Centre for Sustainable Healthcare

Modelling of Greenhouse Gas Emissions and Cost Impacts of Sustainability Interventions in Kidney Care

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INSPIRE EMPOWER TRANSFORM

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Project

Sustainable Kidney Care – Implementing Best Practice

Collaboration

UK Kidney Association and Centre for Sustainable Healthcare

Supported by

Greener NHS

Author

Ingeborg Steinbach, Centre for Sustainable Healthcare

Contributors

Gareth Murcutt, UCL Department of Renal Medicine, Royal Free Hospital, London

Stephanie Choo, Hull University Teaching Hospitals NHS Trust

Joseph Jones, Greener NHS

Keith Moore, Sustainable Healthcare Coalition

Suren Kanagasundaram, Newcastle NHS Foundation Trust

Frances Mortimer, Centre for Sustainable Healthcare

Lucy Brown, Centre for Sustainable Healthcare

1. Introduction

The following report is part of the project Sustainable Kidney Care – Implementing Best Practice, a collaboration between the Centre for Sustainable Healthcare (CSH) and the UK Kidney Association (UKKA), and supported by Greener NHS.

The project's focus is the development of a robust benchmarking survey https://skc.ukkidney.org/, for tracking the implementation and impact of 10-15 sustainability interventions across UK kidney units. Most of these interventions are based on case studies and publications and have been shown to reduce the environmental impact of kidney care.

To explore how the implementation of the sustainability interventions and the scale of their spread can contribute to NHS's net zero targets, water and financial savings, we have modelled the interventions' potential impact on greenhouse gas emissions and water use. We have also modelled their financial impact and specified where this needs to be balanced against a quantifiable investment required for its implementation. For each intervention, we have assumed a current adoption rate and a potential adoption rate over the next two years.

The report below describes in detail the carbon footprinting methodology used, assumptions underpinning the modelling and results.

2. Methodology

A process-based cradle-to-grave carbon footprinting methodology has been used to estimate the annual greenhouse gas (GHG) emissions impact of the sustainable interventions. The carbon footprint analysis solely focussed on the resource use that changed as a result of implementing the sustainability interventions. The GHG emissions factors applied to convert resource use into greenhouse gas emissions were sourced from freely accessible databases, academic or grey literature. Assumptions around the change in resource use as a result of the interventions and choice of emissions factors are detailed in Section 4 under each intervention. A comprehensive list of emissions factors used for the modelling can also be found in Appendix 1.

For the estimation of the interventions' annual impact on water use, only direct water use has been taken into consideration. The study did not, for example, take into account the impact of different dietary choices on water use during food production.

The financial impact has been calculated based on the costs of the resources that changed following the interventions. Various sources have been consulted for the cost of resources. A comprehensive list of the cost data and their sources can be found in Appendix 2.

The investment costs were based on case studies adjusted for inflation.
For each intervention, the GHG emissions, water use and financial impact of the intervention at a main kidney centre and at a satellite centre has been estimated.
To model the potential impacts of the interventions across the UK, two scenarios have been considered:

- Current adoption rate of the intervention amongst kidney centres
- Potential adoption rate over the next 2 years

Assumptions about the current and potential adoption rates over the next 2 years were based on discussions with healthcare professionals working in kidney care.

3. General Assumptions

According to the UK Kidney Association (UKKA), there were 70 main kidney centres and 205 satellite centres in the UK in 2022/23[1]. However, there is a lack of information on their average number of dialysis stations.

According to the 27th Annual report of the UK Renal Registry, there were 26,613 patients receiving in-centre haemodialysis (ICHD) in 2023[2]. Assuming, that an ICHD patient receives 3 treatment sessions a week, 52 weeks a year, UK kidney centres provided approximately 4,151,628 dialysis sessions in total in the year 2023.

This translates roughly to an average size of 28 dialysis stations for a main kidney centre and 12 dialysis stations for a satellite centre on which this study's carbon modelling was based. Offering 3 shifts per dialysis station a day, 6 days a week over 52 weeks, 70 main kidney centres and 205 satellite centres would be able to provide 4,137,120 dialysis sessions a year.

It was assumed that currently 90% of haemodialysis is conducted as haemodiafiltration (HDF). It is the assumption that in cases where the dialysate flow rate is not blood-flow dependent a flow rate of 600 ml/min is used for haemodiafiltration (HDF) – 500ml/min dialysis solution plus 100ml/min substitution fluid as evidenced in the CONVINCE study[3] - and in cases of haemodialysis (HD) a flow rate of 500 ml/min is applied.

Caveats

1. All interventions, apart from intervention 4.12 (remote consultations), are specifically relevant to In-Centre Haemodialysis (ICHD) provision.
2. The authors are aware that not all dialysis machines have the same maximum dialysate flow rate. However, for the purpose of modelling the identified sustainable kidney care interventions, it was not possible to consider all the different maximum dialysate flow rates as information on the proportion of different makes of dialysis machines in the UK is not available.
3. Not all patients are on standard dialysis treatment. Some patients receive incremental/ decremental dialysis. As there is uncertainty about the spread of incremental/decremental dialysis across kidney centres and the way it is implemented, standard treatment of a three times weekly schedule is assumed throughout apart from when looking at personalised dialysis prescriptions.

Caveats continued

4. Currently, assumptions associated with each intervention are based on discussions with healthcare professionals working in kidney care. Engagement with the UKRR benchmarking tool (https://skc.ukkidney.org/) will provide more detailed data on practice patterns across the UK to refine these assumptions which will be taken into account in future iterations of this study.
5. Several of these interventions may not be possible without up-front investment, e.g. intervention '4.7 Switching to central delivery of haemodialysis acid concentrate'. Where these are required, we make this clear.

4. Sustainable kidney care interventions

4.1 Reverse osmosis water reclaim

A high proportion of water purified in reverse osmosis (RO) plants is either rejected, used for pre-treatment processes (softeners/Granular Activated Carbon (GAC)) or HD machine, RO and water circuit disinfection routines.

It was found that a reverse osmosis plant at two Royal Free London Kidney Care Centres uses 306 litres of raw water per patient. Assuming that 100% patients are on HDF, 144 litres out of 306 litres are used per HDF session at a flow rate of 600ml/min (HDF). This constitutes a water 'loss' of 53%, equivalent to 162 litres of water which is rejected, used for pretreatment processes or disinfection routines.

With the right infrastructure in place, the water, which is rejected, can be reused, for example, for toilet flushing, gardening and/or steam generation for autoclaves.

Assumptions:

- Taking only the reject water during the haemodialysis session into account, water loss is around 40%. (This rate is lower for the most recent water plant technology).
- 90% of sessions are HDF and 10% HD.
- A dialysate flow rate for HDF of 600ml/min is assumed, resulting in water use of 144 litres per session. With a reject water rate of 40%, 240 litres of 'raw' water are required, resulting in 96 litres of reject water.
- A dialysate flow rate for HD of 500ml/min is assumed, resulting in water use of 120 litres per session. With a reject water rate of 40%, 200 litres of 'raw' water are required resulting in 80 litres of reject water.
- Reusing the reject water would avoid GHG emissions associated with the municipal production and treatment of tap water.
- Emissions factor for municipal water supply is 0.191 kgCO2e/m [4] and for municipal water treatment 0.171 kgCO2e/m [4]. It is assumed 80% of water supplied gets treated.[4]
- The average cost to the NHS of one cubic metre (m^3) of water is £2.80 based on the ERIC 2023-24 report.[5]

Initial investment:

- Investment cost of the infrastructure for reusing reject water is anywhere between £8,900[6] and £28,800[7] (these figures have been adjusted for inflation).

Based on these assumptions a main centre produces 2,474 m^3 of reject water a year and a satellite centre 1,060 m^3. Reusing the reject water, for instance, for toilet flushing, gardening and/or steam generation for autoclaves, would reduce GHG emissions by 811 kgCO2e per year for a main centre, saving £6,927, and 348 kgCO2e for a satellite centre, saving £2,969. Considering the investment cost of up to £28,800, a main centre would be able to recuperate its investment cost after 4 years.

Assuming, that 5% of kidney centres are already reusing their reject water for other purposes, GHG emissions of 6 tCO2e are currently avoided and 19,527 m^3 of water saved per year. Increasing the adoption rate to 100%, would save another 371,017 m^3 of water and 122 tCO2e, saving £1.04 million.

