In 2045 the residual emissions are attributed primarily to transport and medical gases, with small contributions from grid electricity transmission and distribution losses, waste, water supply and treatment, refrigerants and wood pellets.

Figure 29 - Impact of the balanced pathway split by activity area

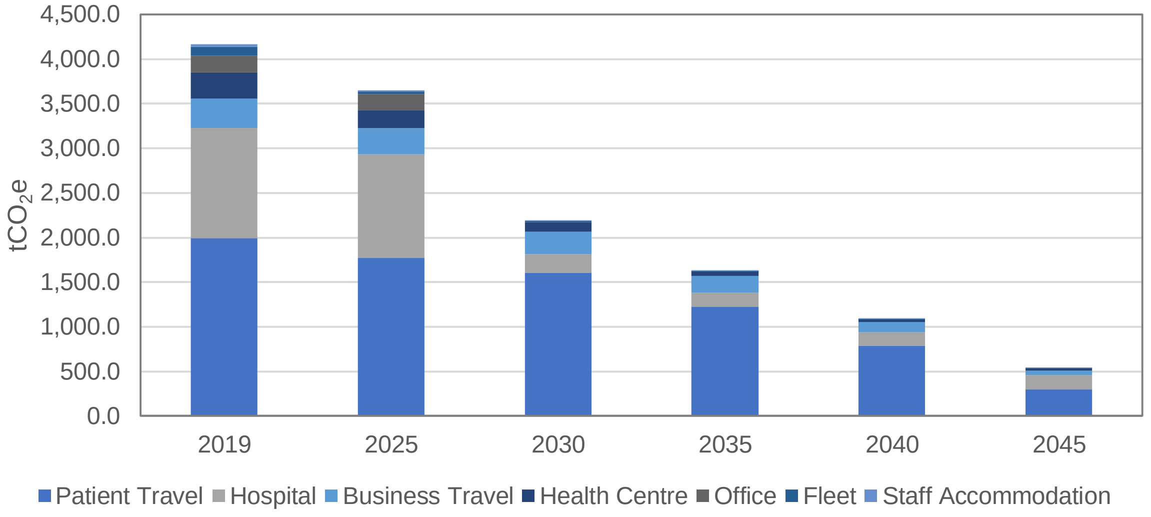
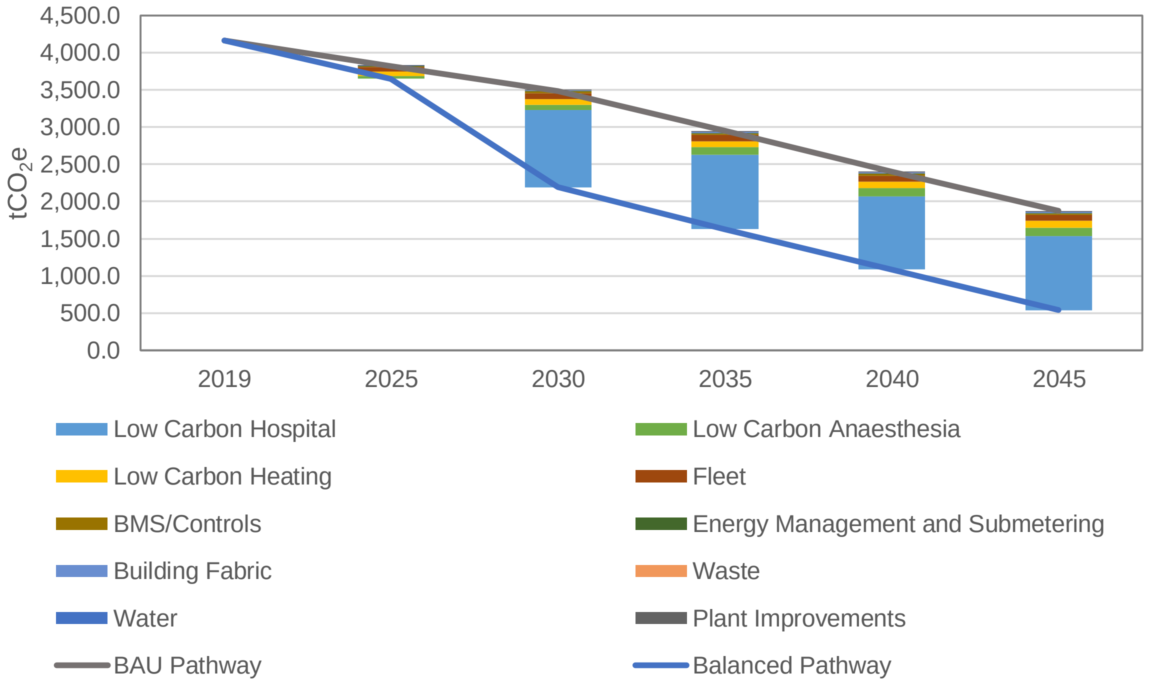


Figure 29 shows how the balanced pathway impacts each of NHS Shetland's areas of activity. The reduction of emissions from the new low carbon hospital is the most influential measure indicated, in terms of quantity of emissions reduced. This is then followed by the reduction in patient travel due to the repatriation of services.

Reductions in emissions associated with business travel and fleet are primarily associated with the projected electrification of the transport sector. The trajectory for these changes is expected to be the same for all scenarios.

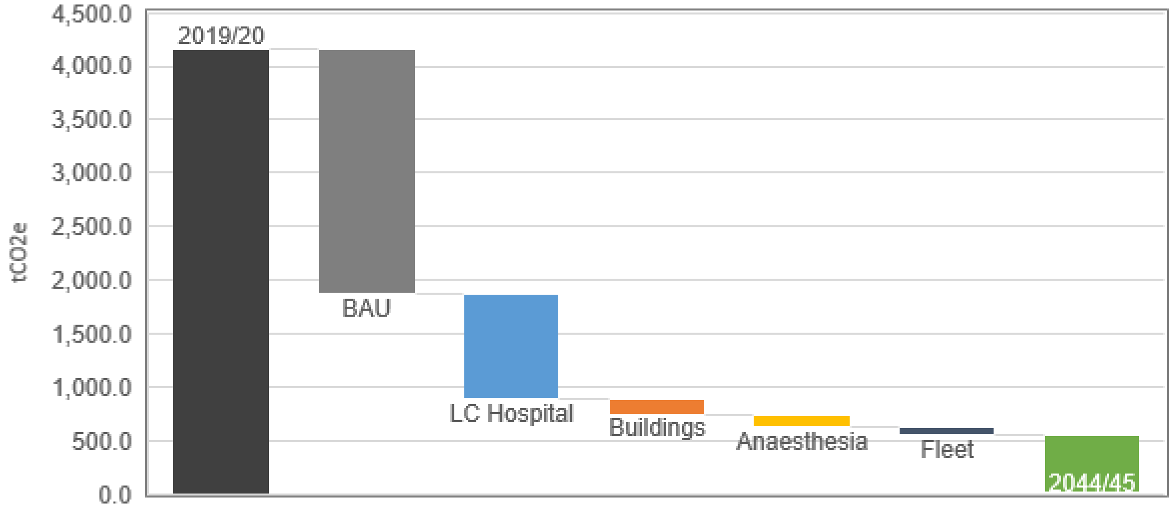
In 2045 most residual emissions (55%) are associated with patient travel.

Figure 30 - Comparing the balanced pathway to business as usual



Under the balanced pathway baseline emissions are reduced by 87% compared to 55% under a business as usual scenario. Figure 30 shows the overall contribution of groups of measures to the emissions profile of the balanced pathway, which is shown as a waterfall diagram in Figure 31 below. Again the reduction of emissions from the low carbon hospital is the most influential measure indicated, in terms of quantity of emissions reduced.

Figure 31 - Carbon savings by measure for the Balanced pathway, cumulative from 2019/20 baseline to 2044/45

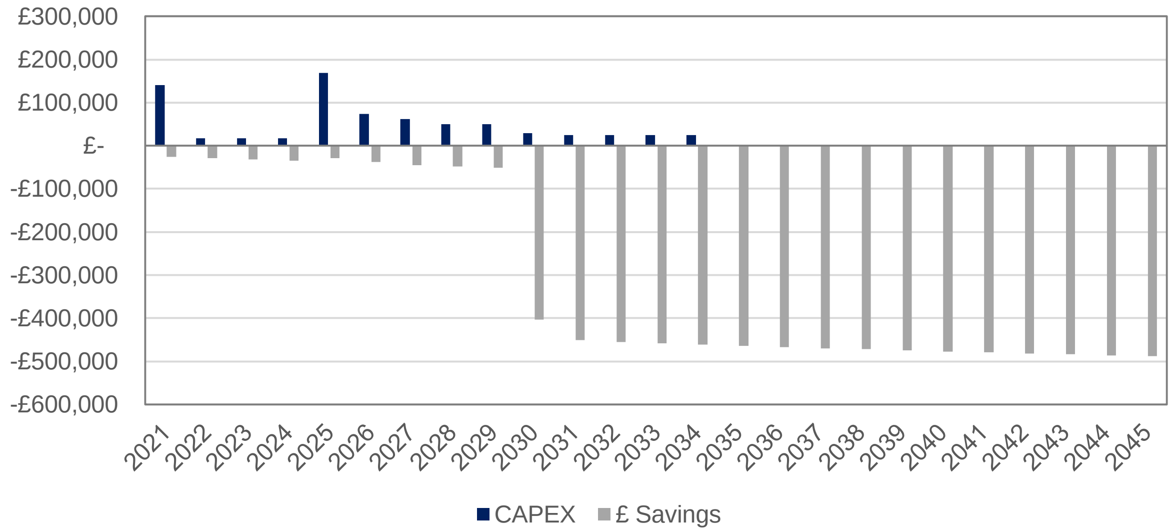


Note In Figure 31 LC Hospital is shorthand for Low Carbon Hospital.

4.3.3.4 Indicative investment costs and potential cost savings

Figure 32 shows the estimated capital investment costs and fuel cost savings that NHS Shetland can expect to see when following the balanced pathway capital expenditure schedule, excluding the cost of constructing the new hospital.

Figure 32 – Estimated annual investment costs and cost savings for the balanced pathway



Investment is highly variable from 2022-2029 with a peak in 2025 due to low carbon heating installations. Fuel cost savings will peak at around £450,000 in 2031 after the replacement of the Gilbert Bain. Fuel savings from this measure alone account for ~75% of fuel savings from 2031 onwards.

Figure 33 – Estimated investment costs and cost savings for each measure in the balanced pathway

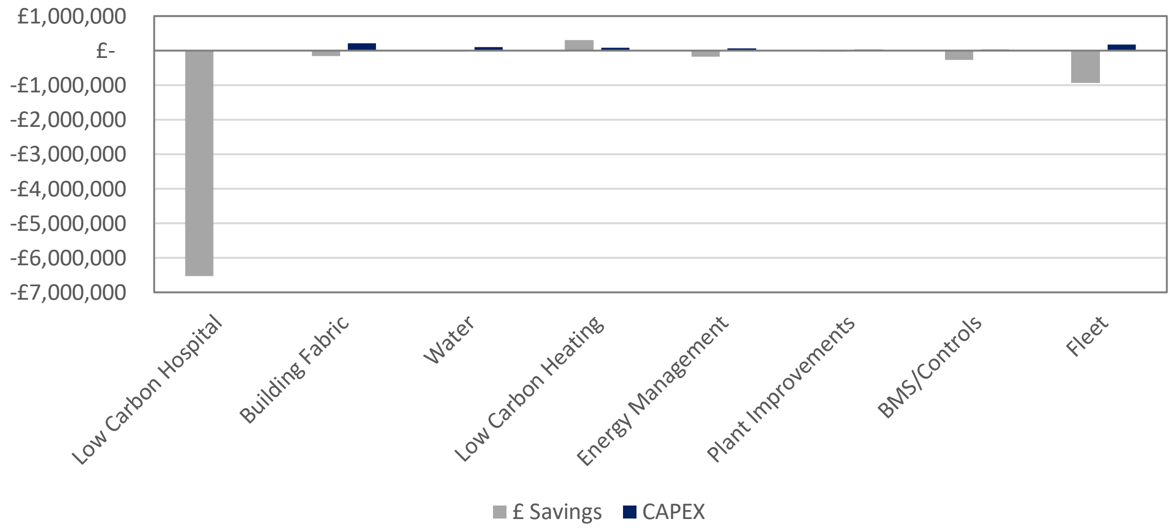


Figure 33 shows the cumulative total estimated CAPEX cost and fuel savings for all measures from 2021-2045. It can be seen that the low carbon hospital realises fuel savings of over £6.5 million from the date of implementation (2030) to 2045, though it will likely require significant investment during its construction. The replacement of the current vehicle fleet with EVs is the second largest source of fuel savings, followed by improving building BMS and controls.

