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Accelerating the transition towards a **net zero NHS**

Delivering a sustainable and resilient UK healthcare sector

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This report is the independent opinion of the authors

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Foreword

The NHS and wider health system are a source of great national pride. Since 1948, the system has provided free at-the-point-of-use health care services to people across the country at their time of greatest need.

During the pandemic, the NHS and its 1.3 million staff have been a source of inspiration for the country, with healthcare workers operating in the most trying circumstances to deliver urgent care for sick COVID-19 patients and continue to deliver wider care needs such as cancer services and routine operations. We all know that as we move to living with the virus, the NHS faces a monumental patient backlog. In modern times, never has the need to support the NHS been greater.

The challenge that coronavirus has posed on our health system has been greater exacerbated by wider and deep-seated social, economic and health concerns. The pandemic has unfolded alongside a backdrop of a global climate emergency, which in itself is also a health emergency. Unabated, the climate crisis will continue to disrupt care, and affect patients and the public at every stage of our lives.

Given the impact of climate change on the health of the population, we must accelerate efforts to reduce our impact on the environment, to leave the planet in a healthy and prosperous state for future generations. With poor environmental health contributing to major diseases, including cardiac problems, asthma and cancer, the right response is therefore not to duck or defer action on these longer-term challenges even as we continue to respond to immediate pressures. It is right to confront them head on and directly.

In this sense, there is much work to do, across all industries and sectors. Healthcare accounts for 4% of the UK's greenhouse gas emission. Of this, Scope 3 emissions (indirect emissions that occur in the supply chain) make up a staggering 62%. This fact has rightly prompted politicians and health leaders to set an ambitious goal: to achieve a net zero UK health system by 2040.

As the trade association representing the interests of suppliers of diagnostic medical imaging, radiotherapy, healthcare IT and care equipment in the UK, AXREM's members play a critical role in every part of the patient journey and are committed to working with the NHS to help it achieve its net zero target. AXREM has a dedicated Special Focus Group, committed to working with the NHS and members to reduce emissions and we continue to welcome new members as we work closely with key stakeholders on our collective task.

As an industry, we have some of the world's leading players employing circular economy practices and business models to deliver first class outcomes and causing minimal waste and emissions. It is vital we learn from each other, innovate, and help the NHS reduce its Scope 1, 2 and 3 emissions.

I am delighted that this research – authored by the University of Exeter's Centre for the Circular Economy in partnership with Philips UKI – has provided a vital and timely contribution, not only for assessing the scale of the challenge and opportunity, but also providing a clear approach to help the NHS achieve net zero.

The medical device and technology community must play a critical role, not only furthering the recommendations made in this report, but supporting the NHS to fulfil its mandates to providing quality care, while simultaneously reducing its carbon footprint. AXREM shares the viewpoint of Philips that the two are not mutually exclusive. The industry must work with the NHS, regulators, HM Government and suppliers to fulfil this critical and urgent ambition. It is our responsibility to embark on this journey, together. We welcome the research and thank both Philips and the University of Exeter for their contributions.

Sally Edgington

Director

AXREM

1.0 **Executive Summary**

The UK health care system comprises the National Health Service (NHS, England, Wales and Scotland), Health and Social Care (HSC, Northern Ireland), GP services and a large private and independent sector offering private care and treatment as well as commissioned services to support the NHS.

The NHS alone has an annual budget of £176bn and is the UK's largest employer with over 1.4m employees and 101.9m out-patient appointments (2019/20). The ambitions of the NHS and its ability to withstand significant pressures in supporting the population of the UK impacts all parties delivering health and care across the nation.

Today the health care sector faces an array of formidable pressures, including an ageing population and comorbidities, inequalities in access to healthcare and health outcomes and environmental impacts on health. This increases demand and competition for budgets. Meanwhile, the ongoing Covid-19 pandemic continues to compound these pressures.

In October 2020 the NHS set its ambitious targets for cutting its greenhouse gas emissions, pledging to become the world's first net zero national health service by 2040 with an 80% reduction by 2032. The NHS commitment recognises that climate change and damage to the health of the environment are strongly connected to disease and ill-health. Taking preventative action now on emissions and climate will lower and limit this damage in the long term.

The NHS alone currently accounts for 4% of UK greenhouse gas emissions comprising three categories of emissions. The NHS Carbon Footprint Plus (comprising direct NHS emissions and that of its supply chain) has been reduced by 26%, from 33.8 $MtCO_2e$ in 1990 to 24.9 $MtCO_2e$ in 2019. 62% of these emissions came from the supply chain, 24% from the delivery of care, 10% from travel and 4% from private services commissioned by the NHS.

Removing a further 24.9 $MtCO_2e$ from the NHS will be extremely challenging. Achieving NHS scope 3 targets will require an 8% year-on-year reduction through to 2032, compared to an average reduction of 1% between 2008-2020. Supplier behaviour is therefore fundamental to the NHS net zero ambition and needs to match the ambition and responsibility of the NHS in their own net zero commitments.

Currently, a take-make-dispose 'linear' health system prevails in the health sector involving large volumes of waste including single use products and disposing of medical equipment prematurely. This creates unnecessary carbon emissions and also wastes money. The 8% annual reduction cannot be achieved by incremental innovation. Instead, suppliers and the NHS need to collaborate to deliver net zero care models. Enabling these changes requires new forms of collaboration between suppliers, health sector decision makers and the involvement of all staff and service users.

A framework for enabling systemic change already exists – the circular economy (CE). Pioneering companies already provide CE solutions including product life extension, repair, refurbishment and remanufacture. Such actions can reduce the carbon footprint of individual equipment by 50-85% over its lifetime and at lower cost, without any compromise on performance and patient safety. Combining such approaches with new models of care (such as telehealth) can deliver further savings.

The NHS already has in place a number of key elements to promote CE-innovation including new zero supplier frameworks ('Evergreen') and policy procurement criteria (PPN/06/01) giving higher weighting to net zero and social value.

Innovative NHS Trust are beginning to collaborate with suppliers on broader and long-term net zero strategies, not just procuring products. Similarly, clinical leads are becoming more aware of the potential of medical equipment to contribute to achieving net zero. Forthcoming policies, such as the Department of Health and Social Care Medical Technologies Strategy and changes to IRFS accounting rules will provide further impetus for CE.

NHS net zero teams are developing case studies showing ways in which suppliers can support the NHS to deliver net zero. Other NHS workstreams are embedding net zero into research and innovation pipelines and acceleration platforms. There is also increasing external stakeholder pressure for suppliers to report their plans for scope 1, 2 and 3 emissions and net zero using robust, auditable methods.

In this report, we review how the NHS and suppliers can implement and scale up CE. Three short illustrative case studies featuring medical technologies - telehealth, digital pathology and low-helium MRI scanners - show different ways that medical equipment can impact scope 3 emissions. The same principles can be applied to everything else that the NHS procures. This ranges from medicines and chemicals to construction and catering. Well-designed CE approaches can power true systems change, unlocking economic savings, improving patient outcomes and access to health.

The report concludes that circular approaches in the NHS are not only possible, but a vital enabler to the NHS achieving its net zero ambitions whilst supporting its core aim to deliver care for patients. Moreover, the shift away from the linear approach can be accelerated through many of the initiatives already underway or in place within the NHS.

While there are many barriers to overcome in such a large sector, adopting a CE mindset will accelerate transformational change – not only for net zero but also enhanced health outcomes, reduced costs, improved efficiency and managing workforce challenges. This requires NHS decision makers, commissioners and their partners, suppliers, industry and trade groups to incentivise faster progress.

The report is laid out as follows. In the first half we describe the many challenges facing the NHS and the scale of the net zero challenge. We examine the role of suppliers in delivering NHS net zero targets and the steps being taken by the NHS to implement them. In the second half we describe briefly the idea of a circular economy, why it is essential to delivering net zero and how it works in practice. The final section provides a series of recommendations for the NHS, suppliers and policy makers to consider.

CO_2

Challenges & Scale

Targets & Implementation

Recommendations

2.0 **Introduction**

COP26, held in Glasgow in November 2021, marked a turning point for the NHS and its approach to mitigating climate change. Building on its October 2020 commitment to achieve a net zero NHS by 2040, the government announced a new UK-led COP26 Health Programme[1] and promised to spend £280 million to decarbonise the NHS estate between now and 2025, with a further £1.425 billion in funding for the public sector as a whole.

Why is the NHS taking such a bold commitment?
Then-CEO of the NHS, Sir Simon Stephens, answered this question as follows:

> ***"The climate emergency,…is also a health emergency. Unabated it will disrupt care and affect patients and the public at every stage of our lives. With poor environmental health contributing to major diseases, including cardiac problems, asthma and cancer, our efforts must be accelerated. We therefore make no apologies for pushing for progress in this area while still continuing to confront coronavirus"***
>
> Sir Simon Stephens, Foreword, Delivering a 'Net Zero' National Health Service'

With the NHS responsible for 4% of the nation's carbon footprint[2], achieving net zero in this timeframe is extremely ambitious. Incremental improvements to the energy efficiency of equipment used by the NHS will be insufficient. Instead, systemic change is required across the NHS, which, we argue, can only be achieved through adopting the principles of the circular economy (CE). That means shifting away from the prevailing, linear 'take-make-dispose' approach to a new paradigm with a goal to maintain products, materials and other resources, in circulation at their highest value for the longest period of time possible.

If the NHS and their partners can implement and scale circular health systems, the benefits will go beyond net zero to address the many other acute stresses now faced by the NHS. In short, there is an opportunity to profoundly transform the way the NHS and its partners deliver healthcare, while promoting improved health outcomes, reduced capital and operating costs, freeing up staff capacity, designing out waste and joining up many different initiatives to maximise mutual benefit.

3.0 **The burning platform:** Ambitions for a **net zero NHS** in challenging times

3.1 A system under stress

Established in 1948 to provide healthcare based on need rather than ability to pay, the NHS is pivotal to the health and wellbeing of residents of the UK and Ireland and respected the world over for its high standard of care[3]. In addition, the independent sector makes a significant contribution to UK healthcare (in 2019/20 NHS commissioners spent £9.7 billion on privately delivered services, 7% of the Department of Health and Social Care's total budget)[4]. However, the NHS remains the backbone of the UK's healthcare sector, receiving the equivalent of 10% of GDP in government spending[5].

Despite this public funding, the system is under unprecedented strain, with the ongoing Covid-19 pandemic adding to a raft of challenges already facing acute, community and mental health services:

The ageing demographic profile of the UK population:

Around a fifth of the UK population was aged 65 or over in 2019. The number of people in this age group increased by 23% between 2009 and 2019, at a time when the whole UK population only increased by 7%[6]. The average citizen is now likely to require NHS services far more often in their lifetime than in previous generations, with older people at the highest risk of adverse outcomes, such as falls, disability, admission to hospital, or the need for long-term care[7].

Societal health inequalities:

Those on lower incomes, living in economically deprived areas or from socially excluded groups, such as asylum seekers or homeless people, experience significantly reduced life expectancy. People from certain ethnic backgrounds or sexual orientation, can also be disadvantaged. These impacts are multiplied for those with more than one type of disadvantage[8].

Growing waiting lists:

Since the start of the Covid-19 pandemic, the number of people waiting for NHS treatment in England has grown exponentially, from 5.3 million in May 2021 to 6.1 million in December 2021. This includes a sharp increase in the number of people waiting longer than a year[9]. Reports from Government sources now suggest that the NHS waiting list for treatment could reach 10.7million by 2024[10].

A wave of chronic, non-infectious degenerative diseases, such as obesity, diabetes, cardiovascular diseases, cancer, autoimmune diseases and Alzheimer's disease, triggered by 'western' diets, rich in sugar and salt, and lacking in fruit, vegetables and fibre[11].

Tightening public health budgets:

Despite steady increases in overall health spending, with the NHS England budget set to grow by 3.9% per year in real-terms between 2018–19 and 2024–25[12], as well as £60 billion extra funding for the 2020/21 pandemic response[13] and £5.9bn to cut waiting lists[14], the budget for public health services is still 25% below its 2015/16 level in real-terms[15].

A workforce crisis:

A prolonged funding squeeze, combined with challenges in policymaking, workforce planning, and implementation has resulted in a chronic staff shortage across the NHS, exacerbated by the Covid-19 pandemic. NHS hospitals, mental health services and community providers report a shortage of nearly 84,000 FTE staff, severely affecting key groups such radiographers, radiologists and sonographers, nurses, midwives and health visitors. General Practice is, meanwhile, short of 2,500 FTE GPs, which could rise to 7,000 within five years[16]. A previous commitment to recruit 5,000 new GPs fell short[17] and the current uplift in medical students will take at least 6 years (training time) to have any direct benefit.

Environmental stressors which exacerbate health problems[18]:

Air pollution with lead, ozone or dioxins, is linked to heart disease, stroke and lung cancer, contributing to around 36,000 deaths annually - and directly adds to current pressures in accident and emergency departments[19]. Antimicrobial resistance renders many infectious illnesses harder to treat, while pollution, flooding and climate change is known to cause, or exacerbate, mental health conditions. These harms are not experienced equally across the population, with those living in deprived areas experiencing poorer quality environments with less accessible green space. The NHS could save over £2 billion in treatment costs if everyone in England had equal access to good quality green space[20].

Mounting waste:

NHS providers in England annually create over 590,000 tonnes of waste. Waste is produced across estates and services, including office materials, clinical waste, food, drugs, and medical devices[21], whose management costs the NHS in excess of £700m each year and potentially exposes hospital staff, healthcare workers, waste handlers, patients and the community at large to infection, toxic effects and injuries[22]. Due to its hazardous nature, much of the waste is incinerated, emitting CO_2, nitrogen oxides, and particulate matter. Drivers of these waste arisings are diverse and complex. For instance, rapid advances in technology result in faster obsolescence of medical equipment, while poor stock control and current prescribing methods generate huge quantities of unused pharmaceuticals.

Technology-driven demand:

As new technologies are rolled out across the NHS in the interests of efficiency they can generate new demand, adding to strain felt by frontline staff. For instance, the introduction of the eConsult online consultation reportedly left so many GPs overwhelmed by patient demand that eConsult introduced the ability to turn off its platform[23].

Many of these problems are exacerbated by, if not a product of, the prevailing linear NHS business model. Current practice incentivises a rapid turnover of materials, equipment, devices, products and components. Many of these are regarded as 'single-use' or 'consumables', routinely disposed of at the end-of-life, with the loss of embodied carbon and material value.

To achieve the NHS's ambitious goal of achieving net zero by 2040 and to reduce the healthcare industry's impact on our environmental surroundings requires a systemic redesign of the NHS system itself to align with circular economy (CE) principles. The UK healthcare system will enormously benefit from circular product design and circular business models which prolong the use phase of products. This dramatically cuts overall carbon emissions, by reducing both waste and the need for replacement products. A CE model brings other unexpected benefits by enabling the NHS to deliver far higher productivity, helping it achieve key performance targets and maintain the high standard of patient care the UK public has come to expect. To achieve this collaboration is required by NHS decision makers and commissioners and their partners, suppliers and stakeholders to instigate CE-led change in the system. We discuss this in more detail in Section 4.0.

To better understand the scale of the challenge and the necessity of a CE approach we need to look in more detail at the net zero ambition, pathways for achieving it and how a CE approach could work.

3.2 The **net zero ambition**

Despite many challenges, the NHS is admirably pressing ahead with its aim to become 'the world's first net zero national health service' - indeed the recognition that addressing environmental impacts will yield health benefits only redoubles this effort. In January 2020, a few days before the World Health Organisation officially declared Covid-19 a global health emergency, the NHS launched its campaign 'For a Greener NHS' and began work on a practical, evidence-based and quantified path to achieving net zero[24]. By October it had published a strategy[25] setting out two ambitious targets for greenhouse gas emissions reduction:

> **NHS Carbon Footprint** - net zero by 2040, with an ambition to reach an 80% reduction by 2028 to 2032 at Scope 1[26]
>
> **NHS Carbon Footprint Plus** - net zero by 2045, with an ambition to reach an 80% reduction by 2036 to 2039 at Scope 3

NHS Carbon Footprint covers the 'Scope 1' emissions for which the health service is directly responsible, such as those generated from running hospitals or operating ambulances, as well as indirect (or 'Scope 2') emissions from the generation of purchased energy, mostly electricity. NHS Carbon Footprint Plus applies to all other indirect (or 'Scope 3') emissions that occur in producing and transporting goods and services. This includes the full upstream supply chain, along with emissions from patient and visitor travel to and from NHS services, and medicines used within the home. Figure 1 summarises how the Scopes relate to NHS activities, and the goods and services which it procures.

