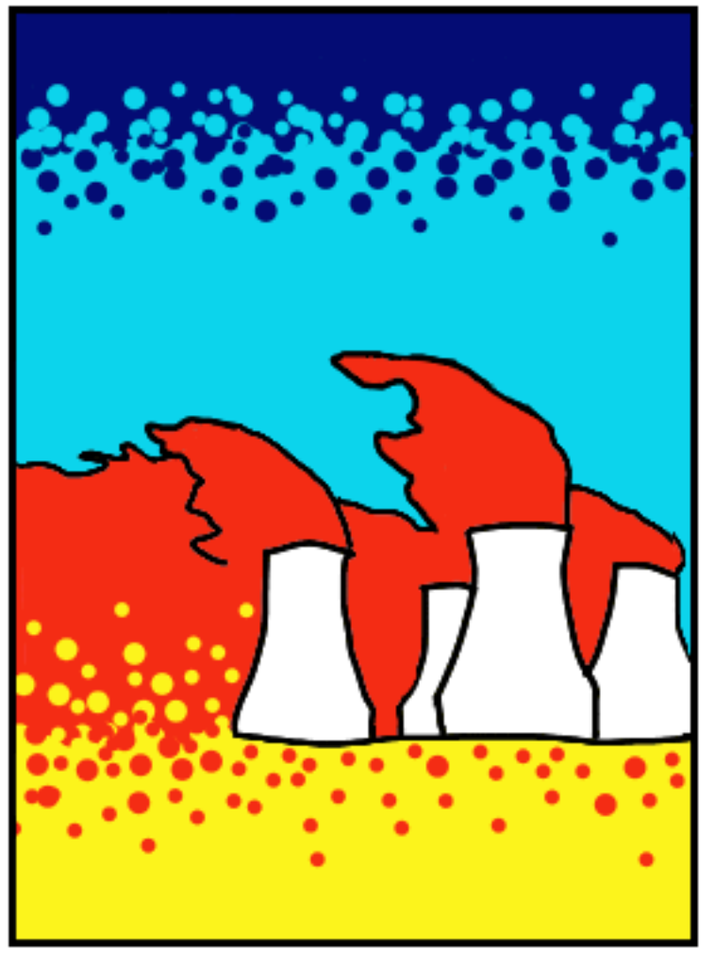
BRE, September 2008

Sustainable Energy

- without the hot air



David MacKay

Department of Physics
University of Cambridge

www.withouthotair.com

Questions about sustainable energy

- Can we live on our own renewables?
  - What would that look like?
- How can we make a sustainable energy plan that adds up?

- We need to get off fossil fuels
  - Numbers, not adjectives
  - Not easy; but possible
- All renewables are diffuse
  - to make a difference, renewable facilities have to be country-sized
- The supply options are:
  - our renewables
  - other countries' renewables
  - nuclear

We have an addiction to fossil fuels, and it's not sustainable

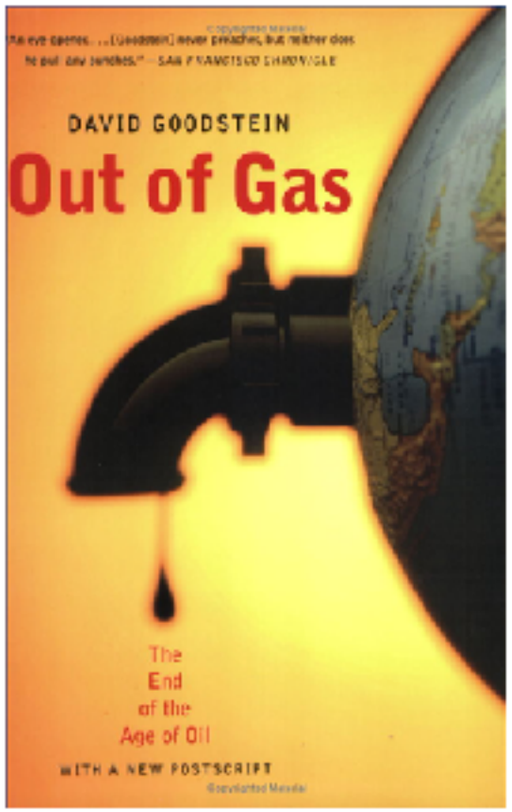


Photo by Terry Cavner

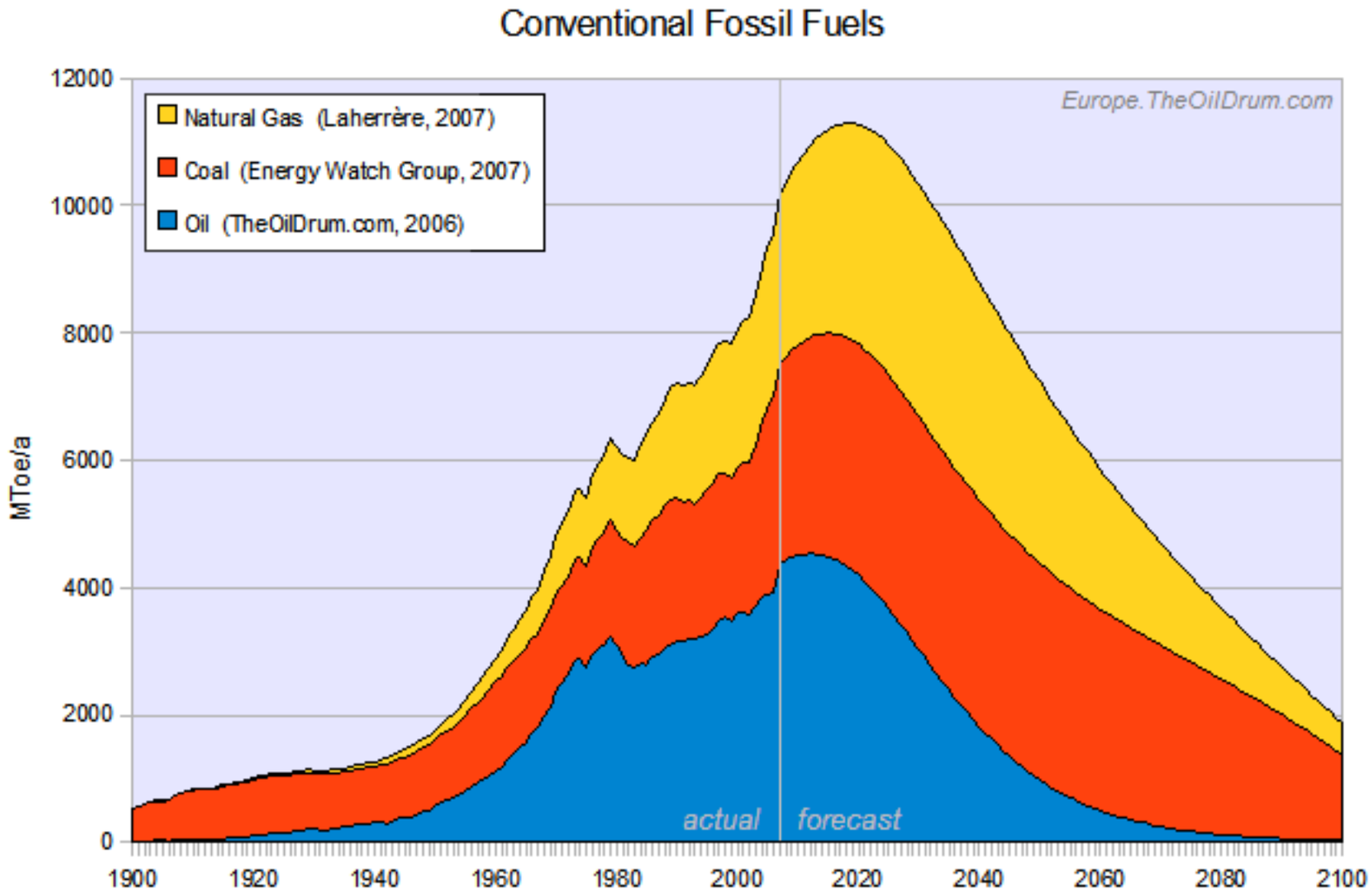
"An eye-opener. . . . [Goodstein] never preaches, but neither does he pull any punches." —*SAN FRANCISCO CHRONICLE*

DAVID GOODSTEIN

Out of Gas

The End of the Age of Oil

WITH A NEW POSTSCRIPT



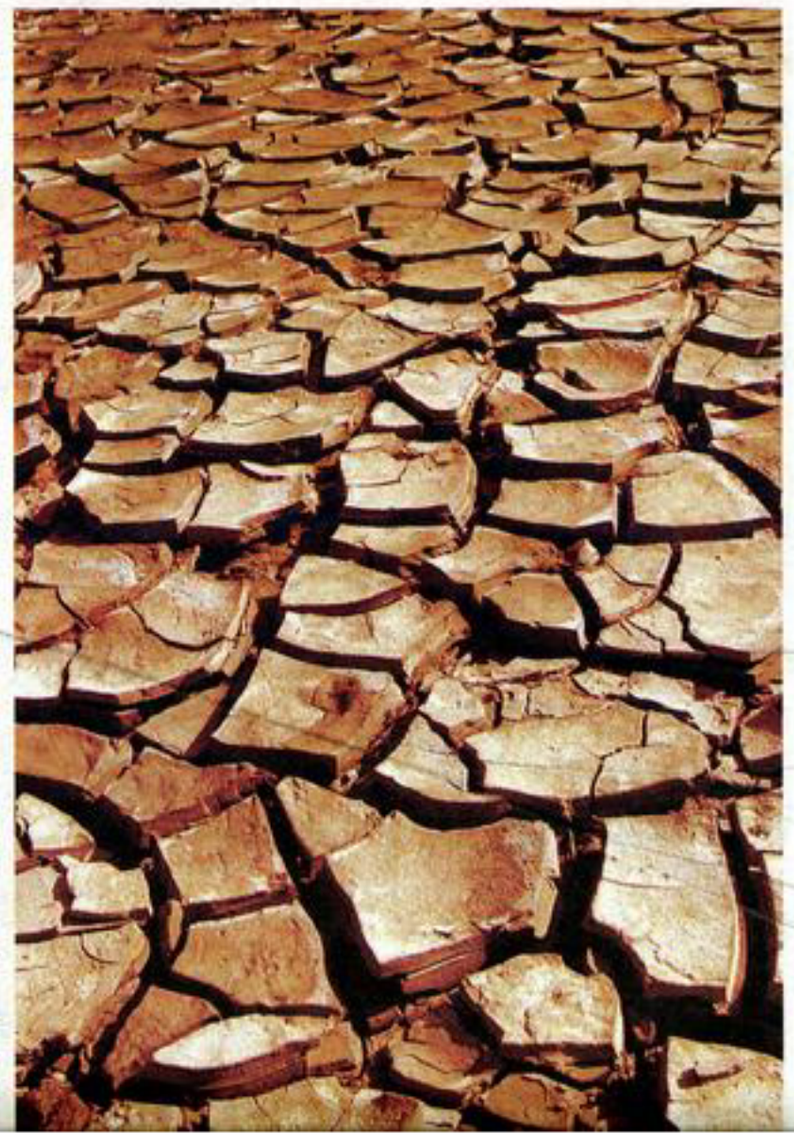
Newspaper of the Year

THE INDEPENDENT

No 5,700 www.independent.co.uk MONDAY 24 JANUARY 2005 ★ (Republic of Ireland €0.95) 60p

Climate change: report warns point of no return may be reached in 10 years, leading to droughts, agricultural failure and water shortages

Countdown to global catastrophe



By Michael McCarthy
Environment Editor

THE GLOBAL warming danger threshold for the world is clearly marked for the first time in an international report to be published tomorrow – and the bad news is, the world has nearly reached it already.

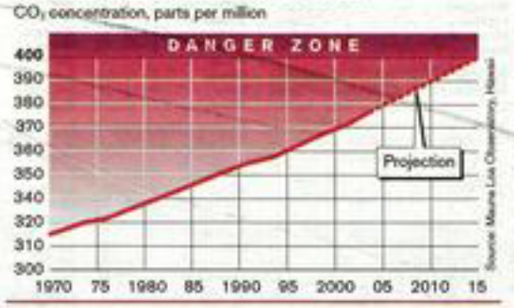
The countdown to climate-change catastrophe is spelt out by a task force of senior politicians, business leaders and academics from around the world – and it is remarkably brief. In as little as 10 years, or even less, their report indicates, the point of no return with global warming may have been reached.

The report, *Meeting The Climate Challenge*, is aimed at policymakers in every country, from national leaders down. It has been timed to coincide with Tony Blair's promised efforts to advance climate change policy in 2005 as chairman of both the G8 group of rich countries and the European Union.

And it breaks new ground by putting a figure – for the first time in such a high-level docu-

ATMOSPHERIC CARBON DIOXIDE

CO_2 concentration, parts per million



changes. These could include widespread agricultural failure, water shortages and major droughts, increased disease, sea-level rise and the death of forests – with the added possibility of abrupt catastrophic events such as "runaway" global warming, the melting of the Greenland ice sheet, or the switching-off of the Gulf Stream.

The report says this point will be two degrees centigrade above the average world temperature prevailing in 1750 before the industrial revolution, to affect the climate. But it points out that global average temperature has already risen by 0.8 degrees since then, with more rises already in the pipeline – so the world has little more than a single degree of temperature latitude before the crucial point is reached.

More ominously still, it assesses the concentration of carbon dioxide in the atmosphere after which the two-degree rise will become inevitable, and says it will be 400 parts per million by volume (ppm) of CO_2.

'Security of supply'

Magnus platform - delivers 5GW; 71,000 tonnes of steel

Photo by Terry Cavner

We have an addiction to fossil fuels, and it's not sustainable

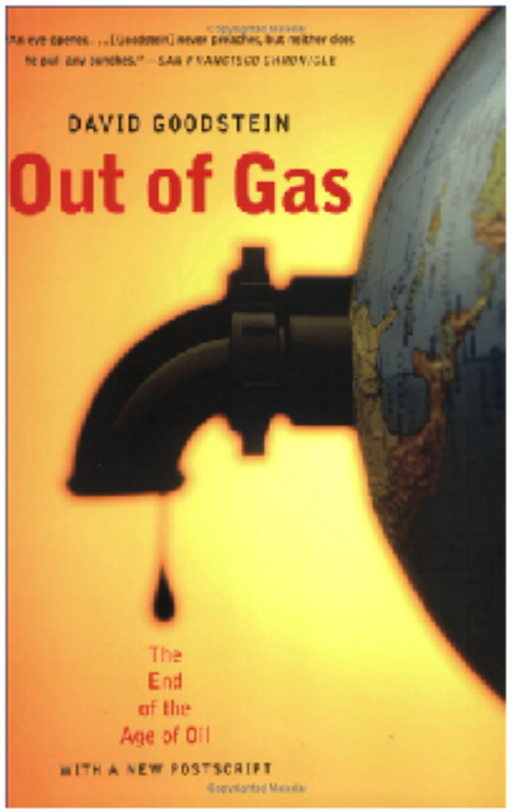


Photo by Terry Cavner

Carbon dioxide concentration (ppm)

400
380
360
340
320
300
280
260

1000 1200 1400 1600 1800 2000

400
380
360
340
320
300
280
260

1960 1970 1980 1990 2000

Sources: Keeling and Whorf (2005); Neftel et al (1994); Etheridge et al (1998); Siegenthaler et al (2005); Indermuhle et al (1999)

Carbon dioxide concentration (ppm)

400
380
360
340
320
300
280
260

1769

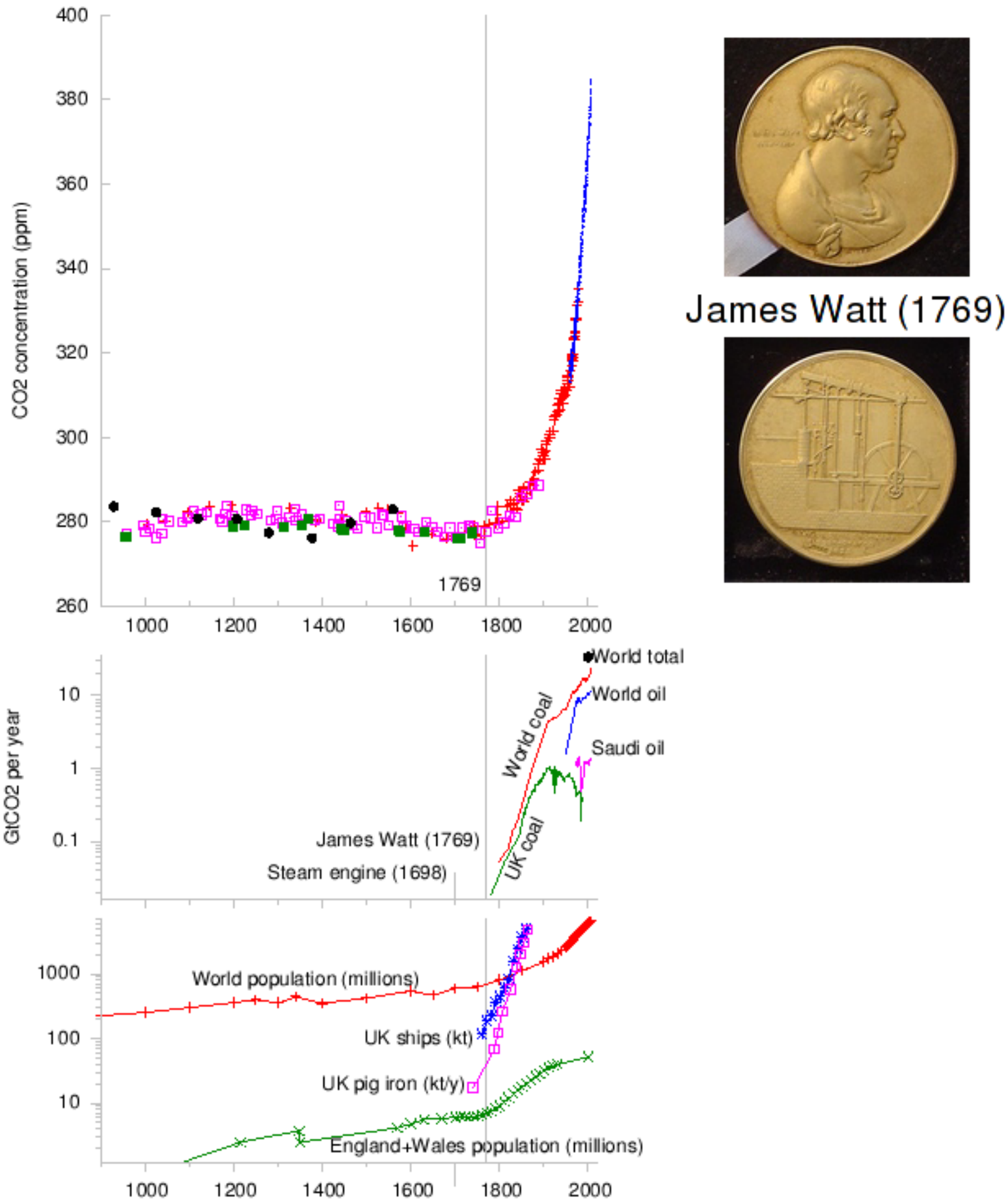
1000 1200 1400 1600 1800 2000

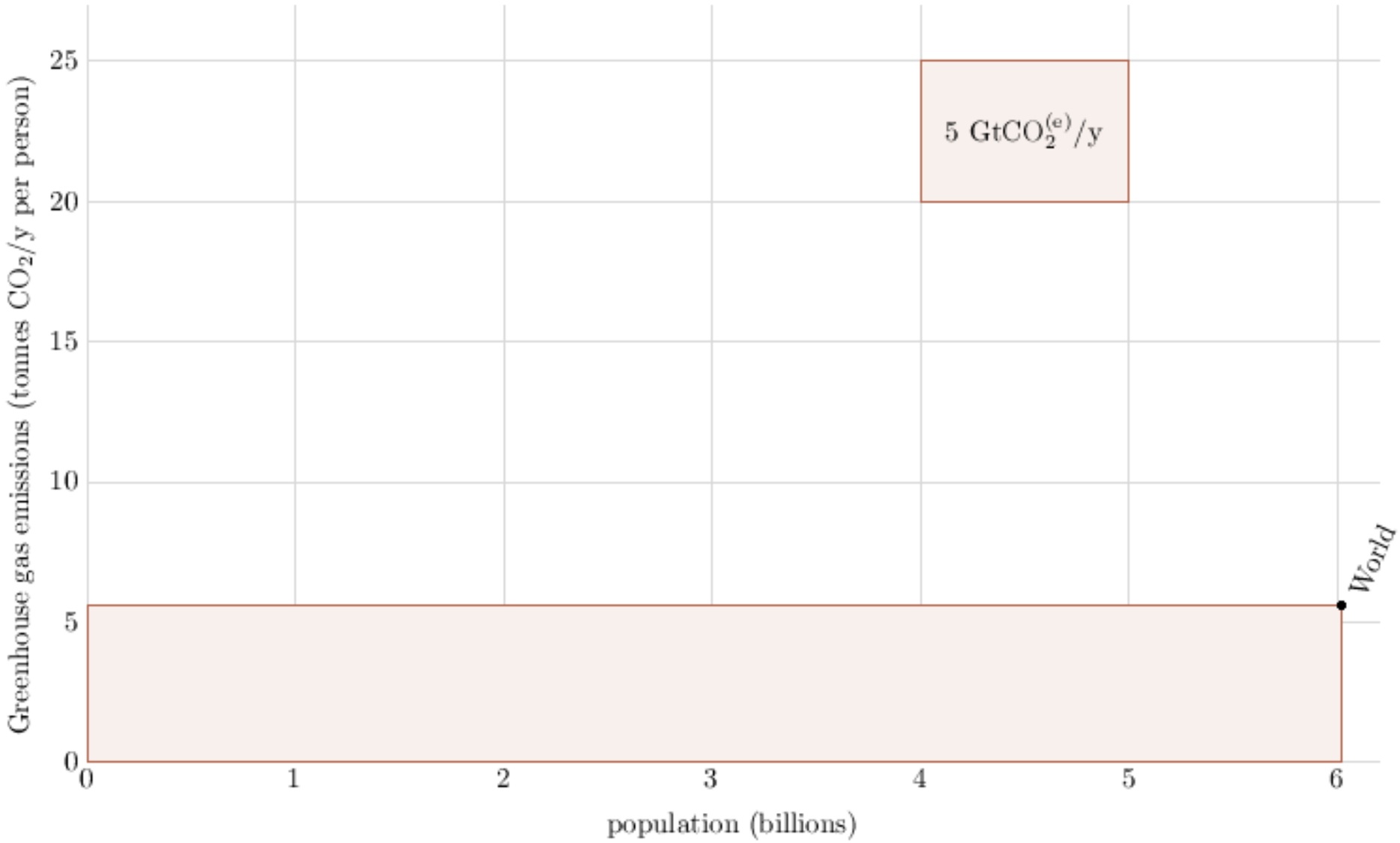
James Watt (1769)

400
380
360
340
320
300
280
260

1960 1970 1980 1990 2000

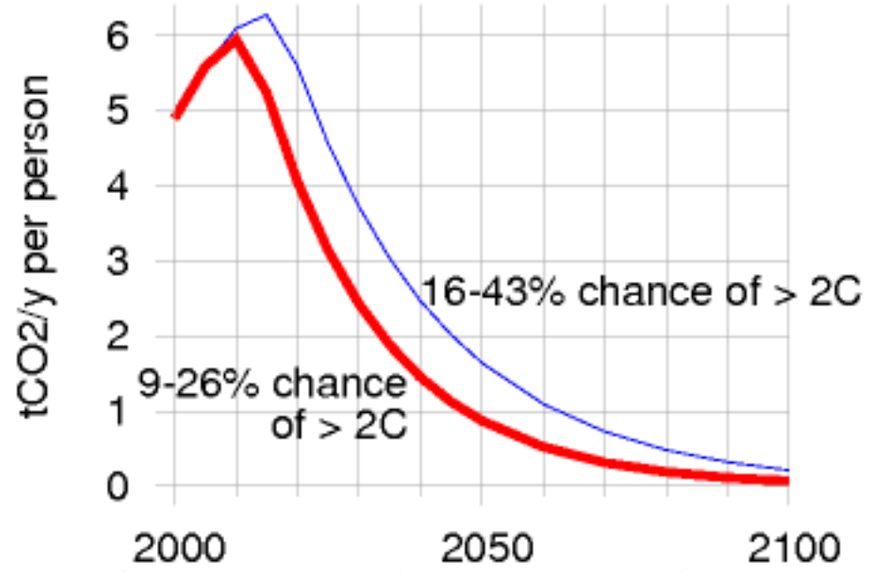
Sources: Keeling and Whorf (2005); Neftel et al (1994); Etheridge et al (1998); Siegenthaler et al (2005); Indermuhle et al (1999)


CO2 concentration (ppm)
400
380
360
340
320
300
280
260
1000
1200
1400
1600
1800
2000
1769
James Watt (1769)
GtCO2 per year
10
1
0.1
World total
World oil
Saudi oil
World coal
UK coal
James Watt (1769)
Steam engine (1698)
1000
100
10
World population (millions)
UK ships (kt)
UK pig iron (kt/y)
England+Wales population (millions)
1000
1200
1400
1600
1800
2000

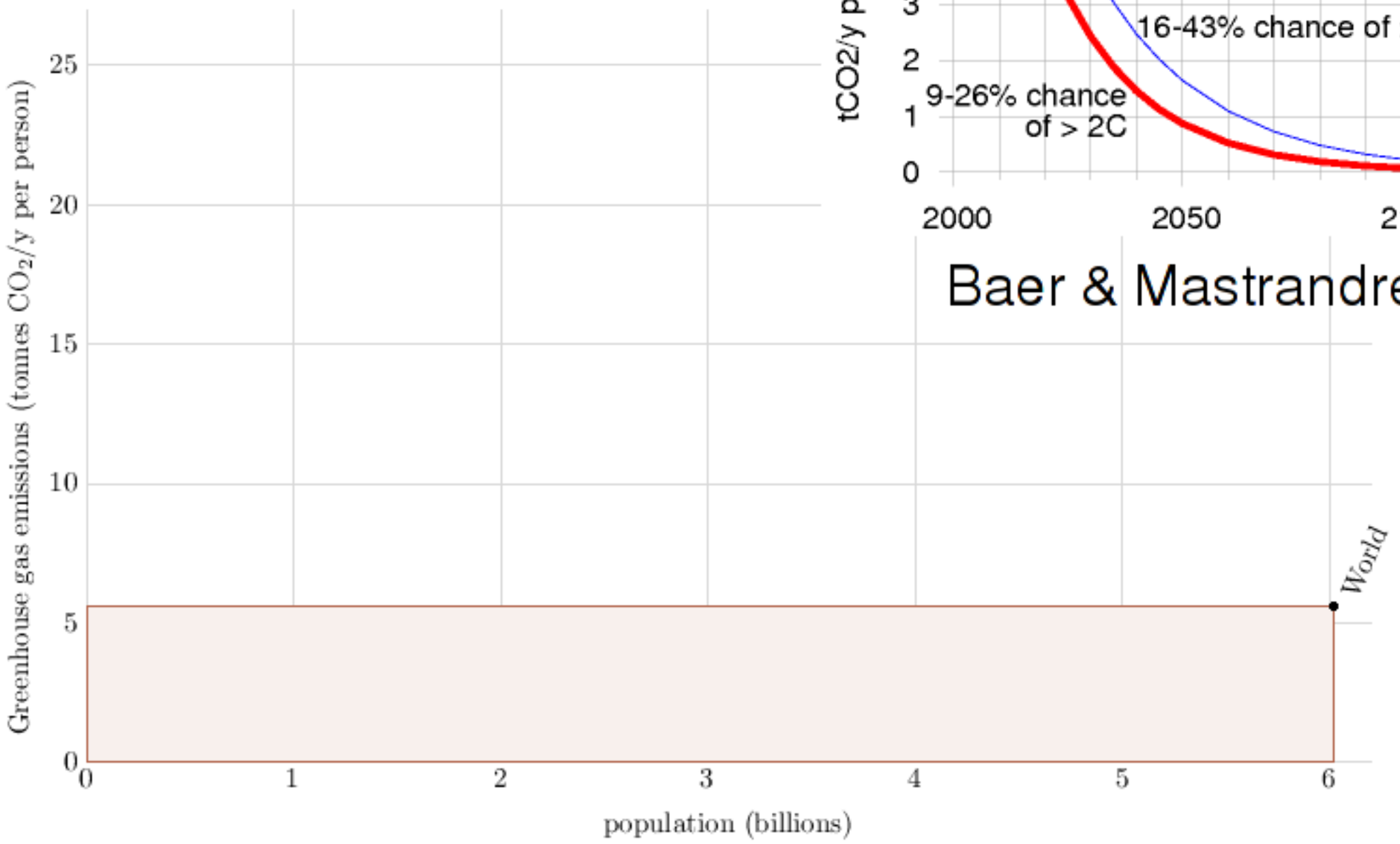


Total GHG emissions (2000) = 34 $GtCO_2^{(e)}$

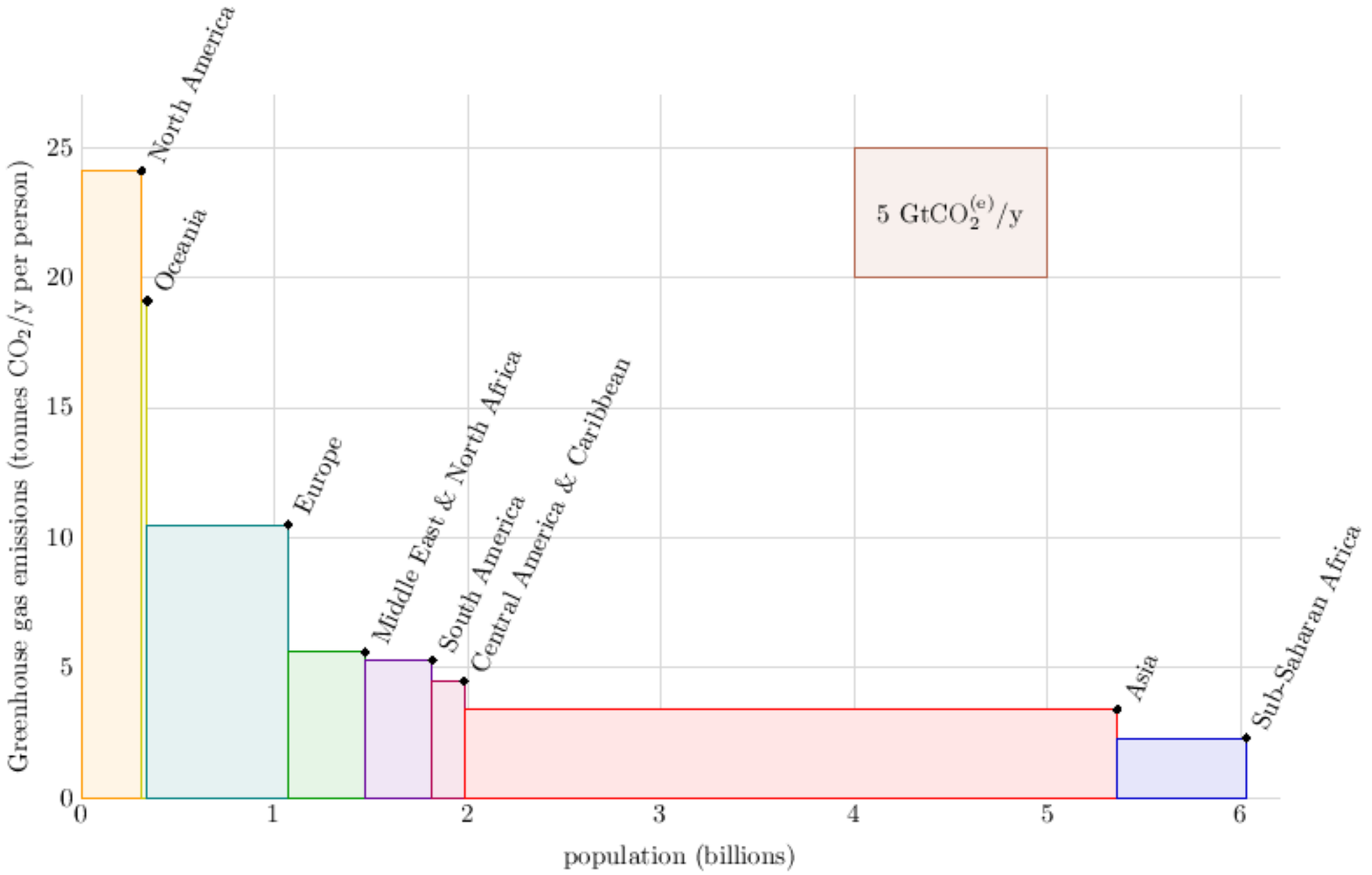
What's required:



Baer & Mastrandrea

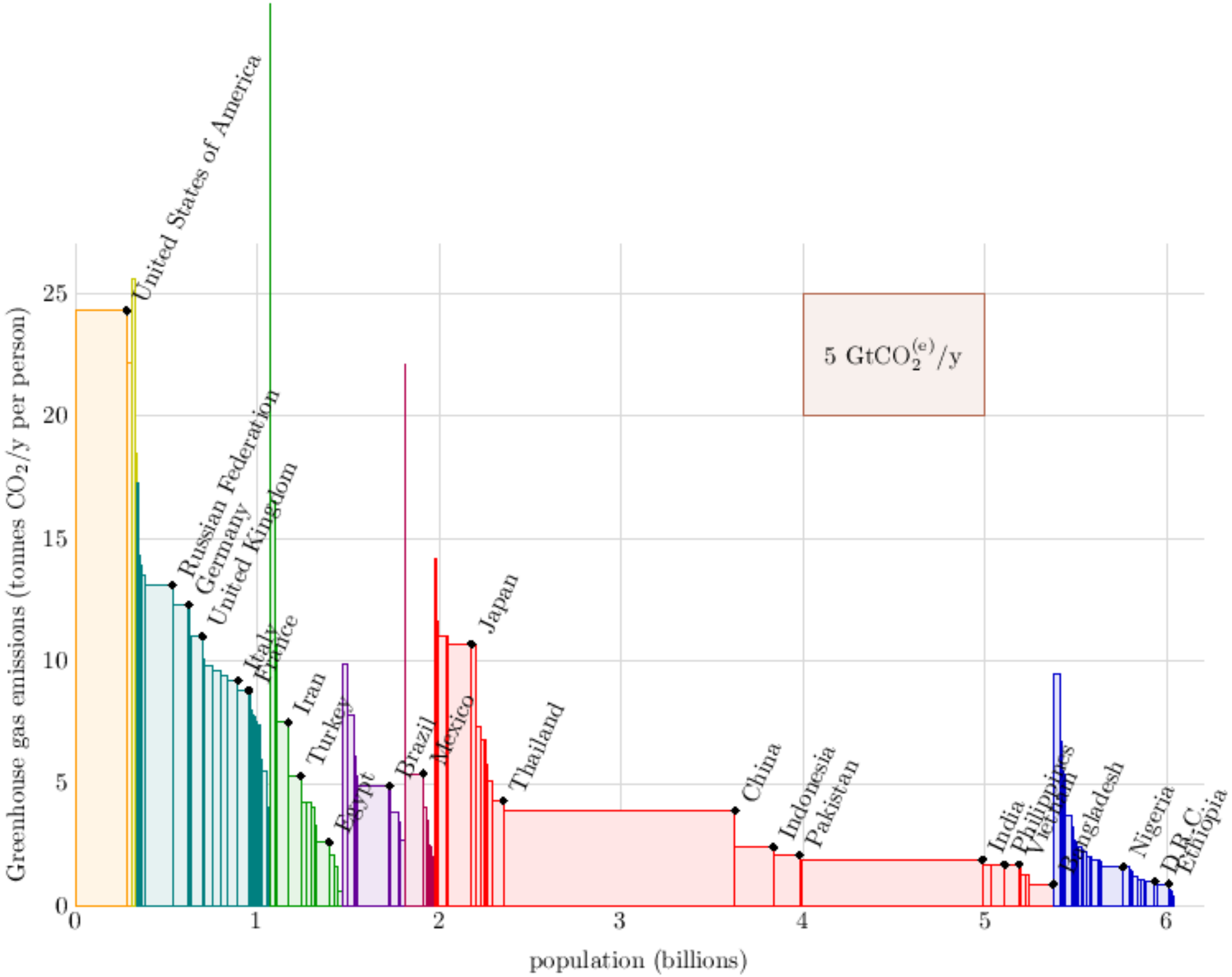


Total GHG emissions (2000) = $34\,\mathrm{GtCO_2^{(e)}}$



$$\text{Total GHG emissions } (2000) = 34\,\text{GtCO}_2^{(e)}$$

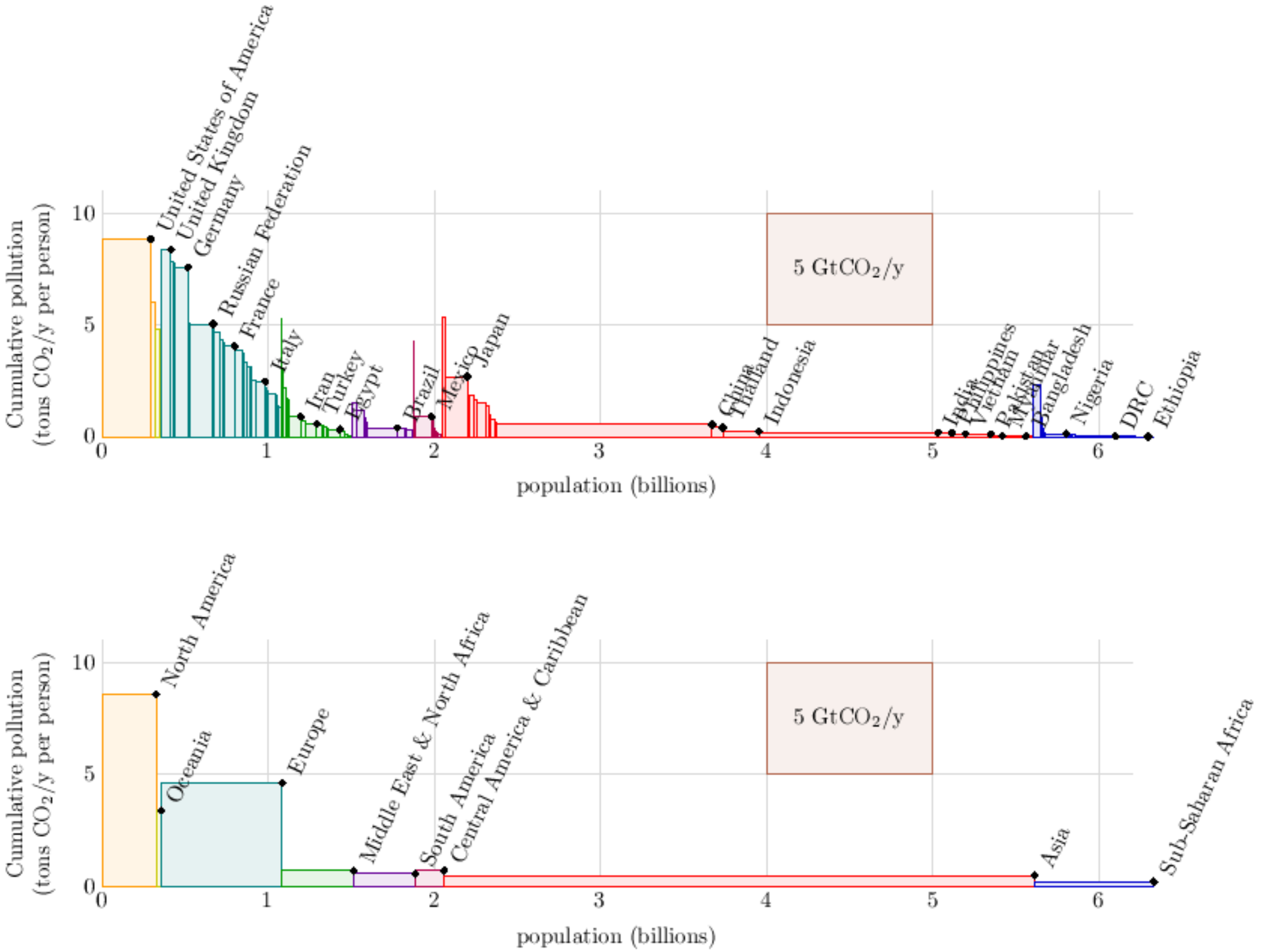
Data source: Climate Analysis Indicators Tool (CAIT)
Version 4.0. (Washington, DC: World Resources Institute, 2007).



$$\text{Total GHG emissions (2000)} = 34\,\mathrm{GtCO_2^{(e)}}$$

Data source: Climate Analysis Indicators Tool (CAIT)
Version 4.0. (Washington, DC: World Resources Institute, 2007).

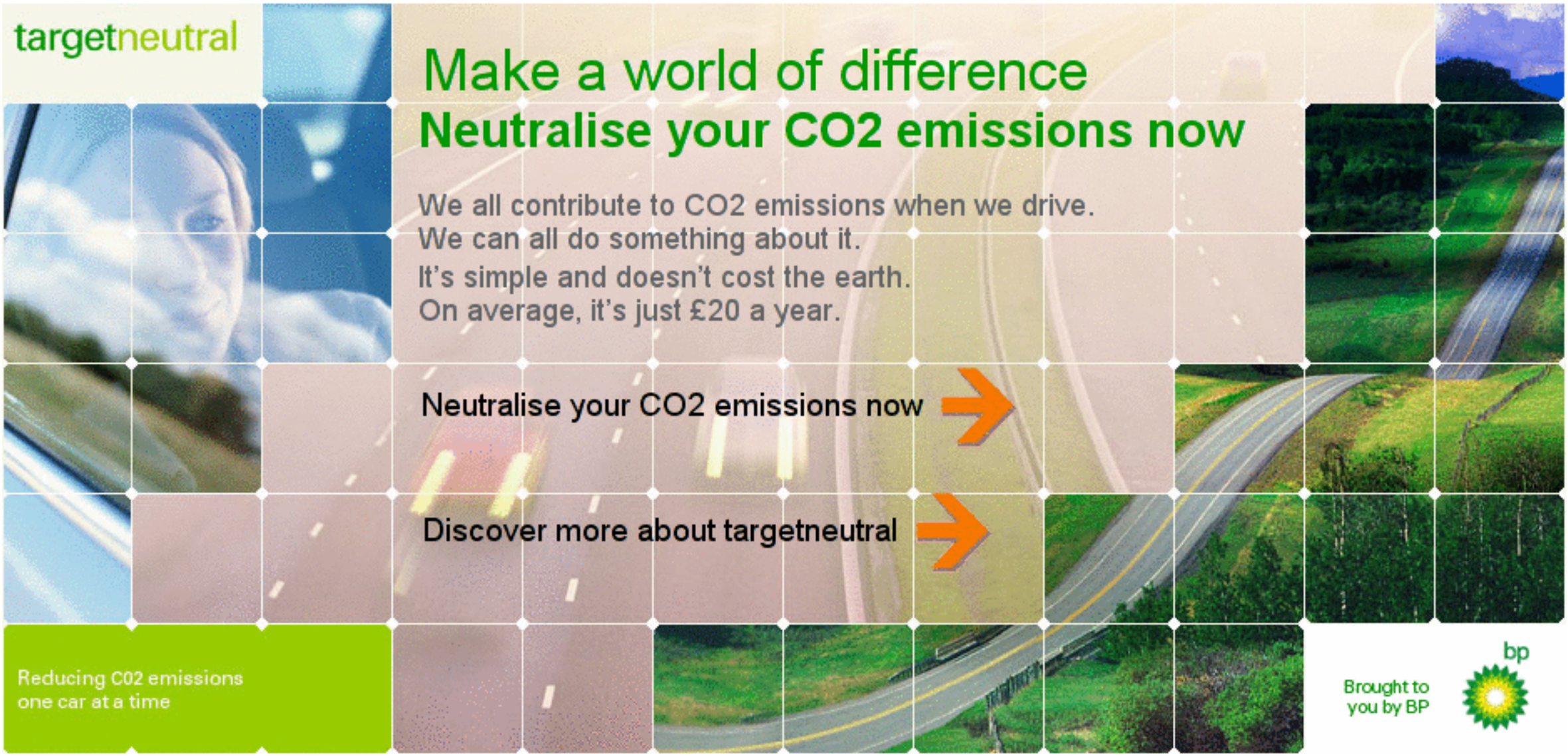
Qatar, United Arab Emirates, and Kuwait


Cumulative emissions (average for 1880–2004) – CO_2 only
Cumulative pollution
(tons CO_2/y per person)
population (billions)
5 $GtCO_2$/y
United States of America
United Kingdom
Germany
Russian Federation
France
Italy
Iran
Turkey
Egypt
Brazil
Mexico
Japan
China
Thailand
Indonesia
India
Philippines
Vietnam
Pakistan
Myanmar
Bangladesh
Nigeria
DRC
Ethiopia
North America
Oceania
Europe
Middle East & North Africa
South America
Central America & Caribbean
Asia
Sub-Saharan Africa

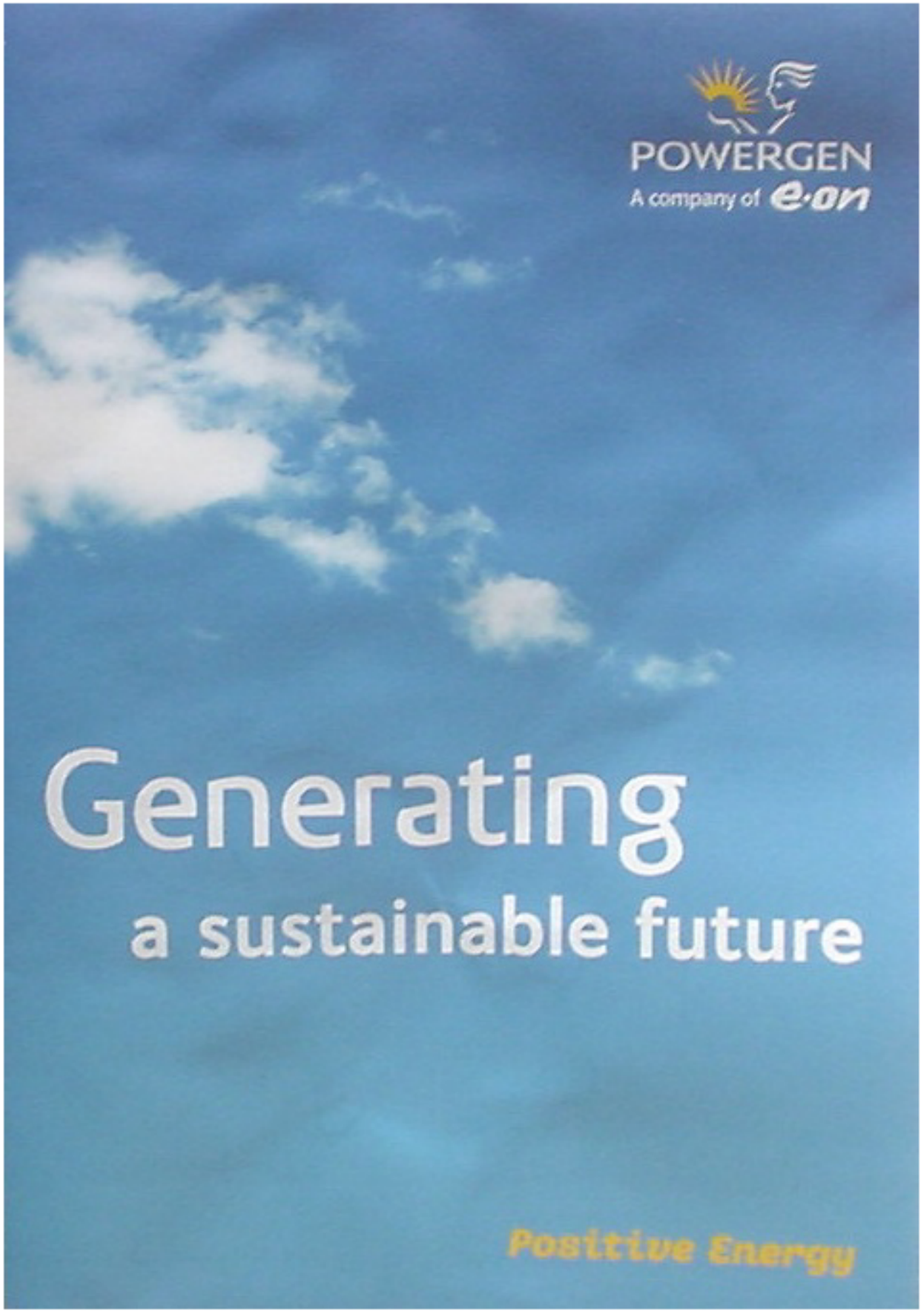
1880-2004

Something must be done!

'Make a difference'



'Do your bit'!



98% of Powergen's electricity is fossil; just 2% renewables

'Industry have done their bit'

The car industry has done its bit by making greener vehicles. Now we have to buy them, says **Sean O'Grady**

34mpg

- **219g/km**

ything.

HEAD

huge prob-
finding a
space and
usually re-
ning that
like
ehi-
V3

te

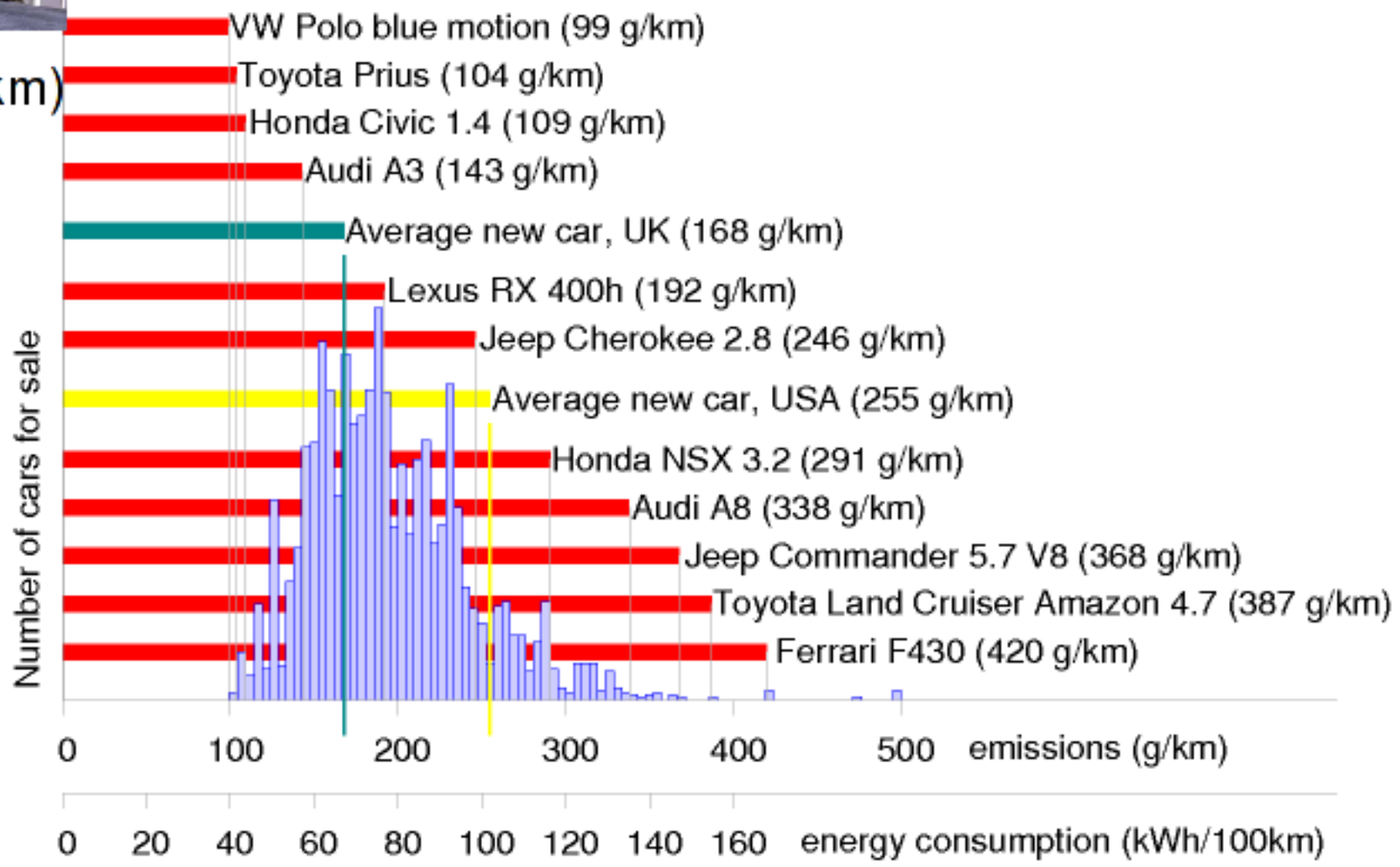
The 2.4 Diesel is efficient and probably the best all-round choice, offering 34mpg overall. During the past few years, it has

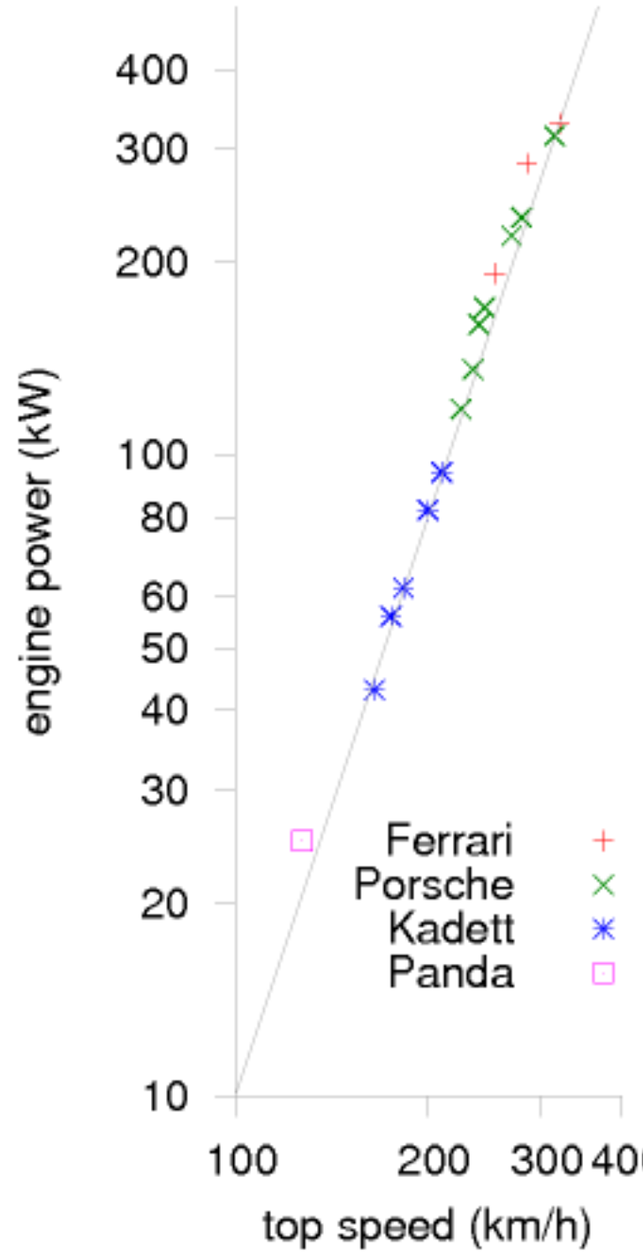
trouble is, the R-Class is furiously expensive, with prices starting at more than £38,000.

Practically perfect: the Volvo XC90

Carbon emissions from cars

Polo (102 g/km)





Efficiency through technology

'a highly fuel-efficient aircraft'

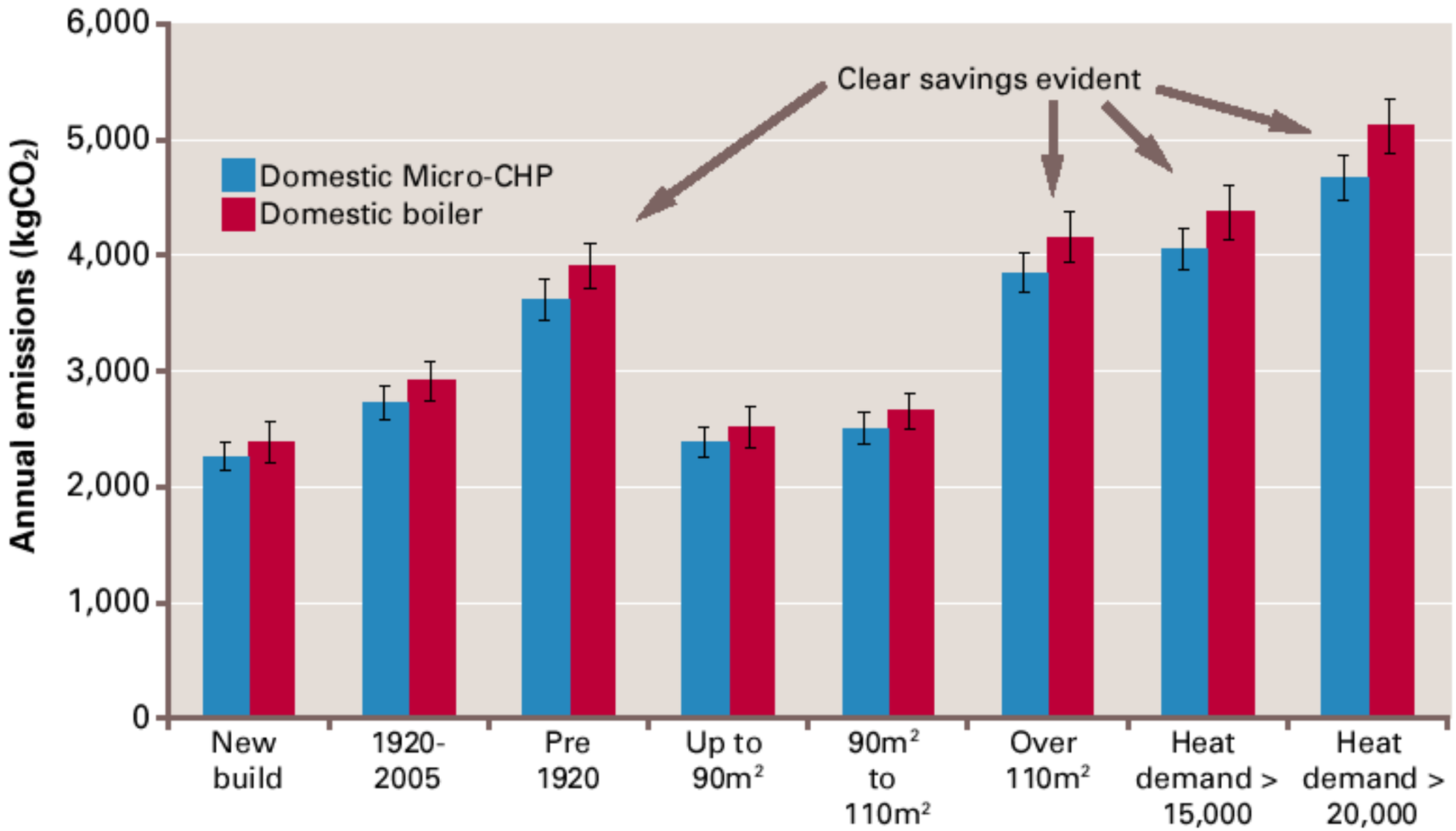
- it burns 12 percent less fuel per passenger-km than a 747

Carbon Trust on Micro-CHP

(combined heat and power) (cogeneration)

"Micro-CHP is an emerging set of technologies with the potential to provide carbon savings in both commercial and domestic environments."

Figure 50 *Annual Micro-CHP and boiler emissions for cluster scenarios*



Solar bra brings conservation closer to the heart

Wed May 14, 2008 8:53pm IST

More Video...

TOKYO (Reuters) - Ladies, take your battle for the environment a little closer to your heart with a solar-powered bra that can generate enough electric energy to charge a mobile phone or an iPod.

Lingerie maker Triumph International Japan Ltd unveiled its environmentally friendly, and green colored, "Solar Power Bra" on Wednesday in Tokyo which features a solar panel worn around the stomach.

The panel requires light to generate electricity and the concept bra will not be in stores anytime soon, said Triumph spokeswoman Yoshiko Masuda, as "people usually can not go outside without wearing clothes over it."

greenwatch

'Cocaine users wrecking forest'

Former Blur bassist Alex James is backing an initiative to encourage drug takers to consider the environmental damage caused by their cocaine use.

Something must be done!

Nuclear versus Wind

"if we're going to cut greenhouse gases by 60% by 2050 there is no other possible way of doing that except through renewables".

Michael Meacher

former Environment Minister

"anybody who is relying upon renewables to fill the energy gap is living in an utter dream world and is, in my view, an enemy of the people."

Sir Bernard Ingham

former civil servant, Chief Press Secretary, Head of the Government Information Service

'We have a *huge* amount of wave and wind'.

'Nuclear is a money pit'.

Ann Leslie

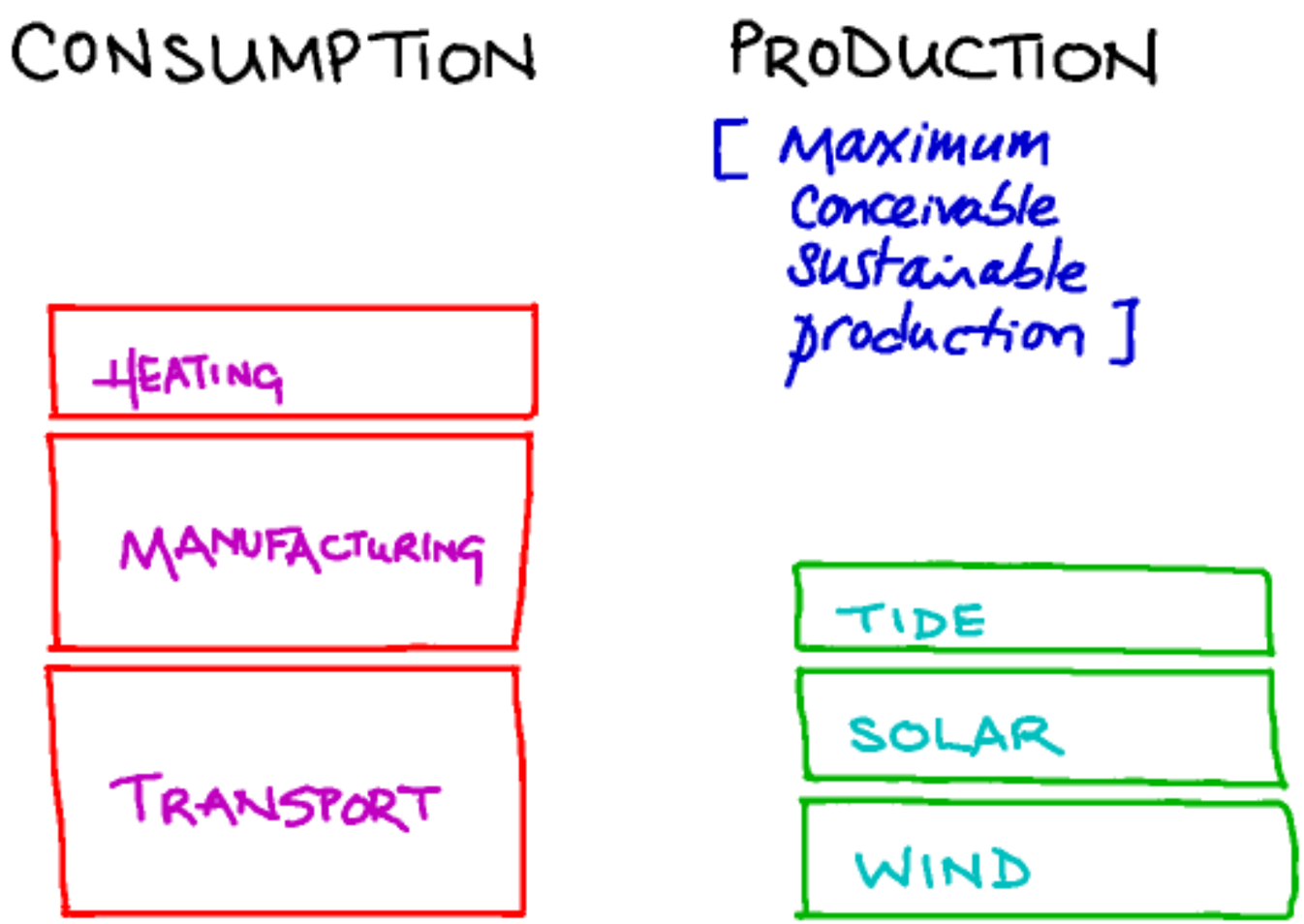
journalist

We need numbers, not adjectives

- Part I: Numbers, not adjectives
  - Could a country like Britain live on its own renewables?
- Part II: Energy plans that add up

Part I: Numbers, not adjectives

- Ignore economic, social, + environmental constraints



Choose good units

- No millions, billions, or trillions
- Make quantities comprehensible and comparable

- Do calculations per person, to one significant figure

- Energy unit: kWh

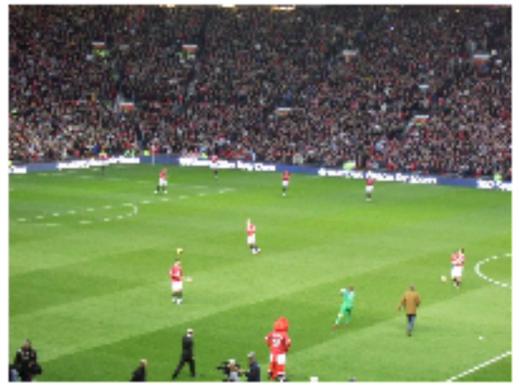
- Power unit: kWh per day

- Fluxes: W per square metre

- Examples
  - 20 mins of kettle - 1 kWh
  - food - 3 kWh / day(*)
  - bath - 5 kWh(*)
  - litre of petrol - 10 kWh
  - aluminium can - 0.6 kWh

- Population density: square metres per person

UK: $4000\ \mathrm{m}^2$ per person



Cars

$$\begin{aligned}
\text{Energy used per day} &= \frac{\text{Distance travelled per day}}{\text{Distance per unit of fuel}} \times \text{Energy per unit of fuel} \\
&= \frac{50\,\text{km/day}}{12\,\text{km/litre}} \times 10\,\text{kWh/litre} \\
&\simeq 40\,\text{kWh/day}.
\end{aligned}$$

Car:
40 kWh/d

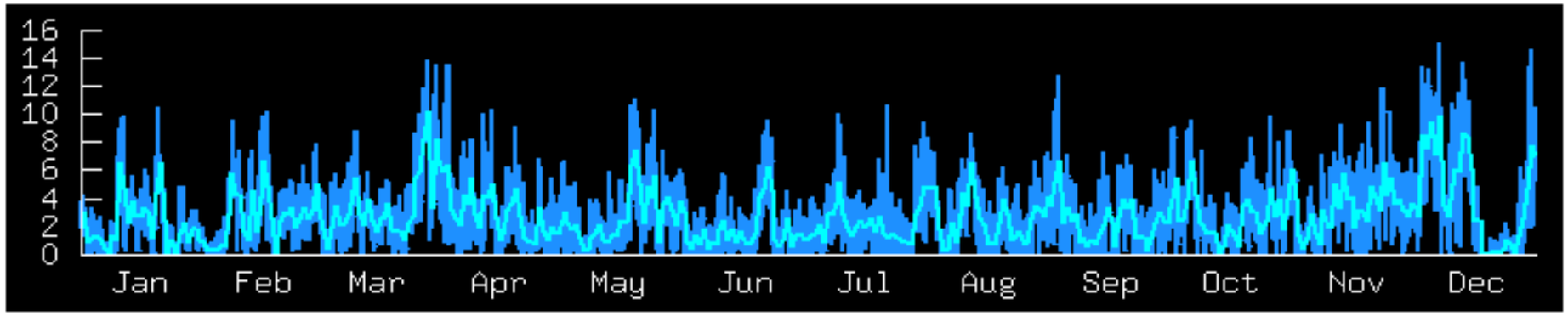
33 miles per UK gallon

40 kWh is not an average figure for UK, but a plausible value for an ordinary car-lover

f

Wind

Wind



Windspeeds Cambridge 2006 (m/s) Half-hourly and daily

Wind

$v = 6\,\mathrm{m/s}$ (force 4)
Wind farm $2\,\mathrm{W/m^2}$ flat ground

UK: 4000 m^2 per person

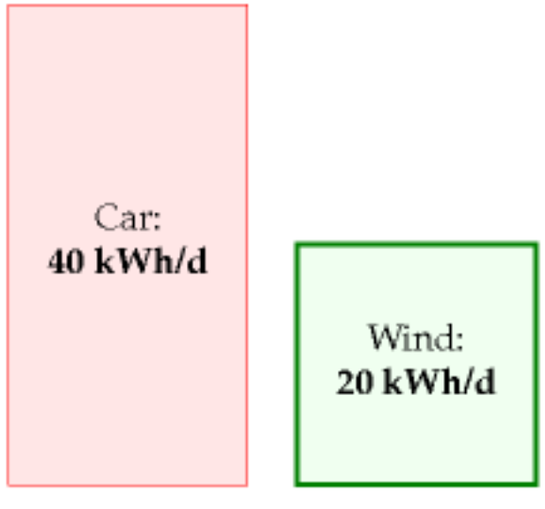
Put wind farms on 10% of the country

- 400 square metres each

...Twice as much windpower as the whole world;

50 x Denmark's

7 x Germany's



Flight

$$7\,600\,\text{miles: one round-trip / year:}$$

$$\frac{2 \times 240\,000\,\text{litre}}{416\,\text{passengers}} \times 10\,\text{kWh/litre/year}$$

$$= 29\,\text{kWh/day}$$

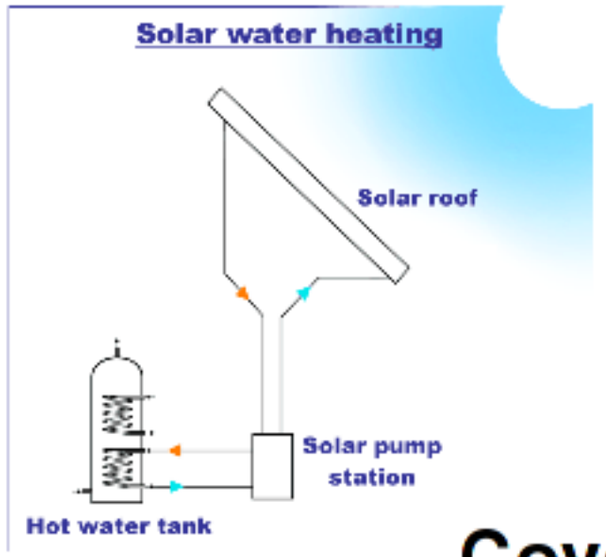
Jet flights:
30 kWh/d

Car:
40 kWh/d

Wind:
20 kWh/d

Solar

- Solar thermal



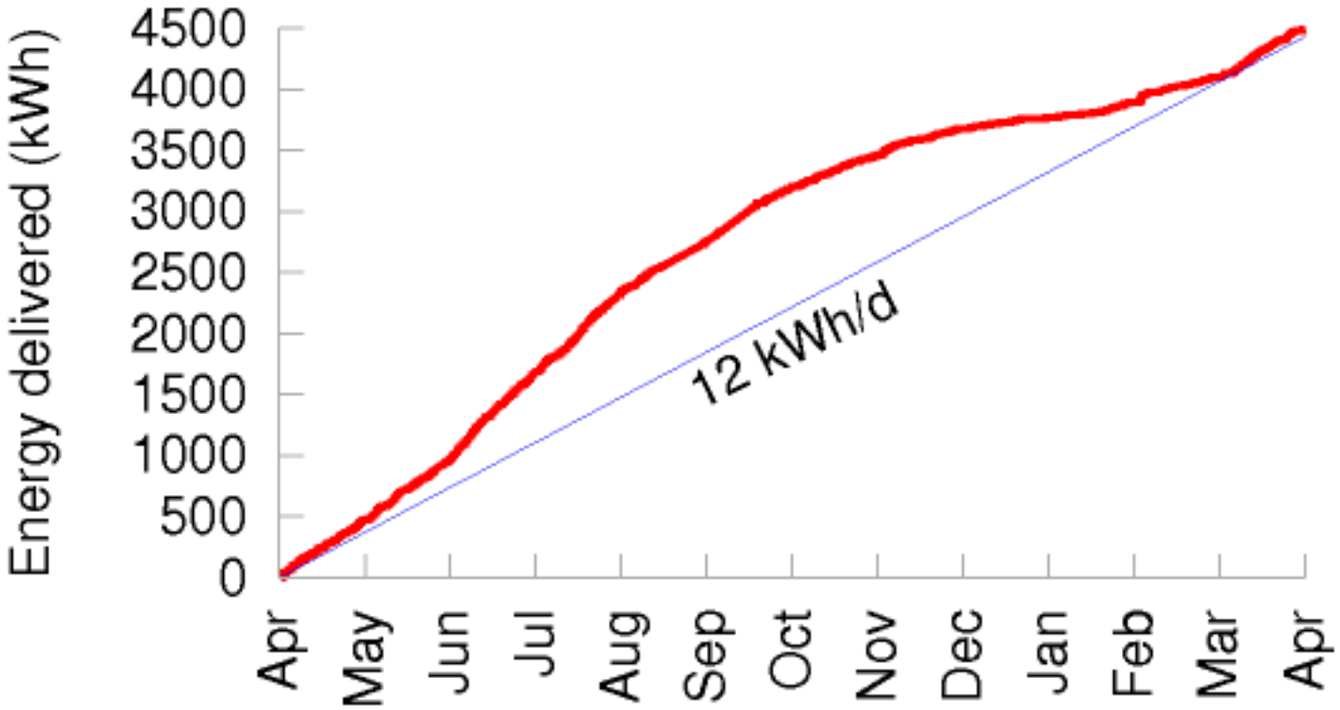
Cover every south-facing roof

Jet flights: **30 kWh/d**		$10\,\mathrm{m}^2$ per person: $11\,\mathrm{kWh/day}$ per person
Car: **40 kWh/d**	Solar heating: **11 kWh/d**	
	Wind: **20 kWh/d**	

Solar electric (photovoltaics)

solarcentury

Solar electric



Data and photo by Jonathan Kimmitt

Cover *every South-facing roof*,
$10\,\mathrm{m}^2$ per person: $5\,\mathrm{kWh/day}$ per person

Jet flights:
30 kWh/d

Car:
40 kWh/d

PV, 10 m^2: **5**

Solar heating:
11 kWh/d

Wind:
20 kWh/d

Solar PV farming

Bavaria Solar Park: $5\,\mathrm{W/m^2}$; this picture shows $0.7\,\mathrm{MW}$ (average)

Solar PV (covering 5-10% - an area bigger than Wales)

Jet flights:
30 kWh/d

Car:
40 kWh/d

PV farm
(200 m^2/p):
50 kWh/d

PV, 10 m^2: **5**

Solar heating:
11 kWh/d

Wind:
20 kWh/d

Solar biomass

- Best plants (0.5% efficient)
  - cover 75% of the country;
  - 1/3 lost in processing.