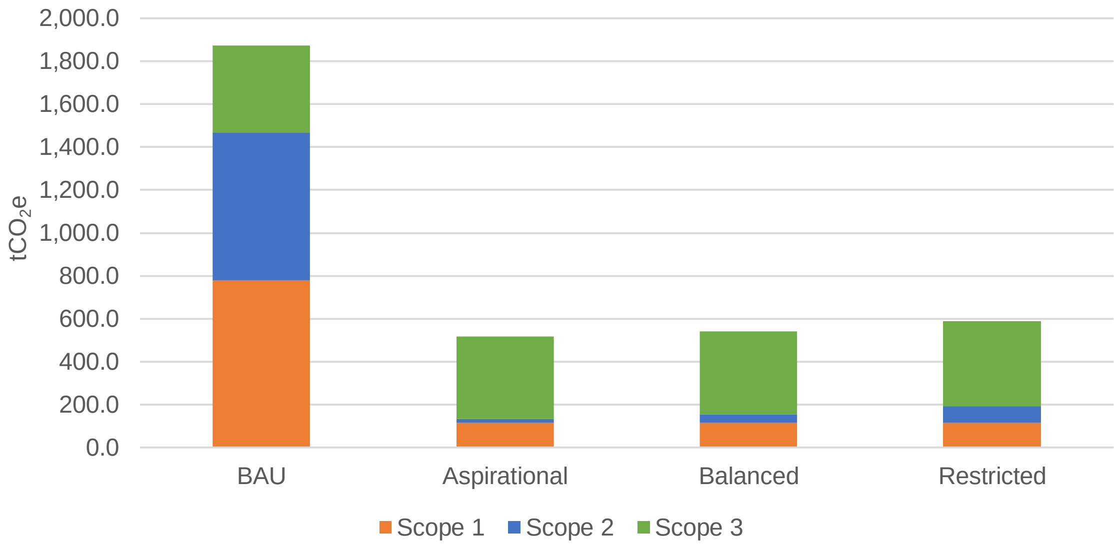
It is worth noting that the "fuel savings" for low carbon heating systems are negative - i.e. fuel costs will increase with the installation of these systems. However, this is because of the high fuel cost of low carbon heating measures compared to liquid fuels, but it is important to note is that the price differential between low carbon fuels and traditional heating fuels may change from those currently predicted in the future as Government policy drives a move away from fossil fuel use.

In summary, the Balanced pathway shows the rationalised pathway to reducing emissions for NHS Shetland, and could achieve an 87% reduction on 2019/20 emissions before considering offsetting or other measures to remove carbon. The key difference between the Aspirational pathway and Balanced pathway is the *rate of implementation of measures* not related to the establishment of the new low carbon hospital. The Balanced pathway assumes there will be very little budget available for other measures until much closer to 2045, which is reasonable when considering the cost of the new hospital.

4.3.4 Residual emissions

Regardless of the scenario that NHS Shetland chooses to adopt, there will be residual emissions remaining in 2045, a breakdown of scope and the categories of emission is provided below in Figure 34 and the supporting table. This has been calculated as a percentage of the 2019/20 baseline for each pathway, and, consistently across all pathways, contains a significant contribution from scope 1 medical gases and scope 3 patient transport emissions. As expected, the Aspirational pathway contains the lowest residual emissions of all possible pathways, with the Balanced pathway achieving very similar levels in the year 2045 once all recommended measures have been implemented.

Figure 34 - Residual emissions in 2045, all pathways



Emissions area	BAU (tCO_2e)	Aspirational (tCO_2e)	Balanced (tCO_2e)	Restricted (tCO_2e)
Transport	435.1	351.6	351.6	351.6
District Heating	611.3	0.0	0.0	0.0
Grid electricity	83.1	20.2	39.9	82.7
Kerosene	463.6	0.0	0.0	0.0
Medical Gases	228.6	114.3	114.3	114.3
Waste (All Types)	24.0	17.6	20.2	22.1
Water	23.3	12.8	12.9	16.8
Other Fuels	4.0	2.0	2.0	2.3
Total	**1,873.0**	**518.6**	**541.0**	**589.9**
% of 2019/20 baseline	**45%**	**12.5%**	**13%**	**14.2%**

4.3.4.1 Offsetting

While outside of the project scope, it is useful to understand the scale and potential cost of offsetting residual emissions to achieve net-zero emissions in 2044/45. We have estimated the cost of offsetting residual emissions in mid-century at £160/tCO_2 based on a recent assessment by the Grantham Institute[10]. This sets the carbon price at a level equivalent to the projected marginal abatement cost, the price signal considered necessary to deliver net-zero in UK industry.

Based on the modelled pathways, the cost of off-setting residual emissions for the year 2044/45 would be:

- BAU: £299,680.
- Aspirational: £82,977.
- Balanced: £86,559.
- Restricted: £94,380.

We understand HFS plans to develop a future national offsetting strategy but would make the point that there are more options than offsetting to tackle residual emissions such as insetting emissions reduction projects within the supply chain and downstream activities. **Of particular relevance to NHS Shetland is the option to offset grid electricity emissions by purchasing renewables tariff electricity, which accounts for approximately 50% of all residual emissions in the BAU, Balanced and Restricted pathways.** This enables climate-related expenditure to remain within NHSScotland's value creation cycle and reduces heavy spend on transactional costs for offsets.

[10] http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2019/05/GRI_POLICY-REPORT_How-to-price-carbon-to-reach-net-zero-emissions-in-the-UK.pdf

5 Summary of outcomes

The figure below shows the emissions trajectory for all pathways.

Figure 35 - Pathway comparison

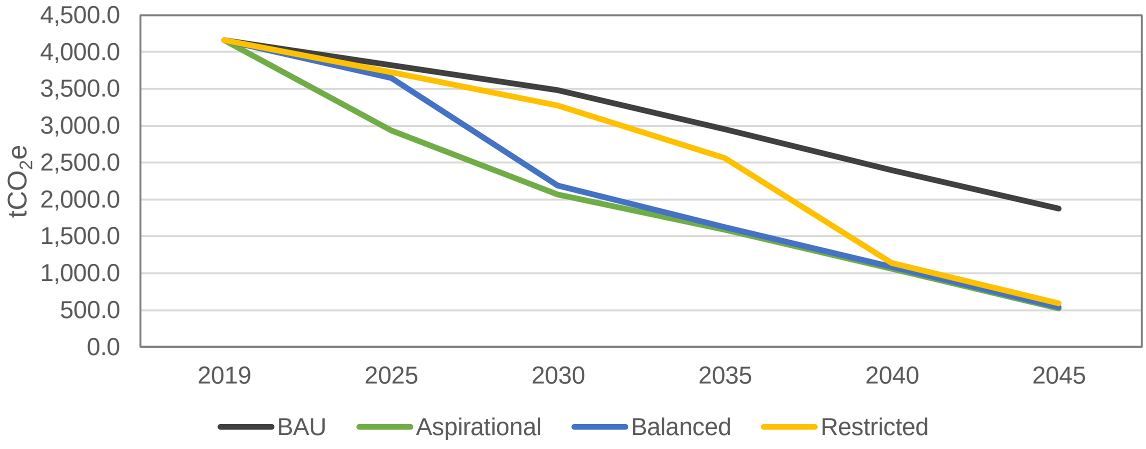
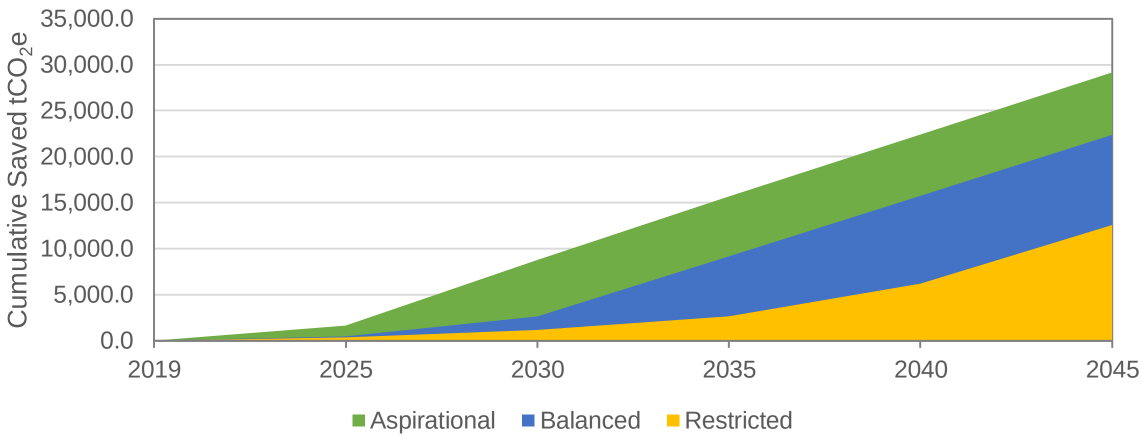


Figure 35 shows that all pathways ultimately lead to a reduction in baseline emissions in 2045 that is greater than the expected 55% under Business As Usual. The key differences are the rate at which emissions are reduced, which is greatest for the aspirational pathway and lowest for the restricted pathway. If the priority for NHS Shetland is achieving the target of net-zero by 2045, then there is no driver to implement measures earlier than this date. Figure 36, below, demonstrates an important implication of these differences, where there is a **clear carbon saving benefit from taking earlier action**. Cumulative emissions savings should be considered alongside the cost of implementing measures (and when budget would realistically be available) as there are wider societal and environmental benefits of saving carbon earlier than the 2045 target.

Figure 36 - Cumulative emissions savings per pathway



Delaying action under the restricted pathway would mean accumulating only 43% of the total emissions saved by 2045 compared to if the aspirational pathway was implemented. This can also be compared to the balanced pathway, which would save 77% of the aspirational pathway total emissions by 2045.

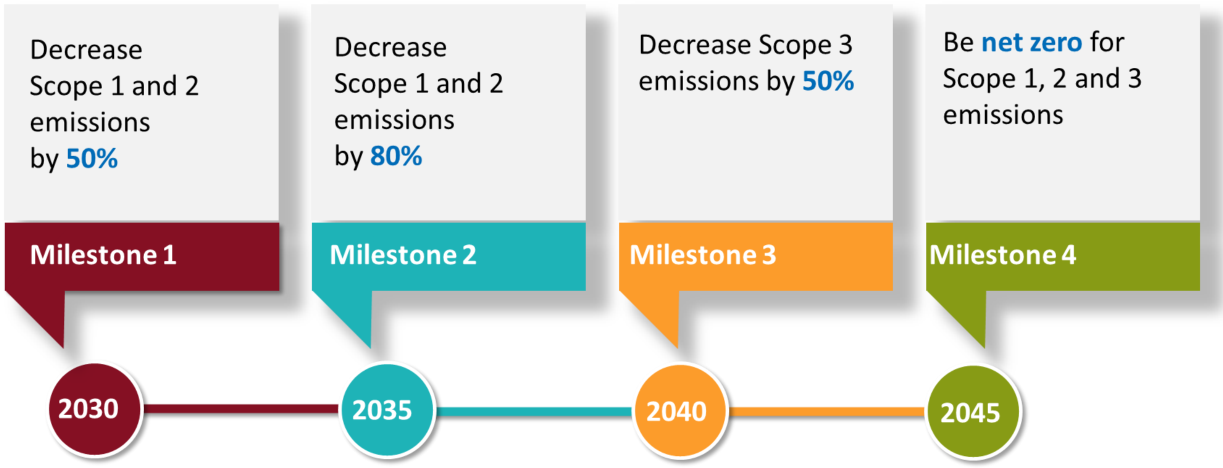
5.1 Supporting targets and commitments

Over and above the NHSScotland commitment to achieving net-zero emissions by 2045, it would be beneficial for each Board to set their own supporting targets that align with the direction of travel across the pathways modelled in this report. Benefits include:

- Sets Board-specific targets that act as drivers for change
- Encourages ownership and accountability within the Board
- Breaks down the target into manageable components
- Readily communicable to external and internal stakeholders
- Assists and implementation planning
- Breaks a long-term commitment down into manageable timeframes

Our suggested supporting targets and commitments for NHS Shetland, taking into account the modelled pathways to net-zero and what is feasible to achieve, are detailed in Figure 37 below.