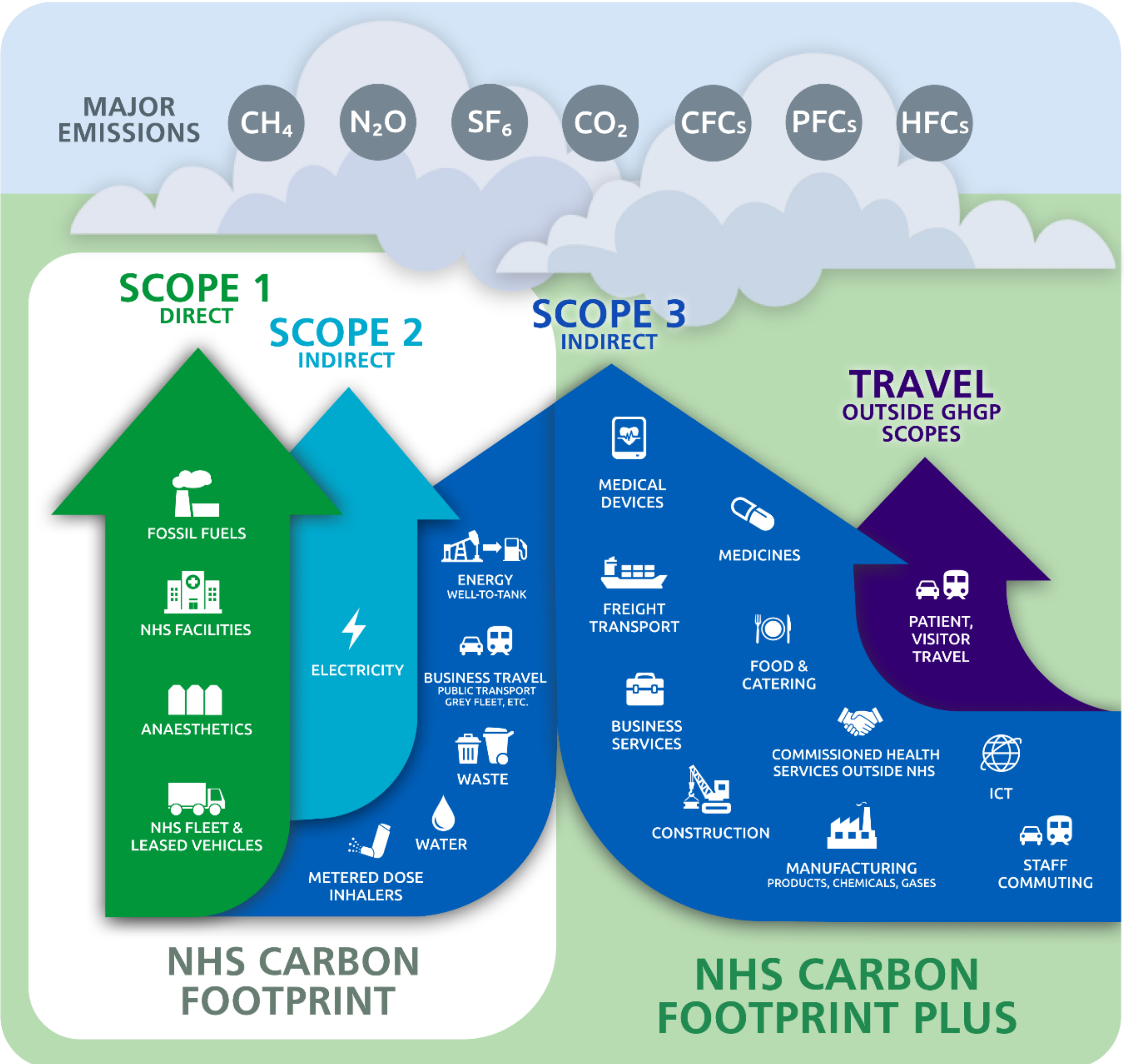


Figure 1: GHGP Scopes in the context of the NHS (Source: Delivering a 'Net Zero' National Health Service).

Since the 2008 Climate Change Act, considerable progress has been made: in 1990 the NHS Carbon Footprint was 16.2 $MtCO_2e$[27]; by 2021 the figure is 6.1 $MtCO_2e$, representing a 62% reduction in emissions. The NHS Carbon Footprint Plus (scope 3) has also been reduced: down by 26%, from 33.8 $MtCO_2e$ in 1990 to the current 24.9 $MtCO_2e$ in 2020. Nevertheless, much remains to be done to close the gap to net zero.

Removing 6.1 $MtCO_2e$ from the NHS Carbon Footprint and 24.9 $MtCO_2e$ from the NHS Carbon Footprint Plus will be extremely challenging. As Figure 2 illustrates, year-on-year compounded reductions are needed, at a rate far higher than historic averages - in the case of Scope 3 an average 8% reduction from 2020 through to 2036.

Achieving net zero will require substantial further efforts to significantly accelerate the transition towards net zero

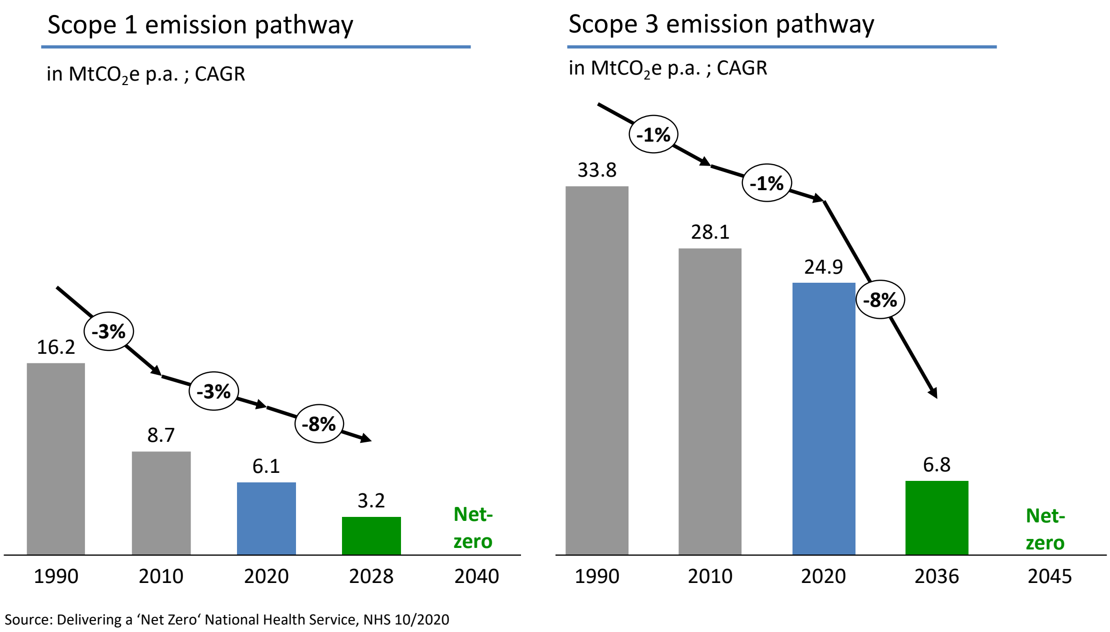


Fig 2: Compound Average Growth Rate for Scope 1 and 3.

3.3 Supply chain **hotspots**

The supply chain is responsible for 62% of the NHS Carbon Footprint Plus, with medicines, chemicals, and equipment alone accounting for 38% of all emissions (Figure 3). Business services, construction and freight, and food and catering are also significant contributors.

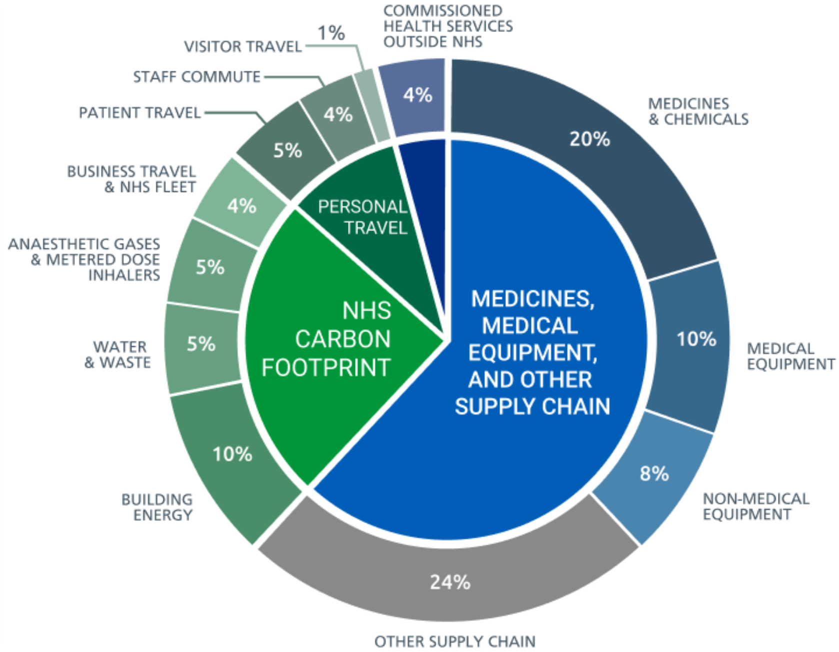


Figure 3: Sources of carbon emissions by proportion of NHS Carbon Footprint Plus (Source: Delivering a 'Net Zero' National Health Service)

These supplier-related carbon impacts are not uniformly incurred across the NHS, but instead dominate certain areas and activities, with acute and primary care settings representing the largest emission hotspots (Figure 4).

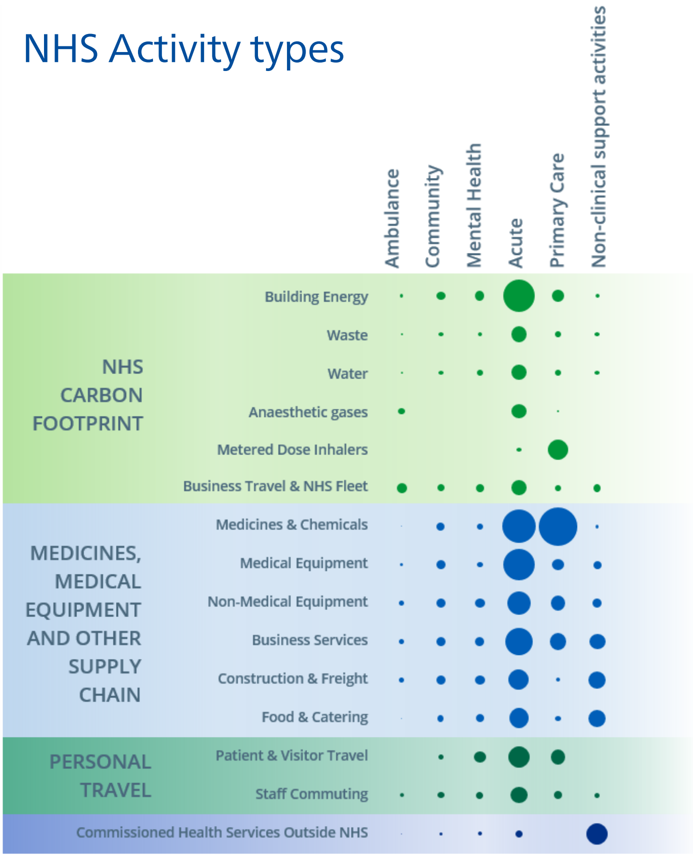


Figure 4: Sources of carbon emissions by activity type and setting of care (Source: Delivering a 'Net Zero' National Health Service)

Table 1 illustrates the carbon footprint of a range of common treatments and activities, highlighting the systemic nature of carbon footprints and interactions between assets, equipment and travel. A more detailed version is available in Annex 1.

Speciality, Procedure or Treatment	Carbon footprint
Renal	3,006 tonnes CO_2e/patient/year
Surgery	3,219-5,188 tonnes CO_2e/ surgical suite/ year 1.7-2.3 tonnes CO_2e/m2 area 0.15-0.23 tonnes CO_2e/case
Intensive care	0.009 tonnes CO_2e/bed day
Emergency medicine	Median emissions: 0.037 tonnes CO_2e/response 0.0035 tonnes CO_2e/service-area resident
Pharmaceuticals	49 tonnes CO_2e/million USD revenues for total pharmaceutical sector 35 tonnes CO_2e/million USD for the group of 15 companies
Pathology	CO_2e emissions ranged from 0.5 g/test (C-reactive protein) to 116 g/test (full blood examination)
Cataract surgery	0.006 - 0.180 tonnes CO_2e/cataract surgery
Asthma inhalers	0.010-0.036 tonnes CO_2e/device 0.017 tonnes CO_2e/patient/year for Relvar-Ellipta/Ventolin-Accuhaler 0.439 tonnes CO_2e/patient/year for Seretide-Evohaler/Ventolin-Evohaler
Laparoscopic surgery	355,924 tonnes CO_2e/year for all U.S. laparoscopic procedures
Hysterectomy	212,000 tonnes CO_2e/year for 500,000 hysterectomies in the U.S.
Renal dialysis	In-centre: 3.8 tonnes CO_2e/patient/year Home: 1.8-7.2 tonnes CO_2e/patient/year depending on technique

Table 1: Carbon by treatment and speciality (Source: Salas et al, 2020).

The NHS Net Zero Strategy sets out early steps towards decarbonisation (Annex 3), and details a systematic but targeted series of interventions across the supply chain, starting with major hotspots (Figure 5).

Pathway to net zero for the NHS Carbon Footprint Plus Scope

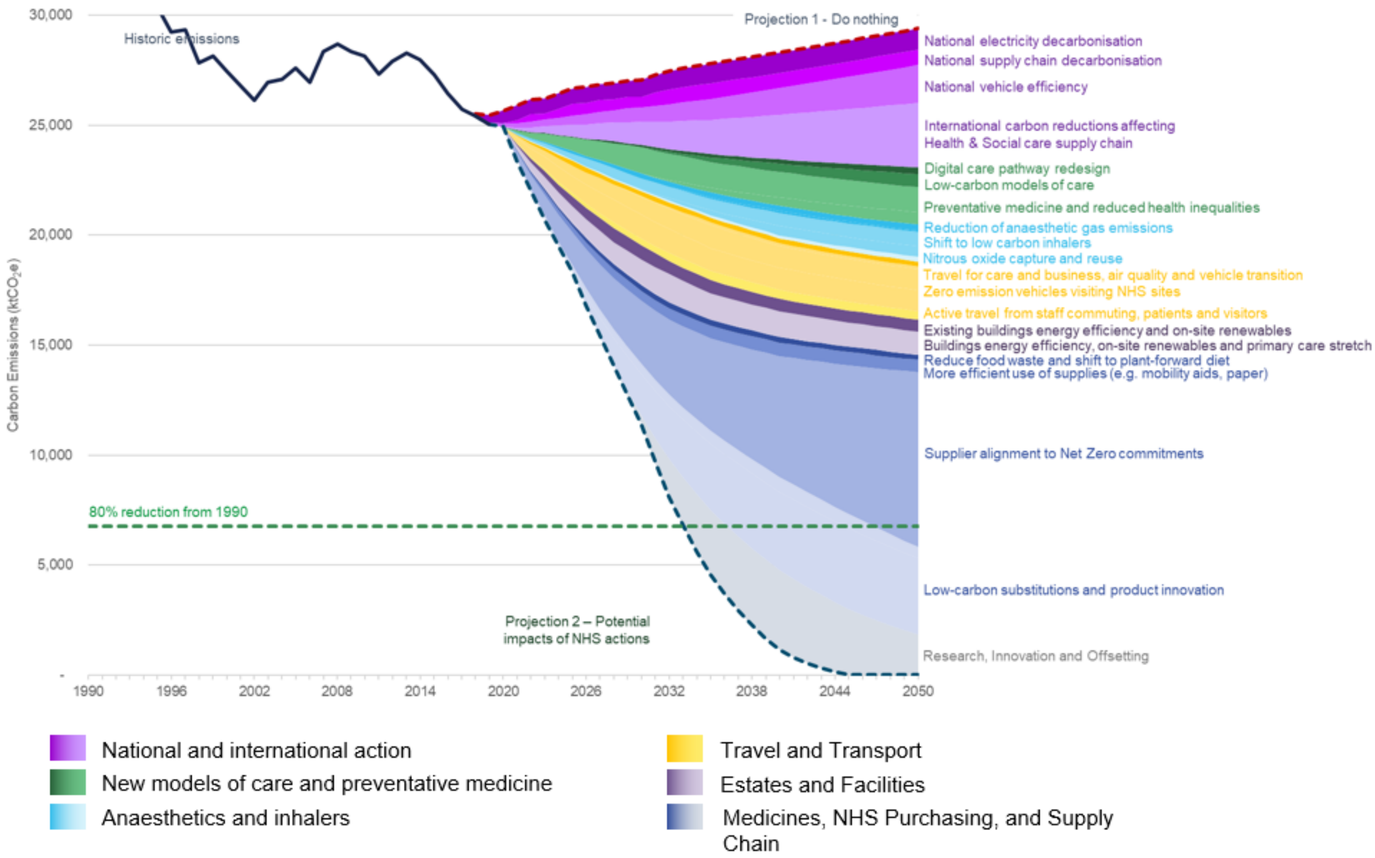


Figure 5: NHS pathway to net zero Scope 1 and 3 emissions (Source: Delivering a 'Net Zero' National Health Service).