However, it is economically and technically unfeasible to realise the reuse of RO reject water at all main and satellite kidney centres, as it would be difficult to retrofit the infrastructure for RO water reuse in existing kidney centres. Installing the infrastructure to allow the reuse of reject water is mainly possible, if there is a new build adjacent to the kidney centre or in case of a new build of the kidney centre itself.

Assuming that within the next two years another 5% of kidney centres would be able to retrofit the infrastructure for RO reject water reuse, another 19,527 m^3 of water, 6 tCO2e and £54,676 (excluding the investment costs of retrofitting the RO plant) could be saved annually across the UK.

Table 1: Annual impact of reusing of reject water

	GHG emissions savings (tCO2e)	Water savings (m3)	Cost savings (£)
Per main centre	0.8	2,474	6,927
Per satellite centre	0.3	1,060	2,969
Nationally[a], assuming an increase in adoption of 5%	6.4	19,527	54,676

[a]'Nationally' refers to all kidney centres across the UK

4.2 Haemodialysis machine disinfection cycles

It is currently unclear how many kidney centres have optimised the disinfection cycles of their dialysis machines. Case studies from a couple of units have shown that some kidney centres are carrying out disinfection cycles exceeding manufacturers' recommended standards and that there is potential for reducing the number of disinfection cycles per day by at least one.[8,9]

Another kidney centre has been able to replace the disinfection cycle first thing in the morning from Tuesdays to Saturdays with a rinse cycle without citric acid at 37 degrees, while still running the disinfection cycle on Monday mornings after the machines were not in use over Sunday.

Assumptions:

- Based on the latter, for each heat disinfection cycle 0.7kWh of additional energy is needed to heat the 9.5 litres of extra water required.
- Taking into account a reject water rate of 40%, 13.3 litres of purified water need to be produced for disinfection. With the production of 1 litre of purified water needing 0.00868 kWh of energy, 0.115 kWh of energy are needed to produce 13.3 litres of purified water.
- Based on the Fresenius disinfectant Citrosterile® - but applicable to other disinfectants and machines - 0.096 litres of Citrosterile® are used per disinfection cycle which contains 0.22 kg of citric acid per litre of Citrosterile®.
- The emissions factor for citric acid is 7.5 kgCO2e/kg[10], for water supply and treatment 0.328 kgCO2e/m^3 and for electricity use 0.2454 kgCO2e/kWh.[4]
- The cost of 5l Citrosterile is £19.81[11], water £2.80/m^3 and electricity £0.282/kWh.

Initial investment:

- No initial investment required.

The total GHG emissions savings of replacing a heat disinfection cycle with a rinse cycle is 0.38 kgCO2e per cycle, saving £0.65 per cycle.

Over 1 year, in a main kidney centre with 28 dialysis stations, 7,280 disinfection cycles could be replaced by rinse cycles saving 96.8 m^3 of water, 5,936 kWh and 698.9 litres Citrosterile®, resulting in GHG emissions savings of 2,750 kgCO2e – 32 kgCO2e for water, 1,261 kgCO2e for Citrosterile® and 1,457 kgCO2 for energy. The financial savings would be around £4,714.

In a satellite unit, 3,120 disinfection cycles could be replaced by rinse cycles resulting in GHG emissions savings of 1,179 kgCO2e and financial savings of £2,020.

If 50% of the 70 main kidney centres and 205 satellite centres have already optimised their disinfection protocol, there is the potential for a further 50% to do the same resulting in savings of 217 tCO2e and cost savings of £372,081.

Table 2: Annual impact of optimising disinfection cycles

	GHG emissions savings (tCO2e)	Water savings (m3)	Cost savings (£)
Per main centre	2.7	97	4,714
Per satellite centre	1.2	41	2,020
Nationally, assuming an increase in adoption of 50%	217	7,642	372,081

4.3 Introducing blood-flow dependent dialysate flows

This intervention was modelled for HDF only as 90% of dialysis is assumed to be HDF.
The majority of dialysis machines have a function which can adjust the dialysate flow rate (Qd) to the patient's blood flow rate (Qb) which is usually between 300 to 400 ml/min, with an average of around 350 ml/min. The haemodialysis machine's factor of Qd adjustment is between 1.2x and 1.5x of the patients' blood flow rate.

If the machine adjusts Qd to 1.2x Qb for HDF, for a Qb of 300 ml/min, Qd (excluding substitution fluid) would be 360ml/min. In comparison to a pre-programmed, fixed Qd of 500ml/min, this would yield savings from a reduction of 140ml/min[b], including water savings of 33.6 litres per session. In the case of a Qb of 350ml/min, the Qd would be adjusted to 420ml/min, leading to savings of 80ml/min in comparison to a fixed Qd of 500 ml/min. This would achieve water savings of 19.2 litres per session.

Not all patients are clinically suitable for Qb-dependent adjustments in Qd (for instance, those with vascular access problems).

Thus, for the purpose of the carbon modelling, we assumed that 90% of patients would be eligible.

Assumptions

- All machines providing HDF can adjust Qd to the patient's achieved Qb.
- Currently, 20% of kidney centres are assumed to practice blood-flow dependent dialysate flow rates.
- As a conservative estimate, water savings of 100ml/min can be achieved when using blood-flow dependent dialysate flow rates.
- The reject water rate is 40%.
- With a reject water rate of 40%, 40 litres less 'raw' water is used per session when using blood-flow dependent dialysate flow rates compared to a pre-programmed Qd of 500ml/min.
- It would take 0.3472 kWh[12] to produce these 40 litres of purified water and 0.67 kWh to heat the 24 litres of water saved through a reduction in dialysate flow rate.
- The emissions factor for water supply and treatment is 0.328 kgCO2e/m^3 and for electricity use 0.2454 kgCO2e/kWh.[4]
- According to the ERIC 2023-24 report, the cost of water to NHS Trusts was £2.80/m^3 and cost of electricity £0.282/kWh.[5]

[b] To be effective the dialysate flow rate should not be below 350ml/min.

Initial investment:

- No initial investment anticipated.

Based on these assumptions, implementation of blood-flow dependent dialysate flow-rates would lead to a reduction in GHG emissions of 0.26 kgCO2e, water savings of 40 litres and financial savings of £0.40 per session.

If a main centre switches to blood-flow dependent dialysate flow rates, annually, 5.6 tCO2e would be avoided and 849 m^3 water saved when compared to a fixed dialysate flow rate of 500ml/min, saving £8,476 (see Table 3). Satellite centres would use 364 m^3 less water each year and reduce their carbon impact by 2.4 tCO2e, saving £3,632 annually.

If kidney centres use central acid delivery, reducing the dialysate flow rate would also use less acid concentrate, leading to additional financial and GHG emissions savings.

Assuming that currently 20% of kidney centres practise blood-flow dependent dialysate flow rates, GHG emissions of 176 tCO2e and costs of £267,585 are avoided each year. Introducing blood-flow dependent dialysate flow to a further 50% of units would lead to GHG emissions savings of 441 tCO2e, water savings of 134,042 m^3 and financial savings of £668,962 annually.

Table 3: Annual impact of switching to blood flow dependent dialysate flow rate

	GHG emissions savings (tCO2e)	Water savings (m3)	Cost savings (£)
Per main centre	5.6	849	8,476
Per satellite centre	2.4	364	3,632
Nationally, assuming an increase in adoption of 50%	440.8	134,042	668,962

4.4 Online priming/bolus/washback

Online priming uses the dialysate to prepare the haemodialysis machine for the patient, saving bags of saline solution and giving sets. When online priming is not used, the dialysis machine is primed using 1 litre of 0.9% saline solution before and washed back with 500ml of saline solution after the dialysis session. The carbon modelling is based on Choo S M Y et al.'s study.[13]

Assumptions:

- For priming, a 1 litre bag of 0.9% saline solution (9 g sodium chloride (NaCl)) is used, with the average weight of an empty saline PVC bag of 22g and weight of the outer PVC packaging of 12g.
- A 500ml bag of 0.9% saline solution (4.5g sodium chloride (NaCl)) is used post dialysis with the average weight of an empty saline PVC bag being 20g and weight of outer PVC packaging of 10g.
- Saline bags and their packaging are disposed of as infectious waste and autoclaved and incinerated at low temperature.
- The carbon footprint of each giving set, 0.156 kgCO2e, has been taken from Rizan C et al.[14]
- Emissions factor (EF) for NaCl of 0.3kgCO2e/kg NaCl[15] was sourced from Carbon Cloud and adjusted for purification.
- EF for PVC is 2,944.76 kgCO2e/tonne [4] and waste disposal, 569 kgCO2e/tonne[16].
- The cost of a 1l bag of 0.9% saline is £0.96, a 500ml bag of saline £0.85[17] and a giving set £0.38.
- All HD machines are capable of online priming.