Figure 37 - Suggested supporting targets and commitments for NHS Shetland, against the 2019/20 baseline



These suggested targets are aligned to NHSScotland commitments[11] including:

1. **NHSScotland will be a 'net-zero' GHG organisation by 2045 at the latest**. Importantly for this routemap, scope 1 and scope 2 being absolute zero by 2045 (other than unavoidable emissions), and net-zero when including scope 3 emissions.
2. **All NHSScotland new buildings and major refurbishments to be designed to have net-zero GHG emissions from April 2020**.
3. **NHSScotland transport GHG emissions from its owned fleet (small/ medium vehicles) will be net-zero by 2025**.

Where Scottish Government has set targets relating to a 1990 baseline[12], an analysis of the equivalent emission scope could be undertaken to compare the baseline with the scope of this study. While much of the energy using equipment and power requirements have remained the same since 1990 for NHS Shetland, no robust emissions factors existed at that time that would provide an equivalent comparison of reductions for the same emissions sources in the 2019/20 baseline and projection without additional work to evaluate this.

[11] http://www.healthscotland.scot/media/2832/1_governance-and-policy_towards-a-net-zerro-nhs_kate-dapre.pdf
[12] https://www.gov.scot/policies/climate-change/reducing-emissions/

6 Conclusions and next steps

This report provides the context and evidence for this assertion and should be viewed as a positive contribution to achieving longer-term sustainability and health goals across the NHSScotland estate.

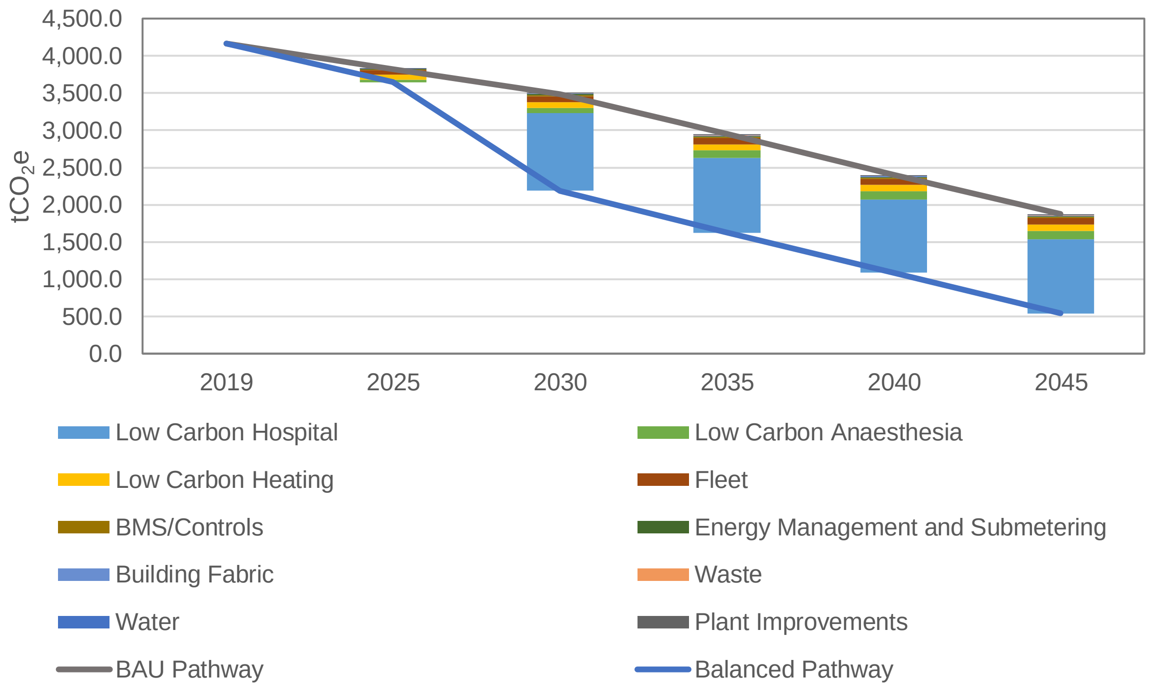
Aligned with this opportunity, a proactive approach as modelled by both the Aspirational and Balanced pathways (and continued in the suggested supporting targets above) could avoid a situation where NHS Shetland finds itself approaching the 2045 deadline and is having to pay a premium for low-carbon solutions because demand exceeds availability. This could be exacerbated by a late rush to adapt by the private sector, facing punitive legislation, which ultimately could lead to NHS Shetland missing the 2045 deadline.

There are, however, risks associated with delaying action until closer to the 2045 deadline; NHS Scotland could find that there is high demand and limited capacity for low carbon solutions as the deadline approaches which could result in planned actions not being taken or higher costs being incurred. This could be exacerbated in the Shetland Isles as they could find UK-based installers less willing to work in the Shetlands when there is significant local work available. Delaying actions will also lead to higher carbon emissions over the period which will exacerbate climate change globally.

As modelled in the three pathways, there are significant differences in the capital investment profile that come about through the mixture of measures selected, their year of installation and the corresponding cost savings from, primarily, fuel switching but also efficiencies in energy use overall. The pathways with the highest investment demonstrate a faster route to net zero, and a higher level of overall long-term savings.

The recommended pathway for NHS Shetland to follow is the Balanced Pathway, which addresses the major emissions sources from the Gilbert Bain through investment in a new low carbon hospital by 2030, while implementing measures to reduce all other emission sources over a longer timescale to 2045 and achieving an 87% reduction in emissions from the 2019/20 baseline, as summarised in Figure 38 below.

Figure 38 - Comparing the balanced pathway to business as usual



In spite of the risks outlined, it can be argued that the public sector has a duty to lead the way on investing in low and zero-carbon, provided that it is given the appropriate funding. Strong policy direction and clear requirements for future low carbon buildings (and low-carbon technologies if the option to establish a new hospital is not deemed feasible or will experience significant delay) will give the market confidence to develop solutions and generate efficiencies of scale, paving the way for the rest of society to follow.

Given Scotland's aging population, early investment to cut carbon emissions would also mean that as the pressure on budgets increases over time, NHS Shetland will already have made the investments necessary to transition to a low carbon solution and will be benefitting from the efficiencies it generates.

Most importantly, early adoption of low and zero-carbon solutions will lead to early cuts in carbon emissions which will have long term global health benefits. These benefits will be a direct result of NHS Shetland cutting its emissions and, just as significantly, through supporting market transformation.

Wider conclusions

Ricardo completed a study of local energy systems on small islands across Scotland in 2019, which highlighted that island resilience was reliant on key anchor services, such as those provided by the NHS and that the NHS infrastructure can form a hub for the decarbonisation of local island energy systems[13] identifying options for the decarbonisation of heat, power and transport as an interconnected system. Heat networks and district heating are likely to feature strongly in heating for NHS sites in the coming years. Scottish Government work in this area (e.g. LHEES) shows strong desire to develop these systems. NHS Shetland is one of the first to have a relationship with a heat network and efforts to maximise utilisation and decarbonise the heat network as well as how commercial relationships are handled could all be invaluable in providing guidance to other health boards who are in areas where district heating is being developed. We recommend NHS Shetland seek to share learning and experience with other island health boards.

Emerging technologies such as hydrogen have the potential to play a significant role in NHS Shetland achieving its zero carbon target, however the technology is not yet at a point where it can be widely deployed. We recommend NHS Shetland keep a watching brief on the market readiness of hydrogen and, if possible, seek to identify opportunities for demonstrator projects which could inform future revisions of this strategy. For example, a pathfinder project is proposed to convert the gas network in Stornoway to Hydrogen and NHS Western Isles will be an important stakeholder in that project as well as being a potential trial site for integrating hydrogen heat or CHP technologies into the NHS estate more widely.

Finally, from a funding perspective, published in February 2021, the Scottish Government Draft Heat Strategy[14] highlights the plan to bring forward a new Scottish Green Public Sector Estate Scheme during 2021 - drawing together capital grants, loans, and other revenue funding mechanisms - as the main government-led capital funding mechanism to support leadership for heat decarbonisation right across the public sector, so it will be vitally important that NHS Shetland continues to develop the business case for some or all of the recommended measures.

[13] https://www.hie.co.uk/research-and-reports/our-reports/2020/april/06/small-islands-energy-system-overview/

[14] https://www.gov.scot/publications/heat-buildings-strategy-achieving-net-zero-emissions-scotlands-buildings-consultation/

NHS Shetland has a strong opportunity to achieve net-zero by 2045, with significant options to implement measures to reduce the need for expensive off-setting requirements in the year 2044/45.

To achieve net zero through divestment from all fossil fuels, NHS Shetland needs to implement the following measures at a minimum when following the balanced pathway outlined in this document:

General

- Develop an action plan for the implementation of measures outlined in the balanced pathway, and set up strong internal governance by:
- Setting up a Net Zero taskforce within NHS Shetland that has responsibility for driving the implementation of the measures outlined in the balanced pathway, as well as monitoring the outcomes of these measures.
- Maintain the routemap as a live document, with regular reviews of the measures recommended within the report, in particular whenever there is a major investment decision that would have a significant impact on emissions and/or ahead of major milestones being reached, such as emissions calculations for 2029/30.

Buildings

- Replace the Gilbert Bain hospital with new low carbon hospital – this must have no fossil fuel consuming plant.
- District heating: As multiple properties (likely including the new low carbon hospital) are connected to the district heat network, the network needs to become zero carbon by divesting from using heavy fuel oil during fuel shortages or periods of high demand.
- Other properties: Replace fossil fuel heating systems with electric heating systems such as heat pumps or electric heaters.
- Source all electricity from renewable sources, either from on-site renewables, power purchase agreements, or green tariffs from energy suppliers.
- Improve waste segregation to increase proportion of recycled waste across all properties, and implement policies and awareness campaigns to reduce waste where possible.

Transport

- Continue with current plans to replace all fleet vehicles with low carbon models such as EVs or hydrogen fuel cell vehicles.
- Ensure there is sufficient charging infrastructure on NHS properties to enable the above.
- Work collaboratively with Shetland Islands Council on an EV infrastructure strategy that will cover grey fleet for the Board.
- Develop low carbon business and patient travel policies and reduce all travel by high carbon forms of transport (e.g. aircraft) where possible.
- Participate as an active stakeholder in promoting and supporting low carbon air and ferry transport to influence decision making across the region.

Other identified measures across all three potential pathways are aimed at reducing absolute emissions through efficiency improvements, better operating practices through implementation of policies, generating electricity from renewable sources, or replacement of existing equipment with high-efficiency models.

