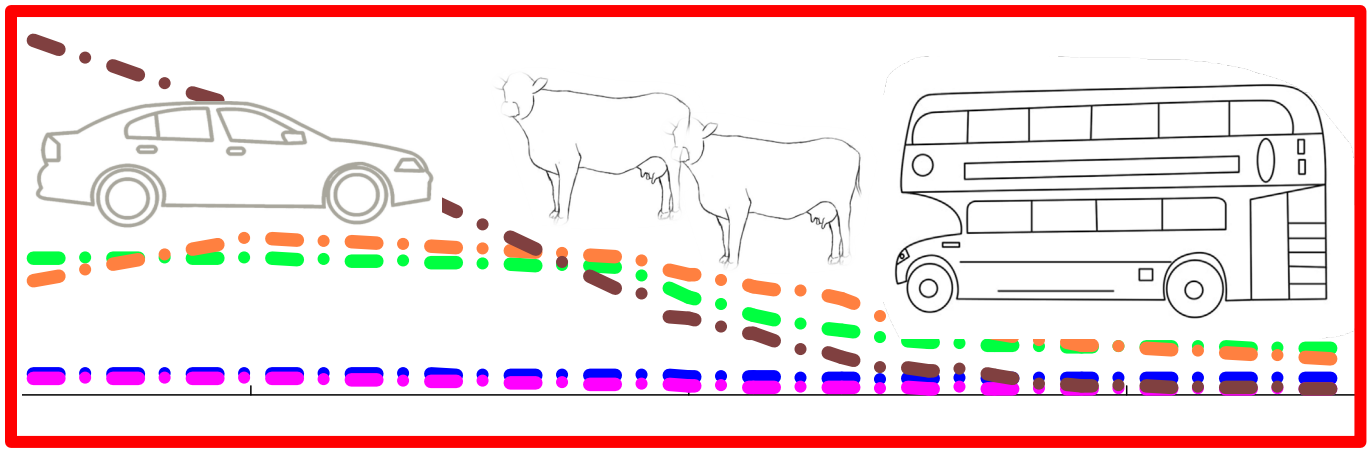
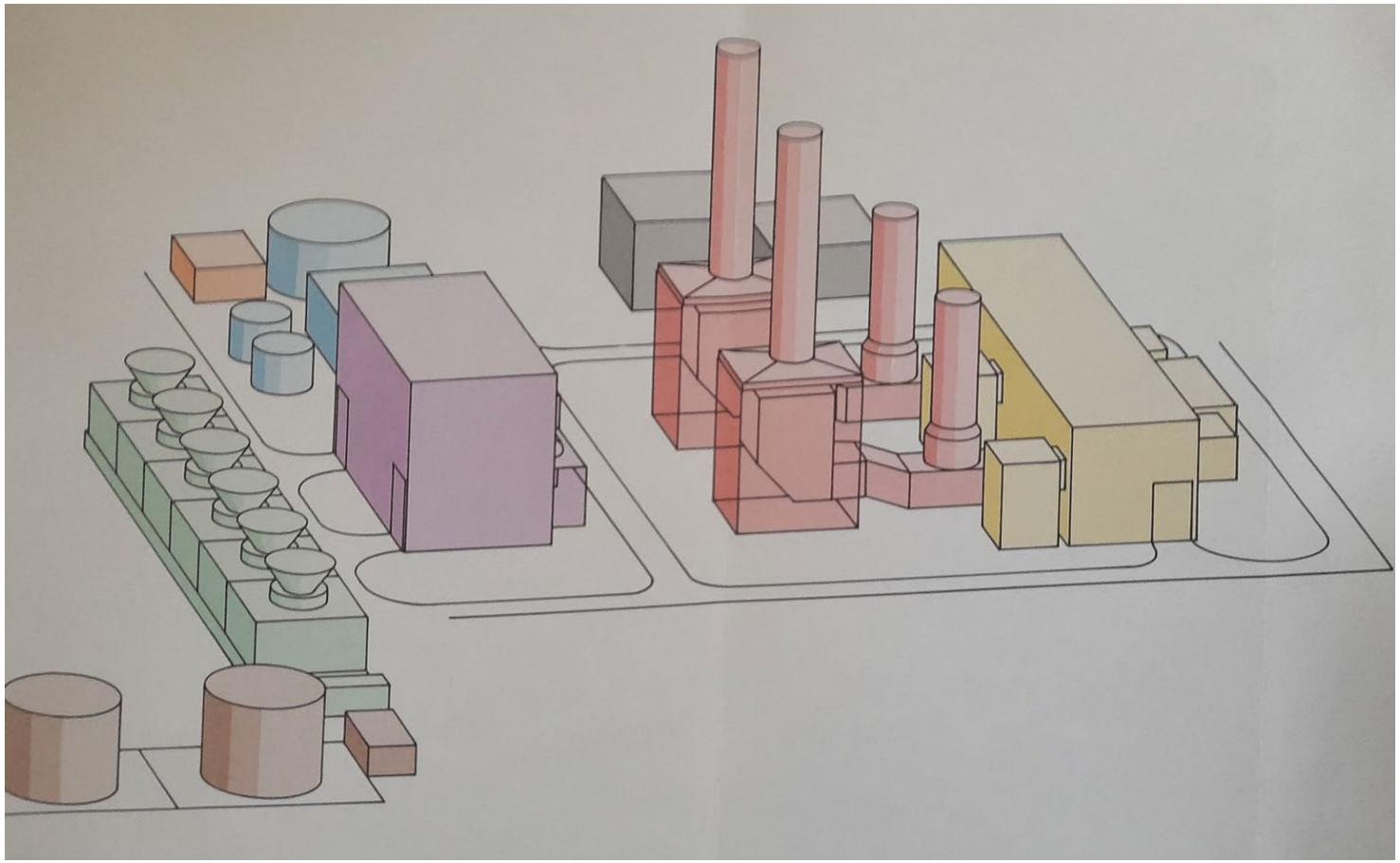