Jet flights:
30 kWh/d

Car:
40 kWh/d

Biomass: food, biofuel, wood, waste incin'n, landfill gas:
24 kWh/d

PV farm (200 m^2/p):
50 kWh/d

PV, 10 m^2: **5**

Solar heating:
11 kWh/d

Wind:
20 kWh/d

includes

sustainable waste incineration

cellulosic ethanol

methanol

Heating and cooling

Hot water

Bath: 5 kWh

Shower: 1 kWh

Clothes wash: 4 kWh

Cooking, kettle, microwave, dishes

Hot water: **12**

Hot air

Hot air: **24**

Fridge, Airconditioning

Cooling: **1**

Heating, cooling: **37 kWh/d**

Jet flights: **30 kWh/d**

Car: **40 kWh/d**

Biomass: food, biofuel, wood, waste incin'n, landfill gas: **24 kWh/d**

PV farm (200 m^2/p): **50 kWh/d**

PV, 10 m^2: **5**

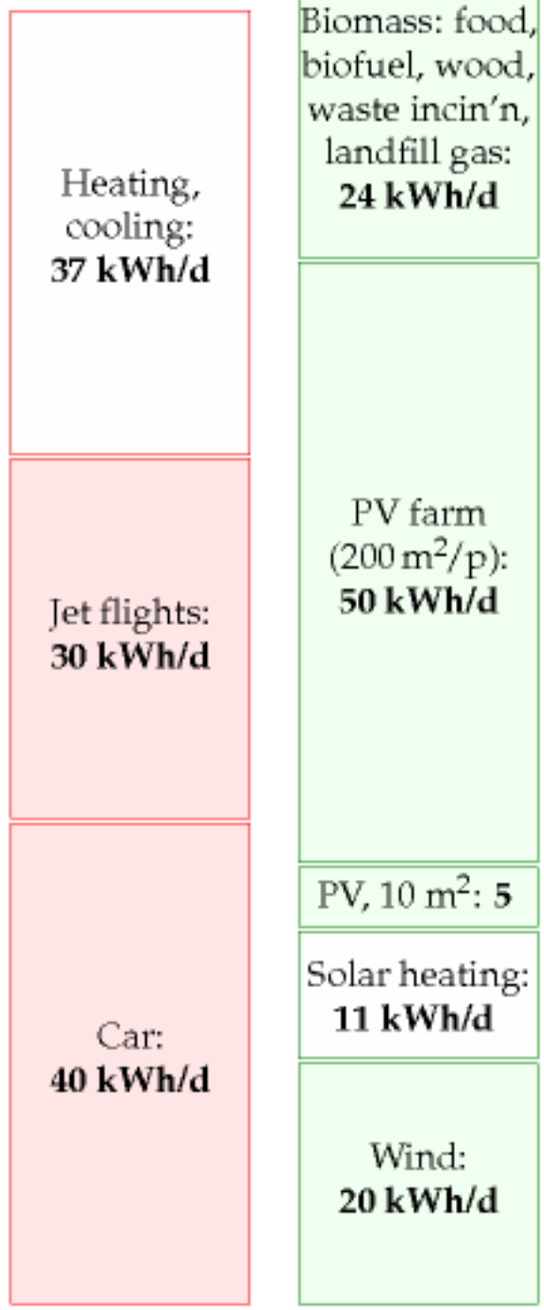
Solar heating: **11 kWh/d**

Wind: **20 kWh/d**

Hydro

- 1.5 kWh/d per person

(currently 0.2 kWh/d per person)

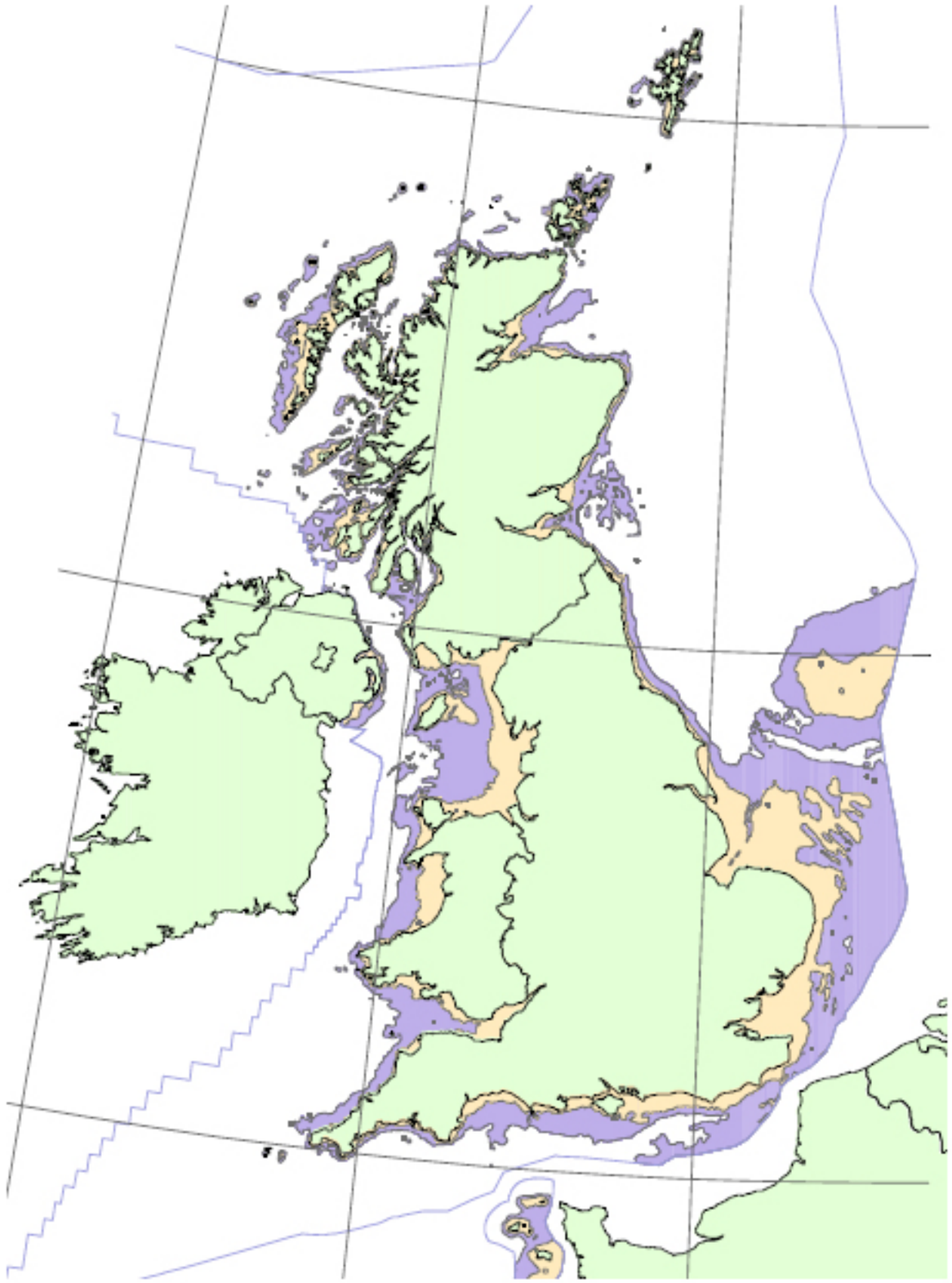


Nant-y-Moch by Dave Newbould
www.origins-photography.co.uk

Light

- 10 bulbs
- 5 hours per day

Offshore wind



depth less than 25m (yellow); depth between 25m and 50m (magenta).
Data from DTI Atlas of Renewable Marine Resources. Crown copyright.

Light: **4**

Heating, cooling: **37 kWh/d**

Jet flights: **30 kWh/d**

Car: **40 kWh/d**

Shallow offshore wind: **16 kWh/d**

Hydro: **1.5**

Biomass: food, biofuel, wood, waste incin'n, landfill gas: **24 kWh/d**

PV farm (200 m^2/p): **50 kWh/d**

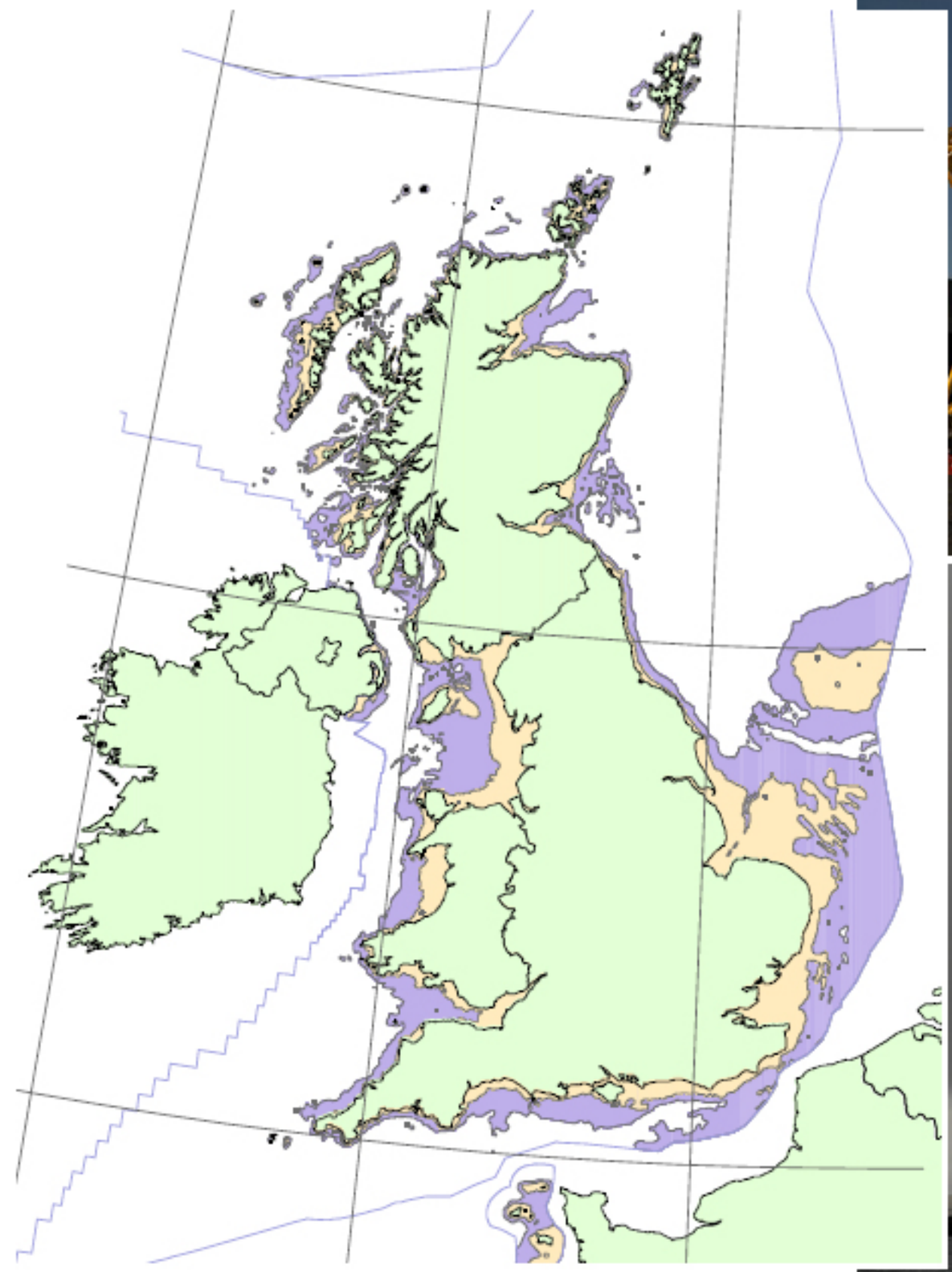
PV, 10 m^2: **5**

Solar heating: **11 kWh/d**

Wind: **20 kWh/d**

(c) Elsam (elsam.com).
Used with permission.

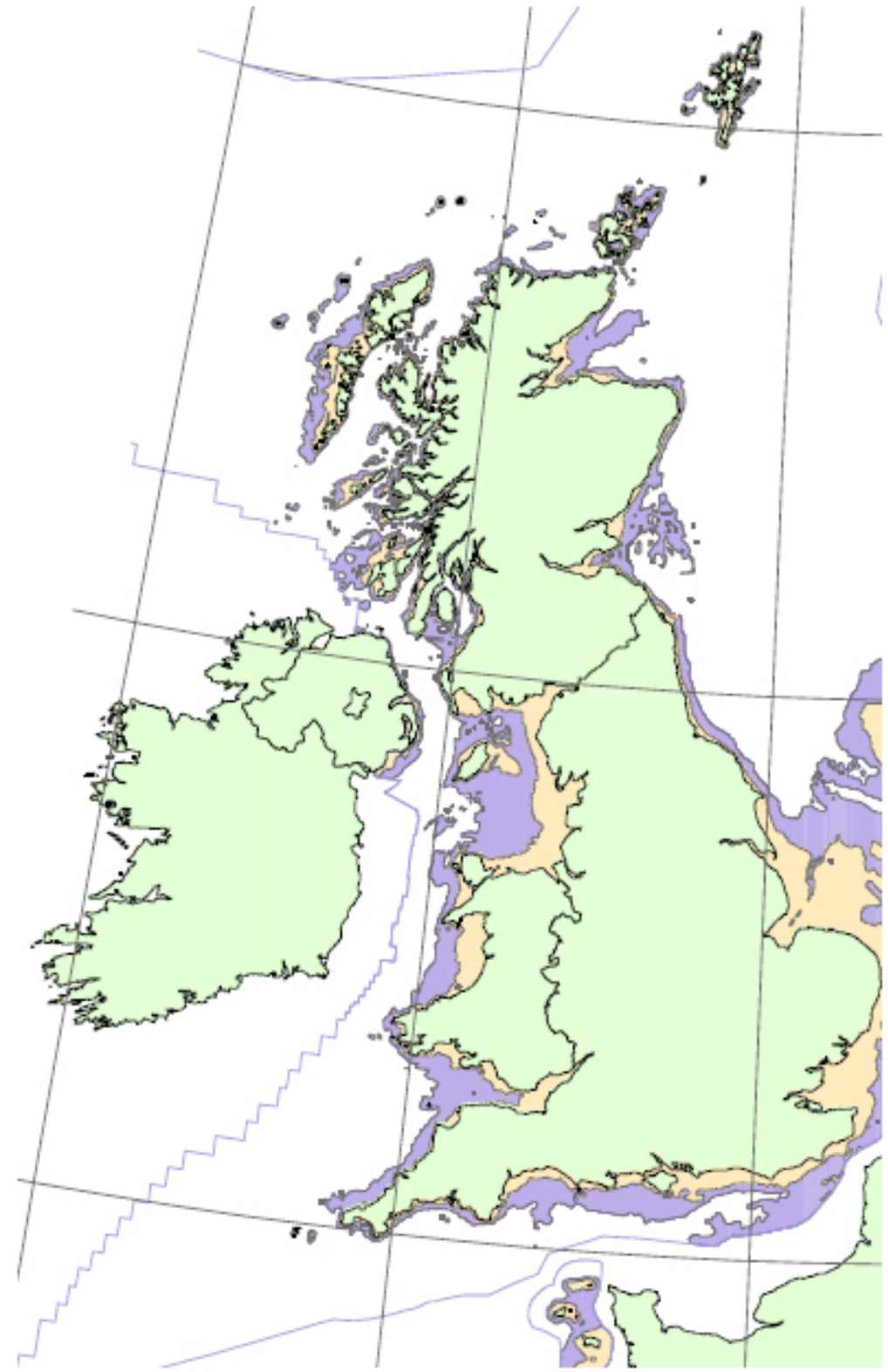
Deep offshore wind



depth less than 25m (yellow); depth between 25m and 50m (magenta).

Data from DTI Atlas of Renewable Marine Resources. Crown copyright.

Deep offshore wind



depth less than 25m (yellow); depth between 25m and 50m (r

Data from DTI Atlas of Renewable Marine Resources. Crow

Light: **4**

Heating, cooling: **37 kWh/d**

Jet flights: **30 kWh/d**

Car: **40 kWh/d**

Deep offshore wind: **32 kWh/d**

Shallow offshore wind: **16 kWh/d**

Hydro: **1.5**

Biomass: food, biofuel, wood, waste incin'n, landfill gas: **24 kWh/d**

PV farm (200 m^2/p): **50 kWh/d**

PV, 10 m^2: **5**

Solar heating: **11 kWh/d**

Wind: **20 kWh/d**

Gadgets

- TV
- Computer
- Cable modem
- Mobile phones
- Bedside radio
- Other gadgets

Charger left plugged in:

0.01 kWh/d

Gadgets: **5**

Light: **4**

Heating, cooling: **37 kWh/d**

Jet flights: **30 kWh/d**

Car: **40 kWh/d**

Deep offshore wind: **32 kWh/d**

Shallow offshore wind: **16 kWh/d**

Hydro: **1.5**

Biomass: food, biofuel, wood, waste incin'n, landfill gas: **24 kWh/d**

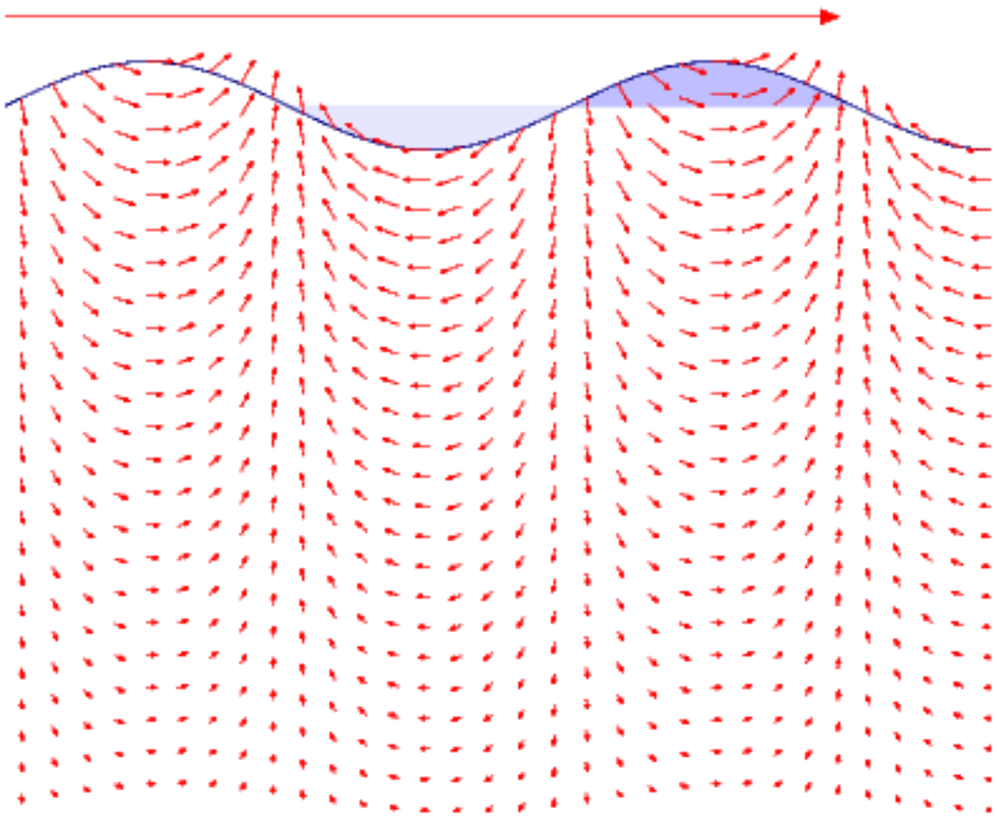
PV farm (200 m^2/p): **50 kWh/d**

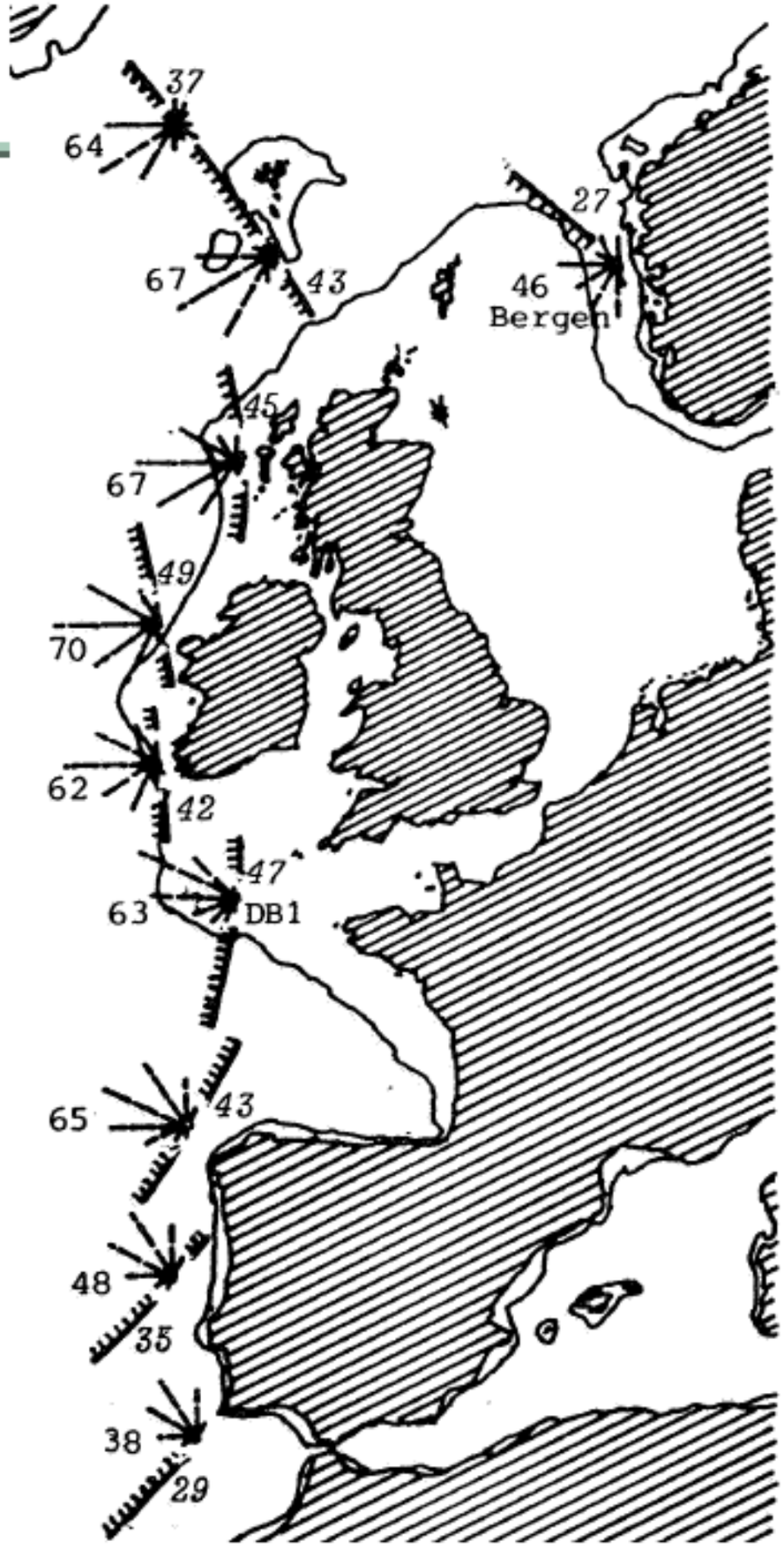
PV, 10 m^2: **5**

Solar heating: **11 kWh/d**

Wind: **20 kWh/d**

Wave





D. Mollison: Wave climate and the wave power resource (1986)

Wave

Gadgets: **5**

Light: **4**

Heating, cooling: **37 kWh/d**

Jet flights: **30 kWh/d**

Car: **40 kWh/d**

Wave: **4**

Deep offshore wind: **32 kWh/d**

Shallow offshore wind: **16 kWh/d**

Hydro: **1.5**

Biomass: food, biofuel, wood, waste incin'n, landfill gas: **24 kWh/d**

PV farm (200 m^2/p): **50 kWh/d**

PV, 10 m^2: **5**

Solar heating: **11 kWh/d**

Wind:

'500 kW' Limpet, Islay

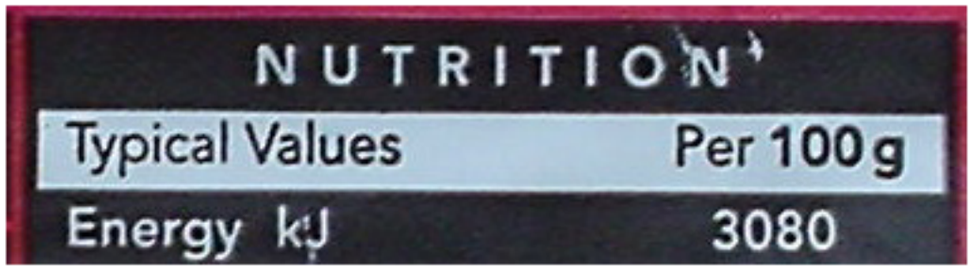
Predicted average power: 200kW. Actual: 21kW.

Total incident power / population of UK

$$= \frac{40\,\text{kW/metre} \times 1000\,\text{km}}{60 \times 10^6} = 16\,\text{kWh/day}$$

Ocean Power Delivery (ocea

Food'n'Farming



(not including energy for food delivery)

Vegans: 3 kWh/d minimum
Vegetarians: 4 kWh/d min
Carnivores: 12 kWh/d min
(260 kg of animal preparing to be eaten)

Food & fertilizer: **14**

Gadgets: **5**

Light: **4**

Heating, cooling: **37 kWh/d**

Jet flights: **30 kWh/d**

Car: **40 kWh/d**

Wave: **4**

Deep offshore wind: **32 kWh/d**

Shallow offshore wind: **16 kWh/d**

Hydro: **1.5**

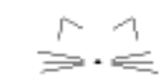
Biomass: food, biofuel, wood, waste incin'n, landfill gas: **24 kWh/d**

PV farm (200 m^2/p): **50 kWh/d**

PV, 10 m^2: **5**

Solar heating: **11 kWh/d**

Wind: **20 kWh/d**

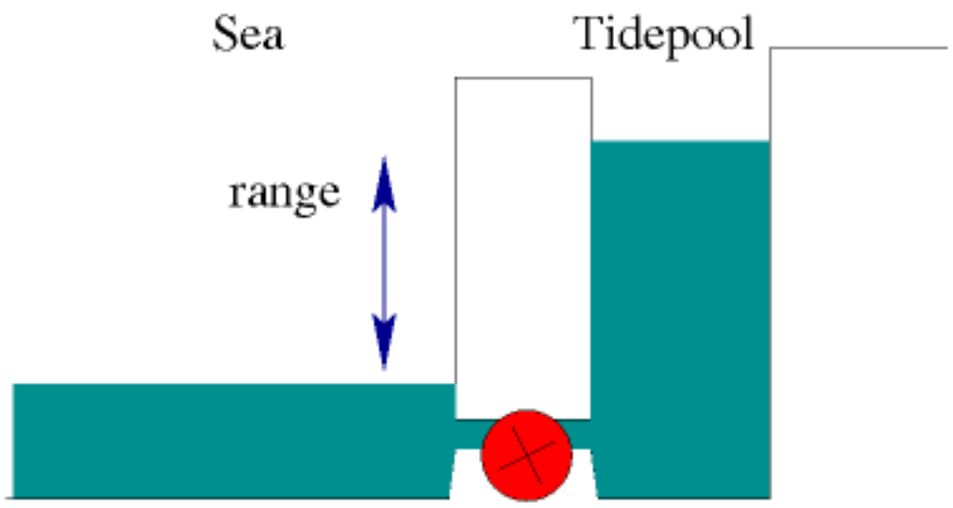


2 kWh/d

9 kWh/d

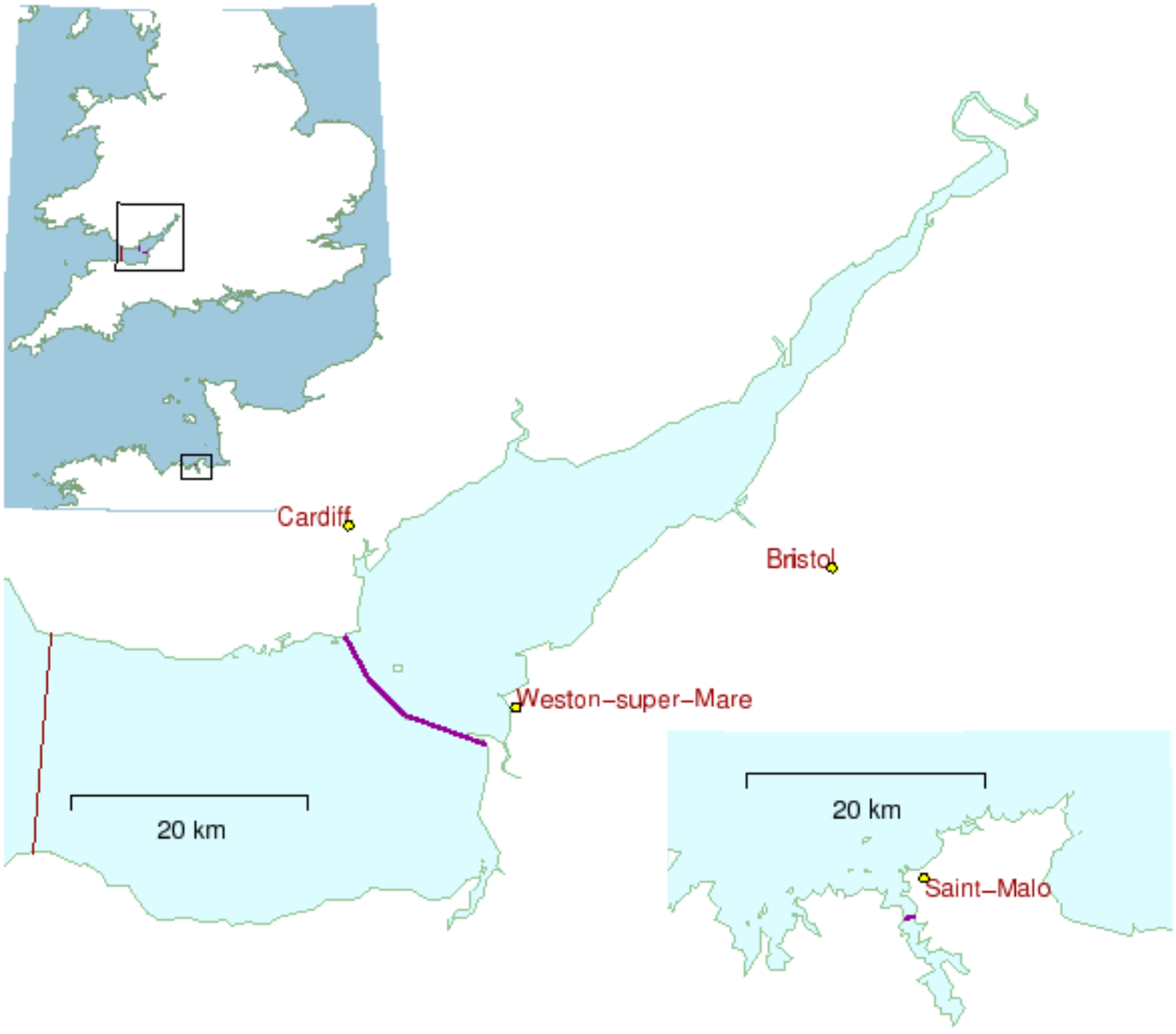
17 kWh/d

Tide - using tide pools



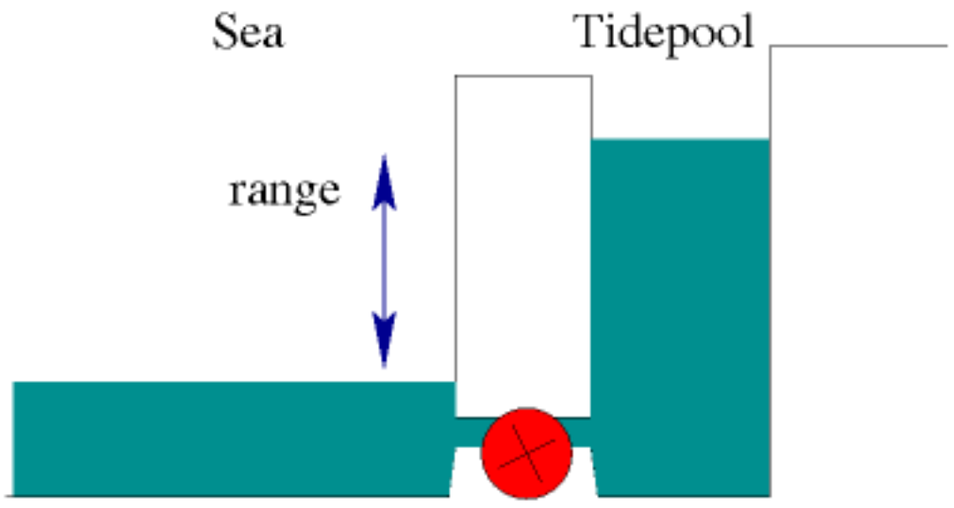
Tidal range	Power per unit area
4 m	3 W/m^2

Severn barrage and la Rance

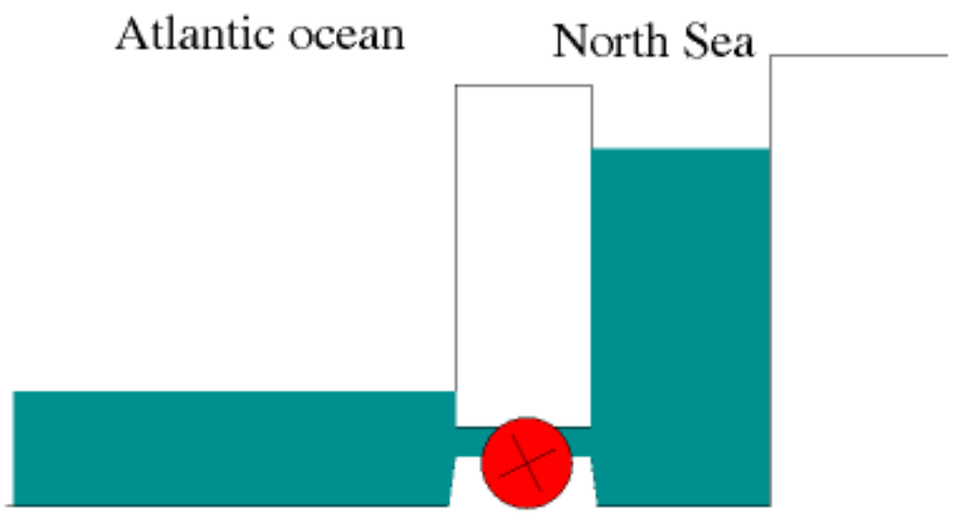


La Rance (60 MW): **2.7** W/m^2

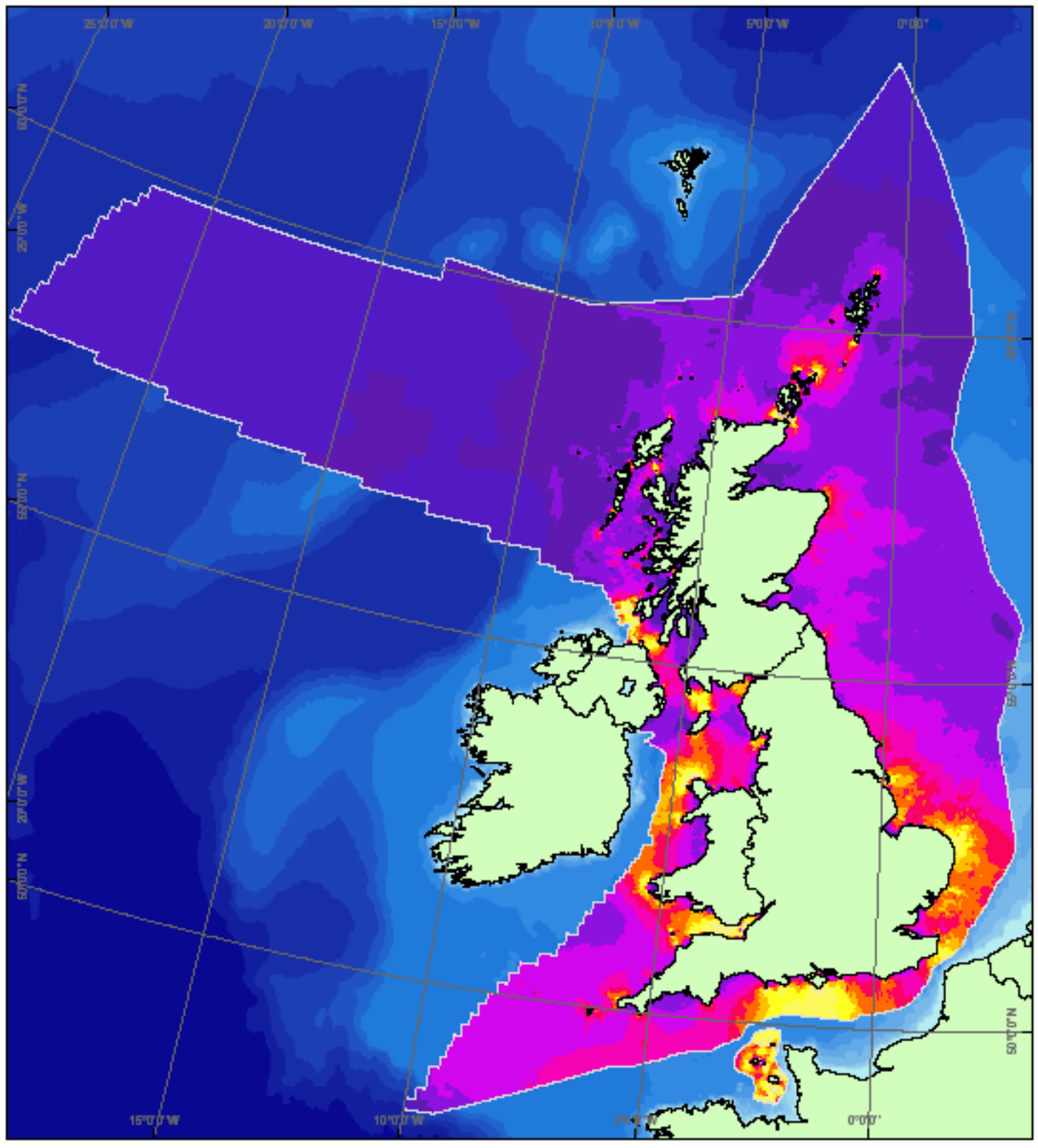
Tide - using tide pools

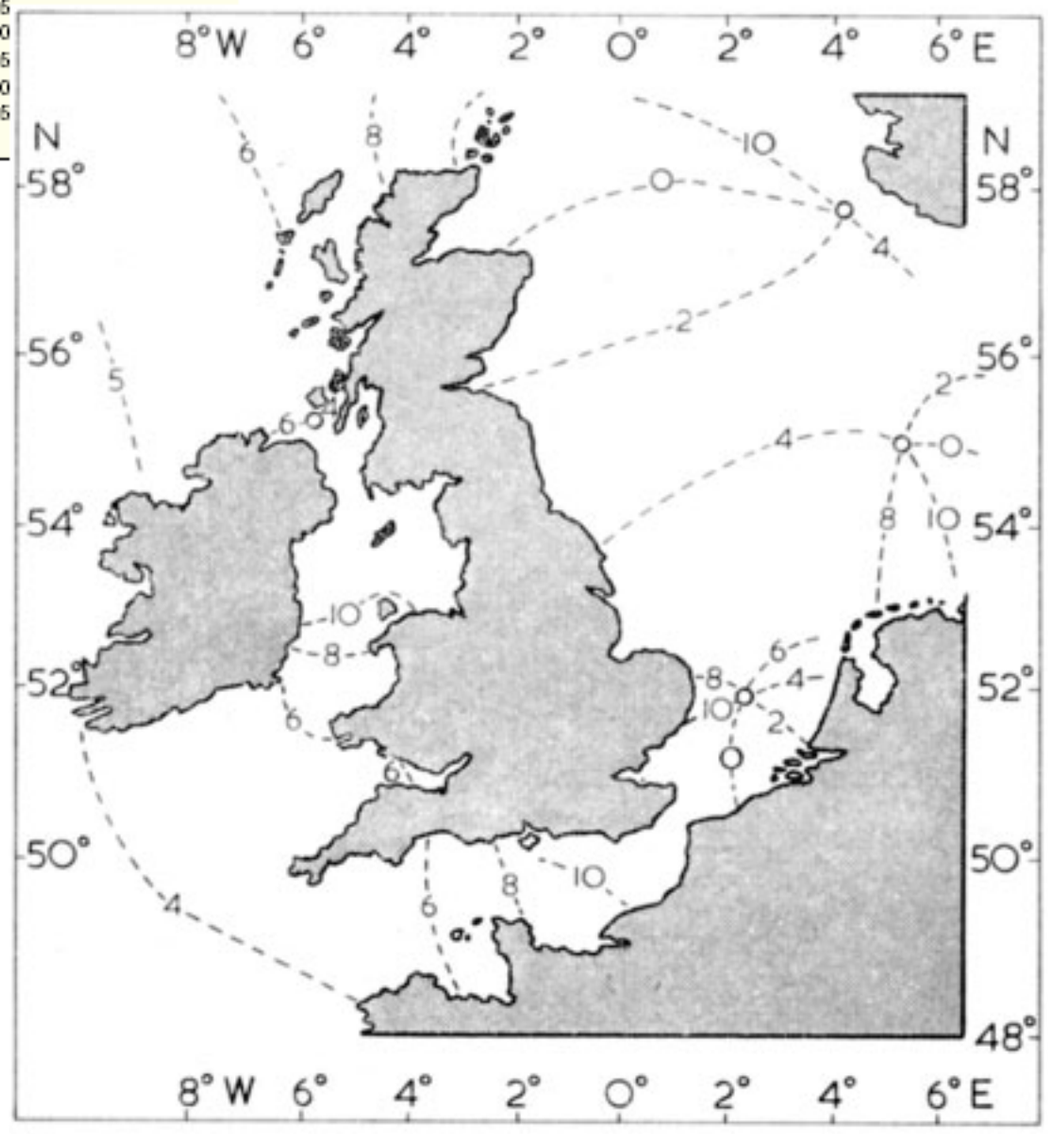


Tidal range	Power per unit area
4 m	3 W/m^2



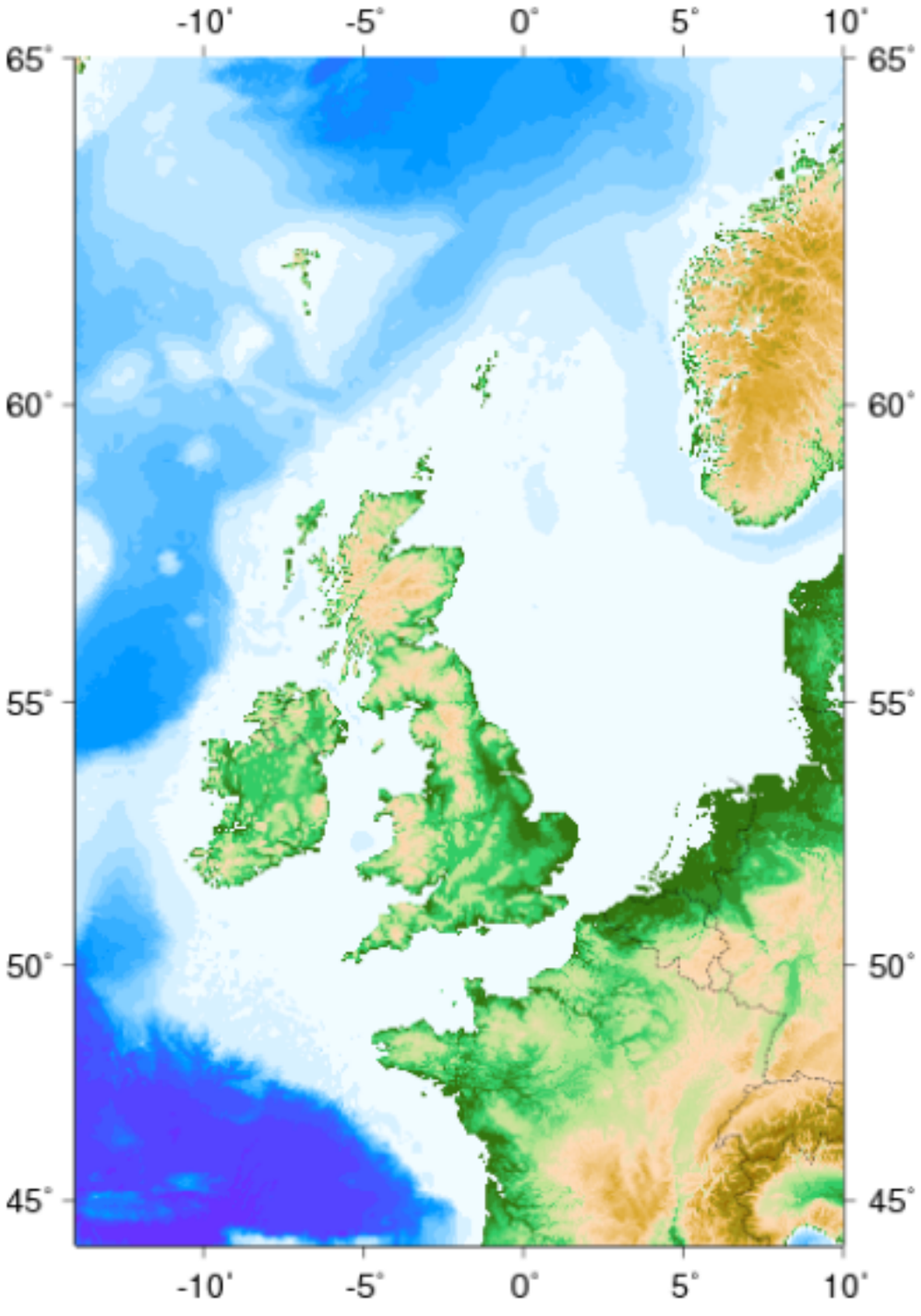
Tide


Peak Flow - (m/s)
> 4.01
3.51 - 4.00
3.01 - 3.50
2.51 - 3.00
2.01 - 2.50
1.76 - 2.00
1.51 - 1.75
1.26 - 1.50
1.01 - 1.25
0.76 - 1.00
0.51 - 0.75
0.26 - 0.50
0.11 - 0.25
< 0.10
Land
UK Continental Shelf & Channel Island Territorial Sea Limit


8° W
6°
4°
2°
0°
2°
4°
6° E
N
58°
56°
54°
52°
50°
48°

DTI

Total incoming power in 'tidal waves'



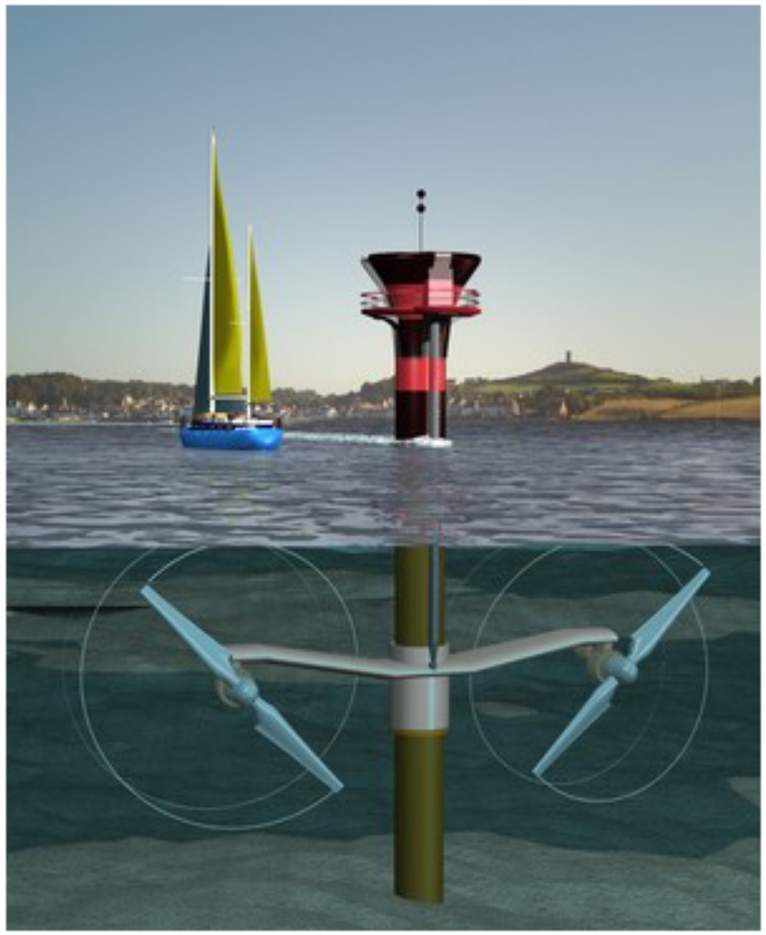
~300 kW per metre

Total: 250 GW

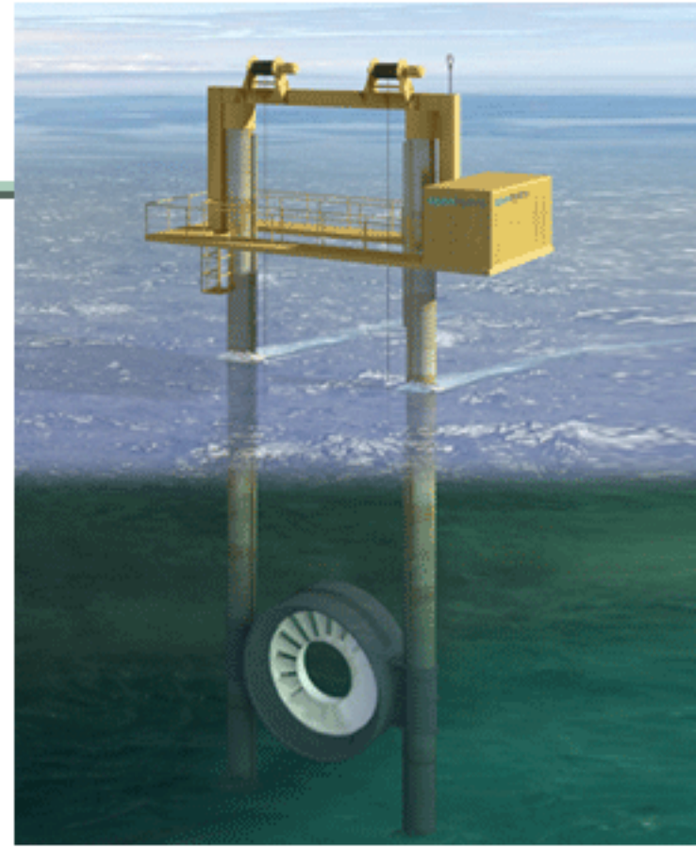
(100 kWh/d per person)

Cartwright et al (1980) Phil Trans R S Series A

Tidal stream power



marineturbines.com



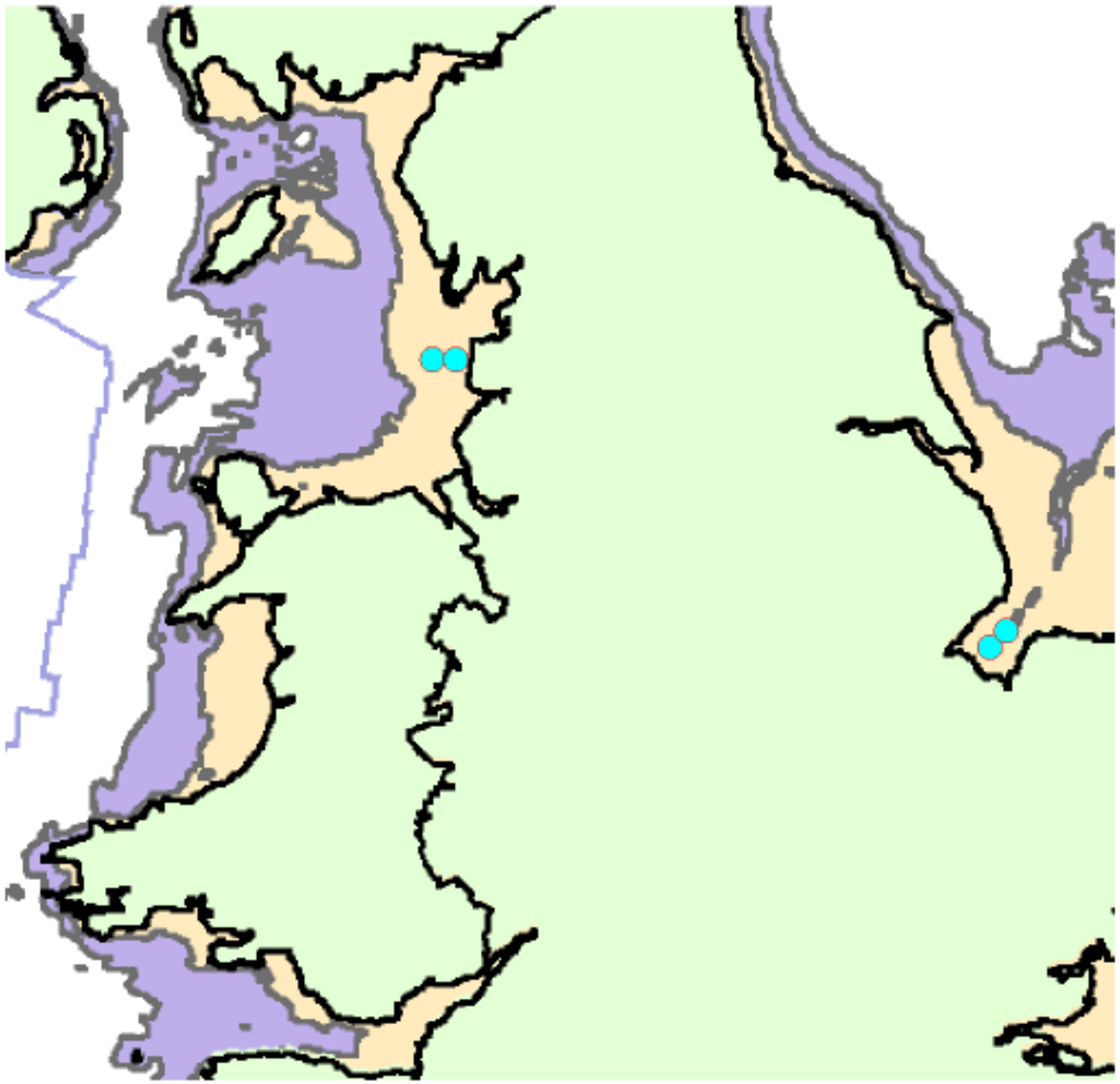
Open Hydro

1kWh/d/person
(DTI figure)

Tide

- Tide farms

- Tidal lagoons



Tide: **11 kWh/d**

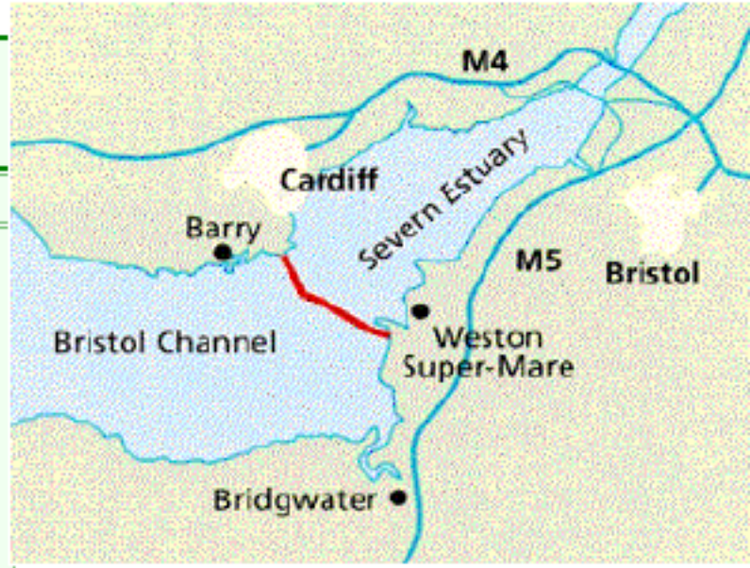
Wave: **4**

Deep offshore wind: **32 kWh/d**

Shallow offshore wind: **16 kWh/d**

Hydro: **1.5**

Biomass: food, biofuel, wood, waste incin'n, landfill gas: **24 kWh/d**



and barrages

0.8 kWh/d per person

Food & fertilizer: **14**

Gadgets: **5**

Light: **4**

Heating, cooling: **37 kWh/d**

Jet flights: **30 kWh/d**

Car:

PV farm (200 m^2/p): **50 kWh/d**

PV, 10 m^2: **5**

Solar heating: **11 kWh/d**

Stuff

- One new computer every 2 years

Chips: **4**
Aluminium: **3**

Newspapers, junk mail, magazines: **2 kWh/d**

- 5 cans per day
- Stuff made in China: 12 kWh/d/p
- Transporting rubbish around

Transporting stuff: **12**

Road freight: 7

Supermarkets: **0.5 kWh/d**

Shipping: **4**

Stuff: **48+**

Food & fertilizer: **14**

Gadgets: **5**

Light: **4**

Tide: **11 kWh/d**

Wave: **4**

Deep offshore wind: **32 kWh/d**

Shallow offshore wind: **16 kWh/d**

Hydro: **1.5**

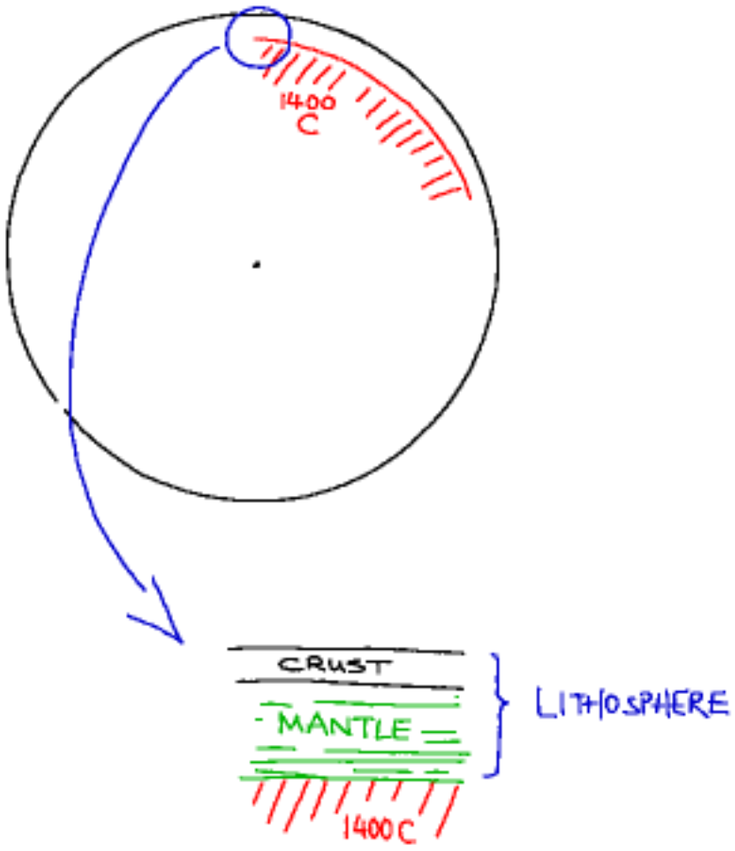
Biomass: food, biofuel, wood, waste incin'n,

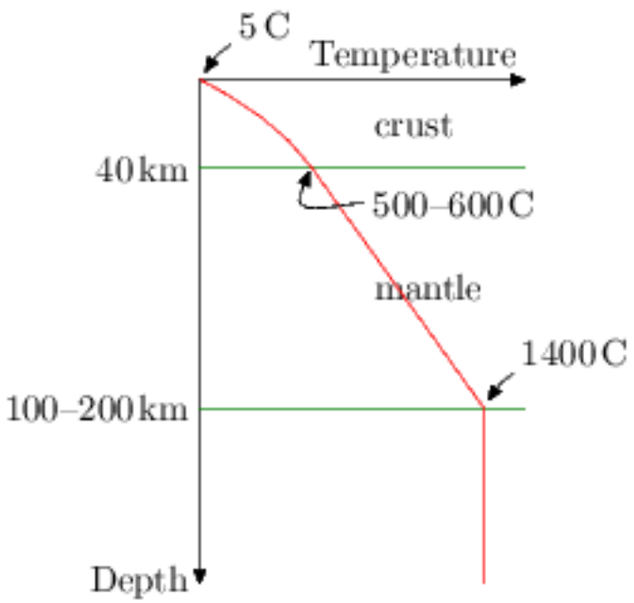
Geothermal

Nesjavellir, Iceland

Average geothermal electricity generation in Iceland in 2006 was 300 MW (24 kWh/d/person)

Geothermal





Transporting stuff: **12**

Stuff: **48+**

Food & fertilizer: **14**

Gadgets: **5**

Light: **4**

Heating, cooling: **37 kWh/d**

Jet flights: **30 kWh/d**

Geothermal: **1**

Tide: **11 kWh/d**

Wave: **4**

Deep offshore wind: **32 kWh/d**

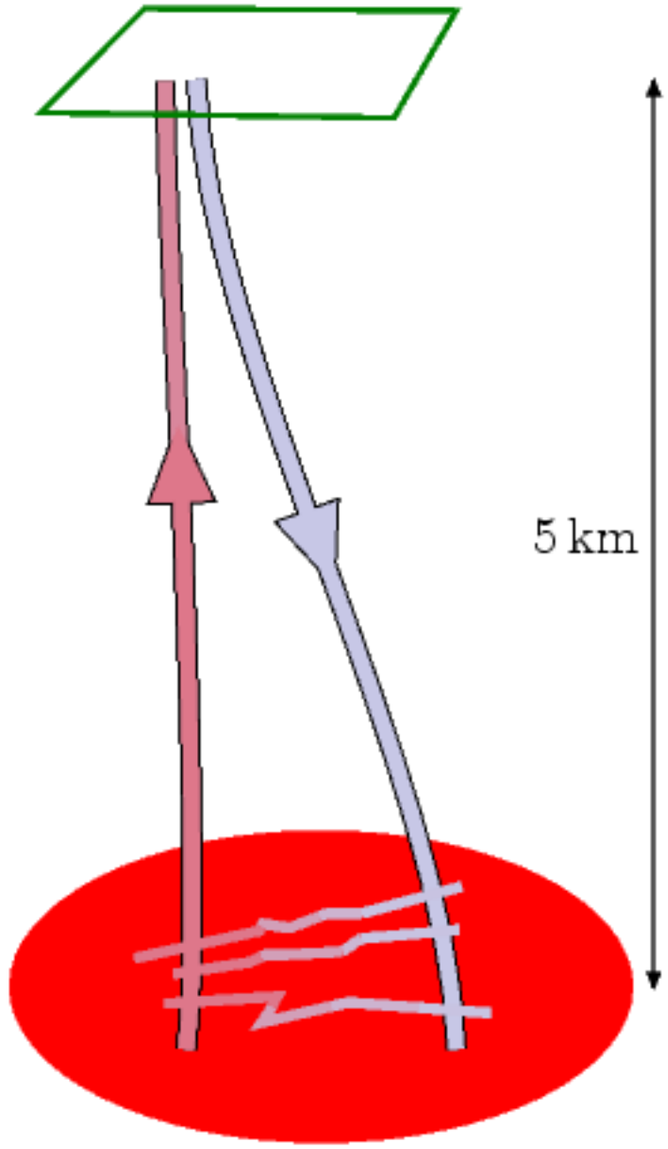
Shallow offshore wind: **16 kWh/d**

Hydro: **1.5**

Biomass: food, biofuel, wood, waste incin'n, landfill gas: **24 kWh/d**

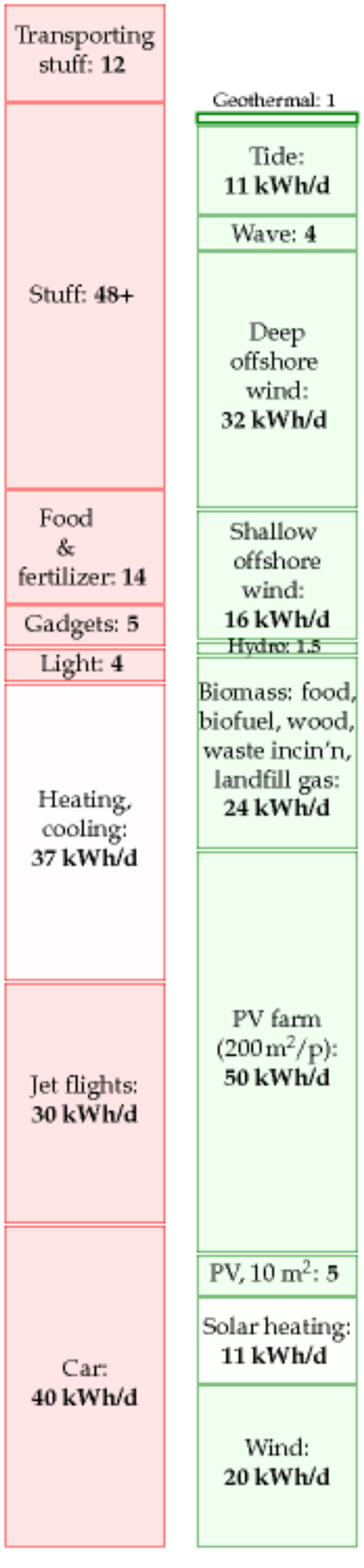
PV farm (200 m^2/p): **50 kWh/d**

PV, 10 m^2: **5**



'Hot dry rock'

Still to come
on the red stack:
- industry,
- road building,
- 'defence',
- hospitals, ...



It would be very difficult to live on our own renewables

- at least, as we currently live

www.withouthotair.com

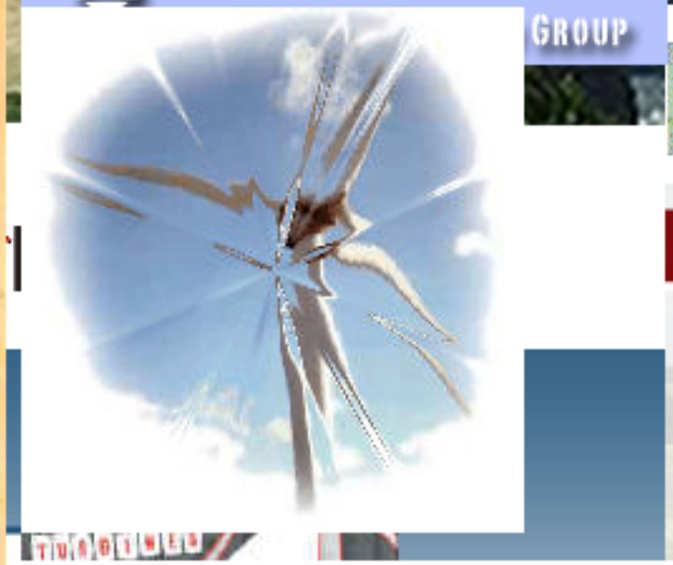
A consultation exercise in full swing


SAY NO
TO WIND TURBINES
IN BENINGTON
BENINGTON NEEDS
YOU"


SWAG
GROUP

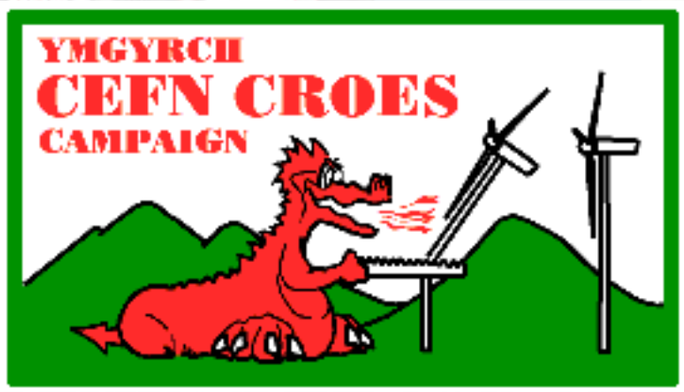

BLOT
Belvoir Locals Oppose Turbines
www.blot-online.org


SAVE the
NO
YES



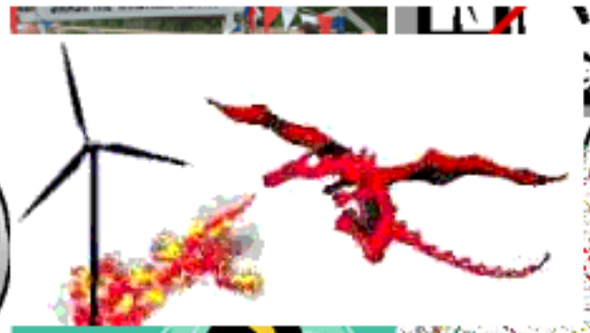

Maer Hills Protect


Hook Moor Wind Farm Action Group


YMGYRCH
CEFN CROES
CAMPAIGN

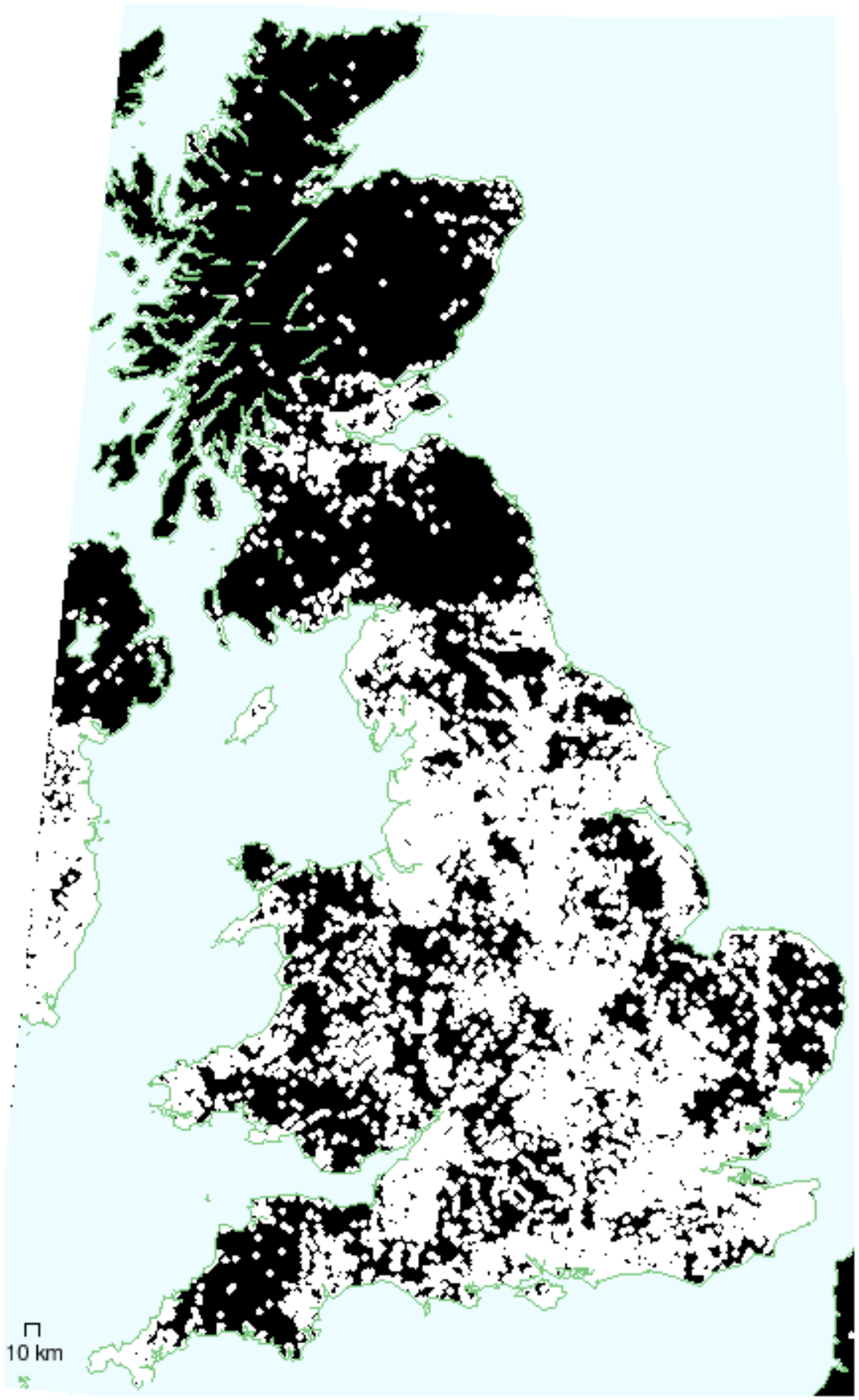

SAY
NO
TO THE
WIND FARM
www.
stopbeningtonwindfarm
.co.uk


B.A.C.K.W.A.G



STOP


STOP Lochluichart
'a windfarm too far'


10 km

Save Our Scenery -

Protecting Our Heritage Coastline

BEFORE

AFTER

FROM LLANDUDNO PROMENADE

FROM COLWYN BAY PROMENADE

saveourscenery.com

Printer friendly
Send to a friend
Tag/Bookmark

News

Giant Wind Farm Off English Coast Pits Town Against Shell, E.ON

Graveney was the site of the last combat on English soil when British forces battled a downed German bomber crew in 1940. Now the village is fighting a new enemy: the world's biggest wind farm. The local council, acting on behalf of the town's 473 residents, refused to permit a substation for the $1.5 billion London Array, which would put 271 wind turbines in the estuary of the River Thames. Royal Dutch Shell Plc and E.ON AG plan to bring power cables ashore near Graveney. "They say this is the only place they could put it — that's rubbish," said retiree George Schneider, 73, strolling on Saxon Shore Way, a rambling route across the coastal plain. "Why use a green-field site when there are other places?"