In order to calculate the carbon impacts arising from healthcare it can be helpful to use the concept of a 'care pathway'[28]. Some examples of the key activities that contribute a certain proportion of the emissions are:

1. **GP Consultation**
2. **Patient Travel**
3. **Emergency Department Visit**
4. **Outpatient Visit**
5. **Diagnostics**
6. **Inpatient / Bed Day**
7. **Surgical Procedure**
8. **Condition Self-Management**

Each care module incurs its own set of impacts, which may include consumables, pharmaceuticals and equipment; energy and water consumption; waste production; and travel of staff required to provide the services. A recent paper in The Lancet estimates the following carbon footprints for common care modules (Tennison et al 2021):

125 kg CO_2e	**76 kg** CO_2e	**66 kg** CO_2e	**75 kg** CO_2e
per bed-day	per outpatient appointment for acute care	per general practice visit	per ambulance emergency response

Each time an activity is repeated, so are its various impacts. Therefore, if a new type of equipment or novel service reduces the number of times a module is repeated, or perhaps avoids it altogether, the benefits accrue in aggregate. For instance, digital pathology (see Case Study 5.2) has the potential to significantly reduce the time taken to diagnose a condition, which in turn may result in reduced patient travel, fewer inpatient/bed days or avoid an unnecessary surgical procedure.

The UK has some 1,256 hospitals. Most are managed by NHS Trusts or Health Boards (see Section 6.1), with around 515 - privately run establishments[29]. Table 2 shows the country's largest private providers.

Provider	Scale
BMI Healthcare	46 hospitals and 7 specialist clinics - BMI handles over 275,000 in-patient and 1,500,000 out-patient visits each year
Spire	38 hospitals, 12 clinics, and 2 specialist cancer units.
Ramsay	34 hospitals
Nuffield Health	36 hospitals
HCA	8 hospitals and 15 diagnostic centres

Table 2: The largest providers of private health care in the UK. (Source: Company websites)
NB. Figures exclude voluntary sector providers, e.g., the c. 90 hospices in England, and dental practices.

When applied nationwide across UK hospitals, any reductions across each module are compounded.

3.4 **Net zero** delivery

3.4.1 Governance and supplier relationships

The NHS is not a single organisation, but a complex network with budgets and decision-making for the procurement of goods and commissioning of services split between centralised bodies, such as NHS supply chain, and regional/local structures, such as Trusts and Boards. The segregation of the Department of Health and Social Care (DHSC) and NHS procurement systems and frameworks inhibits the uptake of circular models and makes tracking carbon emissions difficult.

In England, the commissioning of healthcare services and procurement of goods has been undergoing progressive change since a 2014 decision to integrate the operations of hospitals and GPs, the NHS and social care, physical and mental health into an 'integrated care system' (ICS). In April 2021 42 areas of England became ICSs with responsibility for local commissioning (replacing clinical commissioning groups and some local authority commissioning by April 2022[30]). The NHS and ICSs will both play a critical role in the transition toward a net zero health service. Meanwhile, the governance structure of the NHS varies across the devolved nations of the UK, further complicating the picture. NHS England and Improvement is a non-departmental body in England, responsible for overseeing the NHS foundation trusts, NHS trusts, and independent providers of NHS services. (NHSI) provides leadership at the regional and national level, with the Care Quality Commission acting as the independent regulator of health and social care in England, with powers to inspect, monitor, and regulate hospitals, surgeries and care homes to ensure standard of service delivery[31]. In Scotland, Wales and Northern Ireland there are different governance structures (Table 3).

Nation	Care providers	Governance
England	223 NHS Hospital Trusts 42 ICS	Care Quality Commission Details still evolving[32]
Scotland	14 Health Boards	Care Inspectorate (regulating NHS) & Healthcare Improvement Scotland (regulating independent care sector)
N. Ireland	6 Health and Social Care Trusts	Regulation and Quality Improvement Authority
Wales	7 Health Boards and 2 NHS Trusts	Care and Social Services Inspectorate Wales

Table 3: NHS governance structures

Whilst delivering net zero is the responsibility of all health sector and NHS staff and stakeholders, the overarching responsibility and leadership is directed via two key units, a net zero delivery team and an NHS supply chain team reporting to Dr Nick Watts, NHS England's Chief Sustainability Officer. On the supply side, a net zero supplier roadmap "Evergreen" that builds on UK Government procurement policy PPN 06/21 provides a framework for benchmarking and reporting progress against the net zero strategy. From April 2023 all suppliers with contract values greater than £5m will need to publish a carbon reduction plan for all direct emissions and all emissions by 2027.
From 2028 there is a requirement for any individual product supplied to the NHS to have a carbon footprint measured against an approved methodology. By 2030 suppliers wishing to be eligible for NHS contracts will need to publish a carbon emissions report and progress through the supplier framework.

Other commitments made by NHS Supply Chain include:

Promote and champion hybrid working, using technology as a standard solution for working with all stakeholders

+

Reduce direct CO_2 emissions, eliminate single-use plastics (where possible), and reduce all packaging used in operations

+

Champion the supply of environmentally sustainable products and services to the NHS, including these requirements in all future tenders

3.4.2 **Net Zero** Delivery Teams

Interviews with Net Zero Delivery team members revealed a rapid scaling up in team numbers, initiatives and several drivers that can incentivise CE-led product-service and systemic innovation opportunities. The scale of the carbon reduction challenge in reducing the Scope 3 emissions is modelled and forecast by the NHS on suppliers meeting 'best in class' benchmarks at organizational and product scale. Those suppliers that can meet or exceed those best-in-class standards will therefore be advantaged through the Evergreen approach (see above). It is arguable whether the 10% weighting for net zero and social value is sufficient to bring about transformational change in the short term, and to be impactful there needs to be more evidence that NHS decisions will use these criteria to incentivise innovative suppliers and send a signal to the market.

The NHS is lacking use cases for CE and product level net zero case studies based on actual adoption and implementation. There is an urgent need for an improved evidence base at product and care model scale based on robust, reliable and transparent data. Suppliers such as Philips are well positioned to undertake and provide carbon, cost, health outcome and staff feedback data and evidence from their installed devices. The three case examples described in Chapter 4 provide a foundation for more detailed analysis and evaluation and which should be extended across the full product portfolio to match NHS priorities and needs. Further work is also needed to showcase the compounding benefits of applying CE innovations systemically – for example by extending the life of products, intensifying their use and shifting towards service and performance-based business models (see next section). The team lead for the net zero workstream supply chain and supplier engagement held the view that incremental innovation will not be sufficient to achieve net zero, hence there is a strong appetite for systemic innovation approaches with a number of internal and external drivers[35] likely to drive and incentivise more service-oriented business models in the future.

Discussions with the research and innovation arm of the Net Zero delivery team highlighted how net zero will be embedded in the research and innovation pipeline which has the ambition to scale up by a factor of 10 or more in the coming years. Mechanisms to accelerate innovation and adoption are being ramped up. NHS would welcome suppliers sharing their research and innovation pipeline to support net zero and also influence their future funding and research calls.

The picture gained from interviews with net zero and supply chain teams is that net zero is opening up the organisation's ambition, capability and support to drive and scale innovation at scale. With such a large and complex organization there is of course a huge legacy of systems, work practices, barriers and challenges that will take time to shift. Proactive Trusts such as County Durham and Darlington NHS Foundation Trust however are showing the way through their CEO and sustainability leadership team and the urgency and need for 'sustainable care models'. This Trust is at an early stage of engaging with Philips and other suppliers to collaborate on large-scale, long-term carbon strategies and has the potential to integrate procurement and purchasing with service design to produce system-wide benefits beyond incremental change. In this interview it was felt the 10% weighting to net zero and social value was a start but unlikely to make a real difference compared to cost and clinical performance requirements.

Clinicians we spoke to as contributors to our three case studies also see the wind of change and want to innovate, reduce and avoid waste whilst enhancing health outcomes and overall productivity. At one very simple but practical level, one clinician bemoaned the amount of unnecessary product waste such as multiple cables, fixings for multiple regions, included as standard by global suppliers, rather than specific to a UK installation. This requires storage, recording and eventual disposal all adding cost and taking up space and staff time.

3.4.3 **Barriers**

During our interviews we heard many potential barriers that need to be overcome in order to deliver net zero through adoption of CE.

Currently, 80% of NHS purchases (worth over £100bn) are made through three pathways: Medical (localised supplies, such as sterile packs, infection control, ward consumables, orthopaedic equipment), capital (diagnostic equipment), and non-medical (office equipment, food, hotel consumables). From a net zero and circular economy perspective, the current system is focused on buying equipment rather than circular models, though some Trusts are experimenting with new partnerships and innovation procurement, where tenders are focused on meeting unmet needs, as shown in the case studies presented in Section 5.0. Anecdotal evidence suggests little use of refurbished or remanufactured medical equipment in the NHS, although there is some sale of devices to UK third-party refurbishers who then sell them on the global market. Instead, most single-use devices are either sent to landfill or incinerated due to the costs associated with, and availability of, reprocessing.

Purchasers tending to buy new and single-use devices and equipment do so for the following reasons[37]:

Negative preconceptions and safety concerns:
about repaired, refurbished or remanufactured products. Despite broad adoption of single-use disposables, however, there is no compelling evidence that they reduce health care-acquired infections.

Restrictions on import of reprocessed devices:
Restrictions on import of reprocessed devices; this impacts where devices are transferred between jurisdictions, however there is an opportunity for regulators to address this with imminent changes in UK medical device legislation.

NHS procurement rules:
Encompassing the protocols and standards which suppliers must adhere to for technology provided to the NHS.

Liability concerns:
For instance, NHS Scotland does not routinely purchase refurbished/remanufactured equipment. This is due in part to concerns within the UK that, should the device malfunction, the original hospital would remain liable. As a result, end-of-life devices are either sent to auction houses or sold for scrap.

Regulatory requirements:
To re-use medical equipment can be particularly burdensome. Annex 2 is a non-exhaustive list of the key regulations and policies in this area which need to be observed, including Product liability and Waste Electrical Electronic Equipment (WEEE).

There are however, standards and guidance including from the Medicines and Healthcare Products Regulatory Agency (MHRA), which promote good practice, and ensure those undertaking re-use comply with the necessary rules (Annex 2).

Elsewhere we heard that there is capital and political will to overcome these barriers, and there is an urgent need for a small number of innovative Trusts and clinicians to work with suppliers on vanguard projects that can be evaluated and where the results and outcomes are positive, support given to promote and snowball interventions across the NHS and health sector.

Against this backdrop, the following section describes more fully the idea of a circular economy and how it fits with the NHS net zero strategy.

4.0 **The structural solution:** Circular economy will accelerate the transition towards net zero and universal service obligation

4.1 **What is the circular economy?**

The circular economy (CE) concept is best captured in the Ellen MacArthur Foundation's 'butterfly diagram' (Figure 6). In this diagram the linear take-make-dispose economic model is shown as the vertical and either side is two material spheres: the technical which encompasses materials that are durable, and the biological where materials biodegrade, are consumed or compost. The focus of this report is the technical sphere. The objective in the techno-sphere is to maintain the materials, products and components as long as possible at the highest level of functionality in service. At the point of obsolescence or end-of-service, products are then aimed to be returned at the earliest point in the linear value chain (for example, through repair, remanufacture or refurbishment) to maximize the value of the embedded material, labour, capital cost and retain the embedded upstream emissions-footprint.

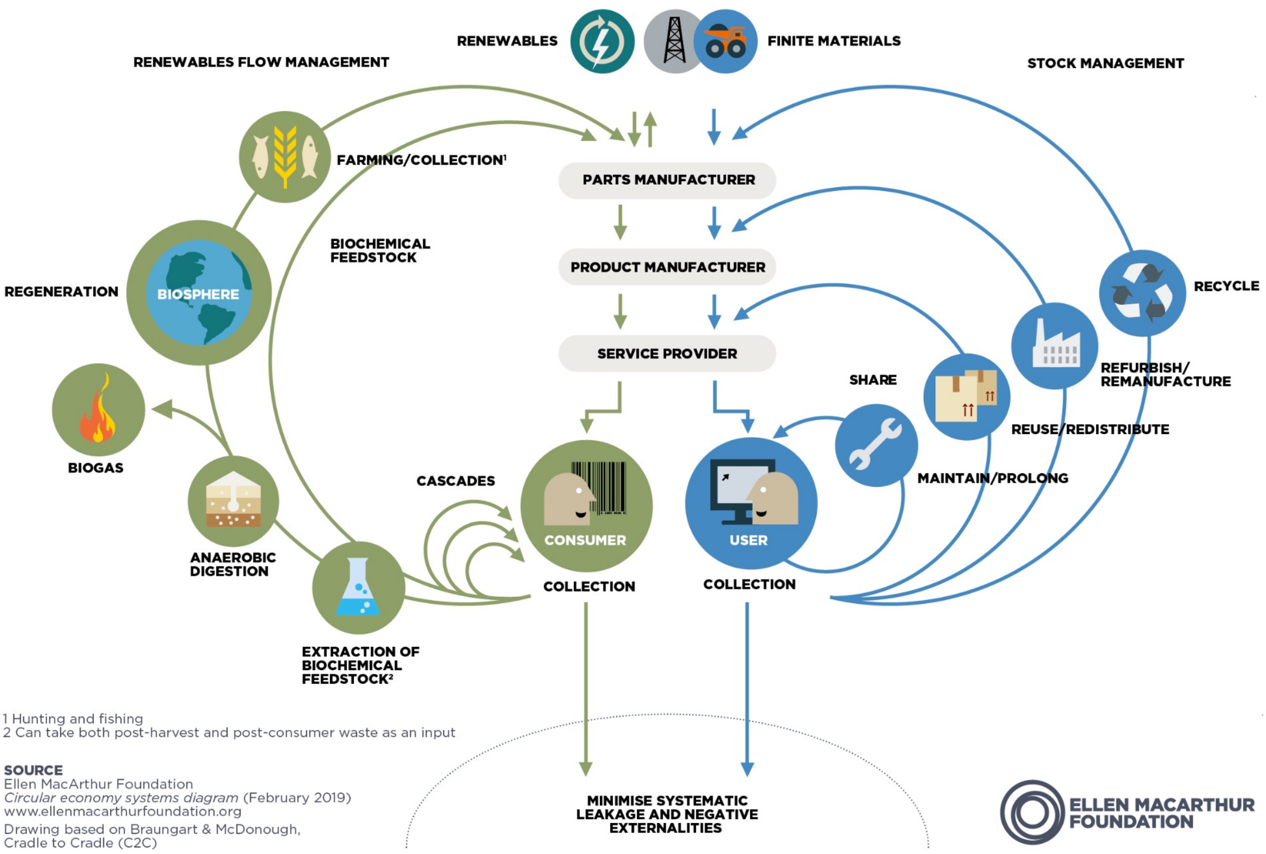


Figure 6: Circular Economy System Diagram (Ellen MacArthur Foundation)

In a circular economy, business models maintain these elements at the highest level of functionality for as long as possible, through upgrades, repair, refurbishment, remanufacture and other strategies. Over time, valuable materials, products and components are deliberately cascaded to other uses with lower performance requirements, and eventually recycled in closed material loops. Circular products and services are designed in such a way to facilitate this approach to reduce reliance on single-use products and eliminate any substances that might reduce the ability to recirculate or recycle materials. The impacts of CE approaches further accrue when combined with strategies to address linear challenges. CE is especially relevant for supply-side interventions. Innovative companies progressing CE already and producing products and services often not only reduce Scope 3 emissions but also impact on Scope 1. For example, a telehealth device can be designed and manufactured to minimise Scope 3 whilst their adoption and deployment would impact patient and staff travel (Scope 1).

