The environmental impact of anaesthetists

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Association of Anaesthetists
Core Topics 18th October 2019

Outline

- Definitions
- Domestic details
- Global trends
- Volatiles and the atmosphere
- CO_2e of drugs and combinations
- NHS Long Term Plan
- Leaner and greener anaesthesia

Disclosure

- Not in receipt of grants or bursaries
- Voluntary work for
  - Royal College of Anaesthetists
  - Association of Anaesthetists
  - Health Care Without Harm
- Visited the SageTech Medical facility


72% 07:12
BBC WEATHER
Updated a moment ago
Southampton
Next hour
06:50 19:07
16°
0%
10
Sunny and a gentle breeze
M UV L Pollution
Today 22° 17°
Sun 19° 12°
Mon 18° 15°
Tue 18° 14°


BOSCH
0800 519 2111


BUDGET
Today
1.81kWh
next
usage
menu
£
kW


BUDGET
Today
0.90kgCO2
next
usage
menu
£
kW

Carbon dioxide equivalence CO_2e

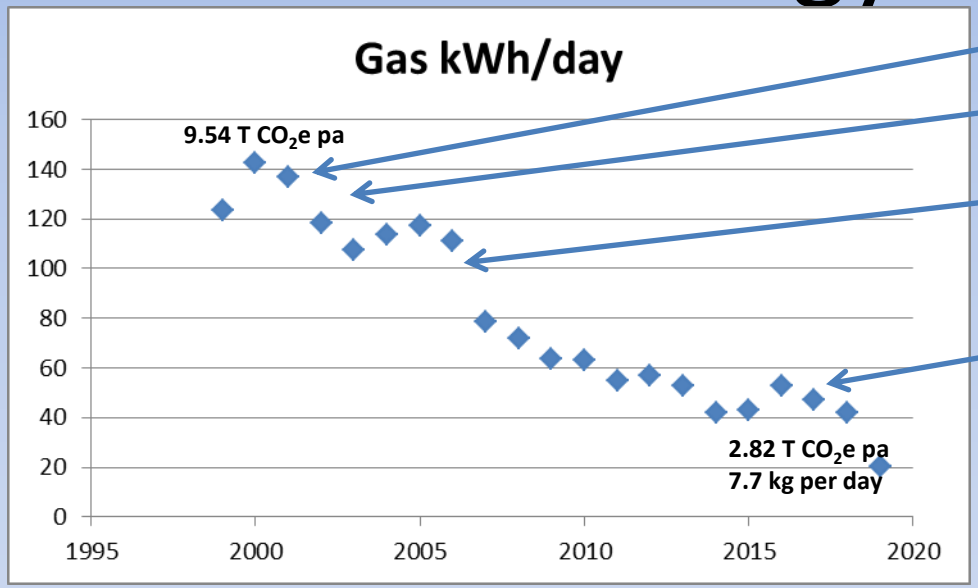
- Carbon dioxide equivalency (CO_2e) of a GHG
  - The amount of CO_2 that has the same warming effect as the GHG over the 100 year period
  - CO_2e reflects the time-integrated radiative forcing of a rate of GHG emissions that flow into the atmosphere
  - Not the instantaneous value of the radiative forcing of the concentration of GHGs
- CO_2e is the concentration of CO_2 that would cause the same level of radiative forcing as a given type and concentration of the GHG.

CO_2e for a gas = mass released x GWP of the gas

CO_2e for CO_2 = 1

Possible confusion; CFCs have significant GWP (5000-10000)

Domestic energy consumption

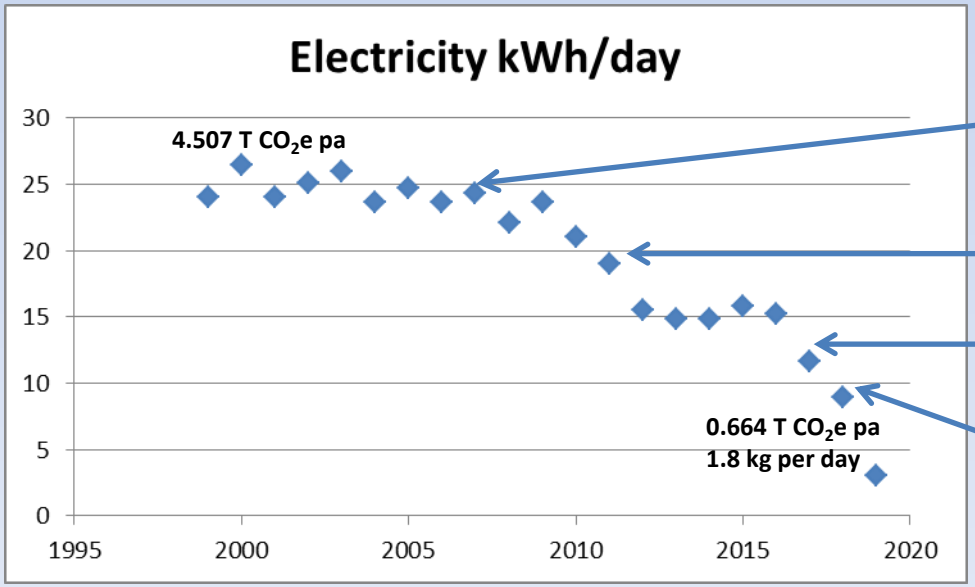


Solar thermal system

Improved pipe insulation

Over heated and destroyed the gas boiler 2007

Internet enabled boiler controls



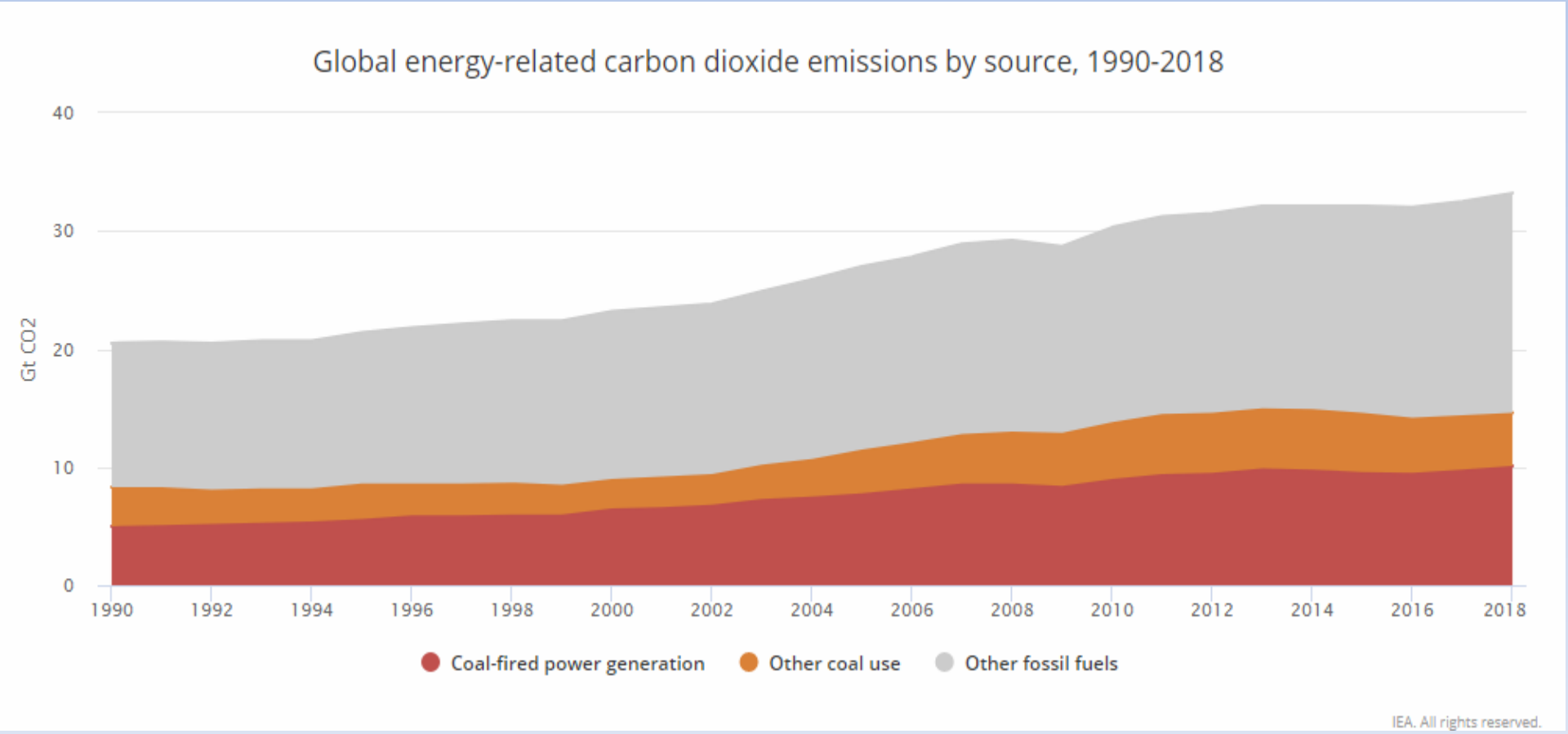
Installed an air source heat pump to replace the gas boiler

Installed solar PV system 2011

LEDs

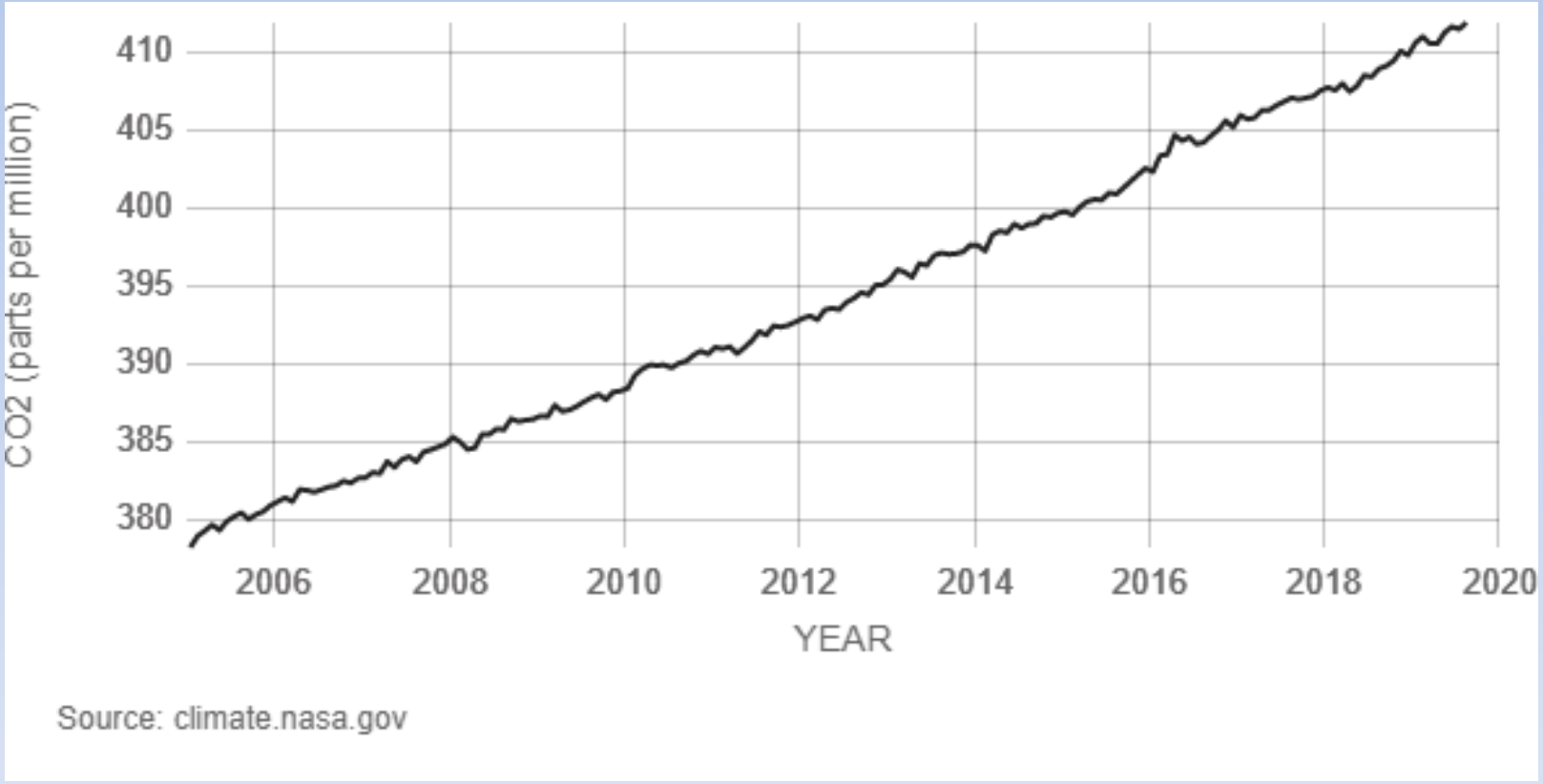
Timed my electrical energy use with the solar gain 2018