Setting a joint UK target for air quality and greenhouse gas emissions

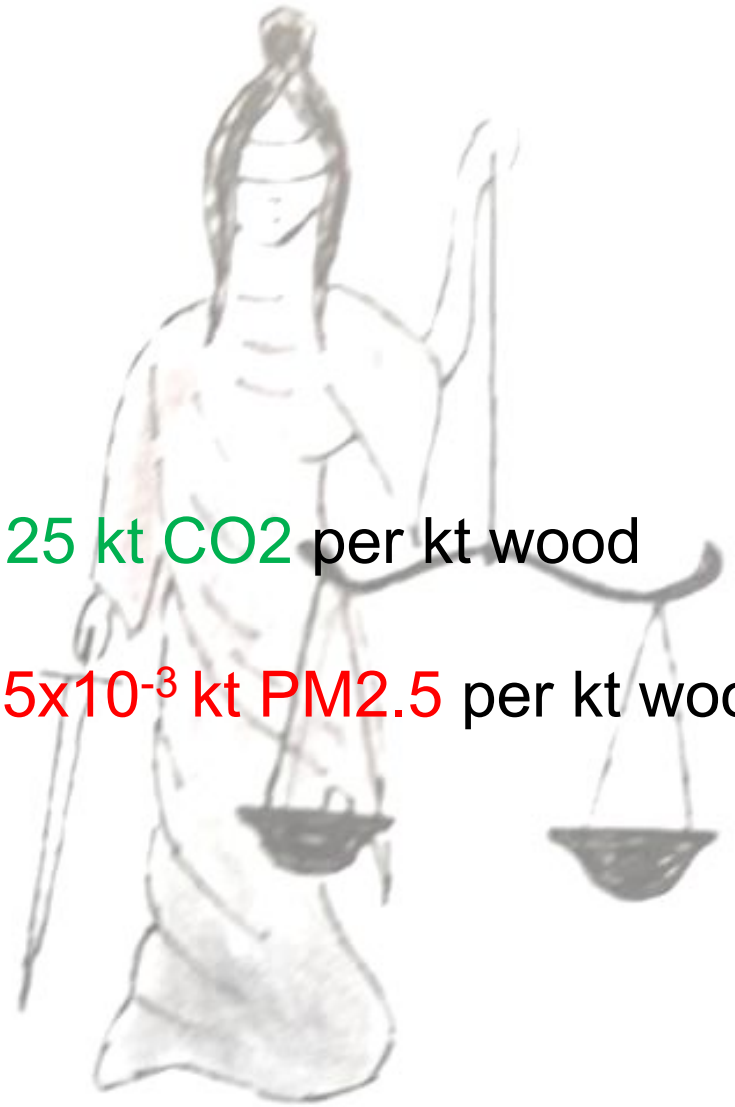
Bernard Fisher University of Hertfordshire
beafisher@cantab.net