Initial investment:

- No initial investment anticipated.

Based on the assumptions, the carbon footprint of priming using saline bags is 0.39 kgCO2e and costs £2.19, resulting in an annual carbon footprint of 10 tCO2e for a main kidney centre and 4.3 tCO2e for a satellite unit. Annual costs for priming with saline bags amount to £57,396 for a main centre and £24,598 for a satellite centre.

Assuming, that 90% of kidney centres in the UK are already carrying out online priming, GHG emissions of 1,434 tCO2e and costs of £8.2 million are avoided each year.

If we assume that the remaining 10% of kidney centres would be able to introduce online priming another 159 tCO2e and £906,029 could be saved.

Table 4: Annual impact of carrying out online priming

	GHG emissions savings (tCO_2e)	Cost savings (£)
Per main centre	10.1	57,396
Per satellite Centre	4.3	24,598
Nationally, assuming an increase in adoption of 10%	159.3	906,029

4.5 Reducing linen use

The majority of kidney centres dress their chairs or beds with linen. Though dressing beds with linen is seen as a necessity, dressing chairs with sheets is not required. Moreover, kidney centres often offer their patients blankets for their dialysis sessions. However, it has been shown that some patients prefer to bring their own blankets. Hospital linen and blankets need to be laundered after every use, so a reduction in unnecessary use will reduce GHG emissions embedded in hospital laundry services.[18,19]

Assumptions:

- 95% of main and satellite kidney centres dress their dialysis beds and chairs with linen sheets and provide patients with blankets.
- 80% of dialysis stations in main kidney centres are beds, 20% are chairs.
- Satellite kidney centres predominantly use chairs, so we assumed 100% chairs.
- Blanket: medium thickness, weight of 1kg, made of 100% polyester
- Linen sheet: weight 0.573 kg , made of 70% cotton and 30% polyester[20]
- Cost of laundry per item: £0.47[21]
- As the blankets patients bring to the kidney centre will have been produced, freighted and disposed of similarly to the blankets in hospital, for the carbon modelling only the laundry of the blankets has been taken into account.
- Laundry at patients' homes has not been included as it was assumed that patients would wash their blankets less often than in the hospital and that the blankets would be washed together with other laundry.
- In case of the linen sheet, laundry plus manufacture, freight and disposal has been included in the carbon modelling.
- The carbon footprint of a blanket (laundry only) and linen sheet (laundry plus manufacture, freight and disposal) has been taken from the life cycle assessment study by John J et al.[20]
- In case of the blanket, the carbon footprint from John J et al. has been adjusted to take the lighter weight of our blanket into account.
- The carbon footprint of the hospital blanket is 0.508 kgCO2e and the carbon footprint of the linen sheet 0.341 kgCO2e per use.[20]
- The volume of water used per item laundered has also been derived from John J et al. 8.5 litres of water are used to launder a blanket and 3.8 litres of water to launder a sheet.[20]
- 50% of kidney centres might be able to reduce linen use in the next two years.

Initial investment:

- No initial investment anticipated.

If a main centre stops dressing their chairs with linen and does not provide any blankets, it could save 15 tCO2e, 243 m^3 water and £14,781 a year. For a satellite centre, the savings would amount to 9.5 tCO2e, 138 m^3 of water and £10,558 (see Table 5).

Assuming, that 5% of kidney centres currently are not dressing their dialysis chairs with linen and do not offer blankets to their patients, GHG emissions of 151 tCO2e, water use of 2,265 m^3 and costs of £159,955 are avoided each year.

If an additional 50% of main and satellite kidney centres stopped dressing their dialysis chairs with linen sheets and offering blankets, asking patients to bring in their own blanket, total GHG emissions savings of 1,506 tCO2e, water savings of 22,655 m^3 and cost savings of £1.6 million could be achieved annually.

Table 5: Annual impact of reducing linen use

	GHG emissions savings (tCO2e)	Water savings (m3)	Cost savings (£)
Per main centre	15.1	243	14,781
Per satellite centre	9.5	138	10,558
Nationally, assuming an increase in adoption of 50%	1,506.10	22,655	1,599,549

4.6 Haemodialysis acid concentrate: Switching from 1:34 to 1:44 dialysis acid concentrate canisters

Increasing the concentration of acid concentrate from 1:34 (requiring 34 times dilution during dialysis) to 1:44 (requiring 44 times dilution during dialysis) can contribute to a kidney centre's carbon reduction efforts as it reduces the amount of plastic per canister of acid concentrate and its associated GHG emissions due to manufacture, transport and disposal. The GHG emissions embedded in acid concentrate of 1:44 though are slightly higher than of 1:34 acid concentrate.

Assumptions:

- 60% of kidney centres use canisters for acid concentrate delivery.
- 40% of those kidney centres relying on canisters use acid concentrate of 1:34.
- Acid concentrate canisters are made of high-density polyethylene (HDPE) and get disposed of via domestic waste by being incinerated at low temperature, generating energy from waste (EfW).[13]
- The weight of an empty 6l canister of 1:34 acid concentrate is 296 g and of a 4.7 litres canister of 1:44 acid concentrate is 260 g, with potential savings of 36g of plastic pro canister if switching to a higher concentrate.[13]
- Production of concentrate was assumed to be 200km away from all kidney centres. Canisters are transported by an average laden rigid HGV to the kidney centre.[22] The transport is calculated per tonne.km.
- The carbon footprint of 1:34 acid concentrate is 0.122 kgCO2e/litre and of 1:44 acid contrate is 0.155 kgCO2e/litre.[13]
- The EF used for the canisters' plastic (HDPE) is 3,095.16 kgCO2e/tonne, for disposal via EfW 172 kgCO2e/tonne[16] and for transport 0.24 kgCO2e/tonne.km.[4]
- The cost of a 4.7l canister of 1:44 acid concentrate is £2.85 and the cost of a 6l canister of 1:34 acid concentrate £3.
- Over the next 2 years, another 20% of dialysis sessions will be switched from 1:34 to 1:44 acid concentrate.

Initial investment:

- No initial investment anticipated.

Using canisters only, switching from 1:34 to 1:44 acid concentrate would save a main kidney centre 64.7 tCO2e and £3,931 and a satellite unit 2 tCO2e and £1,685 per year.

If 60% of dialysis sessions which are provided by canisters are currently using acid concentrate of 1:44, a total of 267 tCO2e and costs of £435,639 are avoided annually. 175 tCO2e are prevented due to less plastic being manufactured for the canisters and, therefore, less plastic being disposed of. Transport emissions of 96 tCO2e are avoided due to the lighter weight of the 4.7 litres canisters. However, the annual GHG emissions associated with the manufacture of the 1:44 acid concentrate are 3.7 tCO2e higher, as the carbon footprint of 1l of 1:44 acid concentrate is slightly higher, at 0.155 kgCO2e, than the carbon footprint of 1l of 1:34 acid concentrate which is 0.122kgCO2e.[13]

If the adoption rate of 1:44 acid contrate over the next 2 years increases by another 20%, an additional 89 tCO2 and £145,213 could be saved.

Table 6: Annual impact of switching from 1:34 to 1:44 acid concentrate

`	GHG emissions savings (tCO2e)				Cost savings (£)
	Canisters (HDPE + waste disposal)	Acid concentrat e	Transport	Total	
Per main centre	3.1	-0.07	1.7	4.7	3,931
Per satellite centre	1.3	-0.03	0.7	2	1,685
Nationally, assuming an increase in adoption of 20%	58.4	-1	32	89.1	145,213

4.7 Switching to central delivery of haemodialysis acid concentrate

One third of the haemodialysis acid concentrate in canisters is typically unused and discarded due to the usual practice of providing fresh canisters at each session. Central delivery systems (CAD) supply only the exact amount of acid concentrate required for each dialysis session, reducing acid concentrate and plastic wastage and the weight of concentrate and plastic canister that needs to be delivered, thereby lowering greenhouse gas emissions.