4.2 **Circular approaches** to **cutting carbon**

The NHS net zero strategy shows a commitment to reduce emissions and highlights the substantial contribution needed from those supplying products and services. Improving the energy efficiency of equipment and reducing overall energy demand will go part of the way towards realising the net zero ambition. But there are far greater savings to be won by applying CE principles to the ways in which the NHS makes and uses hardware, software and digital solutions.

Materials such as steel, aluminium, plastics and concrete which constitute many products essential to health and care services are also among the most carbon-intensive materials in the economy. Yet the NHS routinely disposes of buildings, assets and products containing these and other materials well before the end of their life, losing their embodied carbon and other resources along the way (see Section 3.1 Challenges). Circular models will deliver emissions reductions by reducing the reliance on raw materials and prolonging the life of materials already in circulation. For maintaining hygiene, certain materials, notably single-use plastics, have become embedded throughout health treatments. But there are many areas where new CE business models can provide an alternative to single use, without compromising patient safety (see PPE example below).

The practical implications of these strategies can be seen in Figure 7, with reference to inflow of products, stock in use and outflows. At any point of time, there is an inflow rate driven by demand, a stock of assets and products in use, and an outflow.

Combination of CE-levers deliver non-linear material productivity boosts and associated exponential carbon-benefits

0 Baseline

Given linear take-make-dispose systems configurations stock for productive use need to be replenished and processes after end-of-use at a high rate of throughput

1 Improve utilisation

Improving intensification and prolongation within the use phase, reduces significantly the in- and outflow at systems level

2 Improve revalorisation

Adding revalorisation of equipment and materials at end of use e.g. via reverse-CE-levers like remanufacturing, refurbishment and recycling further decreases the need for material intake and outflow

3 Improve unputs

Improving inputs by optimizing the material productivity (e.g. light weighting) or the mix of materials (e.g. towards less carbon-intensive materials and components) then further reduces the need for stock

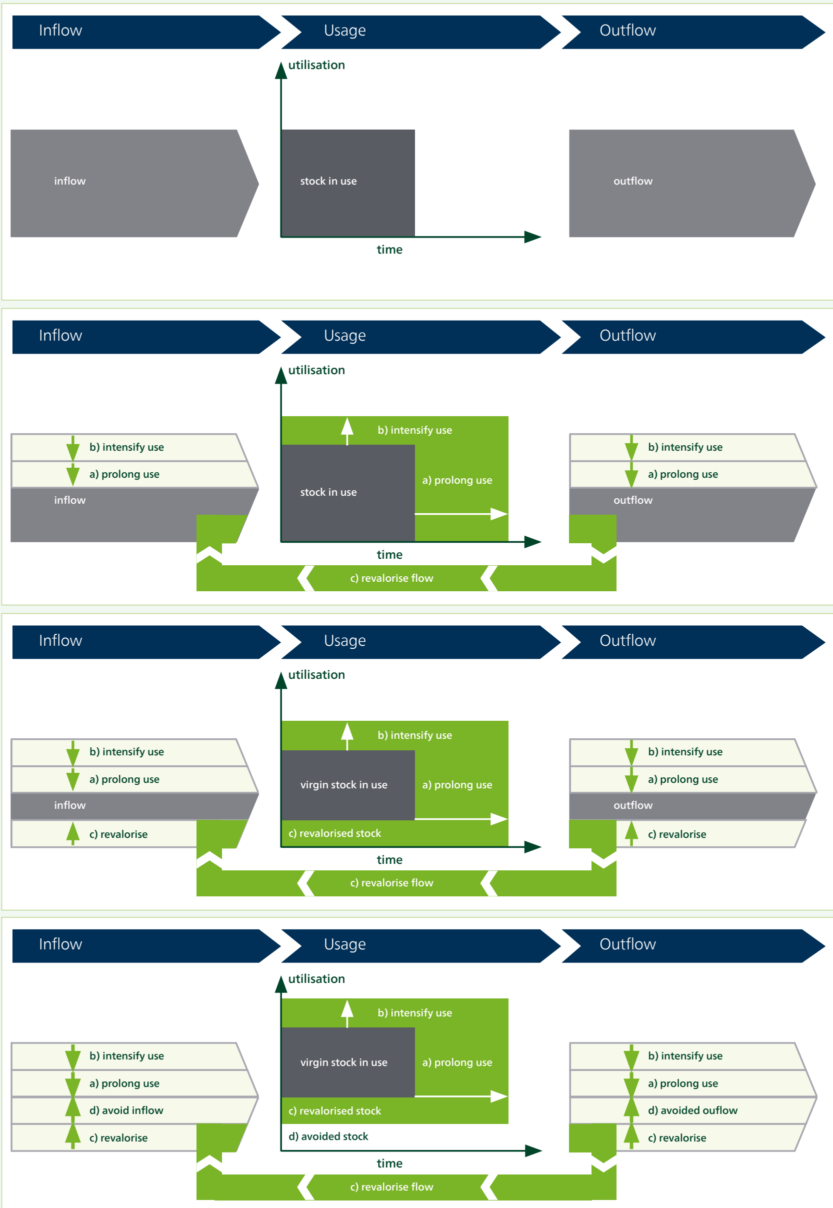


Figure 7: Driving resource productivity and net zero through a system led approach.

Greenhouse gas emissions arise at all three stages of a product life cycle:

Inflow - e.g., emissions from manufacturing a medical product, as well as extracting, refining and transporting the materials used in that product

Product Stock in use - e.g., emissions from the power consumed or from the embedded carbon in consumables (e.g. coolants, lubricants, sterilisations) in operating the product

Outflow - e.g., emissions from transporting and incinerating the end-of-life product

The fundamental contribution of CE approaches is to maximise the length of the use stage, and by doing so this will slow down the inflow (need for new product) and outflow (the rate of disposal). As an example, Philips has an approach to extending product life through managed services that also improves the patient and staff experience and reduces costs.

As the inflow and outflow rates are lowered, this reduces the overall emissions at a rate far greater than could be achieved through improving the energy efficiency of equipment alone (Figure 8). Moreover, innovation in equipment design (to support upgrade, repair) and support service improvements increases the carbon and material savings even more.

The combination of these CE-levers at systems level delivers exponential material productivity gains and in turn significantly reduces their upstream and downstream embedded carbon rucksack. This logic is also aligned with NHS assumptions on the needed acceleration of the net zero trajectory (Tennison et al 2021). In their target setting approach the authors also assumed three broad levers, which are in line with the above CE-impact logic:

1

Improve resource productivity in use

(e.g., via product-life extensions, maintenance regimes)

2

Improve re-use of products, components, and materials

(e.g., by using more reusable items, establishing remanufacturing, and upgrading of procedures)

3

Lower the embedded carbon in the inbound products

(e.g., using more low-carbon material, components, and products) as well as de-carbonising the industrial system required to produce, set-up and decommission products at end-of-use (e.g., low-carbon logistics, low carbon energy provision and industrial processing)

A combination of CE-levers results in exponential decoupling of service from material input and embedded emissions

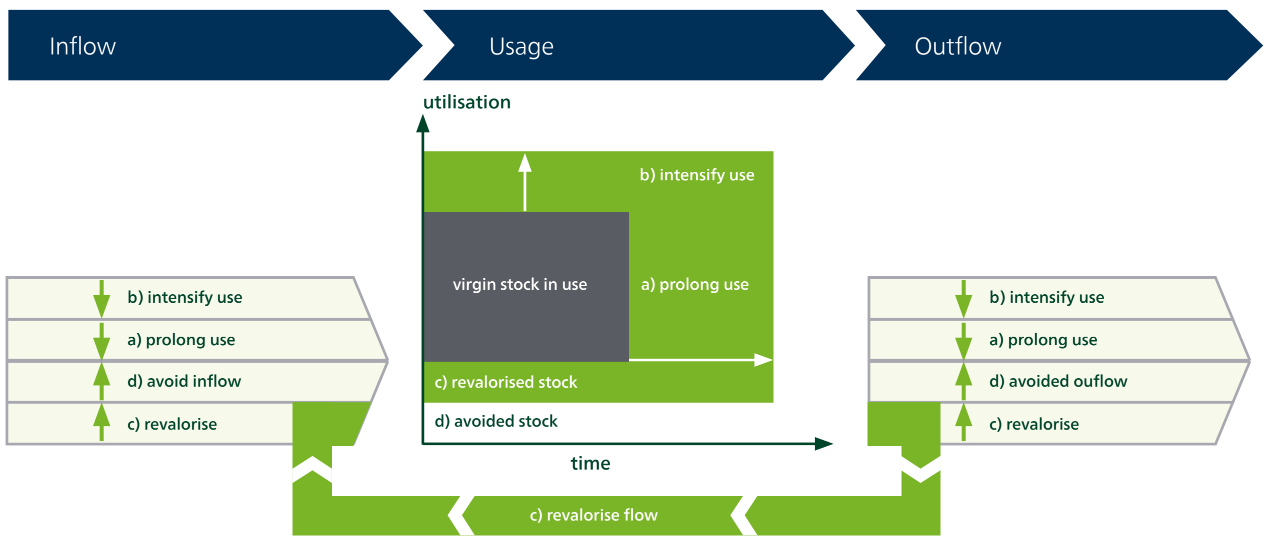


Figure 8: A simulated model illustrating the reductions in inflow, in use stocks and outflows from CE systems.

To illustrate Figure 7 and 8, take the example of the new Philips Ingenia Ambition MRI scanner (detailed in Case Study 5.3), which uses an ultra-low closed helium system. Not only is this product more energy efficient than older MRI scanners, but its design also avoids downtime caused by helium leaks. This, in turn, allows the scanner to be used more intensively, thus reducing both inflow and outflow rates, while increasing the overall productivity of the care activity enabling more scans and higher uptime. These carbon benefits can be enhanced further by extending the life of the scanner e.g via repair, refurbishment or upgrade through a managed service. If the scanner reaches the end of its service life, for performance or reliability reasons, then further carbon benefits can be achieved by harvesting highly valuable functioning parts and components e.g the magnet, which can be incorporated into new products. Alternatively, the scanner can be cascaded into other sectors e.g vetinerary, which have lower performance requirements. Final carbon benefits can be achieved by recycling to recovery material streams such as metals and plastics which can be incorporated back into new products, subject to meeting medical grade standards. Frequently the embedded carbon of recycled materials is only a fraction of the virgin material (e.g., for aluminium savings exceeding 80% are possible).

The reduction in waste and the re-use of medical devices is a critical part of the NHS pathway to net zero. A combination of managed services, upgrades, repair, refurbishment or potentially the remanufacturing of a device (see Ricoh example below) can offer up to 50% cost savings per product, reducing waste to landfill and incineration and reduced CO_2e by between 50% - 80% per device[38].

To illustrate how some of these strategies work in practice, here are a further four short examples of the benefits of working with circular suppliers.

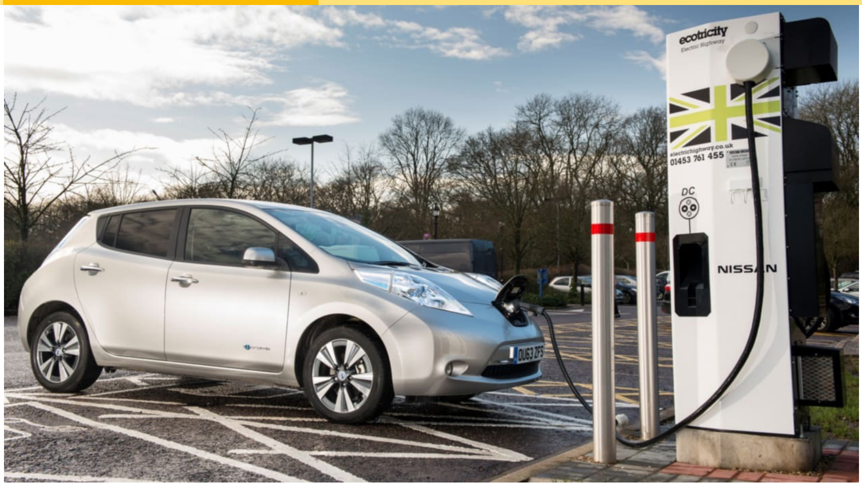
A global product service life extension, pay-per-use business model that saves money, guarantees performance and **90% material retention**

RICOH

Ricoh is the world's number one Digital Imaging and Print Management company. It has operated a Circular Economy Product Service Business Model since 1994. This combines maintenance, upgrades, product life extension and a service arrangement that benefits both the client and Ricoh. This foundation is a pay-per-print model, with the company retaining ownership of the hardware and consumables which are serviced and supported by field engineers. The customer receives guaranteed reliability and full cost transparency. Consumable devices are continually returned and refilled without any loss of performance. At the end of a contract the main imaging device is returned to Ricoh where it can be remanufactured to 'as good as new' (specified by British Standard 8801) and resold at a discount to the customer with a reduced overall Total Cost of Ownership. Each remanufactured device retains more than 90% of its materials and components by weight and the embodied energy and carbon from the original manufacture.

(Source: Hopkinson et al 2018)

A **circular economy ecosystem** driving higher asset utilisation, renewable energy services and **product re-use at profit**



Renault has evolved a CE ecosystem over the past 10 years which is generating cost savings of around 100M euro per annum with a target of 1bn euro per annum by 2030. The CE journey began 10 years ago from the recovery, remanufacture and resale of gearboxes and smaller components and parts at a specialised factory in Paris. The success of this programme had led to a number of national networks involving end of life recovery partners, material processors and more recently mobility-as-a-service and renewable energy grid services on the back of the rapid shift to Electric Vehicles. The company is now redesigning its new portfolio of vehicles to extend product life. Updates will include easier maintenance and upgrades, product life extension, incorporation of more recycled materials and the salvage and remanufacture of many more materials and parts (e.g., metals, plastics and textiles). This reduces the carbon and material footprint of each vehicle whilst mobility as a service is designed to intensify the vehicle use phase and the low occupancy rate of the vehicle ownership model. These shifts are driving new revenue streams, cost savings and addressing supply chain shocks and commodity price volatility which in the past 3 years has cost the business over 1bn euro.

(Source: Hopkinson et al 2020)

Delivering lighting as a **service**

Service based business models provide multiple benefits for both customers and manufacturers. In the case of lighting, many organisations own and operate their own lighting operations. Maintenance teams often replace lighting elements on agreed schedules which can be expensive to run, require large inventory and difficult to manage with often highly varied lighting performance requirements in different locations.

The shift to LED has enabled longer lasting devices and reduced energy demand compared to halogen. Pioneering organisations have gone one step further and moved away from purchasing, running and owning their lighting towards suppliers offering lighting-as-a-service. As an example, Schiphol Airport has a goal to be the world's most sustainable airport, with reduction in energy consumption a top goal. During a refurbishment of Lounge 2, the airport collaborated with Signify – the former Philips lighting division, to design 'sustainable luminaries' to allow for easy and fast repair or replacement – one of the largest cost elements in a lighting operation.