Burning hydrogen in a CCGT instead of methane



-316 kt CO2e + 0.34 kt NOx per TWh

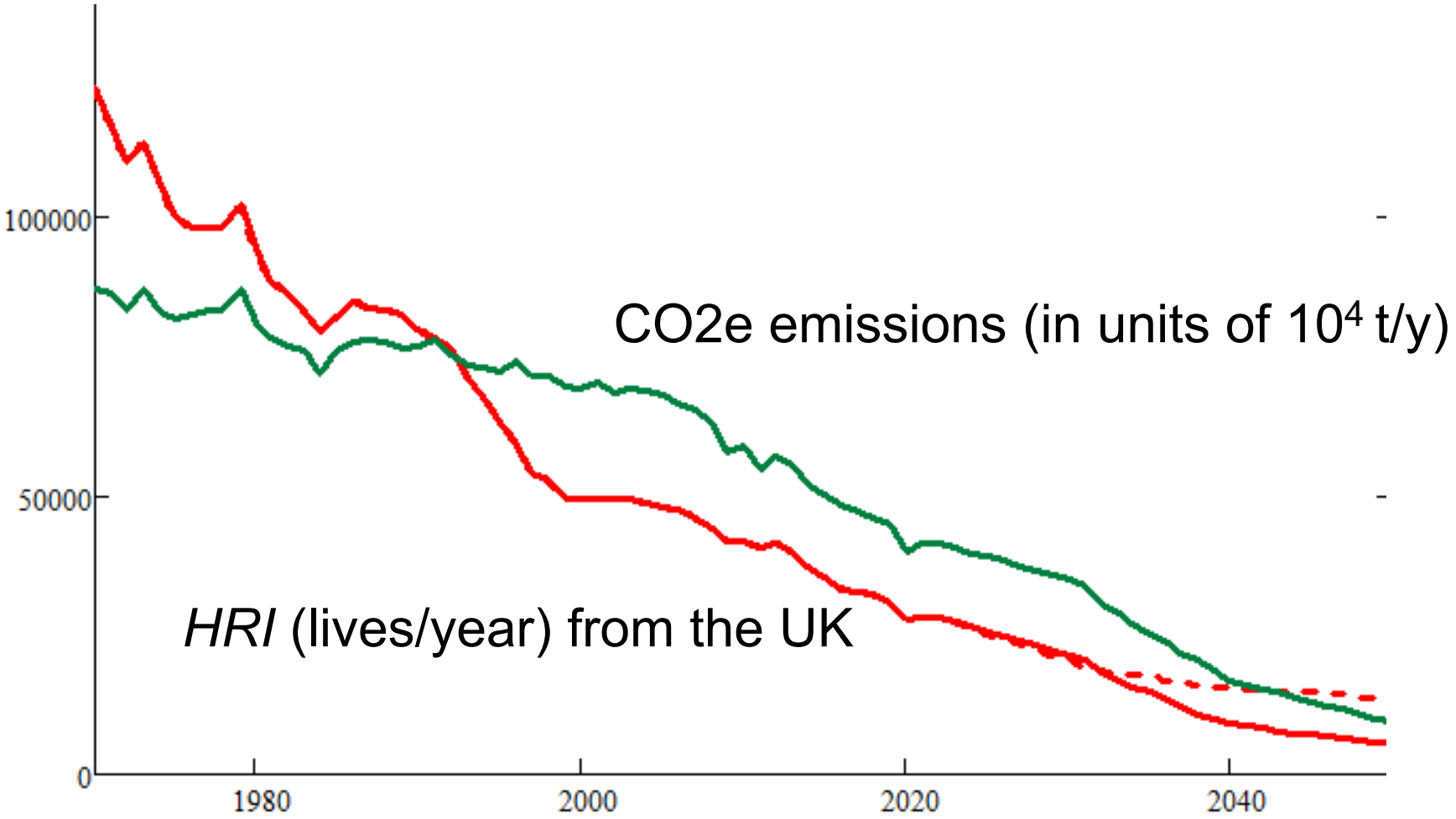
Burning wood in stoves



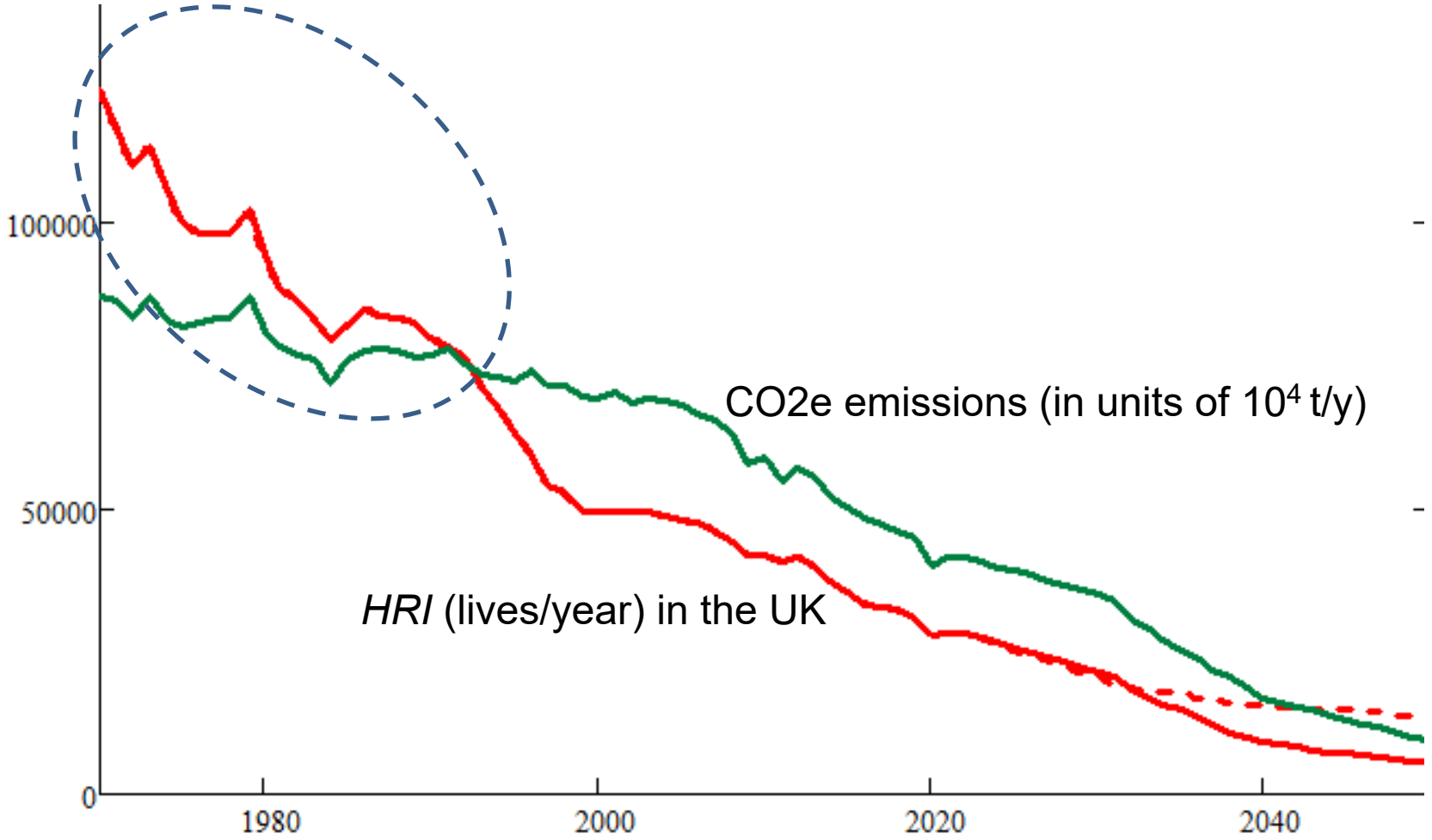
-1.25 kt CO_2 per kt wood

6.75×10^{-3} kt $PM_{2.5}$ per kt wood

UK Health Risk Impact and Greenhouse Gas Emissions 1970 to 2050



UK *HRI* and GHG emissions 1970 to 1990



UK *HRI* and GHG emissions 2024 to 2050

100000

50000

0

1980

2000

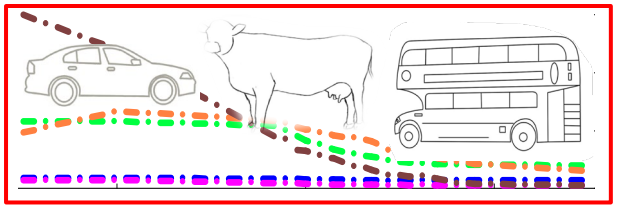
2020

2040

CO2e emissions (in units of 10^4 t/y)

HRI (lives/year) in the UK

Health Risk Impact (lives/year) in UK



Annual mortality

$PM_{2.5}$ concentration

$$HRI_{UK} = k_{DR} k_{PM25} \iint \rho_{popn}(x,y) PM25_{UK}(x,y) dxdy$$

Concentration response function

Population density

EMEP Report 1/2005
Date: August 2005

EMEP/MSC-W:

Leonor Tarrasón, Anna Benedictow, Hilde Fagerli
Jan Eiof Jonson, Heiko Klein, Maarten van Loon
David Simpson, Svetlana Tsyro, Vigdis Vestreng
and Peter Wind

Table B.9: Average 2010 country-to-country blame matrices for **PM2.5**.
Units: ng/m^3 per 15% emis. red. of SO_x. **Emitters →, Receptors ↓.**

	AL	AM	AT	AZ	BA	BE	BG	BY	CH	CS	CY	CZ	DE	DK	EE	ES	FI	FR	GB	GE	GR	HR	HU	IE	IS	IT	KZ	LT	
AL	20	0	1	0	48	0	65	3	0	47	0	3	5	0	0	3	0	4	1	0	16	5	15	0	0	27	1	0	AL
AM	0	6	0	4	1	0	4	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0	AM
AT	0	0	12	0	8	2	7	3	3	7	0	11	40	0	0	3	0	10	3	0	1	4	13	0	0	20	0	0	AT
AZ	0	1	0	8	1	0	4	2	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	9	0	AZ
BA	2	0	2	0	128	1	27	3	0	50	0	6	10	0	0	3	0												
BE	0	0	1	0	2	57	2	2	1	1	0	5	43	1	0	5	0												
BG	2	0	1	0	22	0	217	7	0	31	0	3	5	0	0	1	0												
BY	0	0	0	0	3	1	7	89	0	3	0	2	5	1	3	0	3												
CH	0	0	2	0	3	3	3	1	14	2	0	3	26	0	0	5	0												
CS	4	0	2	0	54	1	59	4	0	94	0	5	8	0	0	2	0												
CY	1	0	0	0	7	0	35	3	0	6	8	1	2	0	0	1	0												
CZ	0	0	5	0	7	3	7	5	1	7	0	38	50	1	0	2	1												
DE	0	0	2	0	3	9	3	4	2	2	0	11	85	1	0	3	1												
DK	0	0	0	0	2	3	2	6	0	1	0	2	19	5	1	1	1												
EE	0	0	0	0	1	1	3	24	0	1	0	1	4	1	13	0	8	1	4	0	0	0	2	0	0	0	2	3	EE
ES	0	0	0	0	3	1	2	0	0	1	0	1	2	0	0	71	0	11	3	0	0	1	2	0	0	5	0	0	ES
FI	0	0	0	0	0	0	1	8	0	0	0	0	2	0	4	0	13	1	2	0	0	0	1	0	0	0	1	1	FI
FR	0	0	1	0	3	6	2	1	1	2	0	2	16	0	0	15	0	50	11	0	0	1	3	1	0	8	0	0	FR
GB	0	0	0	0	1	3	1	1	0	0	0	1	8	0	0	3	0	9	52	0	0	0	1	4	0	1	0	0	GB
GE	0	1	0	4	1	0	7	3	0	1	0	0	1	0	0	0	0	0	0	4	1	0	1	0	0	0	4	0	GE
GL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	GL
GR	5	0	1	0	24	0	140	5	0	23	0	3	4	0	0	3	0	3	1	0	33	3	12	0	0	18	1	0	GR
HR	1	0	4	0	62	1	24	4	1	36	0	9	16	0	0	4	0	7	2	0	3	28	32	0	0	27	1	0	HR