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By Rating ►

search news

are springing up on land-based
some are even becoming tourist
– proposals for offshore farms are
popular.

Estate has
ible 18
d the UK
hough each
ds to gain

ccepted by
others are
tink.

n strong
:o schemes
ms in the
and off Portstewart, near the
seway in Northern Ireland.

Surfers are worried about the impact

About News Opinions Library Press

News

Wind farm 'a threat to our airport'

Southend Airport has raised serious objections to plans to build a new wind farm – even though the turbines would be nearly 15 miles to the n experts say a wind farm next to the defunct nuclear power station, at Br air traffic control issues and might even interfere with radar. Airport mar Alistair Welch raised the concerns at a public inquiry which is being helc

June 22, 2007 in Echo

Southend Airport has raised serious objections to plans to build a new wind farm – even would be nearly 15 miles to the north.

Job creation

In Porthcawl in south Wales, a pressure group called SOS Porthcawl has been set up to oppose plans for a wind farm four miles out to sea.

The proposal is for 30 turbines on Scarweather Sands, each 453 feet high.

It could provide enough energy for more than 40,000 homes.

The production of the turbines could also create 130 jobs – they are made in Wales at Bangor and more could be produced at Port Talbot.

Tourism

But SOS Porthcawl says the turbines will be noisy and visible from beauty spots, which would deter tourists.

Protesters target wind farm plans

Plans of how the wind farm will look are on display

Porthcawl is a popular spot for surfers

Local people opposing plans to build one of the UK's big
south Wales coast met on Friday. Residents in Porthcaw
to highlight their opposition to the proposed 30-turbine
Sands.

SOS Porthcawl was set up by campaigners in the town v
say the wind farm will adversely affect the holiday reso
which attracts surfers and tourists from all over the UK
demonstration coincides with a public consultation into
project by developers United Utilities Green Energy.
Four-times British surf champion, Simon Tucker said the
was a lot of feeling against the proposals within the tow
"This demonstration is to ask the developers not to dest
the very environment they claim they are trying to prote
he said. Mr Tucker said the turbines, which are taller th
the Statue of Liberty in New York, will destroy the pano
views and also have an impact on the sea.

"The turbines will change the shape of the sandbanks a
the waves," he said. "If the waves are changed and peop
sport because of the turbines then the town is going to
company behind the £100m scheme say the turbines, wh
sea level, will generate enough power for 86,000 homes
The site, which is to the west of Porthcawl, is approxima
the nearest household.

Project - Is This A New Klondyke?

y Herald (linked above) talks about the views
and disappearing as we used to know them - vast
st as they had been for hundreds of years and
n industrial scene. As we watch the first massive
aithness and Sutherland coast are we watching
other aspect of our scenery - the coastal views?
another hazard for fishing boats and vessels to
view now of anyone on the east of Caithness are
thers as we face up to rising oil prices and the
. We already see oil rigs with in view. Will wind
ut at sea than on our hills and mountains?

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Last Updated: Friday, 28 May, 2004, 16:58 GMT 17:58 UK

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Fishermen oppose wind farm plans

Hundreds of fishermen gathered in the Wash to protest against plans to build offshore wind turbines.

Hundreds of turbines could be built about five miles off the coast

The men from Boston, Skegness and King's Lynn are unhappy at government proposals to erect 250 wind turbines in the Greater Wash.

If it goes ahead, the facility would be part of one of the largest wind farms in the world.

Planning permission has already been granted for 60 turbines on two sites off the south Lincolnshire coast.

Project 'impractical'

Andy Roper, who organised the protest, emphasised the fishermen's livelihoods are being threatened.

From The Times

November 23, 2002

Winds of change will mean giant sea turbines

By Anthony Browne, Environment Editor

DOZENS of wind farms, each with hundreds of turbines up to 500ft high, are to be given the go-ahead off the coast between Scotland and Wales, around the Wash in East Anglia and in the Thames Estuary.

Yesterday's announcement was welcomed by some environmental groups; others have given warning that it will ruin views and damage sea life. Fishermen have said that they will be forced out of business.

Brian Wilson, the Energy Minister, said: "In theory, these areas could source enough electricity to power the whole of Britain, albeit intermittently. There is no doubt

From The Times

February 4, 2008

Wind farms 'a threat to national security'

Magnus Linklater and Dominic Kennedy

Ambitious plans to meet up to a third of Britain's energy needs from offshore wind farms are in jeopardy because the Ministry of Defence objects that the turbines interfere with its radar.

The MoD has lodged last-minute objections to at least four onshore wind farms in the line of sight of its stations on the east coast because they make it impossible to spot aircraft, *The Times* has learnt. The same objections are likely to apply to wind turbines in the North Sea, part of the massive renewable energy project announced by John Hutton, the Energy Secretary, barely two months ago. They would be directly in line with the three principal radar defence stations, Brizlee Wood, Saxton Wold and Trimingham on the Northumberland, Yorkshire and Norfolk coasts.

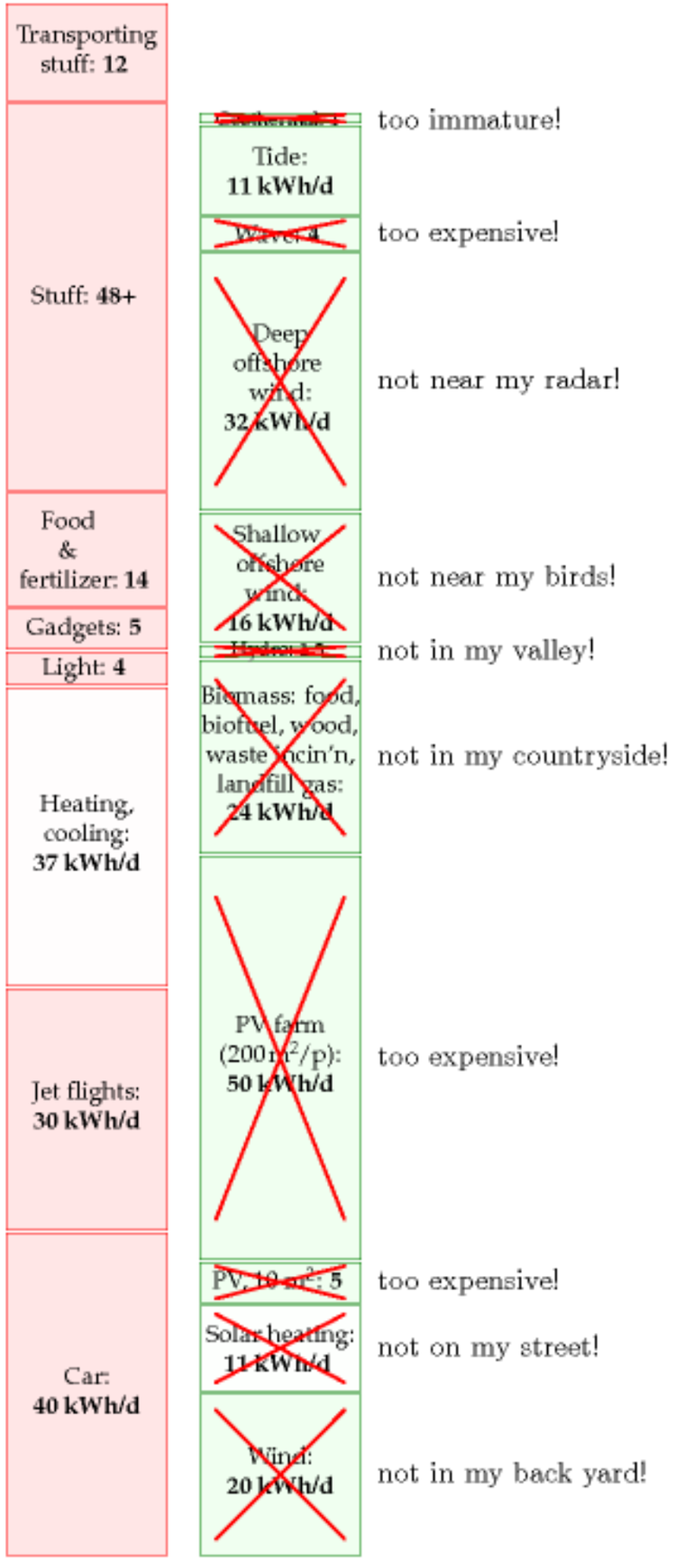
Wind power 'a security ris

02 November 2007 08:15

Defence chiefs threw the future of East Anglia's wind energy industry into confu
last night after claiming that wind turbin
could be a threat to national security.

Experts say the MoD now objects to abou
50pc of applications to build onshore wir
turbines because of concerns they affect
performance of military radar.

Transporting stuff: **12**		
Stuff: **48+**	~~Geothermal: 1~~	
	Tide: **11 kWh/d**	
	~~Wave: 4~~	too expensive!
	~~Deep offshore wind: **32 kWh/d**~~	not near my radar!
Food & fertilizer: **14**	~~Shallow offshore wind: **16 kWh/d**~~	not near my birds!
Gadgets: **5**	~~Hydro: 4.5~~	not in my valley!
Light: **4**		
Heating, cooling: **37 kWh/d**	~~Biomass: food, biofuel, wood, waste incin'n, landfill gas: **24 kWh/d**~~	not in my countryside!
Jet flights: **30 kWh/d**	~~PV farm (200 m^2/p): **50 kWh/d**~~	too expensive!
Car: **40 kWh/d**	~~PV, 10 m^2: **5**~~	too expensive!
	~~Solar heating: **11 kWh/d**~~	not on my street!
	~~Wind: **20 kWh/d**~~	not in my back yard!


Transporting stuff: 12
Stuff: 48+
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Heating, cooling: 37 kWh/d
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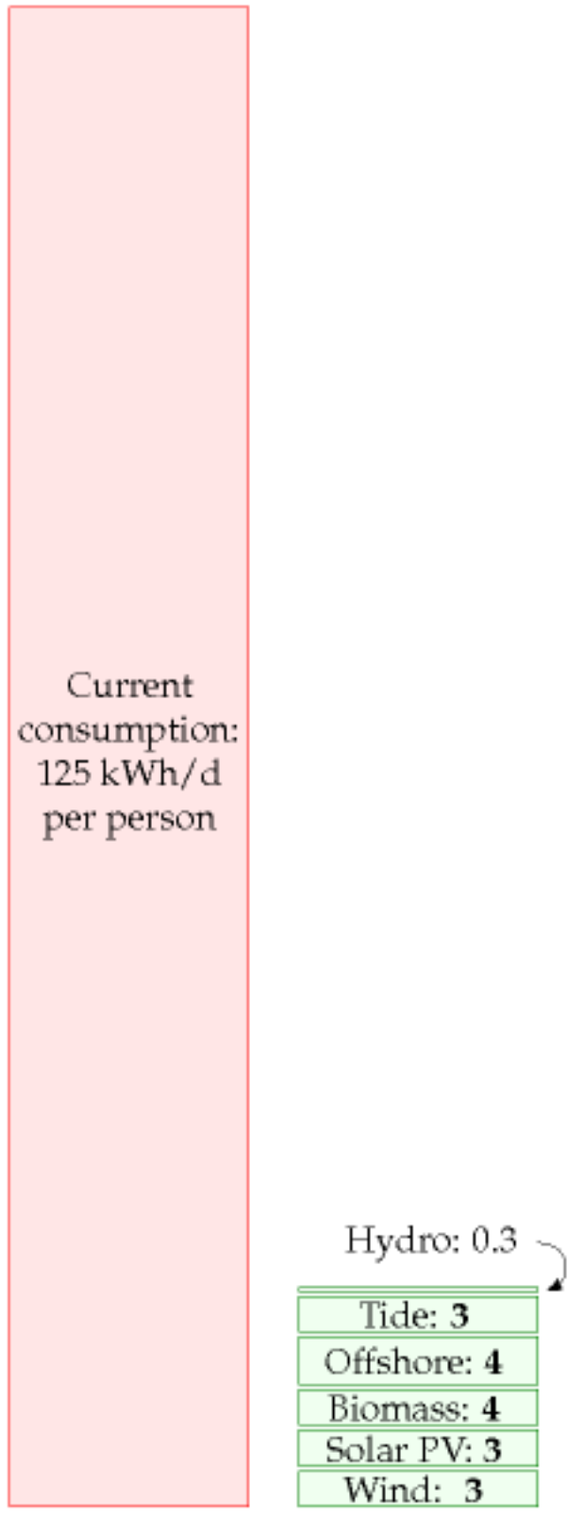
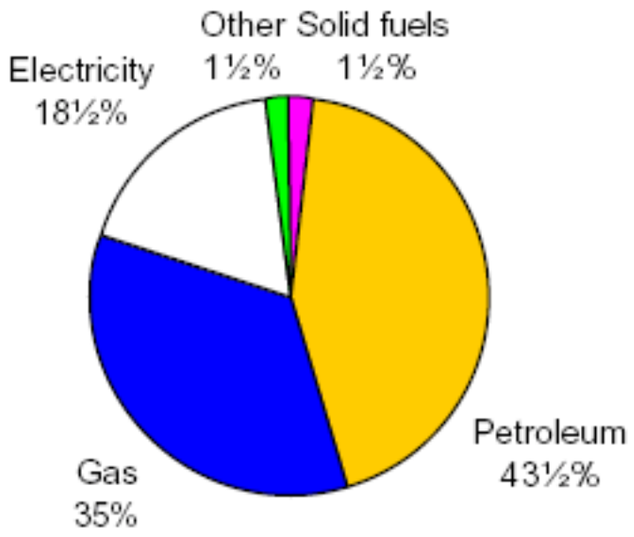
not on my street!
Wind: 20 kWh/d
not in my back yard!

after the great British consultation exercise...

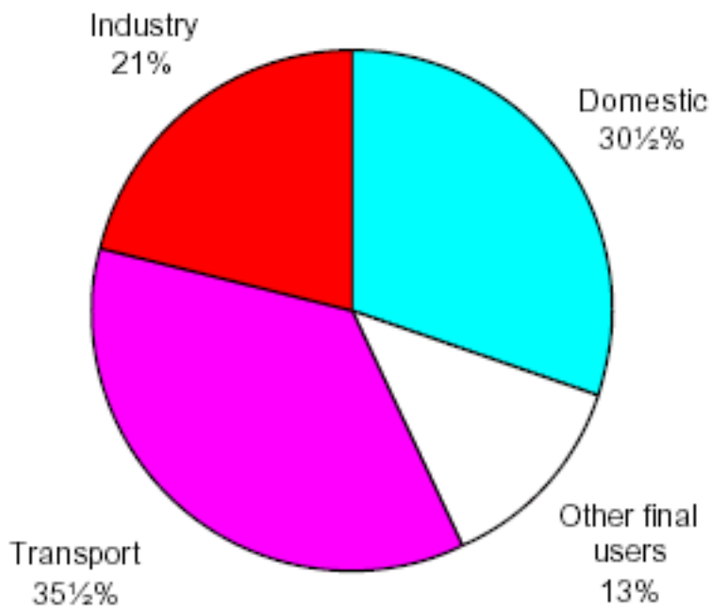


This would be a 15-fold increase of renewables

Average power consumption, UK: 125 kWh/d/p



2004



www.dti.gov.uk

'primary consumption'

125 kWh/day (Europe)

250 kWh/day (USA)

(doesn't include imports,
nor solar energy in food)

For CO_2 pollution, divide by 10:

100 kWh/day $\simeq$ 10 tonnes CO_2/yea

Conclusions - part I

A country like Britain

can't live on

its own renewables

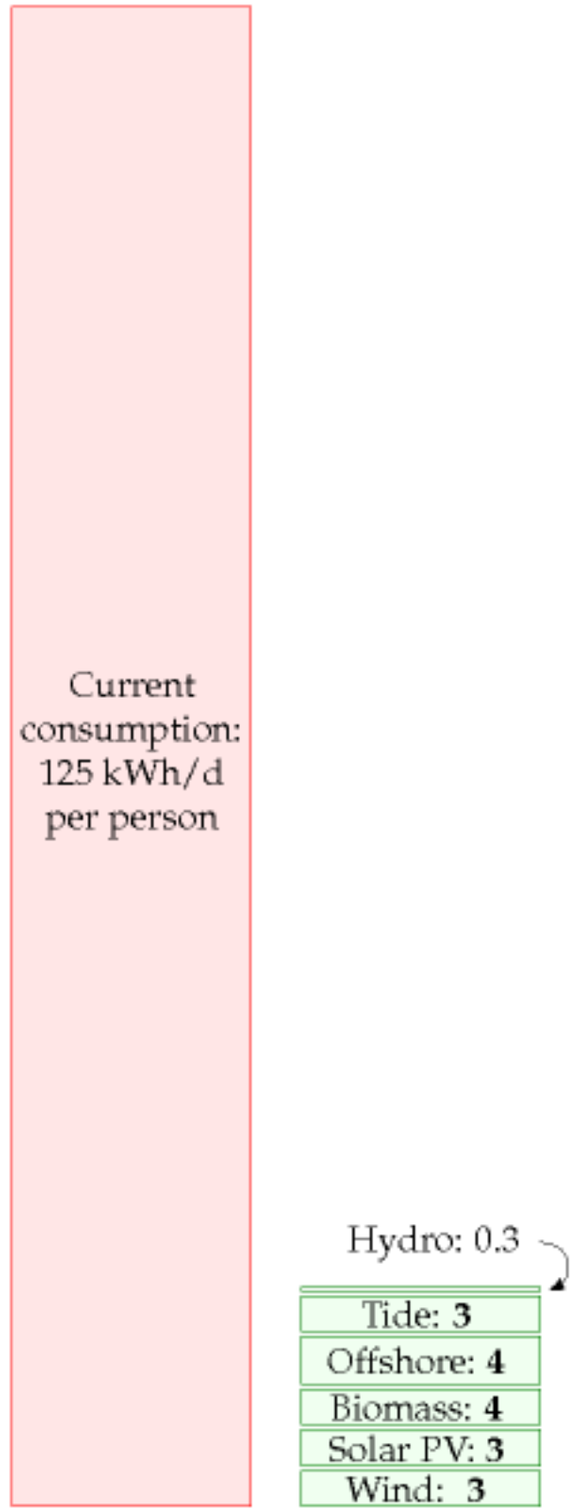
- at least,

not as we currently live

To make a difference,

renewables have to be

country-sized



Renewables are diffuse

	Power per unit land area
Wind	$2\,\mathrm{W/m^2}$
Offshore wind	$3\,\mathrm{W/m^2}$
Tidal pools	$3\,\mathrm{W/m^2}$
Tidal stream	$8\,\mathrm{W/m^2}$
Solar PV panels	5–$20\,\mathrm{W/m^2}$
Plants	$0.5\,\mathrm{W/m^2}$
Solar chimney (Spain)	$0.1\,\mathrm{W/m^2}$
Concentrating solar power (desert)	15–$20\,\mathrm{W/m^2}$
Ocean thermal	$5\,\mathrm{W/m^2}$
Rain-water (highlands)	$0.24\,\mathrm{W/m^2}$
Rain-water (lowlands)	$0.02\,\mathrm{W/m^2}$

- To make a difference, renewable facilities have to be country-sized

Block

News

News
England
Northern Ireland
Scotland
Wales
International
RSS feeds

PRINT Block

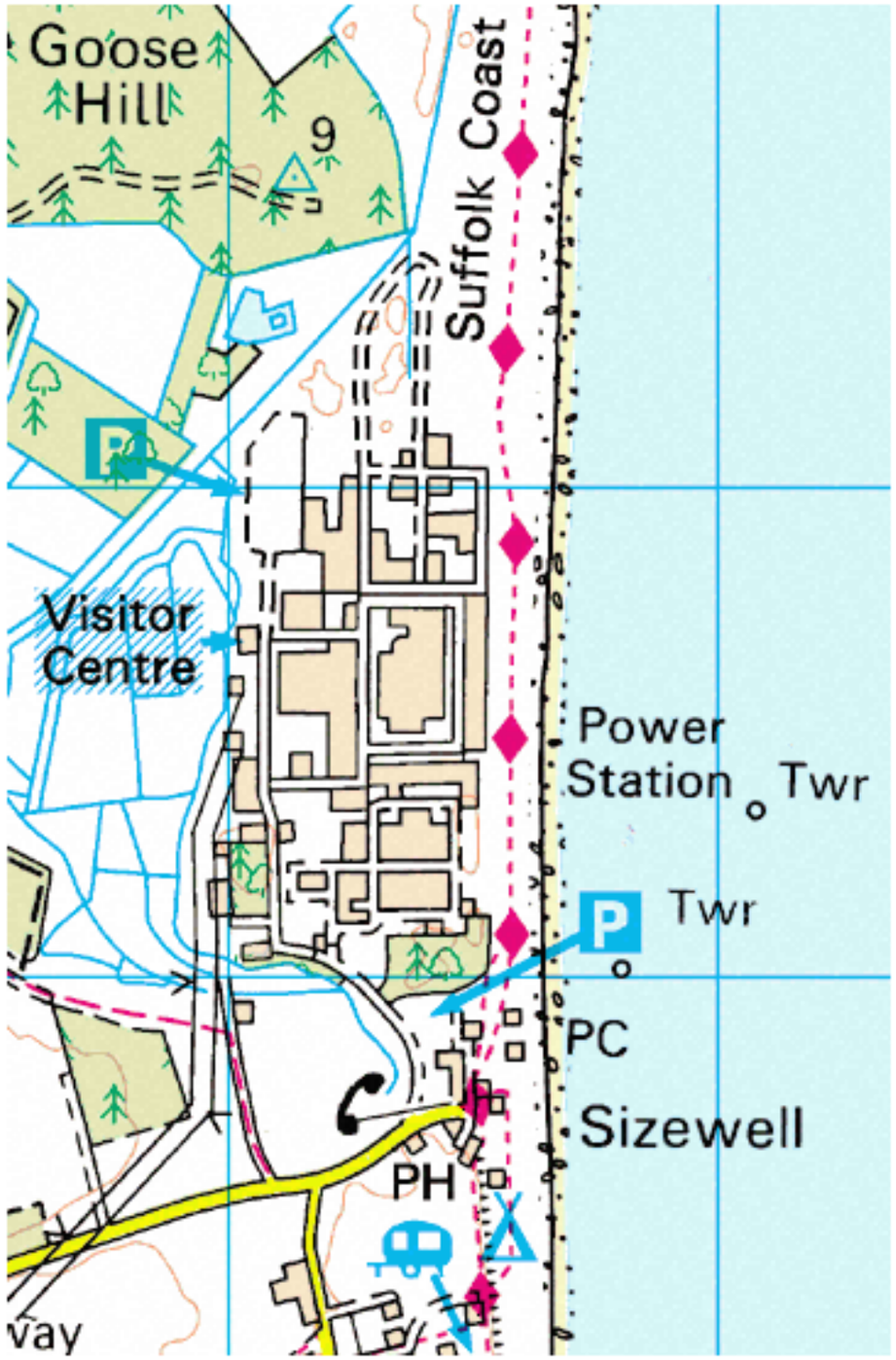
No green light for Severn barrage

Last modified: 01 October 2007

Europe's most dynamic estuary will be destroyed by the construction of a barrage across the Severn while other less striking measures would cost less and could do more to cut carbon emissions.

"other less striking measures"?

To make a difference, renewable facilities have to be country-sized



Nuclear	
Fission	$1000\,\mathrm{W/m^2}$

How to make an energy plan that adds up

- Demand-side
  - Reduce population
  - Change lifestyle
  - Technology, efficiency
- Supply-side
  - 'Clean coal'
  - Nuclear power
  - Use other countries' renewables

Current consumption: 125 kWh/d per person

Hydro: 0.3

Tide: **3**
Offshore: **4**
Biomass: **4**
Solar PV: **3**
Wind: **3**

A Mitsubishi Warrior, yesterday

Efficiency - for transport

- "Baby on board"

80 kWh per 100 person-km (1 person)

How can this consumption be reduced?

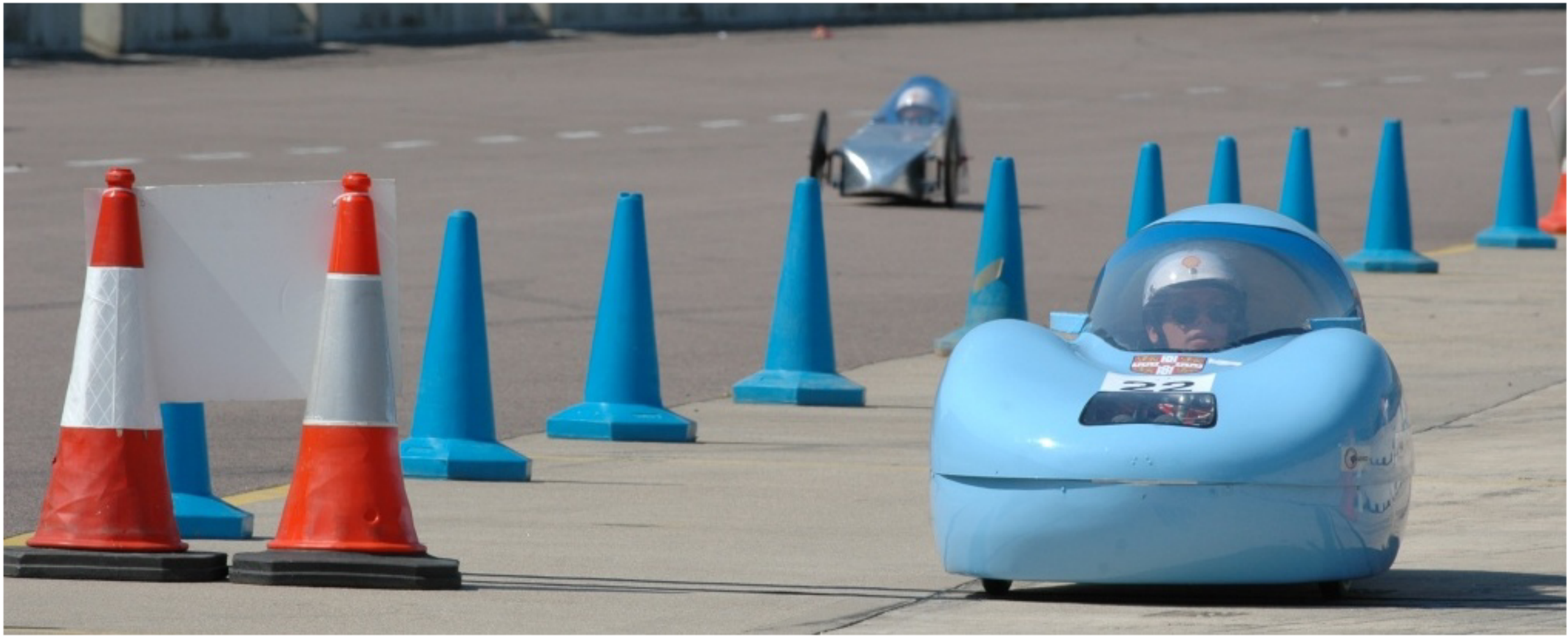
- Two babies on board!

1 kWh per 100 person-km (3 people)

6 kWh per 100 person-km average

3 kWh per 100 person-km if full

Eco-car



1.3 kWh per 100 person-km (takes 1 teenager)

[2200 mpg]

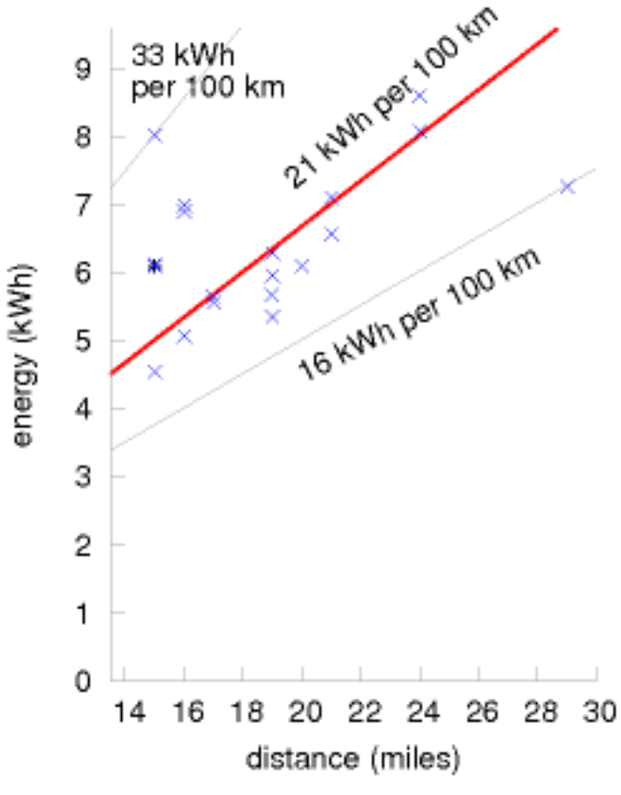
at 15 mph

http://www.teamcrocodile.com/

Electric cars

21 kWh per 100 km (solo)

equivalent to 125 miles per gallon



data from Kele Baker

G-Wiz

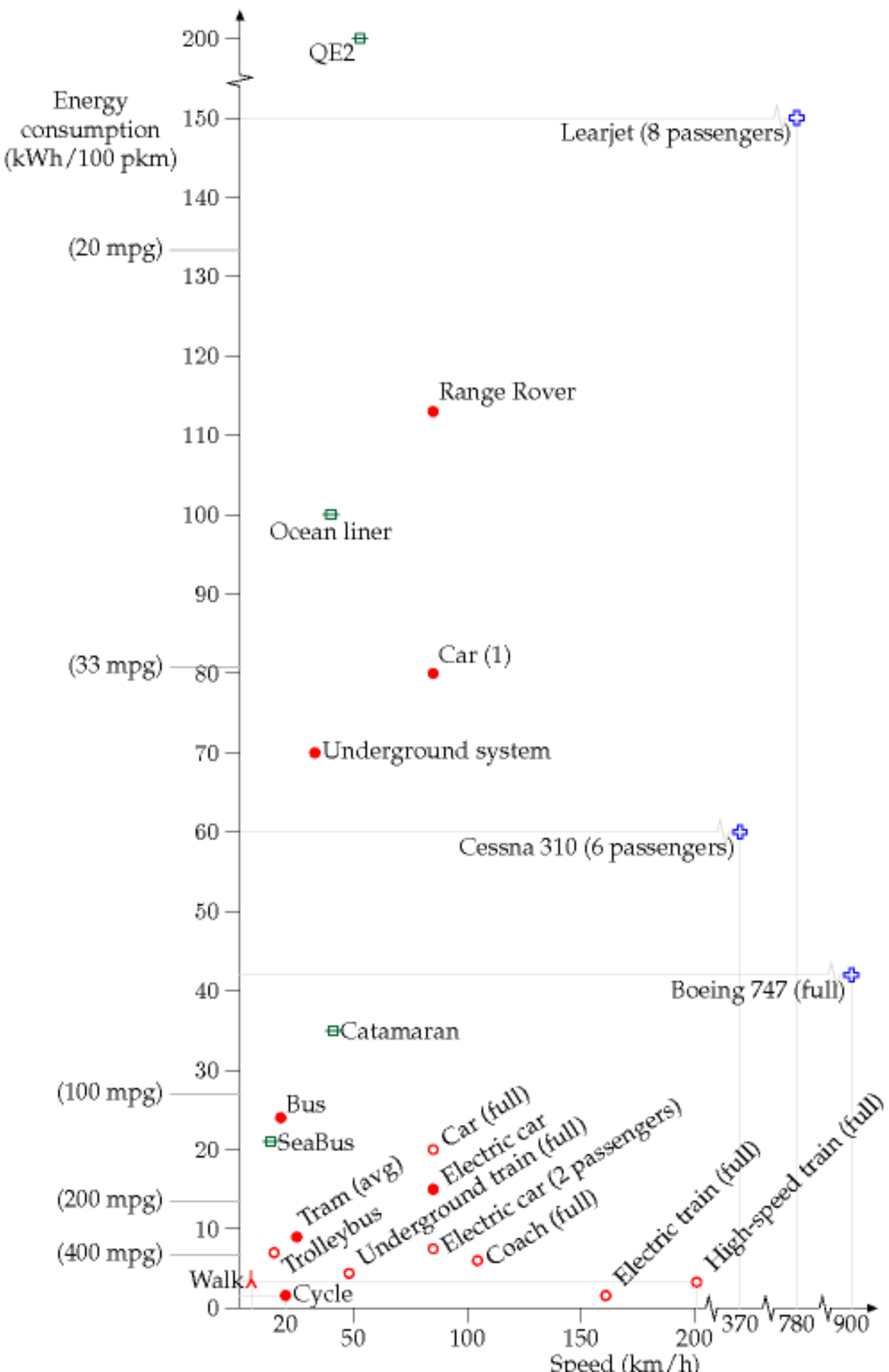
6 kWh per 100 km

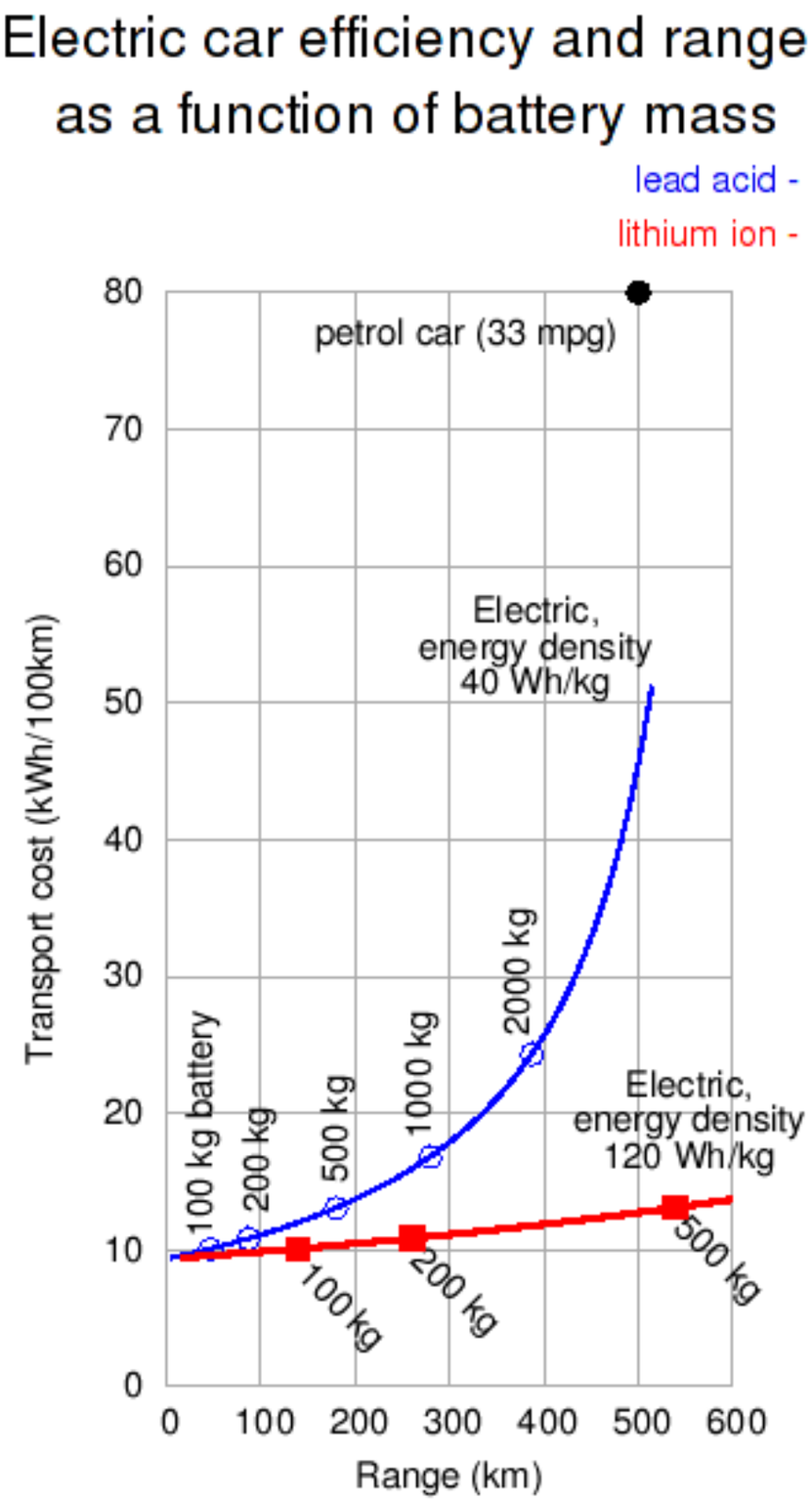
Electric scooters

3 kWh per 100 km

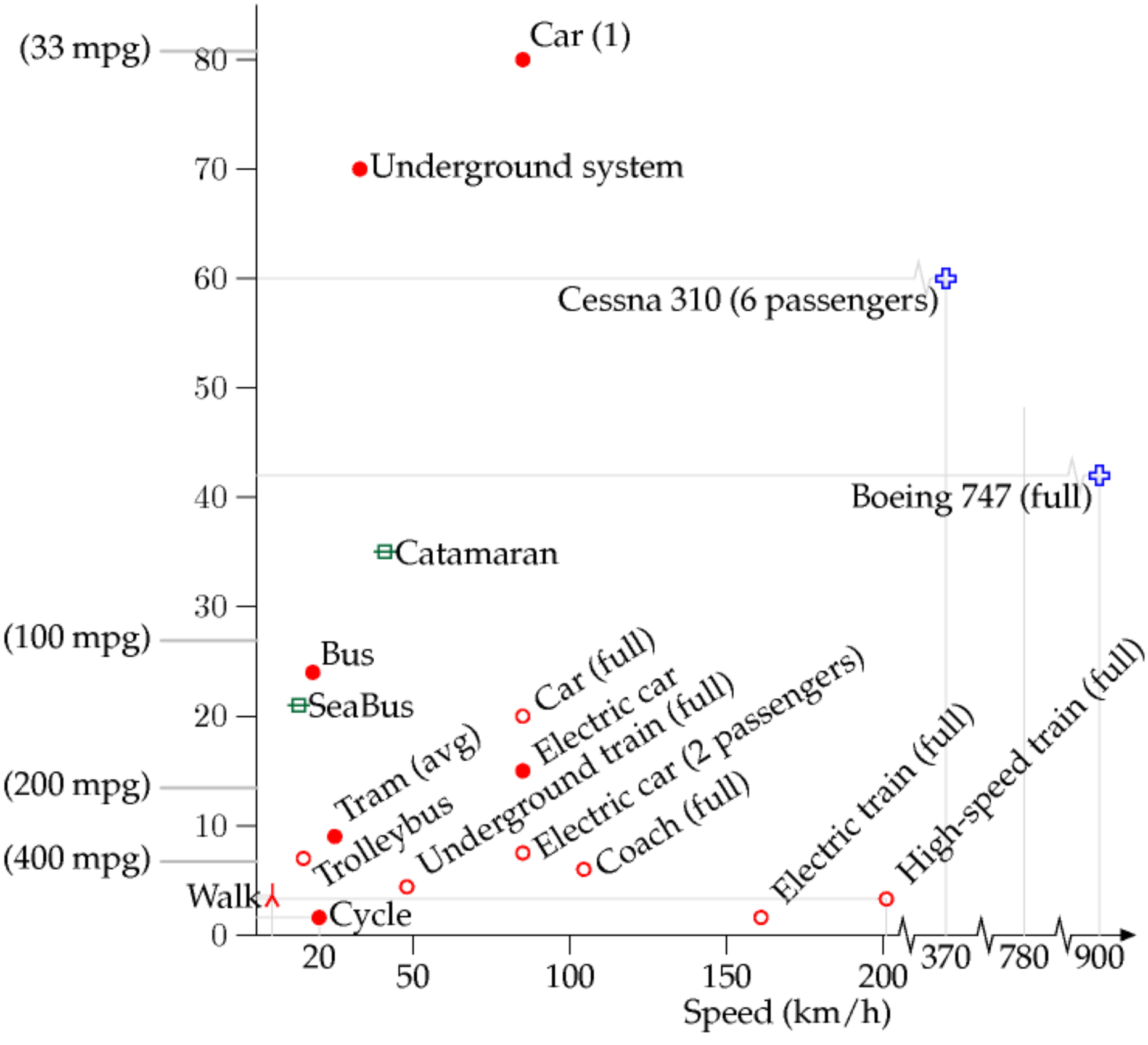
http://www.vectrix.com/

Electric trains


Energy consumption (kWh/100 pkm)
200
150
140
(20 mpg)
130
120
110
100
90
(33 mpg)
80
70
60
50
40
30
(100 mpg)
20
(200 mpg)
10
(400 mpg)
0
QE2
Learjet (8 passengers)
Range Rover
Ocean liner
Car (1)
Underground system
Cessna 310 (6 passengers)
Boeing 747 (full)
Catamaran
Bus
SeaBus
Tram (avg)
Trolleybus
Car (full)
Electric car
Underground train (full)
Electric car (2 passengers)
Coach (full)
Electric train (full)
High-speed train (full)
Walk
Cycle
20
50
100
150
200
370
780
900
Speed (km/h)


Electric car efficiency and range as a function of battery mass
lead acid -
lithium ion -
Transport cost (kWh/100km)
80
70
60
50
40
30
20
10
0
petrol car (33 mpg)
Electric, energy density 40 Wh/kg
100 kg battery
200 kg
500 kg
1000 kg
2000 kg
Electric, energy density 120 Wh/kg
100 kg
200 kg
500 kg
0
100
200
300
400
500
600
Range (km)

Energy consumption (kWh per 100 passenger-km)



Efficiency II

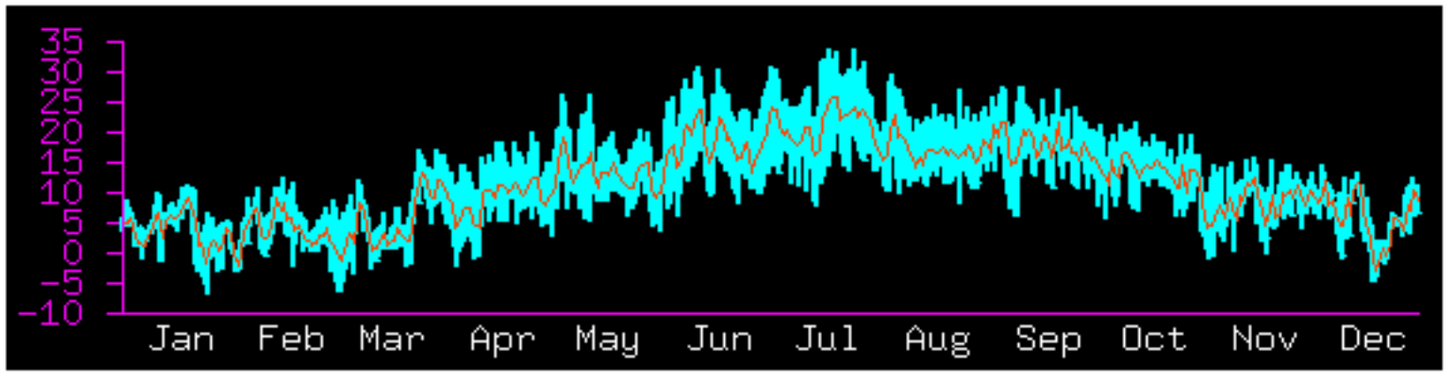
- Heating

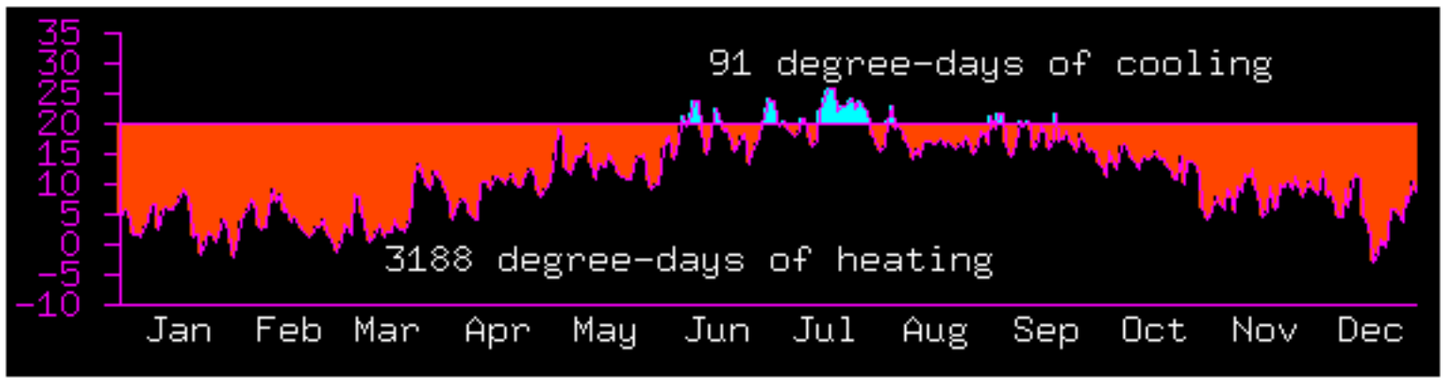
$$\underbrace{\boxed{\text{Heat loss}}}_{\text{(kWh/d)}} = \underbrace{\text{Leakiness}}_{\text{(kWh/d/°C)}} \times \underbrace{\text{Average temperature difference}}_{\text{(°C)}}$$

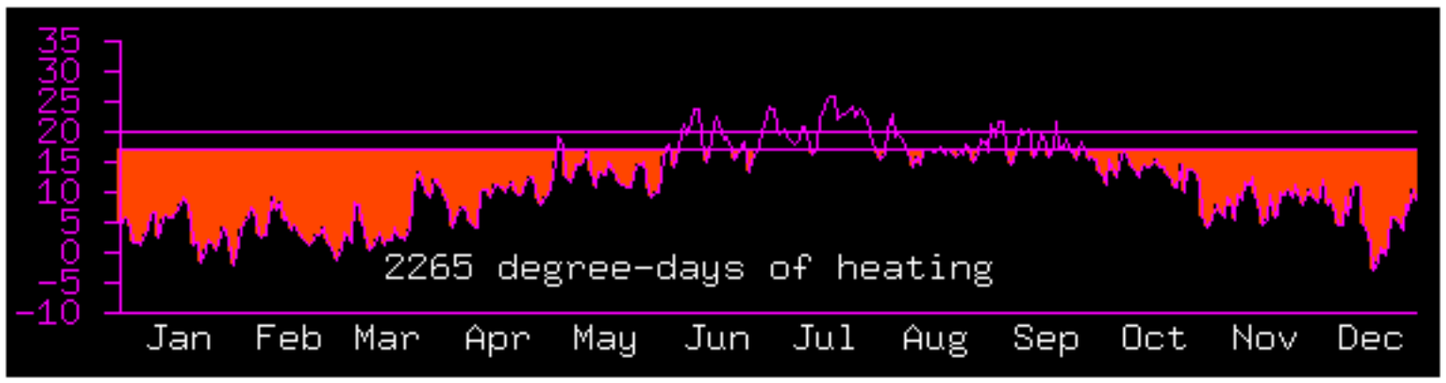
$$\text{Power required} = \boxed{\text{Heat loss}} \Big/ \text{Coefficient of performance of heat-creation}$$

Turn the thermostat down

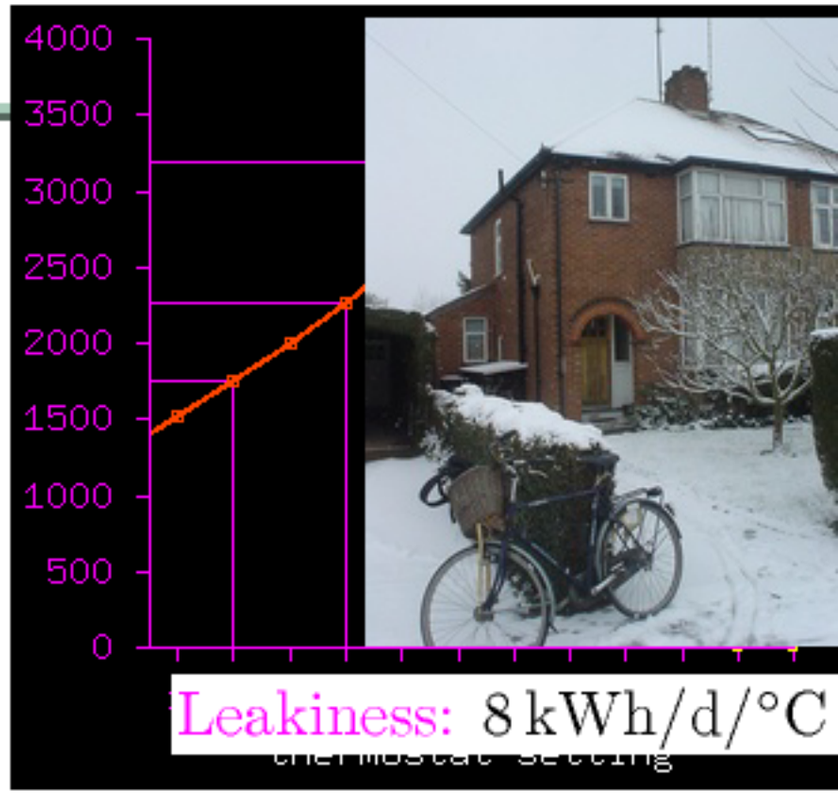
$$\underset{\text{(kWh/d)}}{\boxed{\text{Heat loss}}} = \underset{\text{(kWh/d/°C)}}{\text{Leakiness}} \times \underset{\text{(°C)}}{\text{Average temperature difference}}$$



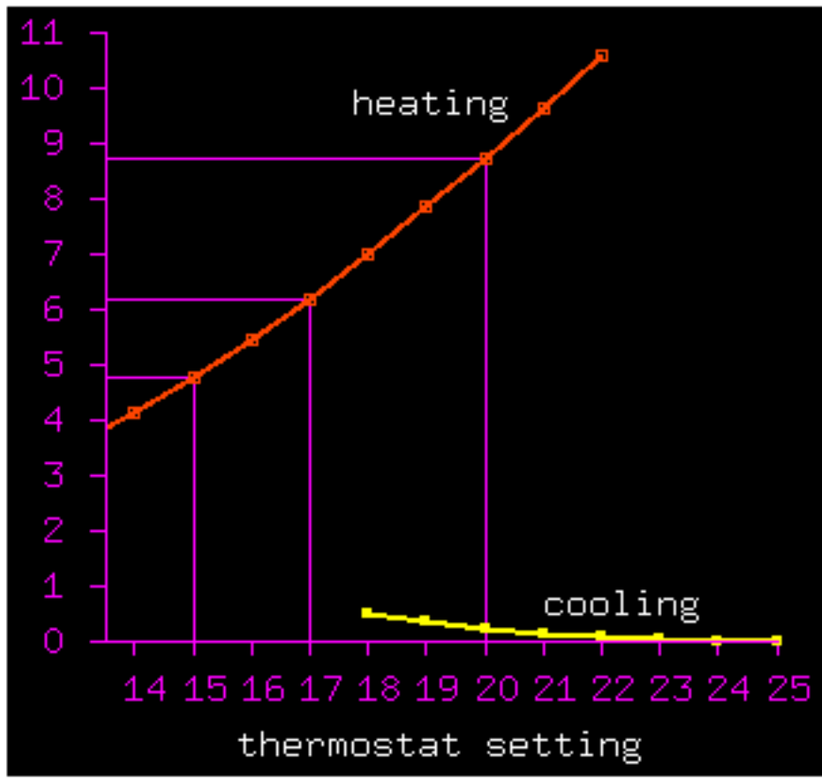




Temperature demand, in degree-days per year



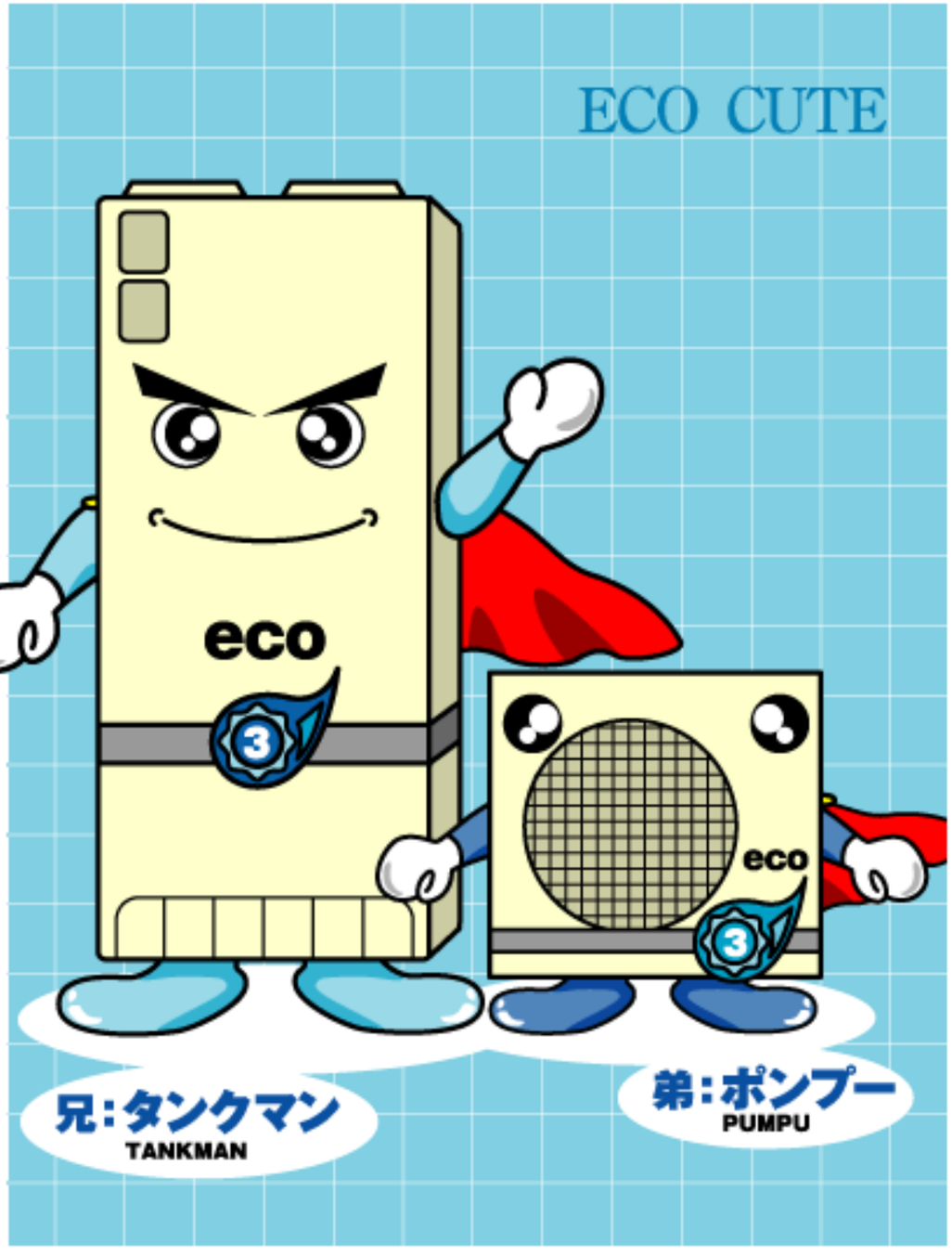
Average temperature difference



Reduce leakiness

New leakiness: 6 kWh/d/°C

Increase coefficient of performance - use Heat pumps



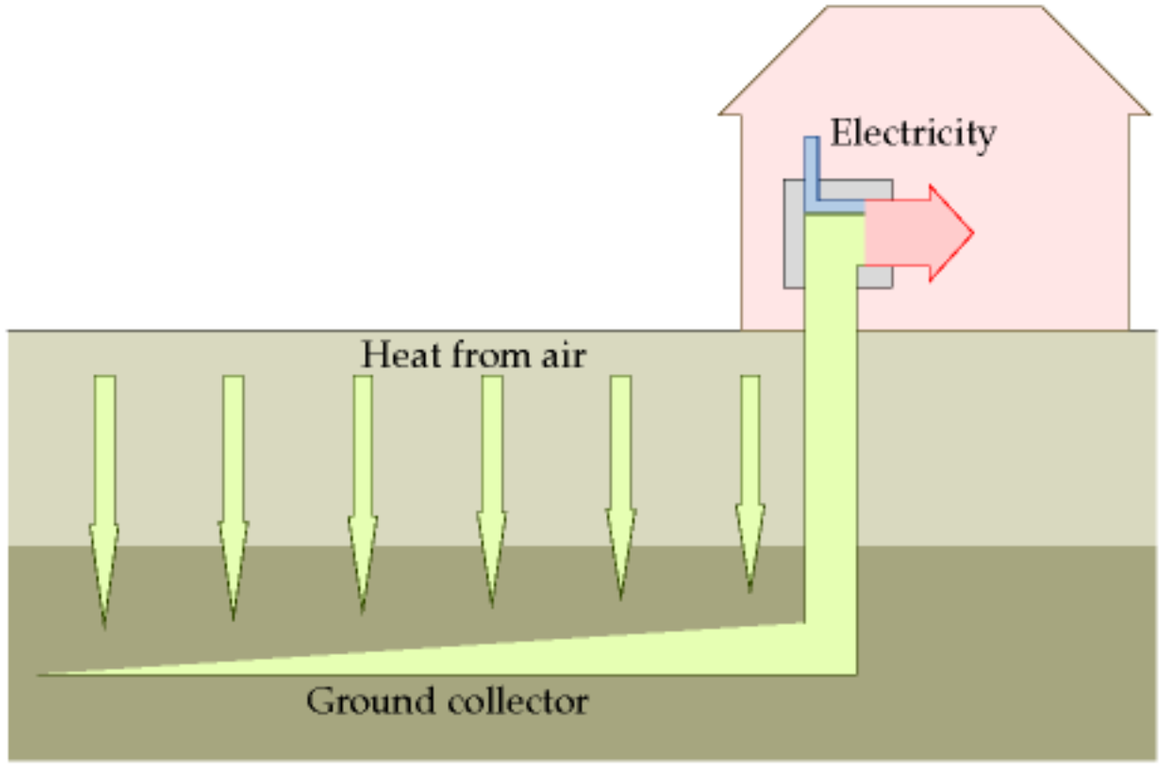
http://www.ecosystem-japan.com/

EcoCute water heater - CoP = 4.9!

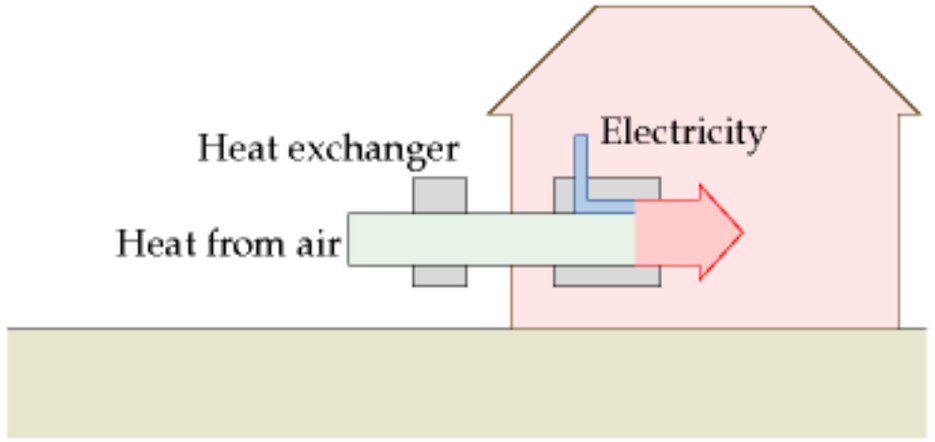
$$\text{Power required} = \boxed{\text{Heat loss}} \Big/ \begin{matrix}\text{Coefficient of performance} \\ \text{of heat-creation}\end{matrix}$$

Heating without fossil fuels

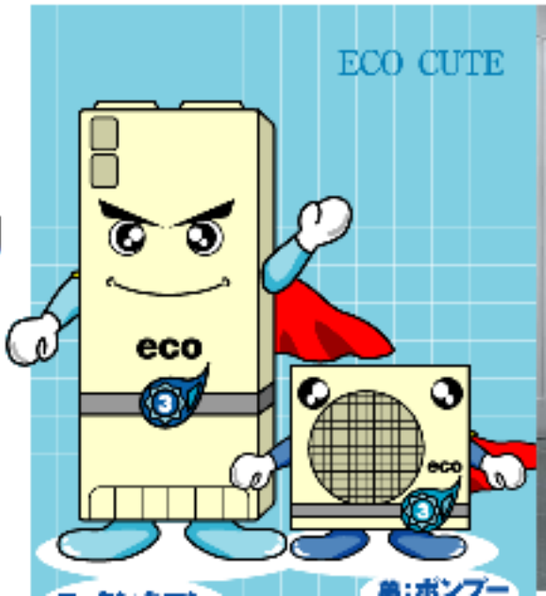
- Heat pumps, powered by electricity
  - Ground-source heat pumps



  - Air-source heat pumps

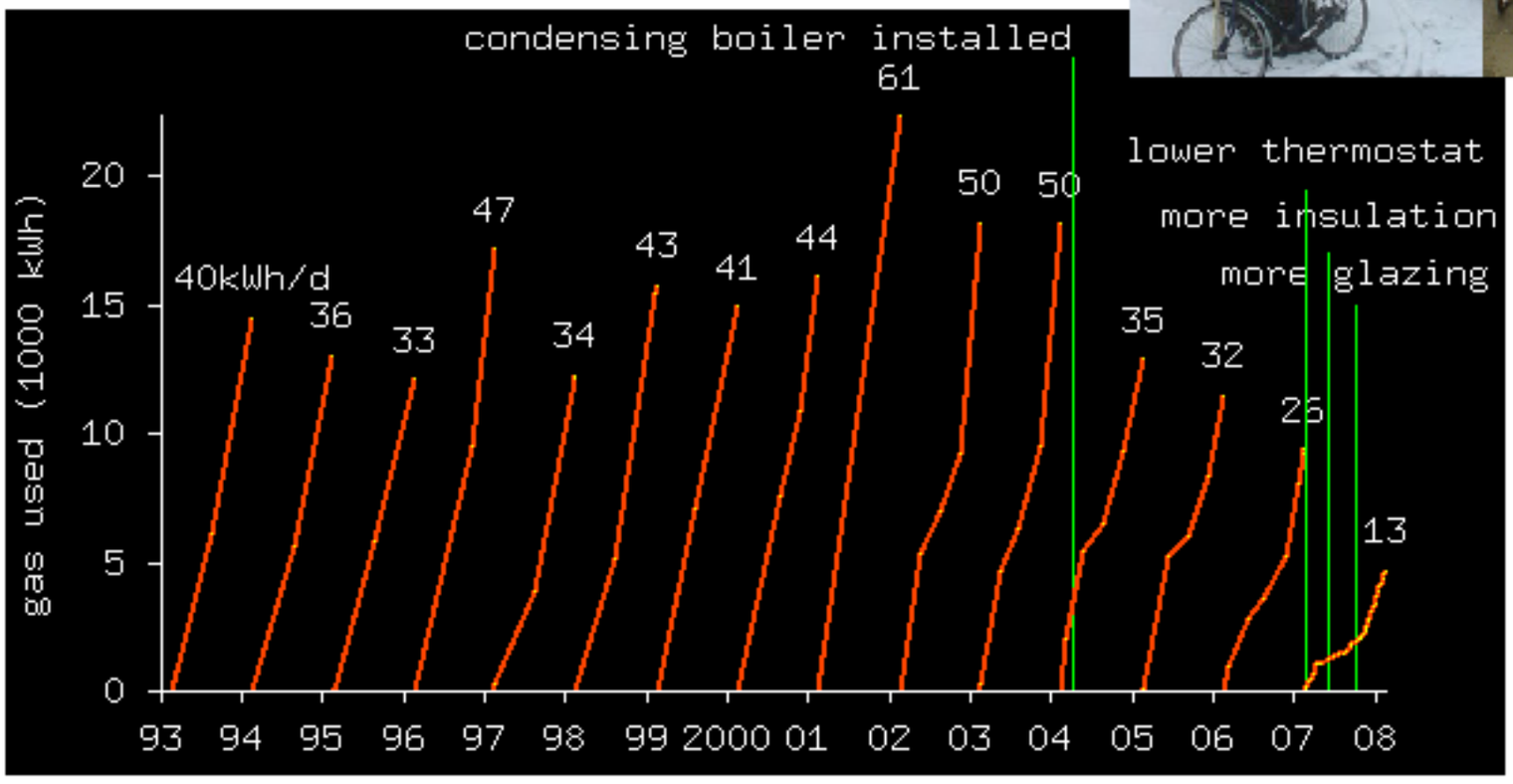


4 times more efficient than ordinary electric heating

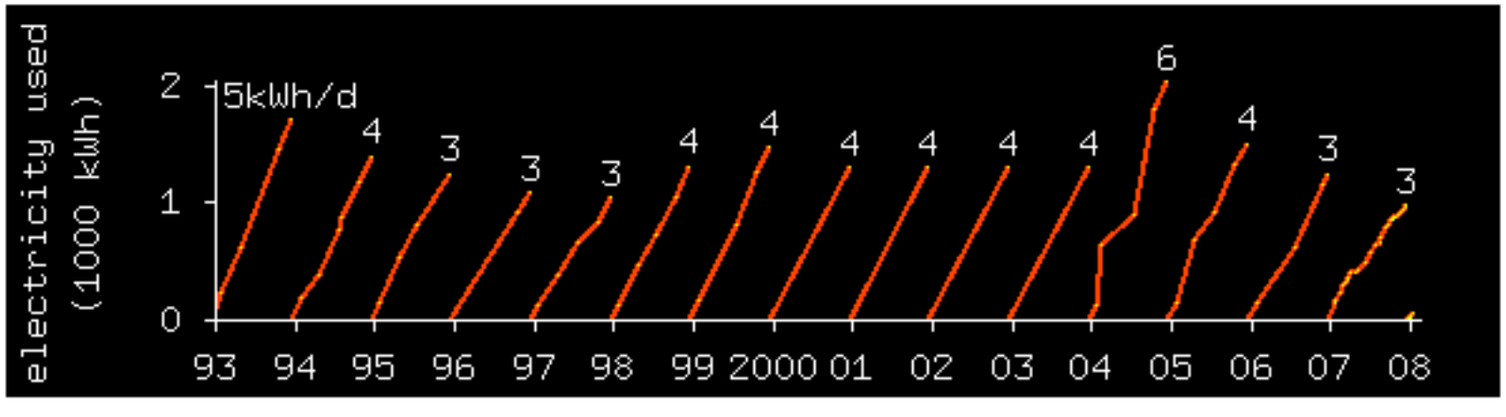


Read your meters!

- Gas

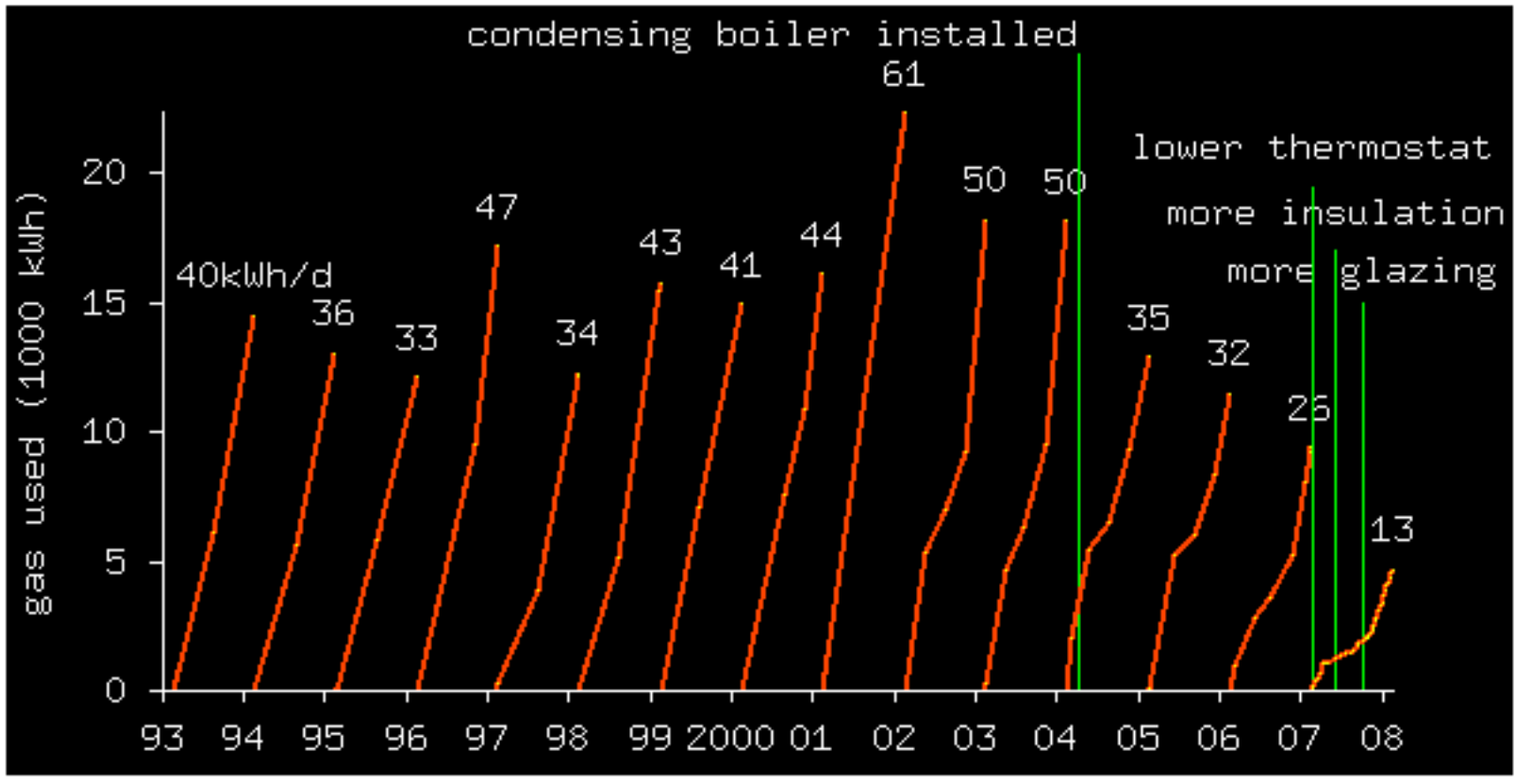


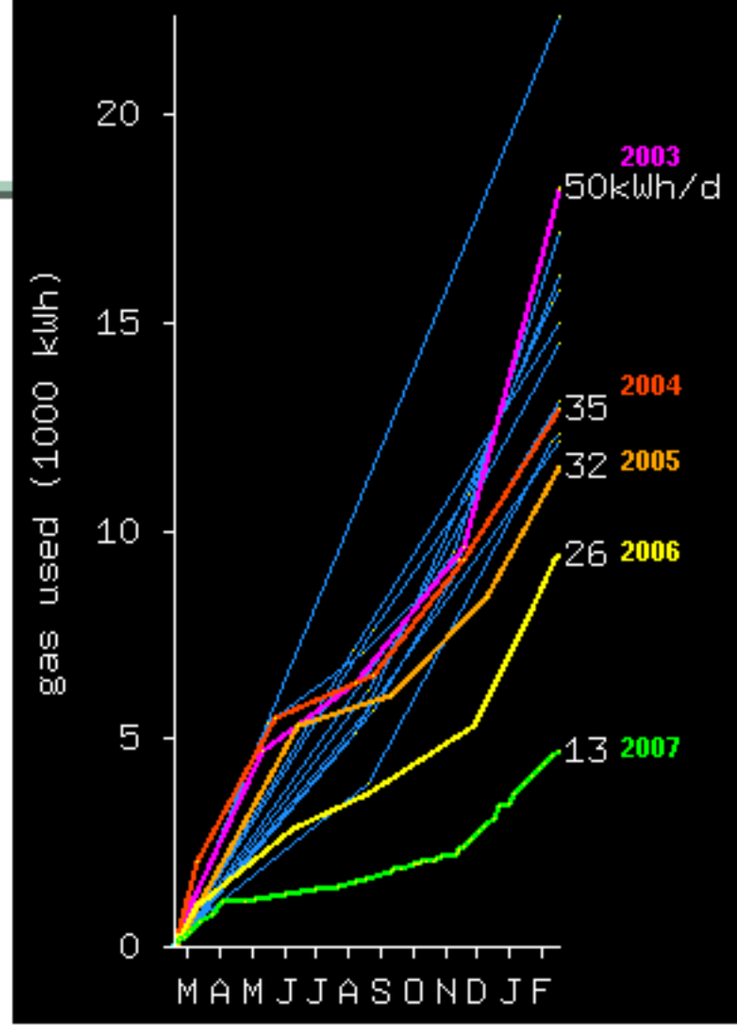
- Electricity



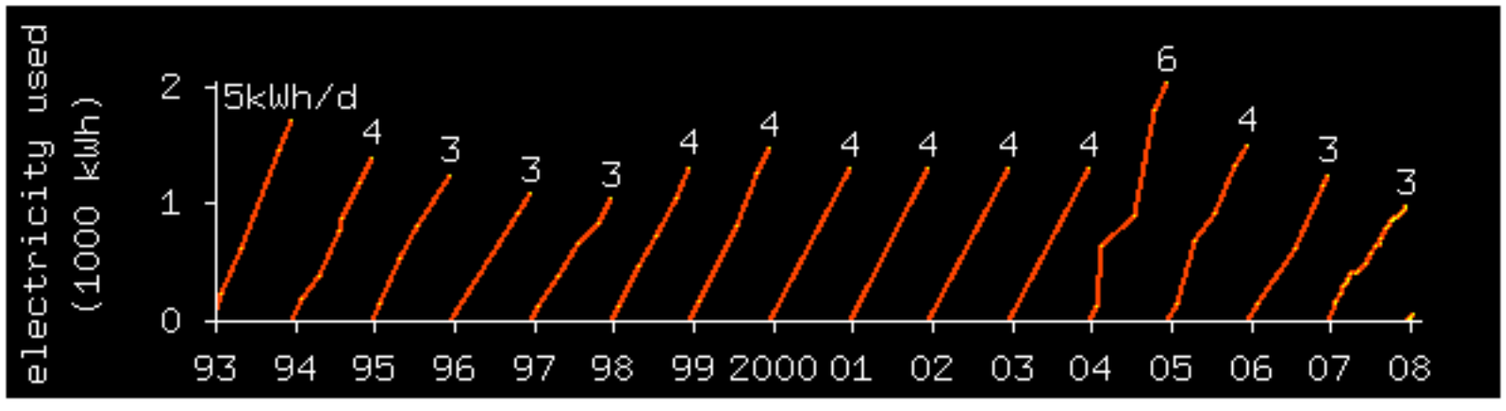
Read your meters!

