THE CLIMATE CHANGE ACT 2008

Ten years progress in anaesthesia to the 2050 target

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The Climate Change Act (CCA) 2008 mandates the Secretary of State to ensure that the UK emission of the six greenhouse gases (GHG) specified in the Kyoto protocol is reduced to 20% of the 1990 baseline by 2050 (Box 1). This article considers the science involved, and how anaesthesia practice has changed since 2008 in order to achieve the target reductions.

Once the earth's surface has been warmed by the sun, it cools by emitting infrared (IR) radiation (peak wavelength 10 µm). The increasing concentrations of GHGs in the troposphere re-absorb the outgoing IR, and the result is atmospheric warming and climate change.

Understanding the specific contribution of anaesthesia

All inhalational agents absorb IR of around the 10 µm wavelength.[1,2] The longer the agent persists in the atmosphere, the greater the Global Warming Potential (GWP) (Box 2). The product of mass of agent released and the GWP gives the CO_2 equivalency (CO_2e). Overall, anaesthesia agents, including Entonox®, contribute 2–5% of the CO_2e of the acute hospital sector in England. Specifically, in hospitals where desflurane is widely used, its use will contribute 50% of the total CO_2e of operating theatres' carbon footprint, the total of which is about 500 kg CO_2e per theatre per day. Since the vast majority of the CO_2e of inhalational anaesthesia relates to the environmental impact once exhaled, the quantification is very closely related to use rather than procurement. Quantifying the CO_2e of inhalational anaesthesia is possible using freely available smart phone apps.*

Reducing the CO_2e of inhalational anaesthesia: reduced nitrous oxide use

There is anecdotal evidence of a move away from the use of nitrous oxide as the carrier gas to the use of oxygen-enriched air. Nitrous oxide sales have fallen – size E cylinders are rarely seen on anaesthesia machines and some new hospitals have simply not installed nitrous oxide pipelines. Quantifying the extent of the fall is possible by using cylinder-return data and theatre activity. In Southampton, the CO_2e apportioned to nitrous oxide has fallen by 64% between 2009 and 2017, from 53.6 kg CO_2e per hour to an average of 19 kg CO_2e per hour of theatre use.[4]

The impact of low-flow anaesthesia

The move from the once widespread use of coaxial circuits (with or without ventilators) to the almost ubiquitous use of circle and low-flow systems can be calculated,* and probably represents at least a 75% reduction in the former. The recent introduction of end-tidal control and of vapour injection rather than vapourisers can be calculated to reduce the CO_2e of inhalational anaesthesia to less than 10% of what it was with a Bain circuit.

Figure 1 Image from the GE Aysis CS2 anaesthesia machine. Use of inhalational agent is is expressed in ml/hour. Cost requires the data to be entered before starting the case. Using isoflurane at this rate costs 15 pence per hour and the CO_2e is 1.53kg per hour.

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Unlike inhalational agents, the CO_2e of intravenous agents is related to the procurement and delivery systems. Authors have used modelling tools to best guess the CO_2e of propofol procurement rather than using the manufacturer's data and process analysis, and conclude that it is four orders of magnitude smaller than that for desflurane and three orders of magnitude smaller than sevoflurane.[3] Similar modelling for remifentanil has not been undertaken.

Electricity use

Coal combustion produces 900 g CO_2 per kWh of electricity generated, while natural gas combustion produces only 400 g. Coal accounts for less than 5% of electricity production and natural gas up to 50%. The inclusion of renewable sources in the UK energy mix reduces the average still further to 200–220 g CO_2 per kWh.

The largest electricity consumption in anaesthesia practice is from convective patient warming systems and anaesthetic gas scavenging systems (AGSS).[4] Choosing to use conductive rather than convective warming will reduce power consumption from 800 W to 40–80 W as well as saving the costs of disposables. Modern AGSS pumps are 800 W, though some older ones are 2–3 times more powerful. Turning off the AGSS out of hours will save at least 200 g CO_2 per hour.