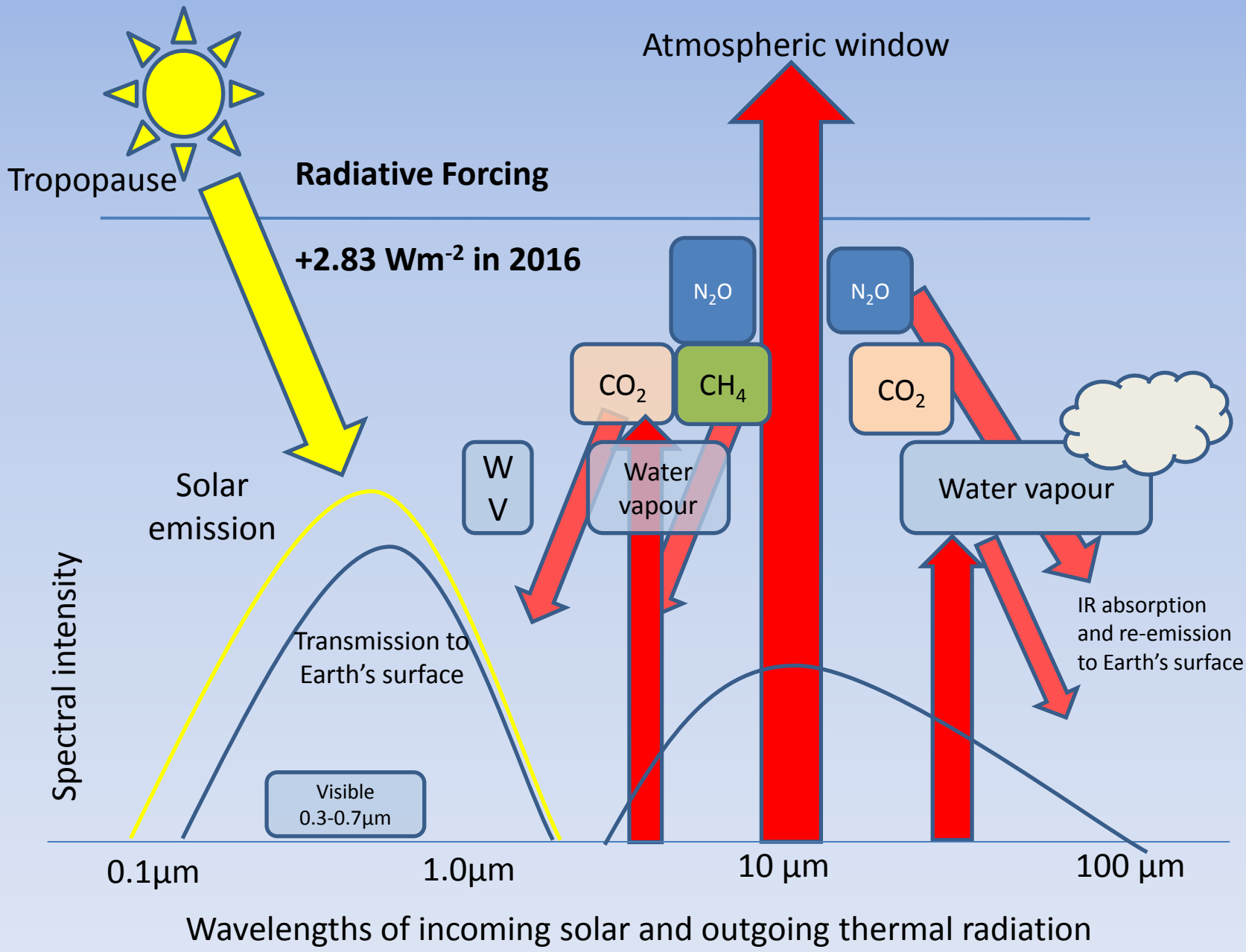
Global energy-related CO_2 emissions



Iea Global energy and CO_2 status report 2018

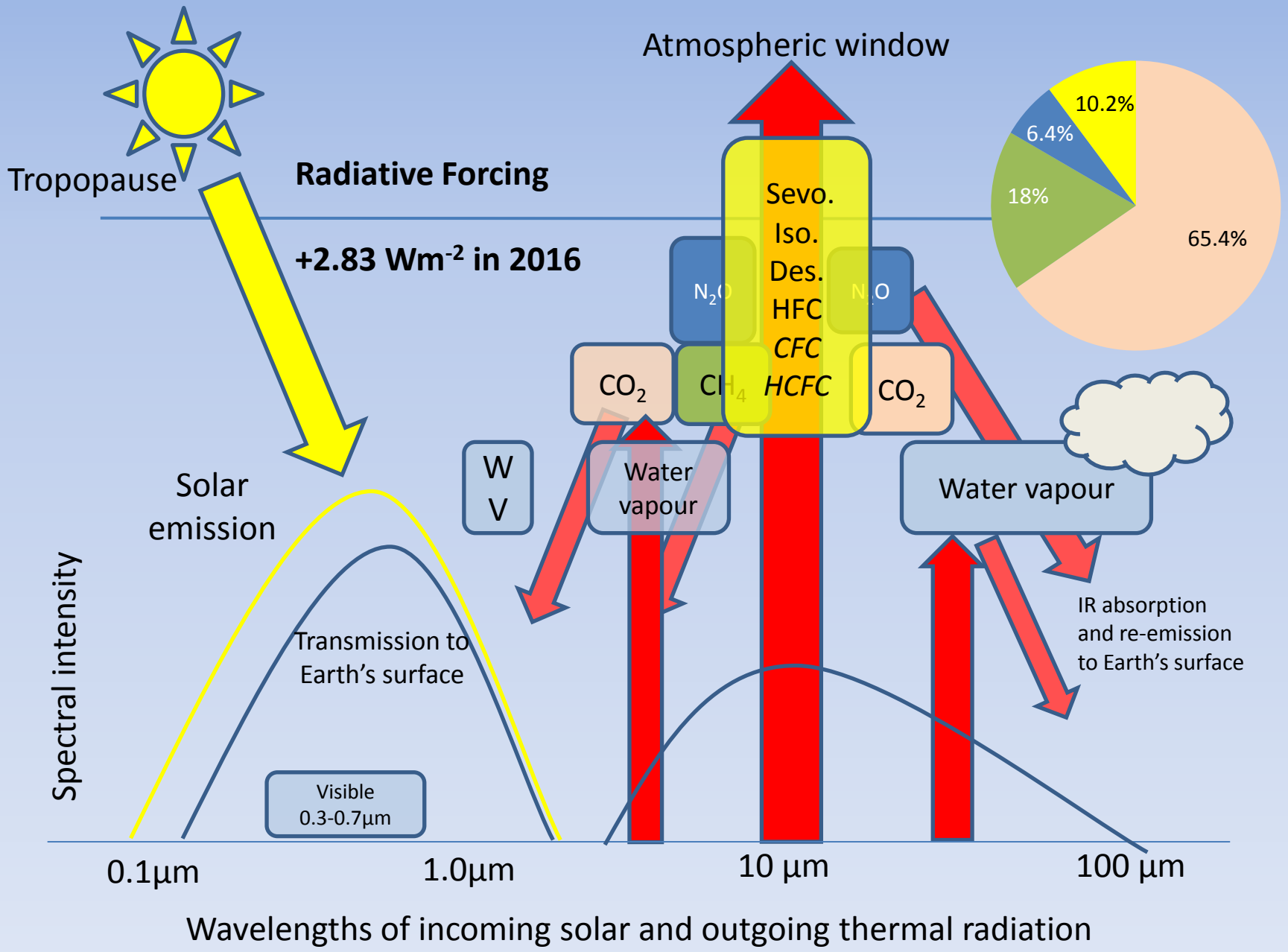
Atmospheric CO_2 concentration




Atmospheric window
Tropopause
Radiative Forcing
+2.83 Wm-2 in 2016
N2O
N2O
CO2
CH4
CO2
W
V
Water vapour
Water vapour
Solar emission
IR absorption and re-emission to Earth's surface
Transmission to Earth's surface
Spectral intensity
Visible 0.3-0.7µm
0.1µm
1.0µm
10 µm
100 µm
Wavelengths of incoming solar and outgoing thermal radiation

Inhalational anaesthetic agents

Agent	IR absorption	Tropospheric lifetime	GWP_{100}	CO_2e of a container's contents
Sevoflurane	7-10 µm	1.1 yr	130	44 kg CO_2e 250ml
Isoflurane	7.5-9.5µm	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


Atmospheric window
Tropopause
Radiative Forcing
+2.83 Wm-2 in 2016
Sevo.
Iso.
Des.
HFC
CFC
HCFC
N2O
N2O
CO2
CH4
CO2
W
V
Water vapour
Water vapour
10.2%
6.4%
18%
65.4%
Solar emission
Transmission to Earth's surface
IR absorption and re-emission to Earth's surface
Spectral intensity
Visible 0.3-0.7µm
0.1µm
1.0µm
10 µm
100 µm
Wavelengths of incoming solar and outgoing thermal radiation

The impact of surgery on global climate: a carbon footprinting study of operating theatres in three health systems

Andrea J MacNeill, Robert Lillywhite, Carl J Brown

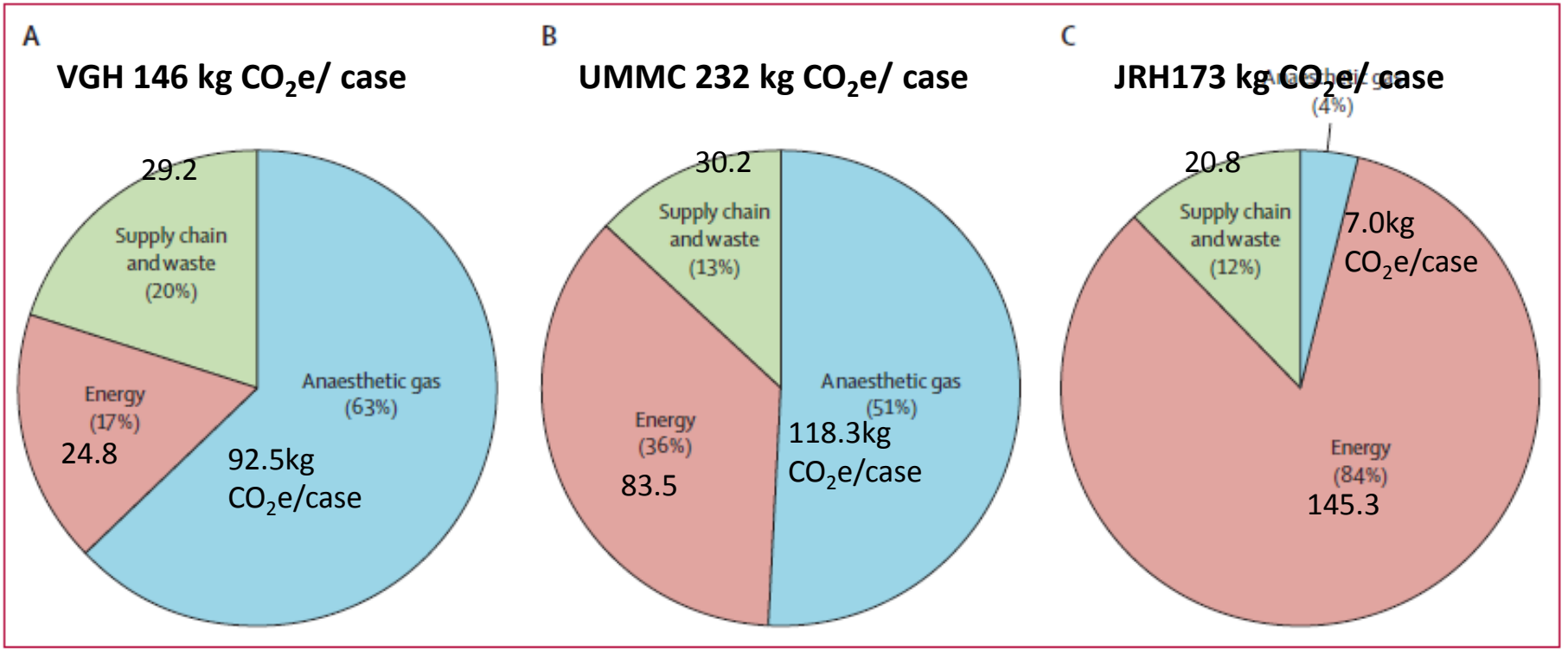


Figure 2: **Relative contribution of scopes 1, 2, and 3 to the carbon footprint of operating theatres at (A) Vancouver General Hospital, (B) University of Minnesota Medical Center, and (C) John Radcliffe Hospital**

Anaesthetic gas=scope 1. Energy=scope 2. Supply chain and waste=scope 3.