Assumptions:

- It is assumed that kidney centres which switch to central acid delivery (CAD) are switching from 4.7l canisters of 1:44 acid concentrate to bulk delivery of 1:44 acid concentrate and that this switch can be made for 85% of dialysis sessions if CAD covers two different types of acid concentrates. For the other 15%, more bespoke acid concentrate compositions are required which continue to be provided in canisters.
- For a conservative estimate, a dialysate flow of 600ml (500ml dialysate plus 100ml substitution fluid) per min is assumed, leading to one third of acid concentrate in canisters being discarded. If we assumed a blood-flow dependent dialysate rate the GHG emissions and cost savings would be higher as less dialysate would be used.
- Similar to Murcutt G et al., it was assumed that bulk delivery of liquid acid concentrate to kidney centres is done in 1000 litres tanks, which have a disposable lining made of LDPE, weighing 2.28 kg and being disposed of via EfW. [22]
- Transport distance and type of lorry is the same in bulk delivery and canister delivery. Production of concentrate in canisters and as bulk was assumed to be 200km away from all kidney centres. Canisters and bulk delivery are transported by an average laden rigid HGV to the kidney centre and transport is calculated per tonne.km.
- Concerning the 4.7l canisters of 1:44 acid concentrate, the same assumptions about the weight and the type of plastic of the canisters were made as under section 4.6.
- The amount of acid concentrate delivered by central acid delivery is a third less of that delivered in canisters as one third of acid concentrate in canisters usually remains unused at the end of each session.
- The EF used for the canisters' plastic (HDPE) is 3,095.16 kgCO2e/tonne, for disposal via EfW 172 kgCO2e/tonne [16], for acid concentrate 0.155 kgCO2e/litre [13] and for transport 0.24 kgCO2e/tonne.km.[4]

Assumptions continued

- The cost of a canister of 1:44 acid concentrate is £2.85 and of a 1000l tank £500 per delivery.[13]
- Currently, 40% of kidney centres receive acid concentrate in bulk delivery. It is assumed that this will increase by 10% over the next two years.

Initial investment:

- According to a case study, the financial costs of installing a two acid two loop system are £59,492 (adapted for inflation).[23,24] However, each instalment will be heavily dependent on local circumstances and existing infrastructure.

With CAD requiring one third less of acid concentrate, CAD would lead to annual savings of 34,900 litres of acid concentrate in a 28 dialysis station kidney centre and 14,957 litres in a 12 dialysis station satellite unit, annual GHG emissions savings of 25.8 tCO2e and 11.1 tCO2e and financial savings of £29,104 and £12,473 respectively (see Table 7). It would take a main centre a little more than two years to recuperate its initial investment costs.

Assuming, that currently 40% of acid concentrate across the UK is already delivered in bulk, wastage of 2.2 million litres of acid concentrate, 1,628 tCO2e and costs of £1.8 million are currently avoided each year. Increasing the adoption rate by another 10% would lead to additional annual savings of 550,926 litres of acid concentrate, 407 tCO2e and £459,428.

To achieve further GHG emissions savings, acid delivery could be switched from liquid central acid to dry powder central acid delivery, reducing the freight weight and frequency of the delivery. However, modelling the GHG emissions and financial savings of dry powder central acid delivery compared to both canister delivery and bulk liquid CAD is beyond the remit of this project.

Table 7: Annual impact of switching to bulk delivered CAD

	GHG emissions savings (tCO2e)				Cost savings (£)
	Canisters (HDPE + waste disposal)	Acid concentrate	Transport	Total	
Per main centre	18.4	5.4	2	25.8	29,104
Per satellite centre	7.9	2.3	0.8	11.1	12,473
Nationally, assuming an increase in adoption of 10%	290.9	85	31	407.1	459,428

4.8 Reducing paper use/Going paperless

Many kidney centres still use paper for record keeping during dialysis sessions. In most cases these notes are subsequently digitalised. Paper is often used when there are not enough computers available to take notes digitally in real time.

Assumptions:

- One nursing record book with 43 pages is used for 40 dialysis sessions.
- The nursing record book is laminated, has a spiral wire binder and is made out of recycled paper.
- It is assumed that the record books are disposed of as confidential waste and incinerated at low temperature, generating energy from waste.
- A main kidney centre would use 655 nursing record books and a satellite unit 281 per year.
- The EFs for recycled paper, 1050.08 kgCO2e/t, laminate made of polyethylene, 3,863.90 kgCO2e/t and metal wire binder, 3,473.12 kgCO2e/t, are taken from the DESNZ database for carbon conversion factors.[4]
- A cost of £2.12 per nursing record book was assumed.[25]

Initial investment:

- At a minimum, enough computers need to be made available to allow digital record keeping in real time. From a software perspective, there are multiple different scenarios of digital replacement including add-ons or re-configuration of an existing IT solution within an organisation, bi-directional HD machine interfaces and installation of new IT solutions. Implementation, running and maintaining these digital substitutes and the IT hardware, required, will have widely varying financial and environmental costs and have not been included in this illustration - these will require evaluation at individual unit level to determine the return on investment.

Switching from nursing record books and digital records for dialysis sessions to digital records only, would reduce a main kidney centre's annual carbon footprint by 262 kgCO2e and of a satellite site by 112 kgCO2e and save £1,407 and £603 respectively.
If 5% of kidney centres currently have stopped using paper nursing record books, GHG emissions of 1.5 tCO2e and costs of £11,105 are avoided each year if there were no initial IT investment costs.

If a further 50% of main and satellite centres would move their dialysis session records to digital only, savings of 15 tCO2e and £111,048 per year could be achieved.

Table 8: Annual impact of reducing paper use for dialysis treatment records

	GHG emissions savings (tCO2e)	Cost savings (£)*
Per main centre	0.26	1,407
Per satellite centre	0.11	603
Nationally, assuming and increase in adoption of 50%	15.4	111,048

** Assumes no initial IT investment costs*

4.9 Improved waste segregation

According to an internal report on the in-centre haemodialysis care pathway by Newcastle upon Tyne Hospitals and the Sustainable Healthcare Coalition, around 0.473 kgCO2e of solid waste and 0.769 kg of packaging waste are generated per dialysis session.

Assumptions:

- All kidney centres produce 0.473 kgCO2e of solid waste and 0.769 kg of packaging waste per dialysis session.
- In centres where there is no recycling, solid waste is treated as non-infectious offensive waste and packaging waste is treated as domestic waste incinerated at low temperature producing energy from waste.
- In centres where recycling has been introduced 10% of solid waste and 100% of packaging waste is recycled. The rest of the waste is treated as above.
- 25% of kidney centres have already introduced recycling.
- It was assumed that another 50% of kidney centres will introduce recycling over the next 2 years.
- According to Rizan C et al. the emissions factor for low temperature incineration of non-infectious offensive waste, generating energy from waste (EfW) is 249 kgCO2e/tonne and of low temperature incineration of domestic waste is 172 kgCO2e.[16]
- The emissions factor for recycling waste is 4.69 kgCO2e/tonne. [4]
- Based on one NHS Trust, the cost of low temperature incineration of non-infectious offensive waste, generating energy from waste (EfW) is £206.86, of low temperature incineration of domestic waste is £109.42 and of recycling waste is £89.

Initial investment:

- The costs of extra waste bins have not been accounted for in this study.

Based on the above assumptions, a main kidney centre which switches from low temperature incineration to recycling of 10% of their solid waste and all of their packaging waste would save 3.7 tCO2e and £558 annually. The savings for a satellite centre would be 1.6 tCO2e and £239 annually.

Assuming that 25% are currently already recycling their solid waste and 100% of their packaging waste, GHG emissions of 148 tCO2 and costs of £22,007 are avoided each year.

If another 50% of kidney centres would start recycling 10% of their solid waste and 100% of their packaging waste, 295 tCO2e and £44,014 could be saved annually.