The luminaries last 75% longer than previous LED, use 50% less energy and work on a 5-year maintenance contract with an option to extend for a further 5 years. Most importantly they meet exacting performance requirements which lie with the supplier as part of the contract. As a result, Schiphol can focus on its core business (travel) and freeing up resources for other energy savings activities. Schiphol benefits from a lower TCO and overcoming the problem of what to do with the lighting when it comes to the end of its life – they return it to Signify for remanufacture or recycling.

Source:
Signify light as a service

Revolution-ZERO
Protecting you and your world

Zero waste Circular PPE through **design for re-use**

The generation of plastic waste by healthcare systems has never been more under the spotlight with single use surgical masks being at the forefront of this attention.

Revolution-ZERO is a UK based zero waste, zero carbon targeted circular PPE start-up addressing the environmental and monetary cost of single-use PPE whilst increasing supply chain resilience through local supply and service. Starting with CE- marked reusable surgical face masks Revolution-ZERO is now supplying NHS Trusts and GP surgeries, whilst rapidly progressing towards being available on central NHS frameworks. Though still in the early stages, Revolution-ZERO has saved over 12 tonnes of CO_2 equivalents. The range has extended to 12 core products with the potential to displace more than 88,000 tonnes of plastic waste produced by the UK NHS annually.

Source: Dawson, T (pers. comm February 7th, 2022)

In practice, companies and organisations who are already benefitting from CE typically succeed by harnessing four core building blocks:

1

Design:
Work with suppliers that design products and services to promote maintenance, product life extension and eliminate toxic materials that prevent re-use or recirculation.

2

Business models:
Work towards business models that focus on the total cost of ownership, create product- service offers that incentivize intensified utilisation with guaranteed performance and options to significantly extend product life.

3

Reverse logistics:
Design in at the outset an end-of-life reverse loop back to the manufacturer to ensure valuable products, components and materials can be recirculated profitably.

4

System enablers:
Think in systems and identify enablers that drive systemic innovation including procurement, new forms of collaboration, health service design, digital and software tools, financial and accounting tools. In the longer-term legislation and policy, such as Extended Producer Responsibility (EPR), will influence cost profiles and impact product design, material selection and future profit pools (see section 6).

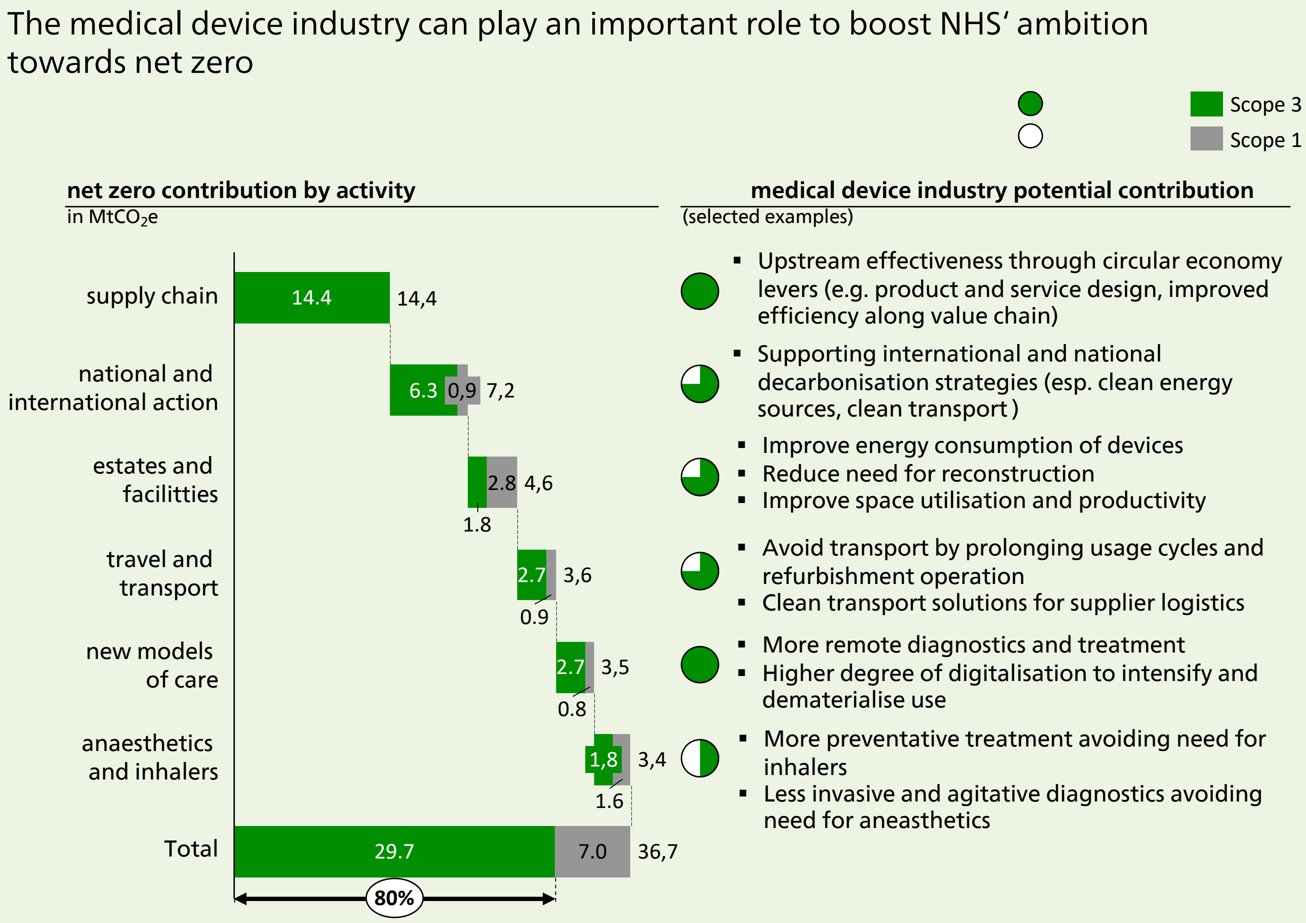


Figure 9: Medical Device contribution to net zero.

4.3 Beyond **net zero**

Well-designed CE approaches not only reduce carbon but could also drive systems-level change across the NHS, helping it tackle many other daunting challenges. These range from efficiencies that enhance the quality of service and health outcomes through to reducing cost and workforce pressures. Taken together these can all drive greater value and higher productivity. But to maximise the opportunity requires a shift in mindset. New forms of collaboration and partnership are needed, as no organisation can achieve systems transformation on its own.

Against this background a summary of ways medical equipment suppliers can influence Scope 3 and Scope 1 emissions is shown in (Figure 9).

The next section looks more closely at how specific items of medical equipment and service delivery are contributing to new zero and what more is needed from suppliers and products to drive CE solutions in support of the 9% year-on-year carbon reduction requirements to 2032.

5.0 Diagnostic **Case studies**:

To demonstrate the feasibility and benefits of applying a CE-led approach to net zero we have selected three examples of how medical equipment can impact Scope 1 and 3 emissions and deliver wider system benefits. The following cases were researched via interviews with NHS practitioners involved in their implementation, medical equipment trade bodies and a leading medical equipment supplier. Figure 10 summarises how each example impacts on the Scope 1 and 3 emissions.

The medical device industry can play an important role to boost NHS' ambition towards net-zero

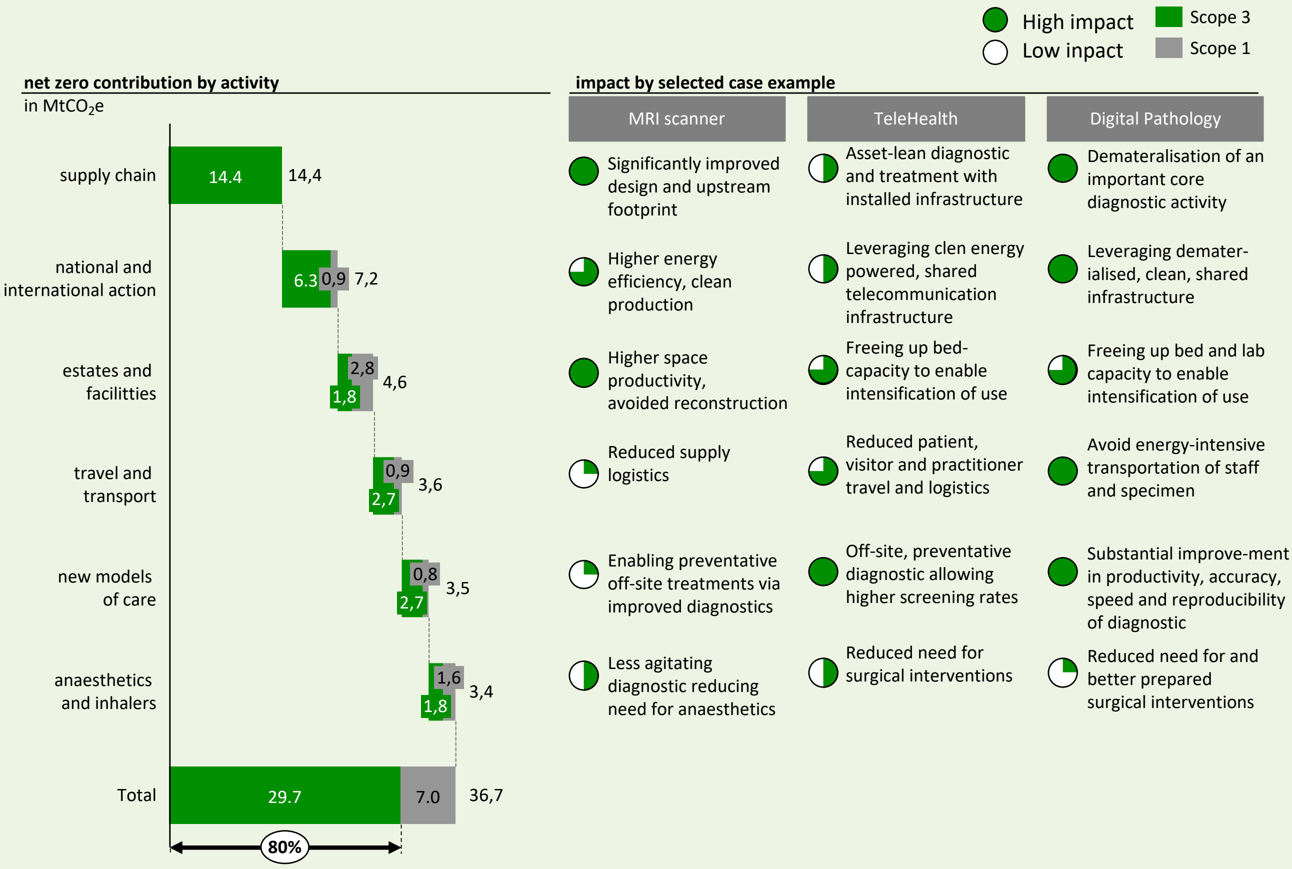


Figure 10: Impact of case study to net zero by activity.

5.1 **Telehealth**: Paediatric Cardiac Surgery: **Increasing capacity, reducing travel, and reducing assets**

Summary and Key Points

Telehealth is the provision of healthcare remotely utilising telecommunications technology. It can take many forms and be used for different applications. Telehealth is a fast-growing business model and forecast to reach $600bn by 2028. Applied appropriately and sensitively telehealth is an approach to supporting children and their families at home, instead of hospitals, to improve health outcomes and well-being. Such approaches are consistent with Philips' reputation for health care innovation and can be designed specifically to support vulnerable groups. To ensure the effectiveness of telehealth requires that families are given appropriate training and support prior to discharge and within the community. From a CE perspective telehealth is an enabler of care models delivered with equipment designed to be repairable, upgradable and reusable. Telehealth will reduce the need for travel. In the following case we reference telehealth in the arena of paediatric cardiac surgery, and interviews with clinical practitioners using such an approach at one UK hospital.

Summary

- Paediatric cardiac surgery can be a life-saving procedure that tends to be highly complex.
- Whilst paediatric cardiac surgery outcomes have become considerably more favourable in the UK, globally there are high mortality and readmission rates after discharge into the community.
- Carefully considered and executed telehealth implementations deliver many benefits for the patient and care and surgical teams through improving surgical outcomes, increasing capacity, preventing readmission and optimising social impacts such as parent and family well-being.
- Using telehealth within a pediatric cardiac surgical setting has the additional potential benefit. to dramatically decrease both monetary and environmental costs.
- Though a relatively niche market, telehealth systems and processes developed for pediatric cardiac surgery would be readily applicable and transferable across both pediatric and adult surgeries and other non-surgical specialties.
- In combination telehealth reduces patient, practitioner and visitor travel and logistics.
- Successful telehealth can free up bed capacity to intensify utilisation of NHS assets.
- To maximise benefits, all devices and equipment should be designed along CE principles.

Current Situation

Every year 36,000 babies are born with congenital heart defects requiring surgery in Europe. The paediatric cardiac surgical journey can start at any time during childhood, often presenting during routine scans whilst the baby is in the womb. The preoperative period often involves detailed diagnostics, counselling and education prior to the intervention. The surgery tends to be lifesaving and highly complex requiring specialist and intensive aftercare. Whereas global rates of deterioration, readmission or death have been reported as high as 30%, following pediatric cardiac surgery the UK has a still high but improved reported rates of 6.7% requiring emergency readmission or dying in the community. Parents and wider family members can find caring for their child at home after surgery challenging and stressful and those who experience the highest health and social inequalities, including language and cultural barriers, are also most likely to have negative outcomes. Appropriately designed telehealth offers a way to reduce stress on parents, carers and family members.

Complication

There is a high environmental and monetary cost of in-hospital pediatric surgical care. This is coupled with increasing waiting lists and a system generally under pressure. Due to the significant rates of readmission and in-community mortality, patients tend to be kept in hospital for longer than they necessarily need to be. After surgery in European pediatric cardiac surgical centres, babies have their discharge delayed by an estimated average of two days, costing £680 (ward) to £5,440 (most intensive ICU care), and incurring at least 250 kg of CO_2 equivalents ($kgCO_2e$). Once discharged to the community, the intensity of monitoring and care is far less than that received in the hospital. Communication between families and healthcare providers can be challenging, especially for families that experience other health and social inequalities.

Solution

An exemplar telehealth solution for pediatric cardiac surgery will improve the education and empowerment of patients, families and clinical teams. The key components are:

- Education and training.
- Communication hubs and infrastructure connecting families in communities with central hospital hubs.
- Software and communications devices to facilitate education, training, and interaction.
- Telehealth monitoring and diagnostic devices which can be stepped up (more devices) or stepped down depending on patient status.
- Analytics, reporting and alerting tools to support both clinical decision making and families.
- In community treatment options including self-help and/or linking with community health centres to allow for early and interim support for patients and their families.
- A triage system so any deterioration in a patient's condition is appropriately escalated within clinical teams to allow for the most appropriate and timely intervention if needed.

Productivity, cost, outcome and social gains

There are clear physical and social wellbeing benefits in enabling people to stay in their homes rather than in hospitals and clinics. Minimising time in hospital and prevention of readmission whilst keeping families together and integrated into their communities are strong arguments for the better care and outcomes for telehealth programmes. These are recommendations in the 2016 NHS paediatric congenital heart disease standards for children's specialist surgical care centres[47].

