

Carbon Footprint from Anaesthetic gas use

- 5% of the carbon footprint for acute organisations is from anaesthetic gases
- For acute organisations, this is equivalent to around half the emissions from gas used to heat buildings and water
- Desflurane and nitrous oxide causes the most global warming and sevoflurane the least
- Measuring, monitoring and reporting carbon dioxide equivalent emissions is crucial for reducing emissions.



Introduction to anaesthetic gases

A number of anaesthetic gases have been identified¹ as potent greenhouse gases (GHG). Emissions of gases from NHS organisations are direct emissions and should be reported in scope 1².

The scale of these emissions for the health system in England is estimated for the first time. Nitrous Oxide (N₂O) and a number of anaesthetic gases are compared here using the carbon dioxide equivalent emissions as used in the GHG Inventory³.

Nitrous Oxide

Nitrous Oxide is reported as part of the UK GHG Inventory⁴, however use as an anaesthetic is listed as “the data are not available and emissions are believed to be small” and therefore not reported and small relative to UK emissions. For the health system these emissions are much more significant. As these emissions have not previously been identified they have not previously been specifically included in the NHS carbon footprint.

Two methods have been used to estimate emissions: average emissions per bed day; and estimates using supplier’s figures.

The EU Greenhouse gas inventory collates both emissions and methods from across Europe. Belgium provides a calculation of Nitrous Oxide emissions using average emissions per bed year. Here is a calculation on this basis for NHS funded care in England:

Nitrous Oxide	Number	Unit	Source
Emissions per hospital bed	10.3	kg N ₂ O/bed/year	EU GHG Inventory 2012 ⁵
Hospital beddays	46,525,725	beddays	HSCIC ⁶
Hospital beds (80% utilisation over 365 days)	159,335	beds	Calculation
Emissions N ₂ O	1,641,147	kg N ₂ O	Calculation
Nitrous oxide conversion factor	310	kgCO ₂ e/kg	Defra conversion factors ⁷
Carbon dioxide equivalent emissions	508,755,616	kgCO ₂ e	Calculation
Carbon dioxide equivalent emissions (tonnes)	0.51	MtCO₂e	Calculation

A number of suppliers provide nitrous oxide and gas and air (nitrous oxide and oxygen mix). Comparing the result from bed days with figures provided by two suppliers suggests estimates of Nitrous Oxide use in England may be an over estimate by up to 30%. As the total coverage of sales is

¹ Sulbaek-Anderson et al <http://www.anesthesia-analgesia.org/content/114/5/1081.short>

² GHG Protocol accounting standard <http://www.ghgprotocol.org/standards/corporate-standard>

³ GHG Inventory UK <https://www.gov.uk/government/publications/uk-greenhouse-gas-inventory>

⁴ Department of Energy & Climate Change, UK Greenhouse Gas Inventory Annual Report 1990 to 2011. Available at: <https://www.gov.uk/government/publications/uk-greenhouse-gas-inventory>

⁵ EU GHG Inventory 1990 – 2011, 2013. Available at: <http://www.eea.europa.eu/publications/european-union-greenhouse-gas-inventory-2013>

⁶ HSCIC Hospital Episode Statistics, Admitted Patient Care - England, 2011-12: SHA residence (total for England). Available at: <http://www.hscic.gov.uk/searchcatalogue?productid=9161>

⁷ Defra Greenhouse Gas Conversion Factors, 2013. Available at: <http://www.ukconversionfactorscarbonsmart.co.uk/LandingPage.aspx>



not known the figure is likely to be between the bed estimate and suppliers figures. Averaging these two results means a reasonable estimate of carbon emissions from Nitrous Oxide use in NHS in England is 0.47 MtCO₂e.

Given this estimate, Nitrous Oxide use by the health system represents 1.3% of UK emissions of nitrous oxide⁸ (34.8 MtCO₂e).

Anaesthetic gases

The Life Cycle Assessment (LCA) emissions of different anaesthetic gases are the subject of a number of research papers. Sulbaek-Anderson et al⁹ includes the following gases: Desflurane, Isoflurane, Sevoflurane, Halothane and Enflurane. Halothane and Enflurane are obsolete and shown here for reference only.