Table 9: Annual impact of improved waste segregation

	GHG emissions savings (tCO2e)	Cost savings (£)
Per main centre	3.67	558
Per satellite centre	1.57	239
Nationally, assuming an increase in adoption of 50%	295.3	44,014

4.10 Reusable sharps bins

Many hospitals still use single use sharps bin. Switching to reusable bins would reduce the amount of plastic bins which need to be produced, transported and incinerated, resulting in a reduction in GHG emissions.

Assumptions:

- There are 26,208 dialysis sessions per main centre per year and 11,232 per satellite centre per year.
- According to Grimmond et al. the carbon footprint of a single use sharps bin is 124 kgCO2e per 1000 patient activity episodes and of a reusable sharps bin 20 kgCO2e per 1000 patient activity episodes.[26]
- A dialysis session is equivalent to a patient activity episode.
- 20% of NHS Trusts are currently using reusable sharps bin (this is based on Grimmond et al.'s study as a proportion of the total number of NHS Trusts).
- Based on the case study from Surrey and Sussex NHS Healthcare Trust, the savings of switching from a single use to a reusable sharps bin are around £0.64.[27]

Initial investment:

- Costs of switch from single use to reusable sharps bins are taken into account in the Surrey and Sussex case study, cited.

If a main kidney centre switches from single use to reusable sharps bins, the centre could save 2.7 tCO2e and £2,050 annually. A satellite centre would be able to save 1.2 tCO2e and £879 per year.

If currently 20% of main and satellite kidney centres are using reusable sharps bins, 86 tCO2e and costs of £64,723 are avoided each year. If the adoption rate can be increased by another 50% in the next 2 years, annual GHG emissions savings of 215 tCO2e and financial savings of £161,807 can be achieved.

Table 10: Annual impact of switching to reusable sharps bins

	GHG emissions savings (tCO2e)	Cost savings (£)
Per main centre	2.73	2,050
Per satellite centre	1.17	879
Nationally, assuming an increase in adoption of 50%	215.1	161,807

4.11 Personalised dialysis prescription

According to Kidney Research UK, 30,000 people in UK receive dialysis per year. 7,500 per year are starting dialysis, 72% of those, 5,400 patients, start on haemodialysis.[28]
The decision to start a patient on incremental HD (iHD) is made on clinical grounds and is dependent on a patient's residual renal function, helping to conserve it. However, a reduction in weekly dialysis sessions has the added co-benefit of reducing the environmental and financial impact of haemodialysis.

Assumptions:

- Studies have found different rates of eligibility for incremental haemodialysis (iHD) in incidental HD patients: 15%[29], 33%[30], 50%[31]. Assuming a median of 32.5%, 1,755 patients would be eligible to receive iHD each year.
- Currently, 5% of new patients, 270[32], receive incremental haemodialysis. This translates to around 15% of all eligible patients.
- A systematic review has shown that the time to switching to full-dose dialysis was 12.1 months. For the carbon modelling we assumed 12 months to full-dose dialysis.[33]
- Incremental HD is 2 HD sessions a week for 4 hours each.
- Standard HD is 3 HD sessions a week for 4 hours each.
- The carbon footprint of standard HD per patient per year is 3.8 tCO2e.[34]
- Based on Murray E et al.'s case study, GHG emissions savings of iHD compared to standard HD are 0.8tCO2e.[35]
- Murray E et al. estimated that between £4,800 and £8,000 per patient year on incremental HD could be saved. For this study, we estimated the cost savings to be £4,800 per patient year on incremental HD.

If a main centre introduces iHD to all its clinically eligible patients, GHG emissions of 8,894 kgCO2 and £53,365 per main centre per year could be avoided. A satellite centre introducing iHD would save 3,812 kgCO2e and £22,871.

If currently 15% of all eligible patients receive iHD, 211 tCO2e of GHG emissions and £1.3 million are avoided. Increasing the proportion of eligible patients who receive iHD by another 50% would increase the GHG emissions savings by 702 tCO2e and financial savings by £4.2 million. If all eligible incidence patients receive iHD, GHG emissions of 1,404 tCO2e and costs of £8.4 million would be avoided.

Table 11: Annual impact of personalised dialysis prescription

	GHG emissions savings (tCO2e)	Cost savings (£)
Main centre	8.89	53,365
Satellite Centre	3.81	22,871
Increase in adoption (50%)	702	4,212,000

4.12 Increasing the rate of remote consultations

Patients with chronic kidney disease (CKD) are monitored over long periods of time. In Newcastle Upon Tyne Hospitals there were 5,983 outpatient appointments offering clinical reviews for CKD patients between September 2024 and August 2025. Some of these appointments could be conducted remotely.

Assumptions:

- All of the main centres conduct around 5,983 outpatient appointments per year.
- In Scotland virtual appointments for patients with kidney disease vary from 0 to 20%.[36] We assume that across the UK an average of 10% of appointments are currently carried out virtually.
- It was assumed, that in the next 2 years 30% of main kidney centres will increase their rate of virtual appointments by another 10% to 20% of outpatient appointments.
- The carbon footprint of a patient's return journey contributes 5.2 kgCO2e (based on travel patterns of Newcastle kidney patients) and a phone follow-up appointment (31 min) 0.1 kgCO2e.[37]
- The cost of a clinical review appointment is the same as the cost of an average consultant-led outpatient appointment which is £193 according to NHS England's 2024/25 National Cost Collection Data.[38]
- The cost of an outpatient clinical review appointment via phone is £164. [38]

Initial investment:

- No initial investment was anticipated, assuming that no additional technology is required to facilitate remote consultations.

Assuming, that 10% of clinical review appointments are conducted currently by phone, a main centre avoids GHG emissions of 5.4 tCO2e and costs of £17,350 per year. Assuming it is clinically appropriate, switching an additional 10% of face-to-face consultations to phone follow-ups would save another 5.4 tCO2e and £17,351 annually per main centre (see Table 12).

If currently all main centres conduct 10% of clinical review appointments by phone, GHG emissions of 213 tCO2 and costs of £1.2 million are avoided.

If 30% of centres could increase their proportion of phone clinical review appointments from 10% to 20%, additional GHG emission savings of 213 tCO2e and financial savings of £364,365 could be realised.

Table 12: Annual impact of increasing the rate of remote clinical reviews from 10% to 20%

	GHG emissions savings (tCO2e)	Cost savings (£)
Main centre	3.05	17,351
Nationally, assuming an increase in adoption of 30%	64	364,365

4.13 Travel and transport

Kidney patients on standard HD/HDF travel three times per week to their kidney centre for dialysis. This contributes substantially to travel associated GHG emissions. Electrifying the mode of transport patients travel in can lead to a significant reduction in emissions.

Assumptions:

- For this calculation we assumed that all patients are on standard HD/HDF.
- 0.8% of taxis in UK are currently electric, 22% hybrid.[39]
- 4.5% of patient transport is currently electric.[40]
- 4.5% of cars in UK are currently electric. [41]
- Assuming travel patterns of kidney patients across the UK are similar to kidney patients' travel patterns at Newcastle Upon Tyne NHS Trust, patients travel as follows:
    - 44% by hospital patient transport
    - 23% by taxi
    - 33% by car
    - A return journey is 23.94 km
- It was modelled that 30% of kidney centres are able to increase the proportion of electric vehicles used for patient transport and the proportion of electric taxis hired to 10% in the next 2 years.
- There was no change in the proportion of patients' private cars assumed that are electric as this is outside the NHS's influence.
- The cost per km using:
    - An electric car: £0.0558
    - A hybrid car: 0.0712
    - A diesel car: 0.097
    - A petrol car: 0.121[42]
- Cost of private car travel has been excluded as it is not a saving to the kidney centres.

Initial investment:

- The NHS Net Zero Travel and Transport Strategy has set out a road map for achieving a zero emissions fleet by 2040. Fleet electrification is introduced gradually. We assumed for this study, that 30% of NHS organisations are able within their regular fleet renewal cycle to increase the proportion of electric patient transport from 4.5% to 10%. Any price difference between fossil fuel and electric vehicles has not been taken into account.

Currently, based on the above assumptions, travel emissions associated with patients attending HD sessions are estimated to be 21,495 tCO2e.

Increasing the proportion of electric fleet and electric taxis used for patient transport to 10% would lead to GHG emissions savings of 5.1 tCO2e per main centre and 2.2 tCO2e per satellite centre and save £1,152 and £494 respectively.