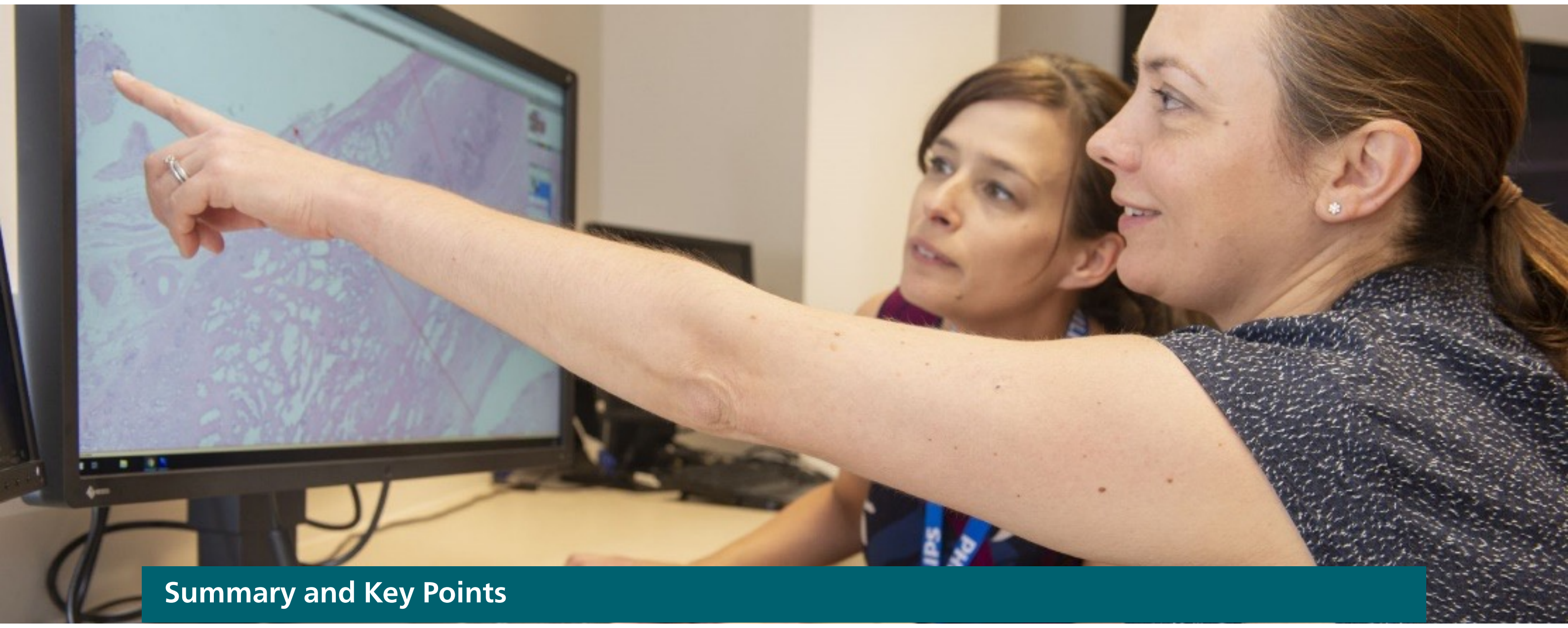
Health and social benefits include:

- Fewer in community deaths and complications requiring readmission
- Increased capacity for corrective cardiac surgery and outpatient appointments
- Fewer indirect costs from time off work, travel and family time in hospitals
- Improved health literacy and empowerment of children and families in the community
- Improved utility of extended family members/ community and sense of purpose in supporting the core family unit post-surgery

Sustainability benefits include:

- CO_2 reductions from reduced patient travel to and from hospitals and GP surgeries
- Less emergency service use at 31.3kg.CO_2e[48] per ambulance call out on average
- Decreased hospital bed days following cardiac surgery at 125kg CO_2e per day for hospitalised patients[45]
- Fewer outpatient follow up appointments at 76kg CO_2e per outpatient appointment[45]

5.2 Digital pathology, **increasing productivity, reducing travel,** and **avoiding outsourcing**



Summary and Key Points

- Pathologists examine samples to diagnose, prevent, treat and monitor disease.
- Consultant workload in the UK - currently standing at 300,000 daily tests, just as skilled diagnostic staff are in decline.
- Digital pathology, which involves scanning glass-mounted tissue samples to produce digital images, enhances productivity by up to 25% by enabling pathologists to view, manage and share samples more rapidly.
- Pathologists feel patient outcomes are improved, and the investment outlay can be recouped through eliminating the need for outsourcing pathology workload.
- The opportunity for remote working reduces pathology consultant commuting emissions by up to 20%.
- Digital pathology has the potential to intensify usage and reduce the need for traditional microscopes.

Current Situation

Working in hospitals and the community, pathologists examine tissue specimens and other samples to prevent, diagnose, treat and monitor diseases. Some 300,000 tests are performed every day across the UK, with 500 million biochemistry and 130 million hematology tests carried out annually, and 50 million reports sent from labs to GPs[49]. Some 95% of clinical pathways rely on patients' access to pathology services. In traditional pathology, consultants use microscopes to directly examine tissue samples mounted on glass slides. In digital pathology - sometimes referred to as virtual microscopy or whole-slide imaging – the samples are scanned rapidly, and in bulk, using an advanced scanning device to create full-colour, high-resolution digital images which can then be viewed on a computer screen.

Complication

Pathologists are struggling to keep pace with an increasing workload, due to:

- An increasing number of cancer cases, which are projected to rise nearly 70% within the next 20 years[50].
- Increase in the complexity of cases, with increases in the number of slides per case, the number of special stains and markers to be analysed, and the number of data items to be reported.
- A more 'time-sensitive' culture to ensure patients with cancer are diagnosed and treated in a timely manner.
- A declining workforce, with 32% of current pathologists over 55 years of age and expected to retire within the next five years. The Association of American Medical Colleges reports an 11.3% drop in the number of active pathologists between 2010 and 2015, and 63.2% of active pathologists expected to retire in the next decade[51].

Therefore, any opportunities to boost productivity are urgently needed.

Solution

In our CE terminology, digital pathology is a product-software combination with the opportunity to intensify use rate, promote new business models, reduce the inputs of new equipment and promote wider service design improvements to compound benefits. We use a recent digital pathology installation at Peterborough City Hospital to illustrate these points.

In April 2020, during the first Covid-19 lockdown, the histopathology department at Peterborough City Hospital – part of the North West Anglia NHS Foundation Trust - took the opportunity of a slowdown in routine pathology work to install the Philips IntelliSite Pathology Solution making it the NHS's first fully digital lab, although pathologists retain their microscopes for certain analyses. The Philips IntelliSite Pathology Solution delivers:

- IntelliSite Ultra Fast Scanner – using a patented autofocus algorithm to scan the irregular surface of tissue samples, rapidly delivering crisp, finished images.
- On average, it takes 60 seconds to scan one slide and the scanning also records other important information such as patient name, typically read off from a QR code or barcode.
- Information management and technology hardware – for viewing and sharing digitized samples.
- Computational pathology module, using AI to support diagnoses.

Productivity gains

At Peterborough, the productivity gains from digitisation now allow the lab's six consultants to process 34,000 specimens annually. This total includes 25,000 samples from Peterborough's own patients and an additional 9,000 samples from Hinchingbrooke, its sister hospital. The lab reports a 10 to 15% reduction in turnaround times within one year of digitisation, and 20% expected from Year 2.

Elsewhere, pathologists using the Philips IntelliSite Pathology Solution report up to a 25% productivity gain.[52] These productivity gains and improvements in pathologists' workflow come from: [53,54]

- The opportunity to view, manage, analyse, interpret, share and discuss samples more rapidly and conveniently.
- The avoidance of slide sorting and distribution - clinicians spend up to 13.5 hours per day on physical slide logistics alone[55].
- The opportunity to work remotely, reducing time spent travelling to and from the lab.
- The opportunity to instantly share digitized samples when a second or expert opinion is needed, rather than relying on the shipment of physical samples which can take weeks.
- The ability to use multiple digitized samples for education, review and discussion in real-time.

There may be a short-term reduction in productivity during the switch to the digitised lab; however, major disruption can be mitigated by transitioning in a planned and phased manner.

Patient outcome gains

Peterborough's pathologists report that turnaround times have improved by up to 20% leading to faster diagnosis. Some 80% of pathologists surveyed felt patient safety and quality of diagnosis has improved.[56] Patient outcomes can be improved for a number of reasons (Williams et al 2017):

- Lowered threshold for seeking a second opinion;
- Lower risk of tissue specimens being lost or damaged;
- Lower risk of patient/slide misidentification errors;
- Computational pathology supports pathologists;
- Ease of formation of networked pathology services and the development of 'hub-and-spoke' collaborations as recommended by the Carter review of pathology[57].

Net zero benefits

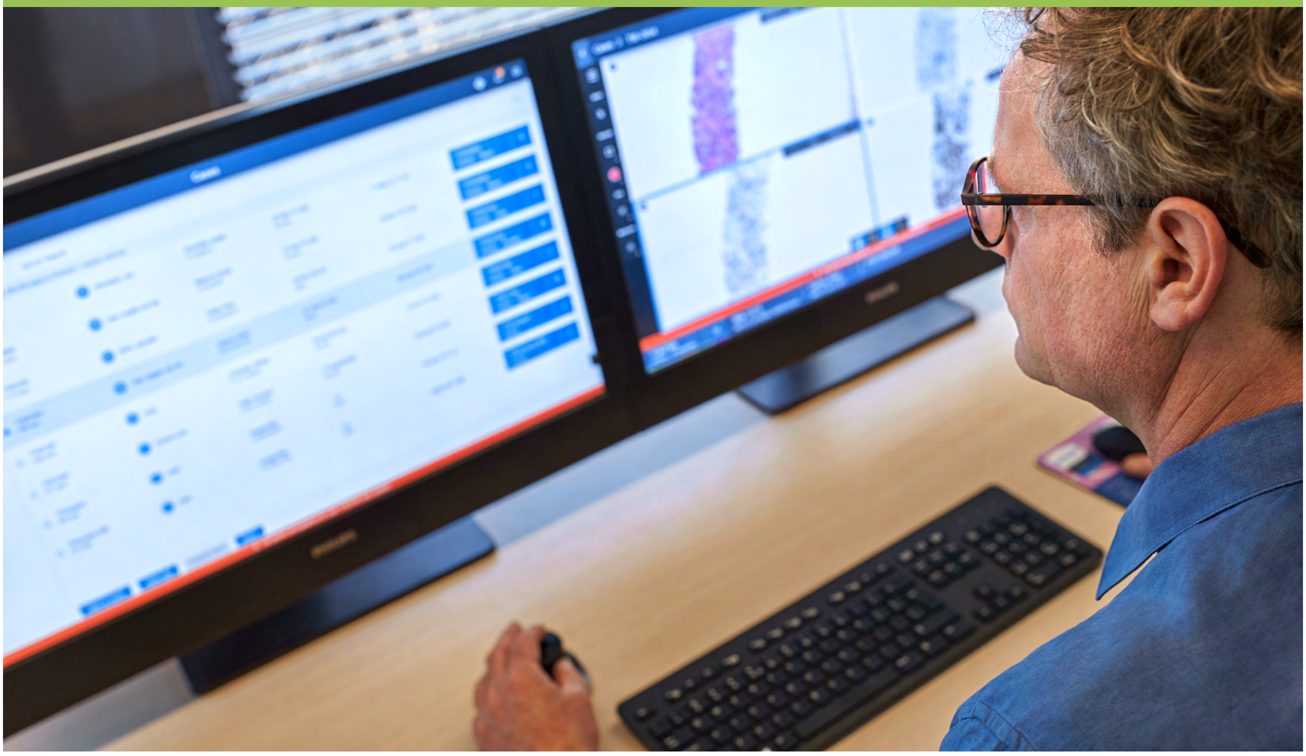
A full assessment of the net zero benefits of this case study will require a deeper analysis of Scope 3 data on the carbon footprint per scan of the digital solution versus a standard microscope. Scope 1 savings are measurable as consultants at Peterborough can now each spend one day per week working from home, representing a potential 20% cut in emissions from commuting. A full carbon account will need to compare the additional electrical equipment - scanner, servers and monitors – versus traditional microscopy and any changes in the shipment of physical samples for second opinions. As with all technological innovations, there is also the potential that more accurate, faster diagnosis may actually increase patient travel as it is more likely to lead to new tests and treatments. Further opportunities to reduce emissions include electrification of the NHS transport fleet and switching to renewable energy to power the lab will offset some or all of the additional emissions from installation of the Philips IntelliSite Pathology Solution. Offering a pay-per-scan or other circular business model may lower the total cost of ownership and reduce material impacts through allowing component upgrades and opportunities for take-back and remanufacturing.

Business case

According to Business Wire, the global digital pathology market by revenue is expected to grow at a CAGR of over 10% during the period 2020-2026[58]. Digital pathology does not replace pathologists: it is a tool to make their lives easier. A survey of pathologists who had switched to digital found that 100% of them preferred to work digitally. This is partly due to the ergonomic advantages of digital pathology: less time spent peering down a microscope means reduced eye strain, back- and neck-ache[60]. The number one driver for the adoption of digital transition is, however, the significant productivity benefits offered.

Indicative annual costs for a digital pathology lab to install technology as part of a managed service contract are in the region of £100 – £200K depending on the size of the workload and consultant pool (Williams et al 2017). As the experience at Peterborough City Hospital shows, the investment can pay for itself by eliminating the high costs of outsourcing pathology work. Other business benefits of digital pathology include the reduced risk of fines from breaching of NHS performance standards, avoided costs of transporting physical samples between sites and a new potential revenue stream from taking on other labs' work.

The business case for Peterborough was overwhelmingly positive. Switching to digital paid for itself in the first year, by saving the Trust 40% on outsourcing costs – Hinchingbrooke's pathology workload was previously being sent to Cambridge for analysis at an annual cost of £1m.



5.3 Helium Free Operations – **reducing waste, anaesthetics** and **improving diagnostic outcomes**

Summary and Key Points

- MRI scanners play an essential role in many acute health diagnostics.
- The UK has one of the lowest MRI/CT scanner rates per capita (6 per million) in Europe and developed countries[61]. Additionally, there is a shortage of radiologists in the UK limiting the throughput of patients.
- The NHS has approximately 450 MRI scanners with wide ranging lifetimes (the majority 8-12 years) before retirement (source: Philips interview).
- In 2018 the NHS carried out 3.5m MRI scans at a cost of approximately £80-130m (incl. staff costs).
- Modern generation scanners reduce the need for anaesthetics, have lower resource requirements and are more energy efficient. One study estimated the carbon footprint of a 3T scanner at 160kgCO_2e/scan.
- The Philips Ingenia Ambition scanner is an ultra-low closed helium system (helium is a non-renewable resource) which benefits in terms of both capital and operational costs as well as health and safety risks.
- NHS MRI scanners are purchased and owned outright by the NHS, reducing the opportunity for working with suppliers on further CE innovations including utilising the full product design life, service models (scanning as-a-service), or harvesting and re-using technical components with the same exacting standards as new , which would all drive down total cost of ownership, improve resource and carbon footprint per-unit treatment whilst maintaining patient safety.

Current Situation

There is a wide range of Imaging technologies used in the NHS including X-ray, CT and Magnetic Resonance Imaging (MRI). MRI, the focus of this case, is a type of scan that uses strong magnetic fields and radio waves to produce detailed images of the inside of the body. The results of an MRI scan are used to help diagnose conditions, plan treatments and assess how effective previous treatments have been. It forms an indispensable component in numerous care models. The quality of the result allows for tailored and efficient treatment of patients.

For some patients an MRI scanner can create anxiety and distress, often requiring anaesthetics to avoid agitation and potentially reduced image quality. MRI scanner design is therefore not just about hardware but also finding ways to manage anxiety within the clinical setting.

As with all imaging devices, technology moves forward, and the speed and resolution of image quality improves over time. Whilst older scanners remain functional, newer machines have a number of innovations and patient benefits (see solutions case study below). New devices also continue to improve their environmental performance which can reduce cost, in-use energy consumption, carbon footprint and waste.

Complication

The UK has one of the lowest MRI scanner-to-patient ratios in Europe (6 per million). Additionally, the NHS is short of radiologists (between 1000-2000). Traditionally MRI scanners are purchased and owned outright by the NHS with an accompanying maintenance and service contract. NHS operates block contracts of 10-15 year with General Practitioners for scanning services therefore reduces innovation cycles or options for innovative business models. As a result, opportunities for business model innovation around utilising the full design life of scanners via upgrades or components to incorporate into fully warranted 'good as new' remanufactured devices - potentially reducing total cost of ownership (TCO), carbon and material footprints without detriment to patient safety - are rarely considered. Service-based business models that work effectively in other sectors – for example, 'scanning-as-a-service' – also lie outside of NHS current practices.