METEOROLOGISK INSTITUTT
Norwegian Meteorological Institute

Transboundary Acidification, Eutrophication and Ground Level Ozone in Europe in 2003

Obtain *HRI* from the Unit Health Risk Impact *UHRI*

The *UHRI* is defined as the number of premature deaths from PM2.5 in a year,

from the emission of 1000 tonnes of each type of primary species (NH3, NMVOC, NOx, PM2.5 or SOx)

distributed around the UK in proportion to the country's national emissions.

Change in exported *HRI* is a linear function of change in UK emissions

$$\Delta HRI_{UK} = [UHRI_{UK,NH3}\,\Delta Q_{NH3_{UK}} + UHRI_{UK,NMVOC}\,\Delta Q_{NMVOC_{UK}} + UHRI_{UK,NOx}\,\Delta Q_{NOx_{UK}} + UHRI_{UK,PPM}\,\Delta Q_{PPM2.5_{UK}} + UHRI_{UK,NH3}\,\Delta Q_{SOx_{UK}}]$$

Typical values of the Unit Health Risk Impact

Order of magnitude of *UHRI*'s

$UHRI_{NMVOC} < UHRI_{NOx} < UHRI_{SOx} < UHRI_{NH3} < UHRI_{PPM2.5}$

plus $UHRI_{PPM2.5local}$ and $UHRI_{NO2}$ contributions

For 2030 to 2050

$UHRI_{NH3}$=26.9, $UHRI_{NMVOC}$=1.5, $UHRI_{NOx}$=9.6, $UHRI_{NO2}$=12, $UHRI_{PPM2.5}$=63.7, $UHRI_{PPM2.5local}$=21.3 and $UHRI_{SOx}$=26.2

(lives/year/kilotonne)

UK Unit Health Risk Impacts similar to damage costs

Pollutant emitted	2023 Damage costs (£/t) national averages latest figures
NOx	8,148
SO2	16,616
NH3	9,667
VOC	172
PM2.5	74,769

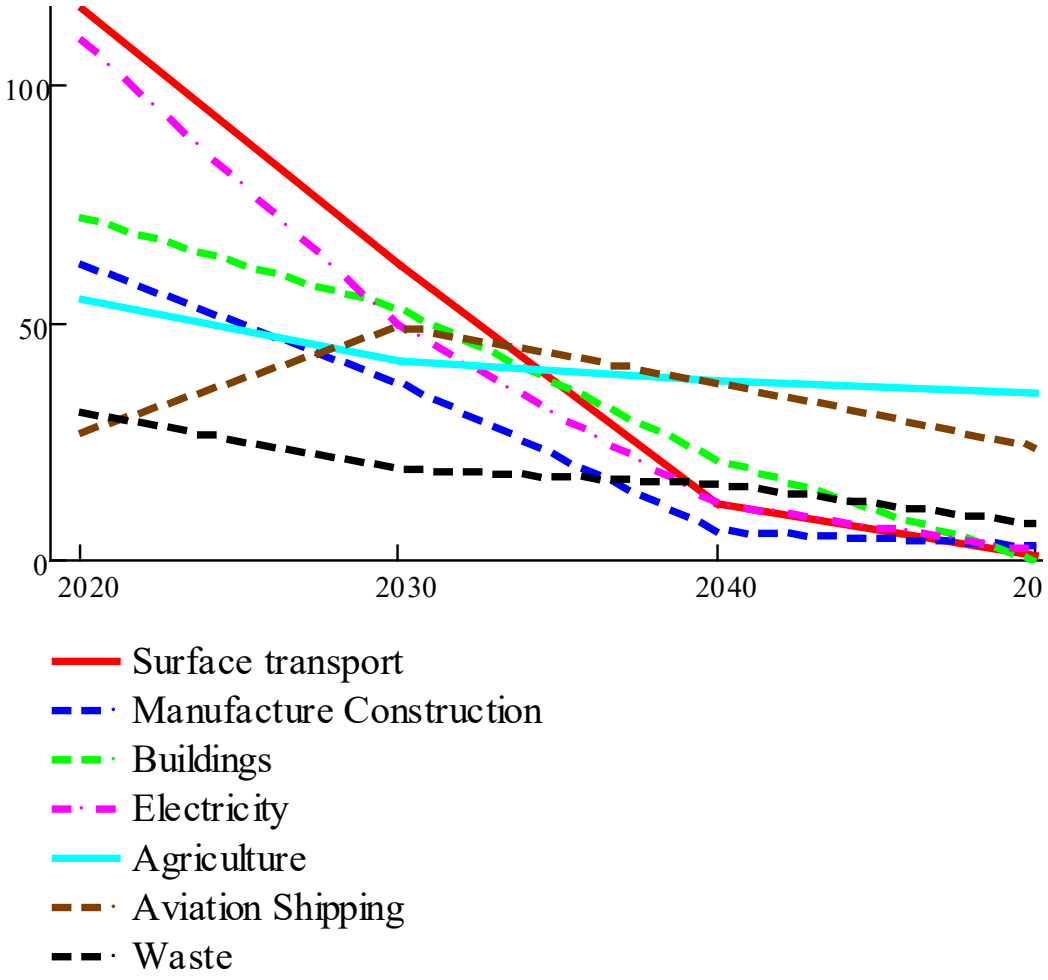
But we are **not** doing a cost-benefit analysis