Appendices

A1 NHS Shetland BAU modelling: modelled changes, growth and efficiency rates

Site/Site Category	Emissions Source	Modelled BAU Changes	Growth (+% y-o-y)	Efficiency (-% y-o-y)
Building stock	Multiple	None - although there are plans for a Net Zero hospital to replace the Gilbert Bain this is not confirmed and as such will be included within the potential net-zero pathways rather than the BAU.	No change	No change
Gilbert Bain Hospital	Electricity	An MRI scanner is due to be installed in the Gilbert Bain Hospital by 2022. This has been modelled to increase the annual consumption by 28,000kWh - based on 19.9kWh per scan and 650 scans/year plus 15,000kWh for cooling systems. A New CT scanner is going to be installed that will increase scans within the Gilbert Bain by 10% (150/year). This will increase annual consumption by 180kWh based on 1.2kWh/patient.	2.2%: Driven by population growth and increasing number of appointments/patient/year, plus new medical technology.	0.5%: Reflects incremental improvements in technology.
	District heating	No projects were highlighted that will impact district heating use within properties.	0%: Despite increasing population the heating requirement for the properties will not change accordingly.	0%: Heating efficiency will not change with time unless improvements made.
	Kerosene (steam cleaning)	No projects were highlighted that will impact steam boiler efficiency.	1.2%: Driven by population growth and increasing number of appointments/patient/year.	0%: Steam boilers efficiency will not change with time unless improvements made.
	Water supply and treatment	No projects were highlighted that will impact water usage in these properties.	1.2%: Driven by population growth and increasing number of appointments/patient/year.	0%: Water use efficiency will not change with time unless improvements made.
	Refrigerants	No projects were highlighted that will impact refrigerant gas losses on site.	0%: No change to usage of AC units.	0%: No changes in refrigerant losses without replacing equipment.
	Medical gases	No projects were highlighted that will impact anaesthetic gas usage on site.	1.2%: Driven by population growth and increasing number of appointments/patient/year.	0%: No changes in anaesthetic gas usage without policy/equipment changes.
	Waste	No projects were highlighted that will impact waste production in these properties.	1.2%: Driven by population growth and increasing number of appointments/patient/year.	0%: No changes to waste practices planned.

Fleet (Cars)	Fuel	Changes to the NHS fleet in Shetland are modelled as part of the three pathways. No changes are modelled as part of the BAU.	0%: No projected fleet growth.	0.5%: Reflects year-on-year improvements in engine/EV technology.
Fleet (Vans)	Fuel			
Grey fleet (personal cars)	Mileage	All grey fleet will be replaced with EVs by end of 2045 due to Scottish Government policy of halting sales of fossil fuel vehicles from 2030. Modelled as gradual change over next 25 years.	0%: No projected fleet growth.	0.5%: Reflects year-on-year improvements in engine/EV technology.
Business travel (flights)	Flight distance	Modelled following aviation improvements: 1) Sustainable aviation fuel (SAF). SAF is a biofuel derived aviation fuel that will form part of the fuel mix in aircraft over the coming decades. Recent studies have predicted it will make up 50% of the fuel mix by 2050. 2) Ongoing efficiency improvements in aircraft engines of 5% over next 25% years. 3) Electric aircraft are modelled as composing 50% of flights to Shetland by 2045 due to the short travel distance.	0.2%: Driven by population growth, assumed staff growth at same rate.	N/A: Any efficiency improvements are modelled as measures here.
Business travel (ferries)	Distance travelled	After discussions with Transport for Scotland, it is likely that all ferries will be replaced with alternative fuel versions by 2045. Due to the length of the route between Lerwick and Aberdeen, the ferry is likely to be replaced towards the end of this time period due to the challenges facing long distance alternative fuel engines. As such a gradual reduction change in ferry fuel towards green hydrogen has been modelled between 2040 and 2045.	0.2%: Driven by population growth, assumed staff growth at same rate.	N/A: Any efficiency improvements are modelled as measures here.
Business travel (Busses)	Mileage	Due to the Scottish Government's commitment to net zero by 2045 it has been modelled that all buses have been replaced with low emissions alternatives (EV/Hydrogen) by 2045.	0.2%: Driven by population growth, assumed staff growth at same rate.	N/A: Any efficiency improvements are modelled as measures here.
Patient travel (flights)	Flight distance	Aircraft efficiency measures are same as business travel (flights). The new MRI scanner will reduce number of journeys to Aberdeen by 1300/year from 2022 (650 scans now carried out in Shetland instead of Aberdeen, modelled as 2 journeys per MRI scan to reflect that multiple journeys are taken for follow up consultations.) 75% of these journeys are modelled as flights due to proportion of patient journeys flying vs taking a ferry from 2019/20	0.2%: Driven by population growth	N/A: Any efficiency improvements are modelled as measures here.

		patient travel data. This results in 975 fewer flights to Aberdeen from 2022. The planned new CT scanner will reduce the number of flights by 150/year from 2021 due to 10% additional CT scans being carried out in the GB Hospital. 75% of these journeys are modelled as flights due to proportion of patient journeys flying vs taking a ferry. This results in 113 fewer flights to Aberdeen from 2022. In addition, it is expected that through repatriation of other services to Gilbert Bain Hospital there will be 200 additional avoided from 2022, 150 of those as flights.		
Patient travel (ferries)	Distance travelled	Ferry fuel measures are same as business travel (ferries). Due to the new MRI and CT scanner, as well as other services being repatriated to Shetland, ferry journeys are modelled to reduce by 413 journeys from 2022.	0.2%: Driven by population growth	N/A: Any efficiency improvements are modelled as measures here.
Patient travel (Busses)	Mileage	Due to the Scottish Government's commitment to net zero by 2045 it has been modelled that all buses have been replaced with low emissions alternatives (EV/Hydrogen) by 2045.	0.2%: Driven by population growth	N/A: Any efficiency improvements are modelled as measures here.

A2 Scenario parameter framework

Scenario parameters relevant to NHS Shetland emissions sources

Parameters	Aspirational Pathway	Restricted Pathway	Balanced Pathway
Budget constraints	No constraints – carbon is leading factor rather than cost	Cost is restricting factor, so all changes are delayed until market matures for each measure	Carbon is leading factor, but cost must be considered
Fossil fuel use	No fossil fuel use for transport by 2030 and for heat by 2040 - the timeline for decarbonisation of heat and transport is **accelerated**	No fossil fuel use for transport by 2030 and for all other major uses by 2045 - the timeline for decarbonisation of heat and transport is **conservative** & dependent on payback	No fossil fuel use for transport by 2030 and for heat by 2045 - the timeline for decarbonisation of heat and transport is **balanced**
Energy source	Fuels are switched to low or zero carbon alternatives as quickly as possible Off-grid energy production is prioritised alongside accelerated decarbonisation as part of reviewing local grid capacity along with off-balance sheet renewables	Fuels are switched to low or zero carbon alternatives over a gradual timescale Green procurement of electricity through Scottish Gov contract is prioritised with only off-balance sheet renewables considered	Fuels are switched to low or zero carbon alternatives as soon as possible Green procurement of electricity through Scottish Gov contract combined with mix of on and off-balance sheet renewables
Efficiency measures	Measures for Energy, Building Fabric, IT, Waste and Water are prioritised & maximised without constraint	Measures for Energy, Building Fabric, IT, Waste and Water are prioritised based on short pay-backs and conservative timeline for implementation	Measures for Energy, Building Fabric, IT, Waste and Water are prioritised based on medium pay-backs and balanced timeline for implementation
Waste arisings	50% reduction in clinical waste arisings per patient episode (from improved segregation practices) 30% reduction in domestic waste arisings and <2% waste to landfill by 2030	15% reduction in clinical waste arisings per patient episode (from improved segregation practices) 10% reduction in domestic waste arisings and <2% waste to landfill by 2030	30% reduction in clinical waste arisings per patient episode (from improved segregation practices) 20% reduction in domestic waste arisings and <2% waste to landfill by 2030
Anaesthetic gases	High carbon anaesthetic gases (e.g. desflurane and nitrous oxide) are phased out and replaced by lower carbon anaesthetic gases by 2030	High carbon anaesthetic gases (e.g. desflurane and nitrous oxide) are phased out and replaced by lower carbon anaesthetic gases by 2040	High carbon anaesthetic gases (e.g. desflurane and nitrous oxide) are phased out and replaced by lower carbon anaesthetic gases by 2035

A3 Minutes of NHS Shetland Options workshop (20 January 2021)

Emissions Area	Measure	Notes/Comments	RAG Rating	Next steps
Multiple	Net Zero Hospital	To be included only in the "High Investment" scenario	Green	Ricardo to discuss internally how this will be modelled and confirm with Lawson
Transport	Electric vehicles	To look at modelling the purchase of electric vehicles in 'high investment' vs leasing in the balanced & restricted scenarios Additional assumption: charging points will need to be shared between the council and the NHS as ultimately the council run more vehicles than the NHS.	Green	Ricardo will investigate the costs/benefits of leasing and buying Ricardo to enquire with Shetland Islands Council whether they have any plans/information relating to EV charging points.
Transport	Patient transfers	Other than setting a policy of patients travelling via lowest-carbon available route, all decisions about timing and investment in low carbon air and ferry transport are out of NHS Shetland's control	Amber/Red	Ricardo to be clear in terms of what is and isn't out of NHS Shetland's control in terms of transport in writing up residual emissions.
Heat	Multiple	To be taken ahead but needs more information to flesh out.	N/A yet	Needs further discussion with NHS Shetland staff to narrow down options.
Energy Management	Energy Management & submetering	Suggested savings of 5-10% too high as staff already very on the ball with energy waste. Need to reduce down and consider eSight capabilities and what impact this may have on the measure.	Amber	Needs further discussions with Tom Pye – Ed has organised a call already.
Energy Management	Controls	To be taken ahead but needs more info to flesh out.	Amber	Ed to discuss with Steve to obtain more information.
Energy Management	Building envelope	All buildings already have roof insulation. Many also have modern glazing and doors because of challenging weather in Shetland.	Amber	Ed to discuss with Steve to obtain more information.
Energy Management	Plant	This will only impact the Gilbert Bain under the Balanced and Low investment pathways. Need more info to fully flesh out.	Amber	Ed to discuss with Steve to obtain more information.

Energy Management	Lighting	Almost all lighting already LED.	Red	Measure not to be taken forward due to most lighting (95%+) already being LED and the rest due for replacement under maintenance replacement.
Renewables	Wind	Model as part of High investment pathway for new hospital. Not relevant for other scenarios as land near the Gilbert Bain is not available for turbine placement.	Green	
Renewables	Roof and car park mounted PV	Good potential option. Interested to see more evidence re stability of car park mounted PV re Lerwick windspeeds	Green	Callum to discuss existing pilot projects on Shetland with contacts at council
Water	Water metering	Will need to be justified in report before inclusion	Amber/Red	
Water	Water plant	All plant recently replaced? Need to check with Steve to make sure no plant remaining. This will only impact the Gilbert Bain under the Balanced and Low investment pathways.	Amber/Red	Ed/Stuart to discuss with Steve to obtain more information.
Water	Reduce sanitary water use	This will only impact the Gilbert Bain under the Balanced and Low investment pathways. All other sites under all pathways. Concerns over meeting healthcare setting needs.	Green/Amber	Ed/Stuart to discuss with Steve to obtain more information.
Waste	Improve waste segregation	Already feel they are segregating waste as best they feasibly can.	Red	Measure not to be taken forward
Anaesthetic gasses	Change to low carbon gasses	Gas supplies are purchased under national contract. Louise Bradney has confirmed that low carbon gases are available under the existing contract, so feasible.	Green/amber	

A4 Description of each short-listed measure

1 Net Zero hospital

During the project it has been highlighted that NHS Shetland has been investigating the potential for replacing the Gilbert Bain Hospital with a low carbon hospital, which could be established within the next decade. The replacement of the Gilbert Brain Hospital with a new-build low carbon hospital would likely only occur under the high investment scenario, unless there are key drivers that would override the financial implications of a full hospital replacement (e.g. building age, condition, cost of repairs). Such drivers can be exemplified through NHS Orkney, which replaced its Balfour Hospital in 2019 with an improved low carbon replacement (see section 4.3.1 for a short case study for more detail).