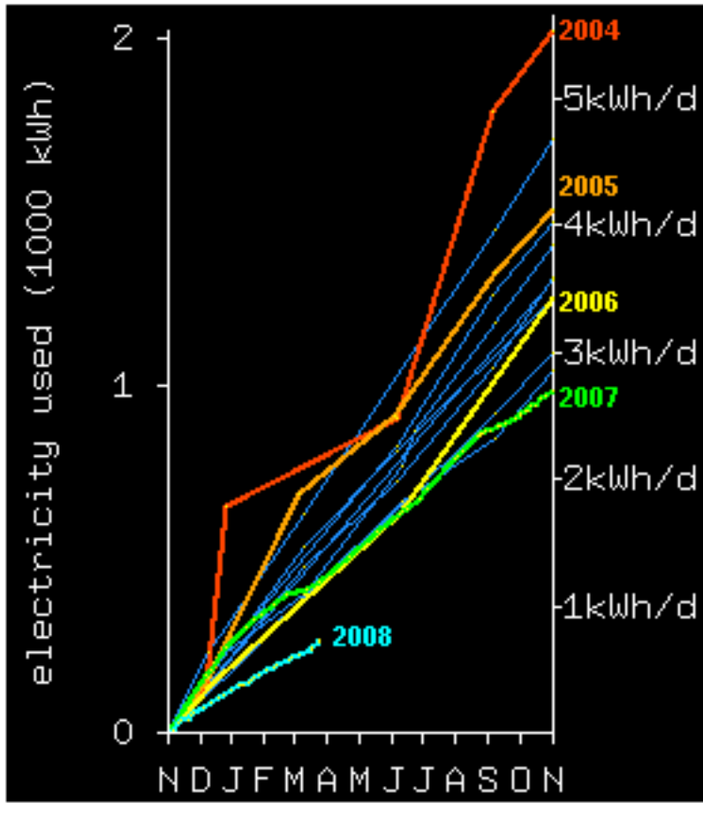
Gas





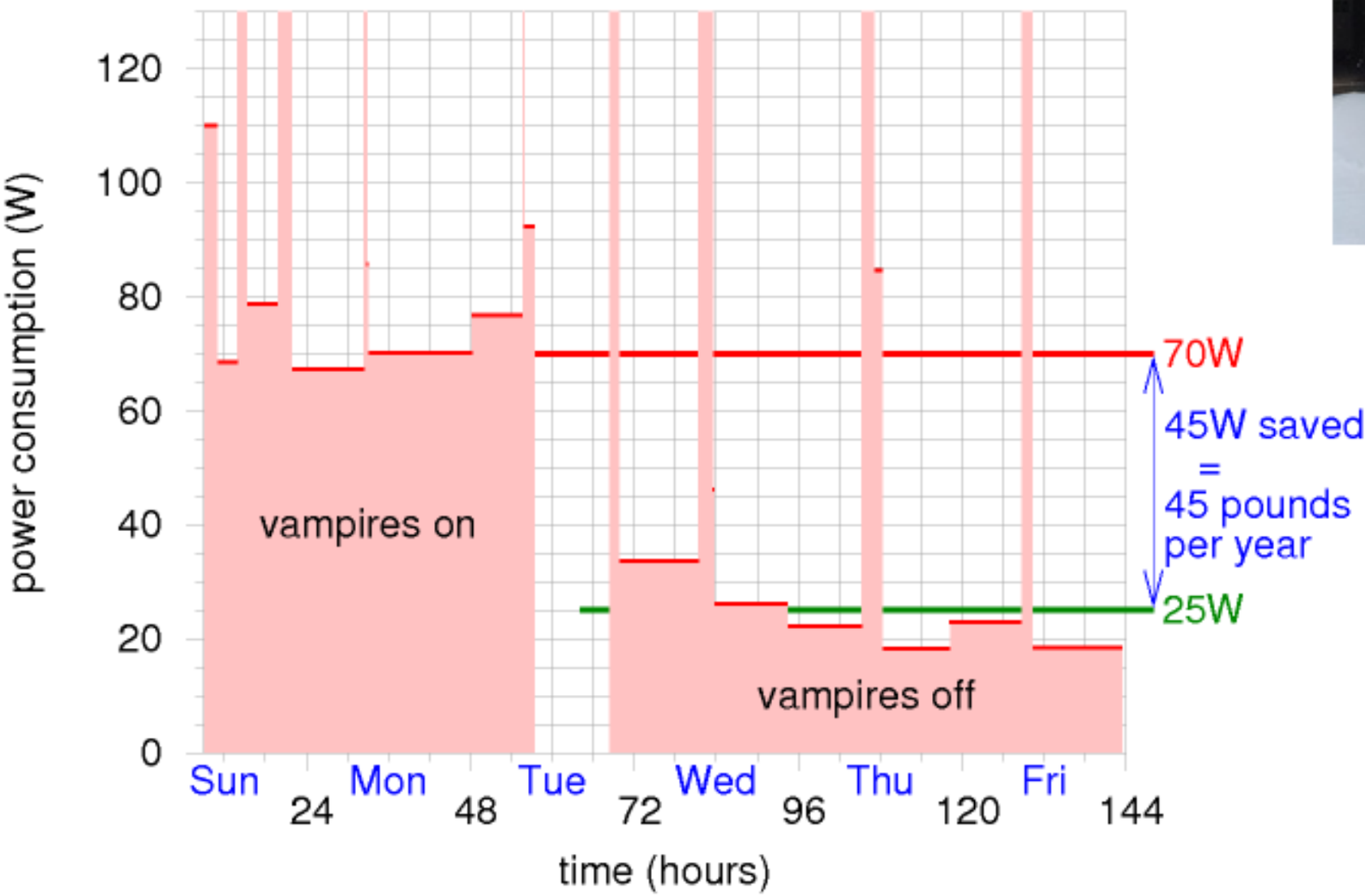
Electricity





Efficiency in the offing

- Electricity



Efficiency and technology

- Jevons' paradox

"as technological improvements increase the efficiency with which a resource is used, total consumption of that resource may increase, rather than decrease."

For example, from 1900 to 2000, passenger transportation in the USA became 5 times more energy-efficient; but nowadays, the average person travels 50 times further.

World Business Council for Sustainable Development

DEDICATED TO MAKING A DIFFERENCE

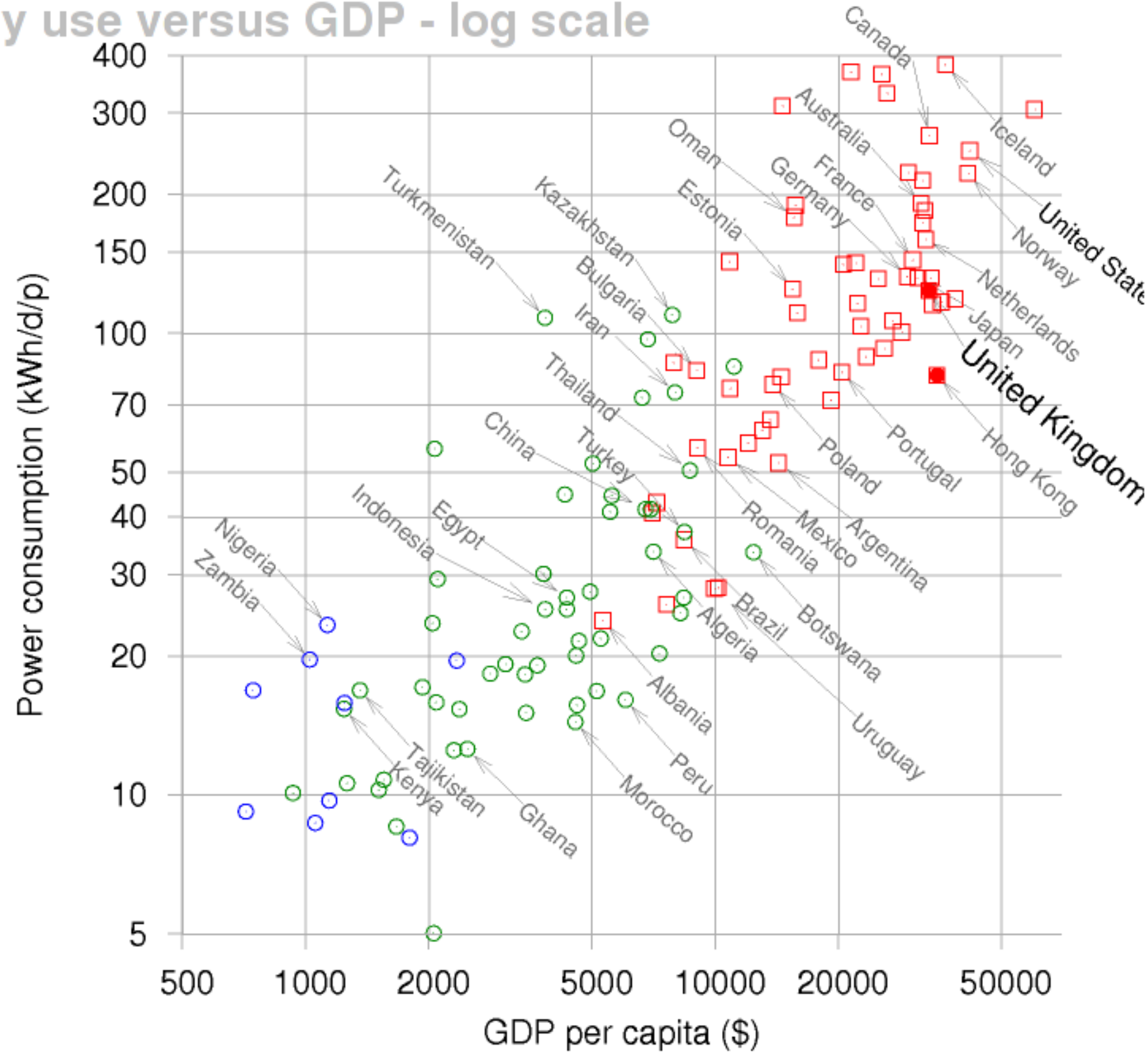
Energy and climate change

"A reduction in growth is not an acceptable path to a lower-carbon world."

"the truth is no country is going to cut its growth or consumption substantially in light of a long-term environmental problem"

Sept 15 2005

Energy use versus GDP - log scale



How to make an energy plan that adds up

- Demand-side
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  - Technology, efficiency
- Supply-side
  - 'Clean coal'
  - Nuclear power
  - Use other countries' renewables

Current consumption: 125 kWh/d per person

Hydro: 0.3

Tide: **3**

Offshore: **4**

Biomass: **4**

Solar PV: **3**

Wind: **3**

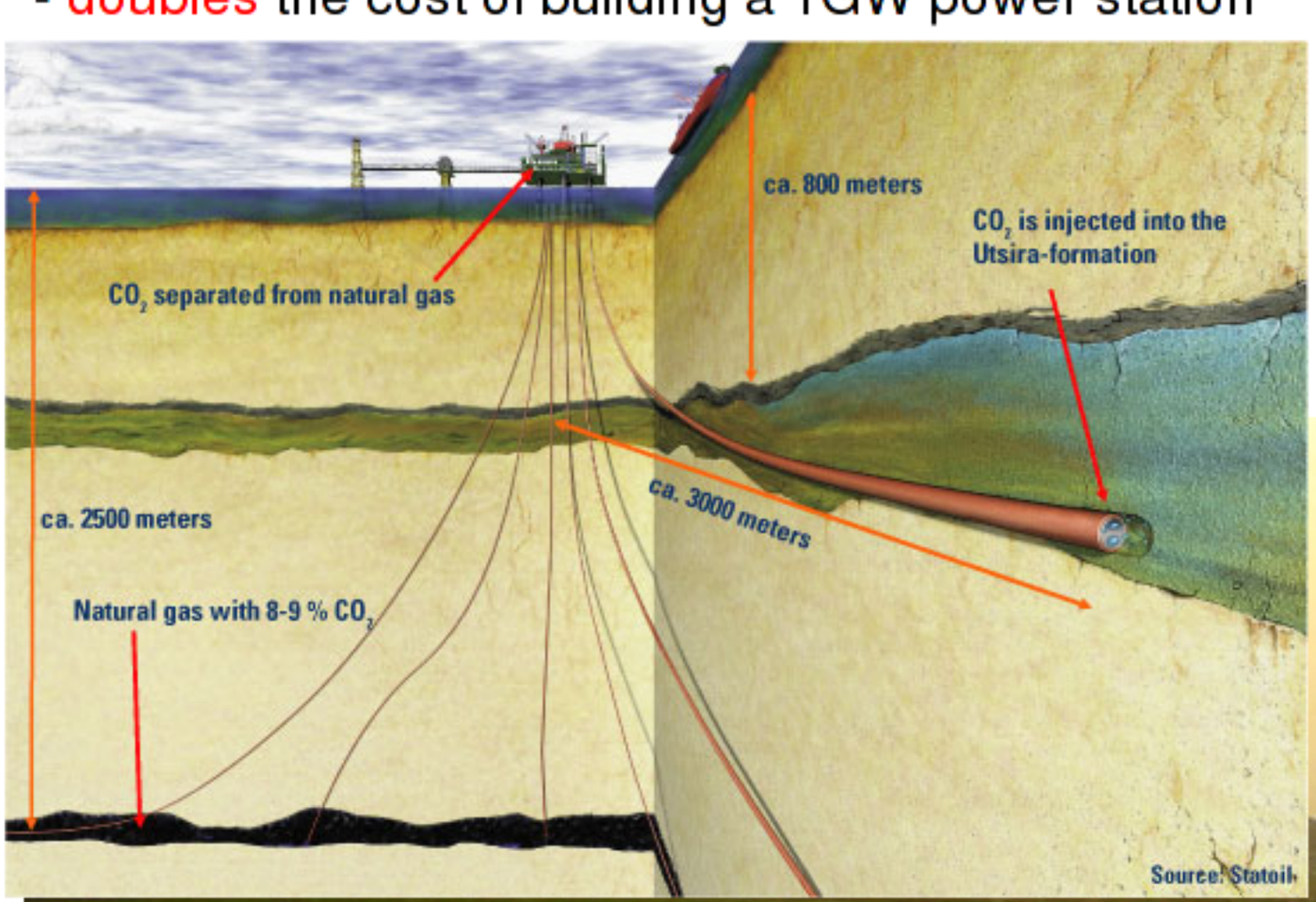
'Sustainable fossil fuels'

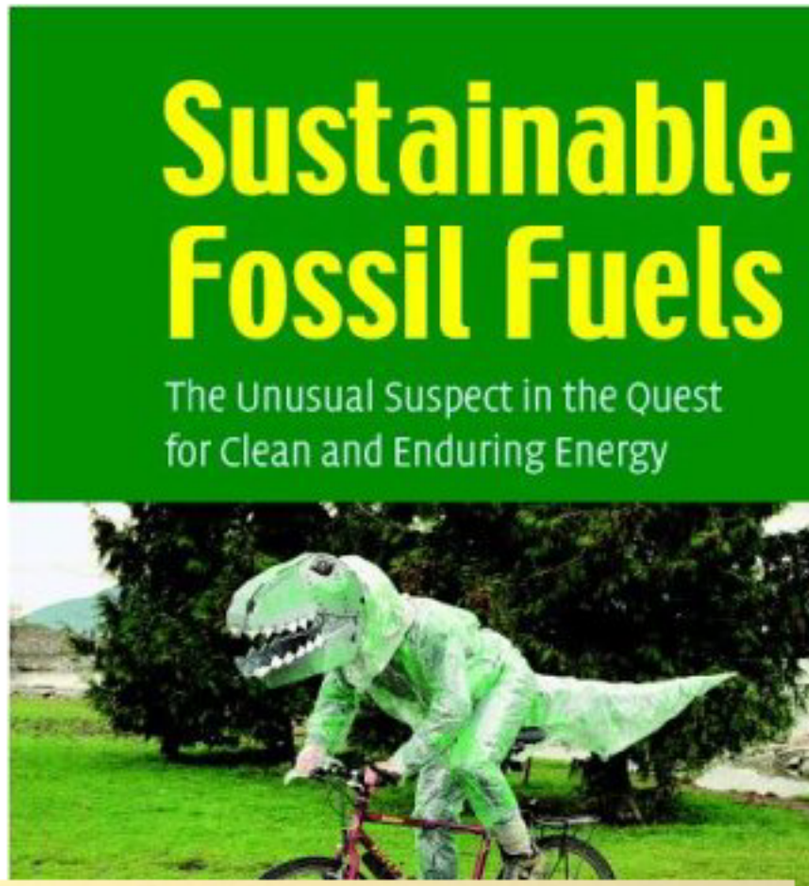
$$\frac{1600\ \text{Gt of coal}}{6\ \text{billion people}} \Big/ 1000\ \text{years} \times 8000\ \text{kWh per tonne} = 6\,\text{kWh per day per person}$$

Coal:
6 kWh/d

Carbon capture and storage

- requires 25% of the generated energy
- doubles the cost of building a 1GW power station





Nuclear Fission ('sustainable' = 1000 years)

Uranium

Assuming 27 Mt U recoverable

	Mined uranium	Ocean uranium	River uranium
Once-through	0.55 kWh/d	7 kWh/d	.1 kWh/d
Fast breeder	33 kWh/d	420 kWh/d	5 kWh/d

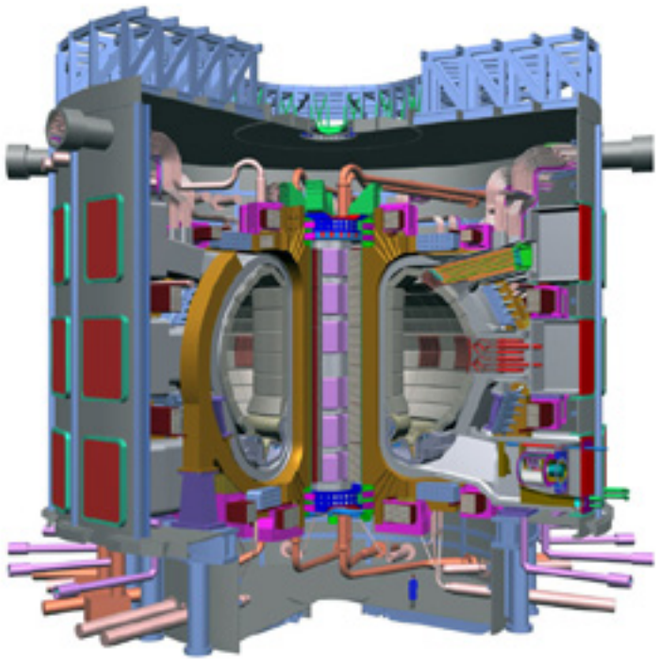
Thorium

Assuming 1.6 Mt Th recoverable

	Mined Thorium
Conventional reactor	4 kWh/d
'Energy amplifier'	24 kWh/d

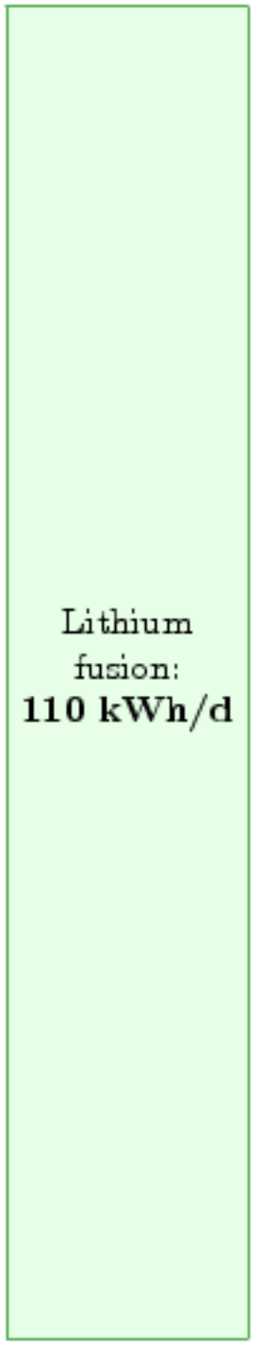
Nuclear Fusion

- Not a sure thing
  - a gamble



- DT reaction
  - requires Lithium and Deuterium
- DD reaction
  - requires Deuterium

(Mined Lithium; there's lots more in seawater)



DD reaction

D lasts ~ 1 billion years

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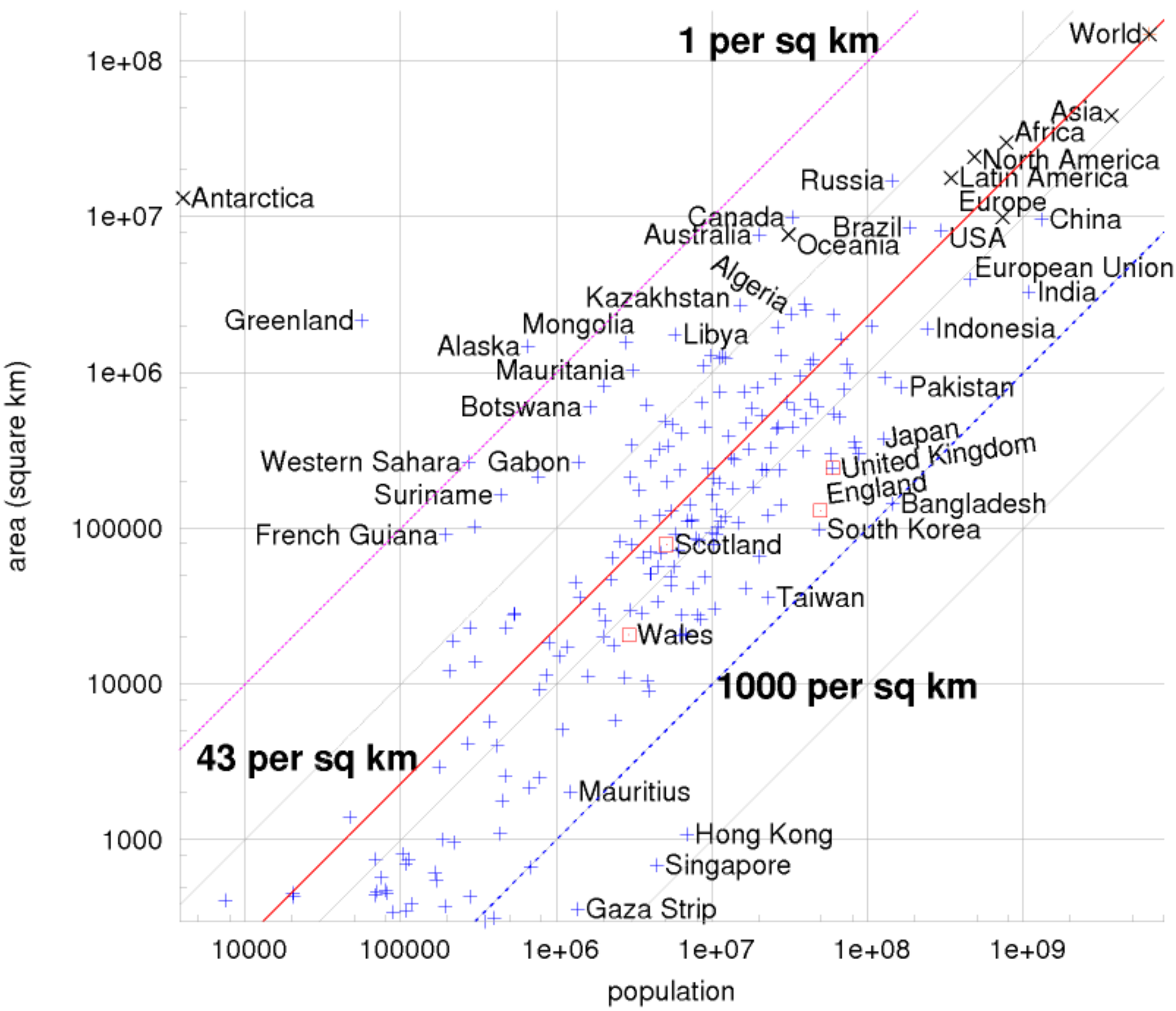
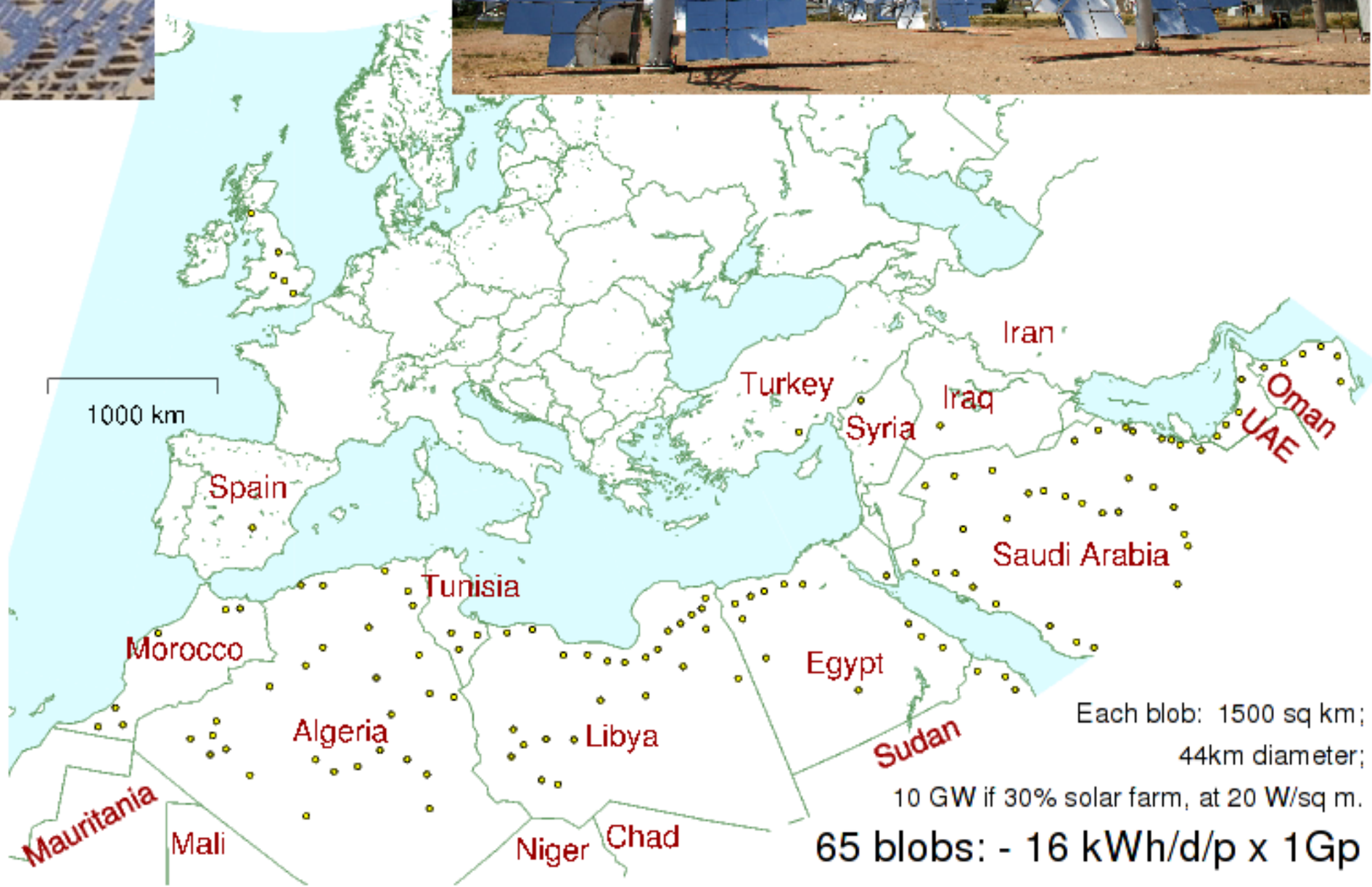

1 per sq km
43 per sq km
1000 per sq km
area (square km)
population
1e+08
1e+07
1e+06
100000
10000
1000
10000
100000
1e+06
1e+07
1e+08
1e+09
World
Asia
Africa
North America
Latin America
Europe
Russia
Canada
Australia
Oceania
Brazil
USA
China
European Union
India
Indonesia
Pakistan
Japan
United Kingdom
England
Bangladesh
South Korea
Taiwan
Wales
Scotland
Algeria
Kazakhstan
Mongolia
Libya
Alaska
Mauritania
Botswana
Western Sahara
Gabon
Suriname
French Guiana
Greenland
Antarctica
Mauritius
Hong Kong
Singapore
Gaza Strip

International options



Spain

1000 km

Morocco

Tunisia

Algeria

Libya

Mauritania

Mali

Niger

Chad

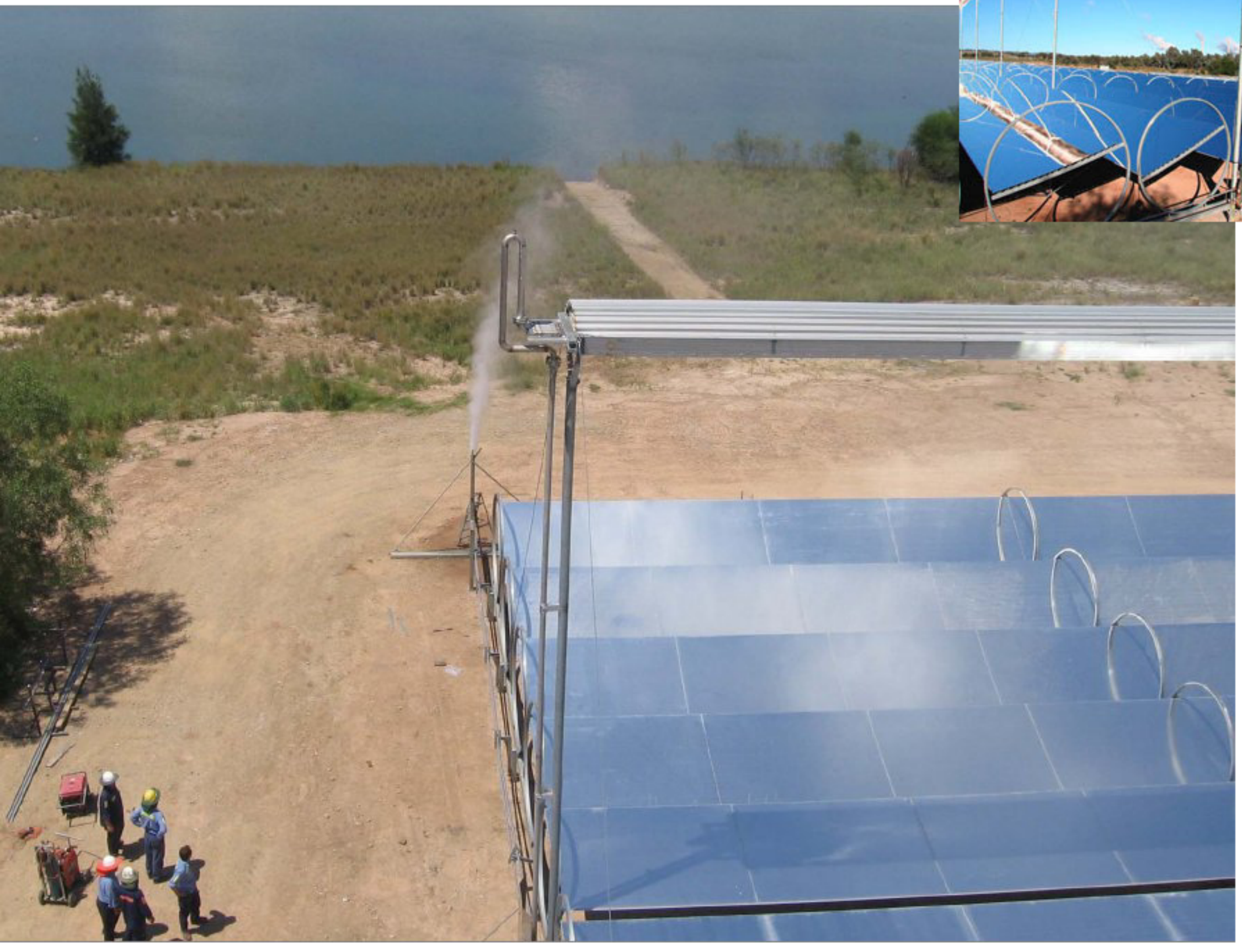
Each blob: 1500 sq km;

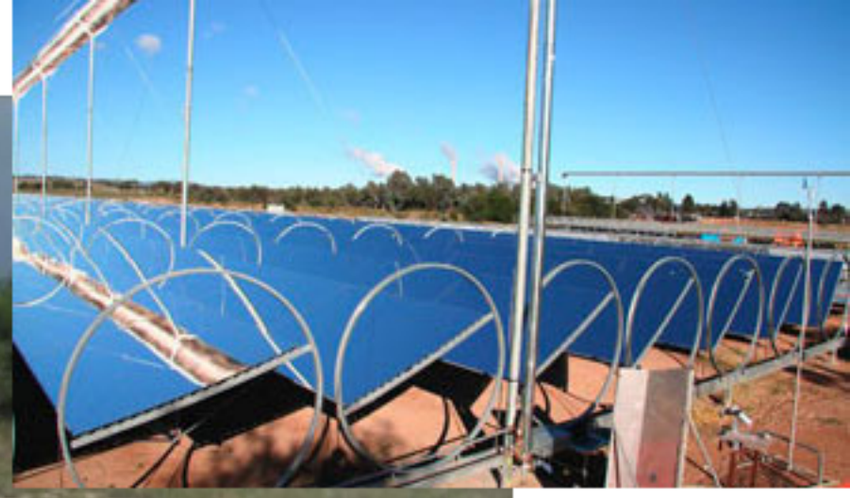
44km diameter;

10 GW if 30% solar farm, at 20 W/sq m.

65 blobs: - 16 kWh/d/p x 1Gp

www.stirlingenergy.com





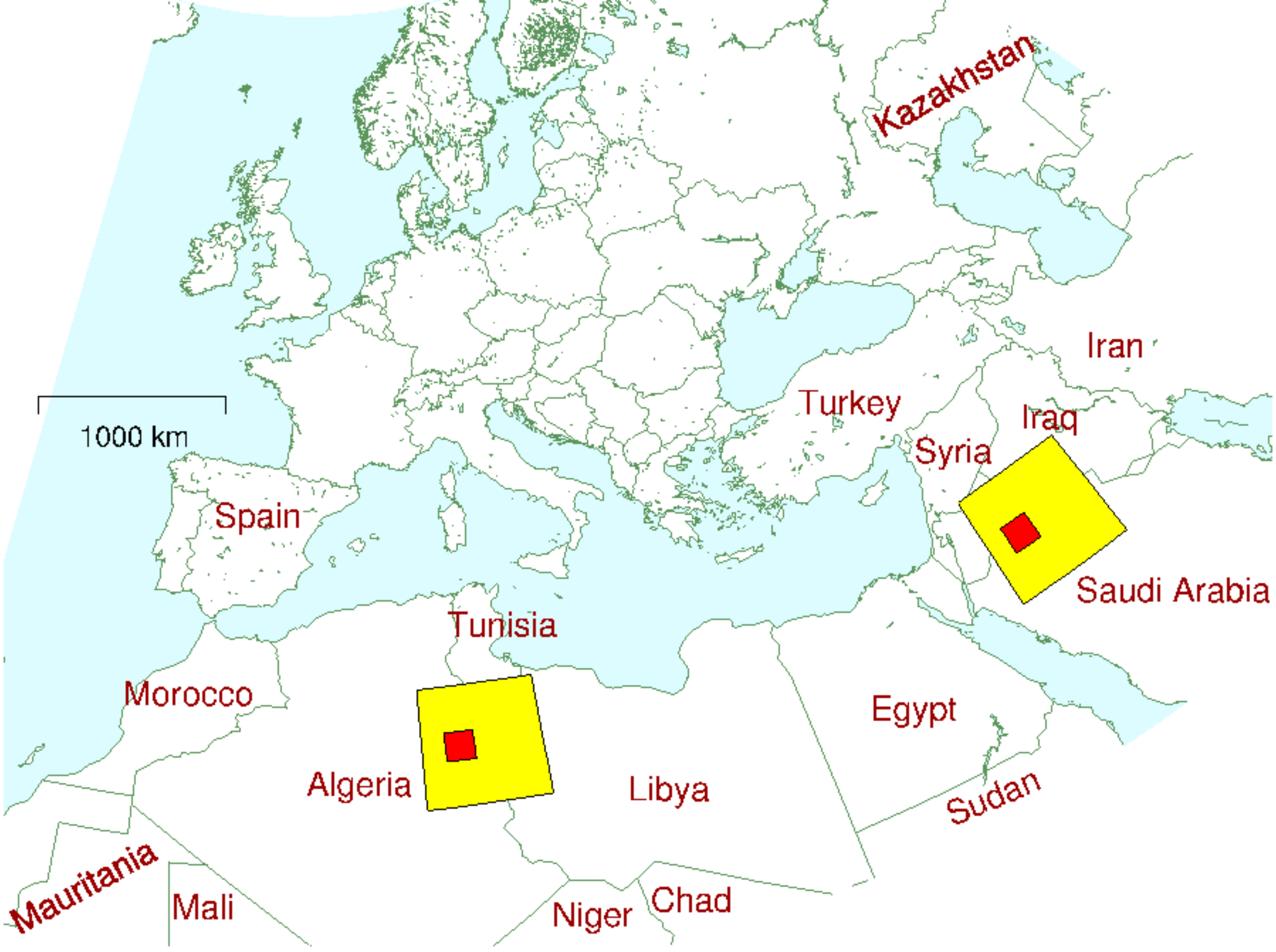
Andasol, Spain

$10\ \mathrm{W/m^2}$

PS10, Solucar

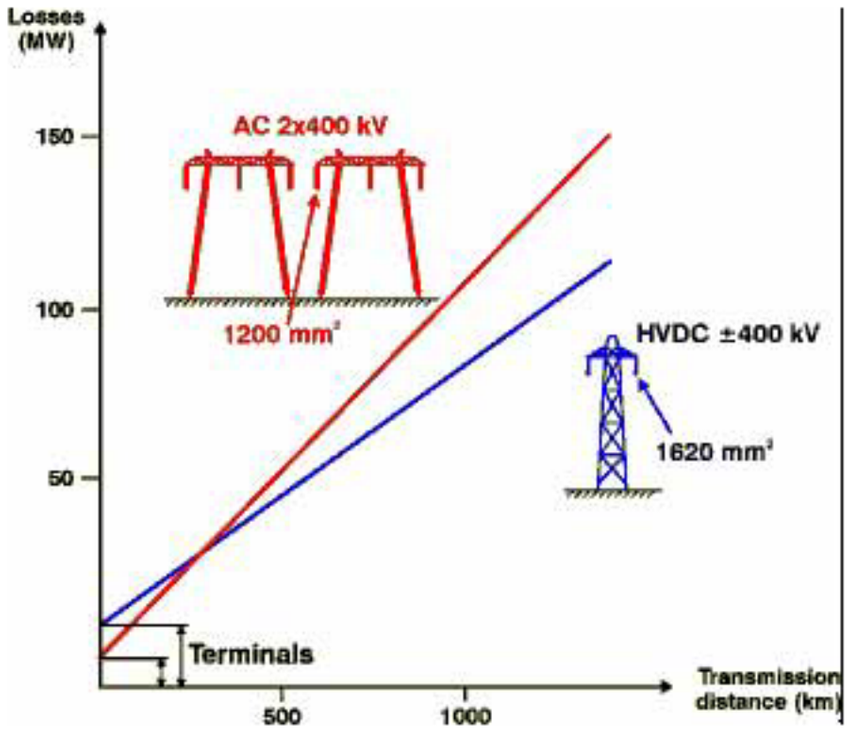
$5\ \mathrm{W/m^2}$

Photo by afloresm



Yellow: 125 kWh/d/p for 1 billion people; Red: 125 kWh/d/p for 60 million people

HVDC transmission



Photos and diagrams: ABB

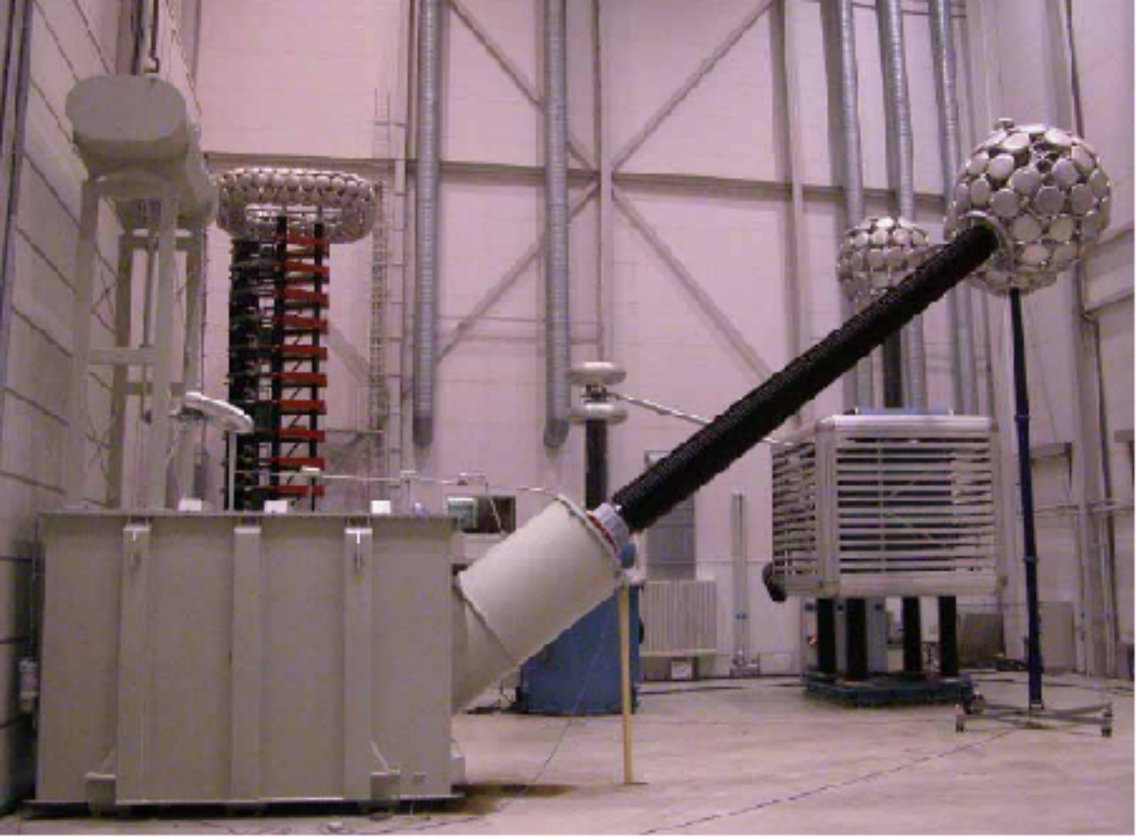
2GW -->

3.1GW, 1360km

1.9GW, 1420km

Mozambique - South Africa

0.7GW, 580km



Photos: ABB

Finland - Estonia:
One pair of cables
transmit 350 MW

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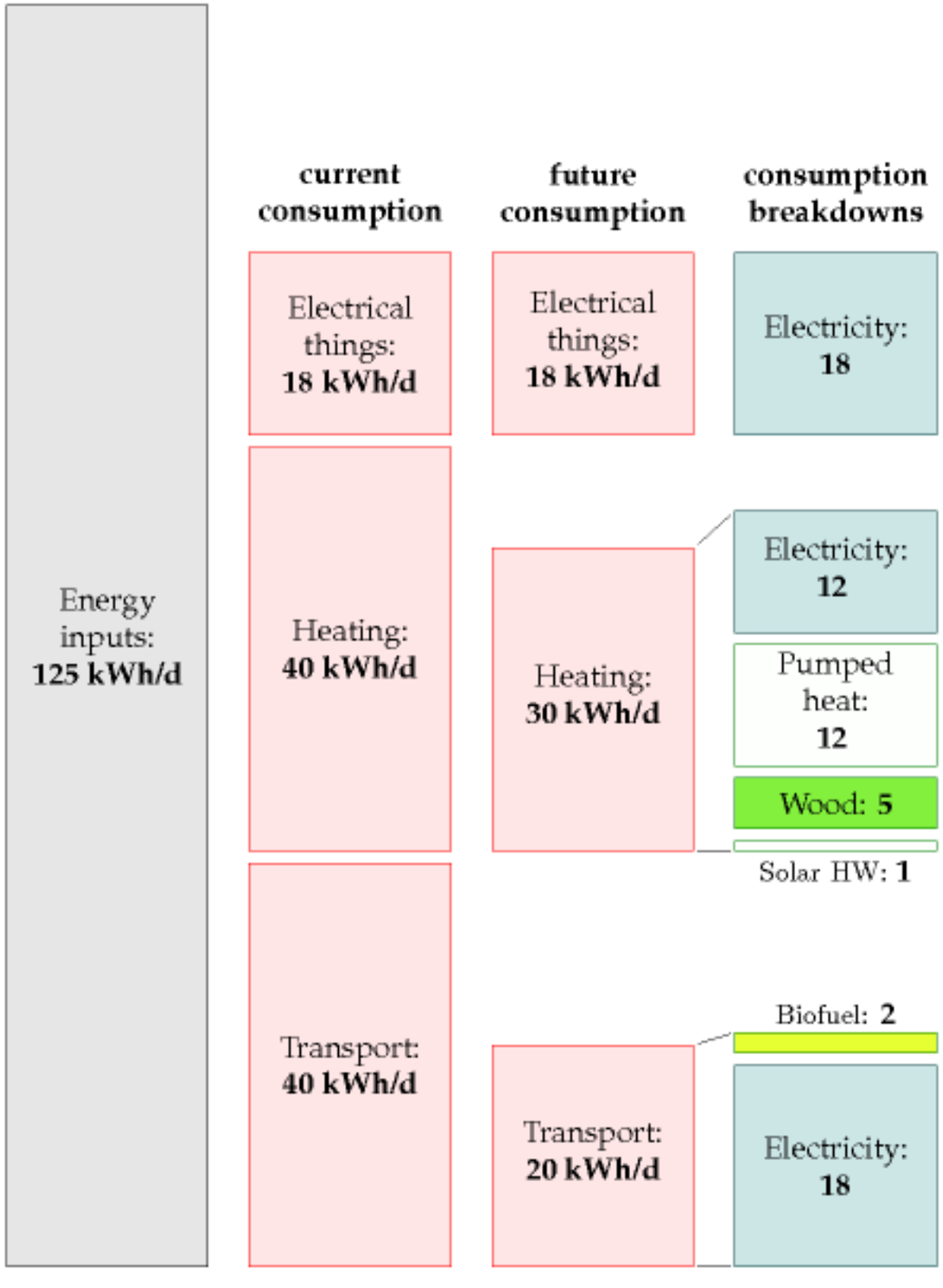
Wind: **3**

How to get the UK off fossil fuels

- Transport, Heating, Electricity
  - Electrify all transport
  - Insulate all buildings; read all meters
  - Electrify all building-heating
    - air-source or ground-source heat pumps
    - (not combined heat and power)

- Our renewables
- Nuclear? (stop-gap?)
- 'Clean coal'? (stop-gap)
- Other people's renewables

One cartoon plan



Key ideas

Insulation

Heat pumps

25% of UK

forests, willow, miscanthus

1 sq m per person HW

12% of UK for biofuels

Electric vehicles

50 kWh/d is 125 GW

tidal stream farms

100 sq km wind farms

Loch Shin

Loch Maree

Loch Ness

Foyers

Loch Morar

Loch Shiel

Loch Ericht

Blackwater

Loch Rannoch

Loch Tay

Cruachan

Loch Awe

Loch Katrine

Loch Sloy

Loch Leven

Biofuels

65km wave farm

100 km

Wood/Miscanthus

Solar in deserts: **16 kWh/d**

Clean coal: **3**

Nuclear: **16 kWh/d**

Tide: **3.7**

Wave: **0.3**

Hydro: **0.2**

Waste: **1.1**

Pumped heat: **12**

Wood: **5**

Solar HW: **1**

Biofuels: **2**

PV: **2**

Wind: **8**

tidal stream farms

100 sq km wind farms

Biofuels

Hartlepool

Wood/Miscanthus

Sellafield

Heysham

100 km

Drax

Ferrybridge

tidal lagoons

Wylfa

Dinorwig

Ffestiniog

Trawsfynydd

Sizewell

Bradwell

Berkeley

Oldbury

Didcot

Kingsnorth

65km wave farm

Hinkley Point

Dungeness

HVDC power lines

Photovoltaics

Solar power in deserts

This plan's mix

Solar in deserts: **16 kWh/d**

Clean coal: **3**

Nuclear: **16 kWh/d**

Tide: **3.7**

Wave: **0.3**

Hydro: **0.2**

Waste: **1.1**

Pumped heat: **12**

Wood: **5**

Solar HW: **1**

Biofuels: **2**

PV: **2**

Wind: **8**

Four Londons' worth

Use for cofiring biomass with CCS

40GW - four-fold increase

25% of UK - forests, willow, miscanthus

1 sq m per person HW

12% of UK for biofuels

Half of all roofs

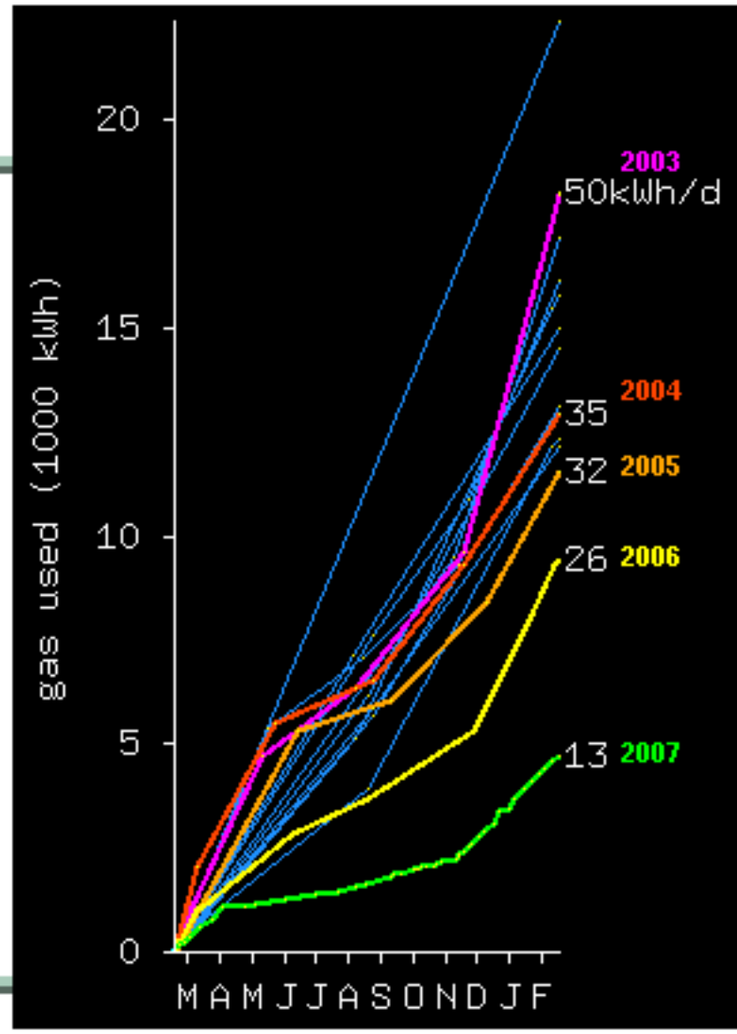
33-fold increase in wind capacity

[Jet flights: 5kWh/d/p, while oil lasts]

Jack-up barges cost 60M

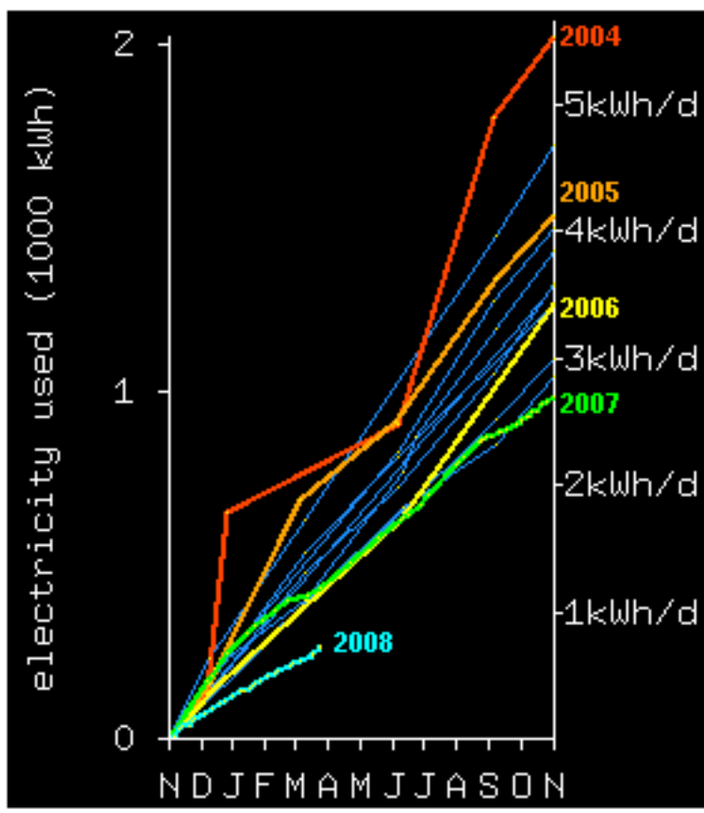
What society must do

- A plan that adds up
- Carbon tax
  - upstream, stable
- Carbon capture at all coal power stations



What individuals can do

- Read meters
- Say yes to plans that add up



Getting off fossil fuels is not easy, but it is possible

- A Plan that adds up must have some or all of:
  - country-sized renewable facilities
  - renewables from other people's countries
  - lots of nuclear power
- And efficiency too of course

'Okay - it's agreed; we announce - "to do nothing is not an option!" then we wait and see how things pan out...'

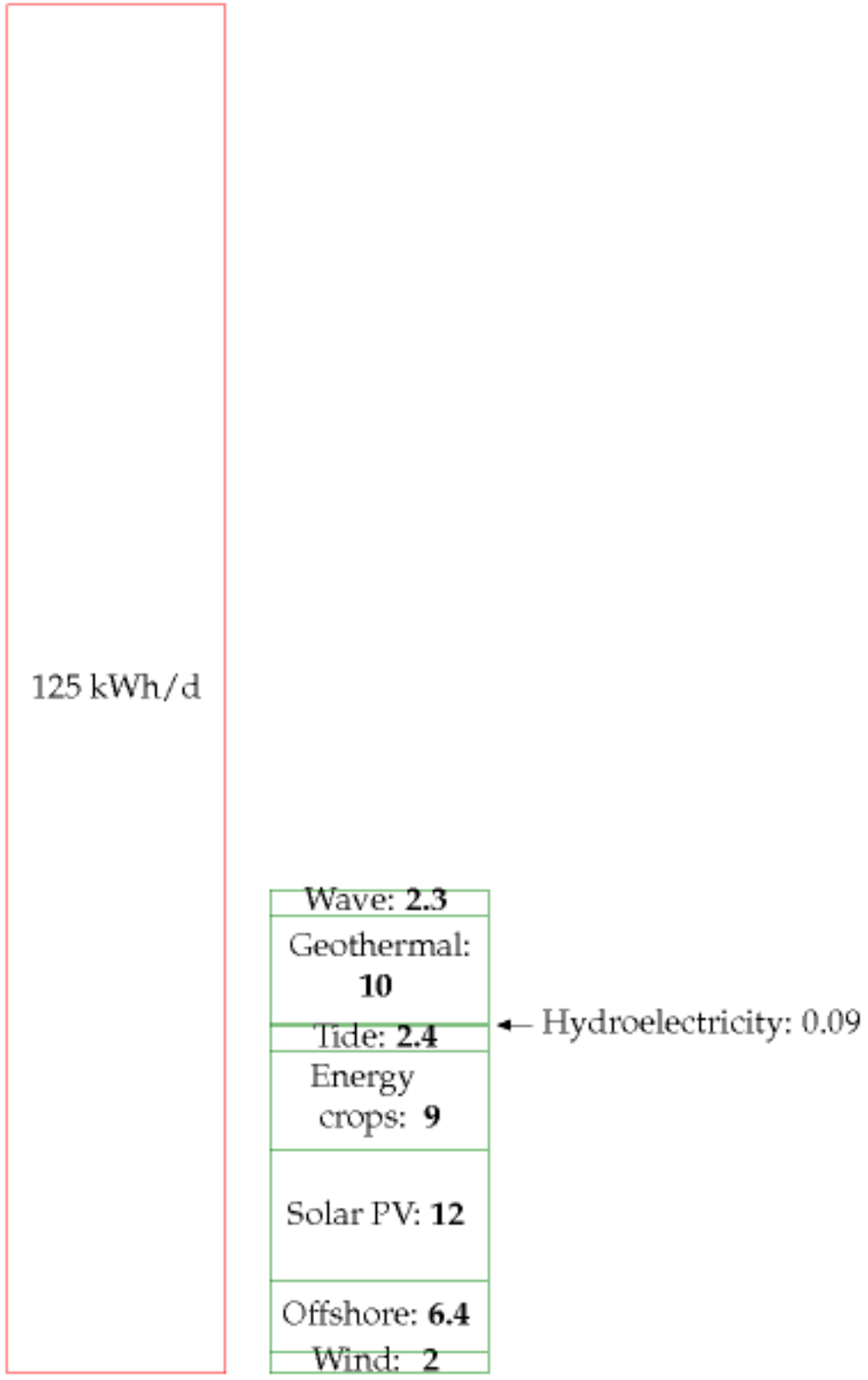
sustainable development commission

The role of nuclear power in a low carbon economy

Paper 2:
Reducing CO_2 emissions - nuclear and the alternatives

An evidence-based report by the Sustainable Development Commission

March 2006

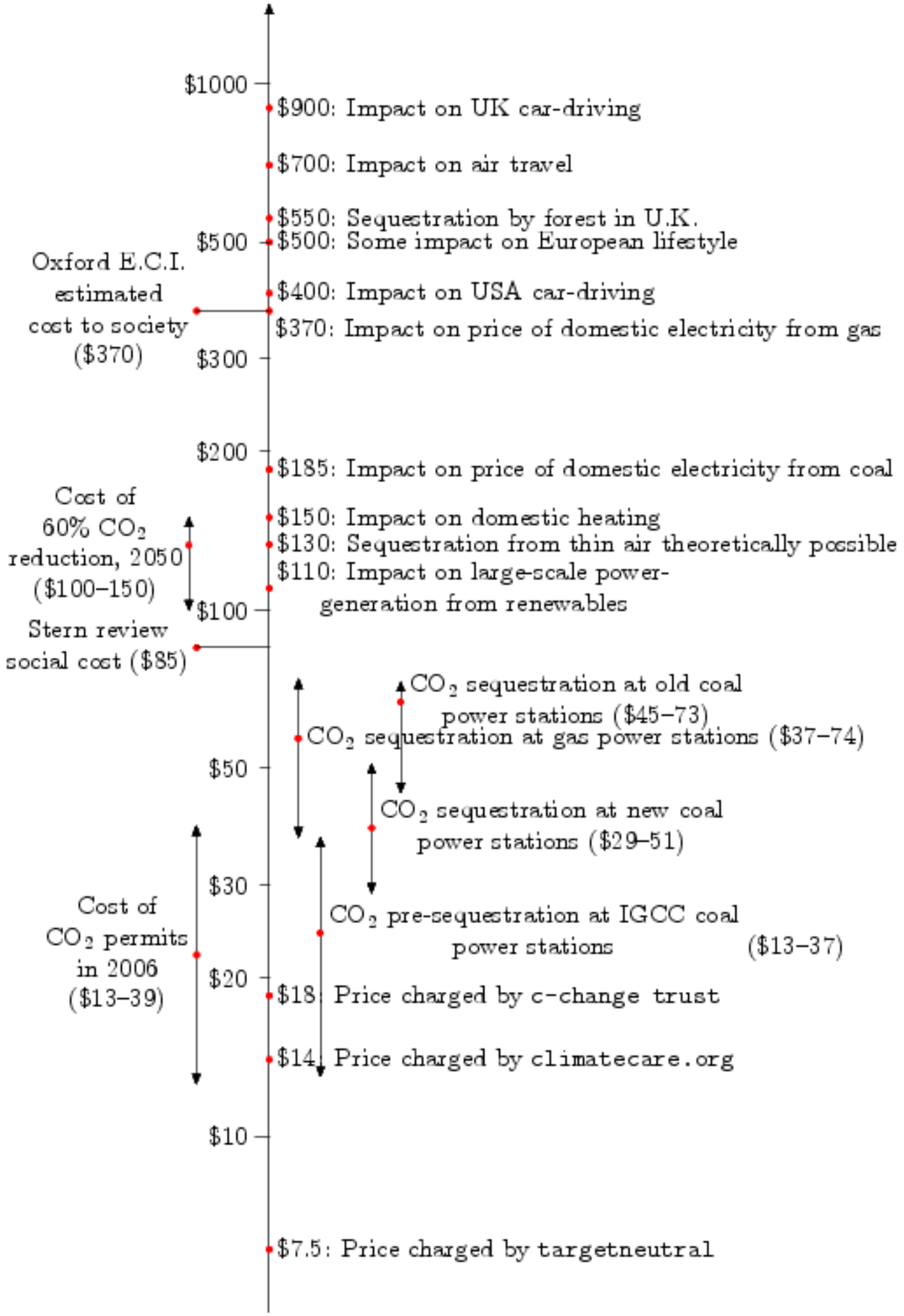


IEE's 'technical potential' is 'an upper limit that is unlikely ever to be exceeded even with quite dramatic changes in the structure of our society and economy'.

Estimates of theoretical / practical resources

My estimates	IEE	Tyndall	IAG	PIU	CAT
Geothermal: 1	Geothermal:10				
Tide: **11 kWh/d**	Tide: **2.4**	Tide: **3.9**	Tide: **0.09**	Tide: **3.9**	Tide: **3.4**
Wave: **4**	Wave: **2.3**	Wave: **2.4**	Wave: **1.5**	Wave: **2.4**	Wave: **11.4**
Deep offshore wind: **32 kWh/d**					
Shallow offshore wind: **16 kWh/d**	Offshore: **6.4**	Offshore: **4.6**	Offshore: **4.6**	Offshore: **4.6**	Offshore: **21**
Hydro: 1.5		Hydro: **0.08**			Hydro: **0.5**
Biomass: food, biofuel, wood, waste incin'n, landfill gas: **24 kWh/d**	Wastes: **4**	Energy crops, waste: **2**	Energy crops, waste, landfill gas: **3**	Energy crops, waste incin'n, landfill gas: **31 kWh/d**	Biomass fuel, waste: **8**
PV farm (200 m^2/p): **50 kWh/d**		PV: **0.3**	PV: **0.02**	PV: **12**	PV: **1.4**
PV, 10 m^2: **5**					
Solar heating: **11 kWh/d**					Solar heating: **1.3**
Wind: **20 kWh/d**	Wind: **2**	Wind: **2.6**	Wind: **2.6**	Wind: **2.5**	Wind: **1**

What should carbon cost?



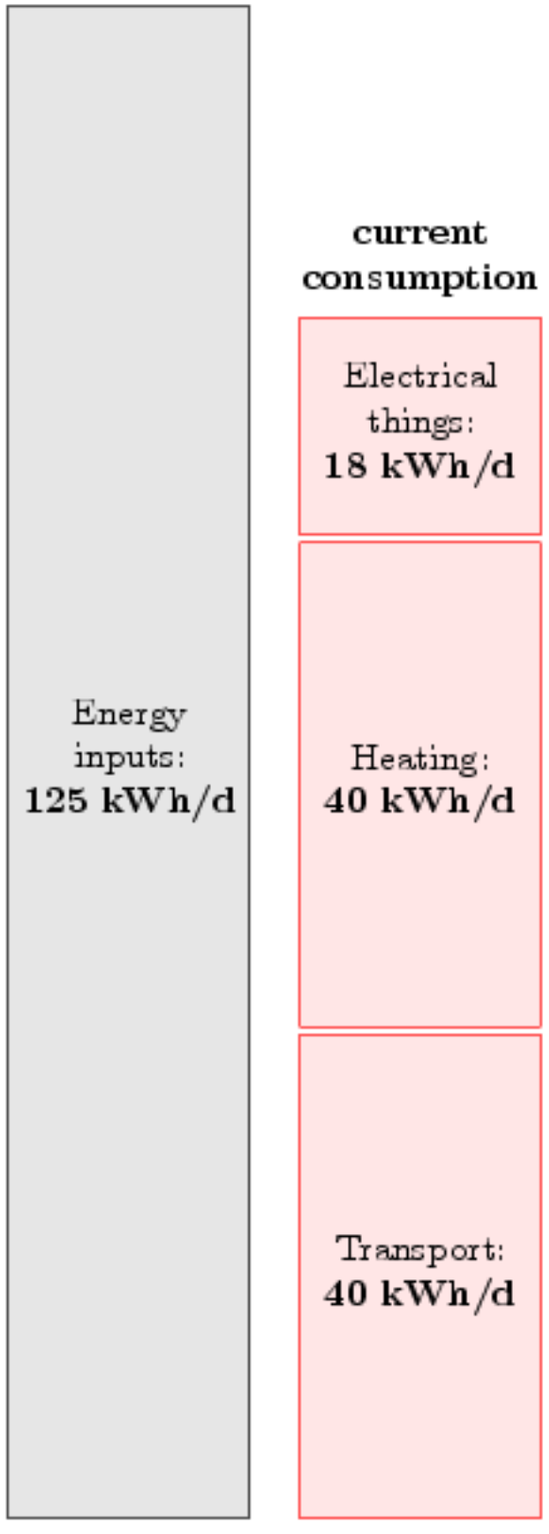
Carbon tax


HARD
ROCK HARD
DIE HARD 4.0
JULY 4
SEE IT IN CINEMAS
NAVARA
NISSAN NAVARA DIE HARD 4.0
NISSAN

Efficiency & technology - for Cartoon-Britain

The current situation in Cartoon-Britain

(ignoring embodied energy in imported stuff)



Efficiency

- Improving transport efficiency
- Improving heating efficiency

Magnetic levitation

The Transrapid Superspeed Maglev System is unrivaled when it comes to noise emission, energy consumption, and land use. The innovative non-contact transportation system provides mobility without the environment falling by the wayside.

Fast trains compared at 200 km/h (125mph)	
ICE	2.9 kWh(e) / 100 seat-km
Transrapid	2.2 kWh(e) / 100 seat-km

Biofuel

'Brown Takes Ride On Green Train'

"And the funniest thing is - it's only 20% biodiesel!"

'Buyers of Jeep's newest full-sized sport utility vehicle will hit the road with a tankful of a diesel fuel blend made from soybean oil, fast-food grease or vegetable oil.'