If 30% of kidney centres are able to increase the proportion of electric transport to 10% over the next 2 years, GHG emissions of 240 tCO2e and £54,549 could be saved.

Table 13: Annual impact of increasing the proportion electric patient transport - fleet and taxis - from 4.5% to 10%

	GHG emissions savings (tCO2e)	Cost savings (£)
Per main centre	5.1	1,152
Per satellite centre	2.2	494
Nationally, assuming an increase in adoption of 30%	239.6	54,549

4.14 Sustainable Food Options

A sustainable predominantly plant-based diet not only benefits the health of individuals with chronic kidney disease (CKD), but is also beneficial to the environment – see 'A How to Guide: Sustainable Eating for Kidney Health'. Offering plant-based drinks and food in kidney centres during dialysis can help to put the message across while providing a healthy meal.

Assumptions:

- All kidney centres offer tea or coffee to their patients during HD/HDF: 2 cups of tea of coffee per session.
- Each cup contains 20ml of milk.
- Currently, in 90% of kidney centres 2.1% of patients are using plant-based milk, representative of the general population.[43]
- In 10% of kidney centres, 10% of patients are using plant-based milk.
- 50% of patients who choose plant-based milk are choosing oat milk and 50% soya milk.
- 30% of kidney centres provide sandwiches to patients.
- It is assumed that a plant-based sandwich is made with hummus.
- Chicken sandwiches contain 50g of chicken and sandwiches with hummus contain 20g of hummus.
- Currently, 90% of kidney centres where sandwiches are offered, 2.1% opt for a plant-based sandwich, representative of the general population.
- At the other 10% of centres, currently 10% opt for plant-based sandwiches.
- It is assumed that the percentage of kidney centres where the proportion of patients opting for plant-based milk and sandwiches increases from 2.1% to 10% will increase by 50%.
- The carbon footprint of cow's milk is 1.9 kgCO2e/kg, of oat milk 0.2 kgCO2e/kg, soya milk 0.4 kgCO2e and UK chicken is 3.8 kgCO2e/kg.[44] and of hummus 1.72 kgCO2e/kg.[45]
- A litre of milk costs £0.4312[46], a litre of soya milk £1.68 and a litre of oat milk £1.48.[47]
- It is assumed that there is no price difference between a chicken sandwich and a plant-based sandwich.

Initial investment:

- No initial investment required.

If the proportion of patients who opt for plant-based milk (50% soya and 50% oat milk) in coffee and tea increases from 2.1% to 10%, a main centre would save 133 kgCO2e per year and a satellite centre 57 kgCO2e. The annual costs for milk would go up by £95 for a main centre and £41 for a satellite centre (see Table 14).

If at 10% of main and satellite kidney centres, 10% of patients already opt for plant-based milk GHG emissions of 2.1 tCO2e are avoided. Increasing the uptake of plant-based milk at another 50% of centres would lead to GHG emissions savings of 10.5 tCO2e and additional costs of £7,509.

If kidney centres which provide sandwiches to their patients who are coming for dialysis increase the uptake of plant-based sandwiches from 2.1% to 10%, main centres would save 322 kgCO2e per year and satellite centre 138 kgCO2e per year. If currently across the UK 10% of kidney centres who offer sandwiches, have increased the uptake of plant-based sandwiches to 10%, 1.5 tCO2 are avoided. If another 50% of kidney centre would increase the uptake of plant-based sandwiches to 10%, GHG emissions will reduce by 7.6 tCO2e

Table 14: Shifting to plant-based drinks and sandwiches - from 2.1% to 10%

	Switch from 2.1% to 10% plant-based milk		Switch from 2.1% to 10% plant-based sandwiches	
	GHG emissions savings (tCO2e)	Cost savings (£)	GHG emissions savings (tCO2e)	Cost savings (£)
Per main centre	0.13	-95	0.322	0
Per satellite centre	0.06	-41	0.138	0
Nationally, assuming an increase in adoption of 50%	10.46	-7,509	7.63	0

5. Summary results

5.1 Impact of interventions at individual kidney centres

Comparing the annual GHG emissions impact of the sustainable interventions at an individual kidney centre shows that switching from canisters to central acid delivery is the intervention which results in the highest GHG emissions savings, followed by reducing linen use and carrying out online priming (see Figure 1). The annual GHG emissions savings of these interventions is between 10 - 26 tCO_2e for a main kidney centre. This does not take into account the GHG emissions impact of installing CAD.

Increasing incremental haemodialysis for clinically eligible patients, switching to blood-flow dependent dialysis rates where clinically appropriate and increasing the proportion of electric patient transport reduces the GHG emissions contributions of a main centre by between 5 - 9 tCO_2e annually. Switching from 1:34 to 1:44 acid concentrate, improving waste segregation, increasing the proportion of phone follow-up appointments, optimising disinfection cycles and switching from single use to reusable sharps bins leads to annual savings between 2.7 to 4.8 tCO_2e.

Reusing reject water, reducing paper use, and increasing the uptake of plant-based drinks and sandwiches has a limited impact on GHG emissions, resulting in reductions of 0.1 to 0.8 t CO_2e.

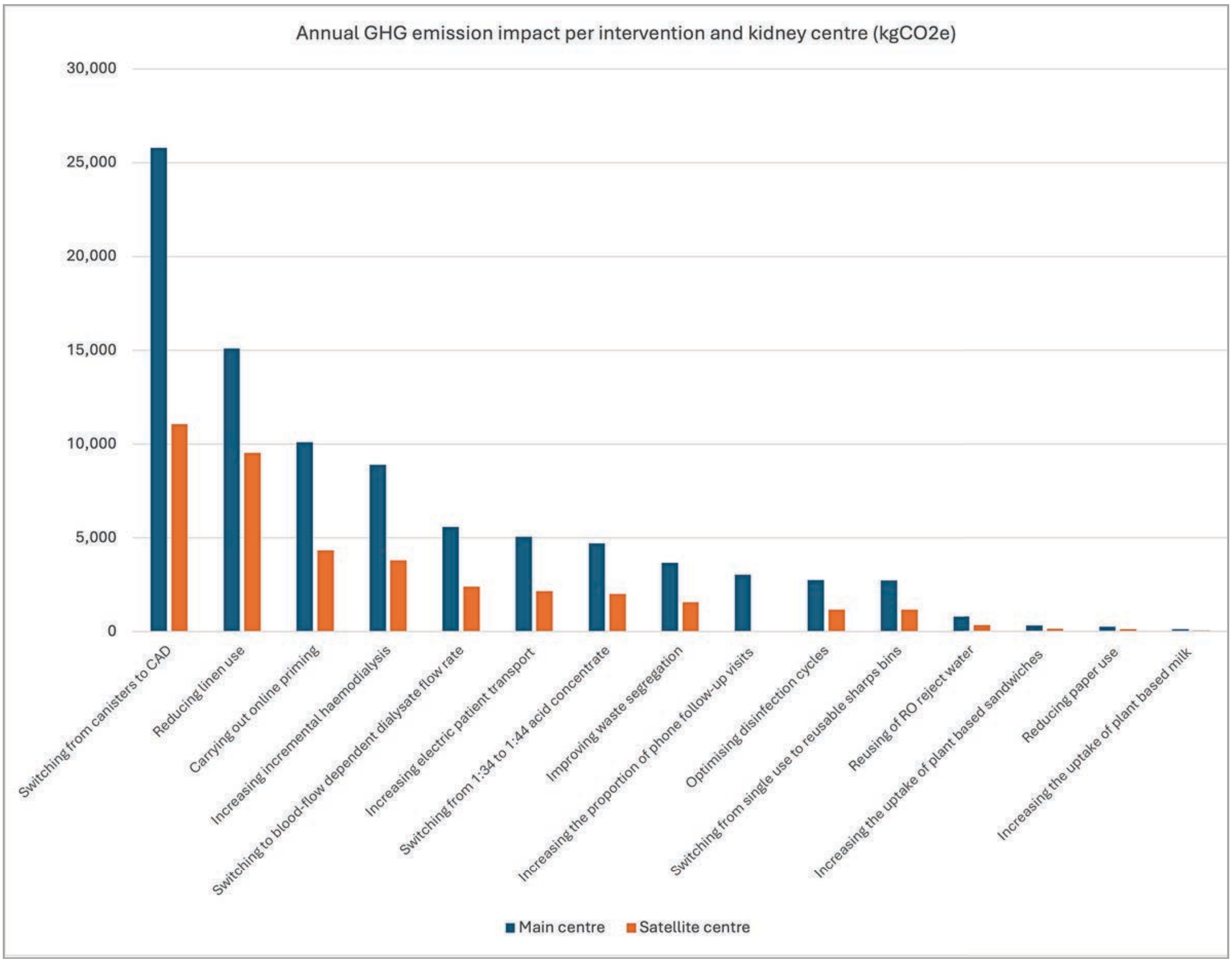

Figure 1: Comparison of sustainable interventions

If implementing all sustainability interventions, a main centre could achieve annual GHG emissions reductions of 89 tCO_2e and a satellite centre of 40 tCO_2e.