Nitrous oxide use at all three centres was minimal

Average three institutions 188 T CO_2e pa = 515 kg CO_2e per day

Lancet Planetary Health 2017

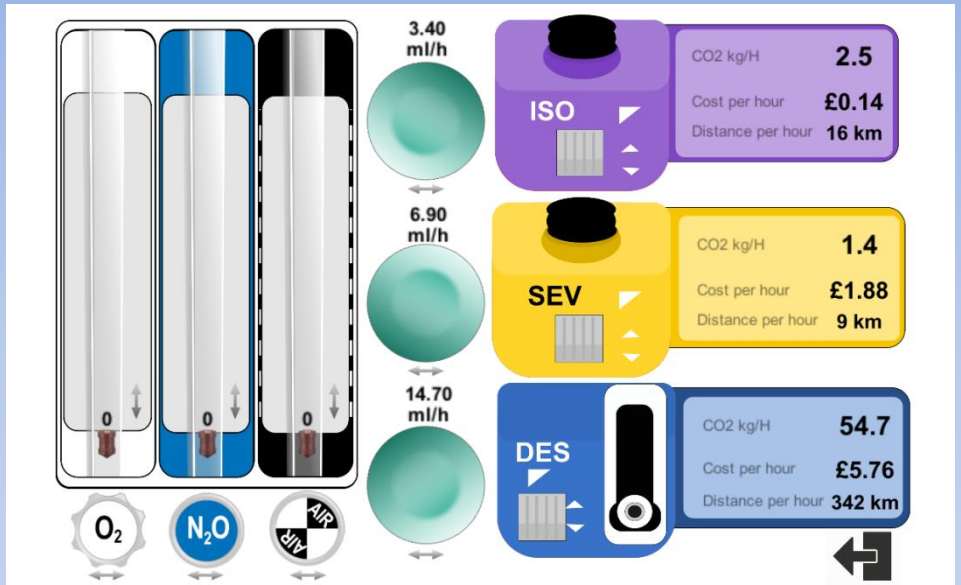
Anaesthetic Impact Calculator

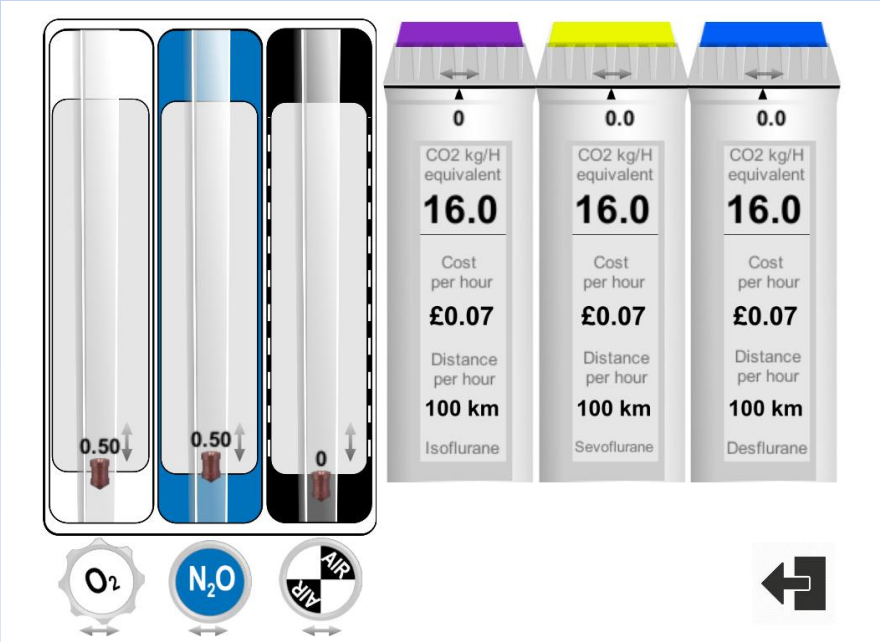
Association of Anaesthetists

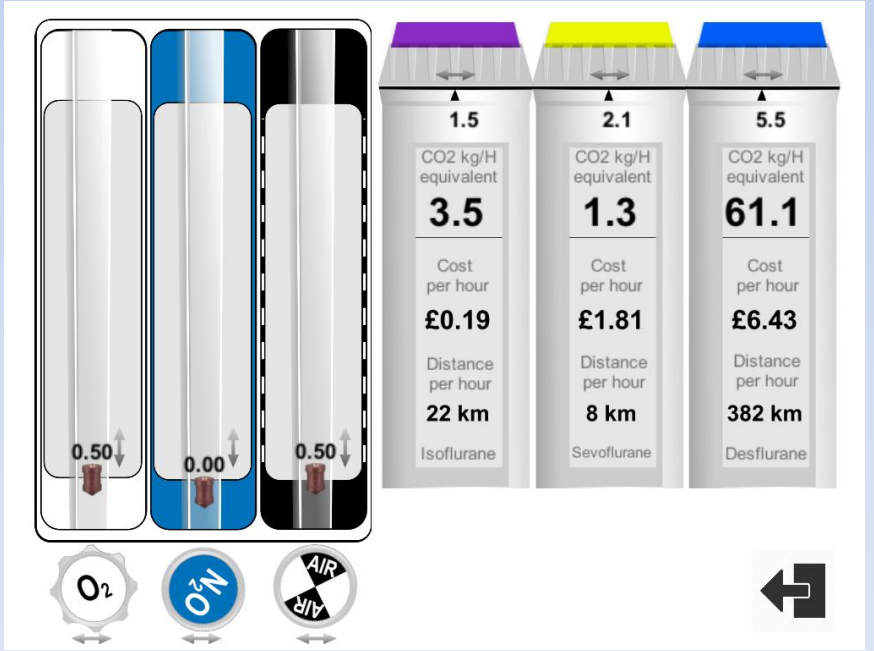
ET control vapouriser

TEC Plenum

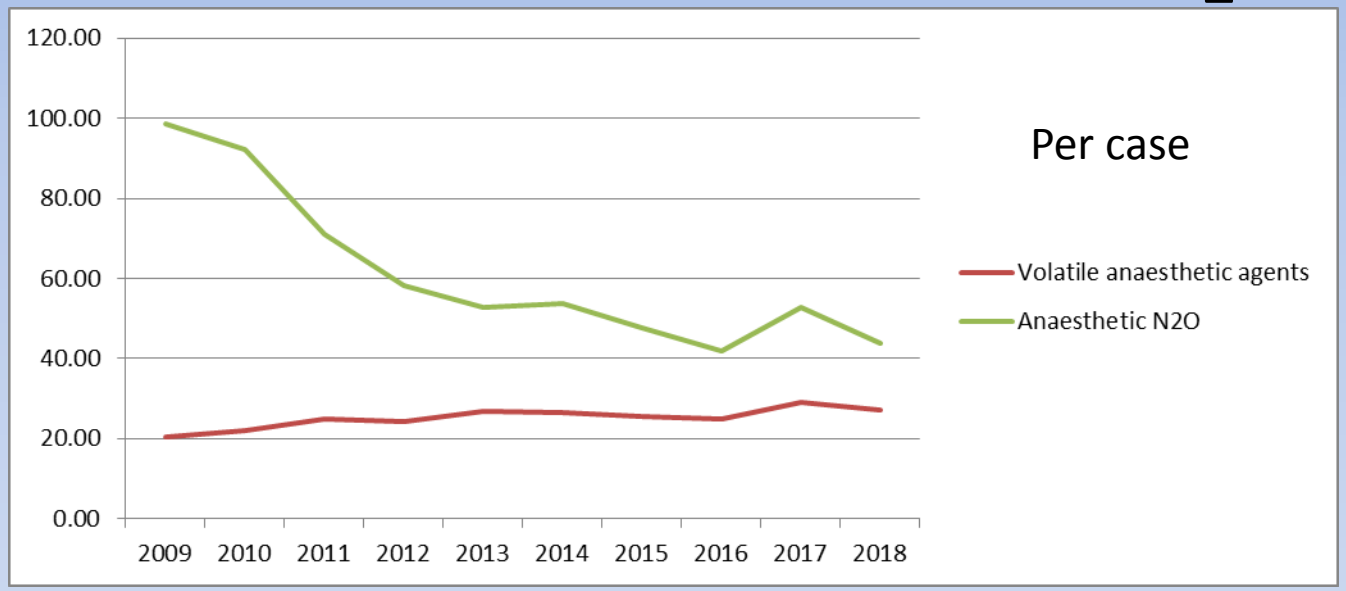
Settings

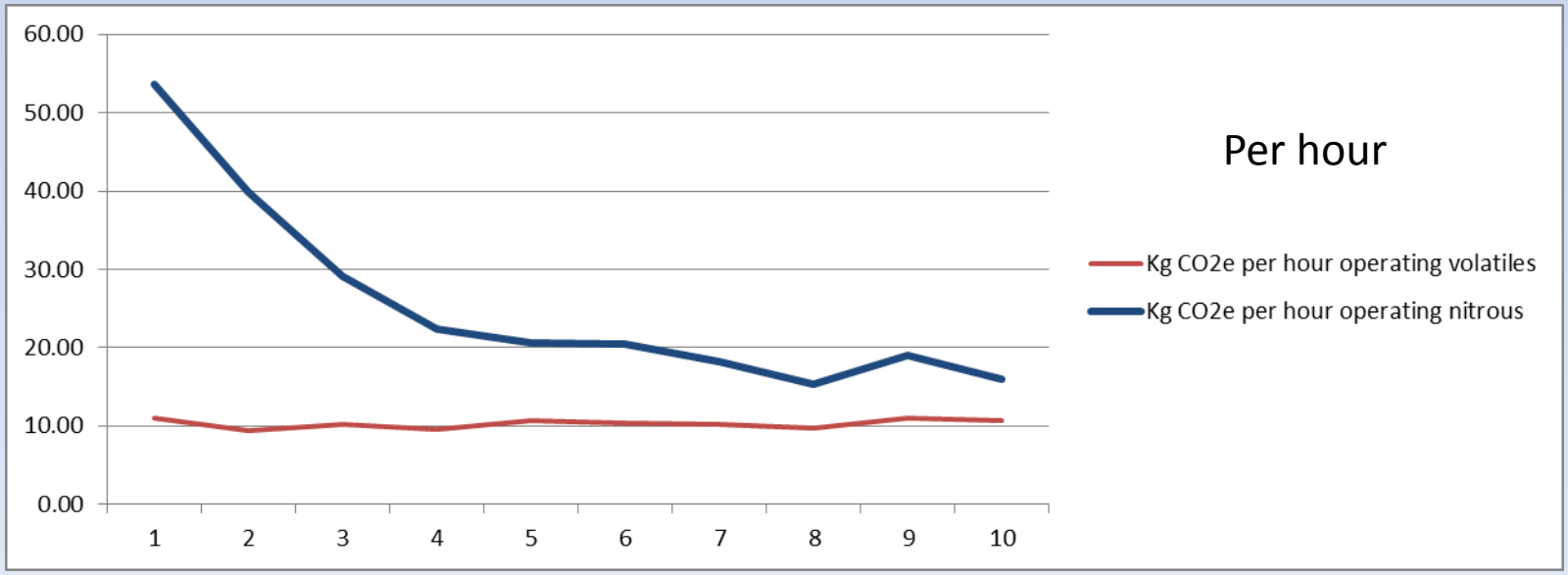






UHS volatile and anaesthetic N_2O use





The carbon footprint of an inhaled general anaesthetic

- Vancouver
  - (2011) 93.5 kg CO_2e per case
    - Switched to sevoflurane and halved the CO_2e
- Minnesota
  - 118.3 kg CO_2e per case
- Southampton
  - 25 kg / hour mean duration 2.6 hours
  - 65 kg CO_2e per case
- Yale
  - 55 kg CO_2e per case
  - Sevoflurane FGF 2l

What about intravenous drugs and local anaesthesia?