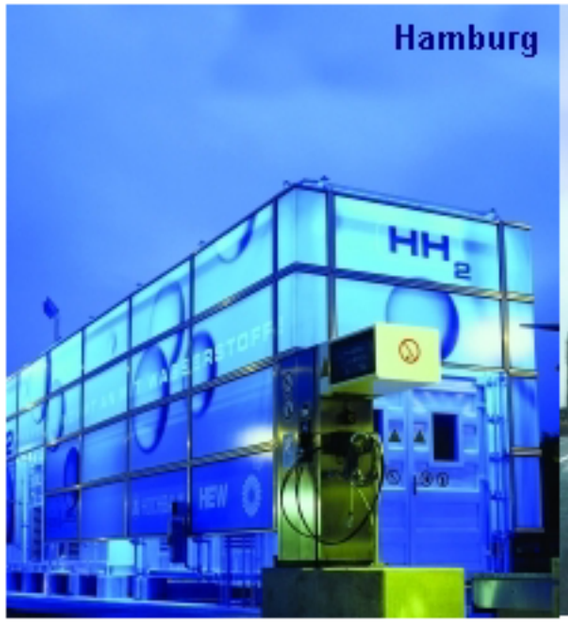
'Green fuel to power G8 Summit vehicles'

A pump full of B5

B5 is 5% biodiesel and 95% fossil fuel

Hydrogen

SUSTAINABLE
TRANSPORT
ENERGY



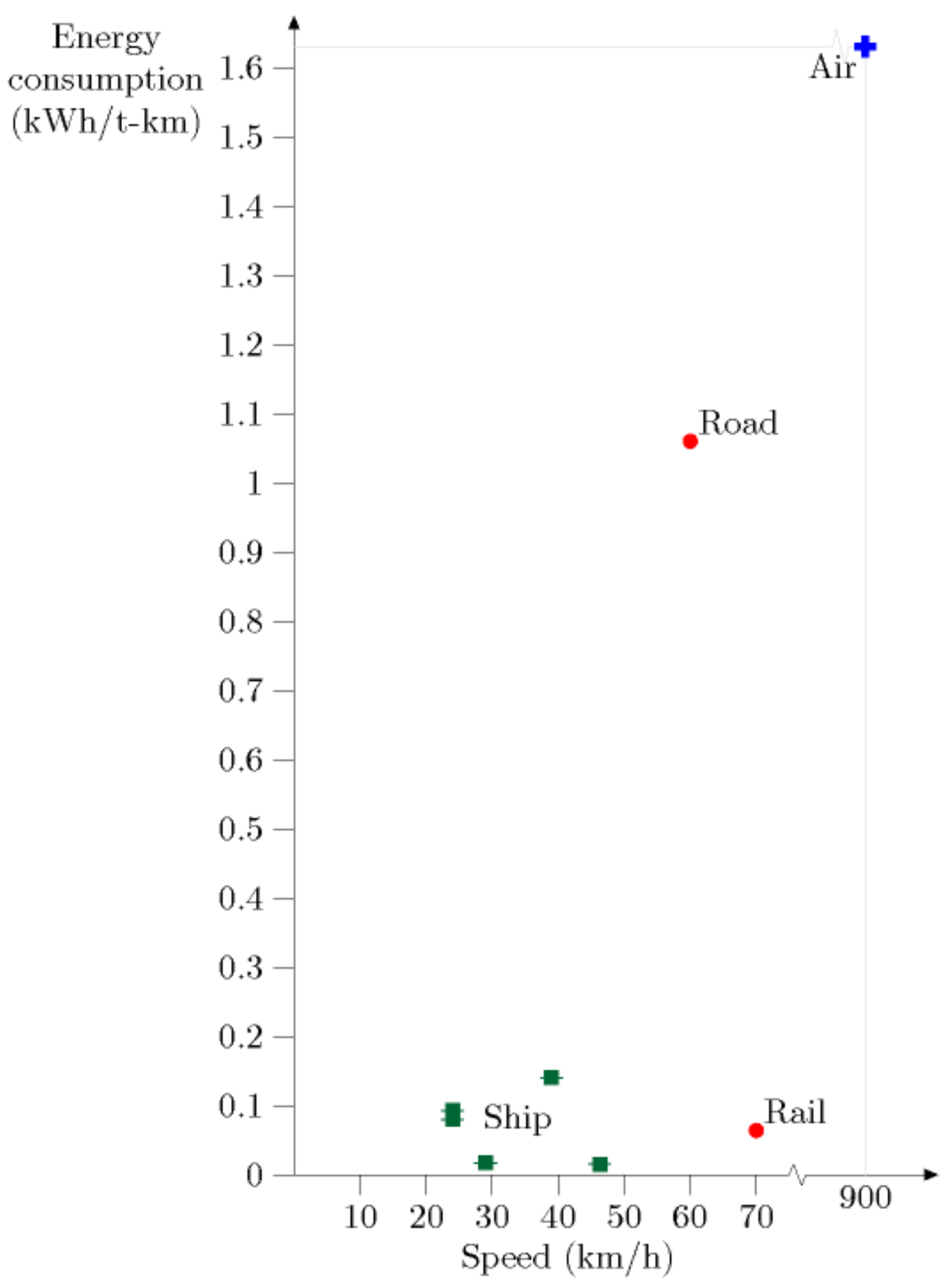
Clean Urban Transport for Europe

hydrogen made from fossil fuels:

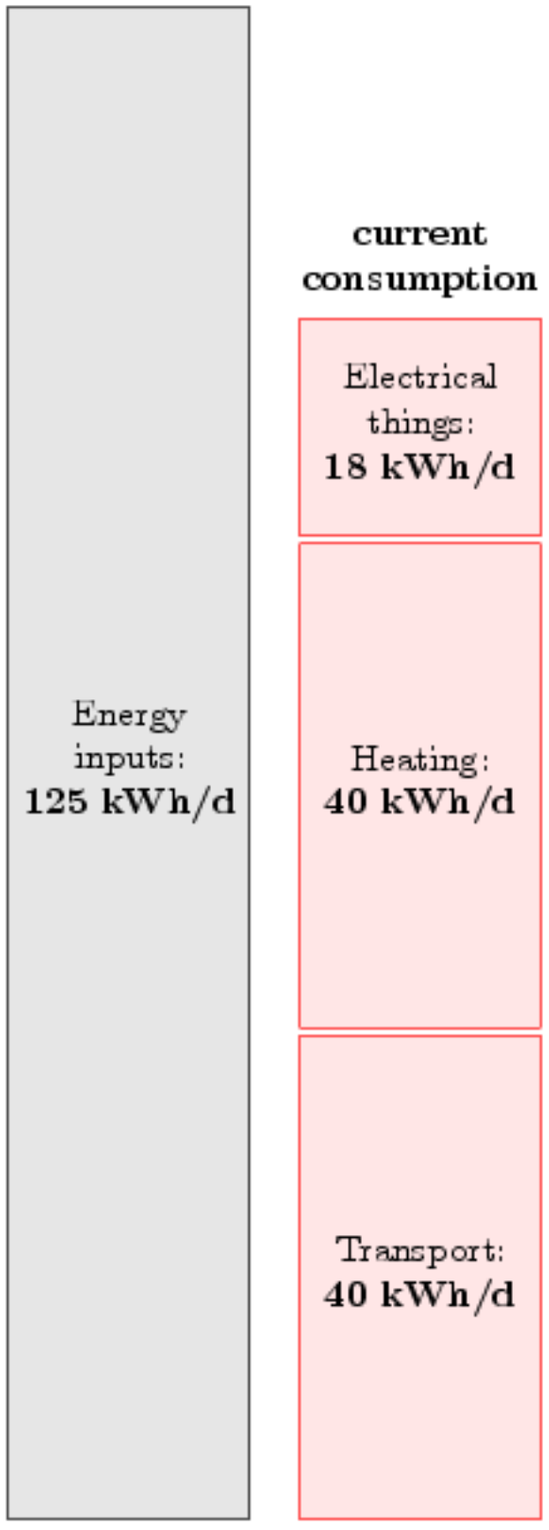
overall primary energy consumption by the hydrogen buses was between 80% and 200% greater than that of the baseline diesel bus.

GHG emissions were between 40% and 140% greater.

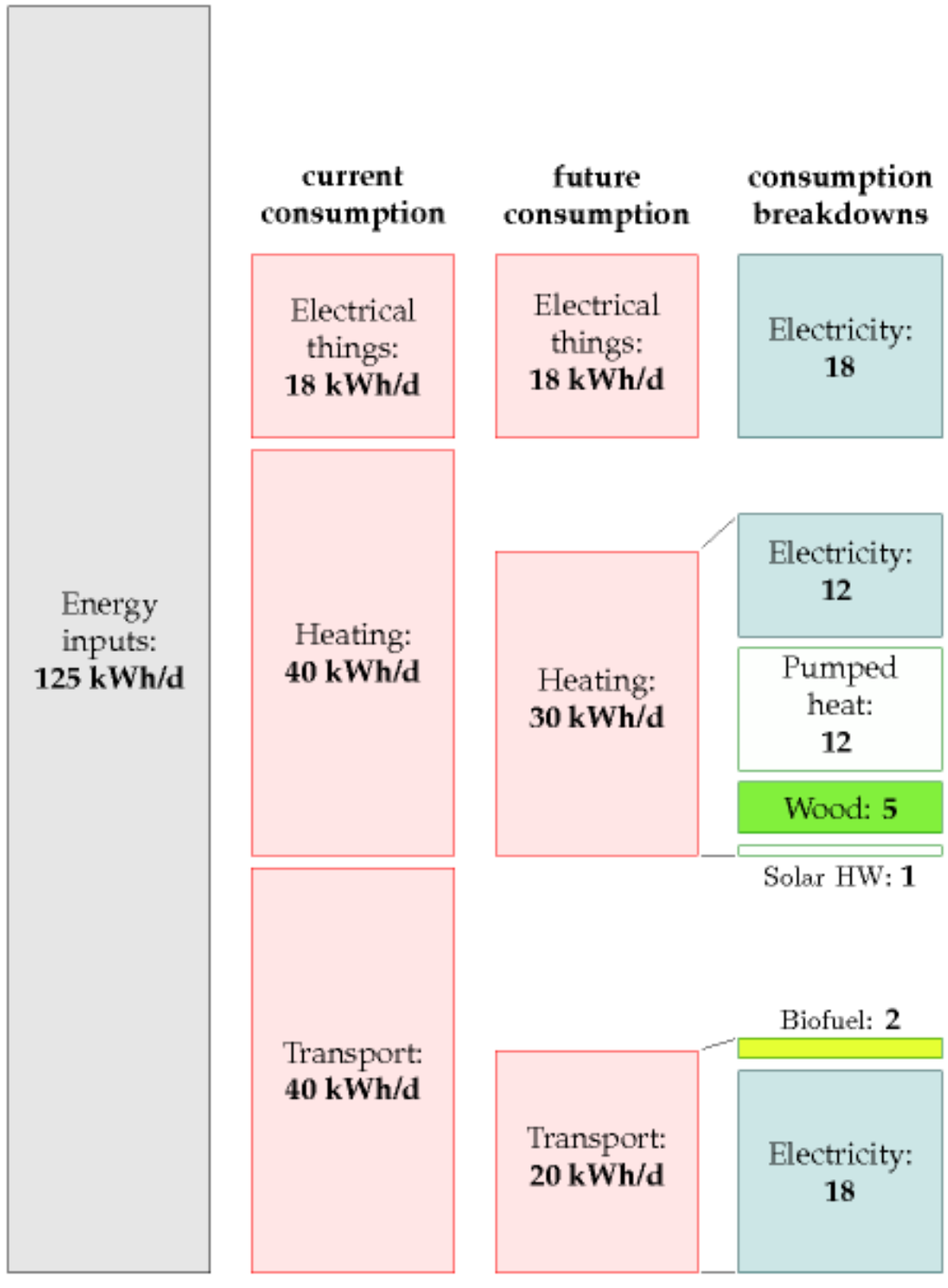
Freight


Energy consumption (kWh/t-km)
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Air
Road
Ship
Rail
10
20
30
40
50
60
70
900
Speed (km/h)

Efficiency & technology - for Cartoon-Britain



Five plans for Cartoon-Britain



Key ideas

Insulation

Heat pumps

25% of UK

forests, willow, miscanthus

1 sq m per person HW

12% of UK for biofuels

Electric vehicles

50 kWh/d is 125 GW

Plan D: 'Diversity'

40GW; triple coal imports

Clean coal: **16 kWh/d**

Nuclear: **16 kWh/d**

Tide: **3.7**

Wave: **2**

Hydro: **0.2**

Waste: **1.1**

Pumped heat: **12**

Wood: **5**

Solar HW: **1**

Biofuels: **2**

PV: **3**

Wind: **8**

40GW - four-fold increase

7500 pelamis, 500km of coastline

all municipal waste incinerated, and equal agri. waste

7 sq m / p

almost all the world's windmills ('60GW')

on 2% of country and equal area offshore

Plan N: 'NIMBY'

40GW; triple coal imports

Solar in deserts: **20 kWh/d**

Clean coal: **16 kWh/d**

Nuclear: **10 kWh/d**

Tide: **1**

Hydro: **0.2**

Waste: **1.1**

Pumped heat: **12**

Wood: **5**

Solar HW: **1**

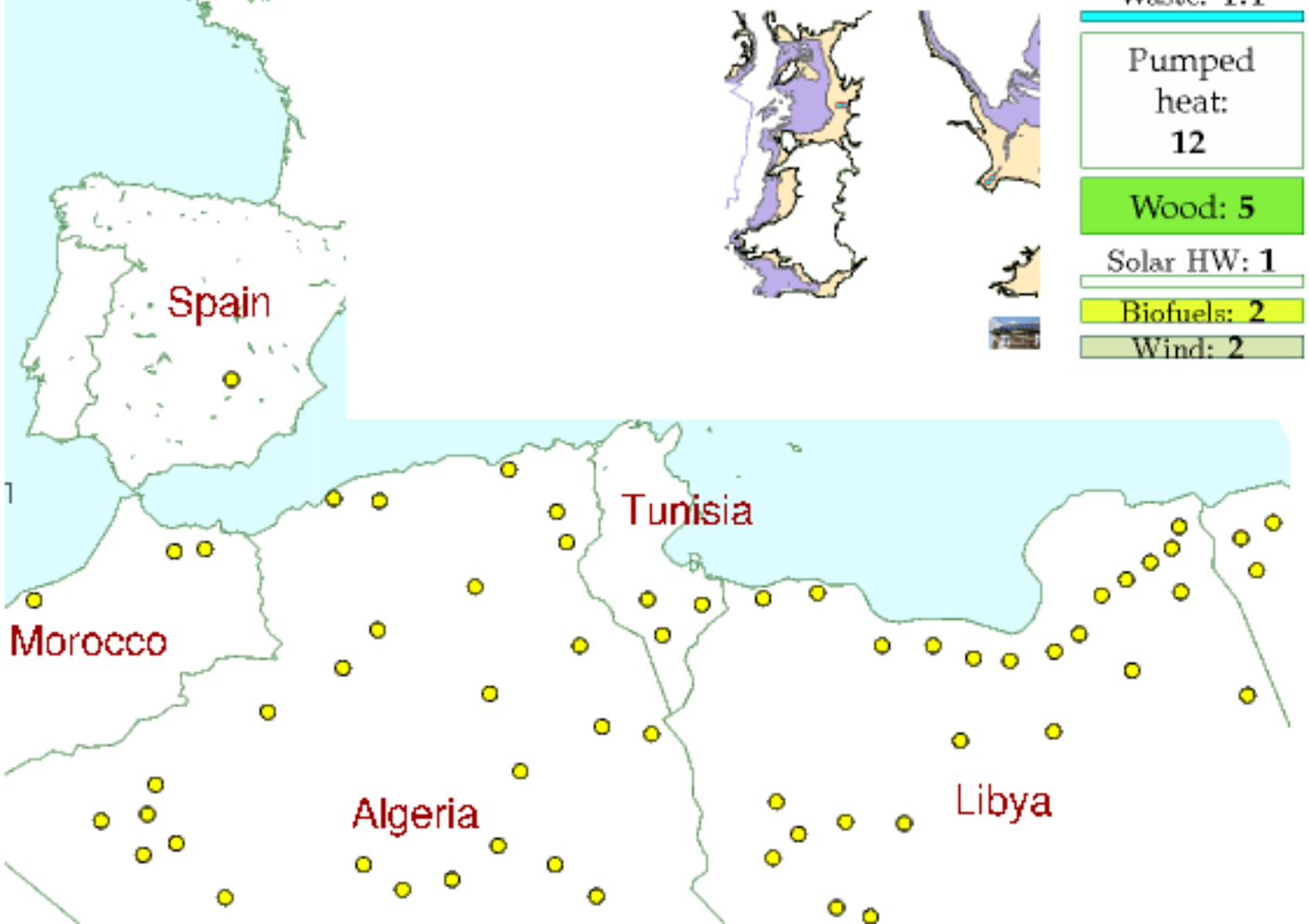
Biofuels: **2**

Wind: **2**

upgrade all current sites

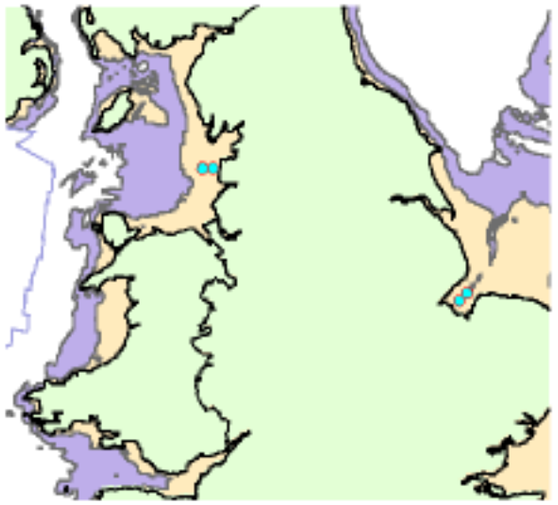
all municipal waste incinerated, and equal agri. waste

8-fold increase in wind ('15GW')



Plan L: 'Libdem'

40GW; triple coal imports



Solar in deserts: **16 kWh/d**

Clean coal: **16 kWh/d**

Tide: **3.7**

Wave: **2**

Hydro: **0.2**

Waste: **1.1**

Pumped heat: **12**

Wood: **5**

Solar HW: **1**

Biofuels: **2**

PV: **3**

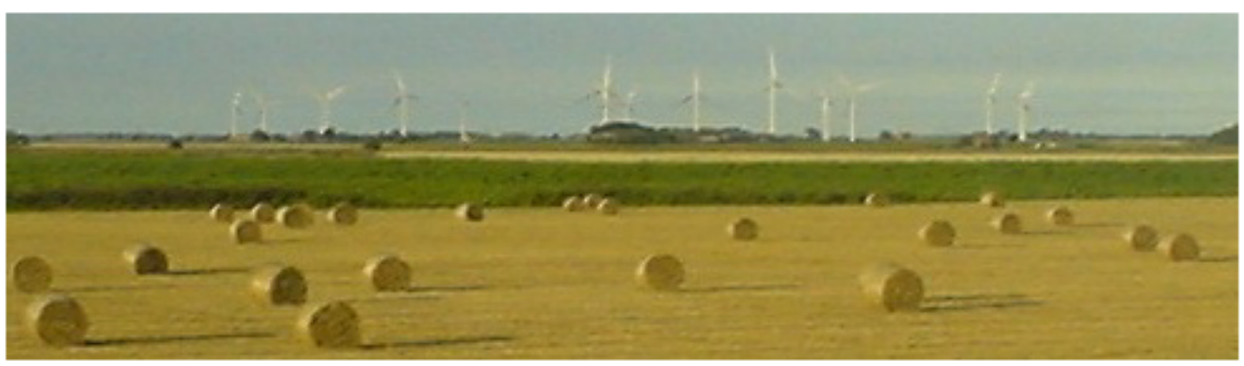
Wind: **8**

No nuclear

7500 pelamis, 500km of coastline

all municipal waste incinerated, and equal agri. waste

7 sq m / p



almost all the world's windmills ('60GW')

on 2% of country and equal area offshore

Plan G: 'Green'

No coal

7 sq m / p

Solar in deserts: 7

Tide: 3.7

Wave: 3

Hydro: 0.2

Waste: 1.1

Pumped heat: 12

Wood: 5

Solar HW: 1

Biofuels: 2

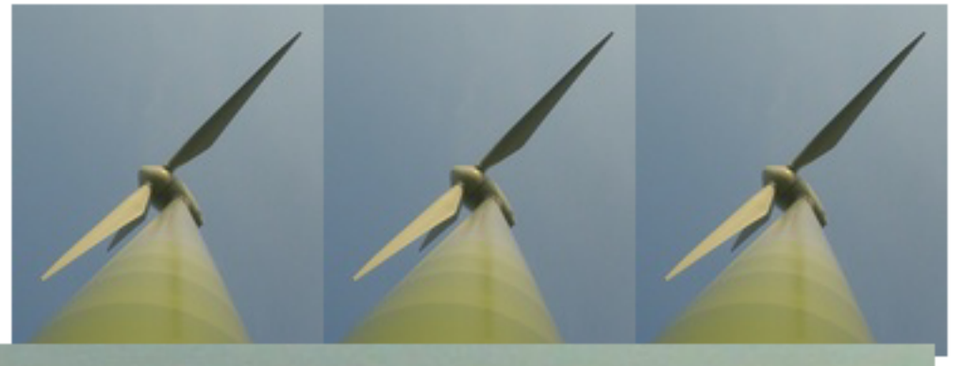
PV: 3

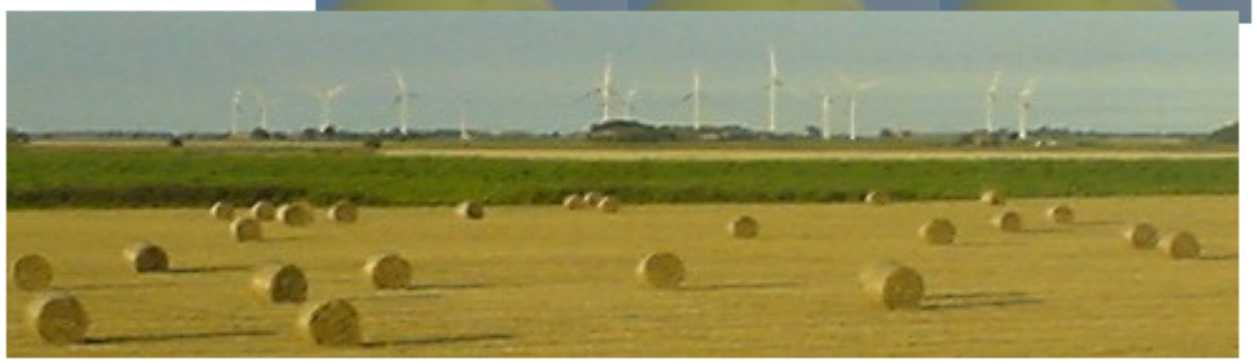
Wind: 32

No nuclear

11,000 pelamis, 750km of coastline

all municipal waste incinerated, and equal agri. waste





3 x all the world's windmills ('240GW') on 8% of country & equal area offshore

Plan E: 'Economist'

no coal - CCS more expensive than nuclear

Nuclear:
44 kWh/d

110GW - twice France's nuclear

Tide: **0.7**

Hydro: **0.2**

Waste: **1.1**

Pumped heat:
12

Wood: **5**

Solar HW: **1**

Biofuels: **2**

Wind: **4**

Tidal lagoons (providing storage too)

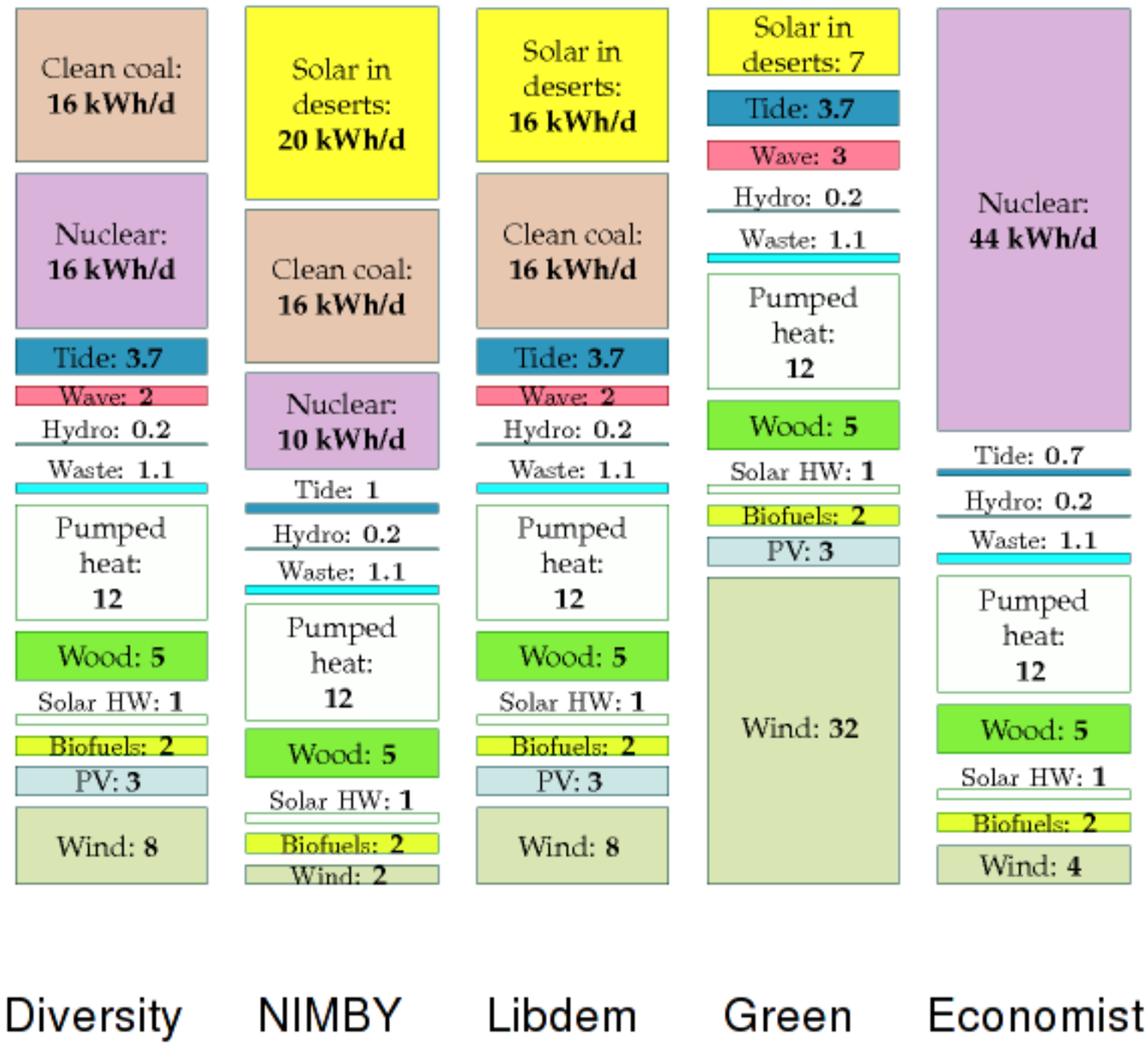
all municipal waste incinerated, and equal agri. waste

half the world's windmills ('30GW') on 1% of country and equal area offshore

10-fold increase in uranium

15-fold increase in wind

Five plans for Cartoon-Britain

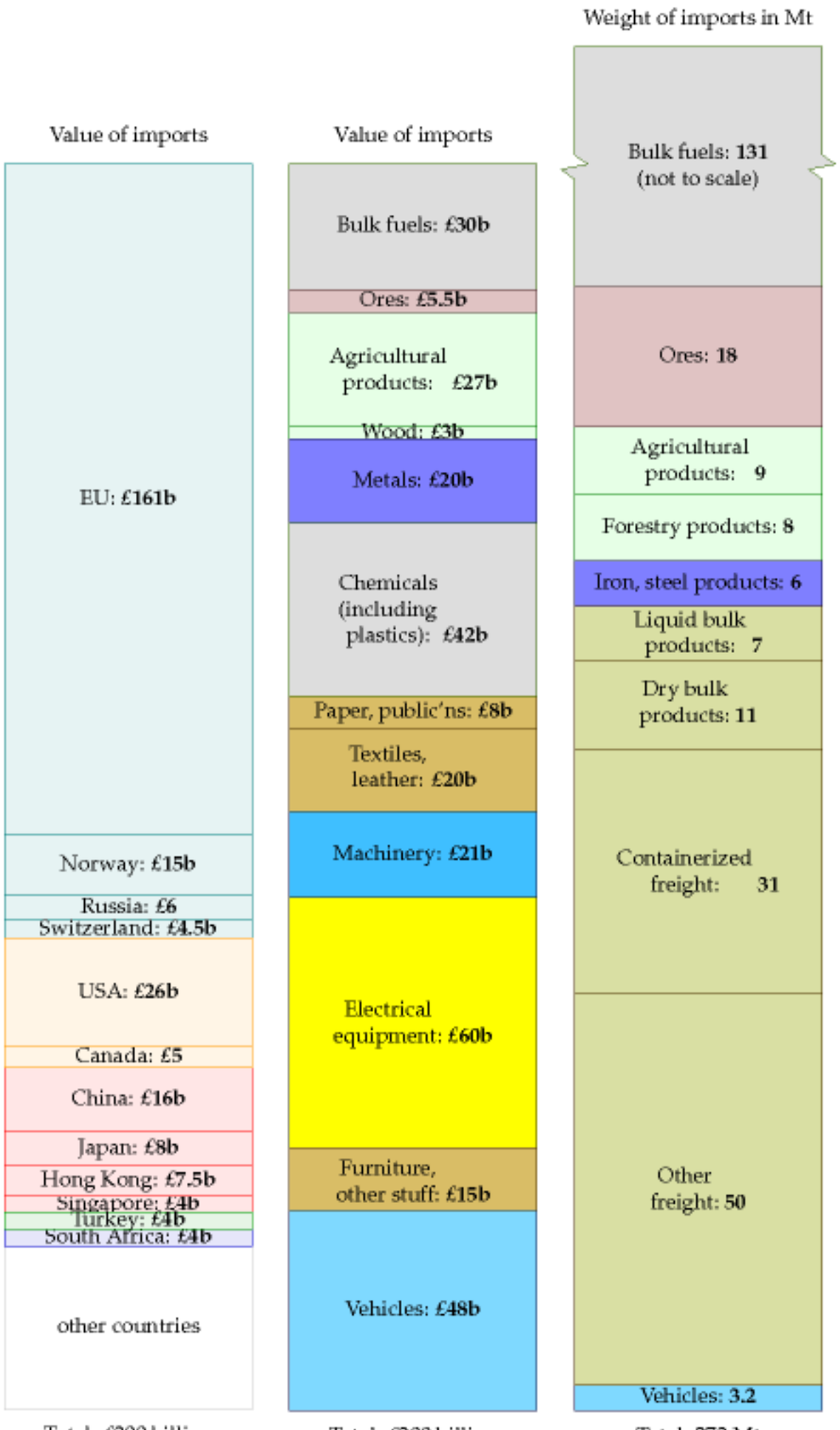


Current imports of energy

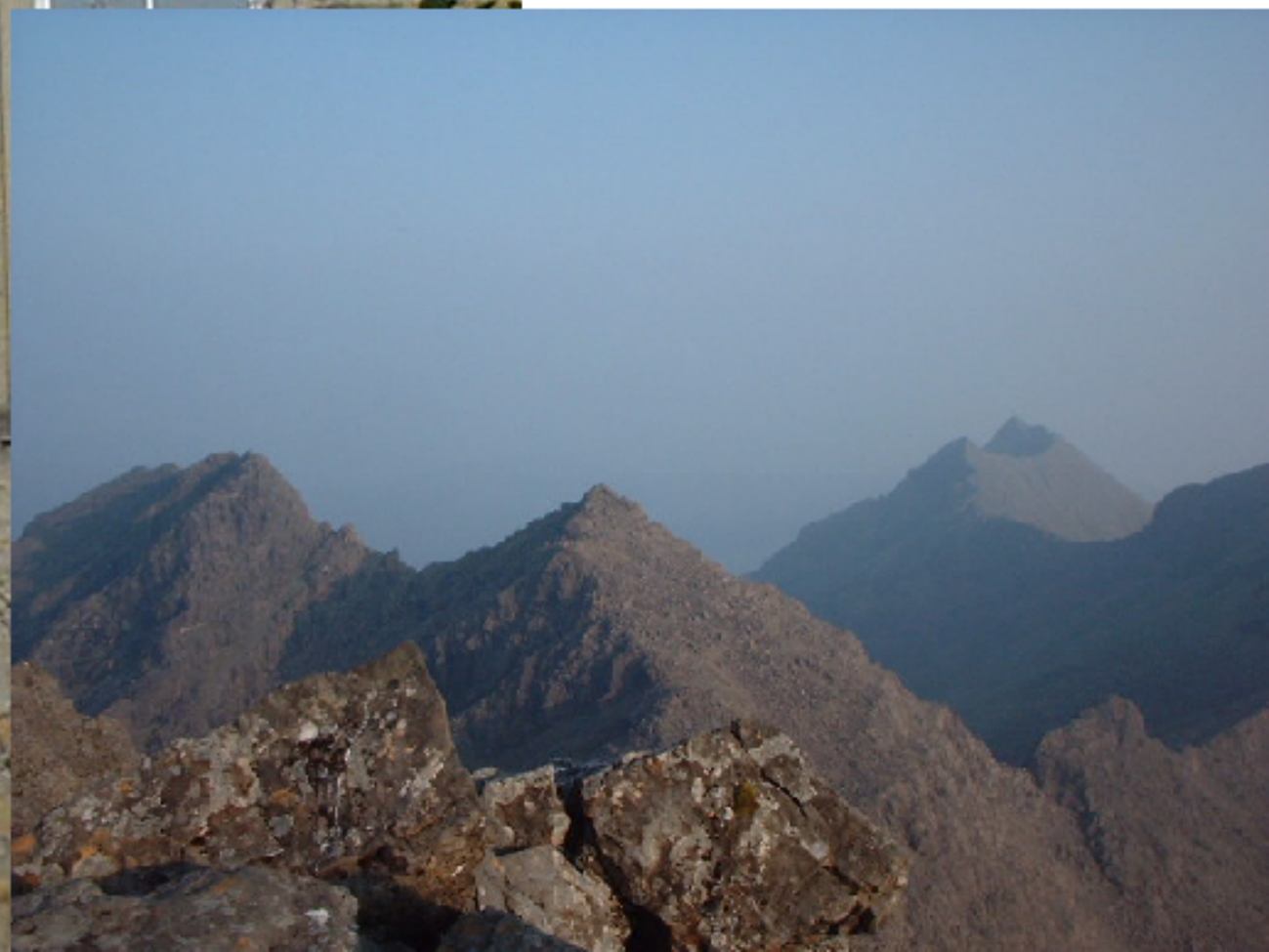
In 2006, the UK imported 28 kWh/d/p of fuel

- 23% of its primary consumption

Imports

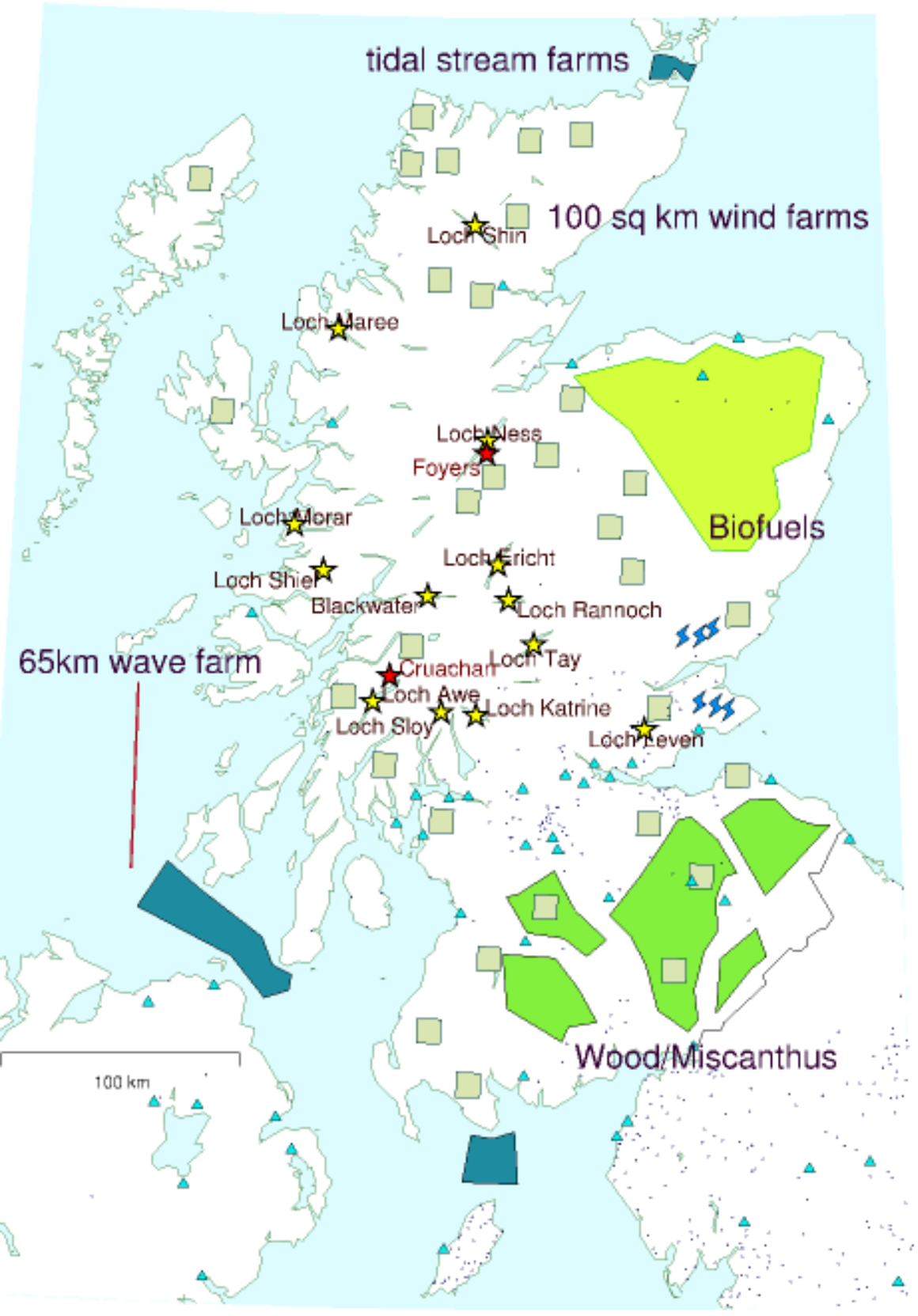

Value of imports
EU: £161b
Norway: £15b
Russia: £6
Switzerland: £4.5b
USA: £26b
Canada: £5
China: £16b
Japan: £8b
Hong Kong: £7.5b
Singapore: £4b
Turkey: £4b
South Africa: £4b
other countries
Total: £300 billion
Value of imports
Bulk fuels: £30b
Ores: £5.5b
Agricultural products: £27b
Wood: £3b
Metals: £20b
Chemicals (including plastics): £42b
Paper, public'ns: £8b
Textiles, leather: £20b
Machinery: £21b
Electrical equipment: £60b
Furniture, other stuff: £15b
Vehicles: £48b
Total: £300 billion
Weight of imports in Mt
Bulk fuels: 131 (not to scale)
Ores: 18
Agricultural products: 9
Forestry products: 8
Iron, steel products: 6
Liquid bulk products: 7
Dry bulk products: 11
Containerized freight: 31
Other freight: 50
Vehicles: 3.2
Total: 273 Mt

Independence for Scotland



Plan S: zero-carbon Scotland

No nuclear



Tide: **15+**

Wave: **3**

Hydro: **2**

Waste: **1.1**

Pumped heat: **12**

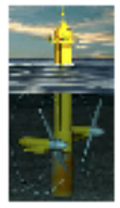
Wood: **5**

Solar HW: **1**

Biofuels: **1**

PV: **3**

Wind: **28**



Tidal stream

1,000 pelamis, 65km of coastline

all municipal waste incinerated, and equal agri. waste

Energy crops: 1200 sq m per person

4% of country

30 windfarms, each 100 sq km

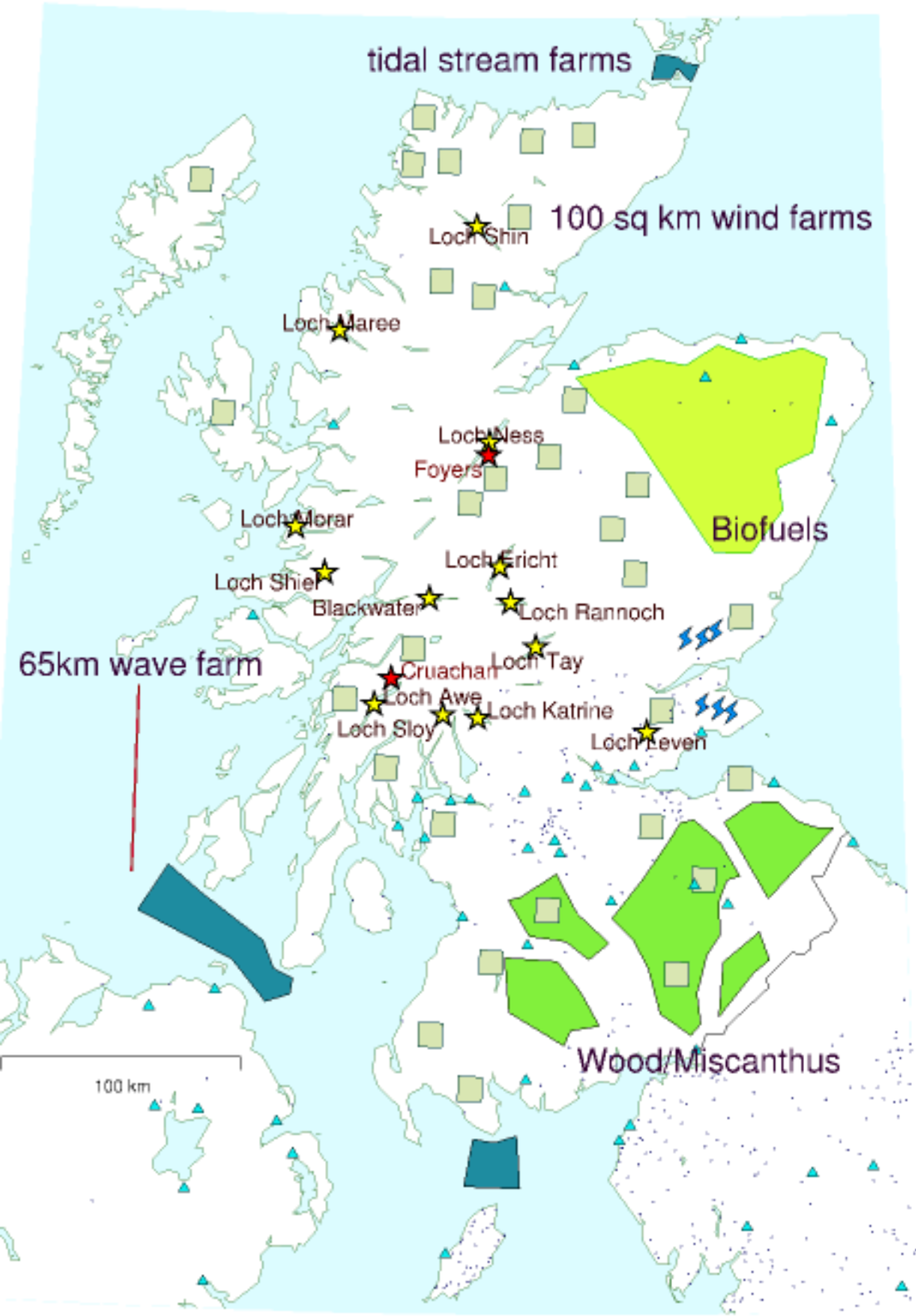
- 6 times as much wind hardware as Denmark

Pumped storage - 30 Cruachans

Upgrade Anglo-Scottish interconnector

Plan S: zero-carbon Scotland

No nuclear



Tide: **15+**

Wave: **3**

Hydro: **2**

Waste: **1.1**

Pumped heat: **12**

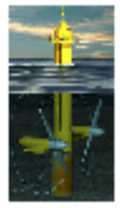
Wood: **5**

Solar HW: **1**

Biofuels: **1**

PV: **3**

Wind: **28**



Tidal stream (20b?)

1,000 pelamis, 65km of coastline (4b?)

all municipal waste incinerated, and equal agri. waste

Energy crops: 1200 sq m per person

4% of country (20b)

30 windfarms, each 100 sq km

- 6 times as much wind hardware as Denmark

Pumped storage - 30 Cruachans (30b)

Upgrade Anglo-Scottish interconnector (1b)

Total ballpark cost: 75b

[Scottish Government budget: 30b/y]

[10 GW nuclear: 10b]

Nuclear-powered ships

NS Savannah

Ice-breaker Yamal

Electric plane

Range: 50 km

Passenger transport efficiency: 11 kWh per 100 p-km

Road planning

What can you do?

- Identify things that might make 1% difference (or more)
  - buildings
  - transport
- Inform politicians
  - how to add 2+2

What Would Jesus Drive?
www.WhatWouldJesusDrive.org

UK government budget: defence = 7%

10% of all industrial energy since 1940 went into making nuclear weapons

'diversity of supply'?

What can you do?

- Legislation
  - Promotion of consumption bill
  - Carbon tax to replace VAT
  - Glorification of travel act

$$2 + 2 \neq 120$$

Cars

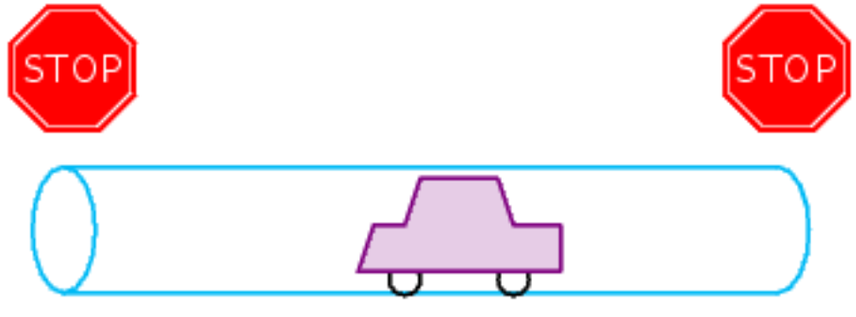
- Engine inefficiency
  - internal combustion is 25% efficient
- Drag

$$\text{Drag} \sim \rho A v^2$$

No viscosity!

- Acceleration/deceleration

$$\text{Power} = \frac{1}{2}\rho A v^3 c_d + \frac{1}{2}\frac{mv^3}{D}$$

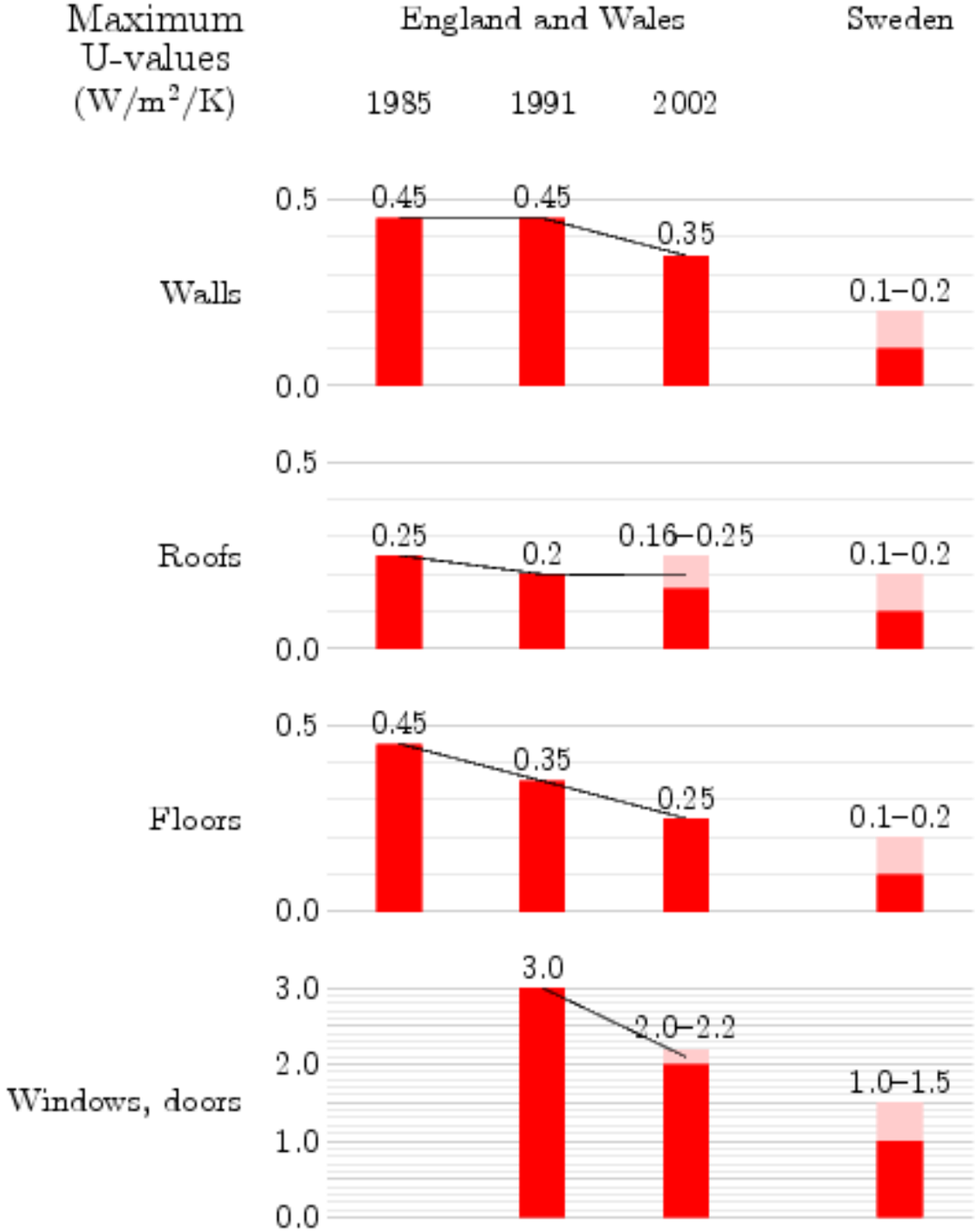


Car:
40 kWh/d

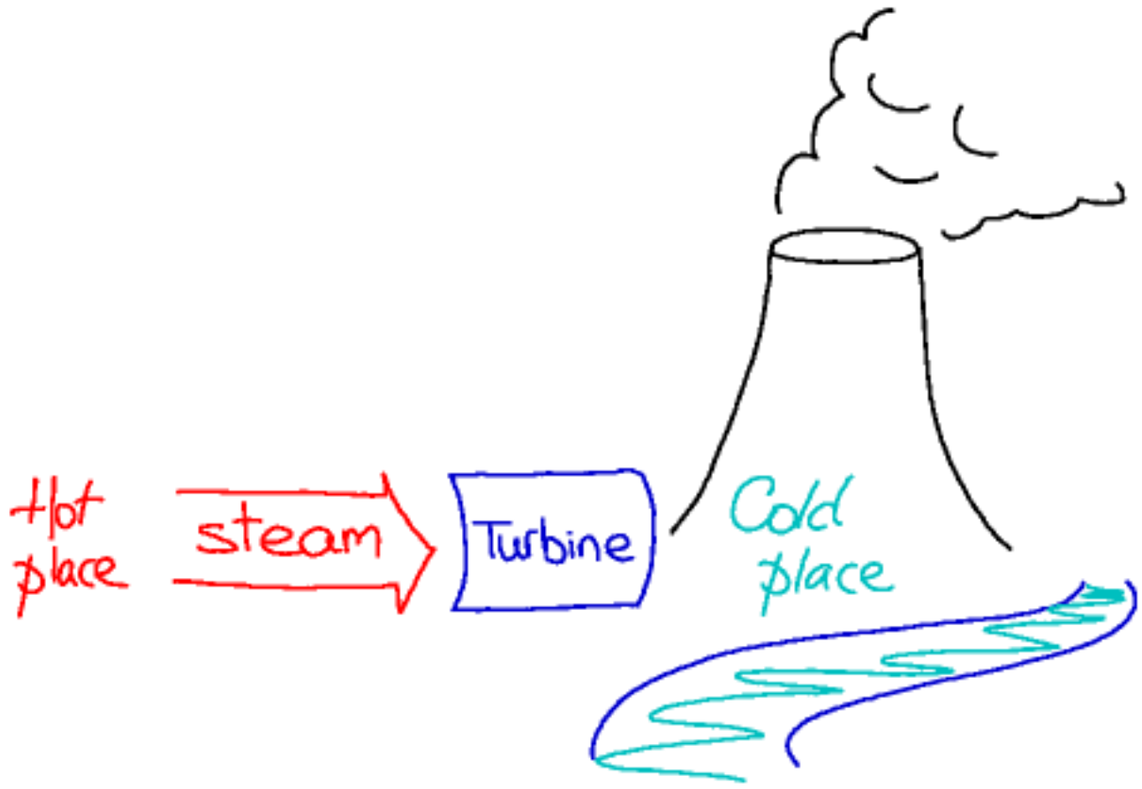
Lifestyle change?

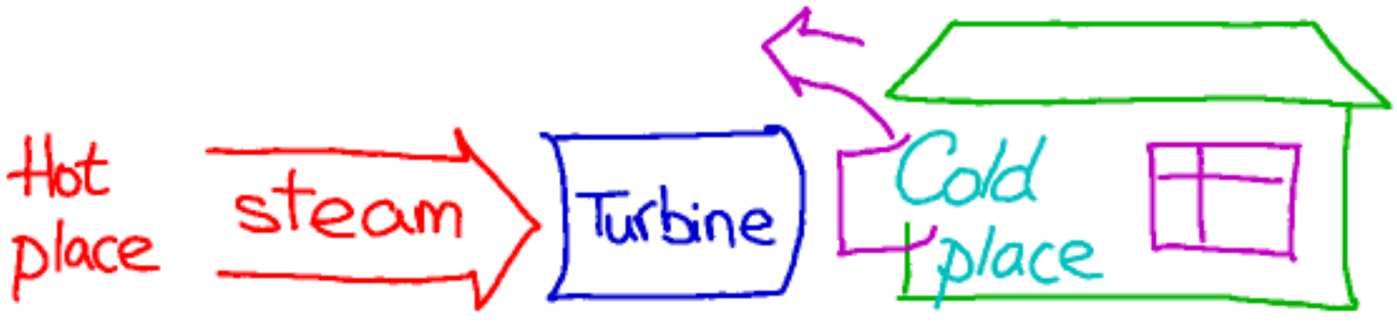
Changing energy consumption

Building regulations

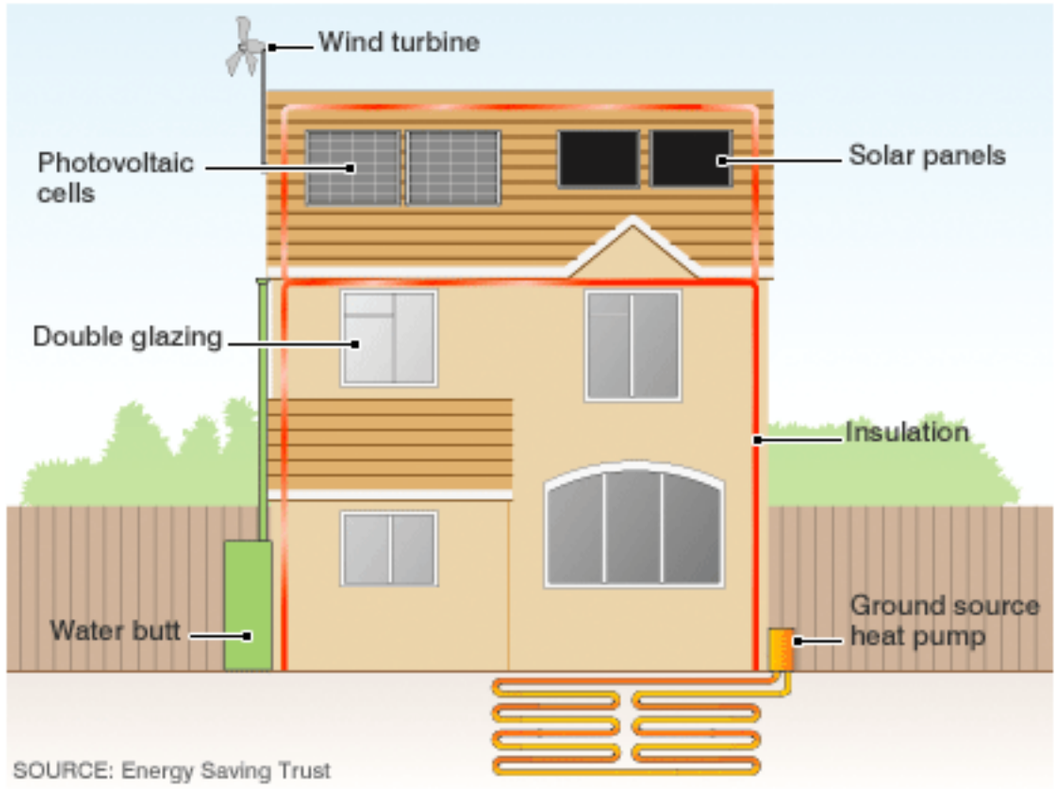


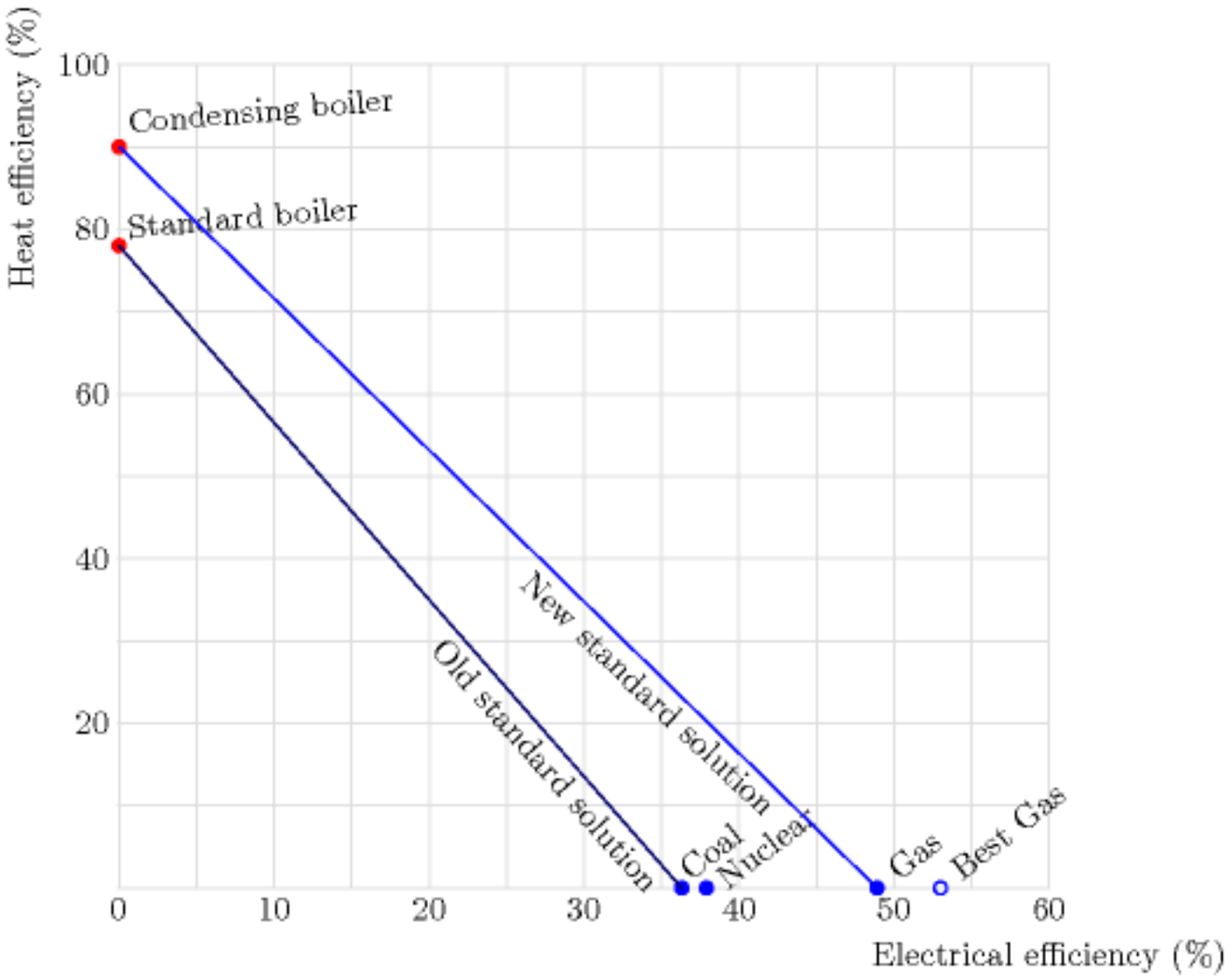
Combined heat and power?





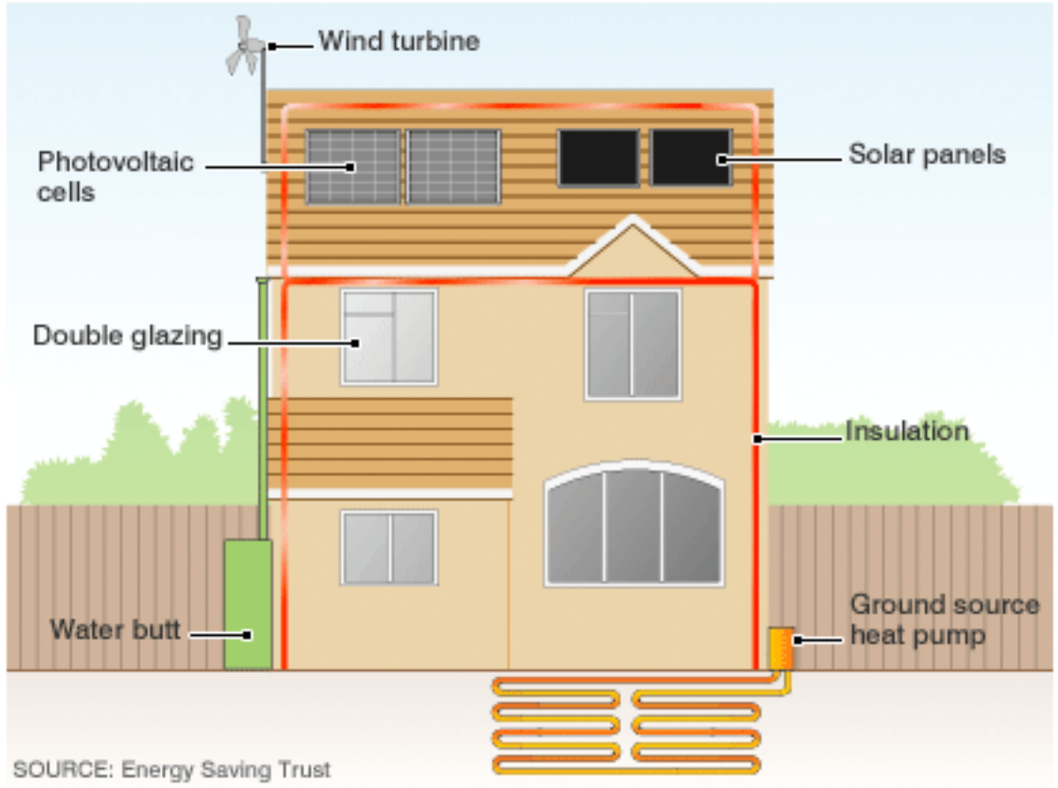
'Microgeneration', 'Decentralization'





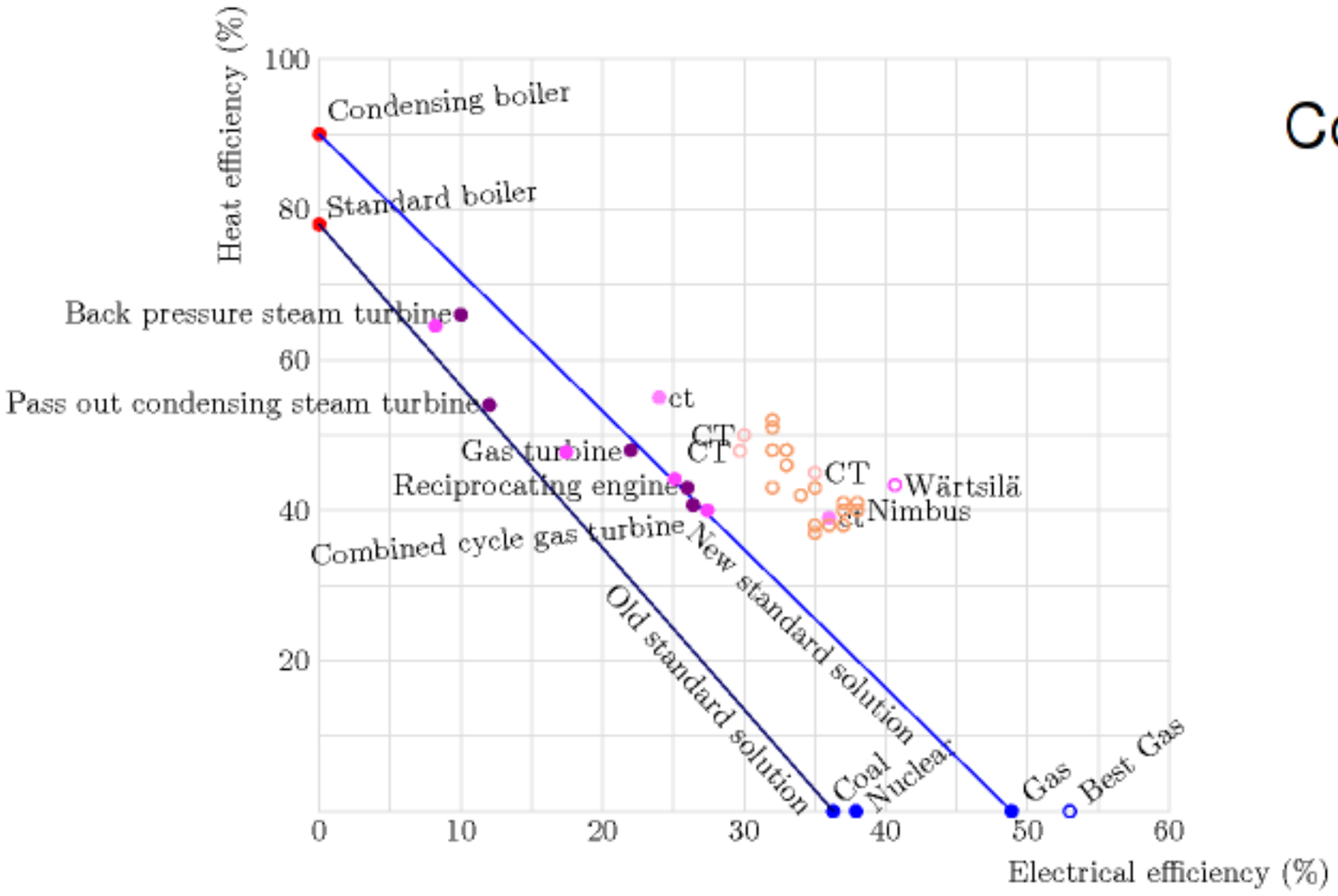
Can we do better than Combined Heat and Power?

- Heat pumps



Can we do better than Combined Heat and Power?

- Heat pumps



DAIKIN

A world Leader in Air Conditioning Technology

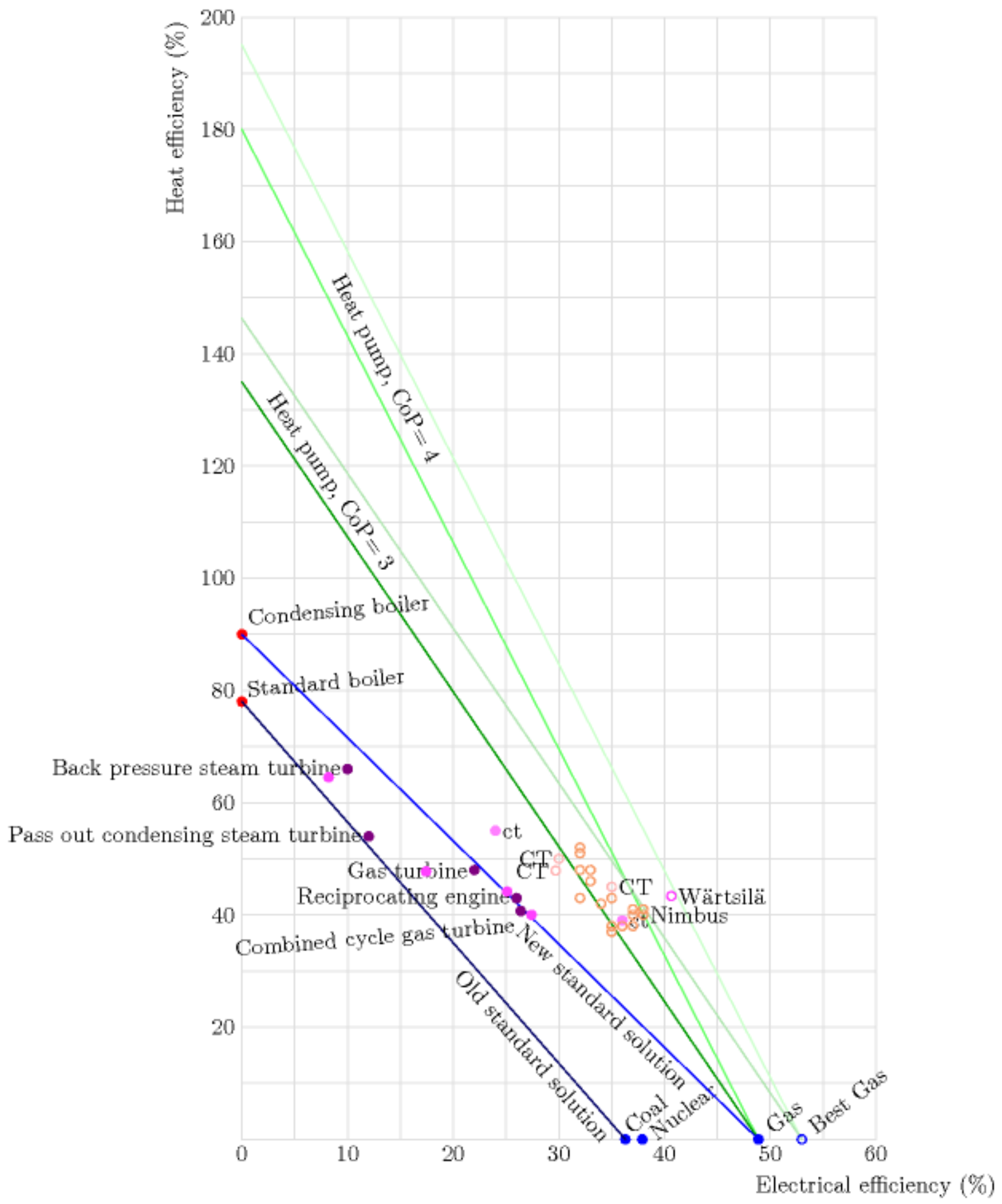
Australia and New Zealand

FTXS25E

A Daikin Split System will air condition one room or an area of your home. Discreet wall-mounted models, compact floor consoles and versatile floor and ceiling units are all part of the Daikin range.

Create perfect conditions all year round with Daikin reverse cycle split system air conditioners.

Unit	Indoor Unit Outdoor Unit	FTXS25EVMA RXS25EAVMA
Rated Capacity	Cool (KW) Heat (KW)	2.5 3.4
Capacity Range	Cool (KW) Heat (KW)	1.2-3.0 1.2-4.5
Indoor Air Flow	Cool (l/s) Heat (l/s)	145 157
Indoor Fan Speeds		5 steps, quiet and automatic
C.O.P		4.17/4.10
Front Panel Colour		White
Power Supply		1 phase, 220-240V, 50Hz



http://www.ecosystem-japan.com/

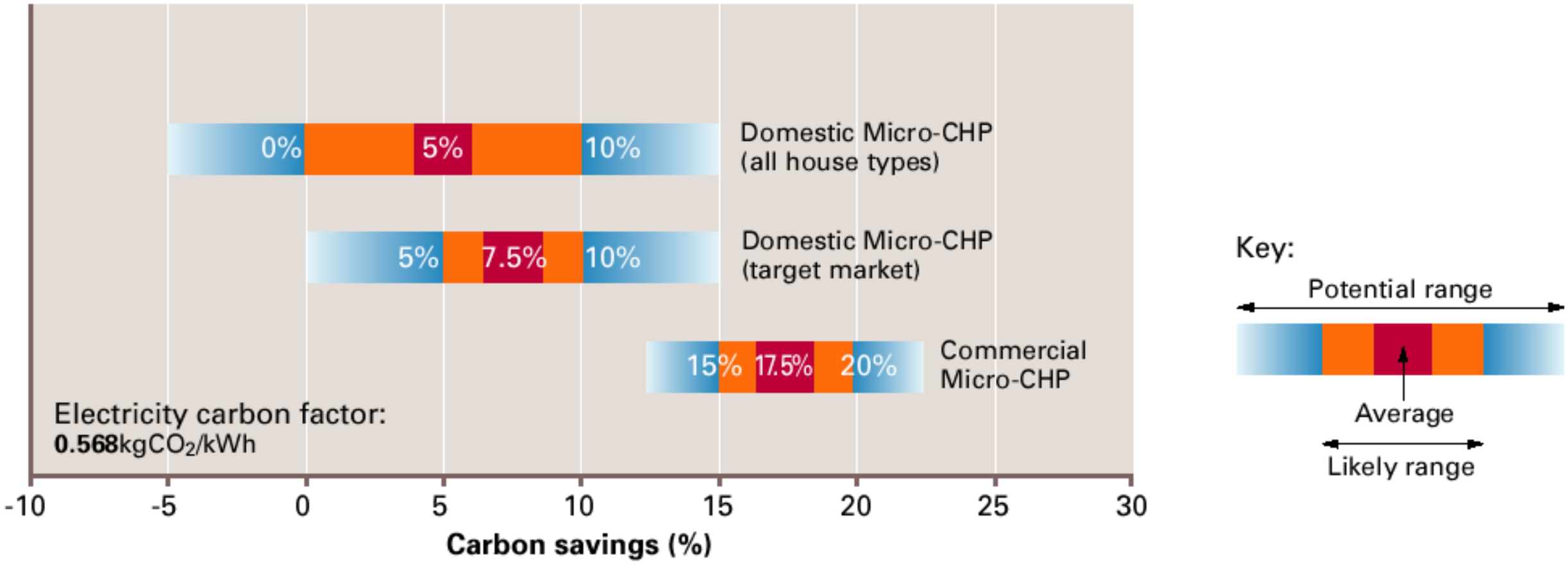
EcoCute water heater - CoP = 4.9!