Replacing the Gilbert Bain Hospital under the high investment scenario would mean that many of the measures in this section are not appropriate, unless they are very short-term and the hospital is not due for replacement in the next few years.

2 Heat

2.1 Air to air heat pumps

Multi-split air to air heat pump systems connect one or more outdoor units to multiple indoor units using refrigerant. These units can provide heating and cooling and many units can recover heat between areas of heating and cooling making them ideal for buildings with cooling and heating demands. Key design considerations and savings include:

- Runs on grid electricity, hence low carbon emissions compared to conventional fossil fuel boilers. Especially when grid mix has a high share of renewables such as wind.
- Coefficient of Performance is highly variable as heat recovery from heated areas to areas being cooled significantly increases SCOP. In heating only SCOP can be expected to be in region of 2.5 - 3 (i.e. efficiency 250-300%).
- Requires refrigerant pipework to distribute heat.
- Does not require underfloor heating or large radiators.
- Different types of internal units can be used in combination depending on room being served – such as ceiling cassettes, wall mounted units in place of radiators or curtain heaters over doors.
- These systems can supply heating and cooling by way of air handling units. This may require existing air handling units to be replaced.
- Suited to offices due to high internal gains due to people and equipment can lead to cooling loads for much of the year.
- Suited to buildings which may otherwise be hard to treat.

2.2 Air to water heat pumps

Ait to water heat pumps have one of the most well-developed supply chains of all low carbon heat sources. They extract heat from outside air and upgrade it using a refrigeration cycle to the temperature required by the building. Most air source heat pumps can continue to operate effectively down to around –20°C outside temperature.

The efficiency of air to water heat pumps is primarily dependent upon the temperature of the water required by the heating systems and they are therefore well suited to wet underfloor heating systems. Where a building has an existing hydronic heating circuit it is likely that upgrades to that system will be required such as replacing radiators with models which have a higher surface area or replacing water to air heat exchangers in air handling units. In practice air handling unit replacement is often required.

- Runs on grid electricity, hence low carbon emissions compared to traditional fossil fuel boilers. Especially when grid mix has a high share of renewables such as wind.
- Lower capital cost than ground or water source heat pumps
- Qualify for Renewable Heat Incentive (to be replaced by Clean Heat Grant) meaning money can be received from UK Government scheme.
- High space requirement and high installation costs for Ground-Source Heat Pumps.
- For water source heat pumps, building must be located near to a sustainable source of water.

- Suitable for sites requiring up to around 500kWt

2.3 Ground/Water source heat pump

Ground/water source heat pumps follow a similar principle to air source heat pumps but extract heat from ground or water rather than air. Key design considerations and savings include:

- Runs on grid electricity, hence low carbon emissions compared to traditional fossil fuel boilers. Especially when grid mix has a high share of renewables such as wind.
- Higher ambient temperature of ground or water in winter can allow higher efficiencies but with significantly higher installation costs.
- However significantly higher capital cost.
- Qualify for Renewable Heat Incentive (to be replaced by Clean Heat Grant) meaning money can be received from UK Government scheme.
- High space requirement and high installation costs for Ground-Source Heat Pumps.
- For water source heat pumps, building must be located near to a sustainable source of water.
- Water source heat pumps are suited to higher capacity systems, such as serving district heating networks or sites requiring more than 500kWt
- Larger water source heat pump systems of over 1MWt can achieve higher temperatures while providing adequate SCOP, meaning they are suited to heat networks or sites such as large hospitals.

Note that GSHP are not considered likely to be viable at this stage due to high capital cost compared to air source. However, could be considered on individual sites at a later date.

2.4 Increase utilisation of heat network

Sites currently served by the heat network still use significant fossil fuels and therefore measures to increase utilisation of the heat network would have a carbon benefit. Key design considerations and savings include:

- Site specific measures would need to be identified to determine if LTHW can meet a greater proportion of the load.
- Existing steam use can be met by local generation for small uses such as sterilisation.
- May require updated equipment (e.g. laundry) if significant steam use remains.
- Heat medium used by air handling units and calorifiers would need to be assessed to determine if replacement units would be required.
- Site assessment would need to be carried out therefore not possible to include specific recommendations.

2.5 Electric boiler and thermal store to absorb excess electricity generation

Shetland has high levels of renewable electricity generation, grid constraints and a smart grid, and could therefore use an electric boiler and thermal store to generate heat at times of low demand to reduce wind curtailment in return for low-cost renewable heat. It may also be possible to derive revenue from such a system, particularly through an aggregator, however this is a developing market at this time. Key design considerations and savings include:

- Large hospital sites have significant heat demand all year.
- Shetland has significant renewable electricity generation and periods when supply exceeds demand leading to curtailment.
- Potential to locate an electric boiler at a hospital to absorb electricity during periods of low demand.
- Would be an innovative project as part of the Shetland smart grid – speculative at this stage.
- Could be designed to generate either low temperature hot water (under 95°) or steam. Storing heat for steam generation would require ahigh temperature phase change material.
- Would need more detailed analysis as part of a feasibility study to determine potential business case and outline technical specification.

3 Energy efficiency

The energy efficiency of a building is essential to maintaining a low carbon performance in its operations. This is often achieved through a mixture of retrofitting and energy management processes including:

3.1 Energy management

The implementation and enhancement of energy management processes in order to ensure a systematic approach to energy use and achieve reductions across the portfolio can be helpful for improving the energy efficiency of a location. This includes the implementation of suitable management processes plus the installation and use of metering / sub metering with energy data analysis, performance reporting, and working toward agreed reduction targets.

Energy management becomes increasingly important as low hanging opportunities are completed and further improvements become more difficult to identify, implement and sustain. This will include aspects such as formal site policies with senior management engagement, the setting of objectives and targets, and systematic programmes and mechanisms to report and account for energy performance at a local level (e.g. by key plant or activity, for example how much energy used per clinic per week). Typically, savings of between 5% - 10% can be anticipated from effective management systems.

Energy management can generally be applied to all operational sites. The level of metering infrastructure will depend on the amount of energy used at each site and their complexity. For example:

- A large hospital is likely to require extensive sub metering by area / department.
- At smaller facilities usually the main electricity supply and gas supply are all that need to be metered, and this can be carried out with smart meters (SMETS2 or similar) - not all facilities already on the eSight metering platform.

3.2 Controls

Improvements to controllers and control systems for buildings can reduce energy consumption through ensuring equipment only operates when required, and that it does not work harder than necessary. This may for example include controls to automatically switch equipment off, adjusting control programmes including timers, changing setpoints and increased use of sensors.

It is commonplace to find equipment operating unnecessarily in buildings and it is not uncommon to realise 10%-15% energy savings through improved control of service plant and equipment. Standard measures may be classed as:

- Amend control settings to optimise energy performance.
- Upgrade controls to facilitate ability to optimise energy performance.

A variety of potential measures exist, examples include:

Upgrades to building management systems (BMS) to increase control capability, plus optimising control algorithms.

- Use of sensors such as occupancy sensors for lighting, or CO2 sensors for air handling plant.
- Rationalisation of boiler controls settings.
- Simply reprogramming existing control units/BMS to optimise energy performance.

Improvements to controls can be applied to all operational sites, and measures will vary according to building type, size, use and installed infrastructure. However, it may be possible to group buildings by size and age in order to come up with common groups of measures. Large facilities are likely to have a BMS whereas smaller facilities are likely to have simple standalone controllers on different plant, e.g. central heating controller, or air conditioning controller.

Simpler measures will be easy to implement at low cost and will only require a competent person to carry out. These are likely to focus on optimising control settings on existing equipment. Changes to BMS will require specialist persons and potentially have modest to high costs. Some measures may require the installation of additional equipment to enable better control, e.g. occupancy sensors for lighting, more advance heating controllers for heating systems in smaller buildings, whereas BMS may require additional functionality, weather sensors, control valves and other hardware.

3.3 Building Envelope

The implementation of improvements to the building envelope can be a useful instrument in order to reduce heat loss / gain and improve insulation. This in turn will save energy through reducing the demand for heating and cooling.

Measures may include:

- Replacing windows and doors to reduce heat loss, and / or fitting better seals around doors and windows.
- Fitting air curtains and air locks to doors with high traffic to reduce heat loss.
- Fitting solar films and shades to large windows reduce heat gain.
- External / internal wall insulation, and loft / roof insulation.

Saving potential varies by measure and are likely to be in the range 3% - 10% of associated energy.

The improvement and implementation of building envelope can be applied to all sites, and measures will vary according to building type, size, use and installed infrastructure. However, it may be possible to group buildings by size and age in order to come up with common groups of measures. Older buildings are likely to have lower levels of insulation and so are likely to be better suited to these measures. For example, buildings over 30 years old are more likely to have low levels of wall / roof insulation and windows and doors older than 20 years are more likely to need replacing. Buildings with low occupancy rates or requiring low levels of heating are less suited to these measures. If the main hospital is due to be replaced in the near future, then only measures with significant carbon saving / short paybacks are advisable.

Some investigation will be required on a building by building basis to determine which measures are best suited and cost effective. For example, cavity wall insulation is relatively low cost whereas external/internal insulation on solid walls may not be economic to implement. Moreover, some insulation measures may be costly to implement, and this should be weighed against the long-term operating cost of the building factoring in the impact on energy costs to determine viability.

3.5 Plant

It is possible to reduce energy consumption through implementing improvements to building services equipment – heating, ventilation, air conditioning (HEVAC) and related equipment.

This method can be applied to all sites. However, there are a large range of efficiency measures that could be applied, and so will vary according to building type, size, use and the existing infrastructure. It may be possible to group buildings by size and age in order to come up with common groups of measures.

Larger sites will have AHUs and extensive infrastructure that could be addressed. Smaller sites are less likely to have AHUs etc, and more likely to have simpler heating systems, e.g. boiler with radiators. Here the focus will likely be on boiler replacement, better heating controller with zones control, TRVs and circulation pumps. Savings potential will vary by measure, typical range is between 5% - 20% of related energy use.

Types of measure include:

- Change technology – migrate from steam to hot water, fit PoU (point of use) hot water supplies.
- Reduce losses – improve insulation, restrict use, fit higher efficiency equipment (upgrade boilers, fans, pumps, electric motors etc.)
- Rationalise plant – consolidate multiple plant in centralised system
- Recover wasted energy – heat recovery on AHUs, boilers and compressors
- Improve controls – enable more efficient operating modes

Measures will be specific to existing infrastructure in each building and should take account of wider decarbonisation plans, e.g. if there are plans to migrate from gas fired boilers to alternative heat sources then there could be a significant impact on the way the heat is delivered, e.g. heat pumps may require larger radiators. Life of existing plant should also be taken into account, and it may be more cost effective to wait to upgrade / change plant when it reaches end of life and implement a larger more wide-ranging improvement.

4 Power

There are a range of methods that NHS Shetland could undertake to decarbonise power supply across their sites and particularly at a new net zero hospital that replaces the Gilbert Bain.

4.1 New roof-mounted solar photovoltaics (PV)

Onsite renewable generation is one solution. Typically, this would consist of rooftop solar PV and/or carpark-mounted solar PV modules directly on site. Key design considerations and savings include:

- ~500kW of cumulative rooftop capacity across all NHS Shetland building types based on roof size and roof availability approximations.
- Largest installation of approx. 100kW at Gilbert Bain Hospital.
- Year 1 generation of 311MWh saving approximately 87tCO_2e.
- Yield (i.e. generation per unit capacity) is lower for roof-mounted schemes than ground-mounted schemes due to unfavourable roof orientation/tilt and increased risk of shading from objects such as plant equipment on the roof of the hospital.
- Important to note PV modules degrade at approximately 0.3-0.5% annually.

This measure is applicable to all sites, including the Gilbert Bain Hospital, health centres, staff accommodation, Montfield Board HQ and Non Opcon. Note that Rooftop PV is easily scalable and provides a renewable generation source for even the smallest of buildings.