Approximate exported Health Risk Impact is a linear function of UK emissions

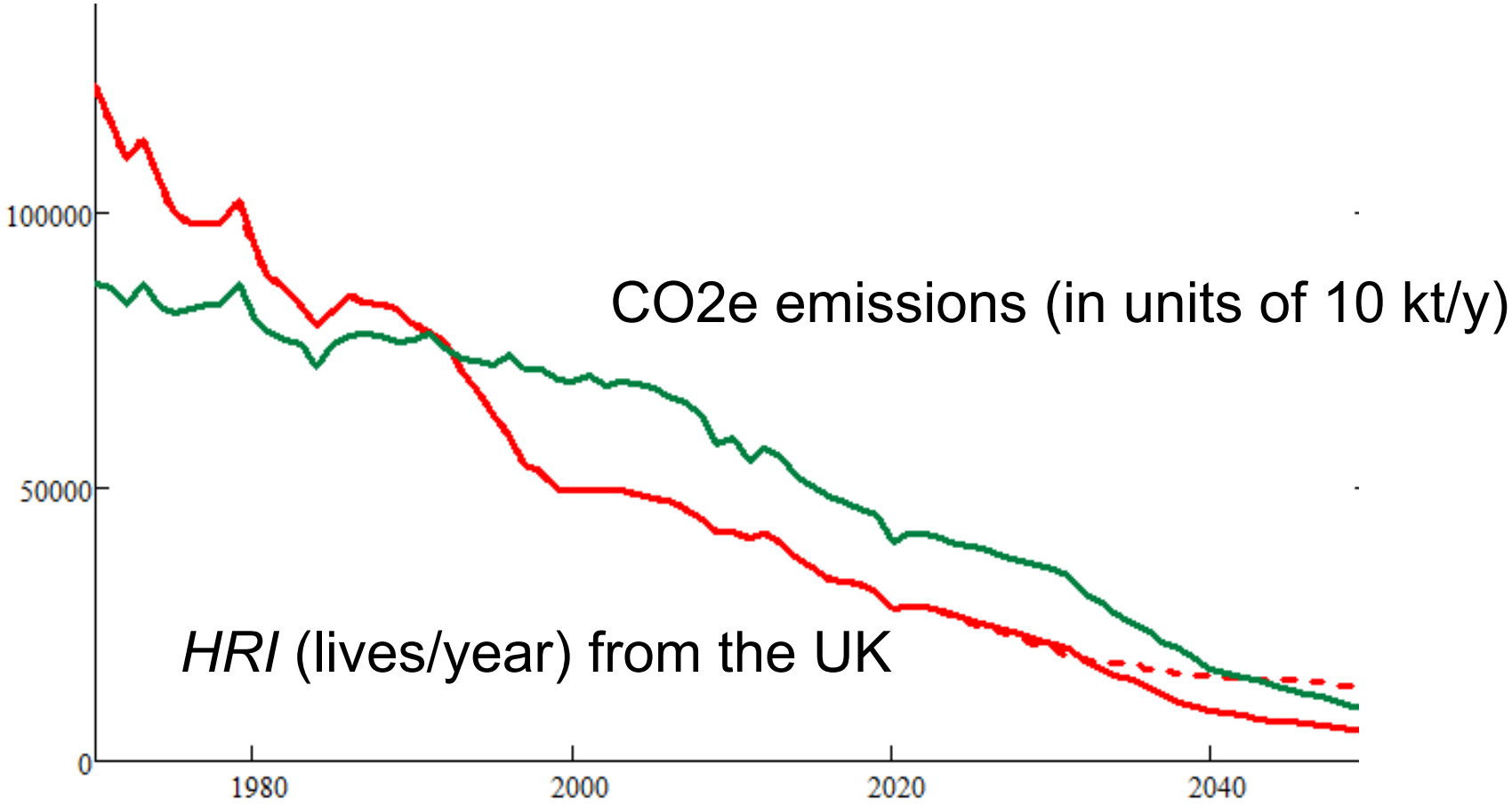
$$HRI_{UK} = [UHRI_{UK,NH3}\, Q_{NH3_{UK}} + UHRI_{UK,NMVOC}\, Q_{NMVOC_{UK}} + UHRI_{UK,NOx}\, Q_{NOx_{UK}} + UHRI_{UK,PPM}\, Q_{PPM2.5_{UK}} + UHRI_{UK,NH3} Q_{SOx_{UK}}]$$

Future air pollution emissions from GHG emissions by economic sector

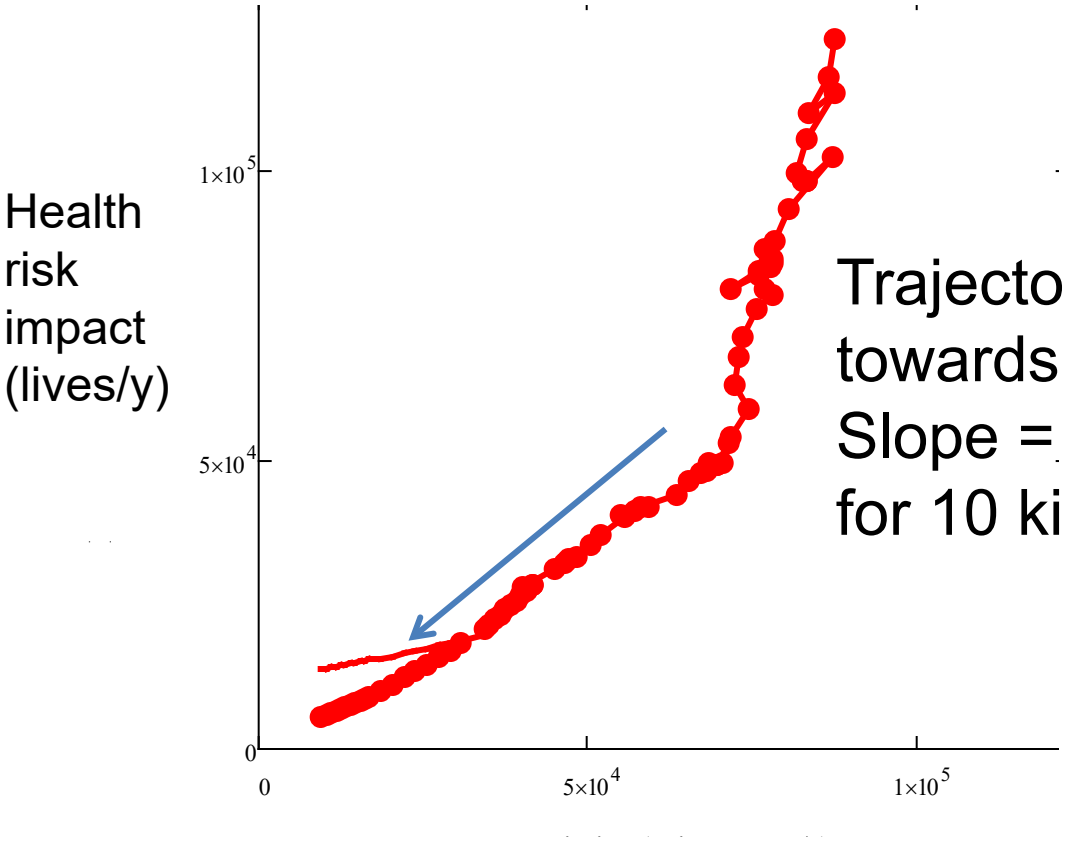
CO2e emissions by sector



UK Health Risk Impact and Greenhouse Gas Emissions 1970 to 2050 (CO_2e 10 kt/y)