The next 10 years

The first 10 years of the CCA have seen a greater understanding of atmospheric science and, with the help of anaesthetic machine manufacturers and a change of clinical practice, a reduction in the emission of one of the Kyoto GHGs, nitrous oxide. As we write this, the Intergovernmental Panel on Climate Change (IPCC) states that to limit global temperature rise to 1.5ºC above pre-industrial levels, the world has to be carbon neutral by the middle of this century.[5] There is no room for complacency.

To make informed choices, anaesthetic drug and device manufacturers should responsibly provide details of the CO_2e of their products to enable us to consider not just the clinical but also the environmental benefit of our choice of agent. Further, without national reporting of nitrous oxide and inhalational agent use, only the doggedly determined will be able to report progress confidently. If we can measure our environmental impact then we can manage it.

*iOS search Anesthetic Impact Calculator Sleekwater Software/Kevin Scott.
*Android search Anaesthetic Impact Calculator Sleekwate Software/Kevin Scott.

References

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2. Sulbaek Andersen MP *et al*. Assessing the impact on global climate from general anesthetic gases. *Anesthesiology* 2012;114:1081–1085.
3. Sherman J *et al*. cycle greenhouse gas emissions of anesthetic drugs. *Anesthesiology* 2012;**114**:1086–1090
4. Pierce JMT Personal observation based on analysis of 440,000 hours of theatre use and 15,000T CO_2e over 9 years.
5. Pierce T, Morris G, Parker B. Reducing theatre energy consumption. *Health Estate* 2014 68(3):58–62.
6. Summary for Policymakers of IPCC Special Report on Global Warming of 1.5ºC approved by governments (http://bit.ly/2zLJ5t0).

Box 1 Glossary of terms used

Carbon intensity of electricity generation The mass of CO_2 produced per kWh of electricity generated. Average for the UK about 200g.

CO_2 equivalency (CO_2e) Carbon dioxide equivalency is a quantity that describes, for a given mixture and amount of greenhouse gas, the amount of CO_2 that would have the same global warming potential (GWP), when measured over a specified timescale (generally, 100 years). GWP x mass released = CO_2e. The single measure of kg CO_2e allows all GHGs to be placed on the same scale and therefore comparable.

Global Warming Potential over 100 years (GWP100) The capacity of a molecule to absorb IR dependent on the degree of absorption, the wavelength of absorption and the tropospheric life time. Expressed relative to CO_2, by convention is unity.

Kyoto Greenhouse gases (GHG) CO_2, N_2O, methane, SF6, hydrofluorocarbons and perfluorocarbons.

Radiative forcing The difference between radiative energy input and output at the tropopause.

Scope 1 emissions of the GHG protocol Are direct emissions from owned or controlled sources, and so easier to quantify than emissions from Scope 2 and 3.

Stratosphere The atmosphere from 10,000m to 50,000m. The ozone 'layer' exists here, and long-lived gases such as CFCs and N_2O contribute to ozone destruction.

Tropopause The boundary between the troposphere and stratosphere where radiative forcing is calculated.

Troposphere The first 10,000m of atmosphere, in which all life exists and in which GHGs exert their effect.

Box 2 Comparative characteristics of the inhalational anaesthetic agents. For the halogenated agents, the longer the tropospheric life, the greater the GWP. The inhalational agents undergo hydroxylation in the atmosphere to species without significant IR absorption.

Agent	IR absorption	Tropospheric lifetime	GWP100	CO_2e of a container's contents
Sevoflurane	7-10 µm	1.1 yr	130	44 kg CO_2e 250ml
Isoflurane	7.5-9.5 µm	3.2 yr	510	190 kg CO_2e 250ml
Desflurane	7.5-9.5 µm	14 yr	2540	886 kg CO_2e 240ml
Nitrous oxide	4.5, 7.6, 12.5 µm	110 yr	290	1003 kg CO_2e Size E