Carbon Trust on Micro-CHP

Executive summary

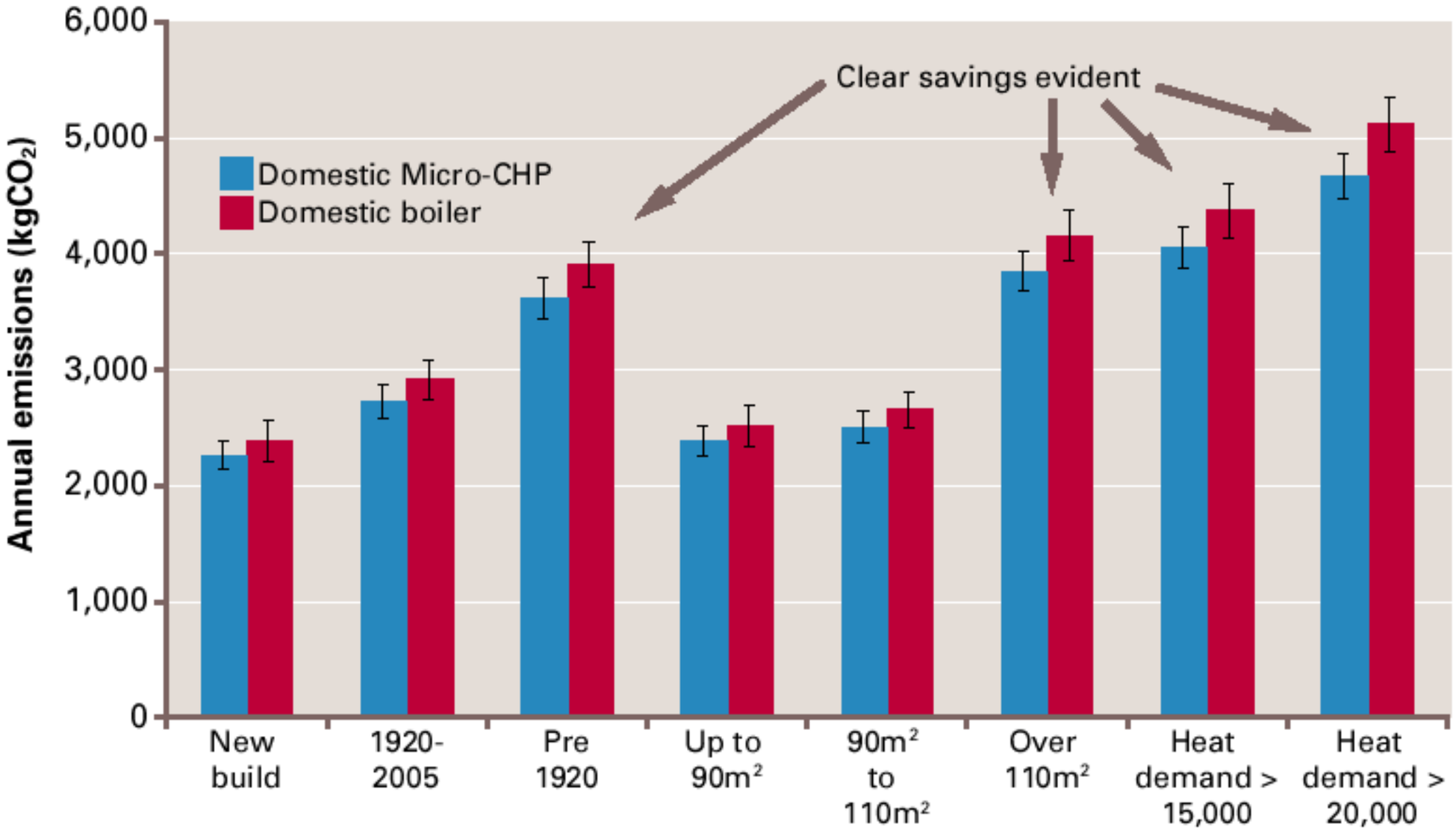
Micro-CHP is an emerging set of technologies with the potential to provide carbon savings in both commercial and domestic environments. Combined Heat and Power (CHP) systems provide potential reductions in carbon emissions and costs by generating both heat and electricity locally with efficient use of fuel and by offsetting the use of centrally-generated electricity from the grid.

Range of carbon savings expected for domestic and commercial Micro-CHP (relative to a typical A-rated condensing system boiler and based on carbon emissions factor of 0.568kgCO_2/kWh for displaced electricity)



Carbon Trust on Micro-CHP

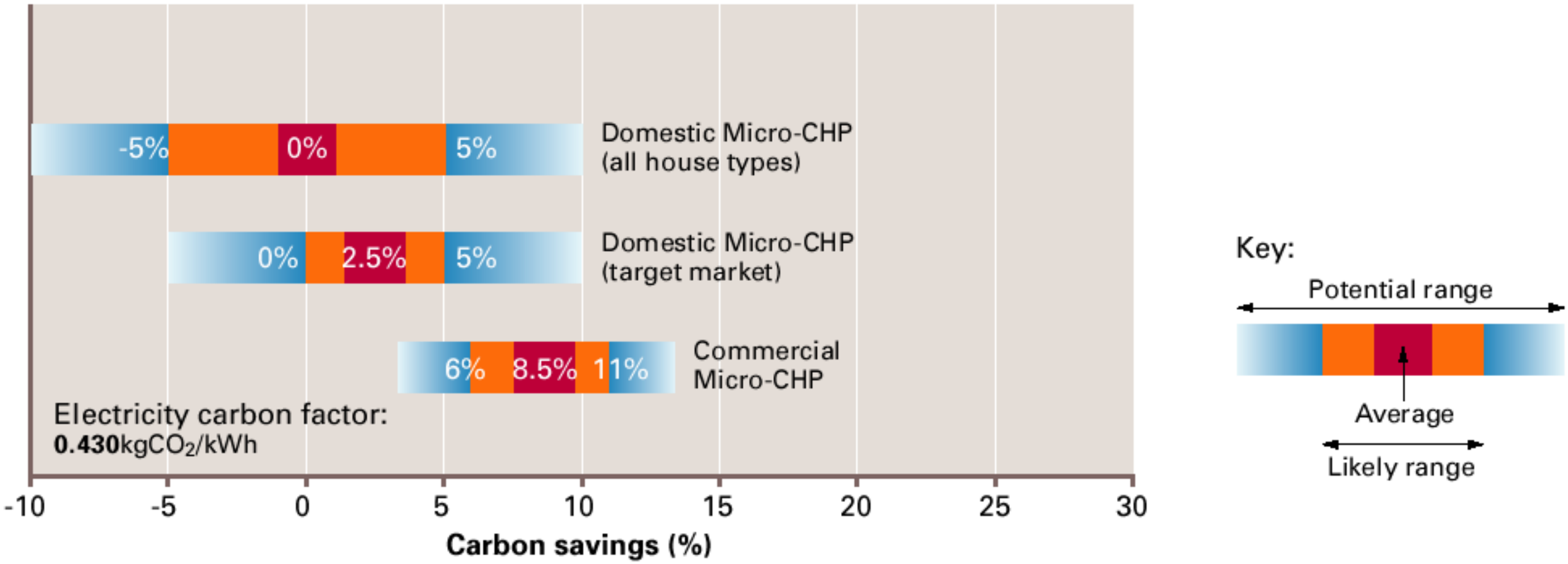
Figure 50 *Annual Micro-CHP and boiler emissions for cluster scenarios*



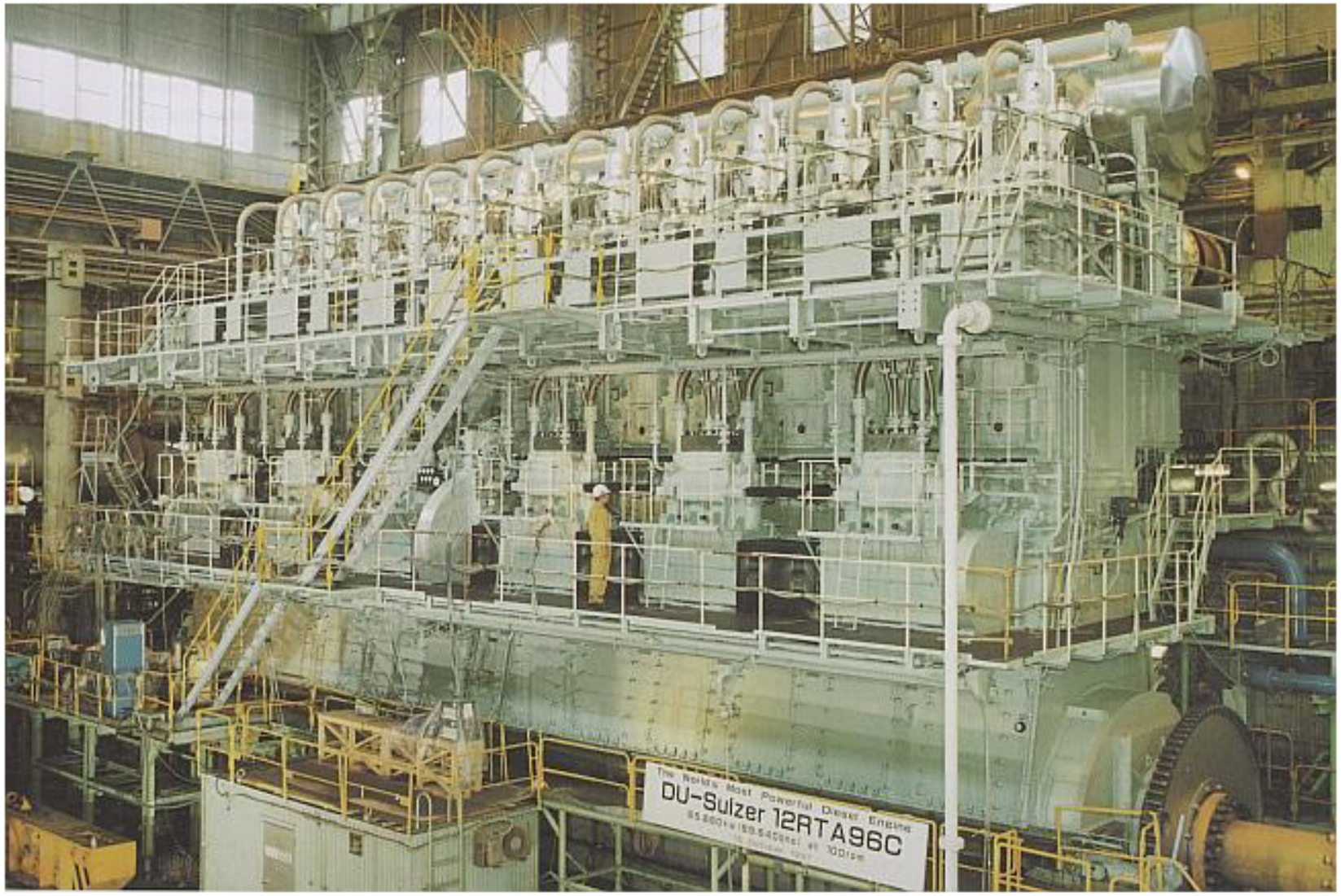
Carbon Trust on Micro-CHP

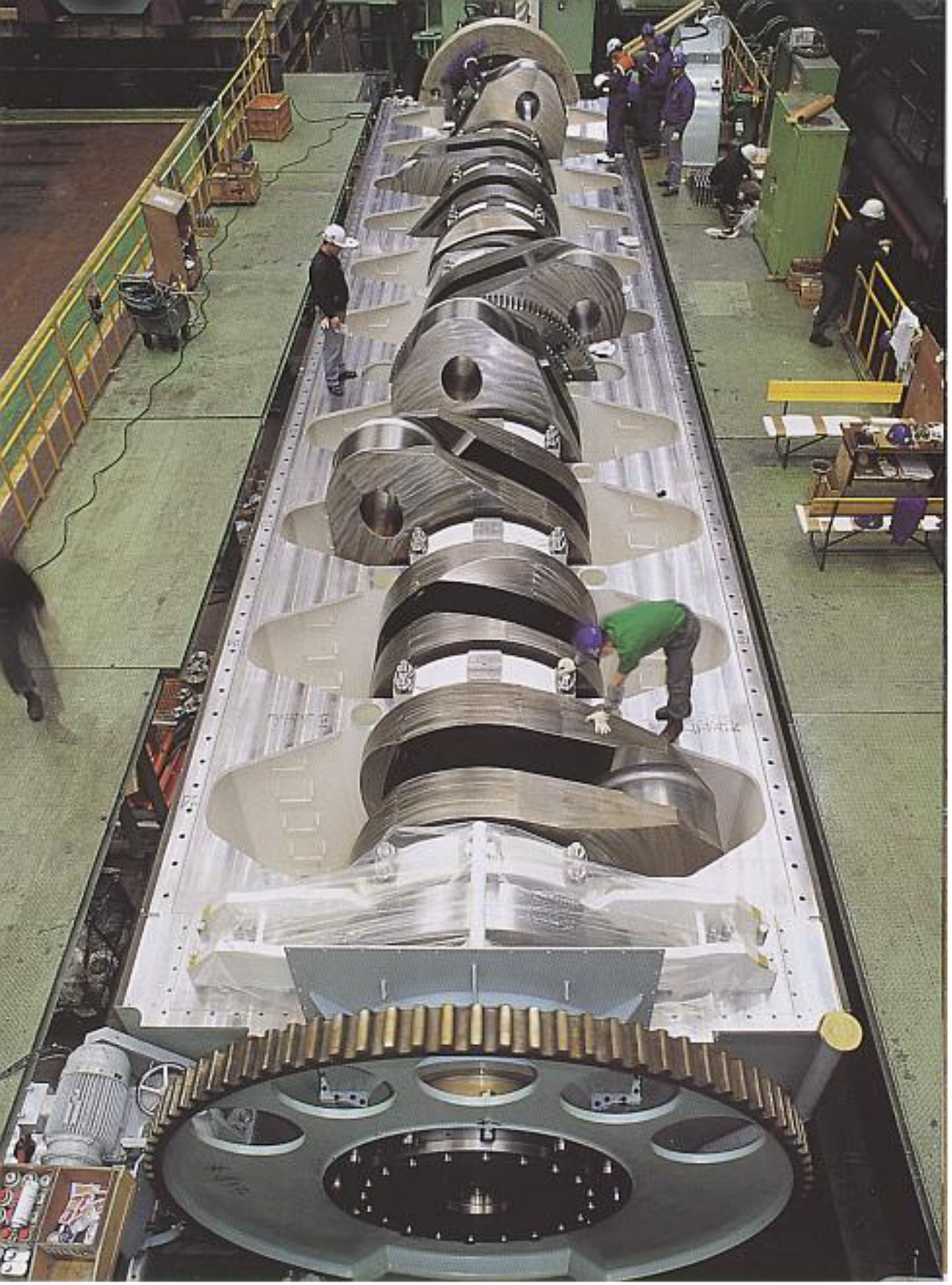
If they used $0.43\,\mathrm{kgCO_2/kWh}$ instead...

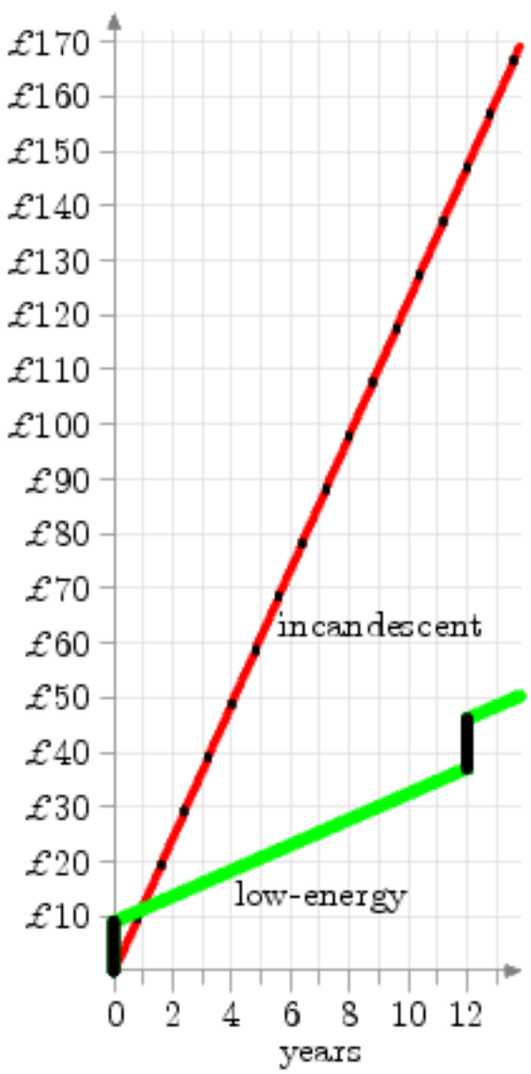
Figure 53 *Range of carbon savings expected for domestic and commercial Micro-CHP (based on carbon emissions factor of 0.43kgCO_2/kWh for displaced electricity)*



Don't knock centralization






£170
£160
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£70
£60
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£30
£20
£10
incandescent
low-energy
0 2 4 6 8 10 12
years


PHILIPS
6
11WATT
Energy Saver
60 WATT


PHILIPS

Micro-wind (one per person?)

David Cameron's chimney ->

1.6 kWh/d if wind speed is 6 m/s

2000 pounds for that!

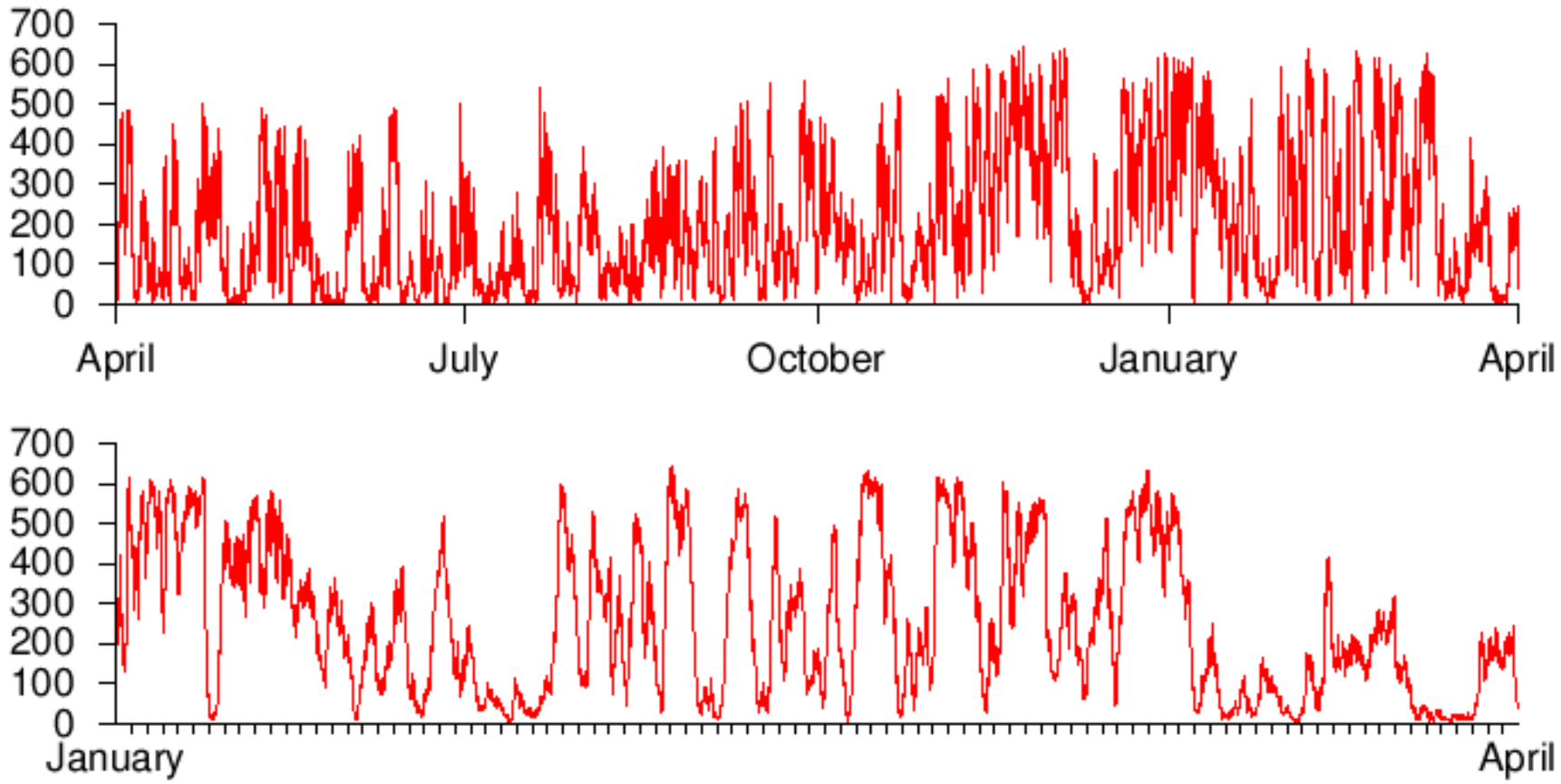
How to make a difference?

"We were going to have a wind turbine
but they're not very efficient"

From Private Eye, April 2007

Wind fluctuates

- Even when added over a whole country



Total output (in MW) of all windfarms in Eire, April 2006 - April 2007

'Wind is intermittent, so requires fossil-fuel back-up'

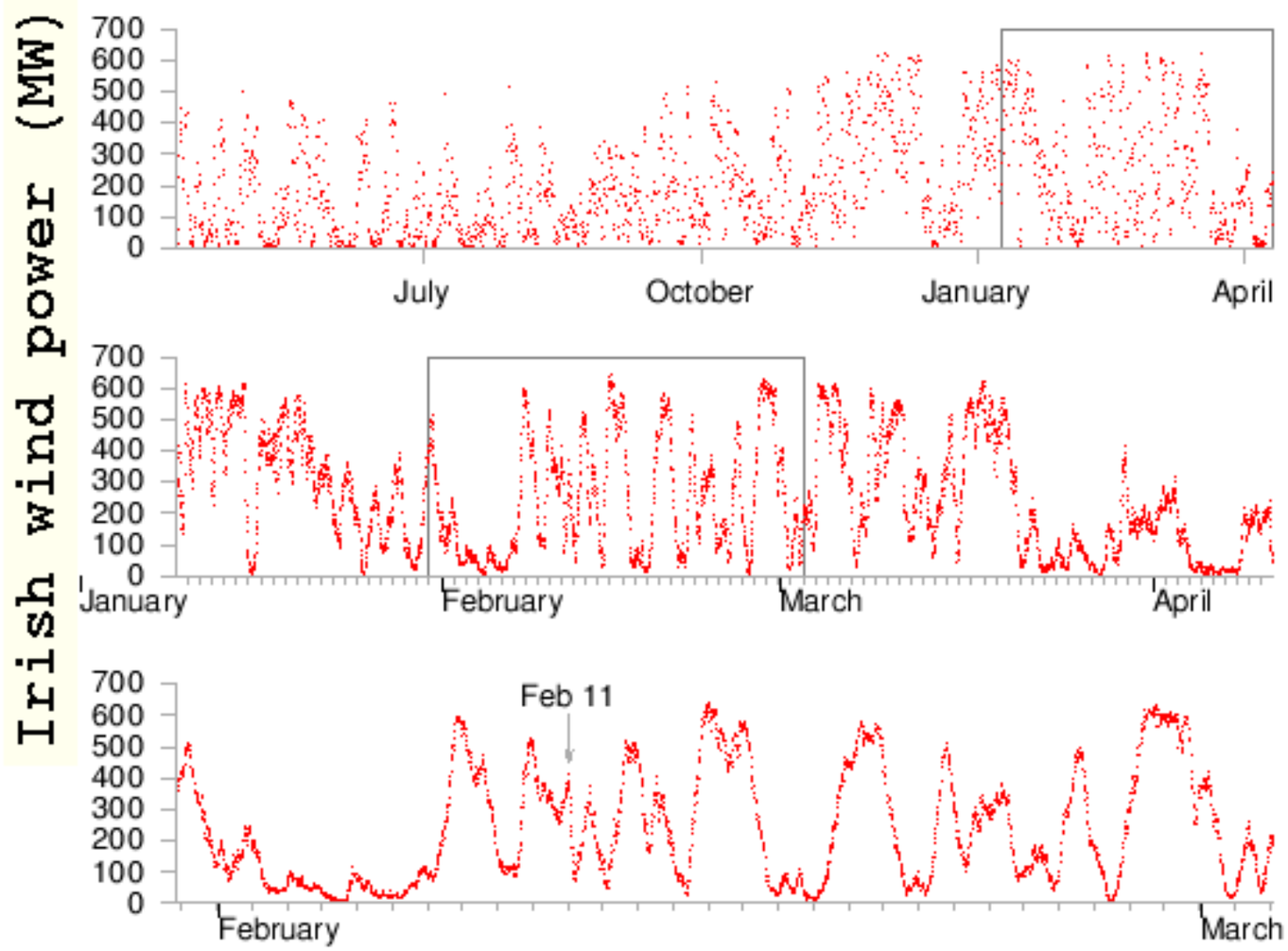
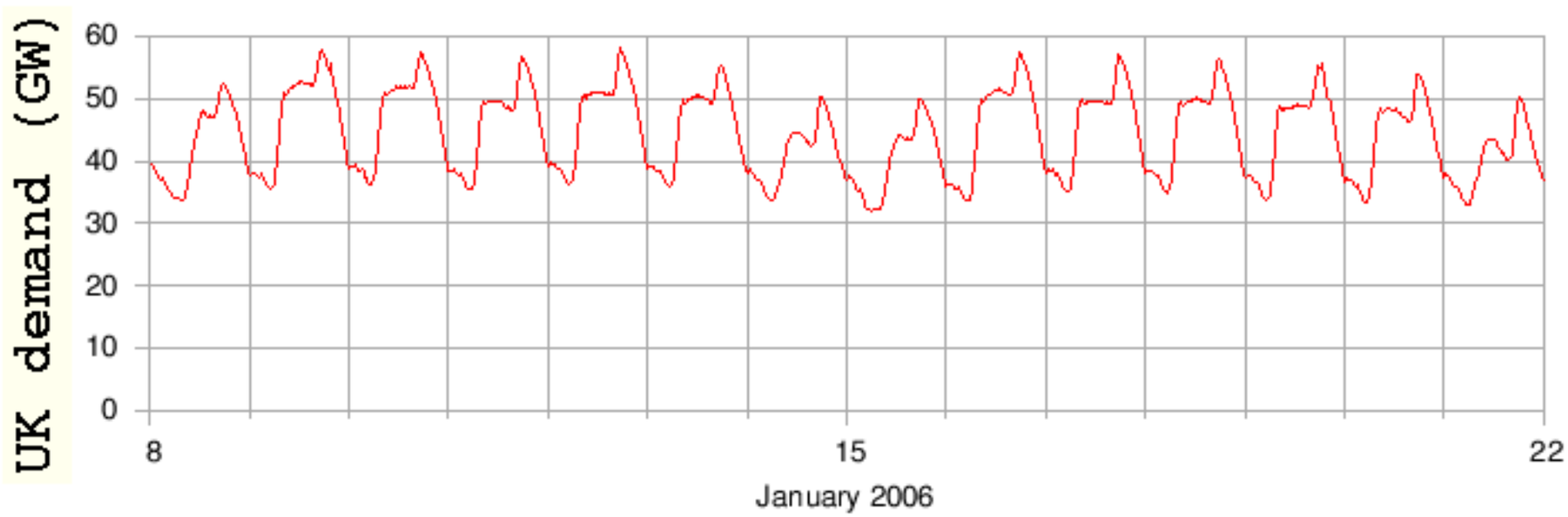


Figure 26.2. Total output, in MW, of all windfarms of the Republic of Ireland, from April 2006 to April 2007 (top), and detail from January 2007 to April 2007 (middle), and February 2007 (bottom). Peak electricity demand in Ireland is about 5000 MW. Its wind 'capacity' in 2007 is 745 MW, dispersed in about 60 wind farms. Data are provided every 15 minutes by `www.eirgrid.com`.

Scale this up: with 33 GW of capacity, expect slew rate of 3.7 GW per hour - an unprecedented problem for Britain?



Every morning, demand rises at a slew rate of 6.5 GW per hour

Birds killed by windmills

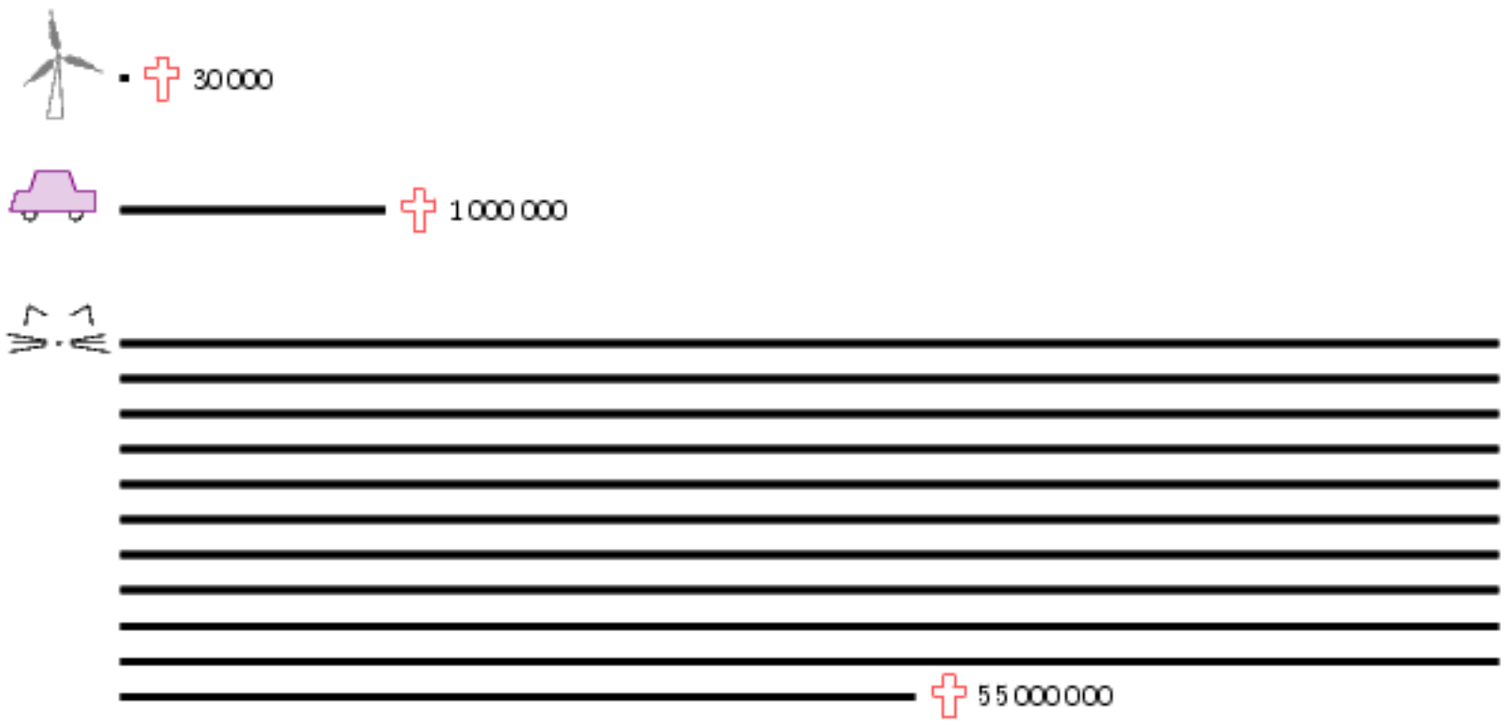
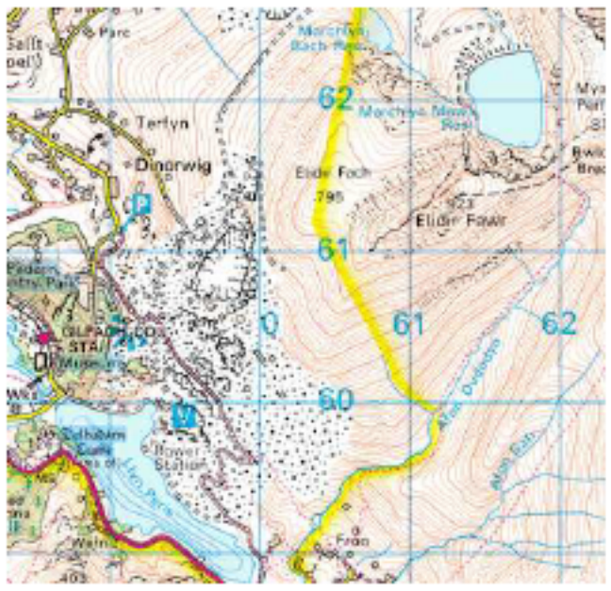


Figure 9.4. Birds lost in action.

Annual windmill- and car-caused deaths in Denmark;
and deaths caused in the UK by cats.

Storage - more Dinorwigs

Figure 29.2. Dinorwig, in the Snowdonia National Park, compared with Loch Sloy and Loch Lomond. The upper maps show 10 km by 10 km areas. In the lower maps the blue grid is made of 1 km squares. Images produced from Ordnance Survey's Get-a-map service `www.ordnancesurvey.co.uk/getamap`. Images reproduced with permission of Ordnance Survey. © Crown Copyright 2006



Dinorwig is the home of a 9 GWh storage system, using Marchlyn Mawr (615E,620N) and Llyn Peris (590E,598N) as its upper and lower reservoirs.

Loch Sloy illustrates the sort of location where a 40 GWh storage system could be created.

or smart storage ('net-energy')

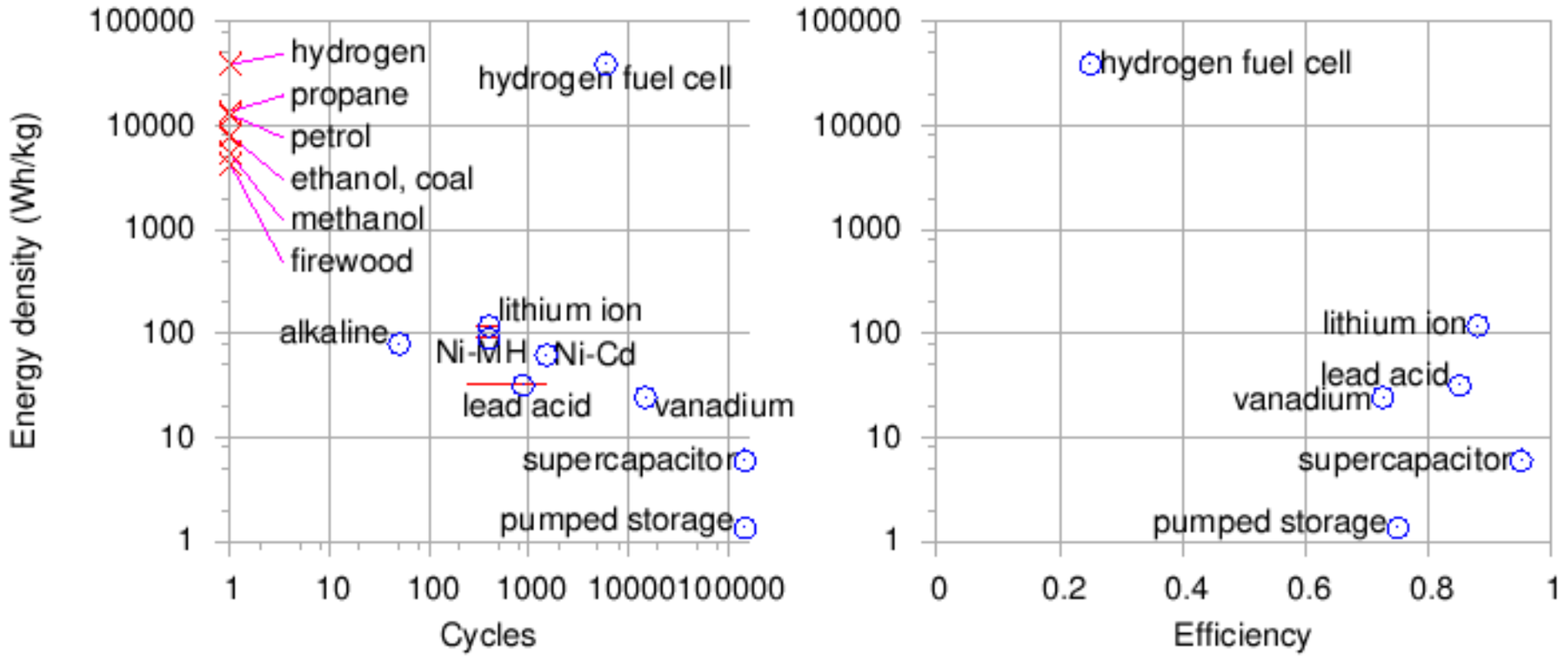
Pumped storage

Okinawa Seawater Pumped Storage Power Plant (0.2 GWh)
www.ieahydro.org
Output - 30 MW

Kannagawa Power Plant (29 GWh)
www.ieahydro.org

- Electric vehicles - another huge easily-switch-off-and-on-able load

Energy storage



Altitudes in the UK

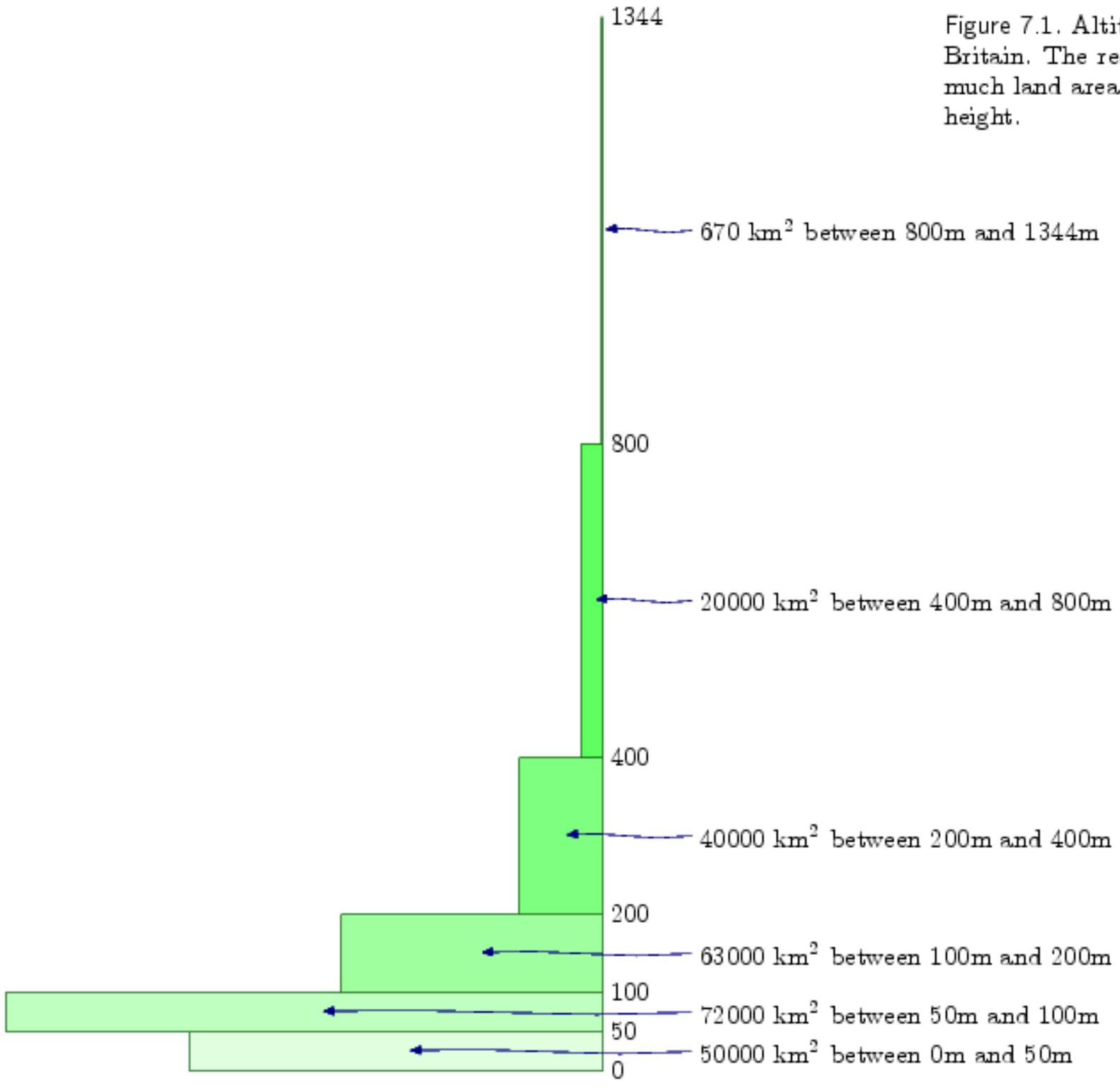
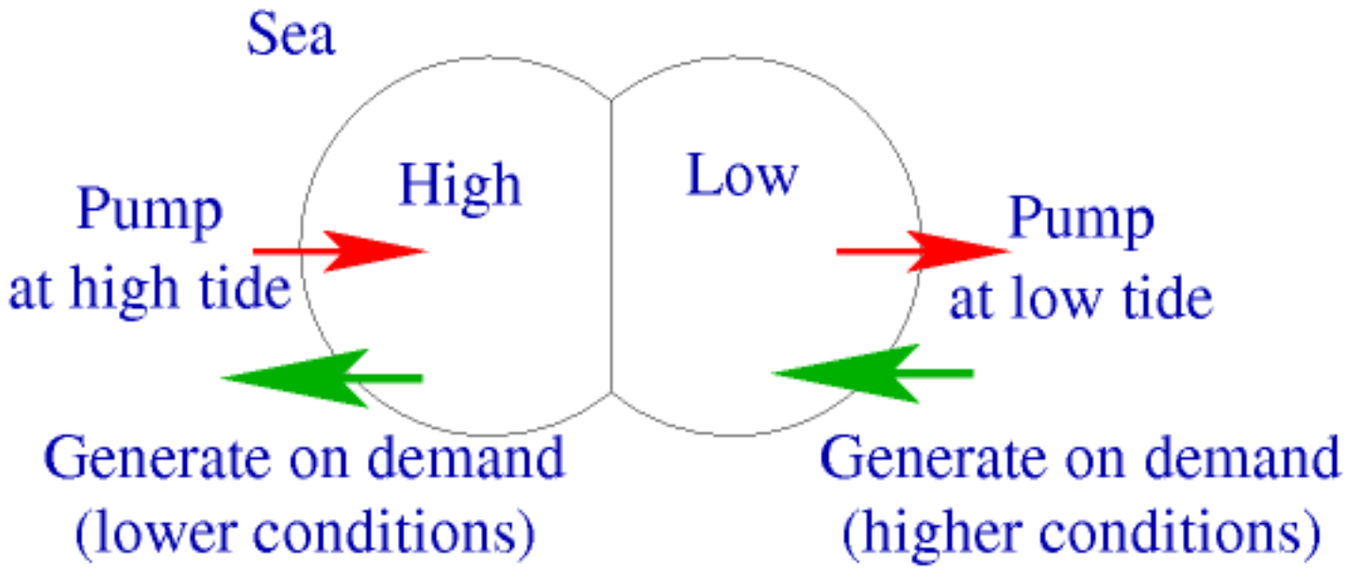
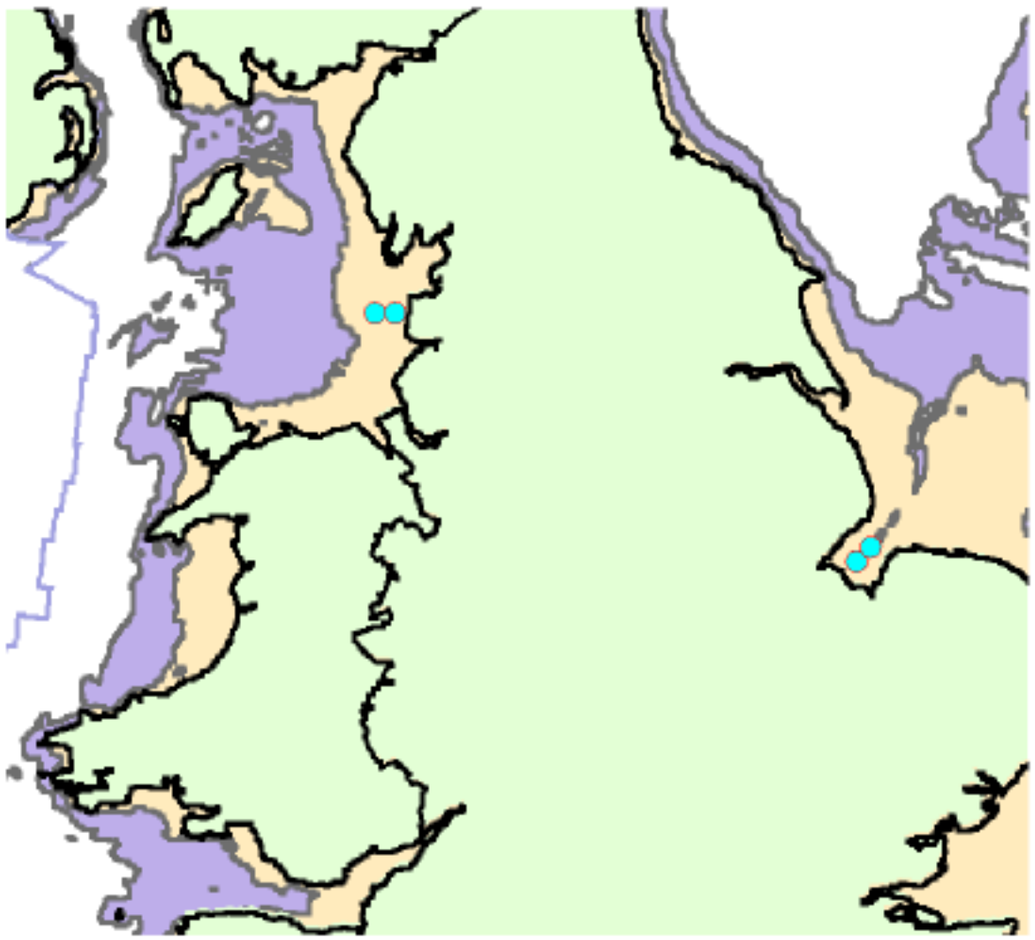
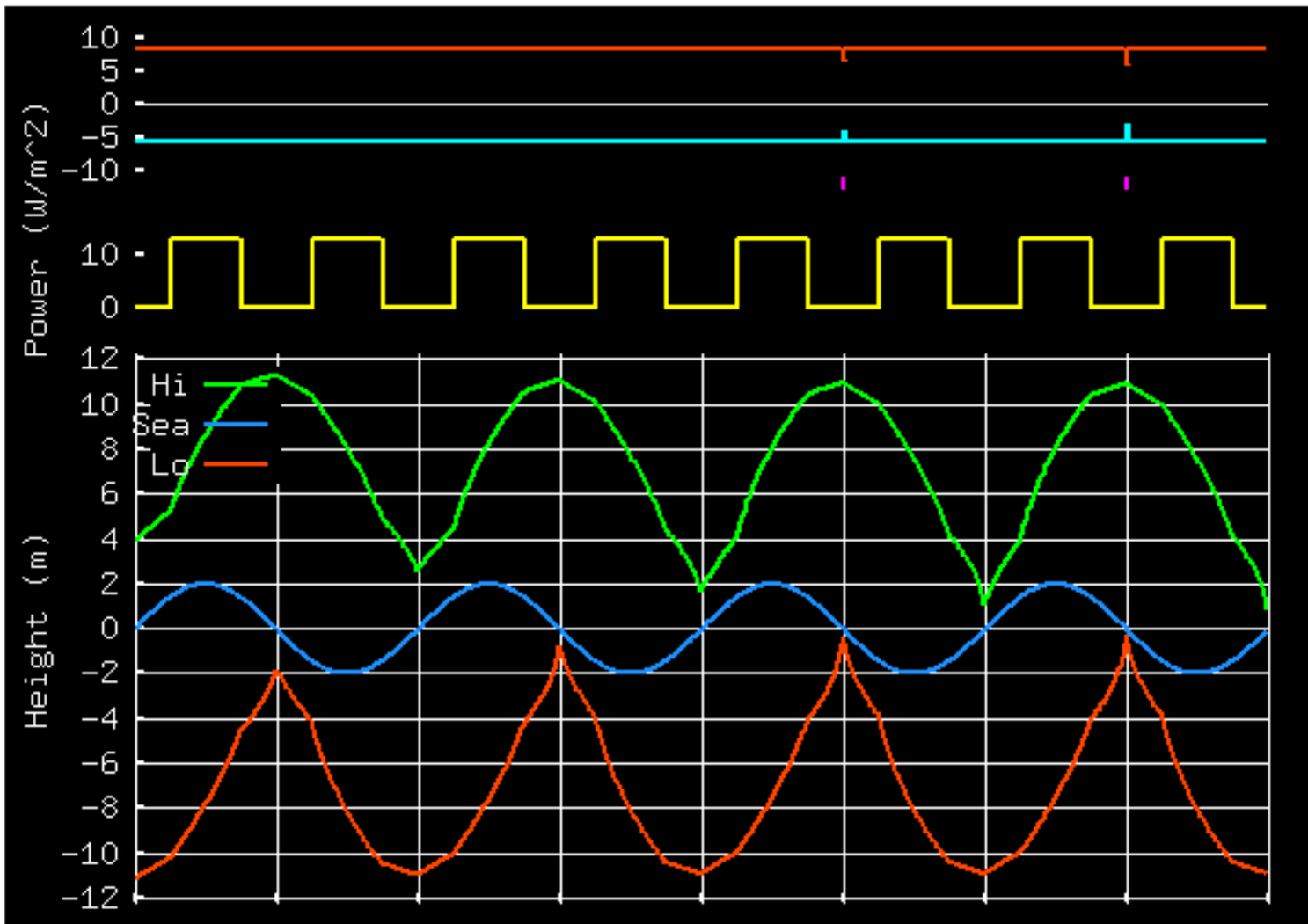


Figure 7.1. Altitudes of land in Britain. The rectangles show how much land area there is at each height.

Pumped storage and tide combined







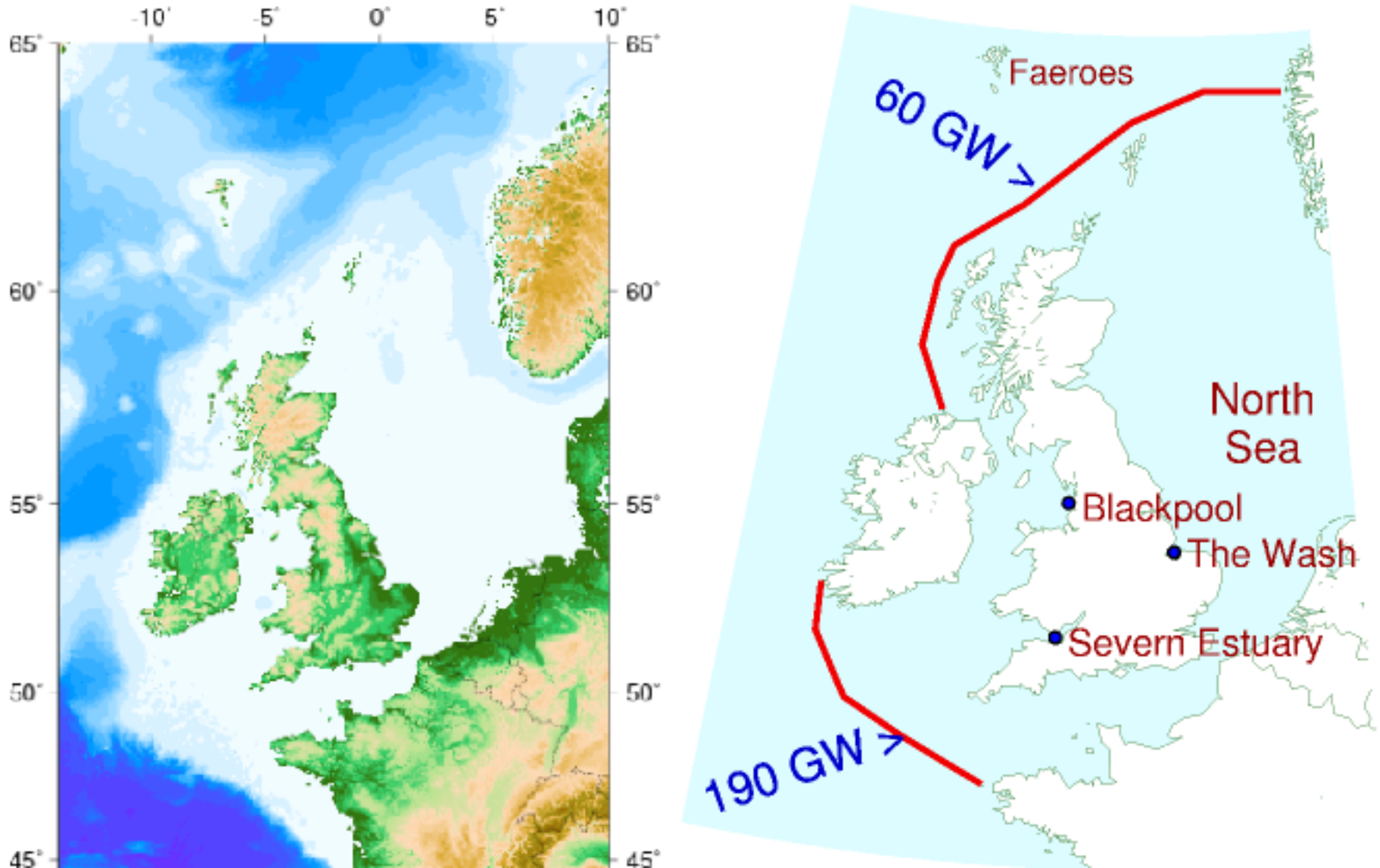
Seagen

marineturbines.com

'Tidal power slows down the earth's rotation'

Natural rotational energy loss is already 3 TW.
Natural slowing rate of the earth's rotation is 2.3 ms/day per century.

World power consumption is 15 TW.
If extra tidal power doubled the slowing rate, then in two
million years, the length of a day would be longer by two minutes instead of one minute.

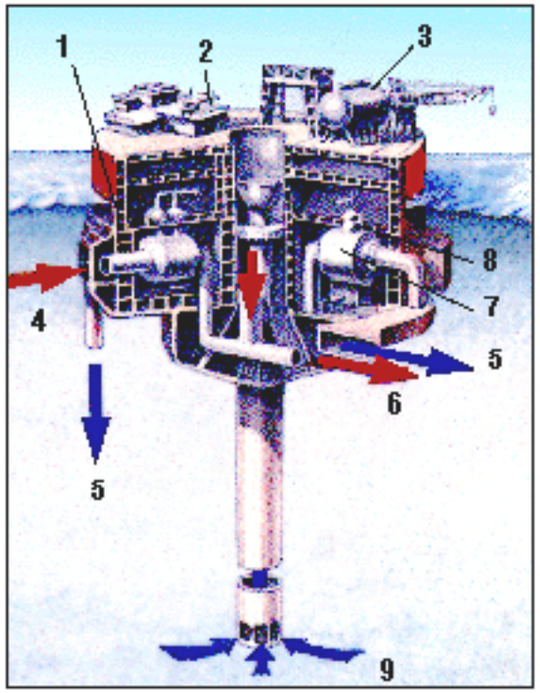


Ocean thermal

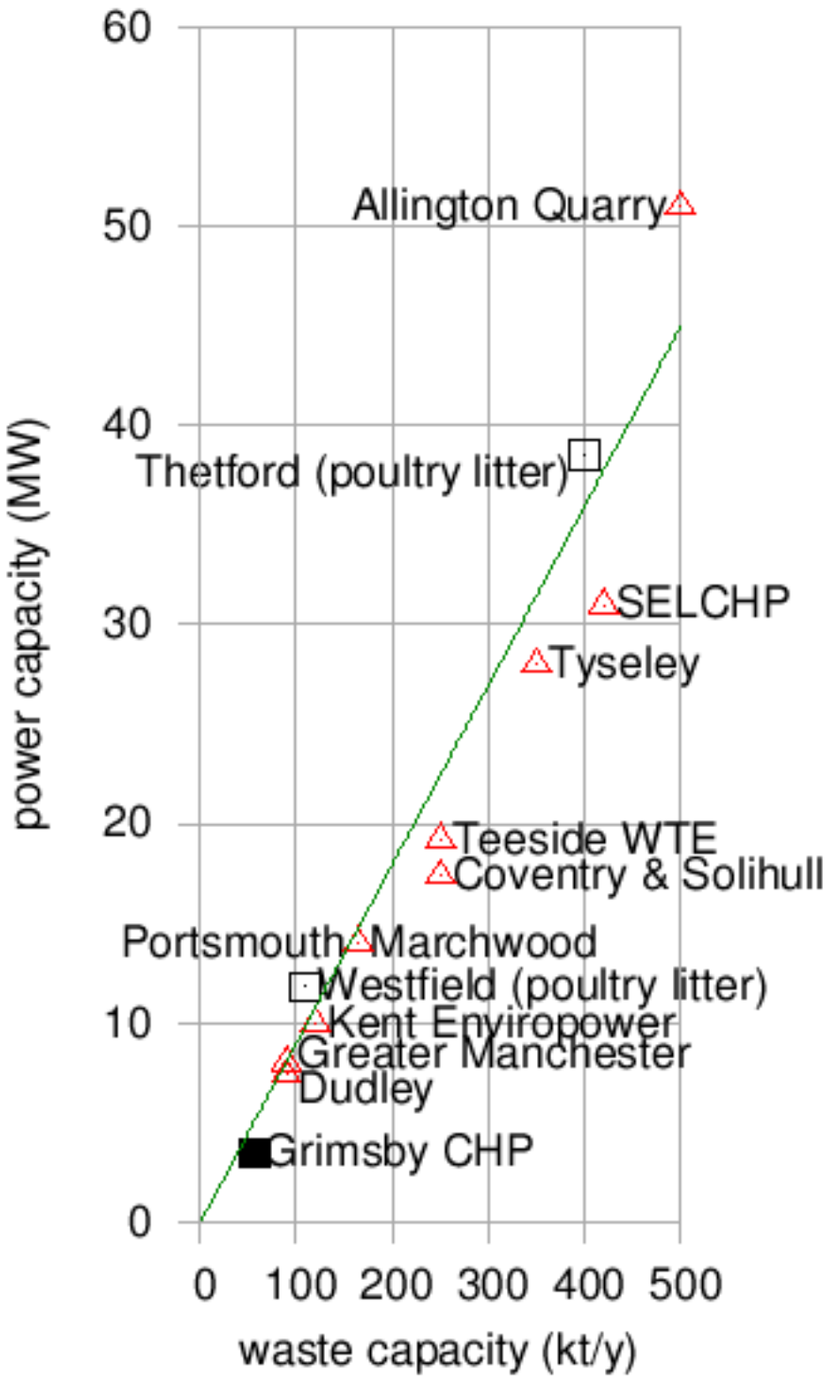
- Not available in the UK

- Theoretical limit: $5\,\mathrm{W/m^2}$
- Spin-offs:
  - Uranium extraction
  - Desalinated water
  - Air-conditioning

- Fantasy:
  - Cover 10% of all tropical oceans with heat engines
  - 120 kWh per person per day

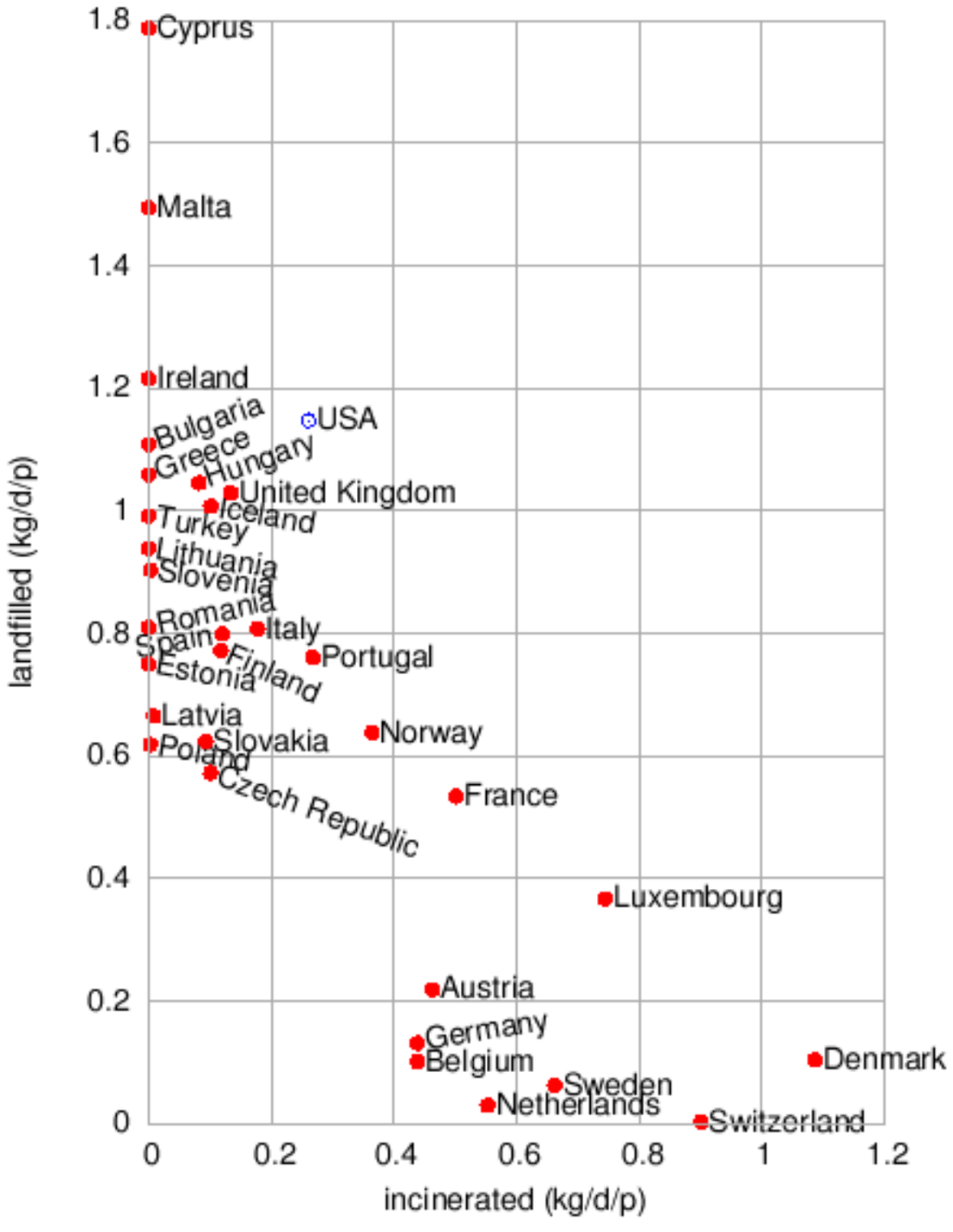


Waste incinerators



1 kg of waste - 0.5 kWh of electricity

Municipal solid waste



Small steps that make a big difference:

CHECK YOUR NUMBERS BEFORE PUBLISHING!

camden.gov.uk

May 2008

YourCamden

your **FREE** monthly magazine from Camden Council

Camden

The green issue

Tackle climate change

Small steps that make a big difference

Small, simple, sustainable steps

It's easy to live a greener life. Here are our top tips.

6 Switch off

Around 8% of the UK's $C0_2$ emissions are caused by people leaving appliances on standby. So when you're done watching the telly, switch it off at the wall. You'll save yourself some money while you're at it.

The truth:

Of domestic electricity,

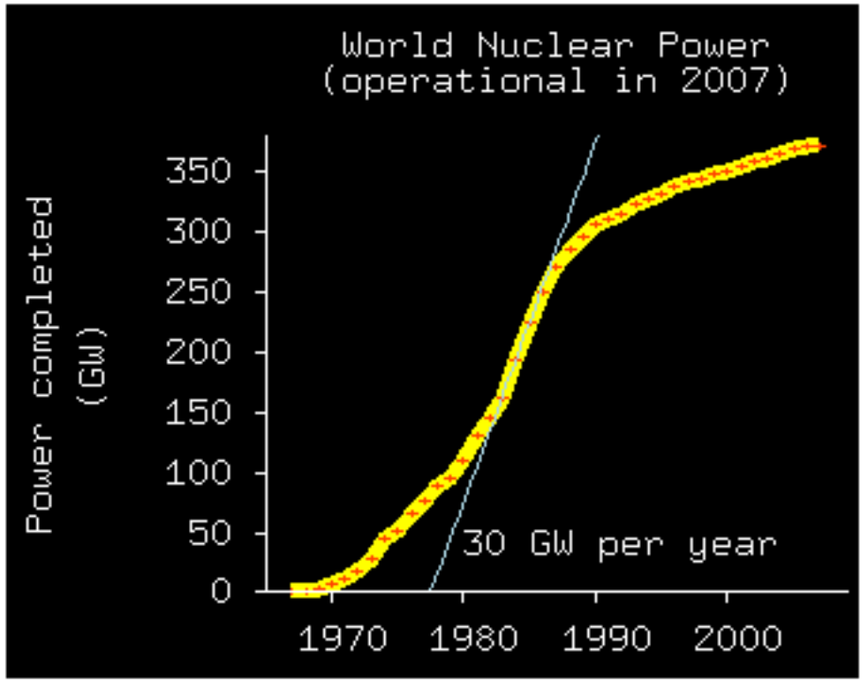
standby is 8%

Nuclear power 'completely infeasible'?

"For nuclear power to make a significant contribution to a reduction in global carbon emissions in the next two generations, the industry would have to construct nearly 3000 new reactors [over 60 years] ...
[This is] a pipe dream and completely infeasible. The highest historic rate of build is 3.4 new reactors a year."

(Guardian, citing an Oxford Research Group report, 4th July 2007)

The truth



Huge expansion for wind turbines

There could be more than two offshore wind turbines per mile of UK coastline under plans being set out by ministers.

The aim is for 20% of EU energy to come from renewables by 2020

Business Secretary John Hutton says he wants to open up British seas to allow enough new turbines - up to 7,000 - to power all UK homes by the year 2020.

John Sauven, the executive director of Greenpeace, said that the plans amounted to a "wind energy revolution".
"And Labour needs to drop its obsession with nuclear power, which could only ever reduce emissions by about 4% at some time in the distant future."

How does nuclear's pathetic 4% compare with the proposed offshore wind?

'33GW' of offshore wind would deliver on average 10GW, which is 4kWh/d per person

4%!

4 kWh/d

4 kWh/d

'all homes'

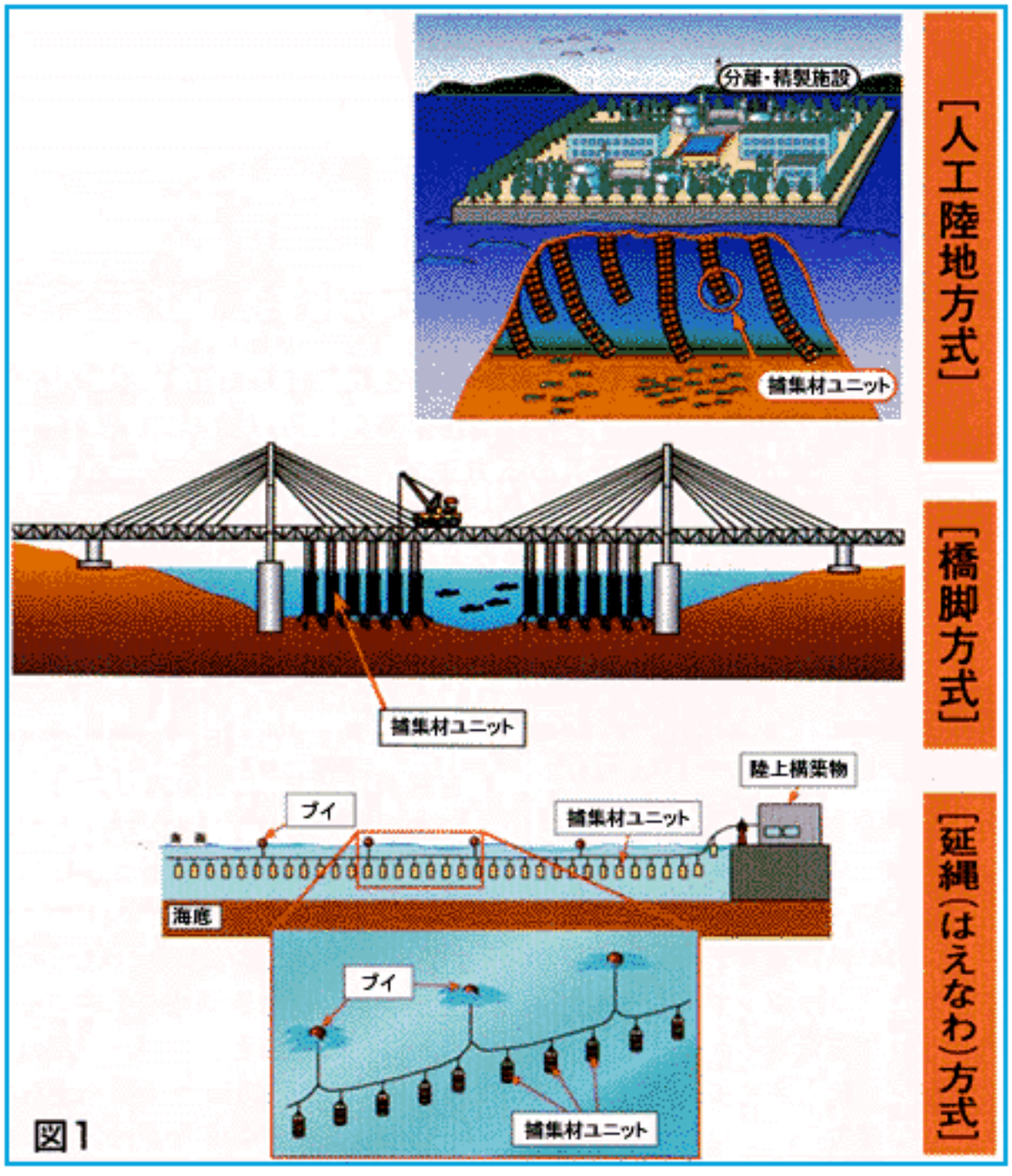
4 kWh/d

10 GW nuclear

4 kWh/d

33 GW wind

Ocean Uranium



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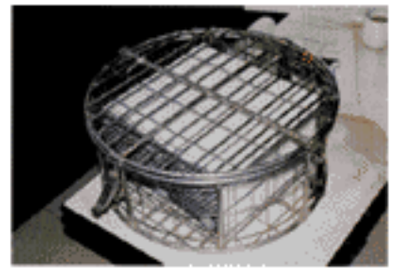
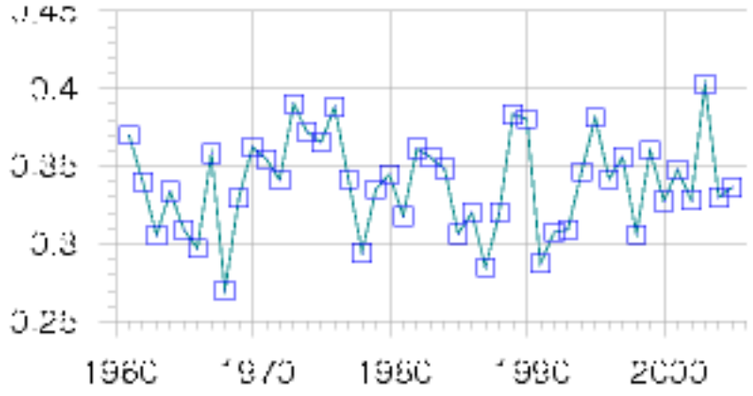
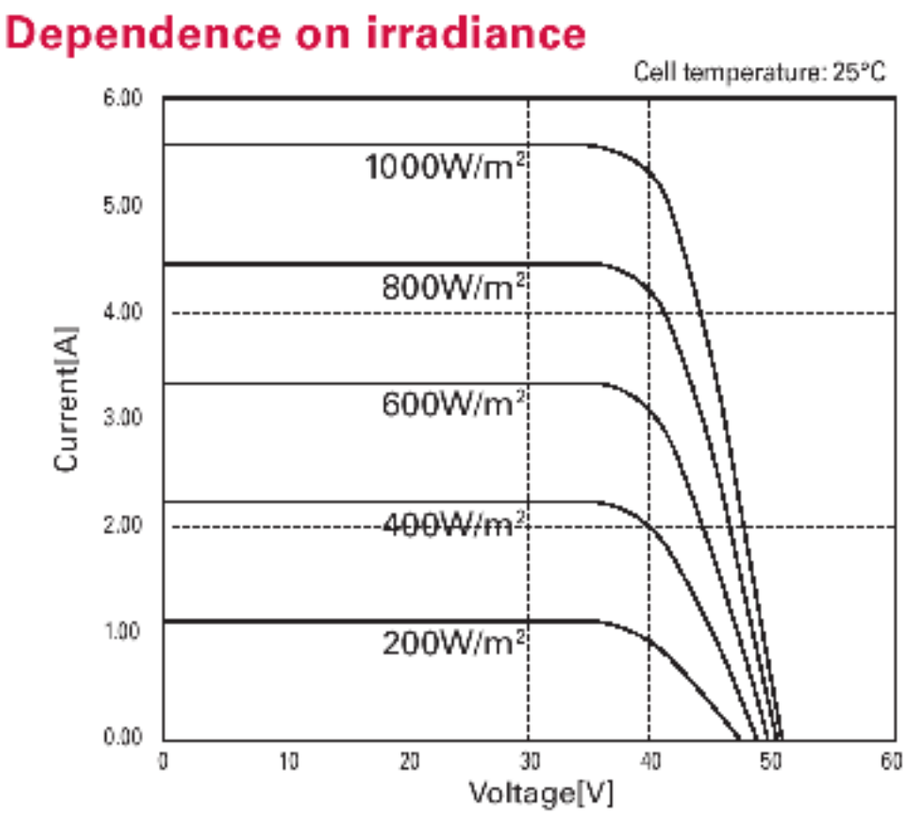


Sunniness



Cambridge

and its effect on PV

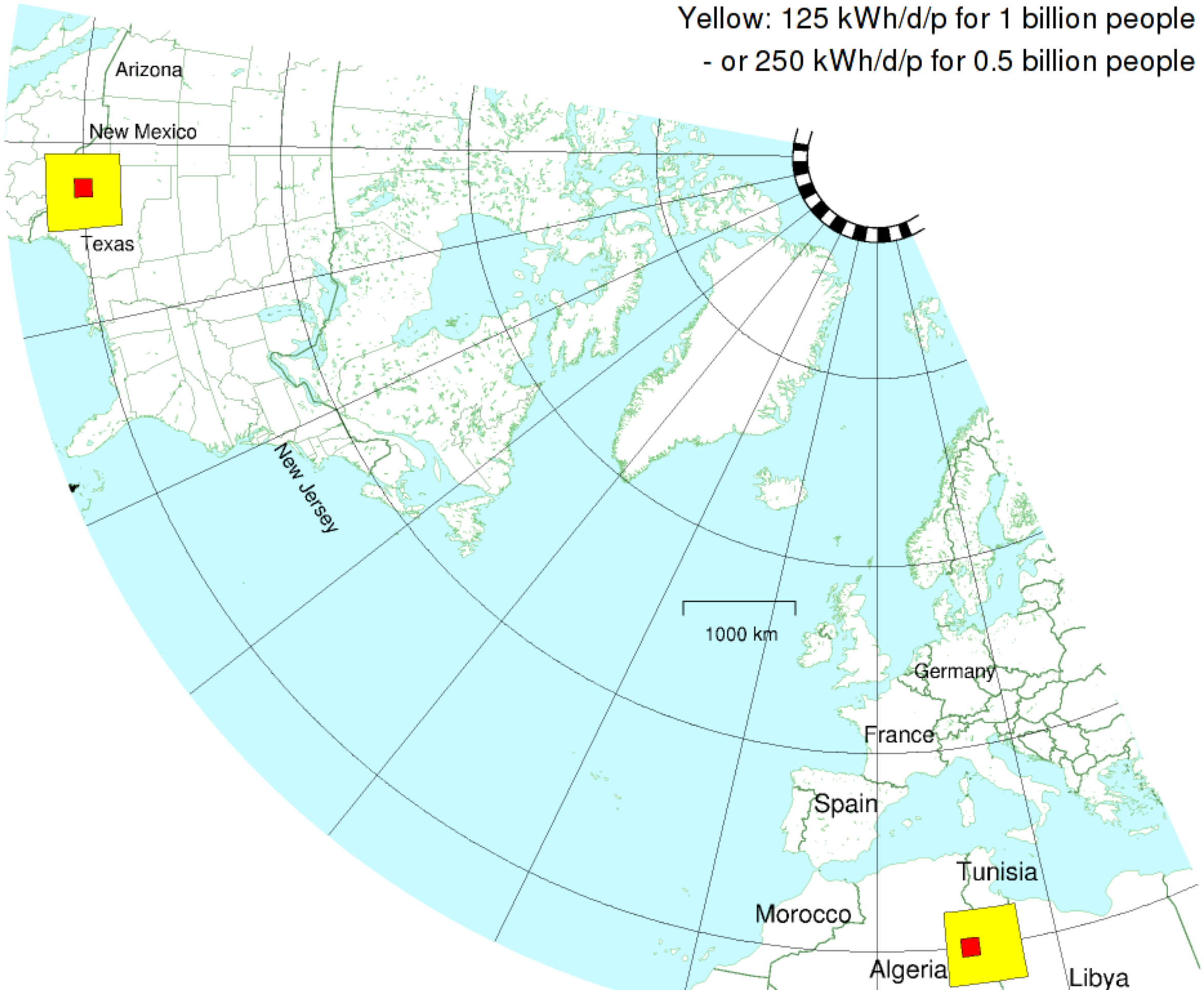


Solar chimney

- No mirrors!