Comparison of the financial impact of the interventions shows that implementing online priming leads to the biggest annual savings, followed by increasing incremental haemodialysis where clinically appropriate, switching to CAD, increasing the proportion of phone follow-up appointments for CKD patients and reducing linen use (see Table 15). If implementing all interventions, a main kidney centre could save around £201,116 and a satellite centre around £82,980 per year. However, in the case of CAD, investment costs of around £60k might be expected. It will take a main kidney centre a couple of years before it can realise its savings.

Table 15: Comparison of sustainable interventions – annual GHG emissions and financial savings per kidney centre

	Annual GHG savings (kgCO2e)		Annual financial savings (£)		Investment costs (£)
	`	Satellite centre	Main centre	Satellite centre	`
Carrying out online priming	10,091	4,325	57,396	24,598	
Increasing incremental haemodialysis	8,894	3,812	53,365	22,871	
Switching from canisters to CAD	25,787	11,051	29,104	12,473	59,492
Increasing the proportion of phone follow-up visits	3,049	0	17,351	0	
Reducing linen use	15,102	9,536	14,781	10,558	
Switching to blood-flow dependent dialysate flow rate	5,585	2,394	8,476	3,632	
Reusing of RO reject water	811	348	6,927	2,969	28,800
Optimising disinfection cycles	2,750	1,179	4,714	2,020	
Switching from 1:34 to 1:44 acid concentrate	4,703	2,016	3,931	1,685	
Switching from single use to reusable sharps bins	2,726	1,168	2,050	879	
Reducing paper use	262	112	1,407	603	
Increasing electric patient transport	5,059	2,168	1,152	494	
Improving waste segregation	3,675	1,575	558	239	
Increasing the uptake of plant based sandwiches	322	138	0	0	
Increasing the uptake of plant based milk	133	57	-95	-41	
Total	88,950	39,879	201,116	82,980	

**bf = blood-flow*

5.2 Impact of interventions if rolled out across UK kidney centres

Modelling the implementation of the sustainable interventions across UK kidney centres shows that under the assumed current adoption rate overall GHG emissions of 4,333 tCO2e are avoided. Over the next two years, if the interventions are taken up at the rate modelled, additional GHG emissions savings of 4,375 tCO2e could be achieved (see Table 16).

Under the current adoption rate, based on the report's assumptions, the highest amount of GHG emissions is saved due to kidney centres having already switched to CAD (40%) and using online priming (90%). GHG emissions of 1,628 tCO2e and 1,434 tCO2e respectively are avoided annually. Having switched from 1:34 to 1:44 (60%) acid contrate has led to further savings of 267 tCOe annually and optimising the disinfection cycle (50%) to savings of 217 tCO2e (see Figure 2). Reducing paper use, increasing the uptake of plant-based drinks and sandwiches and reusing reject water, have so far contributed only slightly to the GHG emissions reduction effort, between 1.5 -1 6.4 tCO2e. This is partly due to the comparatively small impact of the intervention itself, but also due to the relatively small adoption rate assumed.

Modelling the potential annual GHG emissions savings of increasing the adoption rate over the next 2 years shows that reducing linen use would contribute the most to carbon reduction, saving 1,506 tCOe per year. This is followed by increasing the use of incremental dialysis for clinically eligible patients, switching to blood-flow dependent dialysate flow rates where clinically appropriate and switching from canisters to CAD. These interventions save between 400 to 700 tCO2e each (see Figure 2, Table 16). A carbon reduction of 200 tCO2e, 500 tCO2e and 1000 tCO2e over the next 2 years would be easily achieved if the adoption rate for only one or two of these interventions can be reached.

Part of the interventions' potentially high impact over the next 2 years can be explained by the high potential of spreading the interventions across UK kidney centres. Table 16 shows a summary of GHG emissions savings of the current and potential adoption rate over the next 2 years.

The table also provides a summary of the costs currently avoided due to having already adopted some of the interventions. The biggest financial savings, £8.1 million, are achieved through online priming which is assumed to have been implemented at 90% of kidney centres, followed by the switch from canisters to CAD, saving £1.8 million. Over the next 2 years, if the predicted adoption rates can be realised, reducing linen use, increasing incremental haemodialysis where clinically appropriate, increasing online priming by another 10% could lead to another £6.7 million savings annually.

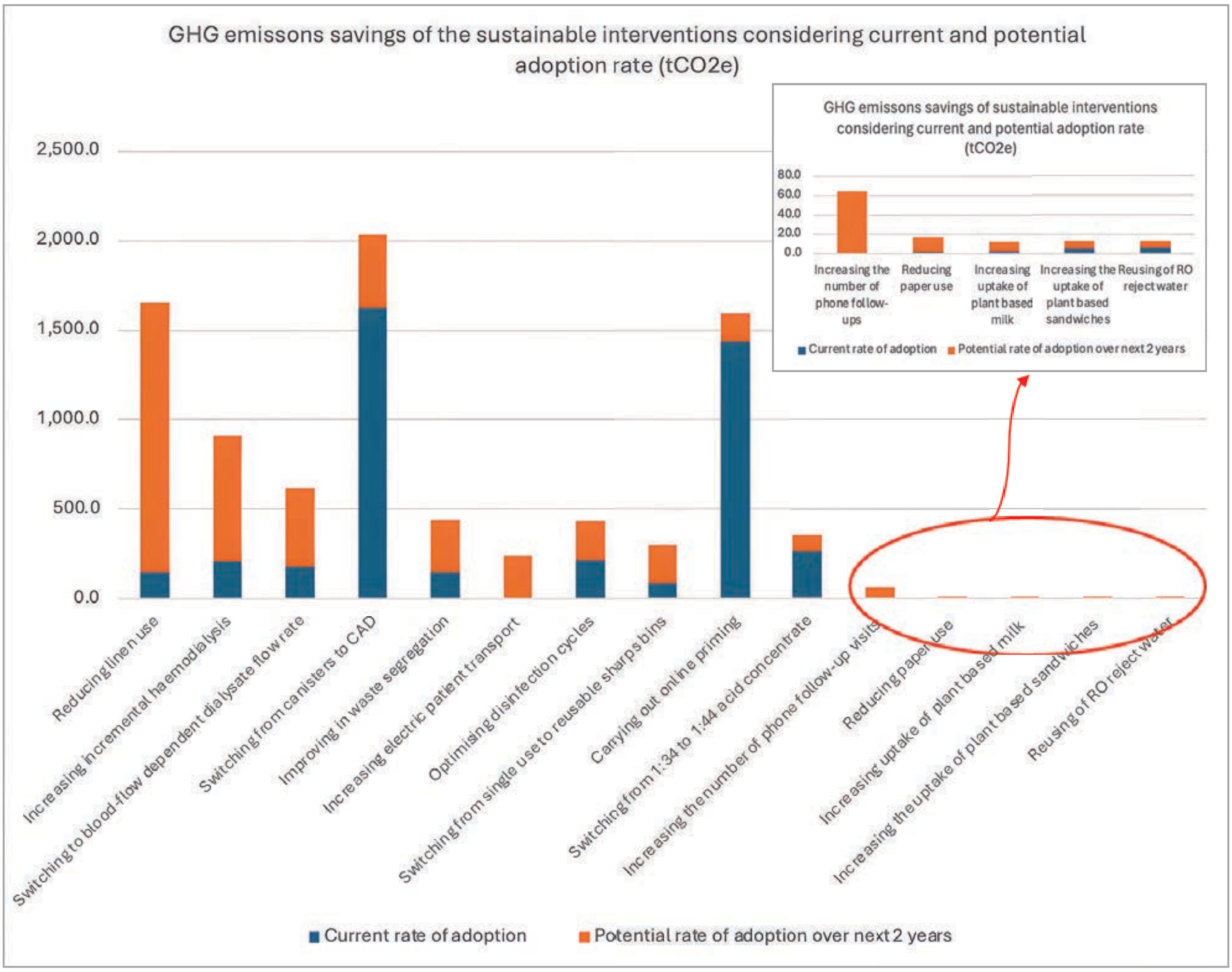

Figure 2: Annual GHG emissions savings of sustainable interventions across UK kidney centres, considering the current adoption rate and the potential adoption rate over the next 2 years