Article

Cradle-to-gate Greenhouse Gas Emissions for Twenty Anesthetic Active Pharmaceutical Ingredients based on Process Scale-up and Process Design Calculations

Abhijeet Parvatker, Huseyin Tunceroglu, Jodi D Sherman, Philip Coish, Paul T. Anastas, Julie B. Zimmerman, and Matthew J. Eckelman

ACS Sustainable Chem. Eng., **Just Accepted Manuscript** • DOI: 10.1021/acssuschemeng.8b05473 • Publication Date (Web): 20 Jan 2019

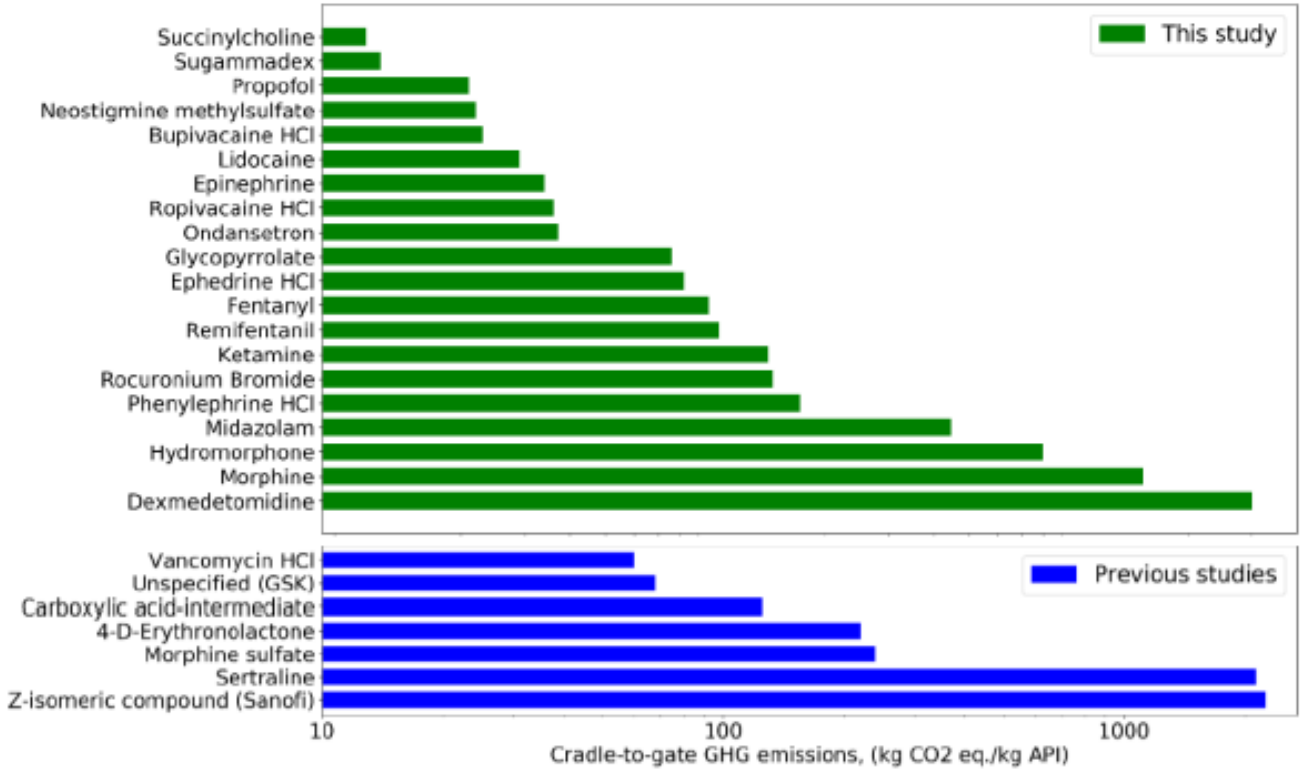


Figure 3: (Top) Cradle-to-gate GHG emissions per kg drug for 20 injectable drugs used in anesthesia care, (Bottom) cradle-to-gate GHG emissions per kg API/intermediate from previous studies.

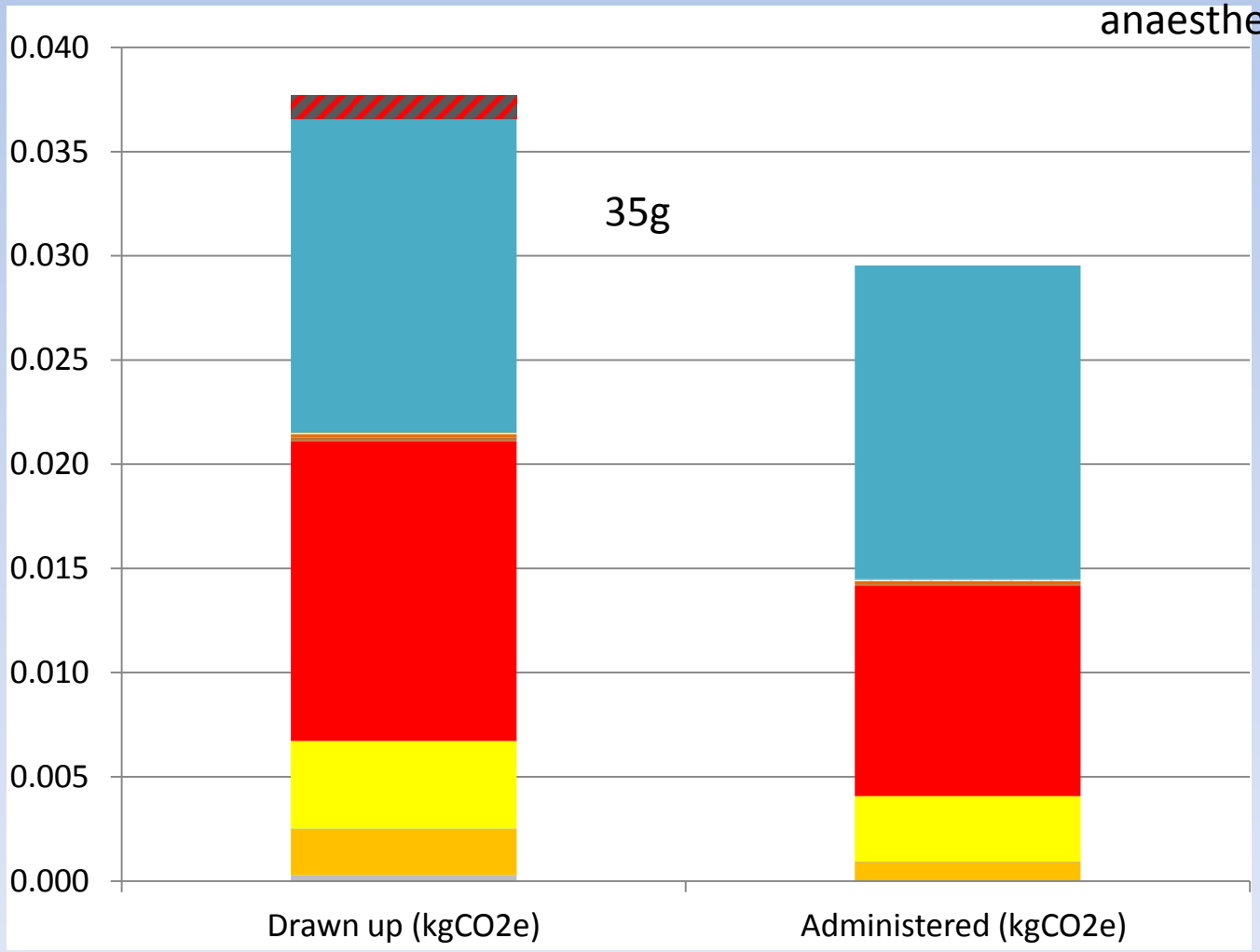
Parvatker et al Supplementary material

Table S2: List of twenty anesthetic drugs with their respective cradle-to-gate GHG emissions, molecular weights and molecular complexities

API	IPCC GWP 100a (kg CO2 eq)	MW (g/mol)	Molecular complexity
Dexmedetomidine	3006	200	205
Morphine	1506	285	494
Hydromorphone	799	322	494
Midazolam	444	326	471
Phenylephrine hydrochloride	171	204	130
Rocuronium Bromide	144	610	898
Ketamine	140	237	269
Remifentanil	103	376	523
Fentanyl	96	336	391
Ephedrine Hydrochloride	82	202	121
Glycopyrrolate	76	318	424
Ondansetron	37	293	440
Ropivacaine HCl	36	311	308
Epinephrine	34	183	154
Lidocaine	29	234	228
Bupivacaine HCl	23	325	321
Neostigmine methylsulfate	22	334	337
Propofol	21	178	135
Sugammadex	12	2178	2790
Succinylcholine	11	361	284