Yellow: 125 kWh/d/p for 1 billion people

- or 250 kWh/d/p for 0.5 billion people

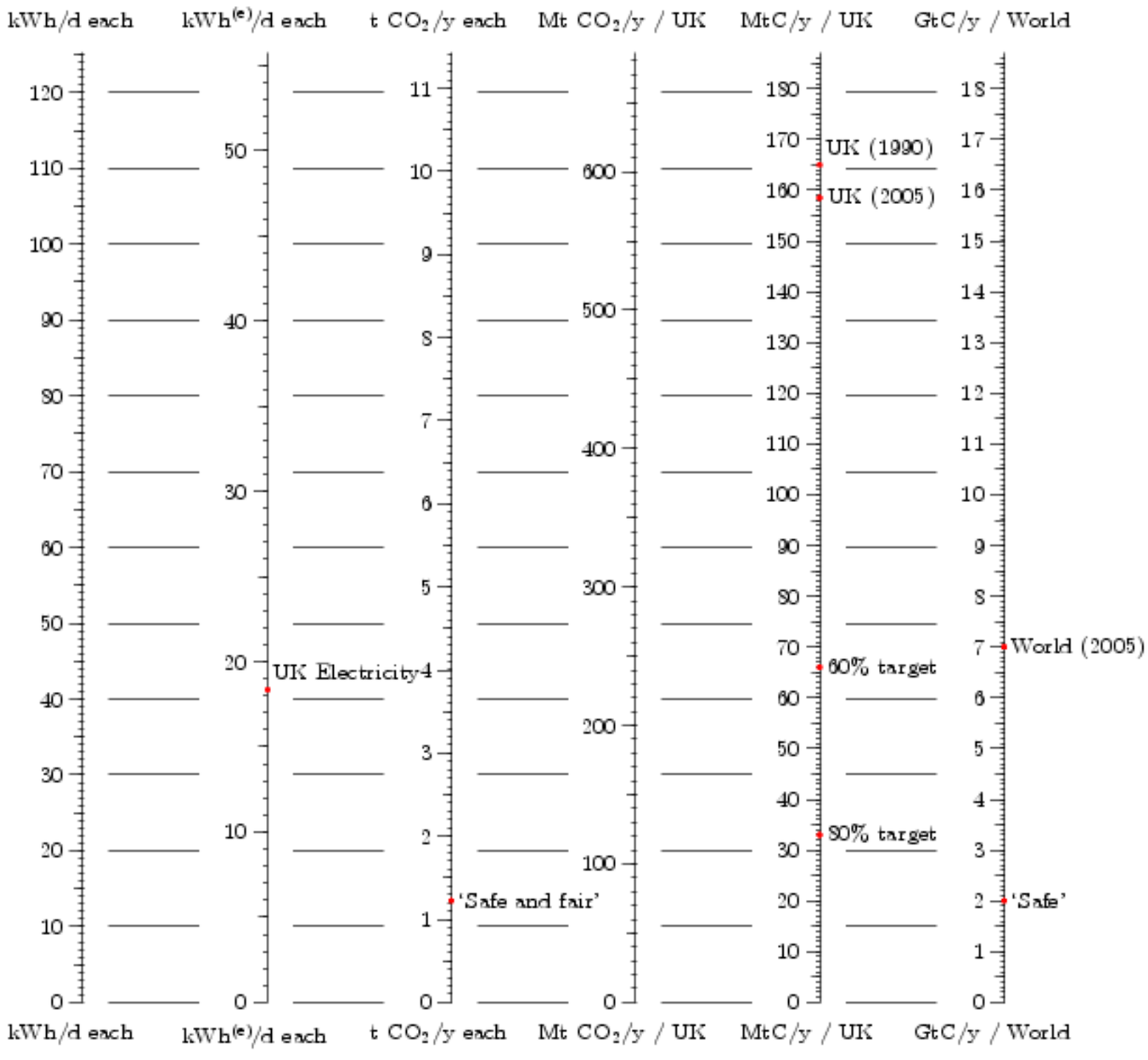


Desalination

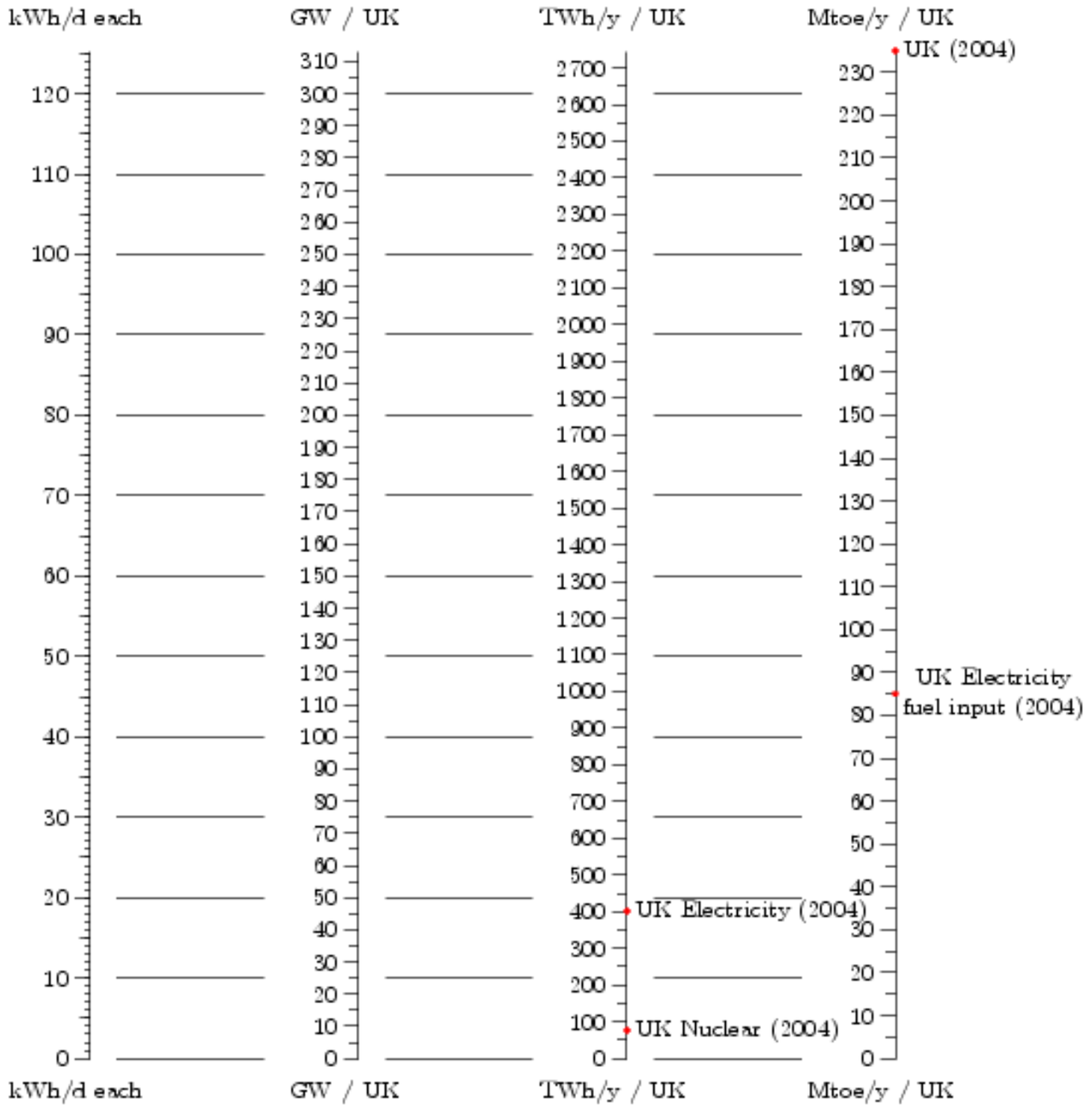
$8\,\mathrm{kWh/m^3}$

Jersey Water

Carbon translation chart

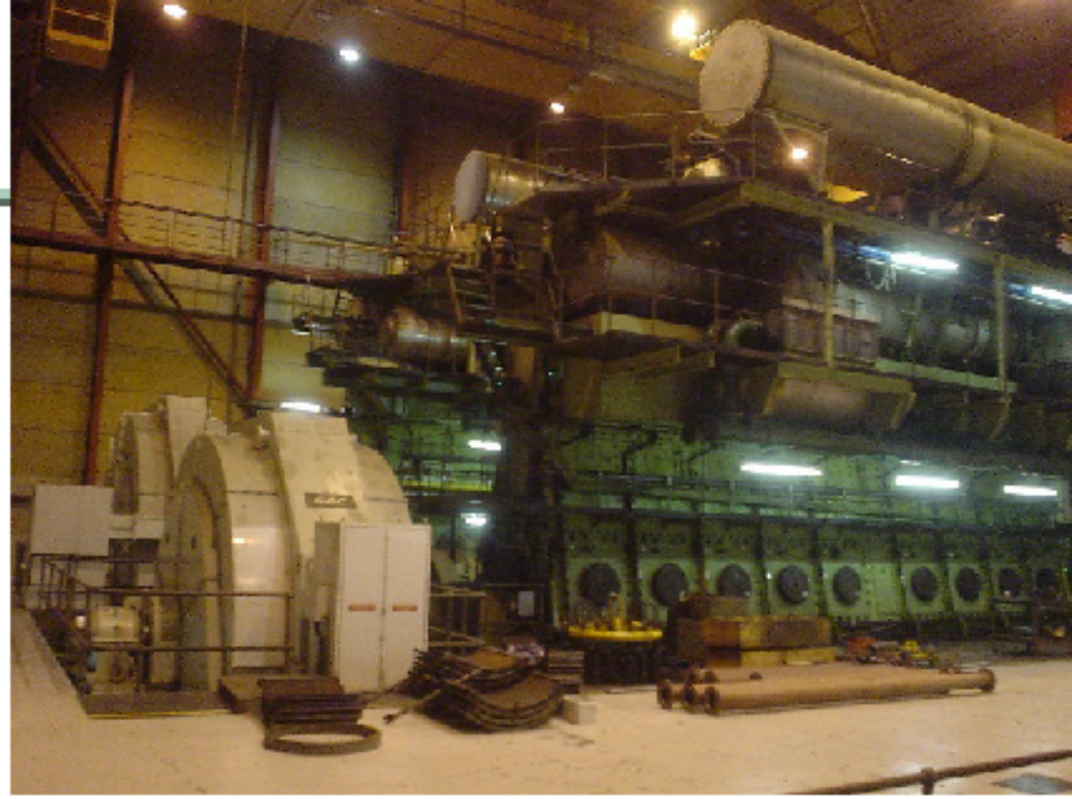


Power translation chart



1 kWh/d	the same as 1/24 kW	'UK'	= 60 million people
GW	often used for '**capacity**' (peak output)		
TWh/y	often used for average output	USA:	300 kWh/d each
1 Mtoe	'one million tonnes of oil equivalent'	Europe:	120 kWh/d each

Numbers

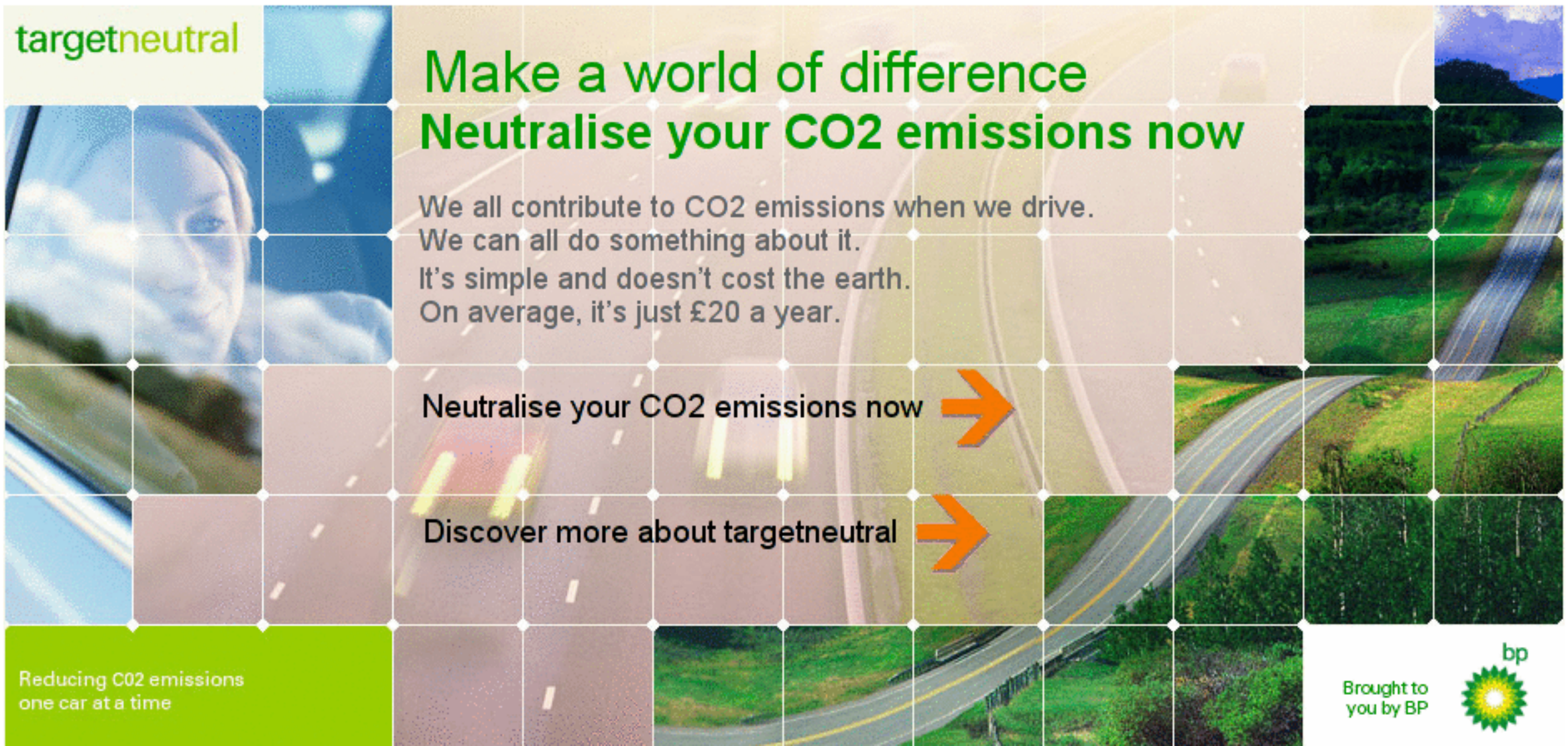


24 MW at Guernsey electricity

20 MW

Something must be done!

- 'Making a difference'
  - Corporate poppycock
  - Media poppycock
  - Consumer scams & ripoffs



BBC on energy waste

Monday, 23 October 2006, 08:57 GMT 09:57 UK

Britain tops energy waste league

British people are Europe's worst energy wasters, with bad habits such as leaving appliances on stand-by likely to waste £11bn by 2010, a study claims.

If current levels of wastage continue, an extra 43m tonnes of carbon dioxide will be pumped into the atmosphere in that time, it added.

Leaving mobile phone chargers plugged in and lights on were among the most common energy-wasting habits.

The Energy Saving Trust surveyed 5,000 people in five countries for the study.

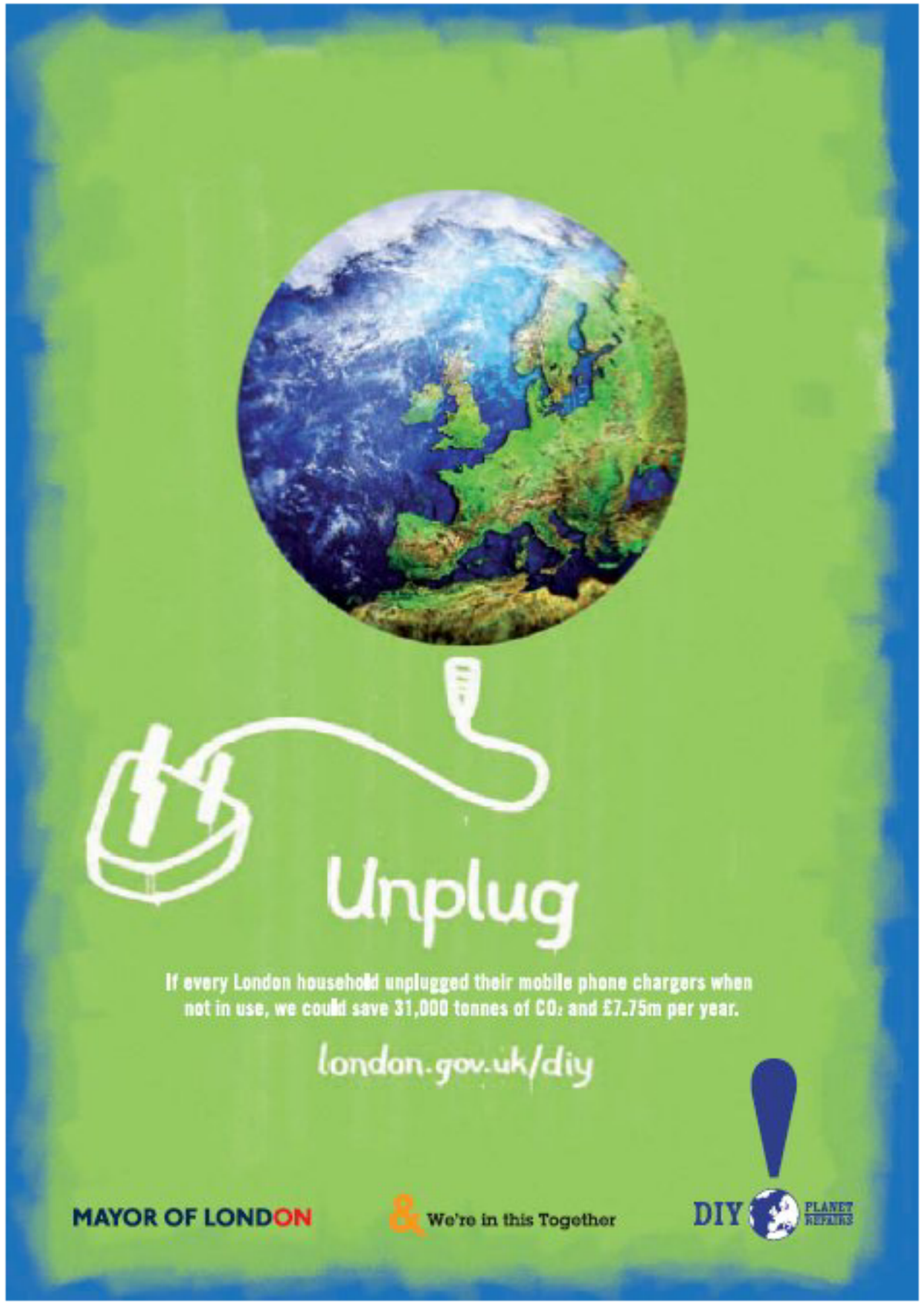
Figures in the Habits of a Lifetime report, commissioned to mark the start of Energy Saving Week, said 71% of UK consumers admit to leaving stand-by buttons on once a week.

Meanwhile, 65% of UK consumers leave chargers on once a week and 63% forget to switch the lights off when leaving the room.

ENERGY WASTERS LEAGUE

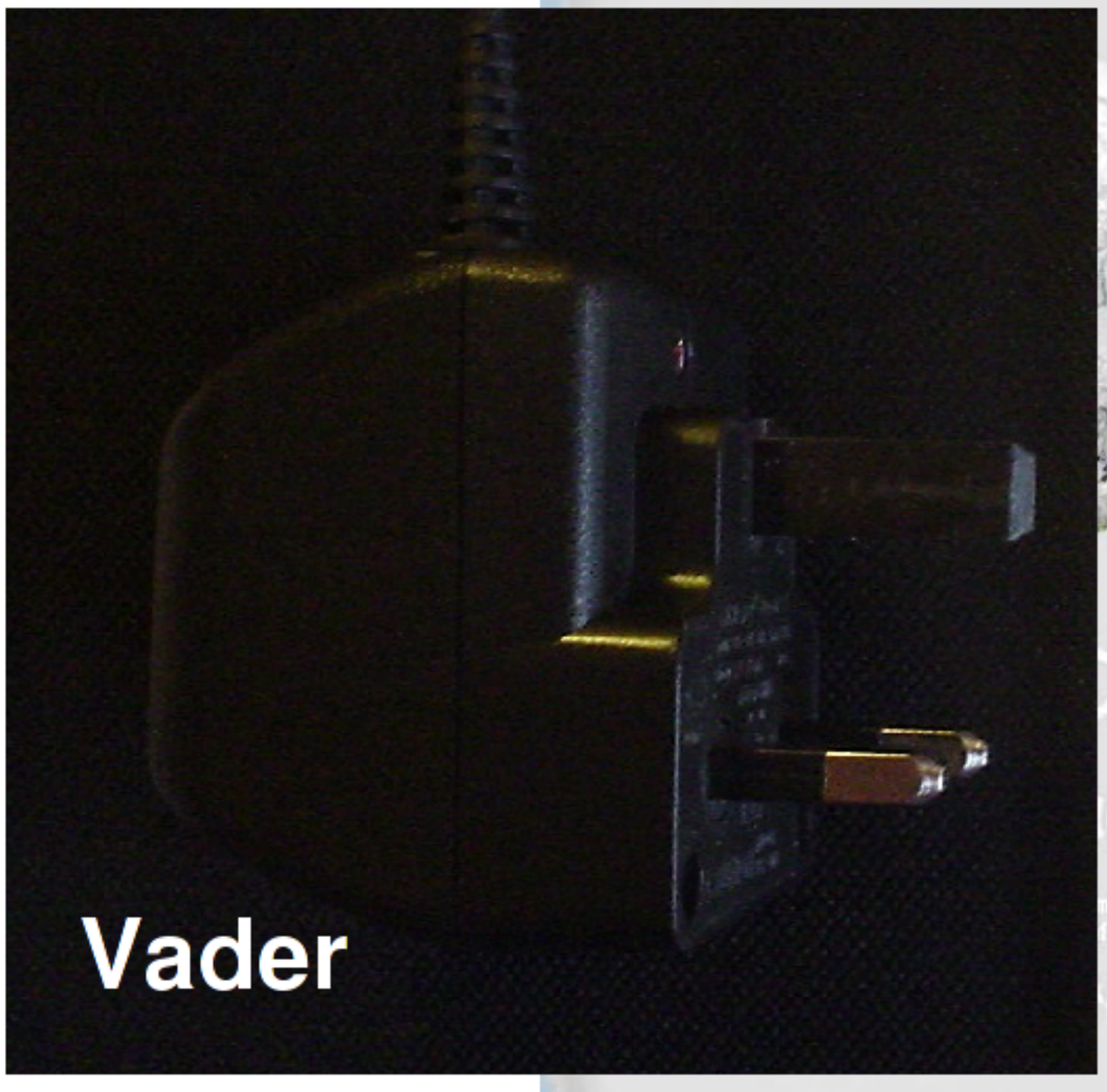
- 1. UK
- 2. Italy
- 3. France
- 4. Spain
- 5. Germany

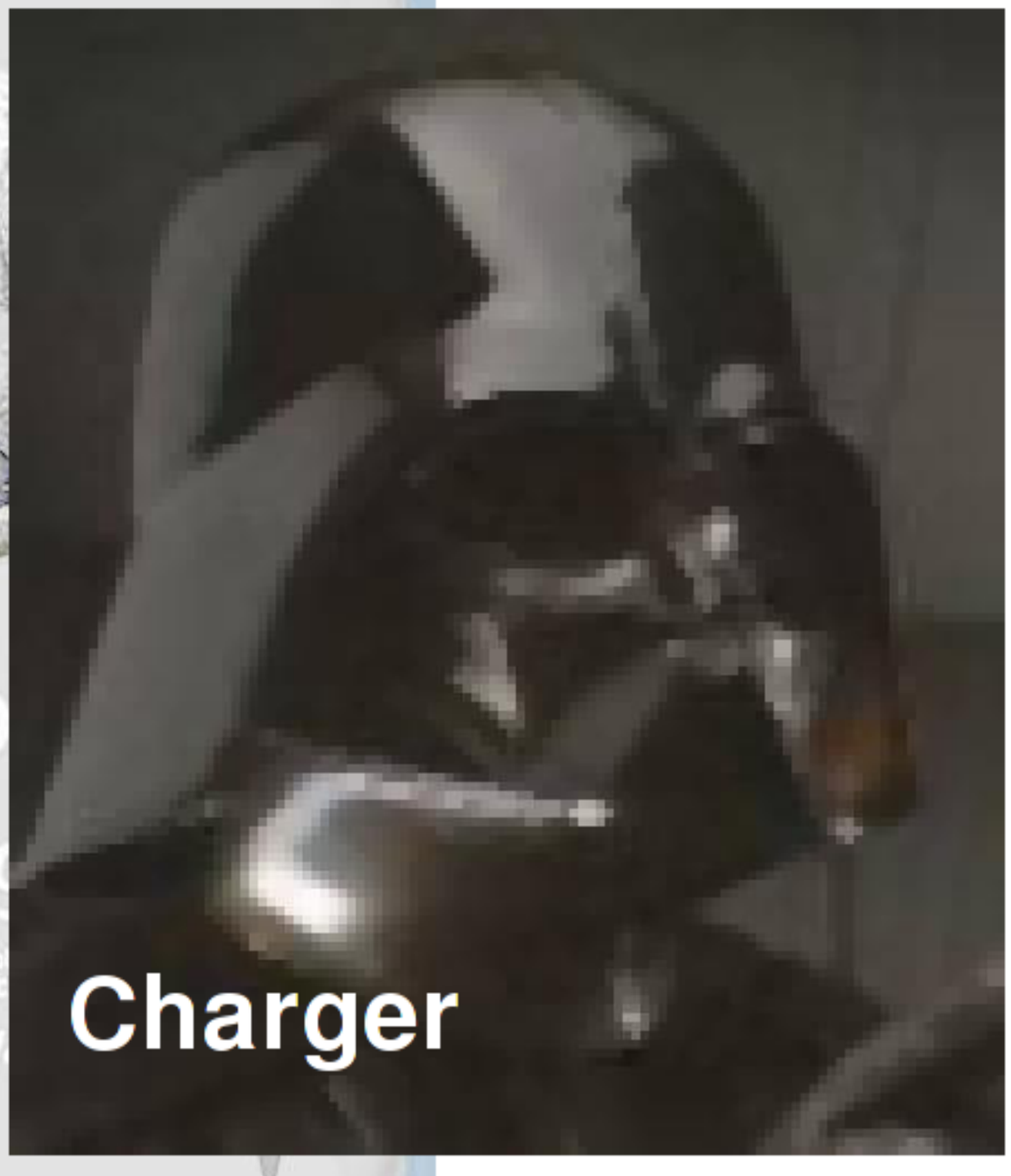
June 2007



'If every London household unplugged their mobile phone chargers when not in use, we could save 31,000 tonnes of CO2 and 7.75m per year.'

Are they related?





MAYOR OF LONDON We're in this Together DIY PLANET REPAIR

1f (new scientist, nature)

3f (phones: every little helps / make a difference)

'If every London household unplugged their mobile phone chargers when not in use, we could save 31,000 tonnes of CO2 and 7.75m per year.'

Water Powered Car Might Be Available by 2009

Forget cars fuelled by alcohol and vegetable oil. Before long, you might be able to run your car with nothing more than water in its fuel tank. It would be the ultimate zero-emissions vehicle.

While water is not at first sight an obvious power source, it has a key virtue: it is an abundant source of hydrogen, the element widely touted as the green fuel of the future.

"The governor is a real-life climate action hero today."
— Nancy Ryan

Arnold Schwarzenegger refuels a hydrogen-powered car (top). His vision is to see vehicles like this replace the polluting models on the road.

Once again, Rosenfeld says, the message for California on saving energy is simple: every little bit helps. ■

Charles Petit is a freelance writer in California.

Every little helps?

reminds me of friend who drove 20 miles in order to take one milk bottle to recycling centre

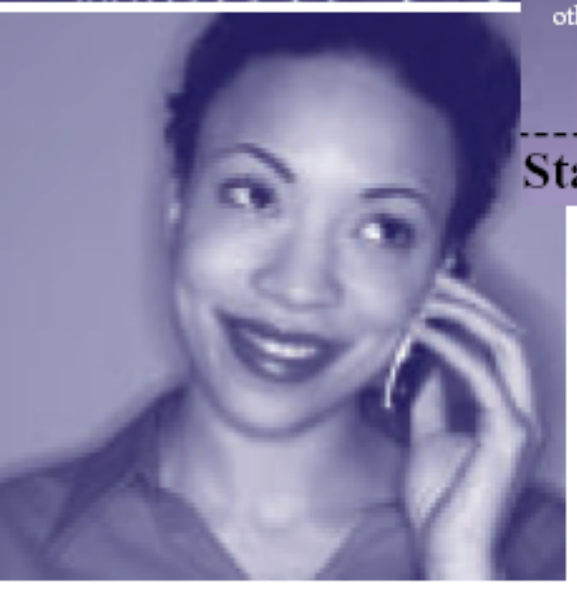
Example Call Savings

	Peak	Off-Peak	Savings vs BT
UK national	3.1	2.1	38 - 54%
UK local	2.5	0.85	0 - 26%
Australia	6.5	6.5	83%
France / Germany	5.5	5.5	76%
Ireland	5.5	5.5	70%
USA	3.9	3.9	80%

All prices exclude VAT. Comparison against BT standard prices. Prices to other destinations can be found on our website.

The Phone Co-op
your voice counts

Start making a difference today. Register now.



Yorkshire CND has joined up with **The Phone Co-op** (www.thephone.coop), an ethical and environmentally responsible telephone service provider, to offer our supporters a great deal on phone calls. We chose **The Phone Co-op** because as well as offering great value for money, they share our values and are extremely green - for instance they neutralise all CO2 emissions generated by your phone calls through their partnership with **Climate Care** (www.climatecare.org). **As well as being able to make big savings on your bill whilst being green,**

values and are extremely green - for instance they neutralise all CO2 emissions generated by your phone calls through their partnership

Every little helps

1 0f

If everyone does a little,

you'll get a little

or perhaps worse...

2f/1f(green mobile)

Every little helps

Recyclable mobile (NEC):
N701iECO

Every little helps

'Latest in ecological and environmental design'

By just adding **water** you are providing your product with an endless source of energy.

The new H2O Desktop Calculator from Tango Group is the latest in ecological and environmental design. Incorporating the revolutionary and patented, H2O **water** powered battery, together with conventional digital technology; the H2O Desktop Calculator offers the user an environmental design solution for a product that is used in every day home or office life.

This has all been made possible by groundbreaking developments in portable power technology operated by an inexhaustible resource - "**water**". The patented technology utilises two electrodes consisting of specially formulated alloys, one positive, and the other negative. When immersed in **water** an electrochemical reaction takes place resulting in the production of electrical energy.

Replaceable H_2O Water Battery

As all the components of the H2O **water** battery are recyclable, the benefits over traditional batteries are countless. Every year billions of conventional dry cell batteries are used, and the recycling of such waste is not only expensive but often incomplete, resulting in hazardous pollution and damage to our environment.

The H2O **Desktop Calculator** is designed and manufactured for both professional and home use in mind. By just adding **water** you are providing your product with an endless source of energy. At the end of the H2O **water** battery's life (indicated by dimming of the display) simply replace the battery and start all over again. (Replacement water powered batteries are readily available from Tango Group Limited).

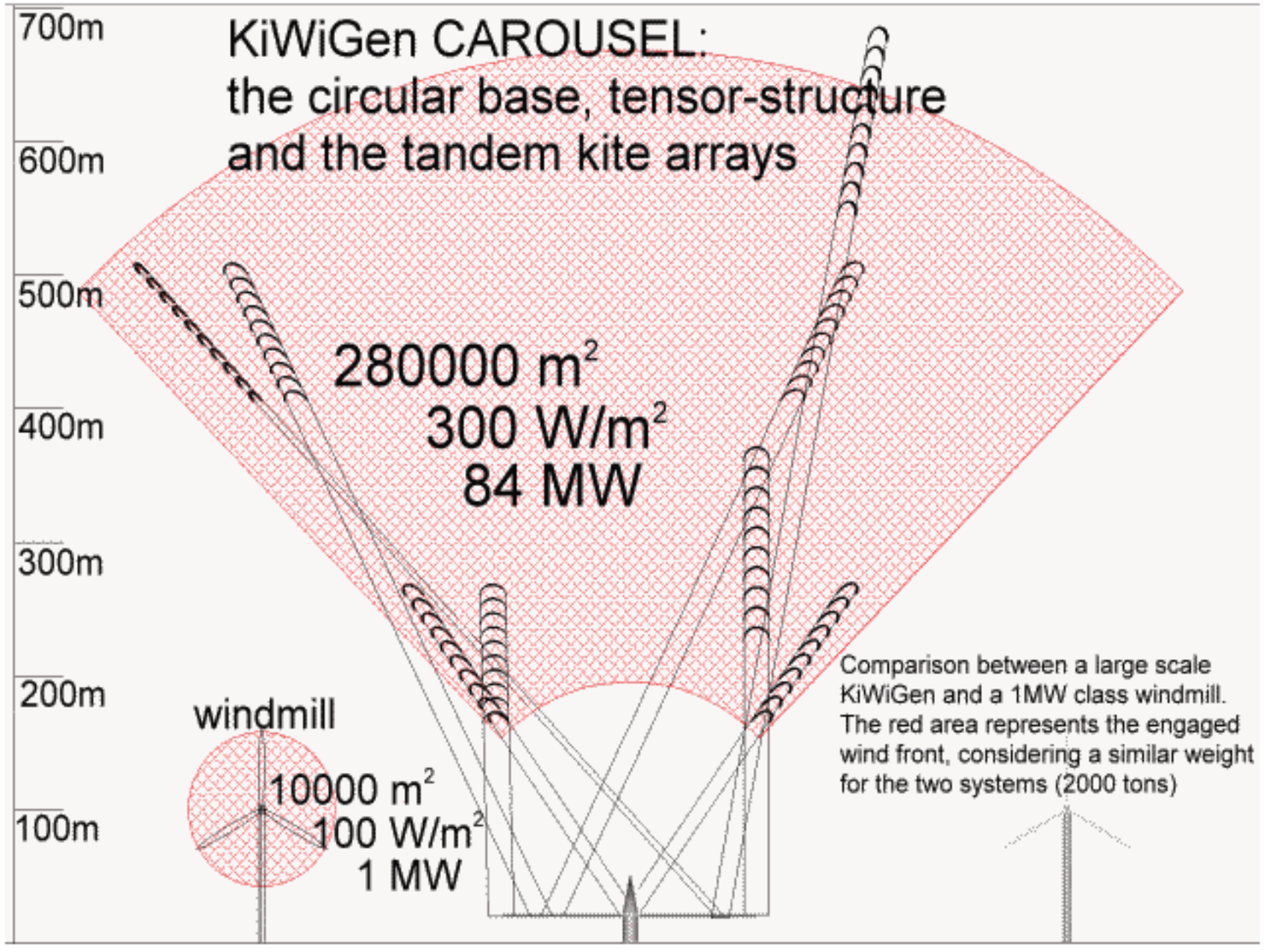
8f/3f/2f/1f(powergen)

Kite power - 'a single installation could replace 5 nuclear power stations'

Sequoia Automation S.r.l. (movie)

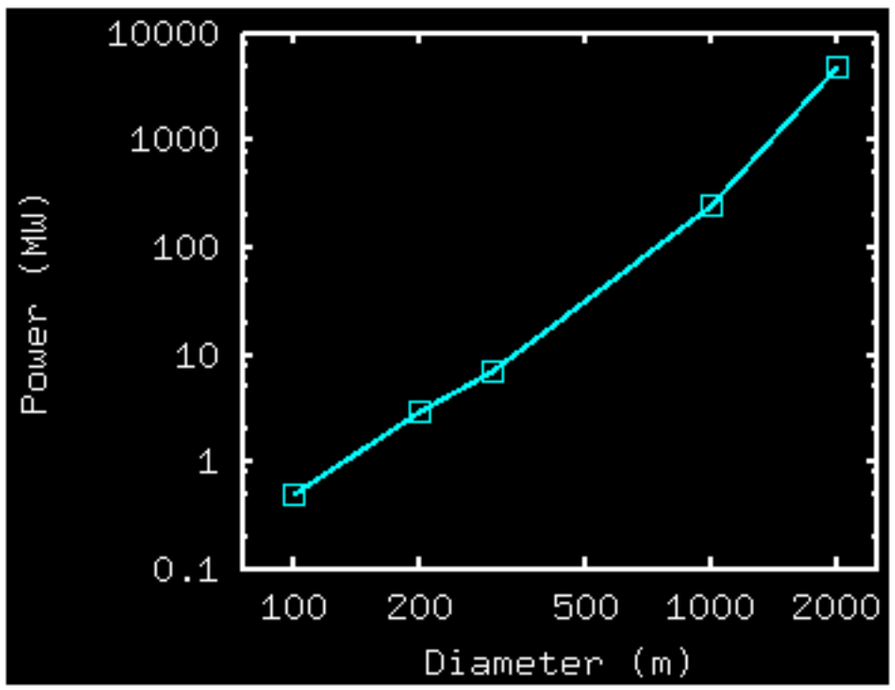
1f/movie

Kite wind generator - Sequoia Automation S.r.l.



5 GW?

Fig. 2. KiteGen small scale prototype



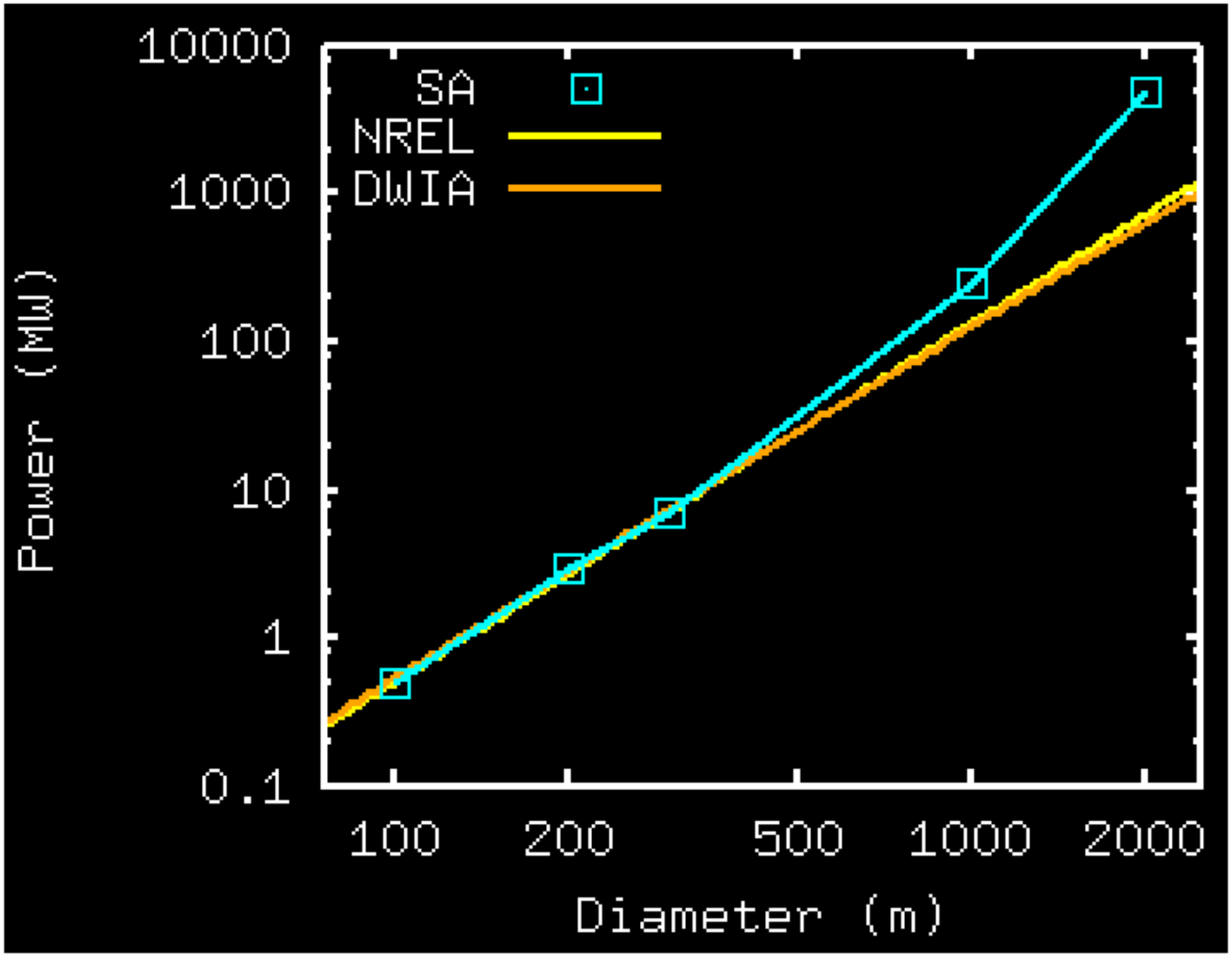
Scalability of the system

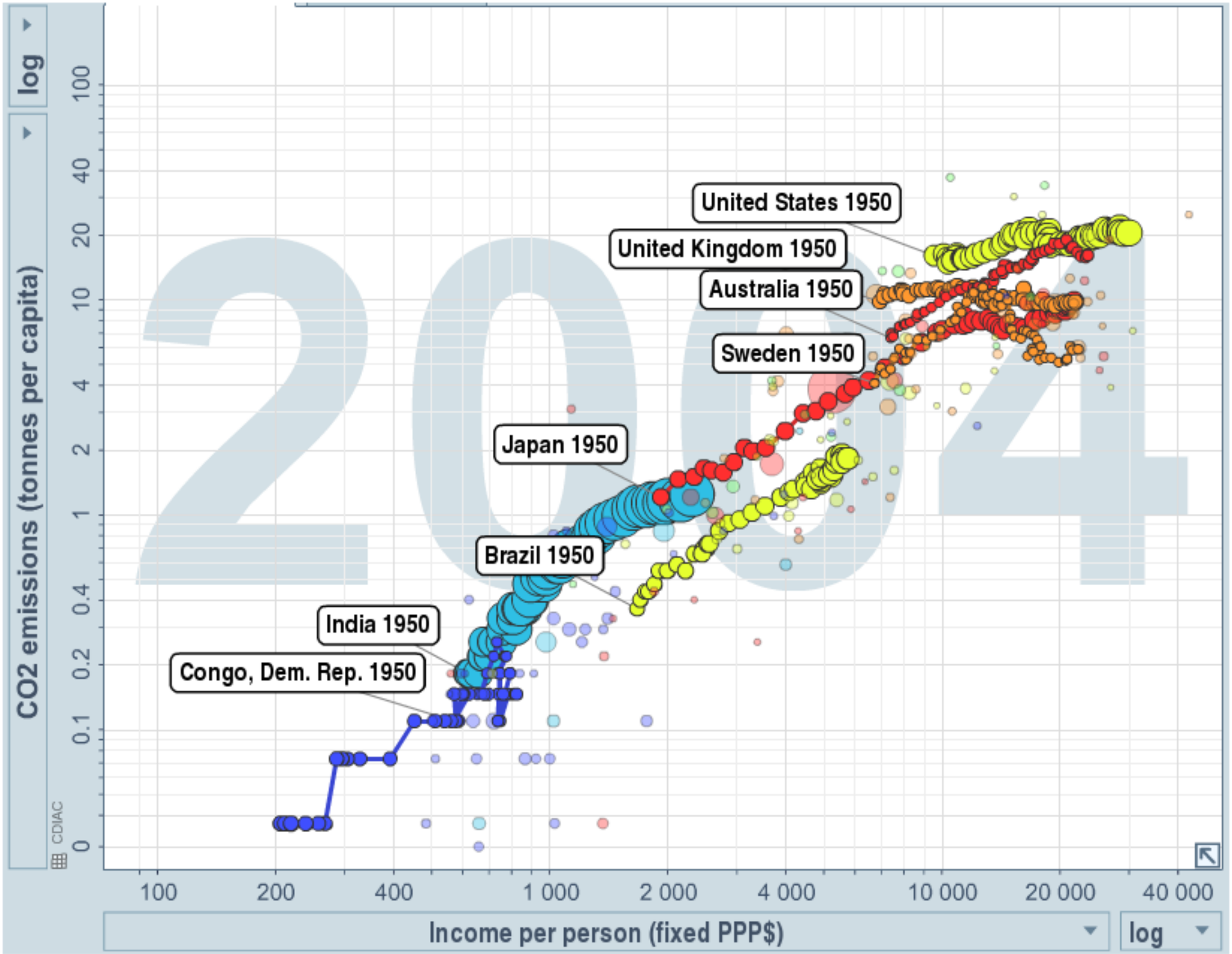
The KITE WIND GENERATOR is an installation that produces energy in proportion to its size. As its diameter is increased, the amount of energy captured grows exponentially. This amount is further augmented by the higher altitude of the kites, thus the stronger winds that they are in contact with. Some examples of these values, can be:

a diameter of	is equivalent to a generator of
100 m	0.5 MW
200 m	3 MW
300 m	7 MW
1.000 m	250 MW

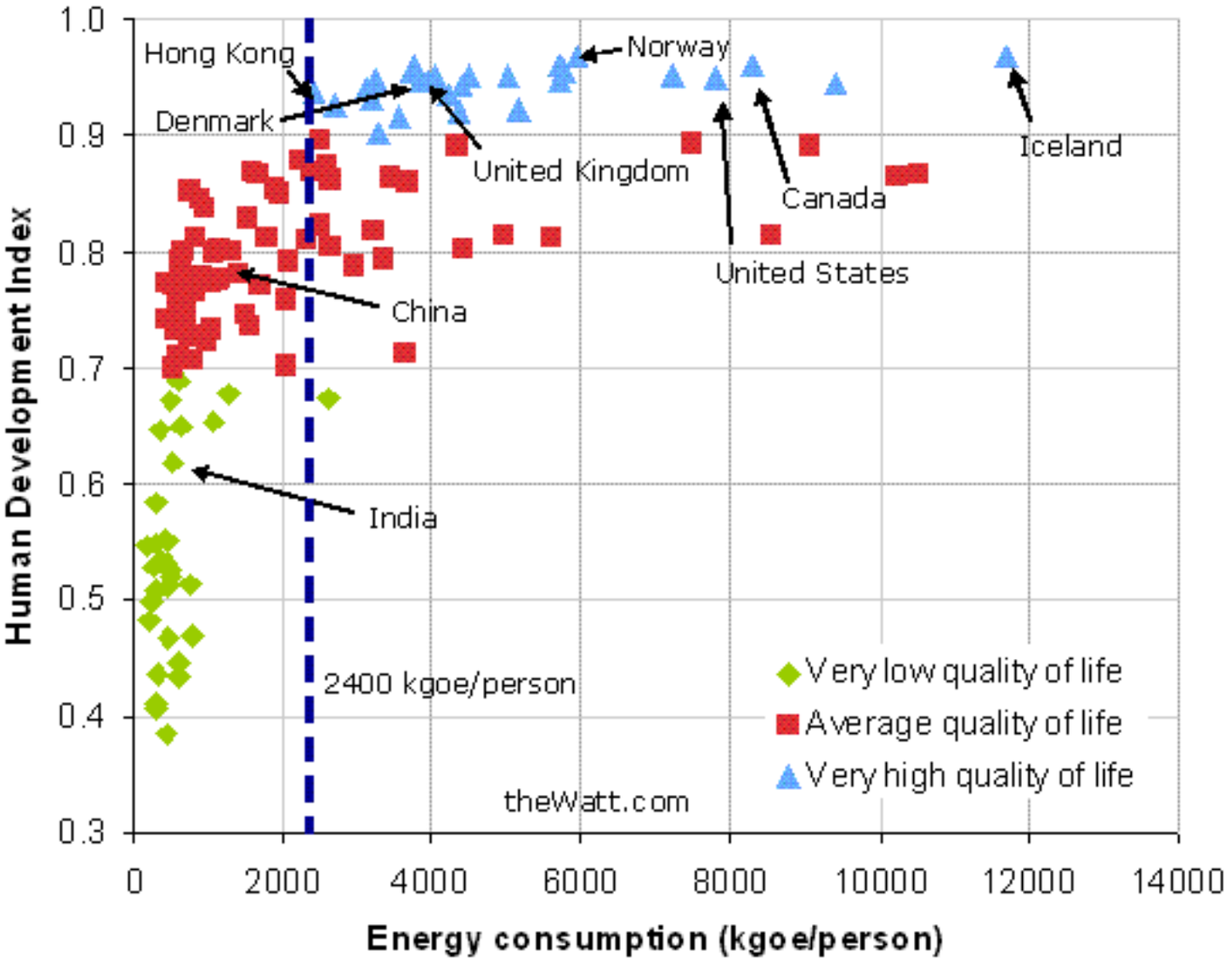
The maximum possible diameter of a KITE WIND GENERATOR is one of the objects of study of this project, but from the initial evaluations, it appears possible to exceed 5,000MW (5 Gigawatts) without great structural risks, with a diameter of slightly more than 2000 metres.

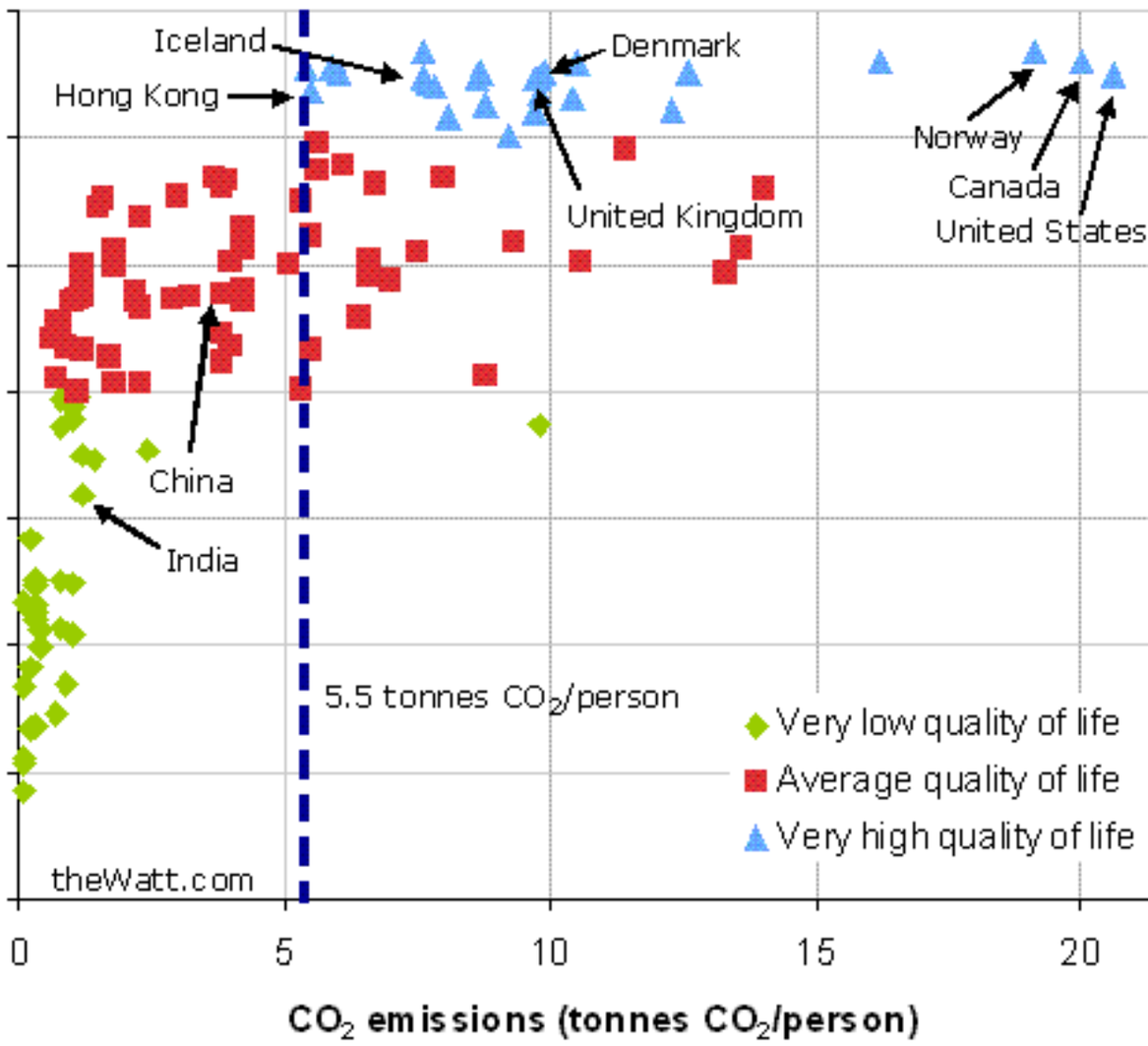
Theoretical limits



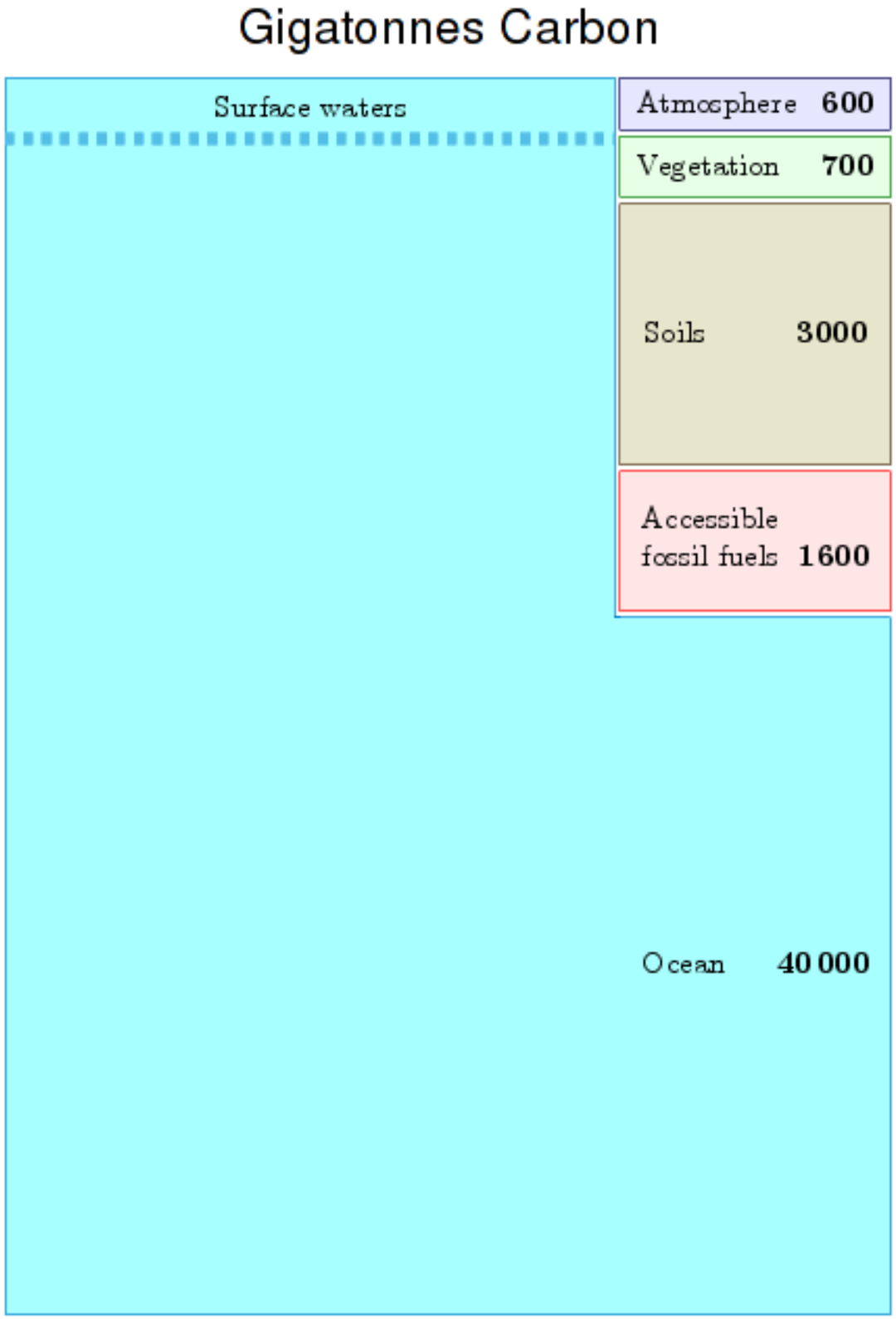


gapminder / google

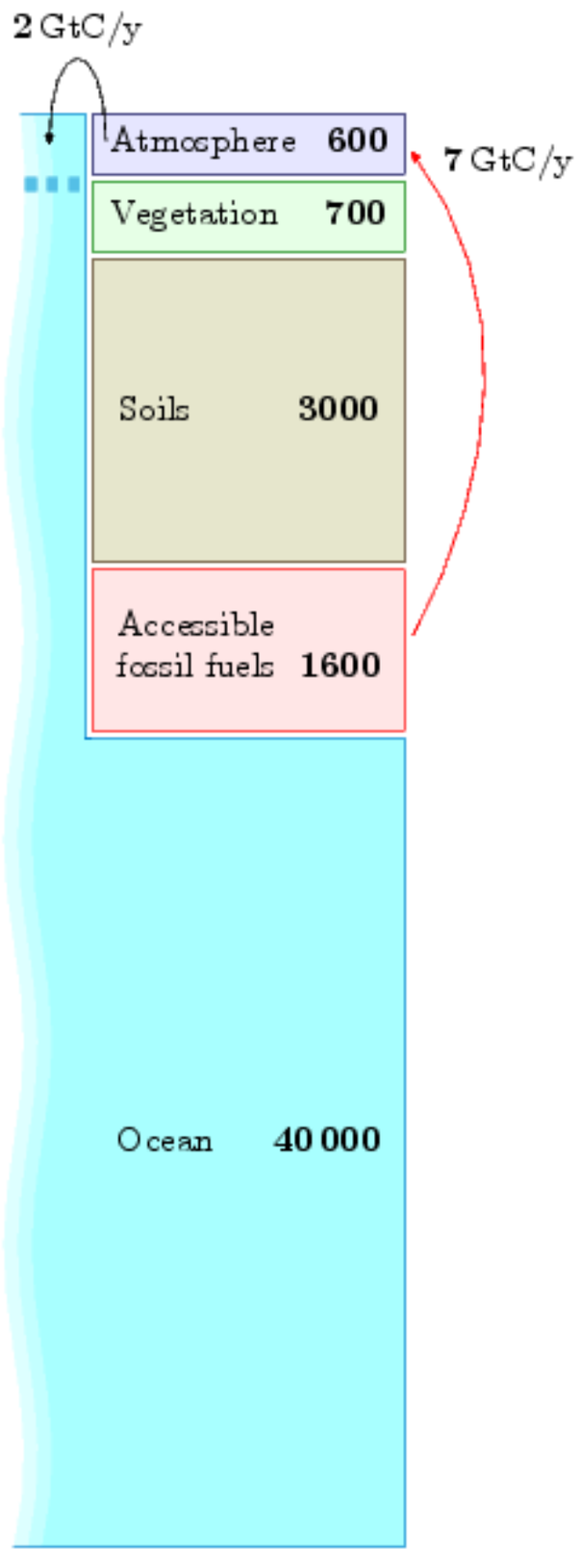

Human Development Index
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
Hong Kong
Denmark
Norway
United Kingdom
Iceland
Canada
United States
China
India
2400 kgoe/person
Very low quality of life
Average quality of life
Very high quality of life
theWatt.com
0
2000
4000
6000
8000
10000
12000
14000
Energy consumption (kgoe/person)


Iceland
Hong Kong
Denmark
United Kingdom
Norway
Canada
United States
China
India
5.5 tonnes CO2/person
Very low quality of life
Average quality of life
Very high quality of life
theWatt.com
0
5
10
15
20
CO2 emissions (tonnes CO2/person)

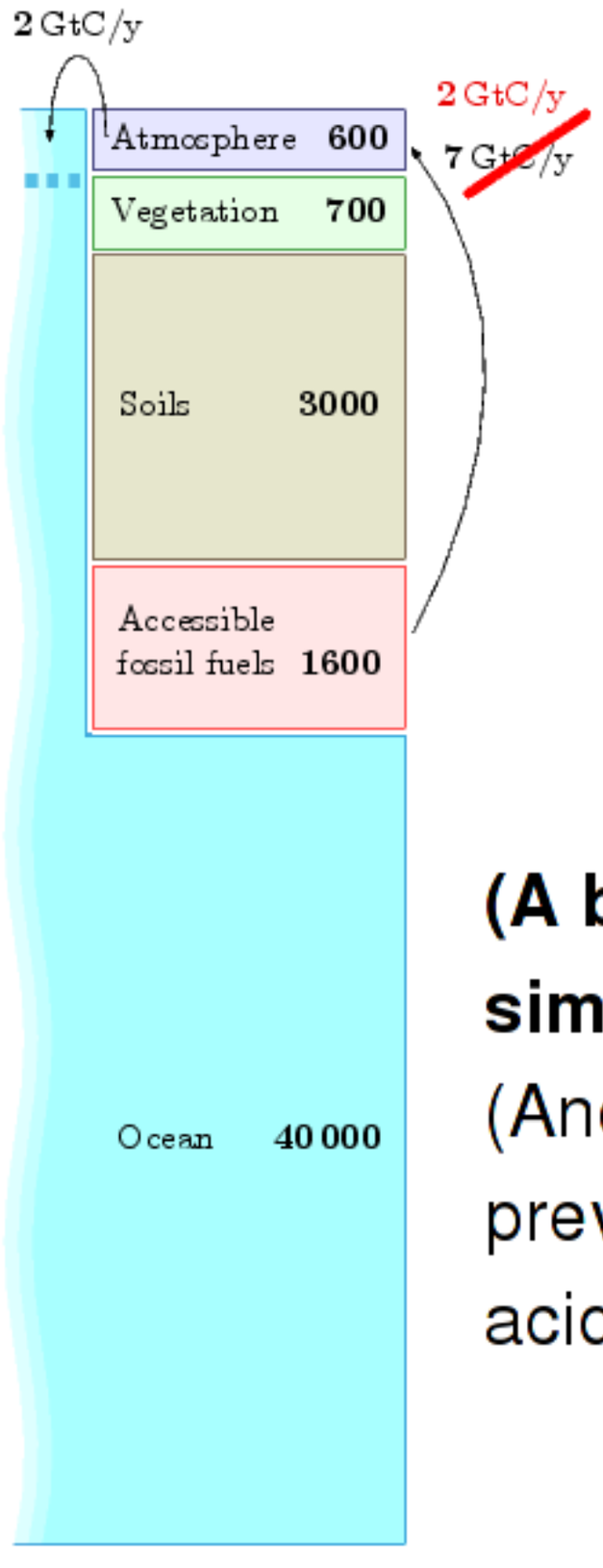
Carbon - where is it?



Carbon - where is it going?



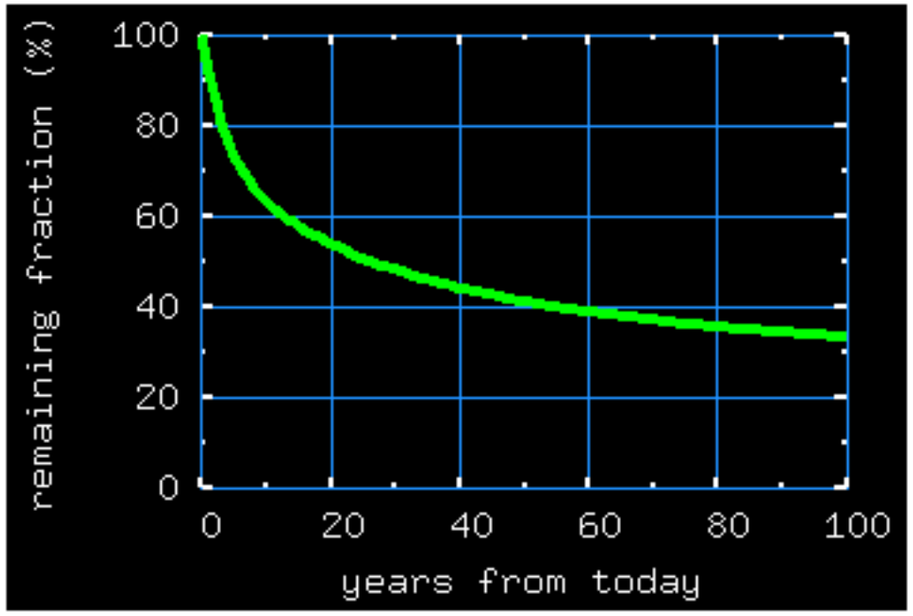
How to fix climate change

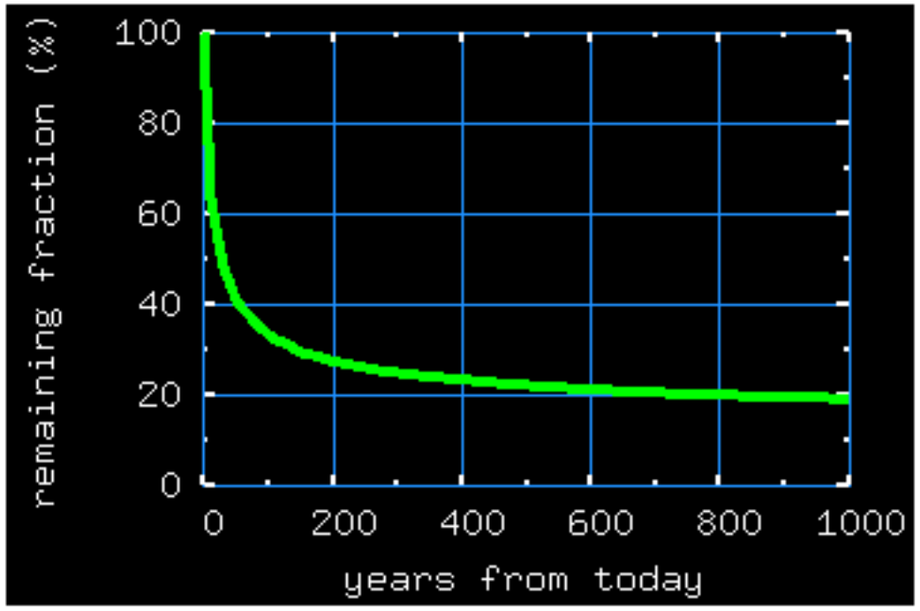


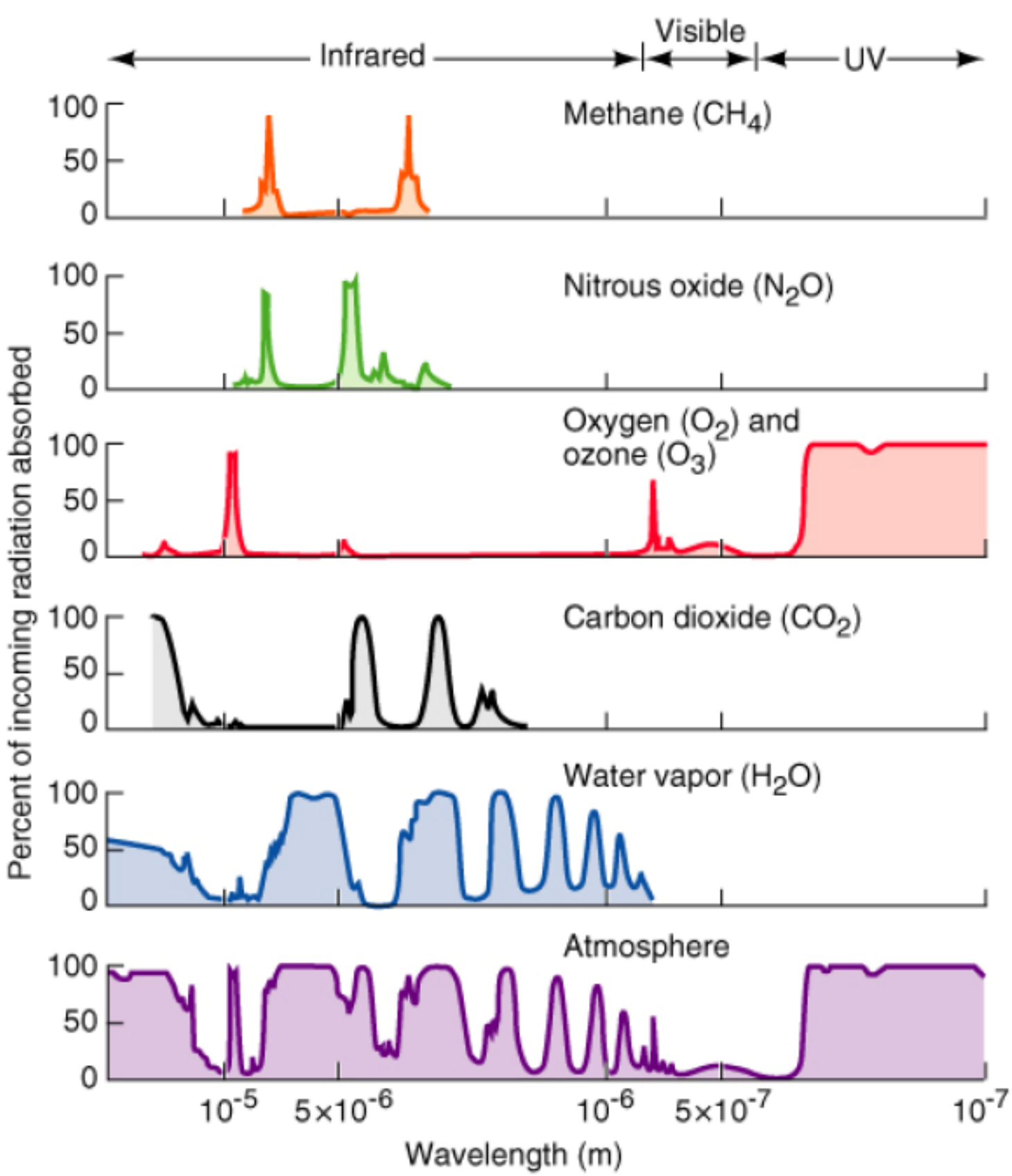
(A big simplification!)