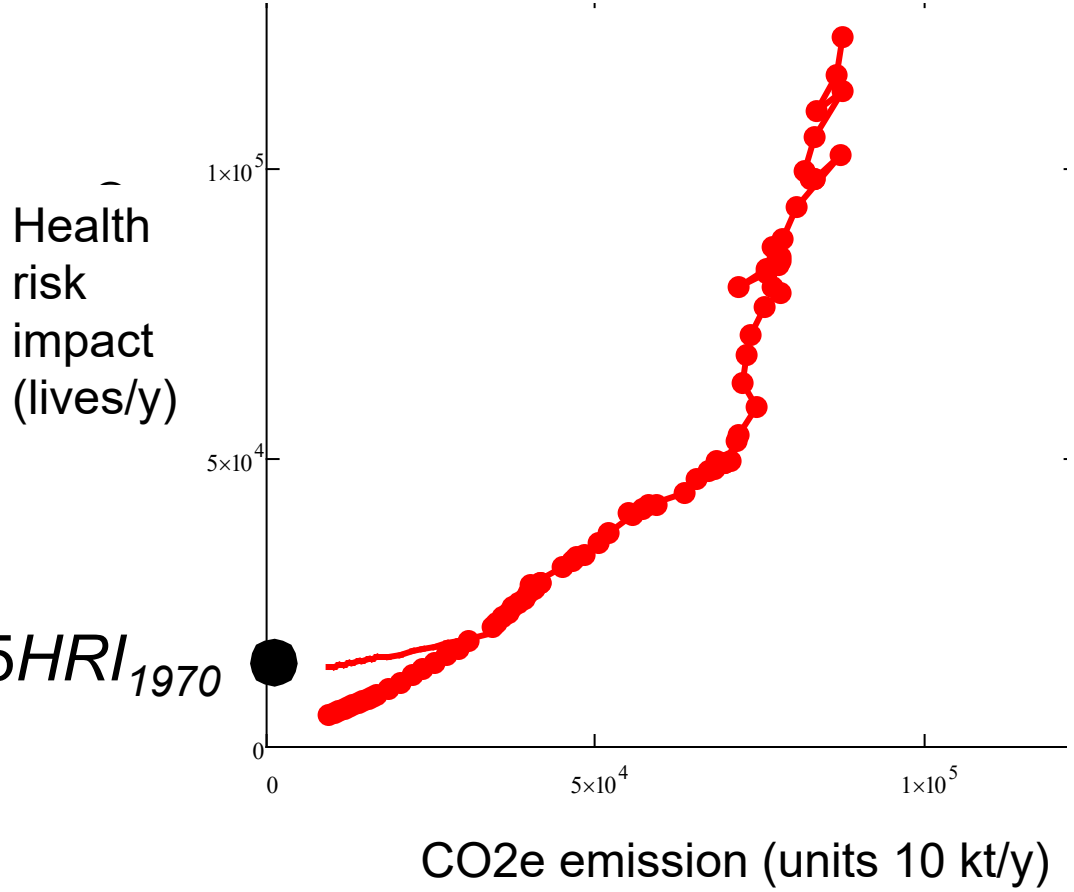
Comparison of UK *HR*I v GHG 1970 to 2050



Trajectory towards zero
Slope = 1 attributable life for 10 kilotonnes CO2e

Target in 2050 for *HRI* and GHG emissions

$HRI_{2050} = 0.15 HRI_{1970}$



Sum Damage from Health Risk Impact and Greenhouse Gas Emissions

Set a target weighting on GHG's

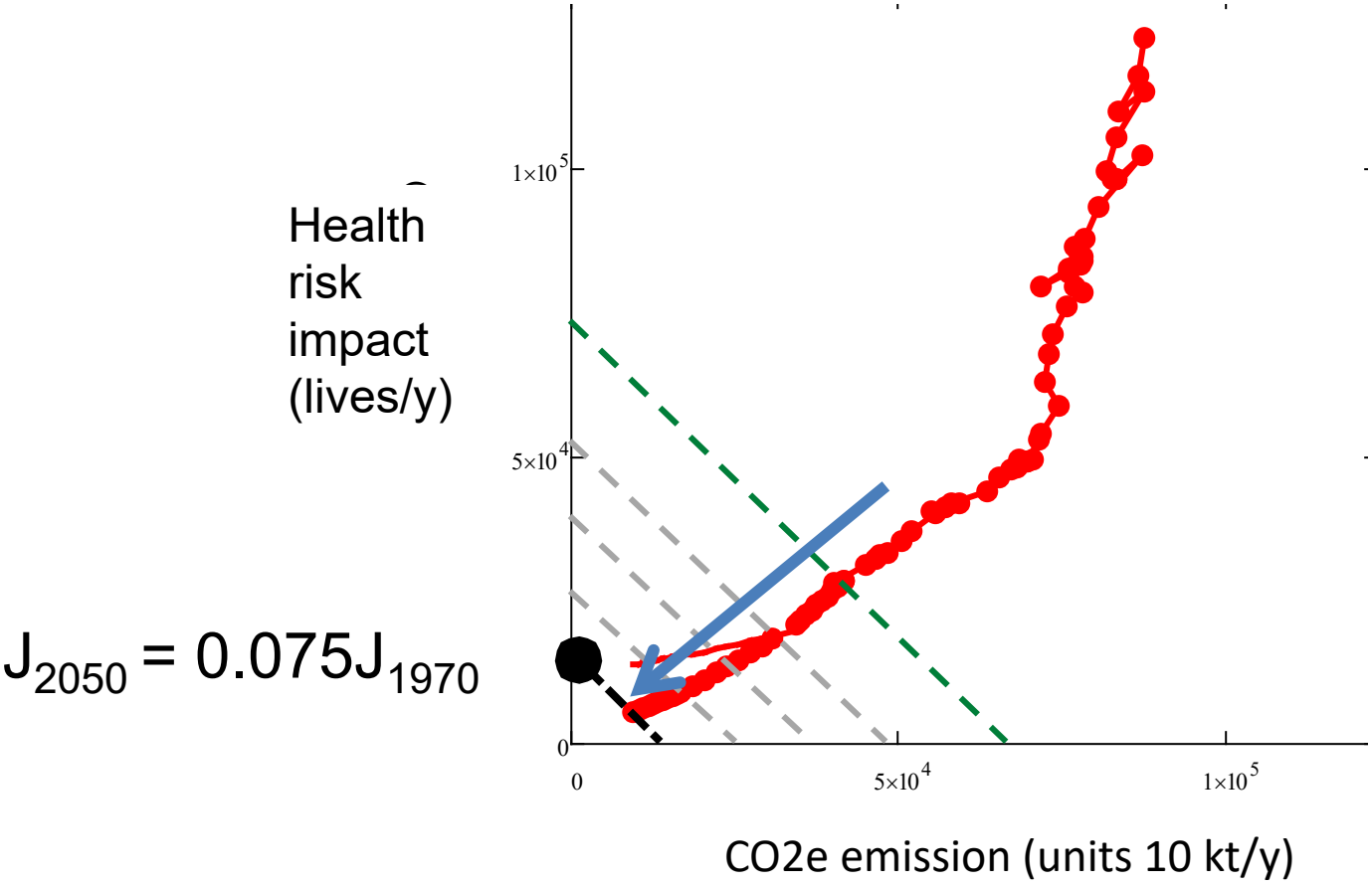
$UHRI^*_{CO2e}$=1/10 (lives*/kt CO2e)