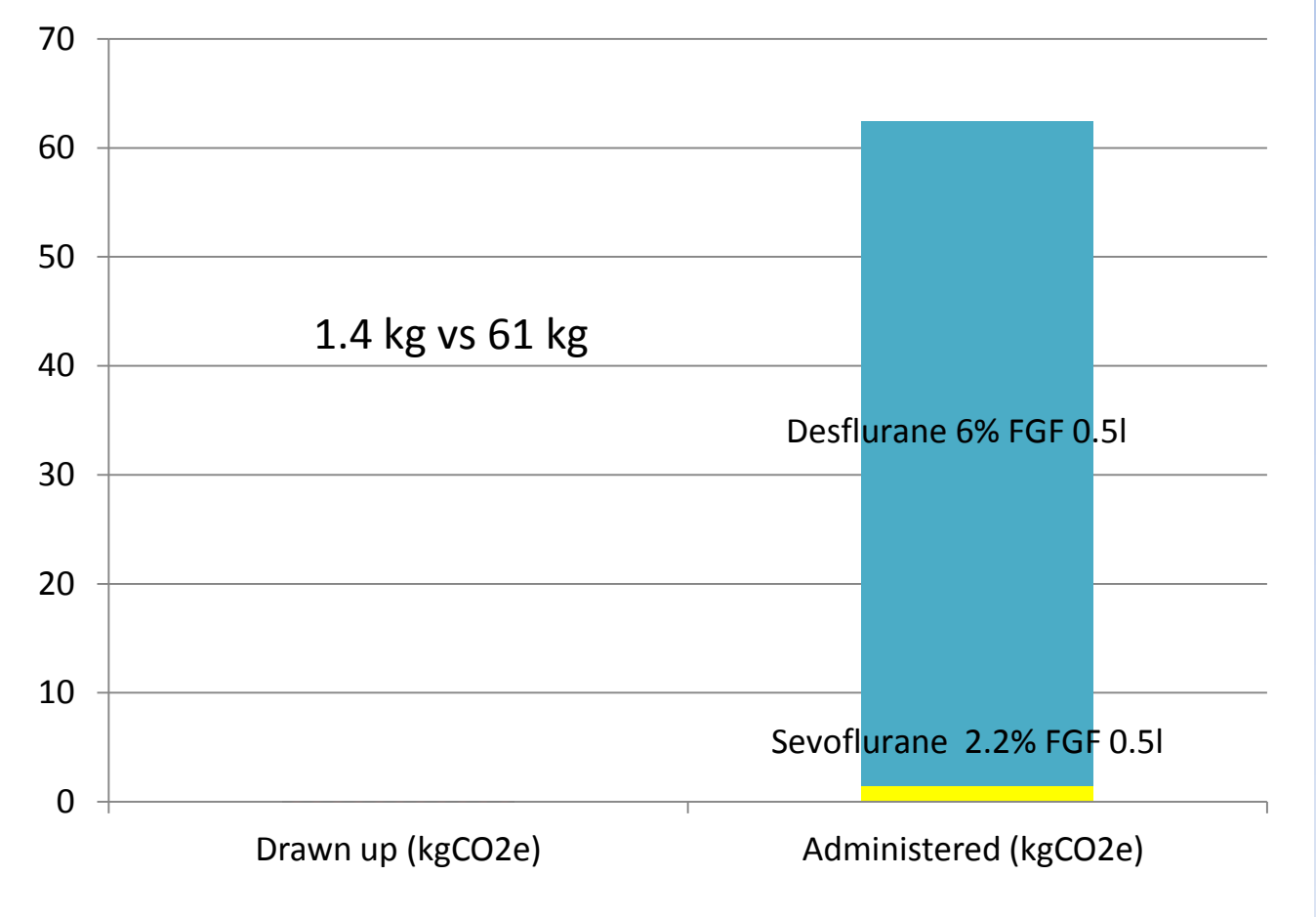
Kg CO_2e of intravenous drugs

Per case 2 hours anaesthesia



Kg CO_2e inhaled anaesthesia

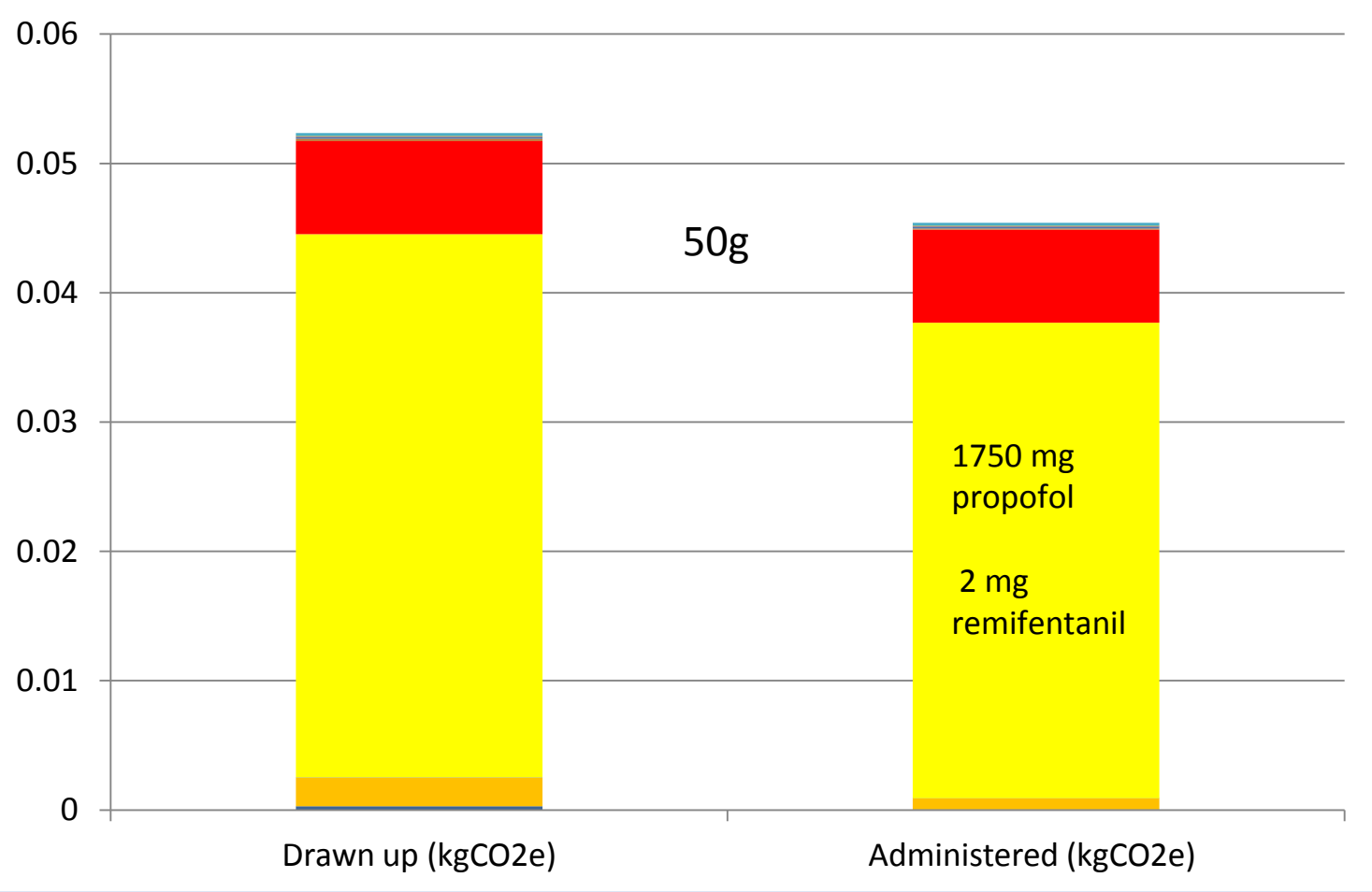
Per case 2 hours anaesthesia



Kg CO_2e TIVA drugs

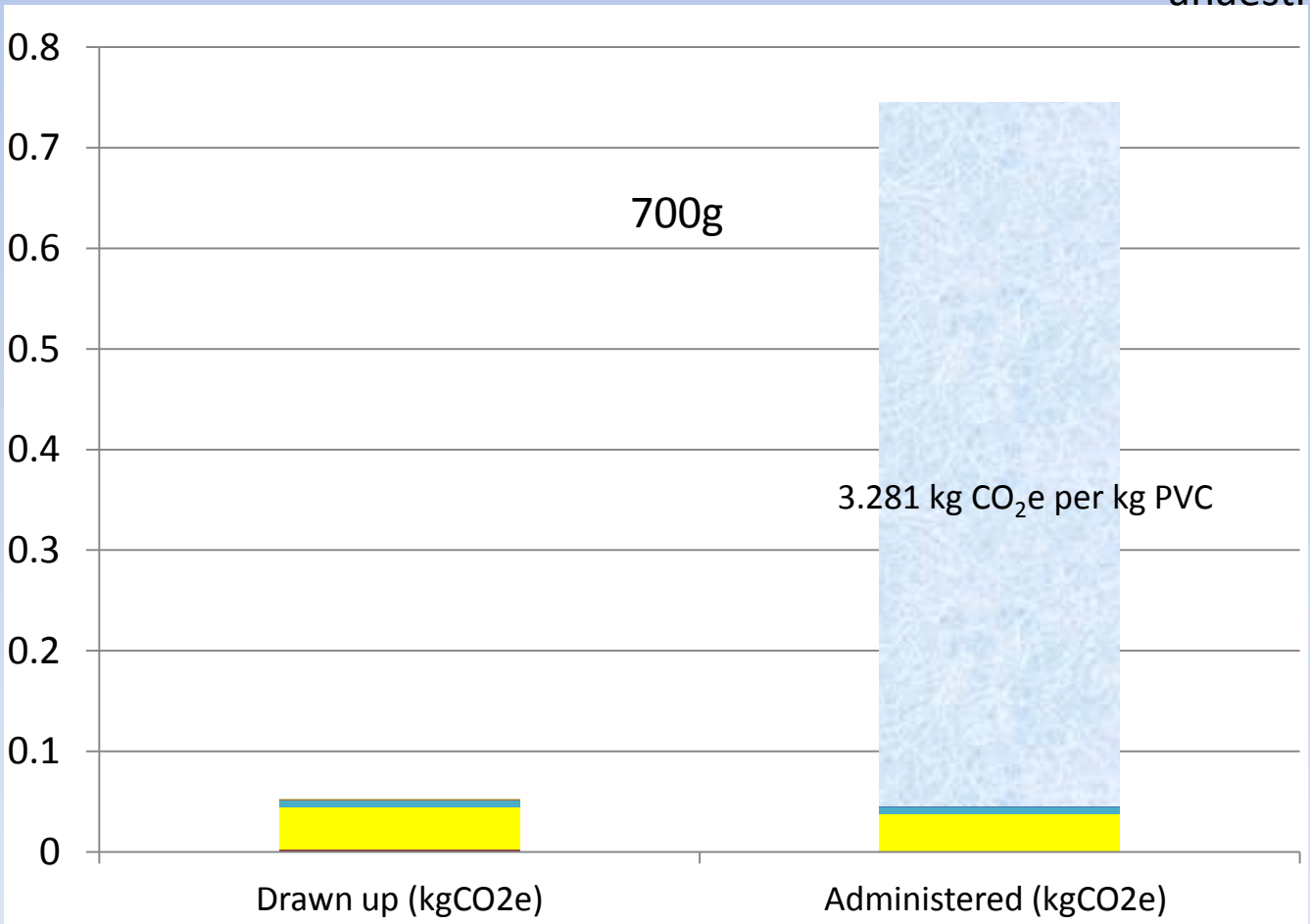
LCI propofol is for the API only

Per case 2 hours anaesthesia



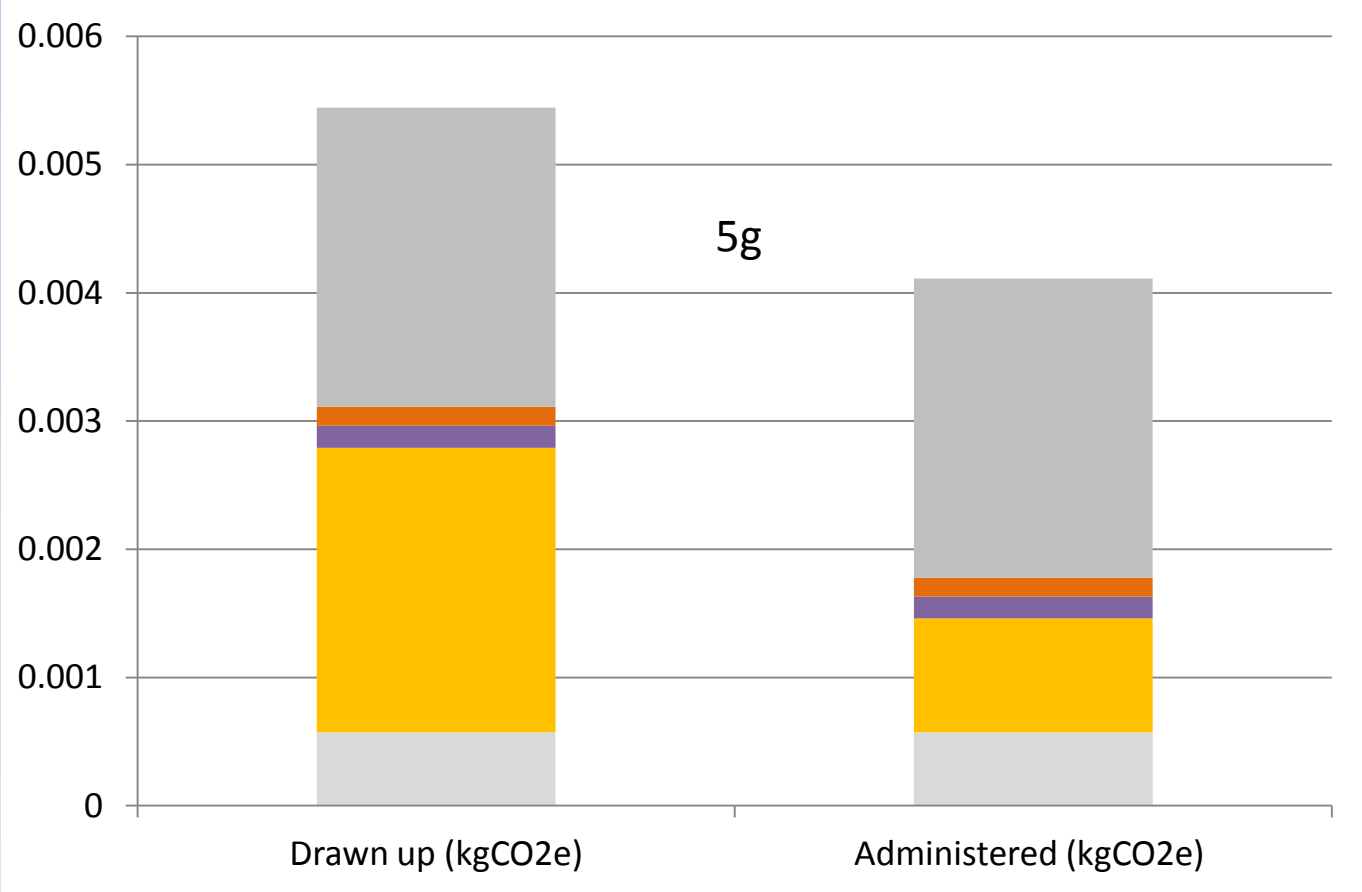
Kg CO_2e TIVA drugs plus PVC

Per case 2 hours anaesthesia



Kg CO_2e bupivacaine epidural

Per case 2 hours anaesthesia

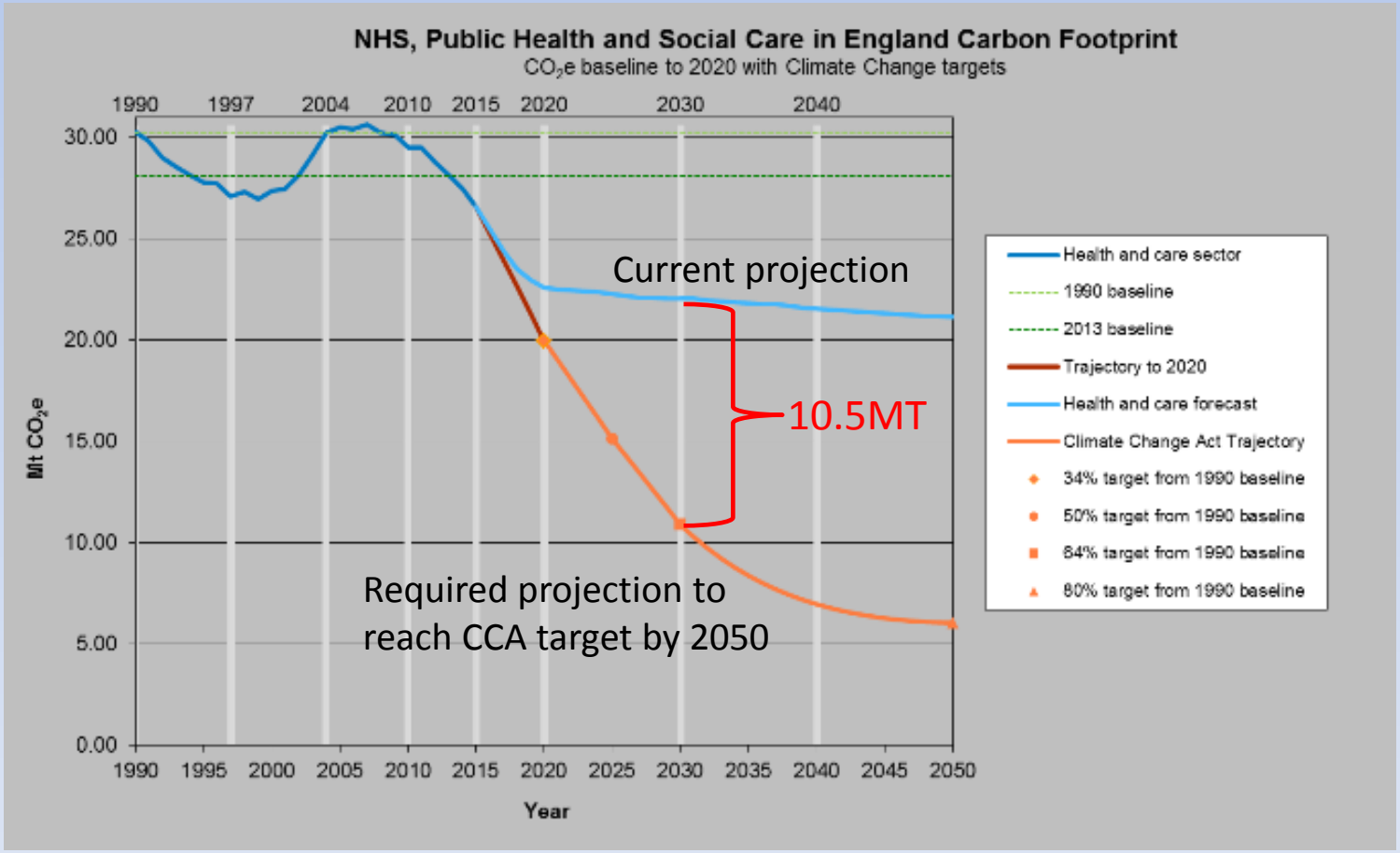


Summary

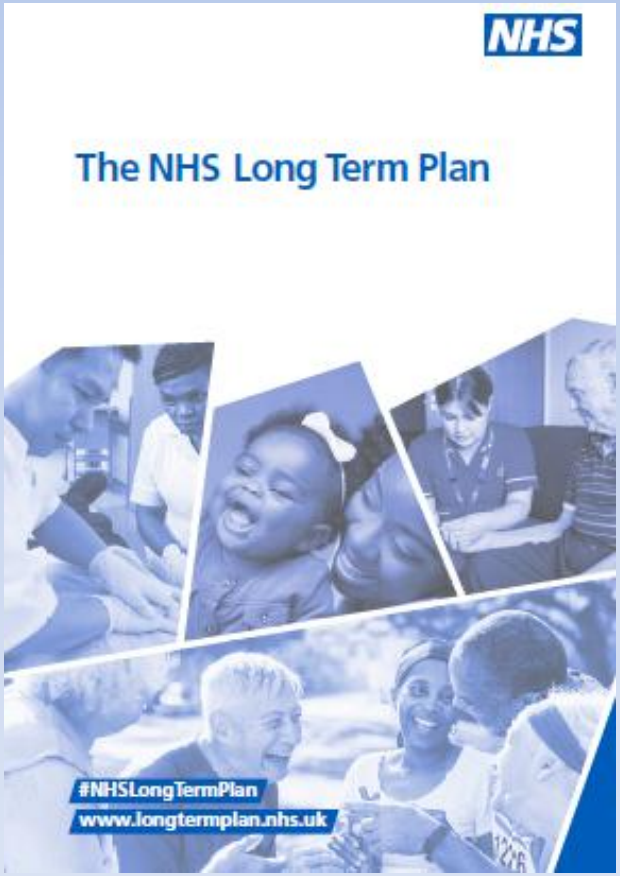
Per case 2 hours anaesthesia