There is a wide range in the age distribution of MRI scanners within the NHS, with some still operational at 15 years and older. Many are retired earlier due to reduced reliability, enhanced performance of new equipment or availability of capital allowance funding which incentivizes a premature replace-it-now culture.

The replaced scanners that are still functional could receive upgrades to match current imaging requirements so that some are collected and re-sold by a third party to a new, non-NHS customer. Data on the eventual fate of NHS MRI scanners is not known. However, it is suspected that few are reclaimed, and few parts recovered (e.g., magnets, high value materials), even though this service is offered by the original equipment manufacturers and suppliers.

Solution

In our CE terminology, MRI scanners represent an important product category with the option to intensify use, extend product life and introduce new business models to reduce costs, improve throughput and accuracy as well as TCO. In our case example, we also show the additional health benefits from patient-centred design. We use a recent MRI scanner installation to illustrate some of the benefits.

It is of high relevance as MRI scanners and other scanning devices will play an increasing role in the NHS and wider healthcare in future.

To illustrate some of the patient and environmental benefits of new generation MRI scanners the following case study illustrates a recent example of a low-helium MRI scanner at NHS Poole Hospital in the South of England.

Poole Hospital installed the first Philips Ingenia Ambition MRI scanner in2018, replacing a 10-year-old model from a different supplier.

Health and social benefits

Consultant Radiologist, Dr Ravi Ayer, explained the rationale behind the choice of the Ingenia Ambition. "The most important criteria in any scanner are image quality, speed of imaging and continuous use of the scanner (7 days a week, 08:00am to 20:00pm)." Poole's previous system was over 10 years old with some leakage of liquid helium", which was a source of concern for Dr Ayer, who believes the NHS should be tackling avoidable leakage of waste around non-renewable resources such as helium in addition to carbon reduction targets.

Whilst there was little difference in the price between the MRI scanners under consideration for purchase, reflecting on the performance of the Ingenia Ambition, Dr Ayer highlighted a number of benefits including "advantages in ambience, lighting and environmental conditions" which reduces the need for anaesthetics to reduce agitation, especially amongst children, to produce clearer images in a shorter period of time. In an MRI scanner the patient's breathing is monitored via chest expansion involving respiratory bellows. Philips has created a new approach to measuring chest expansion (Vitaleye) which has been found to improve imaging as well as also reducing stress for patients who otherwise must hold their breath during one of the scanning stages. A further Philips innovation, Compressed SENSE, utilizes a signal processing technique that speeds up imaging and shortens the duration of MRI examination.

Net zero benefits

The Ingenia Ambition 1.5T MRI scanner for example has reduced the amount of helium required from 1500L to 7L (an almost 100% decoupling of material intake) and is now fully sealed, meaning there is no leakage and no refill required during the lifetime: reducing the need for.4,000L helium over the lifetime of every MRI device. This is a significant improvement especially given the finite nature of helium resources[63] and potential supply chain risks from non-availability and resulting outage time. This and other changes have reduced the weight of an MRI scanner by around 900kg (7%). This reduction in weight means there is no need for reinforced floors in hospital environments resulting in reduced costs, avoided carbon-intensive reconstruction and greater flexibility for where to house or relocate the MRI, so that overall patient throughput times can be improved. Moreover, the new design removes the need for additional pipework, plant room, quenching systems, cryogenic training and handling procedures. As MRI-scanners are also very energy intensive in use, Philips enabled a PowerSave low energy modes to further reduce energy consumption in use. This all significantly improves resource and energy productivity of the MRI scanner as well as those for the support facilities and required building infrastructure.

Dr Ayer commented on the lighter weight of the low helium system and the removal of exhausts and avoidance of liquid wastes, which are both hazardous and a source of risk for patients. Looking ahead, the Trust will look into how best to dispose of the scanner at the end of its first cycle and look into opportunities to refurbish or harvest parts at a higher value.

The various Ingenia innovations improve the reliability and speed of patient examination leading to a lower carbon emission per scan compared to scanners without these features, although this will require more data to evidence fully. Higher throughput maximises the utilisation of equipment and for a given demand, lowers the number of scanners and operating personnel required, reducing costs and space requirements. The Philips Managed Equipment Services ensures equipment is maintained to ensure reliability. Philips offers a take back service for all equipment. The core component of an MRI is the magnet, which can be removed and used in refurbished products at a lower cost and significantly lower carbon footprint compared to a new magnet. Increasing the recycled content of new machines and future design to enhance options for upgrade, repair, and refurbishment can all be considered to further reduce the carbon footprint.

Business case

New scanners such as Philips Ingenia Ambition continue to improve energy efficiency. Whilst the Philips Ingenia Ambition has an improved energy efficiency (9%) relative to its previous design, this only captures a small proportion of the overall health and business benefits. These benefits include reduced capital and operational costs (anaesthetics, helium, floor reinforcement, ancillary equipment, health and safety); greater flexibility in being able to site the device; reduced patient anxiety and associated staff costs; and improved image quality.

By collecting and refurbishing products Philips can further expand its fleet of Circular Edition systems, which refurbish collected MRI-scanners into same-as-new quality and performance kit. In this process up to 80% of their average weight of a returned MRI system can be reused. By replacing obsolete or defective parts with original Philips components, the system can be refurbished to the highest imaging performance standards. This revalorization of the existing stock significantly avoids the need for virgin material intake and cuts down significantly on the embedded carbon (see also Fig. 7). With typical cost-savings of an average of 25% compared to new systems the burden on the payor-system can also be reduced and enables the deployment of more kit for the same budget.

For Philips customers this means that closing the diagnostic gap can also be addressed faster, as for each new installed product another as-good-as-new refurbished product becomes available for service with little lead-time.

Currently the NHS works MRI scanners intensively and prefer to retire old machines for operational/ performance reasons or due to capital budgeting, which can lead to some machines being replaced prematurely. The advances in net zero delivery and external enablers described earlier, may signal a shift in the way that the NHS might think about MRI and other scanning services in the future, such as 'pay-per-scan'. This would open the possibility for combining a range of CE-levers that could harness non-linear productivity gains to deliver more cost, health, performance and carbon benefits than each acting by itself; not only in the upstream manufacturing, but also throughout the full in-use and post-first-use phase.The CE-levers to boost the net zero trajectory presented for MRI-scanners can also be translated to the other imaging technologies (esp. CT and ultra-sound) as well as to other material-intensive equipment as for example image-guided therapy systems or mobile C-arm systems.

5.4 **Conclusions**

The three examples illustrate three different types of medical equipment used extensively in the NHS within three different areas of diagnostics and treatment. All three examples, each in their own way, illustrate the significant potential for optimisation of service delivery whilst reducing product and material requirements. The telehealth and MRI scanner examples have an integrated managed service arrangement to maximise up-time and performance. Each example also highlights additional benefits, from reducing travel, reducing the use of anaesthetics or ancillary facility management. The MRI scanner and Digital Pathology equipment offer a trade-in and ensure end of life equipment is managed responsibly which opens up the potential for refurbishment, remanufacturing, parts recovery and re-use. Each example therefore illustrates ways in which suppliers can make contributions to Scope 1 and 3 emissions, over and beyond the energy efficiency of their product.

Optimisation of service delivery whilst reducing product and material requirements

Rather than a linear take-make-dispose approach, adopting a circular mindset promotes a make-use-return model. To gain the full benefit of circular economy however, more could be done to drive down carbon footprints, while improving cost savings and health outcomes. More products could be designed to optimise and extend the product life. Combining this with performance and outcome-based contracts will typically deliver lower total cost of ownership and create a pathway to closing the loop on devices and equipment, which incentives higher rates of refurbishment, remanufacturing and parts recovery, and thus re-use.

Moreover, each example is only being applied in isolated cases. As we saw in the previous section there are more than 1,000 NHS hospitals and 515 independent hospitals. Hence there is a tremendous opportunity and need to both scale and extend their potential to capture all the benefits across the input, use and output phases of CE. More data would enable the NHS, suppliers and analysts to expand on the work of Tennison et al (2021) and Pencheon et al (Annex 1) to give a whole systems assessment of the total financial, workforce, health, material and carbon benefits from scaling up. This framework would provide a tool to systematically map CE-led intervention and a system scale across the entire NHS.

The three examples show how innovative trusts, hospitals and practitioners are working with medical equipment suppliers to deliver not only net zero benefits but addressing the multiple challenges facing the NHS, critical if the system is to effectively bring down waiting lists over the next five years. Table 11 in the final section illustrates what is required from different stakeholders with an overall CE-system design. To scale these up many system-wide barriers still need to be overcome and Section 6 sets out how these could happen.

6.0 **Making it happen**

For the NHS, hitting the net zero target is a monumental challenge: in England alone, there are some 1.35 million staff[64] working across central NHS, CCGs, hospitals, mental and community health, general practice and ambulance services. If the NHS and wider health services are to reduce their direct and indirect CO_2 emissions necessary for NHS Carbon Footprint Plus, NHS employees must be provided with the tools and direction to lead the transition. NHS suppliers and business partners can play a key enabling role, simultaneously addressing the multiple pressures faced by the NHS whole driving systemic change.

The selected case examples illustrate how innovations in the design, delivery, usage and re-use of medical devices and their components can play an important part in achieving NHS net zero objectives and deliver customer and patient benefits. In addition to reducing the emissions, these CE drivers also promise significant economic benefits due to extending the life of products and increasing the intensification of the use phase. These benefits however can only be realised if all parts of the health care system and business processes are aligned and co-ordinated. A telehealth service for example requires enhanced patient management and scheduling. Further improvements in Digital Pathology or MRI scanners could be achieved via device-as-a-service business models. In all cases, internal and external policy and regulatory enablers all play a major role in determining what is considered feasible, 'safe' and how to incentivise 'remanufactured' over new or how to reflect CE within tenders and procurements.

In order to attain these potential contributions, there are priorities for the relevant stakeholders along each of the main net zero dimensions. An overview in Annex 5 exemplifies a number of levers against NHS main net zero targets with specific examples to further CE-best practices as exemplified in the previous case examples.

Driving CE-based decarbonisation of medical-devise depending health services requires a systematic approach to achieve aspirational targets

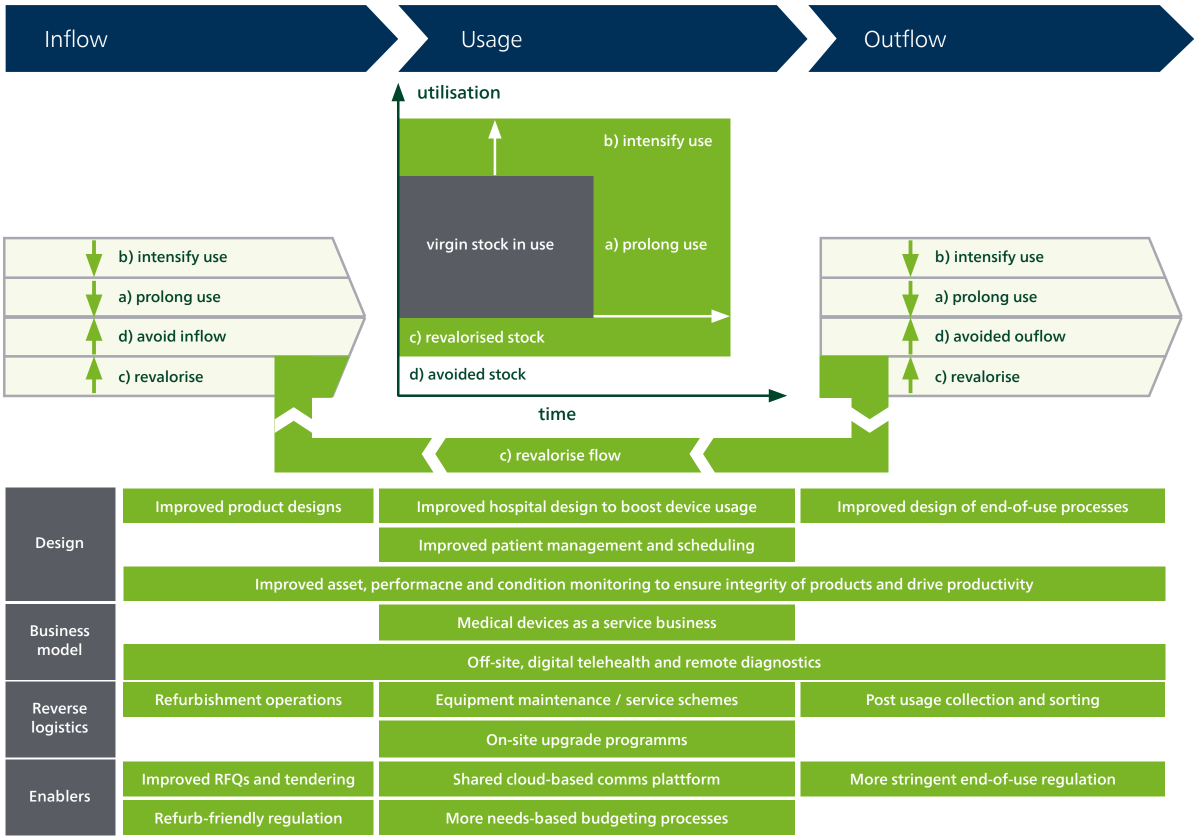


Figure 11: Driving future CE innovation

6.1 **Recommendations**

Achieving net zero will not only require NHS to continue and speed up its current net zero trajectory. NHS will need to activate, stimulate and coordinate collaboration across a wide range of business partners and suppliers to significantly improve Scope 3 emissions, which are four times more significant (as of 2020) than Scope 1 emissions. Given the high annual compounded improvement rates of 8% p.a. innovation is urgent and requires front-loading as any delay will lead to further increases in targets in the following years. While this step-up will require investments by all members of NHS extended value chain, there are also potential gains in operational efficiency and material productivity, which bears the opportunity to render this effort attractive also in economic terms to the wider NHS system.

The following sections comprises a list of recommendations and key priorities that the following stakeholders should focus on to fast-track the adoption of CE-best-practices to boost NHS net zero trajectory:

6.1.1 **Medical Equipment, Service Suppliers, and trade bodies**

There is an urgent and compelling need for suppliers to provide more evidence in line with the NHS Evergreen framework based on stringent, verifiable reporting towards net zero ambitions. This includes:

- Suppliers should more actively showcase solutions from installed innovations with documented cost benefits of CE (to NHS zero delivery teams, NHS supply chains, NHS Trusts) including Scope 3 carbon footprint, and the potential for more efficient models of care for better outcomes – and experience for patients and staff.
- Improving documentation and evidence of product Scope 3 carbon footprint to match NHS supply framework and net zero ambitions; ideally along a standardized sets of CE measures to enable best-practice exchange e.g., total carbon footprint or total cost (per scan).
- Ensuring suppliers trajectory for net zero is aligned to the NHS trajectory and promoting ‘best in class’ using robust and auditable methods and data.
- Promoting CE innovation pipeline matched to NHS net zero ambition.
- Ensuring suppliers strengthen their relationship with NHS and UK Health sector.

Suppliers need to move beyond energy efficiency and incremental innovation. Net zero requires systemic innovation. Leading CE suppliers have already embraced CE-design principles and now need to raise awareness of CE as a concept and its relevance to net zero and other challenges facing the NHS and health care sector better. This includes:

- Improving the longevity of assets and higher level of usage (intensification of use).
- Improving the mix of material inflow from responsible sources and reduced carbon footprint, and by significantly increasing the retention or reclamation of non-hazardous materials and components.
- Significantly reducing energy consumption in use and the need for consumables.

At the same time suppliers need to ensure stringent progress on Scope 1 and 2 emissions and some 'low hanging fruit' actions that have been highlighted by NHS staff including:

- Establishing clean-energy-powered manufacturing and logistics processes across their upstream value chain to drive down emissions.
- Ensuring sourcing from renewable energy and responsible sources.
- Designing out unnecessary waste product and materials from installations such as unnecessary cabling, connectors, documents, packaging.

Designing equipment along CE principles can deliver benefits to the NHS and the supplier. To unlock the value creation potential of CE however requires adoption of end-to-end service-based business models, which:

- Incentivise longevity, upgradability and improved maintenance of equipment to achieve higher uptime, higher utilisation and longer usage periods.
- Integrate reverse recovery activities to ensure higher degree of component and material recovery across their supplier network and certified reprocessing capacities.
- Actively encourage cascading of equipment across different usage cycles and needs-based segments (e.g., cascading from human to veterinary applications) to maximize full usage live of equipment.