Gas	Desflurane	Isoflurane	Sevoflurane	Halothane	Enflurane	Unit
Formula	CF ₃ CHFOCHF ₂	CF ₃ CHClOC HF ₂	(CF ₃) ₂ CHOCH ₂ F	CF ₃ CHClBr	CHFClCF ₂ O CF ₂ H	
GWP (100 year)	2540	510	130	50	680	kgCO ₂ e/kg
Volume weight conversion	1.465	1.496	1.522	1.868	1.52	kg/l = g/cm ³ = Sp.Gr(77°F)
Carbon dioxide equivalent conversion factor	3.72	0.76	0.20	0.09	1.03	tCO ₂ e/litre
Carbon dioxide equivalent emissions (tonnes)	0.06	0.01	0.01	-	-	MtCO ₂ e

These three anaesthetic gases contribute around 0.08 MtCO₂e to the carbon footprint.

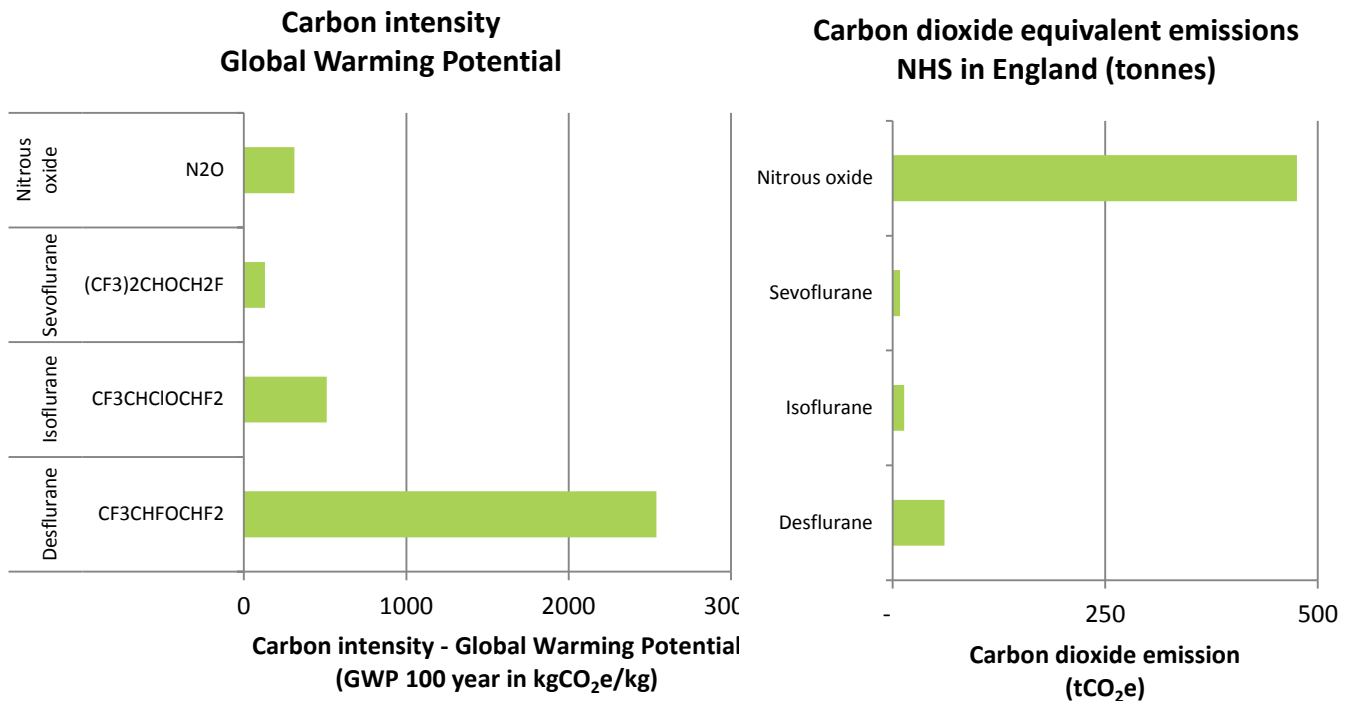
The relative carbon intensity (per kg of gas) is shown on the left below with Desflurane having the greatest effect on our atmosphere and Sevoflurane the least. On the right below are the estimated total emissions for the NHS in England showing that Nitrous Oxide emissions are over 5 times the emissions of any of the other gases.