	CO_2e (g)	Mass of drug (g)
Intravenous drugs	35-50	0.433
PVC syringes	141	38g of PVC + pack
Sevoflurane anaesthesia	1,400	11.683
Desflurane anaesthesia	69,200	27.233
N_2O 500 ml / minute	32,000	110
TIVA drugs	50	2.075
TIVA syringes and giving set	708	216g of PVC + pack
Regional anaesthesia	5	0.130
Regional syringes + set	180	55

SDU; the carbon footprint forecast



The NHS Long Term Plan 2019



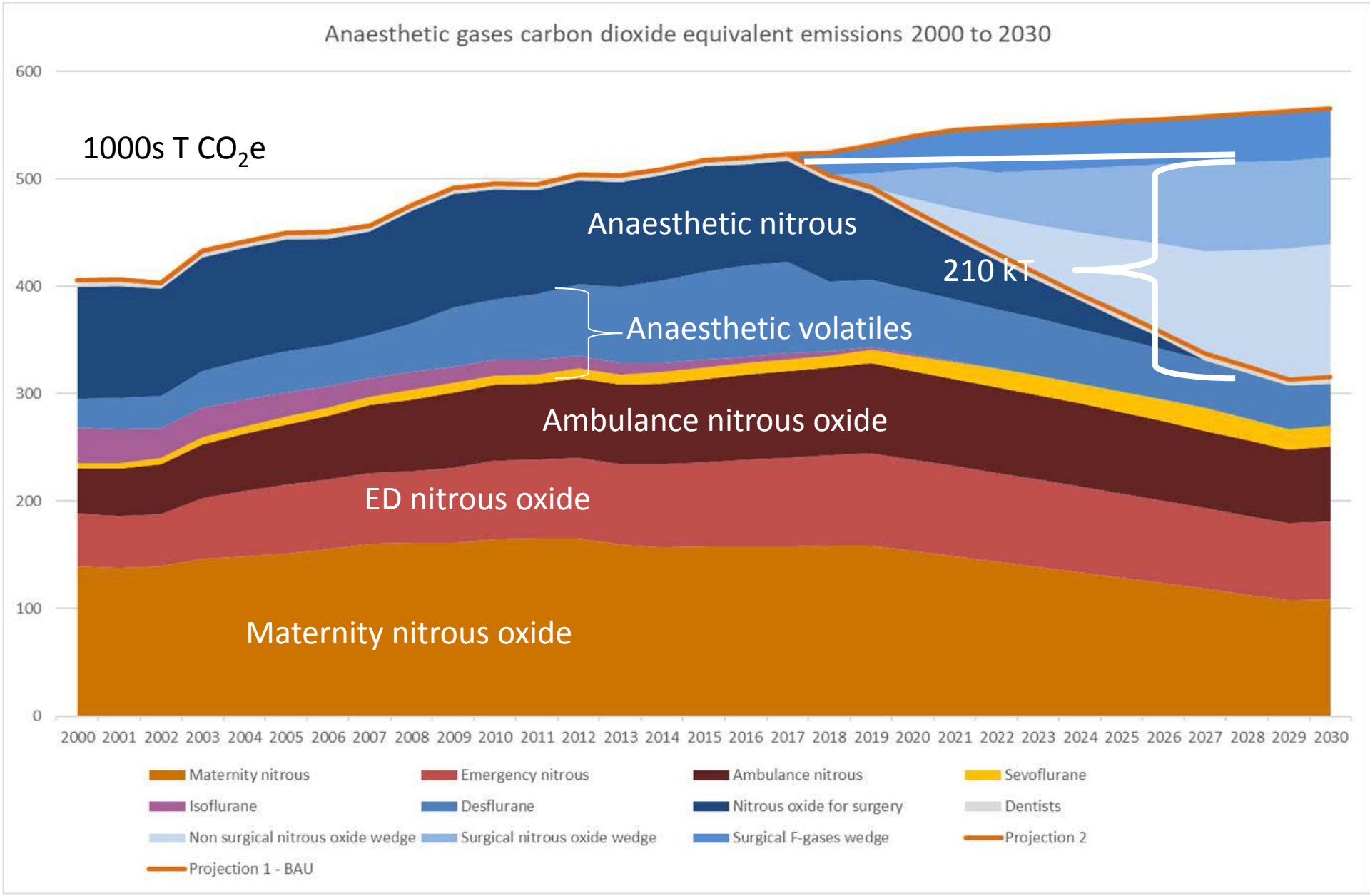
"....a shift to lower carbon inhalers will deliver a reduction of 4% with a further 2% delivered through transforming anaesthetic practices."

How much of a transformation?