Table 16: Annual GHG emissions and financial savings of implementing the sustainable interventions across UK kidney centres

	Rate of adoption (%)		Annual GHG emissions savings (tCO2e)		Annual cost savings (£)	
Sustainable interventions	Current (%)	Potential (%)	Current rate of adoption (tCO2e)	Potential rate of adoption (tCO2e)	Current rate of adoption (£)	Potential rate of adoption (£)
Reducing linen use	5%	50%	151	1,506	159,955	1,599,549
Increasing incremental haemodialysis	15%	50%	211	702	1,263,600	421,200
Switching to blood-flow dependent dialysate flow rate	20%	50%	176	441	267,585	668,962
Switching from canisters to CAD	40%	10%	1,628	407	1,837,713	459,428
Improving in waste segregation	25%	50%	148	295	22,007	44,014
Increasing electric patient transport	0%	30%	0	240	0	54,549
Optimising disinfection cycles	50%	50%	217	217	372,081	372,081
Switching from single use to reusable sharps bins	20%	50%	86	215	64,723	161,807
Carrying out online priming	90%	10%	1,434	159	8,154,264	906,029
Switching from 1:34 to 1:44 acid concentrate	60%	20%	267	89	435,639	145,213
Increasing the number of phone follow-ups	0%	30%	0	64	0	364,365
Reducing paper use	5%	50%	2	15	11,105	111,048
Increasing uptake of plant based milk	10%	50%	2	10	-1,502	-7,509
Increasing the uptake of plant based sandwiches	10%	50%	5	8	0	0
Reusing of RO reject water	5%	5%	6	6	54,676	54,676
Total			4,333	4,375	12,641,845	4,934,212

6. Conclusion

This report has modelled the current GHG emissions and financial savings of sustainability kidney care interventions and has predicted the potential for future savings over the next 2 years.

The benchmarking tool developed by CSH in collaboration with UKKA is collecting data on the current scale of implementation of these interventions. The data collected by the tool will allow us to revise this report's carbon and financial modelling and estimate with greater accuracy how much kidney care has already contributed to carbon reduction. The tool will also facilitate the monitoring of kidney care's progress towards net zero over the next few years.

7. Appendix 1 - Emissions factors

DESNZ (2025)		
	Unit	kgCO2e
Water supply	m3	0.191
Water treatment	m3	0.171
Water supply and treatment	m3	0.328
Electricity use	kWh	0.245
Material use		
HDPE	tonne	3,095.16
PVC	tonne	2,944.76
LDPE	tonne	2,965.08
PET	tonne	3,863.90
Paper	tonne	1,345.08
Recycled paper	tonne	1,050.08
Scrap metal	tonne	3,473.12
Waste disposal		
Paper recycling	tonne	4.69
HDPE recycling	tonne	4.69
Freight transport		
HGV rigid all - average laden	tonne.km	0.24
Passenger transport		
Taxi	km	0.26
Electric taxi	km	0.05
Hybrid taxi	km	0.16
MPV Diesel	km	0.22
MPV electric	km	0.07
Car, avg size unknown fuel	km	0.21
Car, avg size electric	km	0.05
Local bus	passenger.km	0.16
National rail	passenger.km	0.04

7. Appendix 1 - Emissions factors

Rizan C et al. https://doi.org/10.1016/j.jclepro.2020.125446		
	Unit	kgCO2e
High temperature incineration	tonne	1,074
Low temp. incineration EfW	tonne	172
Low temp. incineration EfW non-infectious offensive waste	tonne	249
Infectious waste (autoclaving and low temp. incineration)	tonne	569

Kasel Group (mid point of 6-9 kgCO2e), https://kasel.com/sustainable-citric-acid-production/		
	Unit	kgCO2e
Citric Acid	kg	7.5

Carbon Cloud & Murcutt G et al. https://link.springer.com/article/10.1007/s40620-024-02073-9#citeas		
	Unit	kgCO2e
NaCl	kg	0.06
NaCl including purification	kg	0.3
Hummus	kg	1.72

John J et al. https://doi.org/10.1136/bmjopen-2023-080838		
	Unit	kgCO2e
Blanket (100% polyester)	item (1.305 kg)	0.663
Blanket (100% polyester)	item (1 kg)	0.508
Sheet (70% cotton, 30% polyester)	item (0.573 kg)	0.341

Choo et al. https://doi.org/10.1007/s40620-025-02354-x		
	Unit	
Acid concentrate 1:34	litre	0.121
Acid concentrate 1:44	litre	0.155

Sustainable Healthcare Coalition – Sustainable Care Pathway Module - Inpatient bed day		
Units of healthcare activity		kgCO2e
Low intensity inpatient bed day		37.9
Outpatient appointment		1.58

7. Appendix 1 - Emissions factors

Greener NHS Business Impact Tooling v3.0		
		kgCO2e
Phone consultation (31 min)		0.1

Based on Newcastle Upon Tyne NHS Foundation Trust		
		kgCO2e
Patient travel		9.13

Mike Berners-Lee 'How bad are bananas'. Profile Books Ltd 2020		
	Unit	kgCO2e
Cows milk	kg	1.9
Oat milk	kg	0.2
Soya	kg	0.4
Avg oat and soya	kg	0.3
UK chicken	kg	3.8

8. Appendix 2 – Costs of items

ERIC 2023-24 report		
	Unit	Cost (£)
Water supply and waste water	m3	2.8
Electricity	kWh	0.282
Gas	kWh	0.072

Choo S M Y et al.		
	Unit	Cost (£)
Recycling	tonne	89
Low temp. incineration EfW non-infectious offensive waste	tonne	206.86
Low temp. incineration EfW domestic waste	tonne	109.42

Medisave		
	Unit	Cost (£)
Sharps bins 11.5 litres	item	4.79
Sharps bins 7 litres	item	3.35

Trust data		
	Unit	Cost (£)
Disinfectant citric acid	5l	19.81
	l	3.962
Giving set	item	0.38
Fresenius 1:34 canister	item	3
Fresenius 1:44 canister	item	2.85
CAD 1:44 1000 litres	delivery	500
1l 0.9% saline solution	item	0.96
500ml 0.9% saline solution	item	0.85

NHS England. Delivering Productivity through the NHS Estate. https://www.england.nhs.uk/long-read/delivering-productivity-through-the-nhs-estate		
	Unit	Cost (£)
Laundry	Item	0.47

Amazon		
	Unit	Cost (£)
A4 Pukka Pad	item	2.12

8. Appendix 2 – Costs of items

Murray E at al.		
		Cost (£)
Cost savings of iHD per patient per year compared to standard HD		6,400

NHS Case Study. Surrey and Sussex Healthcare		
		Cost (£)
Avg savings switching one single use to reusable sharps bin		0.64

NHS England. 2024/25 National Cost Collection Data		
		Cost (£)
Cost of an outpatient appointment		193
Cost of a GP phone call		164

Ocean Finance		
		Cost (£)
Electric car		0.0558
Hybrid		0.0712
Petrol car		0.121
Diesel car		0.097
Avg fossil fuel care		0.109

UK Government Statistics - milk prices		
	Unit	Cost (£)
Milk	litre	0.4312

Trolley.co.uk		
	Unit	Cost (£)
Soya Milk	litre	1.68
Oat Milk	litre	1.48
Avg		1.58
Chicken sandwich	item	2.2

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sustainablehealthcare.org.uk

info@sustainablehealthcare.org.uk

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