⁸ Department of Energy and Climate Change, UK Greenhouse Gas Inventory Annual Report 1990 to 2011. Available at: <https://www.gov.uk/government/publications/uk-greenhouse-gas-inventory>

⁹ Sulbaek-Anderson et al <http://www.anesthesia-analgesia.org/content/114/5/1081.short>

Discussion

Anaesthesia using desflurane and nitrous oxide causes the most global warming and sevoflurane the least¹⁰.



Nitrous oxide use in operating rooms is declining due to health impacts on patients¹¹. Nitrous oxide mixed with oxygen is being used as a safe analgesic e.g. in children¹² and during labour¹³. The decline in use in operating rooms is being offset with the use in other settings from a number of suppliers¹⁴ e.g. Entanox¹⁵ and Equanox¹⁶.

Intravenous anaesthesia is an alternative for some patients and has a lower lifecycle carbon footprint¹⁷.

¹⁰ Sherman et al. Life Cycle Greenhouse Gas Emissions of Anesthetic Drugs, 2012 <http://www.anesthesia-analgesia.org/content/114/5/1086.long>

¹¹ ENIGMA2 study of nitrous oxide anaesthesia and cardiac morbidity after major surgery <http://www.enigma2.org.au/summary>

¹² NICE Sedation in children and young people <http://publications.nice.org.uk/sedation-in-children-and-young-people-cg112/guidance>

¹³ NICE Intrapartum care Guidance <http://publications.nice.org.uk/intrapartum-care-cg55/guidance#coping-with-pain-in-labour-non-epidural>

¹⁴ MHRA authorised suppliers of nitrous oxide

<http://www.mhra.gov.uk/Safetyinformation/Medicinesinformation/SPCandPILs/?subsName=NITROUS%20OXIDE&pageID=SecondLevel>

¹⁵ BOC Entanox http://www.entonox.co.uk/en/entonox_in_medical_therapy/therapy_with_entonox/index.shtml

¹⁶ Air Liquide Equanox <http://www.uk.airliquide.com/file/otherelement/pi/equanox%20brochure47640.pdf>

¹⁷ Sherman et al. Life Cycle Greenhouse Gas Emissions of Anesthetic Drugs, 2012. Available at: <http://www.anesthesia-analgesia.org/content/114/5/1086.long>



Conclusion

These results give total emissions for anaesthetic gases including Nitrous Oxide of an additional 2.5% (0.56 MtCO₂e) of NHS carbon footprint for England.

The majority of anaesthesia is in an acute setting. This is 5% of organisation footprint of acute organisations¹⁸ (0.56 MtCO₂e of 10.4 MtCO₂e). For acute organisations this is comparable with half the emissions from gas used for building energy use¹⁹ (1.17 MtCO₂e) and would add around 15% to 25% on the building energy use carbon footprint (2.47 MtCO₂e).

Measuring, monitoring and reporting carbon dioxide equivalent emissions, from inhaled anaesthetics, is crucial for reducing emissions.

¹⁸ SDU Carbon Hotspots report, 2012. Available at: <http://www.sdu.nhs.uk/corporate-requirements/measuring-carbon-footprint/nhs-carbon-footprint.aspx>

¹⁹ SDU Carbon Hotspots report, 2012. Available at: <http://www.sdu.nhs.uk/corporate-requirements/measuring-carbon-footprint/nhs-carbon-footprint.aspx>



Sustainable Development Unit
Victoria House
Capital Park
Fulbourn
Cambridge
CB21 5XB

e: england.sdu@nhs.net
w: www.sduhealth.org.uk
t: 0113 8253220

Twitter @sduhealth

Document published December 2013

 Sustainable Development Unit
Working across the NHS, Public Health and Social Care system