- 2015 RCoA census
  - 9486 non-trainee anaesthetists
  - Added a little expansion in line with previous trends
  - 10,000 Specialist anaesthetists in the UK
  - 2% of 10.5 million tonnes = 210,000 T CO_2e
  - Split evenly over 42 weeks a year

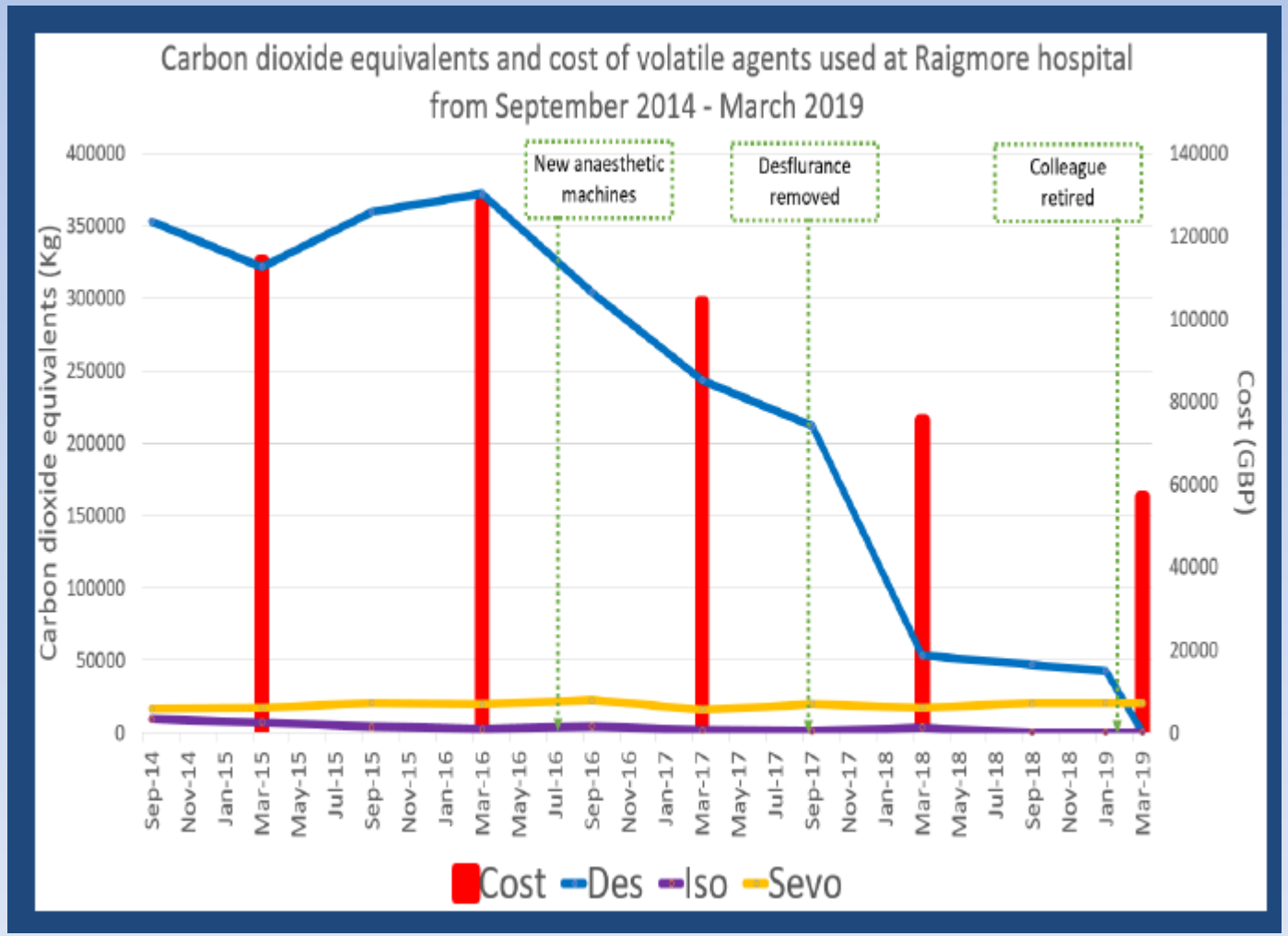
    = 500 kg per anaesthetist every week

    = 3124 km in a car releasing 160g CO_2 per km



SDU Presentation to Association of Anaesthetists Glasgow 2019 with permission

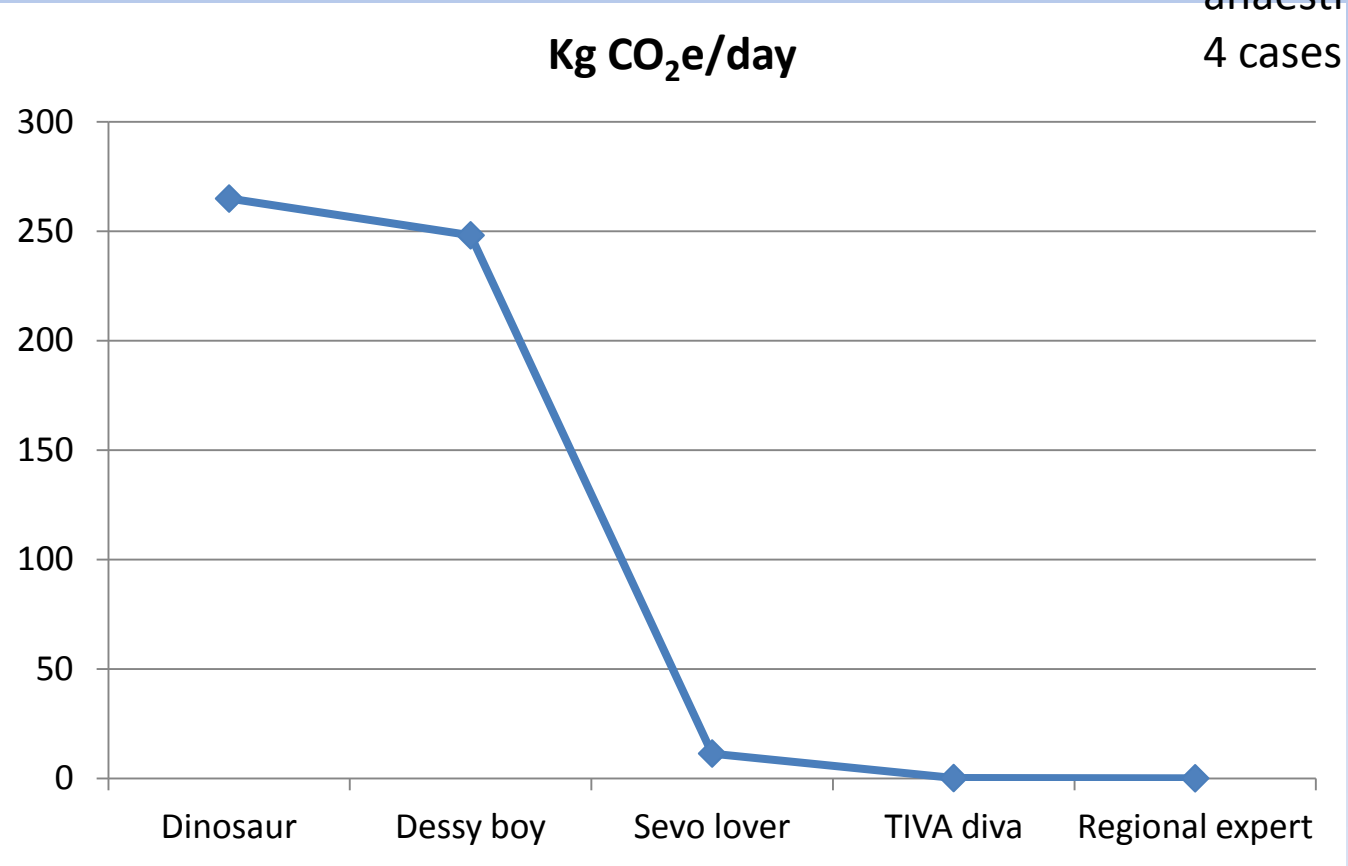
We must talk about Des



Kenneth Barker, Raigmore Hospital, Highlands. HCWH website

Anaesthesia (r)evolution

Per day 2 hours
anaesthesia
4 cases a day



Anaesthesia (r)evolution

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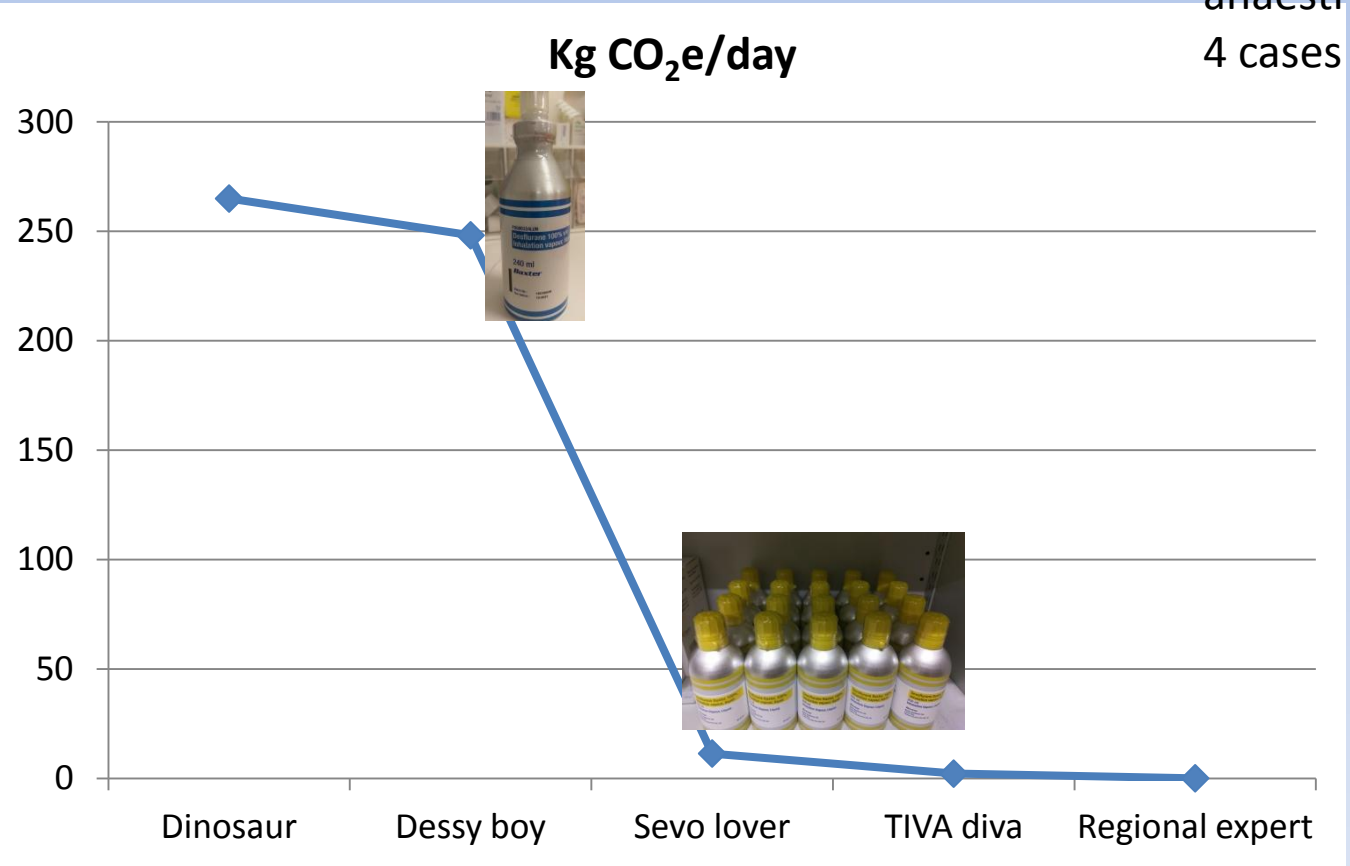
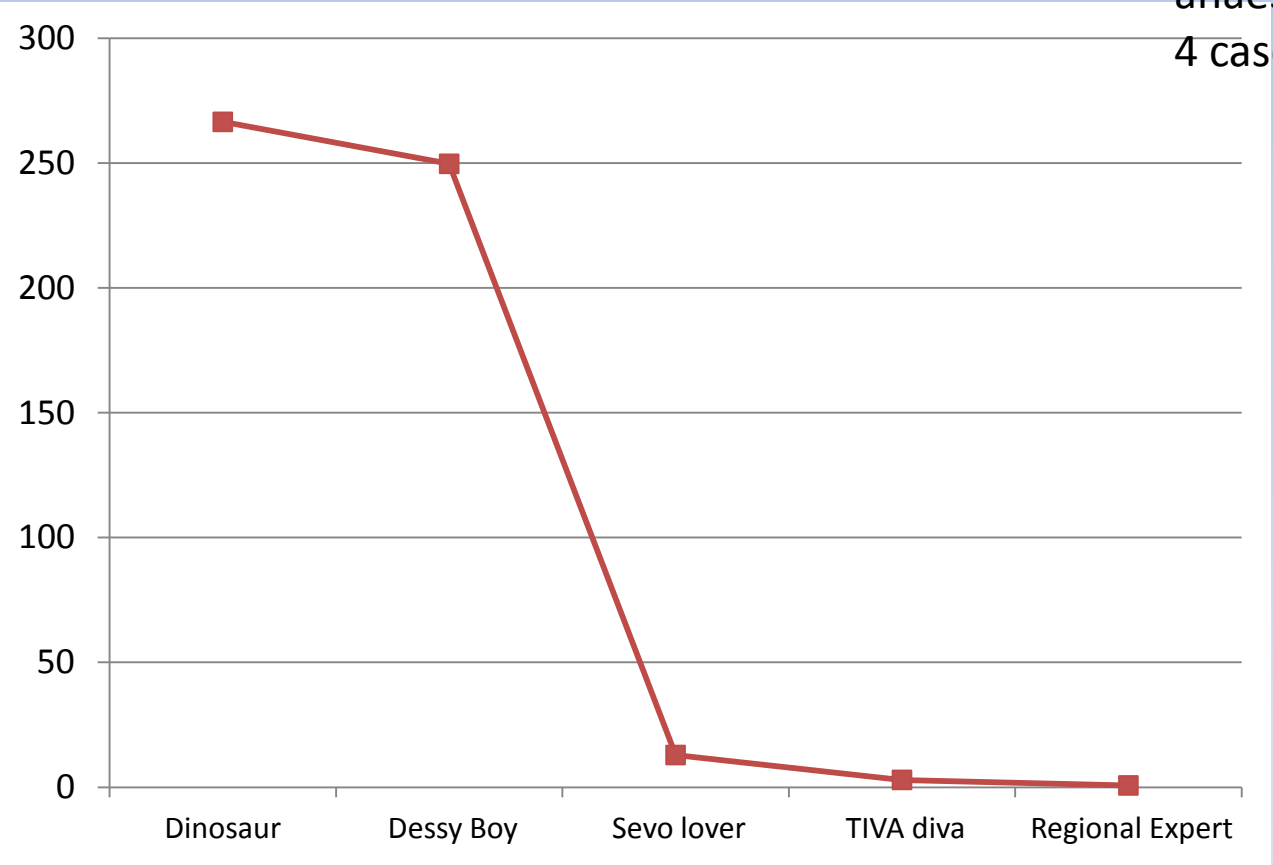