4.2 New ground-mounted solar PV

A ground-mounted solar PV would typically be located near to the site. A larger array would provide a greater return on investment, and it would therefore be appropriate to utilise a larger system at a larger demand sit and connect other sites where possible/appropriate. Key design considerations and savings include:

- 900kW ground-mounted solar PV system located near Gilbert Bain hospital.
- Generates approximately 630MWh annually in year 1, with around 570MWh consumed on site (around 90% of generation used on site).
- A south facing area with an equipment/plant-free area to accommodate PV modules and a 20° tilt where possible.
- Important to note PV modules degrade at approximately 0.3-0.5% annually.
- Year 1 CO_2e savings of approximately 160tCO_2e.

4.3 New carpark solar PV

A solar PV mounted on structures above car parking spaces can be applied to all heath centres and the Gilbert Bain hospital. Carpark PV is best suited to where there are multiple carparking spaces to benefit from economies of scale. Key design considerations and savings include:

- South-facing carpark spaces at the south of the building to minimise/negate shading risk.
- ~750kW of cumulative capacity across all health centres and the Gilbert Bain hospital.
- Year 1 generation of 520MWh saving approximately 150tCO_2e.
- Yield (i.e. generation per unit capacity) is lower for carpark-mounted schemes than ground-mounted schemes due to unfavourable carpark orientation and increased risk of shading from objects as surrounding buildings and trees.
- Important to note PV modules degrade at approximately 0.3-0.5% annually.

4.4 New wind generation

There should also be scope for a small-wind turbine (typically 20-100kW) located on site-owned land nearby where possible. These on-site solutions should consider any planning and grid capacity constraints when sized and should be developed so that the power is largely consumed on site rather than exported. It is recommended that the building is designed with renewables in mind.

Construction of a single wind turbine near the Gilbert Bain hospital with private wire connection include the following design considerations and savings:

- Single 500kW wind turbine.
- Approximately 50m hub height subject to wind speeds of 8-8.5m/s.
- Generates approximately 2,500MWh of power annually, with around 1,500MWh consumed across all sites.
- Provides an annual emission saving of approximately 400tCO2e, based on 2022 grid emissions factors and 1,500MWh of offset energy.
- Note that a smaller turbine could be utilised solely at Gilbert Bain if connection to other sites is not appropriate/possible.
- Grid connection costs would need to be considered for a smaller turbine.

Note that this measure applies to all sites. However, a smaller turbine will most likely be restricted to supply the Gilbert Bain hospital, with other small turbines at individual sites. Larger wind turbines are subject to higher wind speeds and therefore produce disproportionately more power and energy/CO2 savings

<u>4.5 Renewable energy tariff and PPA</u>

Current BREEAM guidance notes that the ‘Excellent’ standard for ‘Ene 01: Reduction of emissions’ requires a 25% reduction in CO2 emissions arising from building energy consumption, whilst obtaining ‘Exemplary level’ for the ‘Ene 04’ standard requires a 30% reduction in regulated CO2 measures.

Other solutions would include the purchase of renewable energy tariffs or establishing a PPA (Power Purchase Agreement). A renewable energy tariff could meet a pre-determined proportion of power from renewables that is agreed with the supplier. Meanwhile a PPA could be established whereby the site (in this case, the new net-zero hospital) is supplied with power from a local renewable energy generator. This could also be in the form of a private wire PPA whereby the site is directly connected to the renewable generator. For Shetland this is likely to come from the proposed Viking onshore wind farm (~500MW).

5 Water

<u>5.1 Water measurement and monitoring</u>

A key consideration should be to improve the measurement and monitoring of mains water supply to each building to increase understanding of water consumption across the site and to identify areas of high consumption. This can be achieved through:

- Installing smart meters / data loggers on mains supply to establish baseline flow, monitor trends and identify continuous use (e.g., leaks).
- Developing water use benchmarks based on patient numbers or occupancy of patient rooms, staff accommodation. This will provide an improved understanding of the trends in water use in the building.
- Developing a water mass balance for the site and use it to identify areas of high consumption which can be further investigated.
- Installing sub meters on water treatment plant and equipment (e.g., water softening units, reverse osmosis (RO) etc) and monitor consumption and record and analyse consumption on monthly basis.

The installation of smart meters / data loggers on mains water supply, and sub-meters on water treatment plant and equipment is applicable to all sites. However, priority should be given to sites with the largest water use, including the Gilbert Bain Hospital, Montfield Board HQ, and Brae Health Centre/Dental/Pharmacy. Smart meters and sub-meters should be installed in these sites in a restrictive spend scenario, then extended to other sites based on total consumption.

It is noted that increased measurement and monitoring does not itself reduce water consumption. However, it will provide a better understanding of water use on site and thus further measures to reduce water use can be identified. Overall, it is estimated that increased measurement and monitoring can lead to water savings in the region of 5% of the total mains supply. The associated carbon savings from reducing consumption will be based on Defra emissions factors for mains water supply / wastewater disposal.

5.2 Reduce water consumption in building plant and equipment

There are a number of opportunities to reduce mains water use through improved water management of plant and equipment in the building plant room. Some measures are applicable to all sites e.g., pressure management and maintenance of water distribution system (e.g., overflows from cold water storage tanks). Other measures will depend on the type of plant and equipment in place within the building e.g., Water treatment and the type of cooling and hot water systems. The main site for this measure is the Gilbert Bain Hospital. Key design considerations and savings include:

- Review use of treated (reverse osmosis (RO), softened etc) water and optimise so that it is only used where essential.
- Investigate the recovery and reuse of waste 'reject' water from the RO units elsewhere in the hospital (e.g., sluice systems, toilet flushing or as feed for site boilers).
- Optimise frequency of regeneration of ion-exchange beds in water treatment units.
- Establish and optimise frequency of blowdown of steam boilers and cooling towers.
- Collect condensate losses and return to the boiler system.
- Inspect cooling towers for drift losses and where necessary, install drift eliminators.
- Pressure management - optimise water pressure across the site through installing pressure reducing valves to 1.5 to 2.5 bar.
- Check and maintain float mechanisms and ballcocks in cold water storage tanks to ensure they are operating correctly.

Savings are more difficult to quantify without further information on the equipment in place and current practices. However, these can generally be as high as 20-30% in some areas i.e., reuse of RO reject water.

In terms of pathway variations, simple measures should be prioritised first e.g., establishing and optimising frequency of blowdown, and regular maintenance of water distribution system etc. Pressure management and reuse of RO reject water should also be considered. However, the latter will require higher investment.

5.3 Reduce water used for sanitary/domestic purposes

There are a number of opportunities to reduce water use in staff and visitor washrooms and toilets and patient bathrooms (i.e., WC flushing, handwashing basins and showering). Measures are applicable to all sites, including staff and visitor washrooms (all sites), patient on suite facilities, and staff accommodation, but must not compromise standards in hygiene. Ultra-low flush WCs are better suited to office buildings as they can be noisy when flushing. Key design considerations and savings include:

- Repair all dripping taps and leaking WCs. Ensure all existing fittings and fixtures are regularly maintained.
- Reduce WCs flush volumes to a maximum of 6 l/flush (minimum) and further through installation of single low flush (4l) or ultra-low flush (1.5l) WCs respectively.
- Reduce flow rates in hand wash basin taps to maximum of 6 l/min. Install electronic auto-shut off taps.
- Reduce frequency of urinal flushing through installation of passive infra-red (PIR) or time controllers to control cistern flushing to periods when the WC is in use.
- Replace urinal troughs with single urinal bowls with integrated flush controls.
- Reduce shower flow rates to 8l/min through the installation of flow regulators or low flow showerheads.

Note that water savings for each of these initiatives will vary but estimated water savings in the region of 25-30% of the total mains supply depending on the building type.

5.4 Reduce water consumption for medical activities

Reducing water consumption for medical activities is something that can be applied to hospital sites but will depend on the type of equipment installed and activities undertaken. Key design considerations and savings include:

- Reuse RO reject water from dialysis units for use in other areas of the hospital (e.g., WC flushing, sluice systems or as feed for site boilers).
- Closed loop cooling of water-cooled equipment (e.g., MRI scanners).
- Install pool covers on hydrotherapy pools.
- All decontamination equipment (washer-disinfectors and sterilisers) should be operated with full loads and wash cycles are evaluated and optimised.

Note that water savings for each of these initiatives will vary but estimated water savings in the region of 60-80% can be achieved through closed loop cooling on equipment.

6 Improved Waste Segregation

It is possible to achieve a reduction in clinical waste arisings and domestic waste arisings through an improved segregation of waste. Which can be applied to sites including the Gilbert Bain hospital, health centres, clinics, and dental surgeries. Key design considerations and savings include:

- Where possible, install dry mixed recycling bins in every ward and department.
- Install dry mixed recycling bins in areas with higher portions of packaging waste (e.g. pharmacy, wards and offices).
- Install dry mixed recycling bins in areas with higher portions of plastic waste (e.g. restaurant, public areas, clinical departments, labs, and offices).
- Install dry mixed recycling bins in areas with higher proportion of non-confidential paper (e.g. pharmacy, wards and offices).
- Provide clear bin labels on all waste bins (e.g. clinical, domestic and recycling).
- Remove clinical bins from public access areas (e.g. multi-bed hospital rooms).
- Review the positioning of clinical waste bins in each department.
- Deliver waste segregation campaign to minimise non-clinical waste in clinical bins.
- Reduce the use of single-use items and consumables (e.g. medical and surgical equipment, appliances, cleaning supplies, clinical supplies, dressings).

7 Reduction and phasing out of high-carbon Anaesthetic Gases

A reduction in anaesthetic gases could be applied to the Gilbert Bain hospital. Key considerations and savings include:

- 15% reduction in the use of anaesthetic nitrous oxide during dental procedures through changes in clinical practices.
- 10% reduction in the use of entonox in maternity settings through improved access to non-pharmacolgical pain relief.
- 20% reduction in the use of entonox in maternity settings through efficiency measures (e.g. maintenance and leak detection).

The Association of Anaesthetists and the Royal College of Anaesthetists note that volatile anaesthetic gases such as desflurane and nitrous oxide are potent greenhouse gases. Clinicians should therefore be informed and encouraged to restrict the use of desflurane and nitrous oxide to cases where they would reduce morbidity and mortality over all alternative drugs, opting for techniques such as low-flow anaesthesia using gases with lower greenhouse gas emissions, total intravenous anaesthesia (TIVA), or regional anaesthetic techniques, which limit harmful emissions. While capture and reprocessing technology exists, avoidance of emissions in the first instance is far preferable.

Sevoflurane is available on the National Procurement Framework and therefore should be a primary choice over Desflurane for NHS Shetland where applicable. This is because it has a lower global warming potential when compared to Desflurane.

8 Transport and travel

The Shetland board runs a fleet of 54 leased vehicles. The majority of these vehicles are car or vans, and there are six electric vehicles and one electric van in the fleet to date. Scope 3 emissions mainly due to travel for patients and staff are significantly higher than scope 1 or 2 emissions. This has previously been covered in business as usual work. The conclusions associated with the emissions through transport and travel are:

- 157 tonnes CO2e – Transport fleet.
- 2,266 tonnes CO2e – Emissions from travel.
- Currently, the fleet is completely managed on a lease basis.
- All vehicles bar one is less than five years old.

The main methods for reducing emissions from travel would be:

- Repatriation (MRI scanner will be installed).
- Decarbonisation of the main flights and ferries. This will only occur gradually.

8.1 Electric Vehicles

Electric vehicles are a fast-growing area. Almost all manufacturers are committing to manufacturing electric vehicles. The vehicle typically consists of a lithium-ion battery pack and an advanced drive train. Vehicle model range is expanding rapidly for cars and vans, while vehicle performance and costs are approaching parity with conventional vehicle types. The situation is less mature for larger vehicle types. Charging can still be an issue, but this is changing, and more electric vehicle chargers are being put in. Electric vehicle charging network needs to be developed and charger costs can be expensive.