and the **sum** of GHG and *HRI* damage is

$\boldsymbol{J} = [Q_{CO2e}/10 + UHRI_{NH3}\, Q_{NH3} + UHRI_{NMVOC}\, Q_{NMVOC} +$ …..similar terms*]*

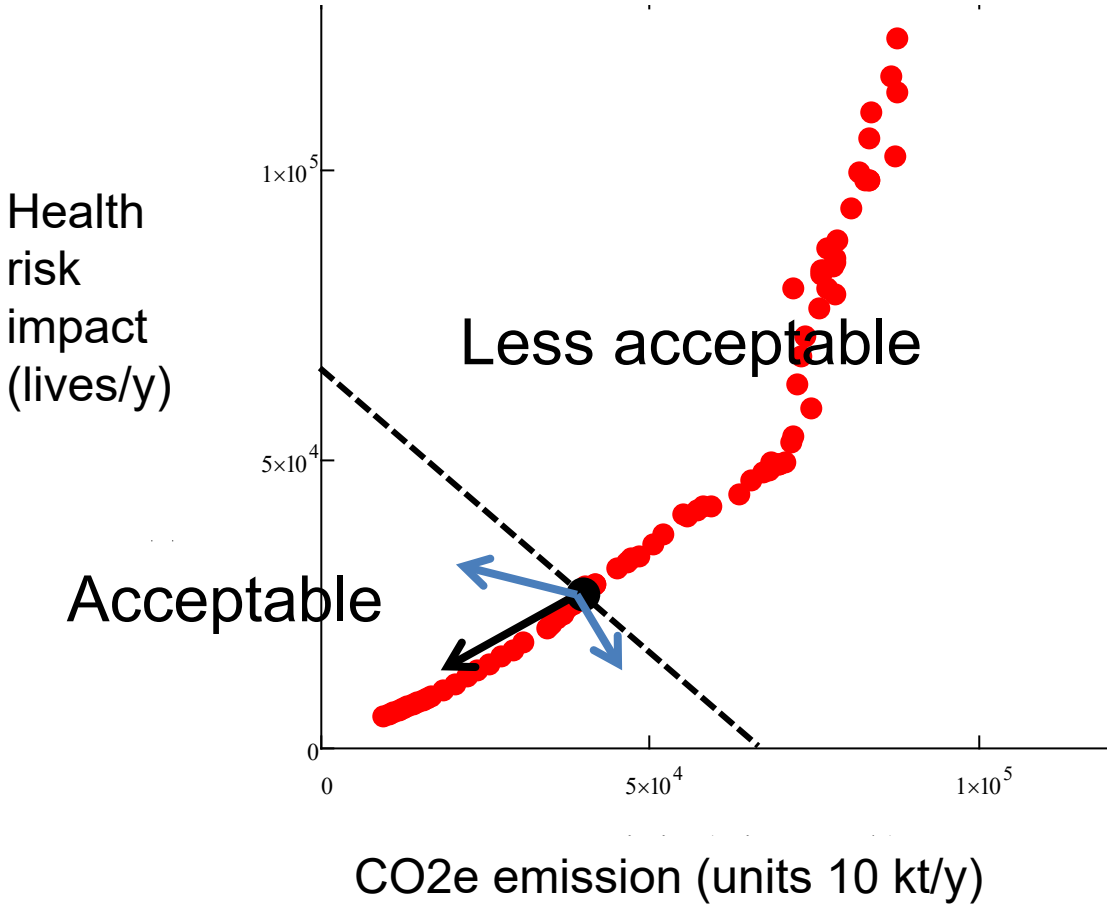
or $\boldsymbol{J} = [Q_{CO2e}/10 + HRI]$