6.1.2 **NHS**

The NHS has started to create incentives and targets for its upstream supply chain partners needing to bring the largest contribution to reduce Scope 3 emissions, especially by establishing and leveraging procurement influence. The NHS however must now make a step-change from incremental approaches to systemic approaches which includes:

- Embracing CE-inspired models of usage, which favour longer and higher intensity usage of equipment.
- That the NHS mandates suppliers to provide proof of circular economy-based practices by 2025, demonstrating how they are extending material lifetime use, refurbishing equipment to sufficient standards, and that where possible, introducing digital-first products and services.
- Promoting the usage of more service-based business models (e.g., pay-per-use, service contracts).
- Demonstrating that decisions in their tender rankings around emission-reducing factors have been taken into consideration (and not only short-term cost focus).
- That the NHS provides training to all staff on minimising waste in work / principles of circular economy for use in the health environment.
- Moving away from the traditional capital allowance model which encourages equipment or components to be replaced before the end of their service life.

Rather than just providing equipment suppliers the NHS needs to work closely with suppliers as partner and enabler for improving:

- Collaboration on overarching carbon strategies over longer-term contracts to scale systemic solutions beyond just 'buying' devices or consumables e.g., wearable monitoring to keep patients away from acute hospitals integrated with fleet and facility management.
- Patient care models and journey pathways which aim to further reduce usage of scarce bed-availability.
- New and alternative forms of diagnostics and treatment (together with the GP community) to ensure more preventative and faster diagnostic and treatment to shorten illness and aggravation of patient circumstances.
- Digital solutions to health and care monitoring and management.

The NHS themselves can lead the way by:

- Applying CE-principles to their own operations (e.g. maintenance, operations of fleets and installations) **Demonstrate.**
- Providing scale to the clean-energy transition by being an active launch customer for emerging technologies. **Pioneer**.
- Questioning whether products, devices, consumables or single use items are needed or can be done differently - look at entire care pathway. **Refuse.**
- Identifying whether a consumable or task (such as providing information) be reused. **Reuse** e.g. digital information, analytics, instruments, equipment, consumables.
- Assessing whether the method, information, consumable or equipment can be fixed. **Repair.**
- Evaluating whether the method, information, consumable or equipment be used for something else. **Repurpose.**
- Determining whether the method, information, consumable or equipment be broken down into constituent parts and reconstituted into a new version or something else. **Recycle.**

To scale up promising early developments the NHS should build a platform for CE-innovation in the UK health care industry by:

- Undertaking a comprehensive and systematic mapping of key medical equipment product categories to produce use cases showing their feasibility and to quantify the carbon and financial benefits from a range of CE interventions including **Reduce, repair, reuse** and **refurbishment.**
- Working with key suppliers to build demonstration and test cases to quantify and evidence the patient outcomes of larger systemic innovation and service re-design with greater resource productivity delivered including remote diagnostics, telehealth and new models of care in the community. **Innovate.**
- Building partnerships with leading CE communities nationally and globally for knowledge exchange, shared learning and capacity building. **Convene and collaborate.**
- Taking the opportunity to become a global leader in both net zero and circular economy. Lead and role-model
- Building CE into education and training programmes to influence staff at all levels about their role and responsibility and how they can support change. **Enable.**
- Capturing financial savings from future CE innovation and making these available to accelerate and scale up further CE innovation. **Capture.**

6.1.3 **Policy and regulators**

Policy and regulatory organisations can enable and accelerate CE and ensure the compliance of CE-models with objectives to protect patients and the public, including:

- Certification of refurbished equipment as good as new.
- Improving the enforcement of standards to ensure viability of innovative services and avoid abuse (e.g., counterfeiting, sub-standard repairs, inappropriate removal and disposal).

They are also in a position to provide incentives and stability of regulation by:

- Incentivising for NHS and suppliers to invest into new models of care and more CE-inspired diagnostic and treatment technologies.
- Undertaking regular review and promotion of supportive policy guidance for re-use, repair, refurbishment and remanufacture whilst maintaining the demands of patient safety.
- Ensuring regulatory control to oversee the implementation and delivery of new care models, such as telehealth, to maintain the highest quality and patient safety healthcare.

Finally, policy and regulation can provide a platform for cross-industry collaboration in pre-competitive spaces, by promoting industry wide standards and certification for refurbished and remanufactured equipment, to ensure that quality is assured. This involves:

- Benchmarking international developments on CE and health care including re-use, repair, refurbishment and remanufacture.
- More funding to activate and stimulate CE-led innovation in the short term to overcome inertia and lack of awareness.
- Policy and regulatory frameworks and interventions to promote and incentivise whole system approaches and systemic innovations.

Given the case examples there are different levels of feasibility in the short, medium and long term. Some are no-regret and under full control of NHS already today (e.g., changing procurement processes to account for service-based business offerings being comparable to sales-based investments into medical equipment). Others require more orchestrated and system-wide-enabled interventions (e.g., systems for the redeployment of medical equipment across hospitals with different levels of diagnostic requirements).

In conclusion, the NHS faces formidable challenges in fulfilling its duty of care with the backlog created by the pandemic. Achieving a net zero health system is not only ambitious but essential if the UK is to meet net zero. It is difficult to envisage how the NHS can deliver net zero by continuing an incremental model of innovation embedded in a largely linear approach to products and service procurement and commissioning.

Applying circular economy at scale provides the direction and a framework for the UK healthcare system to support care for vulnerable patients, reduce costs and deliver net zero.

For those daunted by the scale of the ambition and challenge, we quote the words of Herman Mulders, pioneers of the Equator Principles.

"Nothing is impossible, especially if it is inevitable"

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Case study Interviews and personal comments

Dr Ravi Ayer, Consultant Musculoskeletal Radiologist. Poole Hospital NHS Trust (Zoom 2nd November 2021)

Dr David Bailey, Consultant and Clinical Lead for Cellular Pathology, North West Anglia NHS Foundation Trust, Peterborough City Hospital, Peterborough, UK (Telecon 15 November 2021)

Rafael Geurerra, Clinical Director Congenital Heart Centre, Alder Hey Children's Hospital

Annexes

Annex 1 - Carbon by treatment and specialty

The following table evidences carbon emissions across a range of health care sectors, specialities and treatments. In all instances circular economy best practice can be incorporated reducing the need for travel, reducing the need for medication, anaesthetics, improving pre- and post-operative diagnostics and recovery, reducing equipment and building energy demand.

Specialty	Setting	Carbon footprint	Comments
Renal (inpatient and outpatient care, peritoneal and haemodialysis, transplantation, and administration)	County renal service in UK (population 865 000)[11]	3007 metric tonnes CO2e/year for the overall service	Breakdown: building energy 13%, travel 15%, pharmaceuticals 35%, equipment 25%, waste 10%, misc 2%
Surgery	Three academic hospitals, in US, UK, Canada[12]	3219-5188 metric tonnes CO2e/surgical suite/ year 1.7-2.3 tonnes CO2e/m2 area 0.15-0.23 metric tonnes CO2e/case	Major contributors were anaesthetic gases and energy consumption (high HVAC requirements for surgical suites)
Intensive care	Royal Cornwall Hospital critical care unit, UK[13]	0.008 tonnes CO2e/bed day	Considered only scope 1 and scope 2 electricity use
Emergency medicine	15 EMS systems in US and Canada[14]	Median emissions: 0.037 metric tonnes CO2e/response 0.0035 metric tonnes CO2e/service area resident	75% emissions from diesel and gasoline fuel (Excludes air medical services, with 1.1 CO2e/response)
Dentistry	22 community dental clinics in Fife, Scotland[15]		Breakdown: travel 45%, procurement 36%, building energy 18%; fivefold variation across clinics
Drugs	15 largest drug companies globally[16]	49 metric tonnes CO2e/million US dollar revenue for total sector 35 tonnes CO2e/million US dollars for the group of 15 companies	Considered only scope 1 and 2 emissions Considered only the 15 (of 200) companies that reported emissions 2012-5 Industry mean (49 tonnes CO2e/million US dollars) is 55% higher than automotive sector (31 tonnes CO2e/million US dollars)
Pathology	Two university affiliated health services in Melbourne, Australia[17]	CO2e emissions ranged from 0.5 g/test (C reactive protein) to 116 g/test (full blood examination)	Most emissions associated with sample collection
CO2e = carbon dioxide equivalent, HVAC = heating, ventilation, and air conditioning, EMS = emergency medical services			

Table 4: Estimated carbon footprint across specialties and health industry sectors. (Source: Salas et al, 2020)

Procedure or treatment	Carbon footprint
Cataract surgery	0.182 tonnes CO2e/cataract surgery (University Hospital Wales, Cardiff, U.K.)[18] 0.006 tonnes CO2e/cataract surgery (Aravind Eye Hospital, Pondicherry, India)[19] The Welsh analysis included patient and staff travel, paper and ink, and food, whereas the Indian analysis did not. Aligning the two results for comparison yields 0.130 tonnes CO2e/procedure in Wales and 0.0006 tonnes/procedure in India, approximately a 20-fold difference
Asthma inhalers	0.6-28 kg CO2e/device[20] 0.017 metric tonnes CO2e/patient/year for Relvar-Ellipta/Ventolin-Accuhaler 0.439 metric tonnes CO2e/patient/year for Seretide-Evohaler/Ventolin-Evohaler
Anesthetics	Global heating potential relative to CO2[21]: Sevoflurane: 210 Isoflurane: 510 Desflurane: 1620
Laparoscopic surgery	355 924 metric tonnes CO2/year for all US laparoscopic procedures[22] including scope 2 and scope 3 emissions
Hysterectomy	212 000 metric tonnes CO2e/year for 500 000 hysterectomies in the US[23]
Renal dialysis	3.8 tonnes CO2e/patient/year in centre; 1.8-7.2 metric tonnes CO2e/patient/year at home, depending on technique[24]
CO2e = carbon dioxide equivalent	

Table 5: Estimated carbon footprint across procedures and treatments (Source: Salas et al. 2020)

Annex 2 - Relevant Policy and Legislation (non-exhaustive)

Topic	Relevant legislation or policy
Medical Device (UK)	The Medical Devices Regulations (MDR) 2002, as amended
Medical Device (EU)	The Medical Device Regulations (2017/745) (MDR) The in vitro Diagnostic Medical Device Regulations (2017/746) (IVDR)
Health and Safety	Health and Safety at Work etc. Act (HSWA) 1974, as amended Health and Safety at Work etc. Act (HSWA) 1974, as amended
Product and Liability policies	The Consumer Protection Act 1987, as amended The General Product Safety Regulations 2005, as amended Electrical Equipment Safety Regulations 2016, as amended Law Reform (Contributory Negligence) Act 1945, as amended
Decontamination of medical equipment	NHS. 2021. (HTM 01-01) Decontamination of surgical instruments NHS. 2021. (HTM 01-05) Decontamination in primary care dental practices
Standards	ISO13485:2016 – Medical Devices -Quality Management Systems – Requirements for regulatory purposes ISO14971: 2019 – Medical Devices -Application of risk management to medical devices
Waste Electrical and Electronic Equipment (WEEE) and RoHS Regulations	The Waste Electric and Electronic Equipment (WEEE) Regulations 2013, as amended Restriction of the Use of Hazardous Substance in Electrical and Electronic Equipment Regulations 2012, as amended
Medical Device Guidance	Single-use medical devices: implications and consequences of reuse Jan 2021 MHRA (Medicines and Healthcare Products Regulatory Agency). 2021. Managing Medical Devices Guidance for health and social care organisations. MHRA. 2016. Single-use medical devices: UK guidance on re-manufacturing June 2016

Table 8: Legislation impacting on the application of CE business models to medical equipment

	Intervention
Care	Developing a framework to evaluate carbon reduction associated with new models of care being considered and implemented as part of the NHS Long Term Plan.
Medicines and supply chain	Working with our suppliers to ensure that all of them meet or exceed our commitment on net zero emissions before the end of the decade.
Transport and travel	Working towards road-testing for what would be the world's first zero-emission ambulance by 2022, with a shift to zero-emission vehicles by 2032 feasible for the rest of the fleet.
Innovation	Ensuring the digital transformation agenda aligns with our ambition to be a net zero health service, and implementing a net zero horizon scanning function to identify future pipeline innovations.
Hospitals	Supporting the construction of 40 new 'net zero hospitals' as part of the government's Health Infrastructure Plan with a new Net Zero Carbon Hospital Standard.
Heating and lighting	Completing a £50 million LED lighting replacement programme, which, expanded across the entire NHS, would improve patient comfort and save over £3 billion during the coming three decades.
Adaptation efforts	Building resilience and adaptation into the heart of our net zero agenda, and vice versa, with the third Health and Social Care Sector Climate Change Adaptation Report in the coming months.
Values and governance	Supporting an update to the NHS Constitution to include the response to climate change, launching a new national programme For a greener NHS, and ensuring that every NHS organisation has a board-level net zero lead, making it clear that this is a key responsibility for all our staff.

Table 7: Early steps towards decarbonisation by the NHS (Source: Delivering a 'Net Zero' National Health Service)

Annex 4 – Recommendations for relevant stakeholders

Overview of actions required

Technical transitions		**Stakeholder contributions**			
NHS - core levers	main circular economy	equipment suppliers	NHS	regulator	others
supply chain	- optimize design of products - optimize material and component mix (including revalorized inputs) - clean manufacturing and logistics practices - responsible sourcing - drive dematerialisation / digitalisation of solutions components	- focused innovation for improved CE design - clean manufacutring and logistics practices	- Enforce emission targets on new and refurbished equipment - monitor market evolution and potential and include tragets into evaluation criteria for procurement	- facilitate reuse, refurbishment and repair of medical devices to avoid premature obsolescence	
national and international action	- generation and distribution of clean energy - establishing standards for reducing emissions in use and along full value chain	- actively leverage global footprint for best practice exchange and leveling of playing field across global markets	- promote the rapid take-up of new technology (e.g. procurement of clean transport & lotgistics)	- clean-energy legislation and incentive schemes - embedding CE across multiple sectors to build out required competencies and services	'- effective provisioning of clean shared infrastructure (e.g. cloud computing, clean energy access)
estates and facilities	- improve and intensify use - reduce need for medical device induced reconstruction - reduce energy, consumable consumption and generated waste	- Provide less consumable and energy intensive devices - shorten patient stay time to allow more treatments per space - improve staff productivity to achieve better utilisation	- adopt patient journeys and scheduling to take full advantage of savings potential for patient journeys - enable service contracts to minimise reconstruction and prolong use (incl. Upgrades) of installed assets.	- support the reuse/refurbishment of products at hospitals - increase the cost of waste processing to create positive stimulus to reclaim and reuse more materials.	- engage patients and GPs into improved patient journeys, with potentially more offsite diagnostic and treatment - leverage potential of preventative diagnostic and treatments
travel and transport	- avoid patient and staff travel - migrate to clean transport and logistics solutions	- improve throughput of patient journeys to redcue number of trips needed (e.g. telehealth) - avoid staff transport (e.g. by offline, pooled diagnositcs (e.g. digital pathology))	- reinvest into low carbon fleet of ambulances and logistics vehicles	- boost EV- and hydrogen power based transport solutions	- research, development and provisioning of zero-carbon transport solutions (e.g. by OEMs, charging infrastructure, ...)
new models of care	- bring diagnositc closer to the patients home to avoid trips and allow intensification of use of NHS facilities	- provisioning of out-of-facility, remote and mobile diagnostics and treatment alternatives	- active engagement and collaboration with communities to provide closer to home health services		active involvment of GPs to reduce need for patient travel to hospitals with improved diagnostics
anaesthetics and inhalers	- reduce usage - improve equipment reuse	design improved diagnostics and treament solutions requiring less anaesthetics	- increased emphasis on therapeutic pathways to reduce need for inhalers		- provide more diagnostics and preventative services to reduce need for inhalers

Table 9: Overview of core actions and required contribution by stakeholder

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