The Gilbert Bain Hospital is where most vehicles are operated from. The measure has applicability across all vehicles, and there would be an additional cost for the installation of charging equipment. The number of vehicles to be converted to electric vehicles is modest and therefore by itself should not impose grid constraints. Key considerations and savings include:

- Range: Typically, around 200 miles but less for large trucks.
- Capex Cost: Typically, around 1/3rd to ½ more expensive than conventional vehicles but the differential is reducing.
- Opex cost: Cheaper to run and maintenance costs are typically lower than conventional vehicles due to fewer moving parts.
- Lease cost: Leased vehicles used to be charged higher due to the perceived less value on selling off at five years. This has changed for cars and lease values can be expected to be only slightly higher. Availability may be an issue.
- Emissions savings: EVs have zero tailpipe emissions, while indirect emissions will depend on the carbon intensity of the electricity supply, which is improving.
- Limitations: Heavy duty vehicles are less well suited to electric today, although battery performance (range) and price is continuously improving. For these vehicle types, hydrogen and biofuels offer viable alternatives.
- All other transport sectors likely to be dominated by electric vehicles.

A5 Measure savings and cost details

The table below shows the cumulative total savings and costs from the date of implementation to 2045 for all modelled measured under each pathway.

The costs indicated are based on a high-level desk-based assessment of potential measures, with all information on current systems and practices provided by the NHS Board. As such, full financial and technical feasibility studies would need to be carried out before measures were implemented.

Non-CAPEX costs of implementing measures are not included in the report, particularly in terms of staff resources for managing the implementation, procuring services to deliver the work, clearing out and/or moving of staff and equipment during the works etc. This 'unseen enabling cost' cannot be quantified at this level of granularity within the study. Where a measure is likely to incur significant disruption to normal operating procedures, this has been noted within the report.

Costs for backlog maintenance are not in scope for this work as this is considered Business As Usual and does not impact on the additional emissions reduction measures modelled for NHSAA. It is recognised that the maintenance backlog could have both positive and negative emissions impacts once completed, that have not been quantified under Business As Usual, unless where already noted.

A5-1 Aspirational Pathway

Measure	Sites Impacted	Emissions Impacted	Measure Type	Year(s) of Implementation	Total tCO2e Savings	Total Fuel £ Savings	Total CAPEX
Replace Gilbert Bain with new low carbon hospital	Gilbert Bain & consolidated sites	Electricity, heating fuels and water	Capital	2025-26	20,873	8,260,702	110,000,000*
Upgrade and expand BMS systems or install smart heating controls	Health Centers and Staff Accommodation	Electricity and heating fuels	Capital/ Maintenance	2022	584	347,799	39,000
Energy Management and Submetering	All sites	Electricity, heating fuels and water	Capital/Policy	2022-25	375	261,548	90,000
Install low carbon heating systems	Health Centers	Heating fuels	Capital	2022-25	1,575	-306,738**	80,000
	Staff Accommodation				249	-48,847**	15,000

Upgrade AHU plant	Health Centers with AHUs	Electricity	Capital/ Maintenance	2022-25	21	40,496	40,000
Reduce water use in sanitary, domestic, laundry and kitchens	Health Centers	Water supply & treatment	Capital/ Maintenance	2022-24	12	28,424	153,000
	Staff Accommodation				1	2,246	32,500
Phase out high-carbon medical gasses and rationalise usage	Gilbert Bain	Medical Gasses	Maintenance & Policy	2021-30	2,178	0	0
Improve waste segregation	All sites	Orange stream, municipal and food waste streams	Policy	2030-40	70	0	10,000
Install renewables (Solar and wind)	Health Centers	Electricity	Capital	2022-24	1,076	2,175,630	1,085,608
	Staff Accommodation				37	58,092	33,000
Improve building fabric to reduce thermal losses	All properties except Hospital	Heating fuels	Capital	2022-27	285	188,562	215,000
Replacement of NHS owned fleet with EVs	All sites	Vehicle fuel	Capital/Lease	2021-30	1,839	945,007	183,066***
Total					**29,174**	**11,952,920**	**111,976,174**

* CAPEX for replacement of Gilbert Bain with new low carbon hospital provided by NHS Shetland

** Fuel cost savings are negative because of the high fuel cost of low carbon heating measures compared to liquid fuels, but it is important to note is that the price differential between low carbon fuels and traditional heating fuels may change from those currently predicted in the future as Government policy drives a move away from fossil fuel use.

*** Cost of charging infrastructure (£65,000) and annual lease cost increase of leasing EVs rather than standard vehicles (£118,066) provided by NHS Shetland. Note: the annual cost increase of leasing EVs has only been counted once as this is considered a one-off cost increase to the NHS. In subsequent years it is not considered an additional cost as the NHS has committed to replacing their fleet with EVs or other low carbon vehicles, and the price differential between low carbon and "standard" vehicles will decrease over time due to technological improvements and policy pressure from Government bodies.

A5-2 Restricted Pathway

Measure	Sites Impacted	Emissions Impacted	Measure Type	Year of Implementation	Total tCO2e Savings	Total Fuel £ Savings	Total CAPEX
Replace steam system in Gilbert Bain	Gilbert Bain	Kerosene	Capital	2035-40	3,204	-320,811*	500,000
Upgrade and expand BMS systems or install smart heating controls	Health Centers and Staff Accommodation	Electricity and heating fuels	Capital/ Maintenance	2030-35	458	370,466	15,750
Energy Management and Submetering	All sites	Electricity, heating fuels and water	Capital/Policy	2025-35	608	335,332	30,000
Install low carbon heating systems	Health Centers	Heating fuels	Capital/ Maintenance	2025-35	1,169	-218,854*	80,000
	Staff Accommodation				179	-33,658*	15,000
Upgrade AHU plant	Health Centers with AHUs	Electricity	Maintenance	2030-40	4	15,765	6,000
Reduce water use in sanitary, domestic, laundry and kitchens	Gilbert Bain	Water supply & treatment	Capital/ Maintenance	2025-35	78	187,126	14,000
	Health Centers				7	29,767	40,500
	Office				5	11,698	4,500
	Staff Accommodation				1	1,391	10,000
Phase out high-carbon medical gasses and rationalise usage	Gilbert Bain	Medical Gasses	Maintenance & Policy	2021-30	1,688	0	0

Improve waste segregation	All sites	Orange stream, municipal and food waste streams	Policy	2030-40	21	0	5,000
Replacement of NHS owned fleet with EVs	All sites	Vehicle fuel	Capital/Lease	2021-30	1,839	945,007	183,066**
Total					**9,286**	**1,323,580**	**908,816**

* Fuel cost savings are negative because of the high fuel cost of low carbon heating measures compared to liquid fuels, but it is important to note is that the price differential between low carbon fuels and traditional heating fuels may change from those currently predicted in the future as Government policy drives a move away from fossil fuel use.

** Cost of charging infrastructure (£65,000) and annual lease cost increase of leasing EVs rather than standard vehicles (£118,066) provided by NHS Shetland. Note: the annual cost increase of leasing EVs has only been counted once as this is considered a one-off cost increase to the NHS. In subsequent years it is not considered an additional cost as the NHS has committed to replacing their fleet with EVs or other low carbon vehicles, and the price differential between low carbon and "standard" vehicles will decrease over time due to technological improvements and policy pressure from Government bodies.

A5-3 Balanced Pathway

Measure	Sites Impacted	Emissions Impacted	Measure Type	Year of Implementation	Total tCO2e Savings	Total Fuel £ Savings	Total CAPEX
Replace Gilbert Bain with new low carbon hospital	Gilbert Bain & consolidated sites	Electricity, heating fuels and water	Capital	2029-30	15,890	6,530,404	110,000,000*
Upgrade and expand BMS systems or install smart heating controls	Health Centers and Staff Accommodation	Electricity and heating fuels	Capital/ Maintenance	2025-28	405	270,257	34,000
Energy Management and Submetering	All sites	Electricity, heating fuels and water	Capital/Policy	2022-27	252	179,774	60,000
Install low carbon heating systems	Health Centers	Heating fuels	Capital	2025-28	1,427	-273,295**	80,000
	Staff Accommodation			2025-28	223	-42,880**	15,000
Upgrade AHU plant	Health Centers with AHUs	Electricity	Capital/ Maintenance	2025-35	10	27,102	30,000
Reduce water use in sanitary, domestic, laundry and kitchens	Health Centers	Water supply & treatment	Capital/ Maintenance	2025-30	11	27,690	81,500
	Staff Accommodation			2025-30	1	1,714	22,500
Phase out high-carbon medical gasses and rationalise usage	Gilbert Bain	Medical Gasses	Maintenance & Policy	2021-35	1,937	0	0
Improve waste segregation	All sites	Orange stream, municipal and	Policy	2030-40	42	0	7,500

		food waste streams					
Improve building fabric to reduce thermal losses	All properties except Hospital	Heating fuels	Capital	2025-35	200	145,363	215,000
Replacement of NHS owned fleet with EVs	All sites	Vehicle fuel	Capital/Lease	2021-30	1,824	938,212	183,066***
Total					**22,223**	**7,804,343**	**110,728,566**

* CAPEX for replacement of Gilbert Bain with new low carbon hospital provided by NHS Shetland

** Fuel cost savings are negative because of the high fuel cost of low carbon heating measures compared to liquid fuels, but it is important to note is that the price differential between low carbon fuels and traditional heating fuels may change from those currently predicted in the future as Government policy drives a move away from fossil fuel use.

*** Cost of charging infrastructure (£65,000) and annual lease cost increase of leasing EVs rather than standard vehicles (£118,066) provided by NHS Shetland. Note: the annual cost increase of leasing EVs has only been counted once as this is considered a one-off cost increase to the NHS. In subsequent years it is not considered an additional cost as the NHS has committed to replacing their fleet with EVs or other low carbon vehicles, and the price differential between low carbon and "standard" vehicles will decrease over time due to technological improvements and policy pressure from Government bodies.

A6 Supporting modelling information for pathways

Site/Site Category	Emissions Source	Aspirational Pathway modelled measures	Restricted Pathway modelled measures	Balanced Pathway modelled measures
Gilbert Bain Hospital	Electricity	A new “Low Carbon” hospital replaces the Gilbert Bain in 2025-2026 in this pathway. Montfield HQ and Breiwick House are consolidated into the hospital at this date and existing sites are decommissioned. The new hospital sources all its electricity from zero carbon sources - either on-site renewables or local renewables with a PPA (power purchase agreement). The hospital retains a district heating connection for heating, hot water and steam generation, but the network is zero carbon by the time the new hospital is built and connected. Steam use on site is minimised - all hot water from laundry equipment is generated from the district heat network, and local electric steam generation is only used where absolutely necessary. Water use and wastewater is minimized in the new hospital during the design phase. Cooling systems are all closed loop, and all fixtures and fitting are ultra-low flow. Submetering is designed into the hospital from the ground up to allow for in-depth monitoring of energy use throughout - *supports energy management measure outlined in more detail in the Health Centres section of this table.*	A new “Low Carbon” hospital replaces the Gilbert Bain in 2029-2030 in this pathway. Montfield HQ and Breiwick House are consolidated into the hospital at this date and existing sites are decommissioned. The new hospital sources all its electricity from zero carbon sources - either on-site renewables or local renewables with a PPA (power purchase agreement). The hospital retains a district heating connection for heating, hot water and steam generation, but the network is zero carbon by the time the new hospital is built and connected. Steam use on site is minimised - all hot water from laundry equipment is generated from the district heat network, and local electric steam generation is only used where absolutely necessary. Water use and wastewater is minimized in the new hospital during the design phase. Cooling systems are all closed loop, and all fixtures and fitting are ultra-low flow. Submetering is designed into the hospital from the ground up to allow for in-depth monitoring of energy use throughout - *supports energy management measure outlined in more detail in the Health Centres section of this table.*	The current BMS system is updated and expanded in 2025-2028 to allow for improved monitoring and remote control. Through more effective monitoring, rationalization of set points and improved control (including placing thermostats in the location being controlled - not always the case currently), 10% savings across electricity and heating energy use in all connected systems is achieved. Energy management & submetering: 5% savings for all electricity, heating fuels and water from 2022-2027. Achieved through: Setting up green teams with local responsibility for energy use, allocating an energy manager to monitor and take actions on collected data, setting site-by-site benchmarks and targets, conforming to (but not obtaining certification for) ISO 50001, carrying out regular staff energy awareness training, installing smart fiscal meters on all properties (electricity and water), and submetering of major plant in largest sites (including hospital). Due to the high cost of on-balance sheet renewables these have not been considered as part of this pathway. There would be potential to set up PPA agreement with local renewable installations but these have not been included within the modelling for this pathway.
	Heating systems			Heating systems at the Gilbert Bain are fed by the district heating network, and so no changes to the heating systems energy source is suggested. However, the district heating network is assumed to transition to a zero-carbon energy source by 2035.