Lines of equal damage from sum of GHG emissions and *HRI* 2020 to 2050

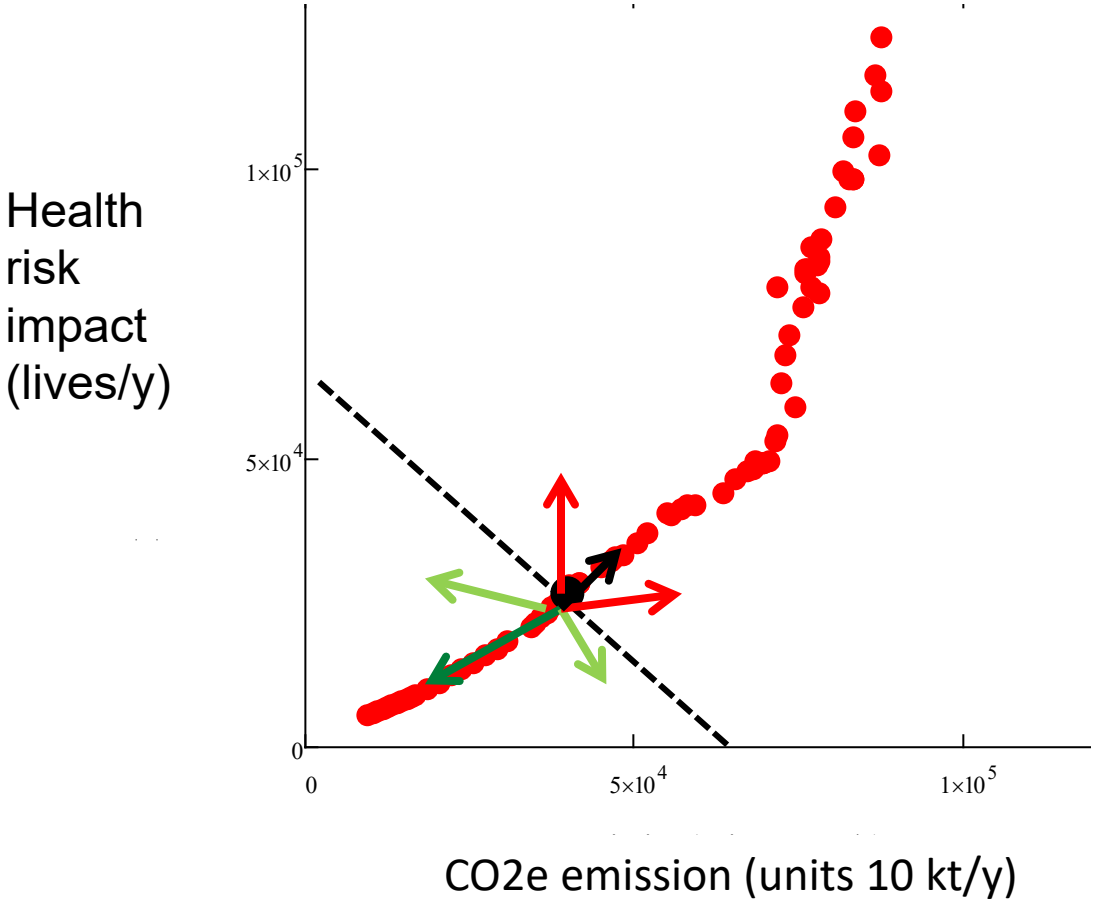


$J_{2050} = 0.075 J_{1970}$

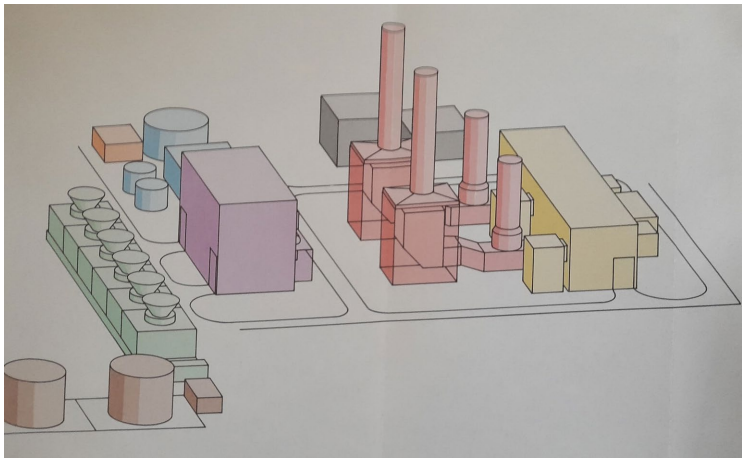
Acceptable policies as one moves forward from the present

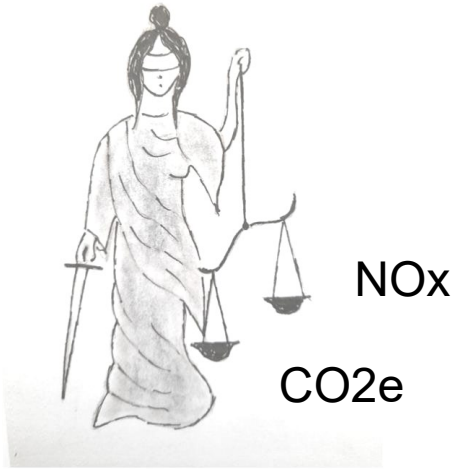


Good and bad pathways for new developments from 2024



Change in joint damage H2 burning in CCGT

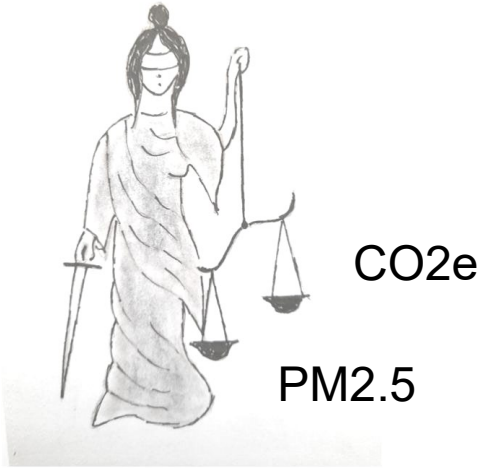




Assuming $UHRI^*_{CO2e}$=0.1 lives per kt CO2e and $UHRI_{NOx}$=15.377 lives per kt NOx

ΔJ = – 0.1 x 316 +15.377 x 0.343 = -26 lives per year per TWh or 300MW CCGT unit, so acceptable

Assessment of wood burning in stoves current standard



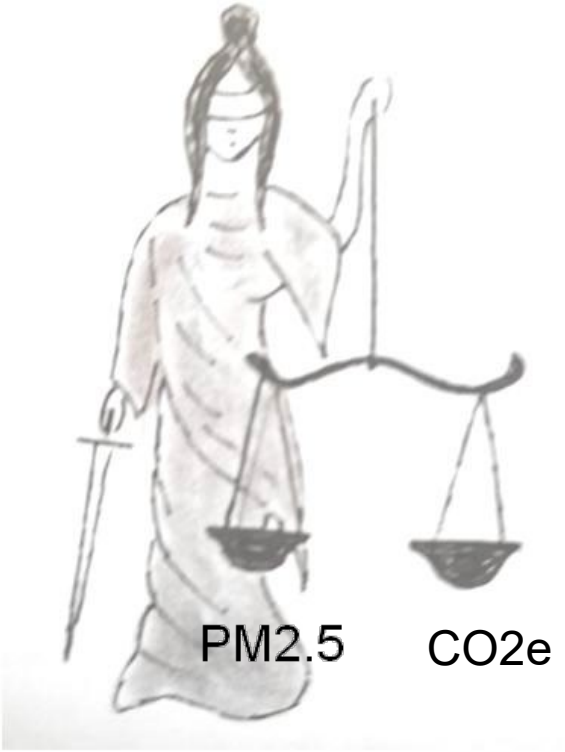
Assuming $UHRI_{PM2.5}$ = 75.4 lives per kt PM2.5,

the joint damage is the sum of the $\Delta QCO2e$ decrease and the $\Delta PM2.5$ increase

ΔJ = - 0.1 x 1.25 + 75.4 x 0.00675 = +0.38 lives/kt wood

So unacceptable

Assessment of wood burning in stoves with tighter standard



The PM2.5 dis-benefit may be lower with a tighter 40% stove standard, then

the joint damage ΔJ = +0.08 lives/kt wood - almost acceptable

How can policy maker judge between air quality and greenhouse gas emissions?

If in the EU-27 in 2020, the number of lives lost from air pollution = 200,000 = $2x10^5$ and the GHG emissions = $3x10^6$ kilotonnes CO2e then the joint damage condition is

$$\Delta J_{EU27} = \Delta Q_{CO2e} / 15 + \Delta HRI < 0$$

For the UK the condition is

$$\Delta J = \Delta Q_{CO2e} / 10 + UHRI_{NH3}\, Q_{NH3} + UHRI_{NMVOC}\, Q_{NMVOC} \ldots < 0$$