Including PVC

Per day 2 hours anaesthesia
4 cases a day



End of the day's operating check-list

- Have I ***reduced*** the carbon footprint of my day in theatre?
  - Anaesthetic technique, resources consumed
  - Plastics and disposables
  - Switched off all anaesthesia-related electrical items?
  - Have I used active travel for my commute?
- Have I ***reused*** volatile anaesthetic agents?
  - Low flow anaesthesia
- Have I made best use of ***recycling***?

Conclusions

- Tools are improving to quantify the CO_2e of anaesthesia, but we need cradle to gate of
  - Volatile manufacture, from the manufacturer
  - Propofol excipients
- For nitrous oxide and desflurane users
  - Impact at work is up to 25 times greater than domestic energy emissions
  - Area of focus for the NHS Long Term Plan


Generator
Ventilation
Normal
Setback
Low Air Flow
Replace Filter
AGS-System
Main On and Air Flow
Duty Pump Failed
System Failed
Normal
Plant Fault
Plant Emergency
Timer Controls
General Control
Lamp Test


BEACON MEDI


Generator
Ventilation
Normal
Setback
Low Air Flow
Replace Filter
AGS-System
Main On and Air Flow
Duty Pump Failed
System Failed
Normal
Plant Fault
Plant Emergency
Timer Controls
General Control
Lamp Test


BEACON MEDI


ROGER MASON '14
"Daddy, what did YOU do
to prevent climate change?"


Well,…. where shall I begin?
I've got lots to tell you.
ROGER MASON '14
"Daddy, what did YOU do to prevent climate change?"

Thank you

Measurement tools

Smart phone app to calculate the real-time CO_2e of inhalational anaesthesia

- Anaesthetic Impact Calculator (Kevin Scott)

Greenhouse Gas Protocol

- Scope 1
  - Direct emissions
    - Gas burnt or GHG emitted
- Scope 2
  - Indirect emissions from purchased energy
    - Energy use
- Scope 3
  - Services
    - Drug and disposable production

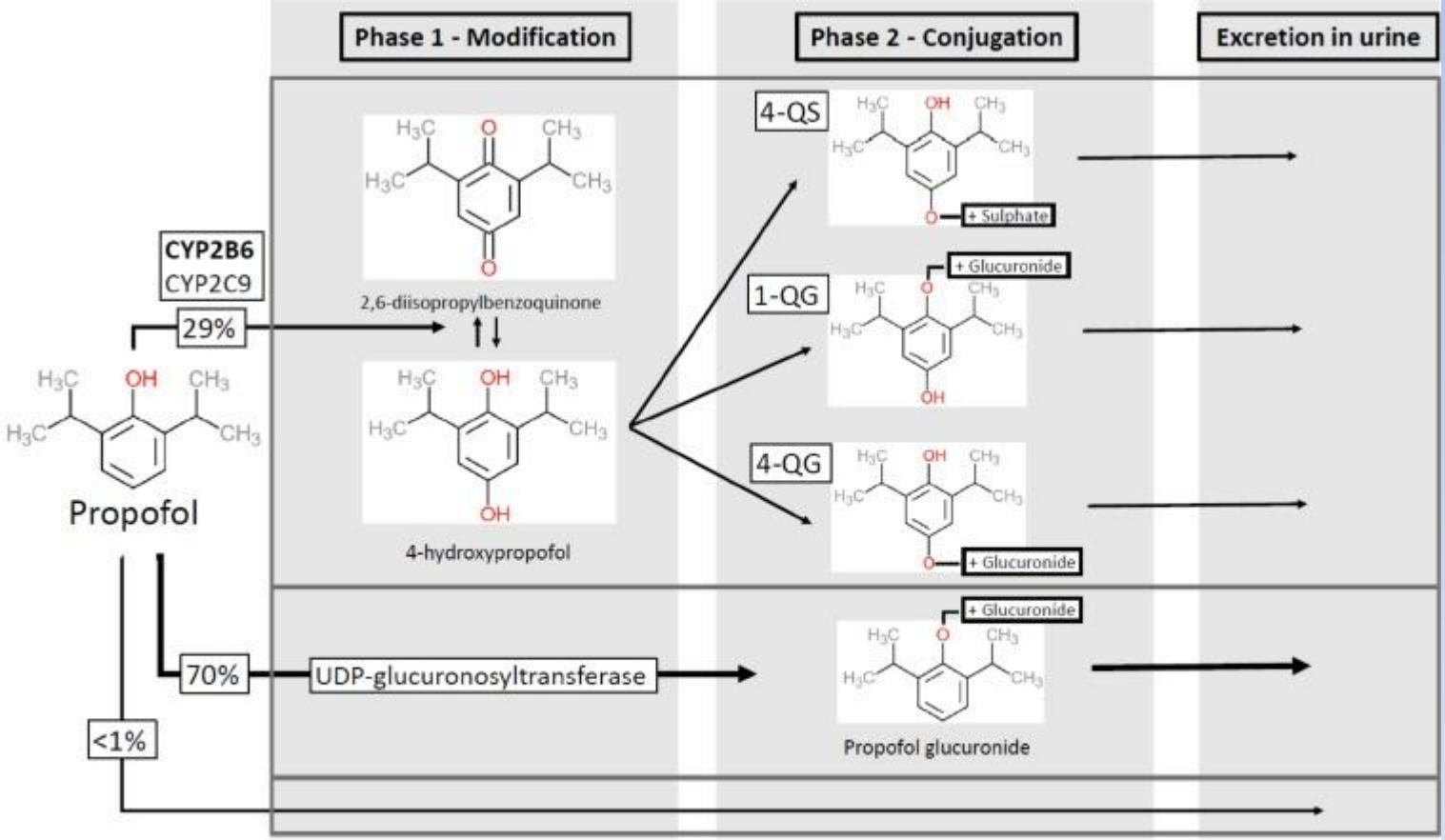
The next steps

- 2% group
- Syllabus
- E-learning program
- Green guide
- Patient information leaflets
- Industry
  - Venting of nitrous oxide
  - Propofol excipients; LCA

Kenneth Barker, Raigmore hospital, Highlands. HCWH website

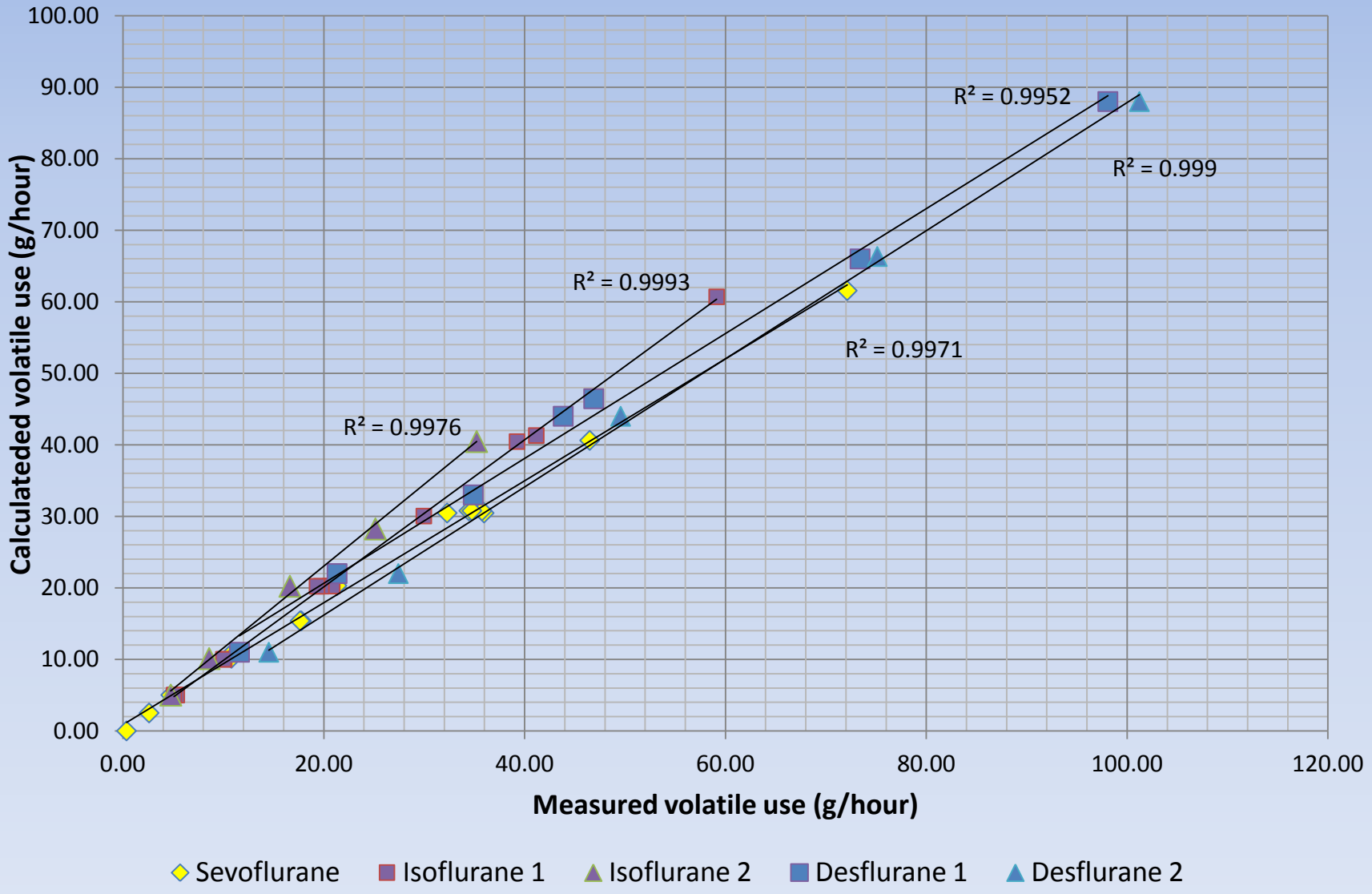
Pathways and waste

Propofol metabolism and excretion



4-QS: 4-(2,6-diisopropyl-1,4-quinol)-sulphate a.k.a. 4-hydroxypropofol-sulphate
1-QG:1-(2,6-diisopropyl-1,4-quinol)-glucuronide a.k.a. 1-hydroxypropofol-glucuronide
4-QG: 4-(2,6-diisopropyl-1,4-quinol)-glucuronide a.k.a. 4-hydroxypropofol-glucuronide

Clin Pharmacokinet. 2018; 57(12): 1539–1558.



In press Anaesthesia