	Steam (Kerosene)			The steam system at the Gilbert Bain a significant source of carbon emissions at present, and will continue to be so until the system moves away from using Kerosene. Due to the age of the current plant (<5 years old), the system will not be cost-effective to replace until 2030 and there will be challenges to do so. The laundry will need to be moved away from using steam, and hot water for laundry equipment can be raised using the district heating system as the heat source. Clinical uses for steam (e.g. sterilization) could be met with local electric steam generation, though the running costs of these systems are high so moving away from using steam altogether is a better option if possible. Under this pathway, kerosene use in the Gilbert Bain is replaced with district heating and electric steam/hot water generation, phased from 2030-2035.
	Water supply and treatment			Water use and wastewater use in sanitary, domestic, laundry and kitchens are minimized by installing low flow fixtures for toilets, taps and showers. Under this pathway, works to upgrade the fixtures are carried out in 2023-2028 and can achieve water savings of 30%. Maintenance of current water distribution pipework will reduce water losses by 5% and is modelled as occurring annually from 2023.
	Medical gases	Emissions from medical gasses are reduced by 50%, phased from 2021 to 2030. This is through use of lower carbon impact gasses and rationalizing use of such gasses within the hospital. It is also expected that advancements in technology utilised in the new hospital will aid this reduction.	Emissions from medical gasses are reduced by 50%, phased from 2021 to 2040. This is through use of lower carbon impact gasses and rationalizing use of such gasses within the hospital. It is also expected that advancements in technology utilised in the new hospital will aid this reduction.	Emissions from medical gasses are reduced by 50%, phased from 2021 to 2035. This is through use of lower carbon impact gasses and rationalizing use of such gasses within the hospital. It is also expected that advancements in technology utilised in the new hospital will aid this reduction.

	Waste	Through improved waste segregation practices, a 50% reduction in waste in the orange stream and 30% in municipal waste are achieved by 2040 (phased from 2030).	Through improved waste segregation practices, a 50% reduction in waste in the orange stream and 30% in municipal waste are achieved by 2040 (phased from 2030)	Through improved waste segregation practices, a 50% reduction in waste in the orange stream and 30% in municipal waste are achieved by 2040 (phased from 2030)
Health Centres, Staff Accommodation and Offices	Electricity	BMS systems are updated and expanded in 2022 to allow for improved monitoring and remote control in Brae Health Centre and Bixter Health Centre. Through more effective monitoring, rationalization of set points and improved control (with installation of comprehensive control points), 12% savings across electricity and heating energy use in all connected systems is achieved. Note: Montfield HQ and Breiwick House have BMS systems but are excluded as they are to be consolidated into the new hospital before reasonable payback of the upgrades can be achieved. Energy management & submetering: 7% savings for all electricity, heating fuels and water from 2022. Achieved through: Setting up green teams with local responsibility for energy use, allocating an energy manager to monitor and take actions on collected data, setting site-by-site benchmarks and targets, conforming to and obtaining certification for ISO 50001, carrying out regular staff energy awareness training, installing smart fiscal meters on all properties (electricity and water), and submetering of major plant in largest sites (excluding hospital). Potential for renewable installations has been identified on health centre roofs as well as car parks. These installations are modelled to be installed from 2022-24 and could generate up to 475,000kWh/year - reducing the amount of electricity purchased from the grid.	BMS systems are updated and expanded in 2030-2035 to allow for improved monitoring and remote control in Brae Health Centre, Bixter Health Centre, Montfield HQ and Breiwick House. Through more effective monitoring and rationalization of set points (no additional hardware is included in this pathway due to the cost), 5% savings across electricity and heating energy use in all connected systems is achieved. Energy management & submetering: *As with Hospital section above* Due to the high cost of on-balance sheet renewables these have not been considered as part of this pathway. There would be potential to set up PPA agreement with local renewable installations but these have not been included within the modelling for this pathway.	BMS systems are updated and expanded in 2025-2028 to allow for improved monitoring and remote control in Brae Health Centre, Bixter Health Centre, Montfield HQ and Breiwick House. Through more effective monitoring, rationalization of set points and improved control (with installation of limited control points), 10% savings across electricity and heating energy use in all connected systems is achieved. Energy management & submetering: *As with Hospital section above* Due to the high cost of on-balance sheet renewables these have not been considered as part of this pathway. There would be potential to set up PPA agreement with local renewable installations but these have not been included within the modelling for this pathway.
	Heating systems	Smart heating controls to be installed in all properties that do not have a BMS system. This includes properties that have kerosene boilers or storage heaters. Both heating	Rationalising heating set point temperatures through introduction of an NHS policy should reduce energy use in heating systems across the property	Smart heating controls to be installed in all properties that do not have a BMS system. This includes properties that have kerosene boilers or storage heaters. Both heating

		systems can be controlled by smart control systems that would reduce their energy consumption through better control and response to external temperatures. Savings of 12% can be achieved and new controls are installed in all properties in 2022 in this pathway. Improving the insulation levels in all properties would reduce the thermal losses through building fabric and therefore reduce heating system energy use. Many of the properties in Shetland have un-filled cavity walls, with four properties having solid walls due to their age. All wall cavities are filled and external wall insulation installed in this pathway, with the works being carried out from 2022-2027. All properties have had roof insulation upgraded within the last 10 years, and all windows and doors are double-glazed or well insulated and air-tight and are therefore not due for an upgrade. 5% heating energy savings can be achieved through this measure. For all properties with a fossil fuel heating system, air-to-water heat pumps are installed in this pathway and are sized to the heat demand of the property taking into account other measures that impact heat demand. Five properties fall under this category, and these new heating systems are all installed in 2022 under this pathway. Generally, air-to-water heat pump systems can achieve a COP of 2.5 to 3, and by installing these systems the sites would divest themselves of fossil fuel use. For all properties with a BMS system that are heated using AHUs (air handling units), upgrades of AHU fans, motors and circulation pumps to the highest standard are included, as well as installation of heat recovery. Savings of 5% on electricity use in	portfolio by 5%. No new control hardware is included within this pathway. Due to the cost of installing cavity wall insulation this has not been included within this pathway. For all properties with a fossil fuel heating system, air-to-water heat pumps are installed in this pathway and are sized to the heat demand of the property taking into account other measures that impact heat demand. Five properties fall under this category, and these new heating systems are all installed in 2025-2035 under this pathway. Generally, air-to-water heat pump systems can achieve a COP of 2.5 to 3, and by installing these systems the sites would divest themselves of fossil fuel use. Despite the cost of these measure, this is still included due to the commitment to be fossil fuel free by 2045. For all properties with a BMS system that are heated using AHUs (air handling units), maintenance replacement of AHU fans, motors and circulation pumps to the highest standard are included. Savings of 3% on electricity use in these systems can be achieved by implementing this measure from 2030-2040.	systems can be controlled by smart control systems that would reduce their energy consumption through better control and response to external temperatures. Savings of 12% can be achieved and new controls are installed in all properties in 2025-2028 in this pathway. Improving the insulation levels in all properties would reduce the thermal losses through building fabric and therefore reduce heating system energy use. Many of the properties in Shetland have un-filled cavity walls, with four properties having solid walls due to their age. All wall cavities are filled in this pathway, with the works being carried out from 2025-2035. No external wall insulation is suggested in this pathway due to the high cost of this measure. All properties have had roof insulation upgraded within the last 10 years, and all windows and doors are double-glazed or well insulated and air-tight and are therefore not due for an upgrade. 5% heating energy savings can be achieved through this measure. For all properties with a fossil fuel heating system, air-to-water heat pumps are installed in this pathway and are sized to the heat demand of the property taking into account other measures that impact heat demand. Five properties fall under this category, and these new heating systems are all installed in 2025-2028 under this pathway. Generally, air-to-water heat pump systems can achieve a COP of 2.5 to 3, and by installing these systems the sites would divest themselves of fossil fuel use. For all properties with a BMS system that are heated using AHUs (air handling units), upgrades of AHU fans, motors and circulation pumps to the highest standard are included. Savings of 3% on electricity

		these systems can be achieved by implementing this measure.		use in these systems can be achieved by implementing this measure.
	Water supply and treatment	Water use and wastewater use in sanitary, domestic, laundry and kitchens are minimized by installing ultra-low flow fixtures for toilets, taps and showers. Under this pathway, works to upgrade the fixtures are carried out in 2022-2024 and can achieve water savings of 40%.	Water use and wastewater use in sanitary, domestic, laundry and kitchens are minimized by installing low flow fixtures for toilets (via cistern water savers), taps and showers. Under this pathway, works to upgrade the fixtures are carried out in 2025-2035 on a maintenance replacement basis and can achieve water savings of 20%.	Water use and wastewater use in sanitary, domestic, laundry and kitchens are minimized by installing ultra-low flow fixtures for toilets, taps and showers. Under this pathway, works to upgrade the fixtures are carried out in 2022-2024 and can achieve water savings of 30%.
	Waste	Through improved waste segregation practices, a 50% reduction in waste in the orange stream and 30% in municipal waste are achieved by 2040 (phased from 2030)	Through improved waste segregation practices, a 50% reduction in waste in the orange stream and 30% in municipal waste are achieved by 2040 (phased from 2030)	Through improved waste segregation practices, a 50% reduction in waste in the orange stream and 30% in municipal waste are achieved by 2040 (phased from 2030)
Fleet (Cars)	Fuel	All fleet cars are modelled as being replaced with EVs in 2021 as step change in fleet.	All fleet cars are modelled as being replaced with EVs in 2021 as step change in fleet.	All fleet cars are modelled as being replaced with EVs in 2021 as step change in fleet.
Fleet (Vans)	Fuel	All vans are modelled as being replaced with EVs by end of 2030. Modelled as gradual change in fleet over next 10 years.	All vans are modelled as being replaced with EVs by end of 2030. Modelled as gradual change in fleet over next 10 years.	All vans are modelled as being replaced with EVs by end of 2030. Modelled as gradual change in fleet over next 10 years.
Grey fleet (personal cars)	Mileage	No additional measures have been modelled under the pathways for grey fleet, business travel or patient travel. All modelled measures are covered under BAU.	No additional measures have been modelled under the pathways for grey fleet, business travel or patient travel. All modelled measures are covered under BAU.	No additional measures have been modelled under the pathways for grey fleet, business travel or patient travel. All modelled measures are covered under BAU.
Business travel (flights)	Flight distance			
Business travel (ferries)	Distance travelled			
Business travel (Busses)	Mileage			
Patient travel (flights)	Flight distance			
Patient travel (ferries)	Distance travelled			
Patient travel (Busses)	Mileage			

A7 Glossary

Abbreviation	Full description
BAU	Business As Usual
ASHP	Air-Source Heat Pump
GSHP	Ground-Source Heat Pump
DH	District Heating
HFS	Health Facilities Scotland
T&D	Transmission and Distribution

T: +44 (0) 1235 753000
E: enquiry@ricardo.com
W: ee.ricardo.com