(And this doesn't prevent ocean acidification)

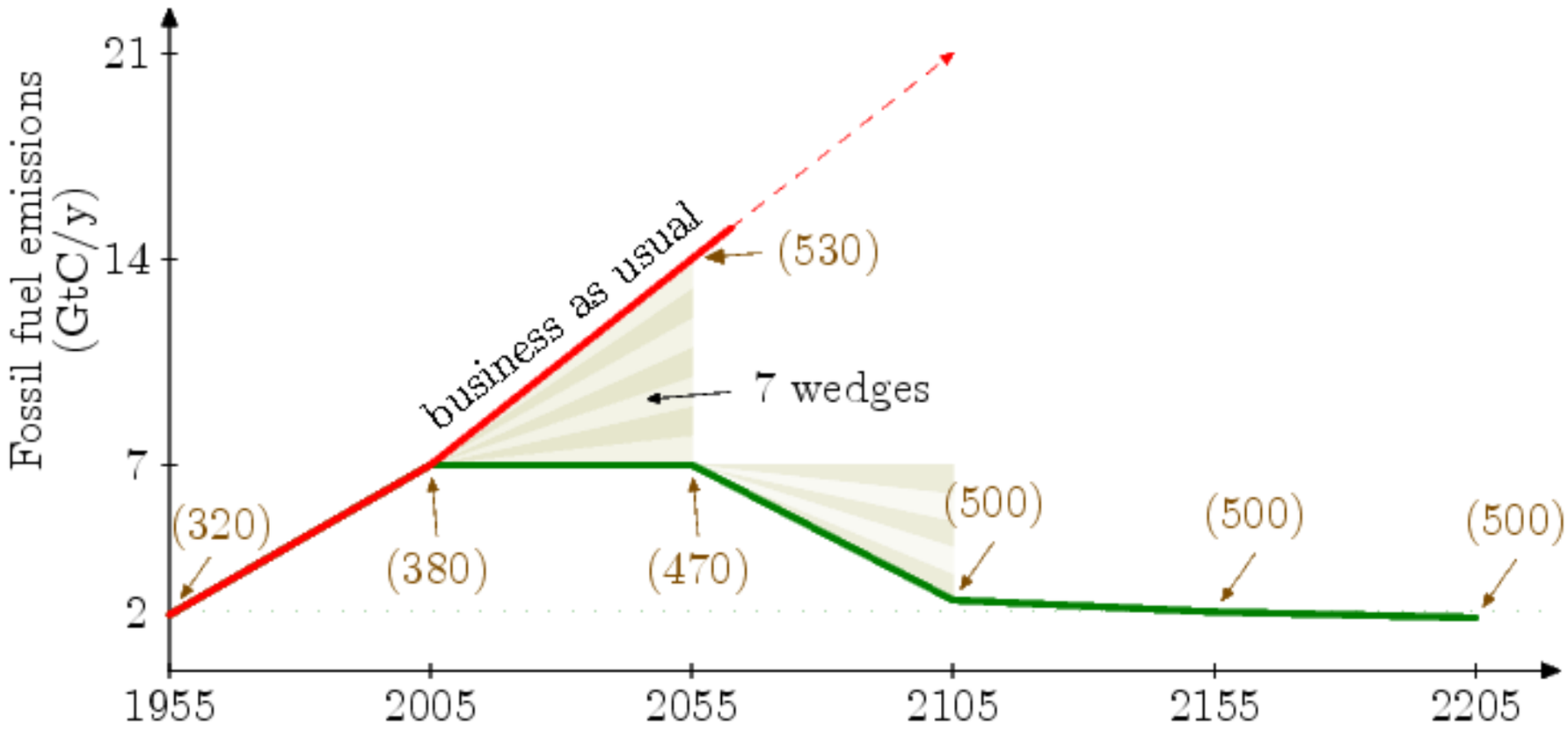
When does it go away?

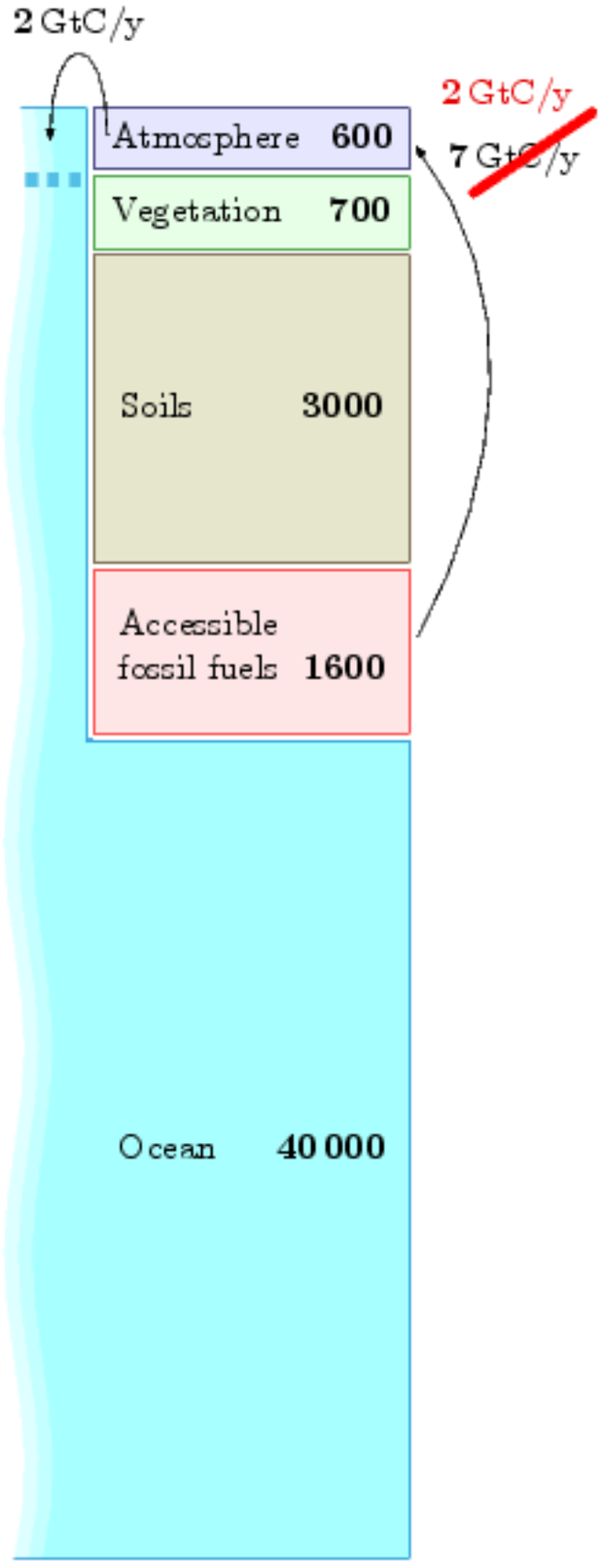




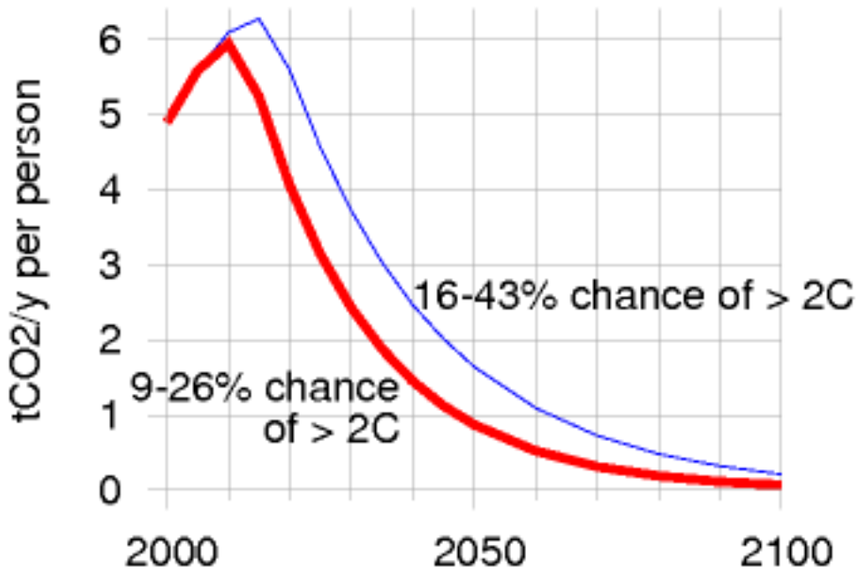


Socolow's model of CO2 emissions





Baer & Mastrandrea: Socolow's trajectory not good enough



Carry on burning

- Sequestration

  (This is NOT sustainable!)

- Sequestration from thin air costs a lot of energy
  - - almost as much as you get from burning the fossil

- Sequestration at the power station (costs 25%)

- Sequestration by trees...

"We plant a tree every time we fly!"

Sequestration with trees

- www.growaforest.com

  - You pay them money
  - They 'plant trees which absorb your CO2 contribution'
- What happens to the trees?
- Managed forest produces

$2.5\,\mathrm{m}^3$ of dry wood per hectare per year,
i.e., $0.05\,\mathrm{kg}$ of Carbon per m^2 per year. So to balance pollution associated with $100\,\mathrm{kWh}$ per day, need

$$50\,000\,\mathrm{m}^2 \text{ of forest}$$

and a permanent storage place to put

$12\,\mathrm{m}^3$ of dry wood per year.

[UK's area is $4\,000\,\mathrm{m}^2$ per person.]

The company has a 10 acre plot. That is only 40,000 m^2.

growaforest.CON

- Alternative model
  - take barren land and produce forest on it

- Mature forest contains

  $25\,\mathrm{kg/m^2}$ of 'standing phytomass',
  i.e., $5\,\mathrm{kg}$ of Carbon per $\mathrm{m^2}$.
  To balance pollution associated with $100\,\mathrm{kWh}$ per day,
  need

  $100\,\mathrm{m^2}$ of new forest
  created per year.

  [UK's area is $4\,000\,\mathrm{m^2}$ per person.]

The company has a 10 acre plot. That is only 40,000 m^2.
So they can service 400 customers for one year in their 10 acres.

Sequestration cost per molecule (from thin air)

$$0.03\%\ \mathrm{CO_2} \longrightarrow \mathrm{Pure\ CO_2} \longrightarrow \mathrm{Liquid\ CO_2}\ (100\text{–}200\ \mathrm{bar})$$

Ideal concentration machine

$$kT \ln \frac{V_0}{V_1} = kT \ln 3000 = 8\,kT$$

Ideal liquefaction machine

$$4\,kT$$

Total

$$12\,kT \text{ per molecule}$$

Ideal sequestration cost

Useful identities	
$1\,kT$ per molecule	$= 2.5\,\mathrm{kJ/mol}$
$1\,\mathrm{kWh}$	$= 3600\,\mathrm{kJ}$

$12\,kT$ per molecule
is 0.2 kWh per kg of CO_2.

Compare with energy created when emitting CO_2:

$$\frac{1}{3}\,\mathrm{kg\ of\ petrol} \longrightarrow 4\,\mathrm{kWh} + 1\,\mathrm{kg}\ CO_2.$$

What's efficiency of generator and compressor?

Realistic sequestration cost

Production:

1 kg of CO_2 $\leftrightarrow$ $4\,\mathrm{kWh}$ heat $\leftrightarrow$ $1.3\,\mathrm{kWh}$ useful energy

$/3$

Sequestration:

1 kg of CO_2 $\leftrightarrow$ $0.2\,\mathrm{kWh}$ ideal cost $\leftrightarrow$ $0.6\,\mathrm{kWh}$ actual cost

$\times 3$

British Airways

BRITISH AIRWAYS

Climate impact of my flight

What impact does your flight have on climate change?

Every flight you take has an impact on climate change that arises from the carbon dioxide (CO2) from burning kerosene and other effects in the upper atmosphere. British Airways supports a long-term approach to tackling this impact...

You can take responsibility for the impact of your flight

British Airways has joined forces with an organisation called Climate Care to enable you to offset the CO2 emissions created during your flight.

You can click on the calculator button to calculate your share of the emissions created during your journey and the cost of neutralising the impact of those emissions. If you decide to pay this cost, the money raised will be used by Climate Care to fund sustainable energy projects around the world on your behalf.

BRITISH AIRWAYS

Climate impact of my flight

FAQs | Air Travel Calculator | Contact us

CLIMATE CARE

BRITISH AIRWAYS

Climate Care Projects

Efficient stoves in Honduras
Reducing firewood to protect forests

Renewable Cooking in India
Renewable Cooking for Indian Schools

Lightening the load in South Africa
Efficient lighting for householders

BRITISH AIRWAYS

CO_2 Emissions calculator

CO_2 Emissions calculator

From

- UK London Heathrow
- UK London Luton
- UK Londonderry
- UK Manchester
- UK Newcastle
- UK Southampton

To

- UZBEKISTAN T'kent
- VIETNAM Hanoi
- ZAMBIA Livingstone
- ZAMBIA Lusaka
- ZIMBABWAE Harare
- ZIMBABWAE Vic. Falls

Number of passengers: 1

Return ◉ One Way ○

CALCULATE MY EMISSIONS

RESET

Emissions for this flight: 1.83 Tonnes CO_2 **Cost: £ 11.91**

ADD ANOTHER FLIGHT

MAKE PAYMENT

Clicking this button will take you to WorldPay's Secure Payment Server.
Note: You can pay in £Sterling, US$ or €
There is a minimum offset of £5.00

Climate Care

- When you fly, drive or heat your home, your CO_2 emissions add to global warming.
- Climate Care lets you offset these emissions by funding sustainable energy and reforestation projects.

"Offsetting"

If true cost of "neutralizing" 2 tonnes of CO_2 is £13,
then our 125 kWh/day can be "neutralized" for £50/year.

which is roughly 1.5% of the 3500 per year we spend on the energy

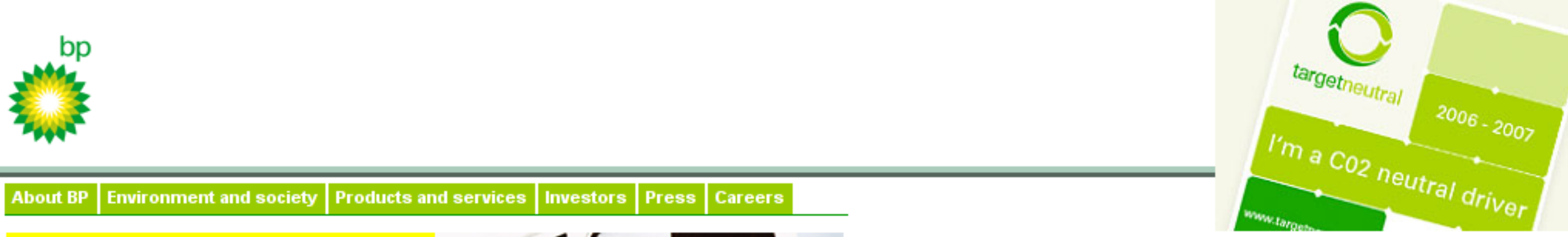
the c-change trust

the c-change trust

make a donation

Every £10 buys 1 tree and offsets 1 tonne of CO_2

75% of your donation will be spent on trees, land and education.



By logging on to www.targetneutral.com, drivers can calculate how much CO2 their car emits, find out how to reduce that figure and also learn more about global projects to minimise CO2. It is easy to participate, and involves a cash contribution to the programme, usually around Â£20 per year, depending on your vehicle, gas mileage and fuel consumption.

... through the scheme, all of BP's UK fuel tankers will now be CO2 neutral.

Targetneutral gives drivers an easy, affordable way to play their part in balancing the equation.

Make a world of difference

Neutralise your CO2 emissions now

We all contribute to CO2 emissions when we drive.
We can all do something about it.
It's simple and doesn't cost the earth.
On average, it's just £20 a year.

Neutralise your CO2 emissions now →

Discover more about targetneutral →

Reducing C02 emissions one car at a time

Brought to you by BP

Karnataka, India

A wind turbine was installed at Chitradurga, Karnataka State in September, 2005. The power generated by the turbine provides renewable power to the state electricity grid that would otherwise have been generated from fossil fuel.

This renewable energy reduces CO2 emissions by 1,260 tonnes every year. That's enough to neutralise the emissions of 315 cars in the UK each year.

Facing the issues

Taking action to make a positive difference

Watch us at work

All your funds (excluding VAT and card transaction charges) are invested in projects that prevent or remove an equivalent amount of emissions (that you produce from driving) from the atmosphere.

This is a non-profit initiative by BP in partnership with scheme members and NGOs. Currently, for the projects we've chosen, one tonne of CO2 can be neutralised for 6 EURO. However, projects do vary in price depending on the type of project and running costs.

At this rate, UK emissions = 40 pounds each; 2.4 billion pounds - c.f. 552 billion bounds, Govt. budget 2006.

Read this carefully

Facing the issues

Taking action to make a positive difference

▸ Watch us at work

In our operations since 2001 we have been aiming to offset, through energy efficiency projects, half of the underlying Greenhouse gas emission increases that result from our growing business.

www.bp.com

What's the best way to suck CO_2 from thin air?

Energy cost $\geq 600\,\mathrm{kWh}$ per tonne

Gasoline from thin air ('Green Freedom')

February 13, 2008, 3:06 pm

Federal Lab Says It Can Harvest Fuel From Air (With a Catch)

By ANDREW C. REVKIN

Fill 'er up from the sky? (Photo: Marilynn K. Yee/The New York Times)

The New York Times **Science**

Scientists Would Turn Greenhouse Gas Into Gasoline

By KENNETH CHANG
Published: February 19, 2008

Two scientists are introducing a concept, which they have patriotically named Green Freedom, for removing carbon dioxide from the air and turning it back into gasoline.

Gasoline from thin air

- Energy cost is dominated by the cost of reversing the reaction

$$\frac{1}{3}\,\text{kg of petrol} \longrightarrow 4\,\text{kWh} + 1\,\text{kg } CO_2.$$

- Realistically

Production:

$$1\text{ kg of } CO_2 \quad \leftrightarrow \quad 4\,\text{kWh heat} \quad \leftrightarrow \quad 1.3\,\text{kWh useful energy}$$
$$/3$$

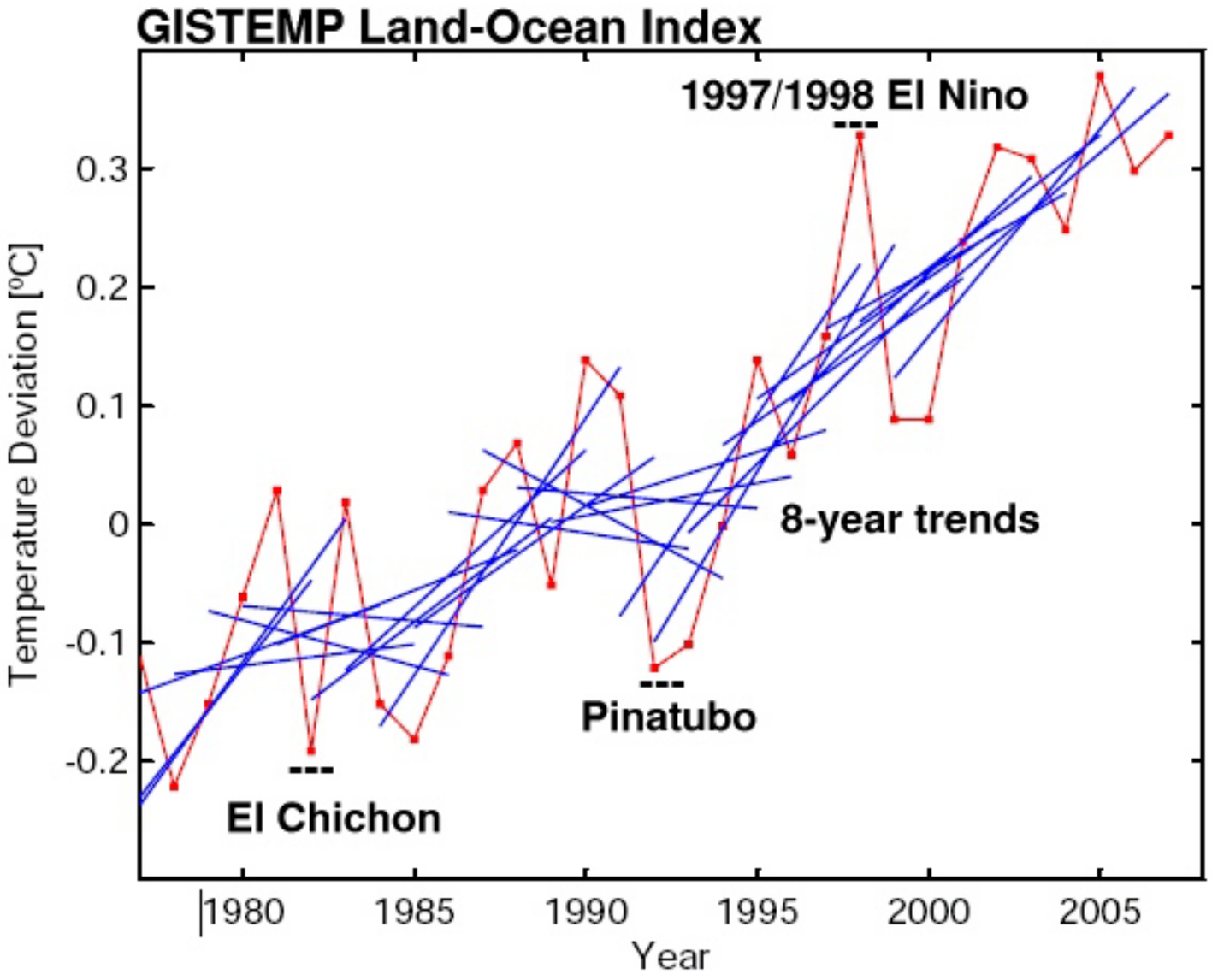
Reversal:

$$1\text{ kg of } CO_2 \quad \leftrightarrow \quad 4\,\text{kWh ideal cost} \quad \leftrightarrow \quad 12\,\text{kWh actual cost}$$
$$\times 3$$

At 5p per kWh, that costs £600 per ton of CO_2.

Under these assumptions, every litre of gasoline (10kWh) would cost 30kWh of nuclear.

'Global warming has stopped'



'looking at 8-year trends makes as much sense as analysing the temperature observations from 10-17 April to check whether it really gets warmer during spring.'

PM outlines climate action plan
The PM outlines plans for a "green hotline" and an end to one-use plastic bags, in his first major climate speech.

PM outlines climate action plan

Mr Brown said there were hard choices ahead

Prime Minister Gordon Brown has said there will be a "green hotline" to advise people on what they can do to cut their impact on the environment.

Mr Brown, who said the UK's emission target of a 60% cut by 2050 could be increased to 80%, said he would also seek the end of one-use plastic bags.

In his first speech on the environment as PM he said there would be "hard choices and tough decisions".

But he said Britain could lead the world and gain thousands of jobs.

From The Times

November 20, 2007

Gordon Brown's bid to seal fate of carrier bags

Francis Elliott, Deputy Political Editor

The plastic bag's status as a symbol of waste was confirmed yesterday as Gordon Brown pledged to help to eliminate its use in Britain.

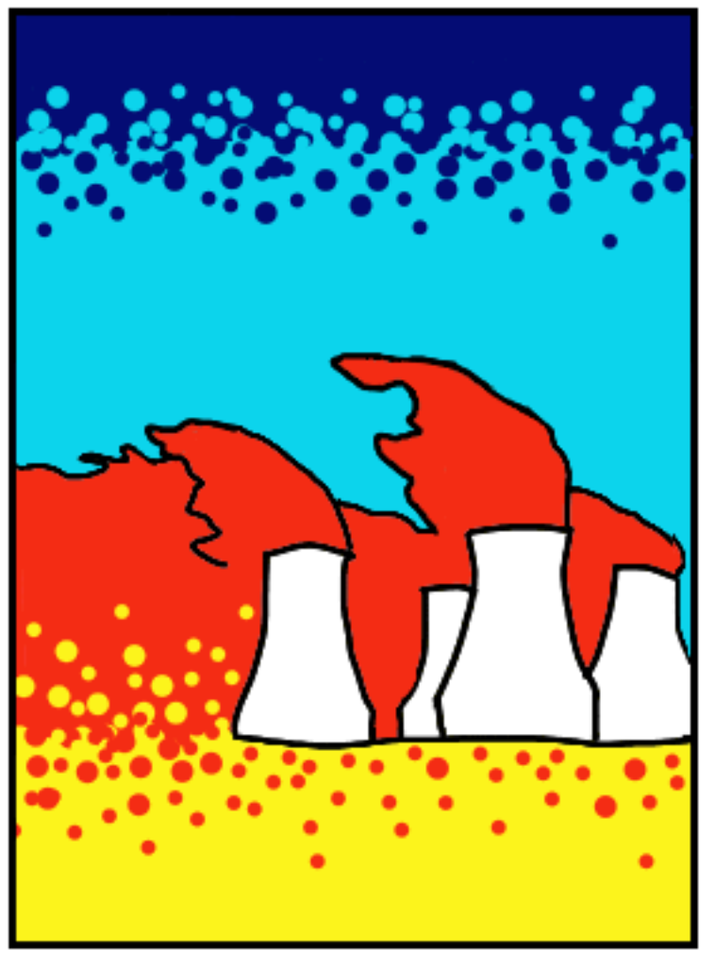
He threw his weight behind the growing campaign against disposable carriers in his first big speech on the environment since becoming Prime Minister. Speaking before an international climate change summit in Bali next month, Mr Brown confirmed that the Government's target of a 60 per cent reduction in Britain's greenhouse gas emissions by 2050 may be extended to 80 per cent.

Environmentalists also welcomed his statement that Britain was committed to meeting its share of an EU target to generate 20 per

Sustainable Energy

- without the hot air

Biofuels



David MacKay

Department of Physics
University of Cambridge

www.withouthotair.com

It is a crime against humanity to convert food crops to fuel

Jean Ziegler,
UN Special Rapporteur on the Right to Food.

The world should wake up to the dangers of the mass production of biofuels

Professor Sir Peter Crane,
Director, Royal Botanic Gardens, Kew.

Biofuel boom 'to raise beer price'

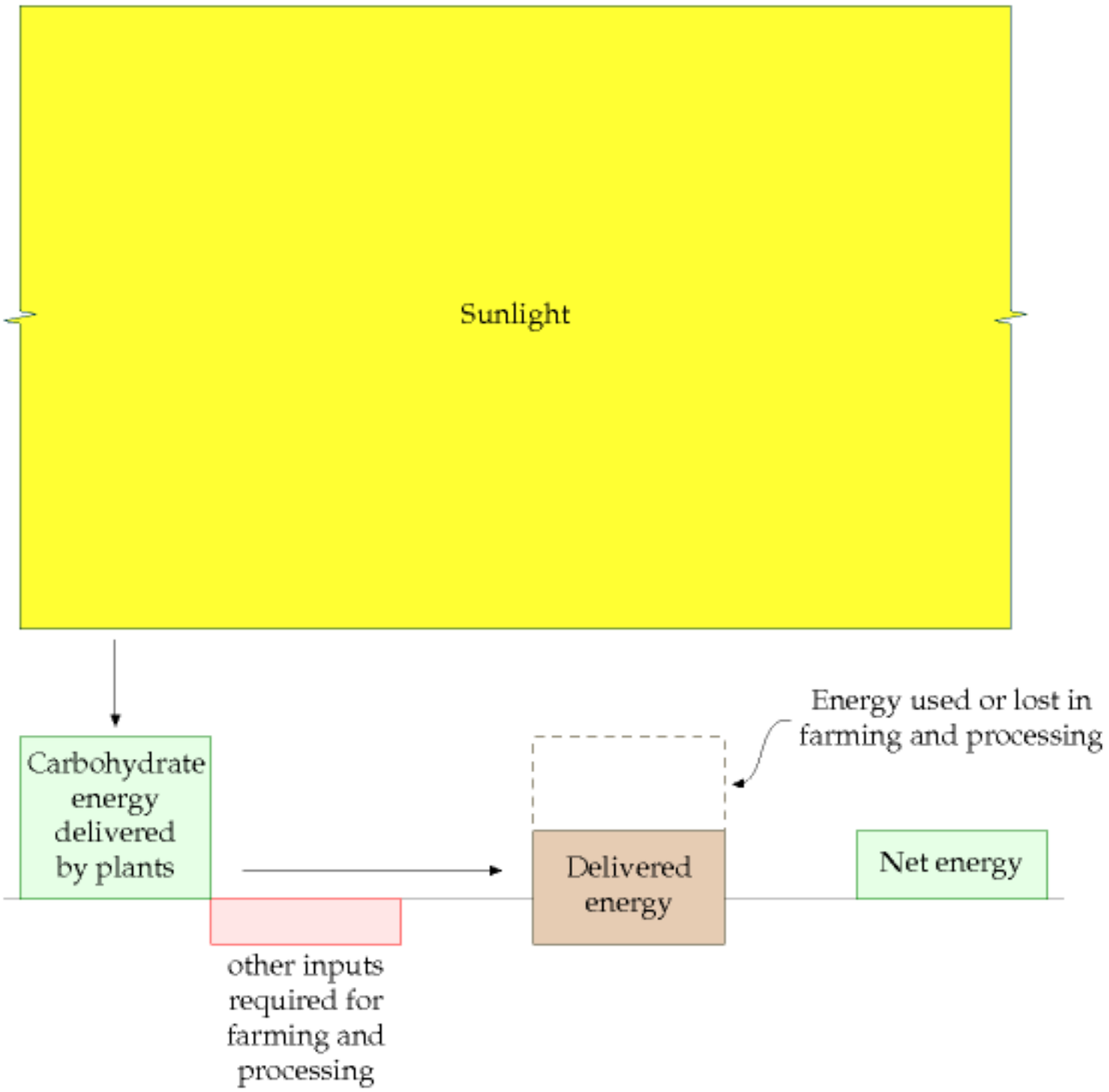
BEER drinkers could face a rise in the price of a pint because farmers are planting crops for green fuels instead of barley. Rising demand for corn, soya beans and rapeseed for use in biofuels is making farmers move away from barley, a key ingredient in brewing. The price of barley has soared in the past year. Heineken chief executive Jean-François van Boxmeere said a long-term rise in beer prices was likely as a result.

Biofuels worsen global warming

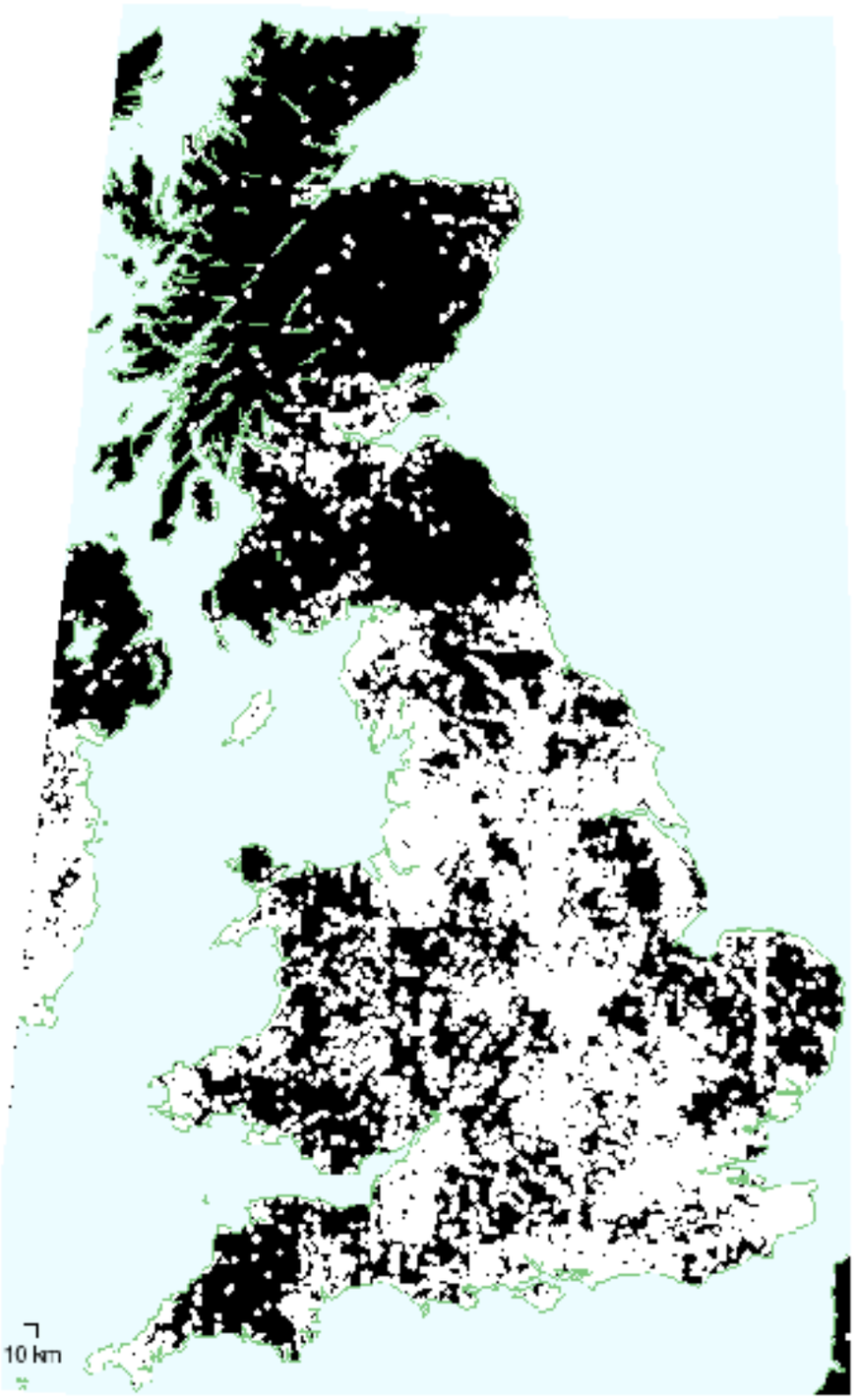
- Borneo - peat-burning
- Rape-seed - nitrous oxide

How much power could Britain get from biofuels?

Power per unit area



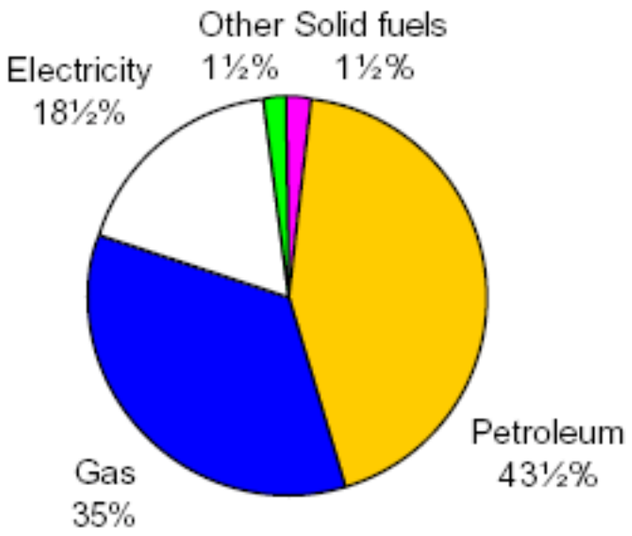
x Area



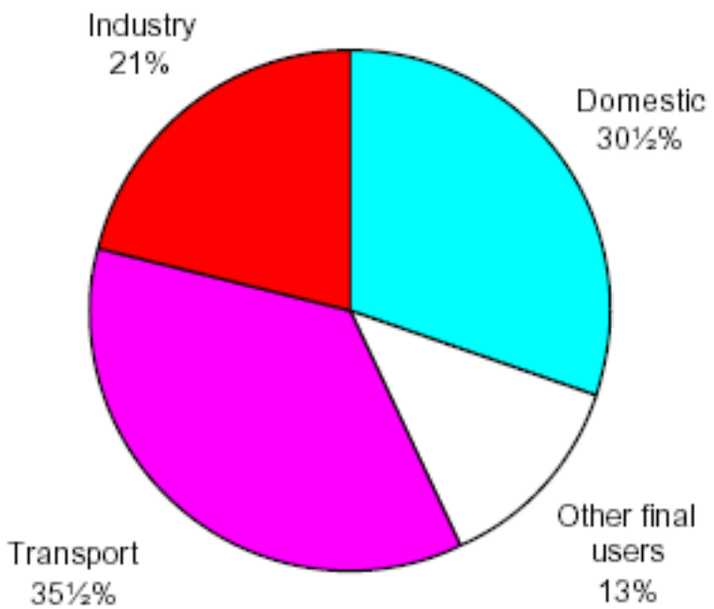
Attention is sometimes focussed on the comparison of the other inputs with the delivered energy

For corn-ethanol, the required inputs and losses are so big, it's difficult to make the Net Energy positive!

Average power consumption, UK: 125 kWh/d/p



2004



www.dti.gov.uk

'primary consumption'

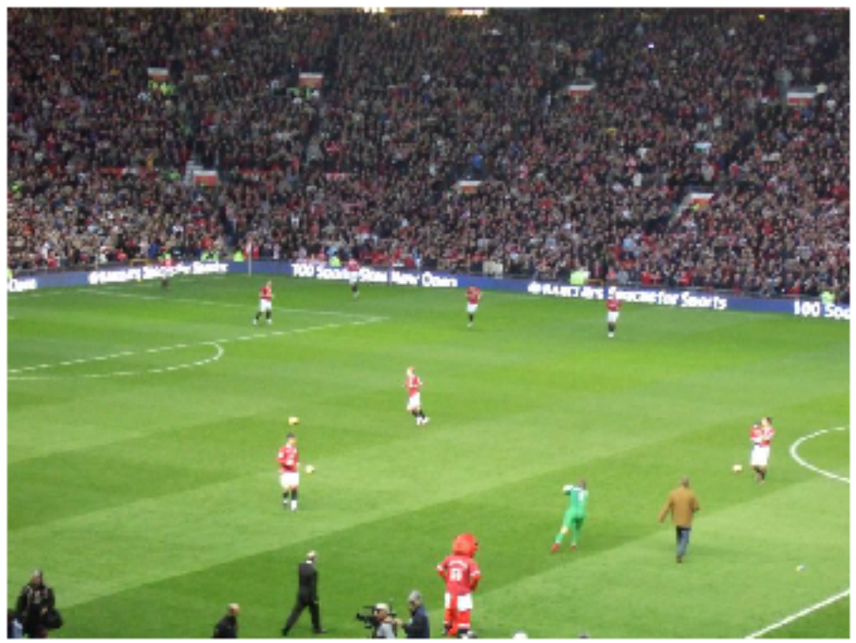
125 kWh/day (Europe)

250 kWh/day (USA)

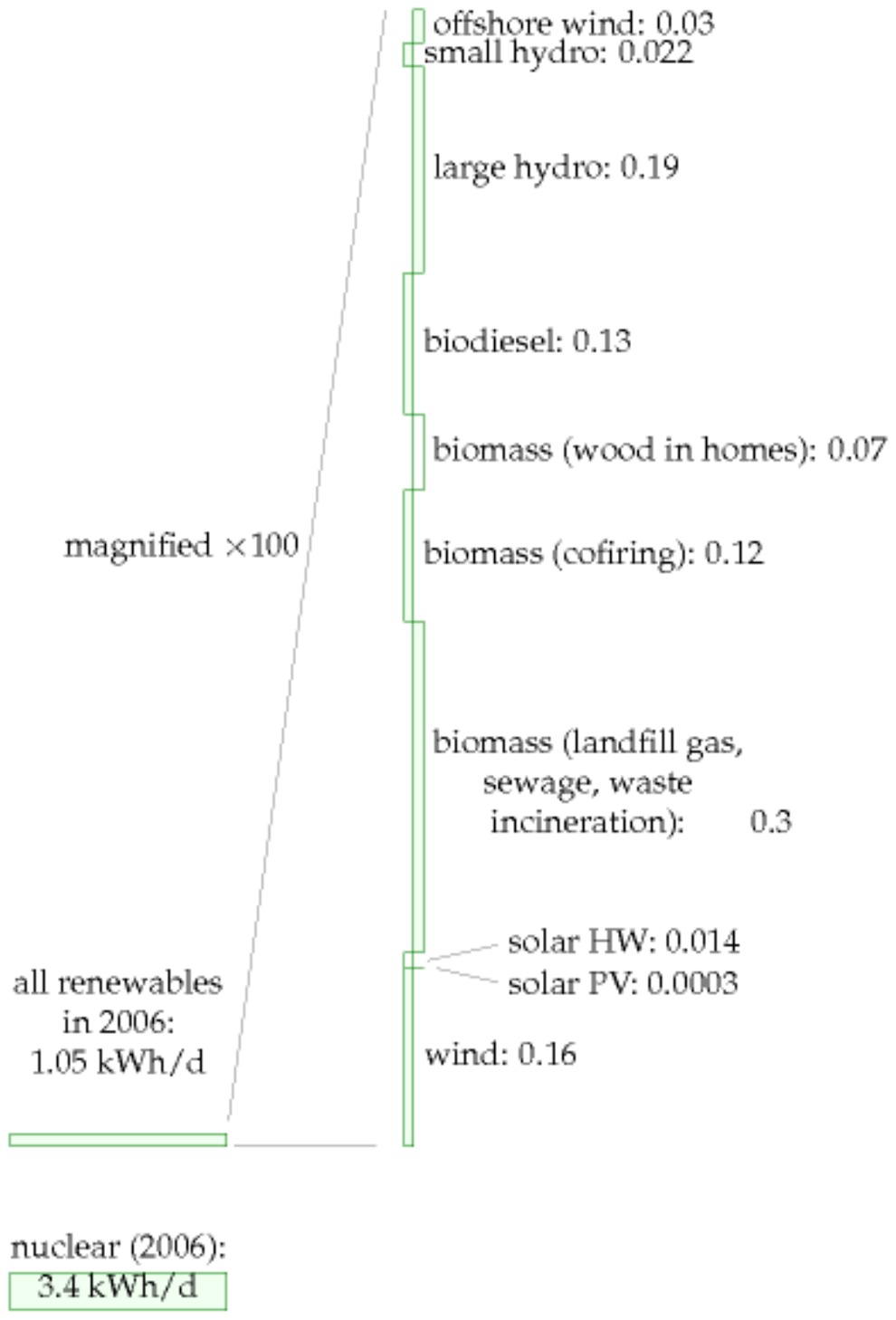
(doesn't include imports,
nor solar energy in food)

Area

UK: 4000 m^2 per person



Today's supply of renewables



How much power could Britain get from biofuels?

Power per unit area

Sunlight

100 W/m^2

Taking the most efficient plants

Carbohydrate energy delivered by plants

0.5 W/m^2

Energy used or lost in farming and processing

Delivered energy

Net energy

other inputs required for farming and processing

x Area

Total UK land area: **4000 m^2** per person

buildings: 48 m^2

gardens: 114 m^2

roads: 60 m^2

water: 69 m^2

arable land: **2800 m^2**

half of arable land: **1400 m^2** per person

How much power could Britain get from biofuels?

Power per unit area

Sunlight

$100\,W/m^2 \times 1400\,m^2$

Carbohydrate energy delivered by plants

17 kWh/d

other inputs required for farming and processing

Energy used or lost in farming and processing

Delivered energy

Net energy

x Area

Total UK land area: **4000 m^2** per person

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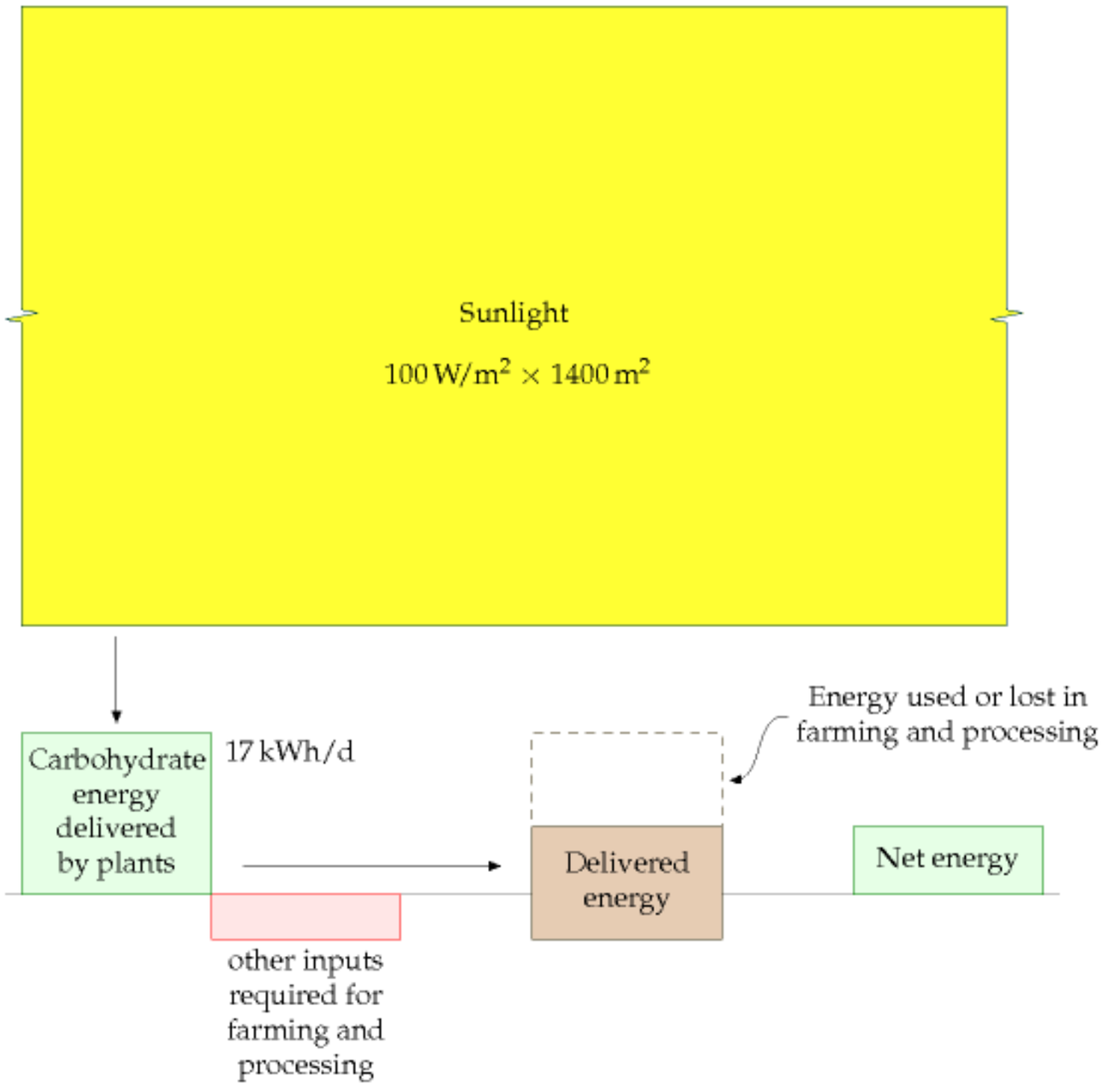
water: 69 m^2

arable land: **2800 m^2**

half of arable land: **1400 m^2** per person

Even if all the other issues were resolved

- Biofuels could make only a small contribution



www.withouthotair.com

References

http://www.grain.org/front/
http://www.grain.org/agrofuels/
http://www.grain.org/seedling_files/seed-07-07-2-en.pdf

"Even if the USA's entire corn and soya harvests were used to produce agrofuels, they would satisfy only 12 per cent of the USA's current thirst for petrol and 6 per cent of its need for diesel. The situation in Europe is even worse: the UK, for example, could not grow enough agrofuels to run all its cars even if it put the whole country under the plough."

MIT lifecycle analysis (Groode and Heywood):
http://lfee.mit.edu/metadot/index.pl?id=2234

Alex Farrell, Science, DOI:10.1126/science.1121416

H. Shapouri, J.A. Duffield, and Michael S. Graboski,
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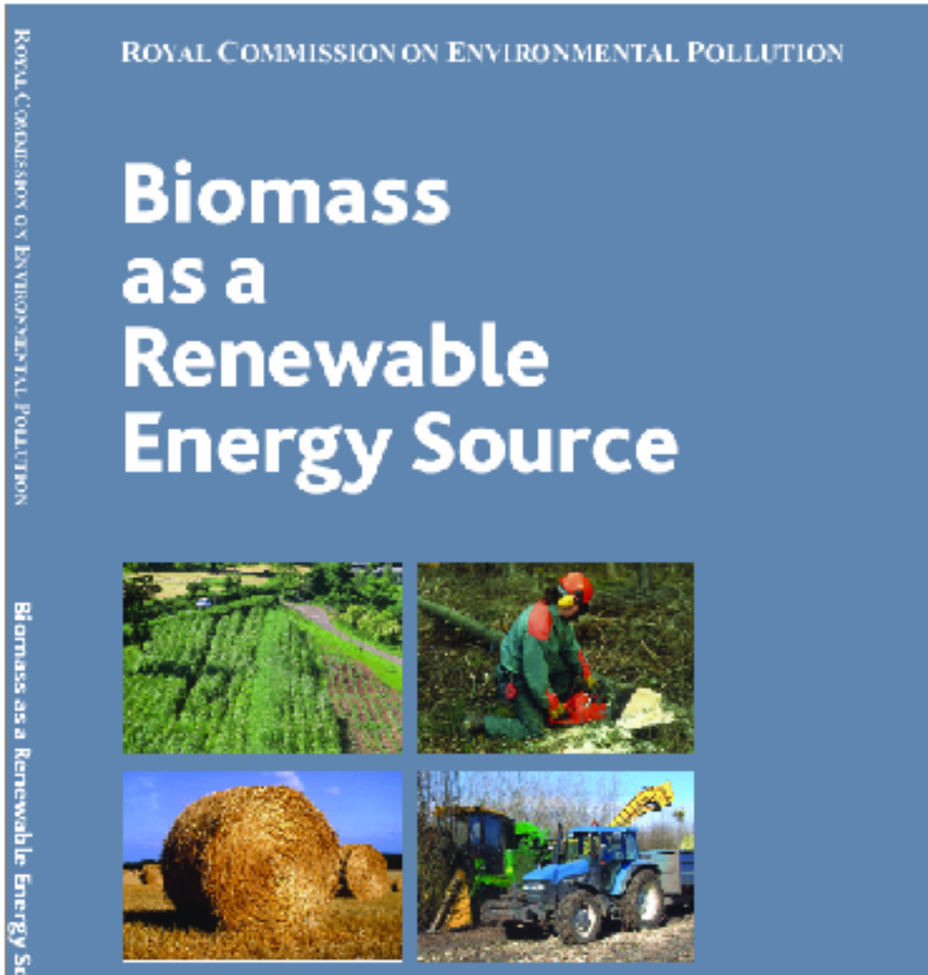
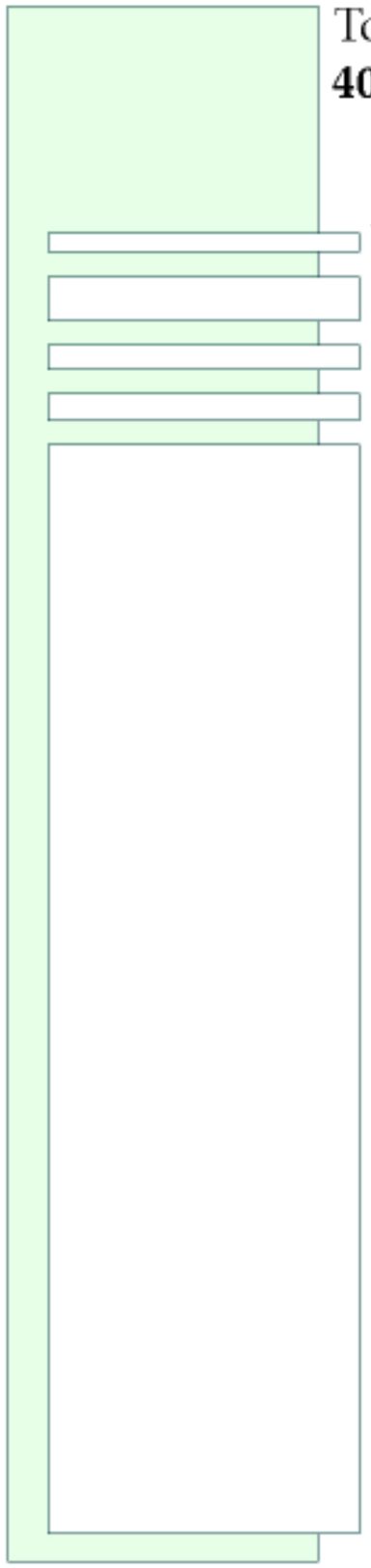
United States Department of Agriculture,
Agricultural Economic Report Number 721



Britain



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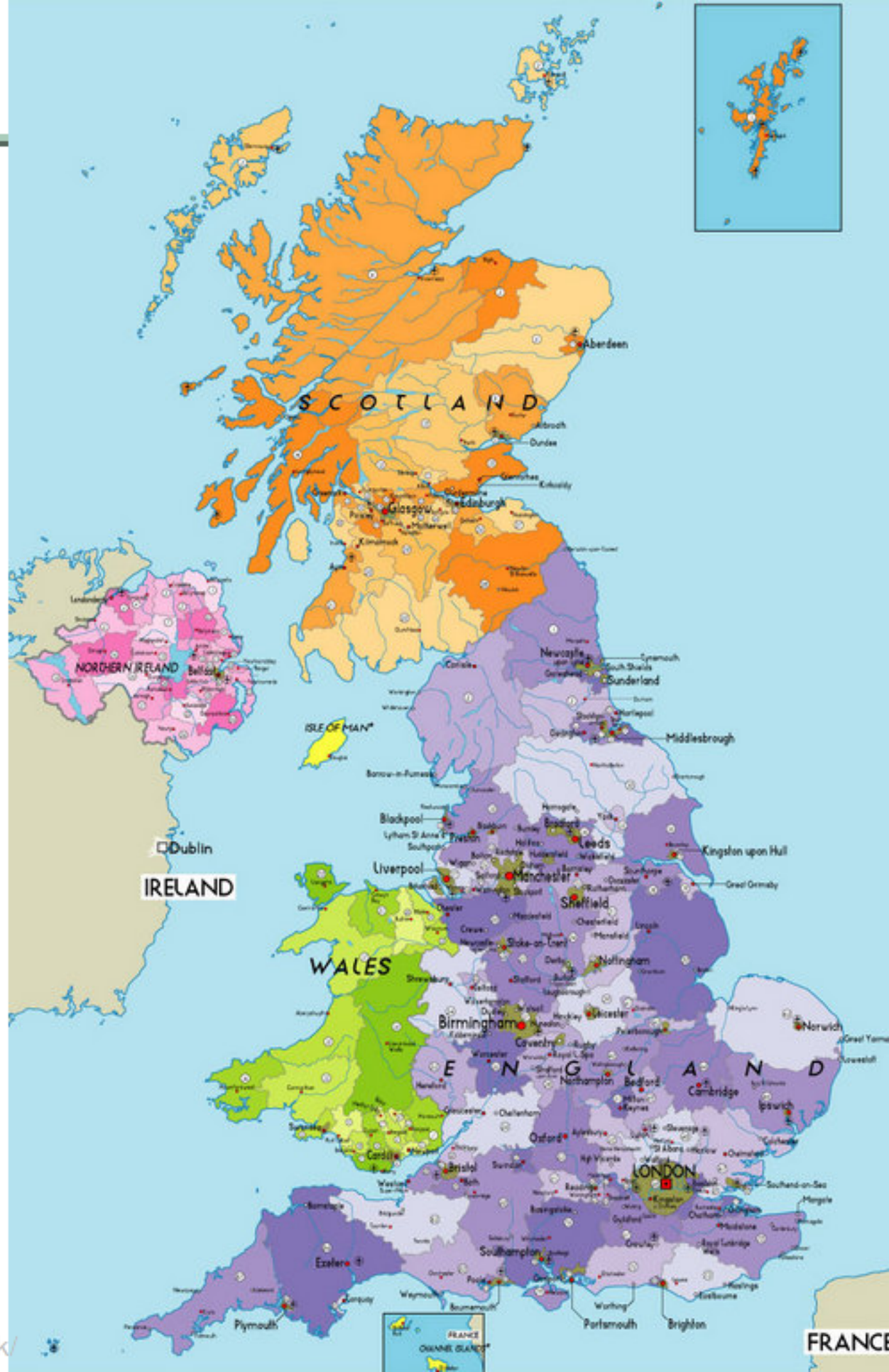


1 per sq km
43 per sq km
1000 per sq km

Area / km^2

1e+08
1e+07
1e+06
100000
10000
1000

10000
100000
1e+06
1e+07
1e+08
1e+09

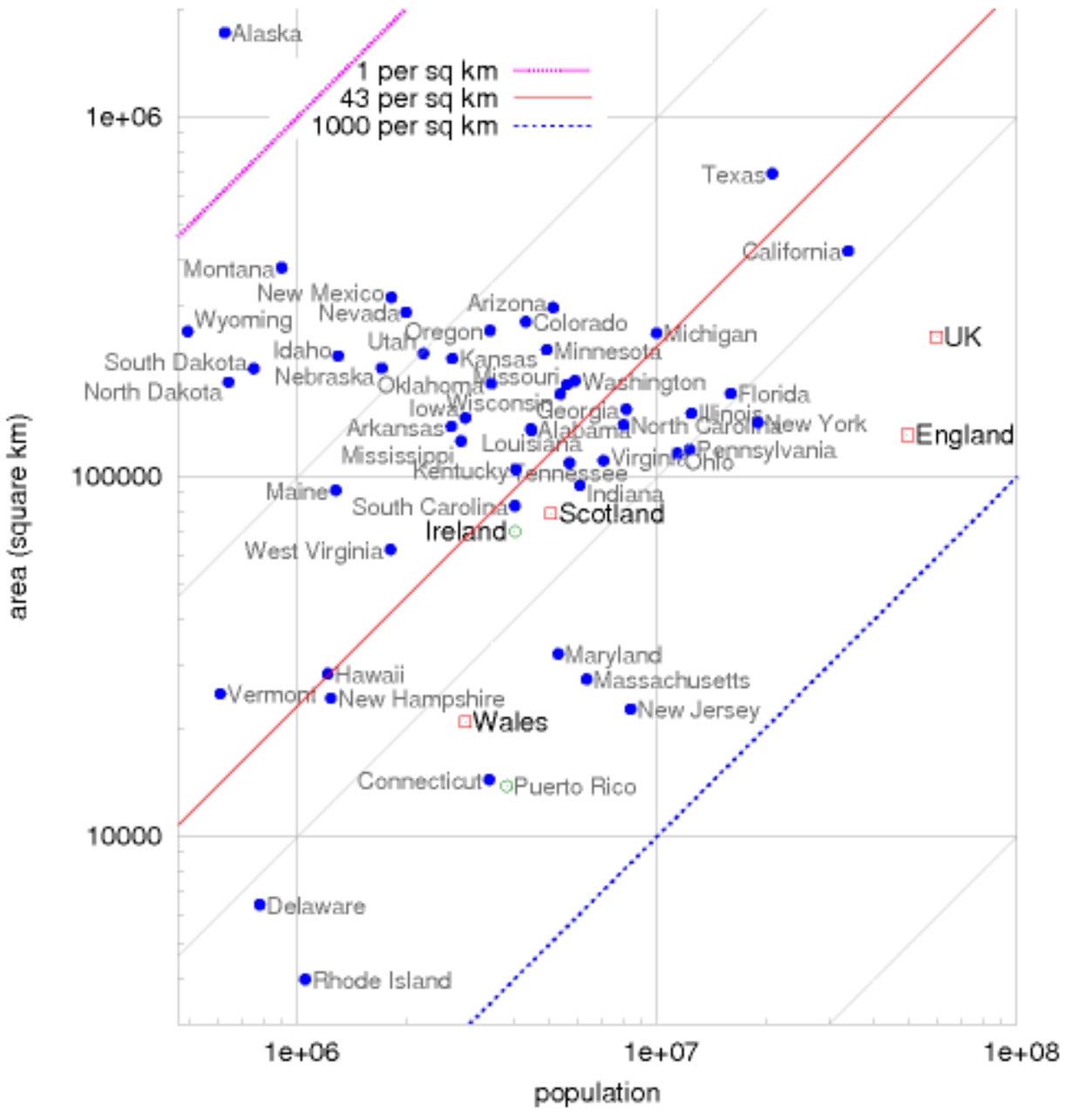
Population

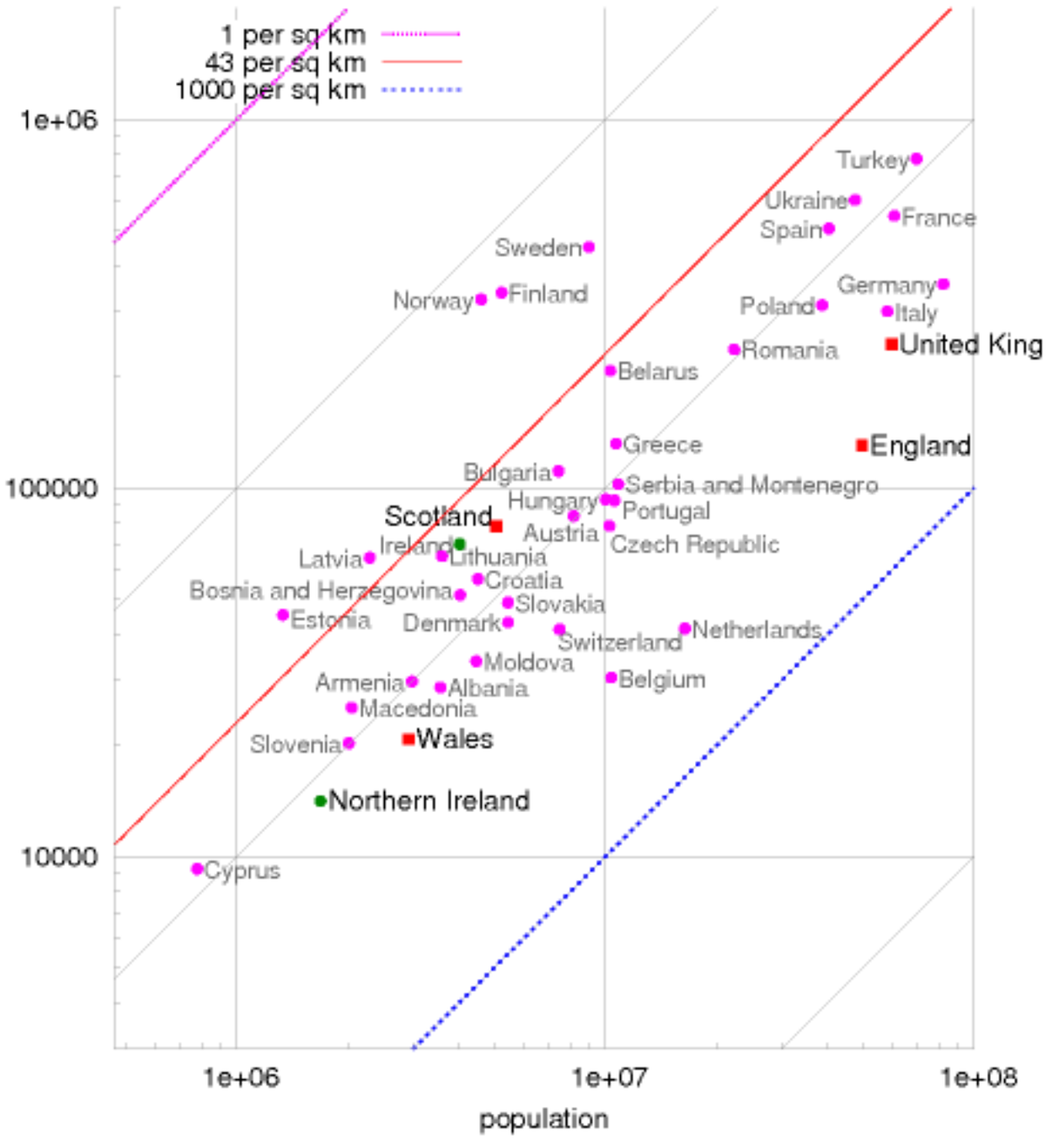
World
Asia
Africa
North America
Latin America
Europe
Antarctica
Canada
Australia
India
Kazakhstan
Greenland
Libya
Alaska
Mongolia
Mauritania
Namibia
Botswana
Western Sahara
Gabon
Guyana
Suriname
Iceland
French Guiana
Bangladesh
England
South Korea
Scotland
Taiwan
Wales
Mauritius
Hong Kong
Singapore
Gaza Strip

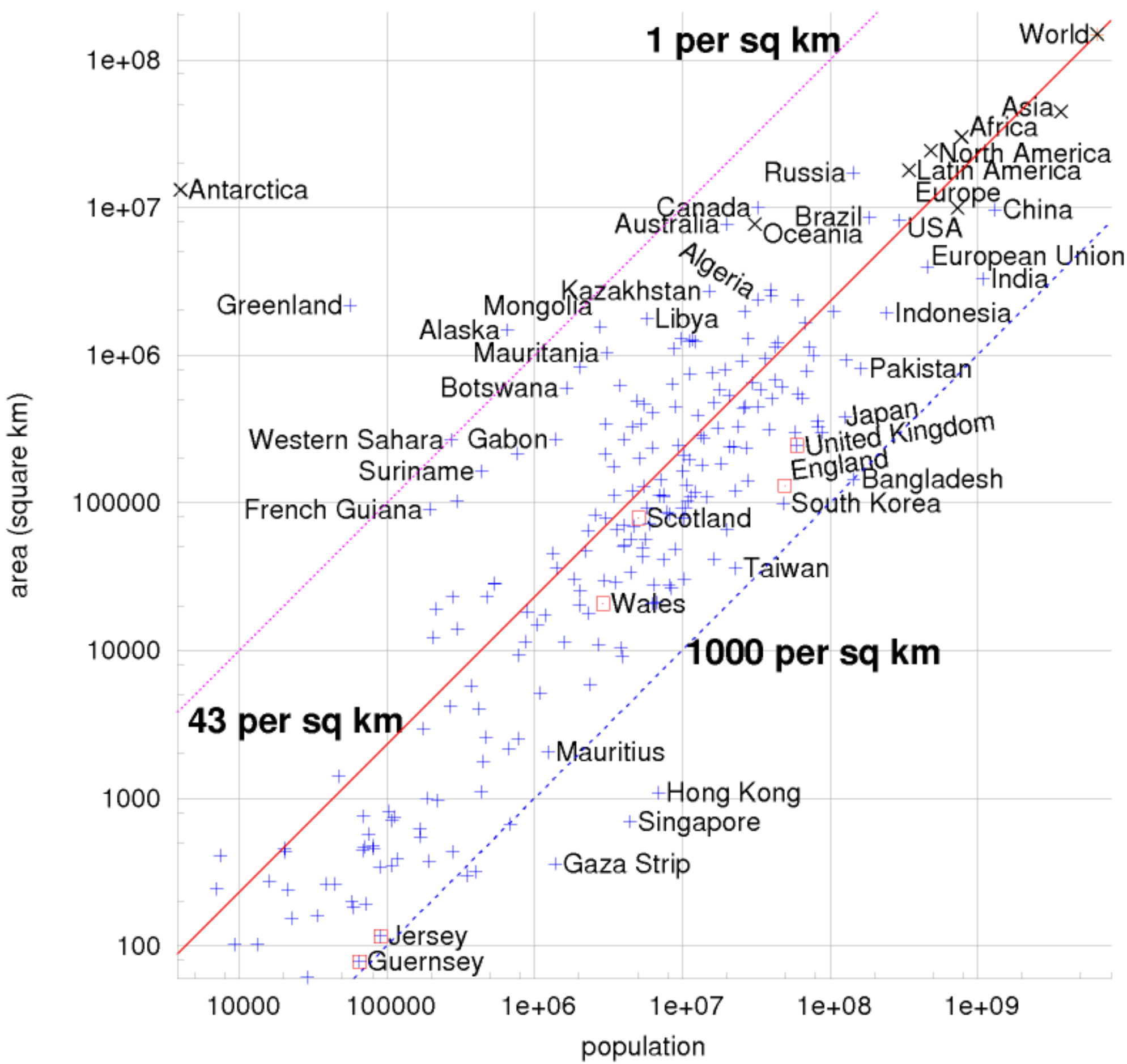
23 000 m^2 per person

1000 m^2 per person

Population densities






1 per sq km
43 per sq km
1000 per sq km
area (square km)
population
1e+08
1e+07
1e+06
100000
10000
1000
100
10000
100000
1e+06
1e+07
1e+08
1e+09
World
Asia
Africa
North America
Latin America
Europe
Russia
Canada
Australia
Oceania
Brazil
USA
China
European Union
India
Indonesia
Pakistan
Japan
United Kingdom
England
Bangladesh
South Korea
Taiwan
Wales
Scotland
Antarctica
Greenland
Alaska
Mongolia
Kazakhstan
Libya
Algeria
Mauritania
Botswana
Western Sahara
Gabon
Suriname
French Guiana
Mauritius
Hong Kong
Singapore
Gaza Strip
Jersey
Guernsey

A rough guide to sustainable energy

- No millions, billions, or trillions
- Make quantities comprehensible and comparable

- Do calculations per person, to one significant figure

- Energy unit: kWh

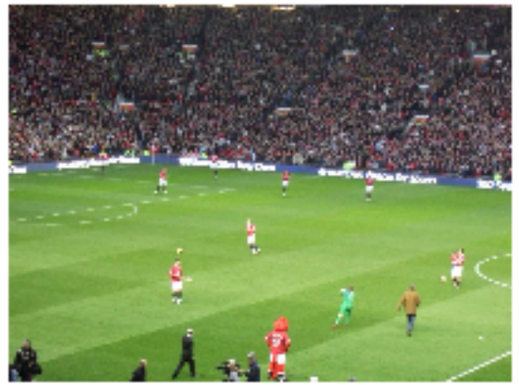
- Power unit: kWh per day

- Fluxes: W per square metre

- Population density: square metres per person

UK: $4000\ \mathrm{m}^2$ per person

- Examples
  - 20 mins of kettle - 1 kWh
  - food - 3 kWh / day(*)
  - bath - 5 kWh(*)
  - litre of petrol - 10 kWh
  - aluminium can - 0.6 kWh



Drive a car 100km...

80 kWh

ything.

HEAD

huge prob-
finding a
space and
usually re-
ning that
like
ehi-
V3

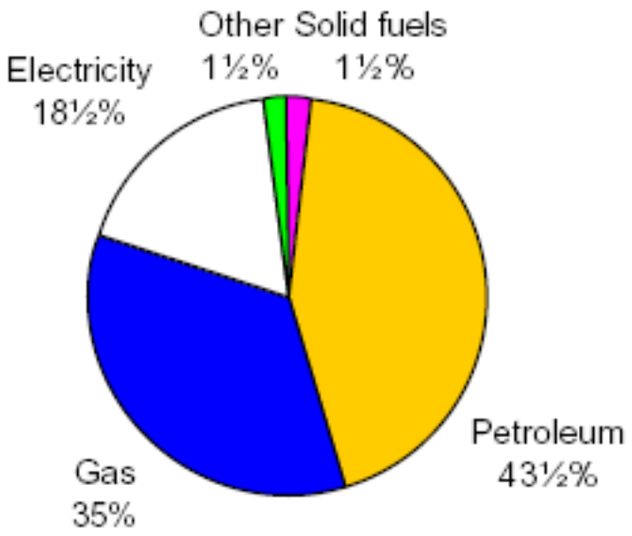
te
vo.
arque
ed V70
he should

The 2.4 Diesel is efficient and probably the best all-round choice, offering 34mpg overall. During the past few years, it has

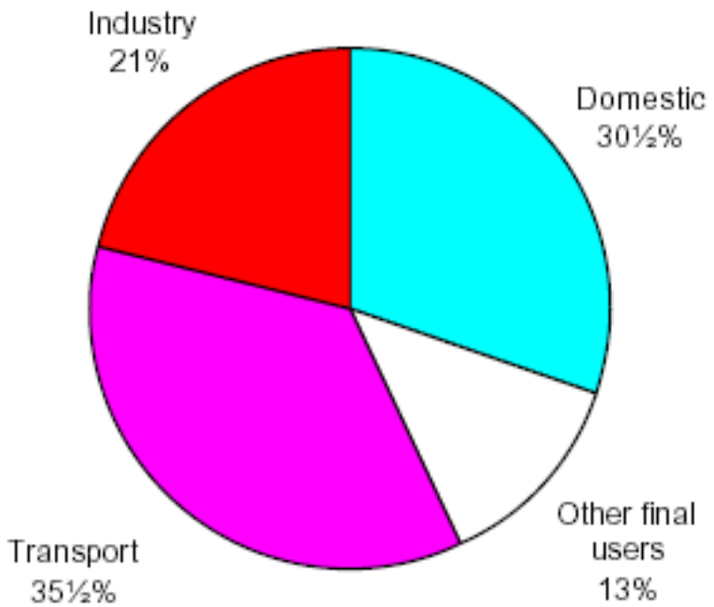
trouble is, the R-Class is furiously expensive, with prices starting at more than £38,000.

Practically perfect: the Volvo XC90

Average power consumption, UK: 125 kWh/d/p



2004



www.dti.gov.uk

125 kWh/day (Europe)

250 kWh/day (USA)

(Not including embodied energy in imports nor solar energy used by agriculture)

For CO_2 pollution, divide by 10:

100 kWh/day $\simeq$ 10 tonnes CO_2/year

Wind

Current consumption

$v = 6\,\mathrm{m/s}$ (force 4)
Wind farm $2\,\mathrm{W/m^2}$ flat ground

UK: 4000 m^2 per person

Put wind farms on 10% of the country

- 400 square metres each

Current consumption: 125 kWh/d per person

Wind: **20 kWh/d**

...Twice as much windpower as the whole world;

50 x Denmark's

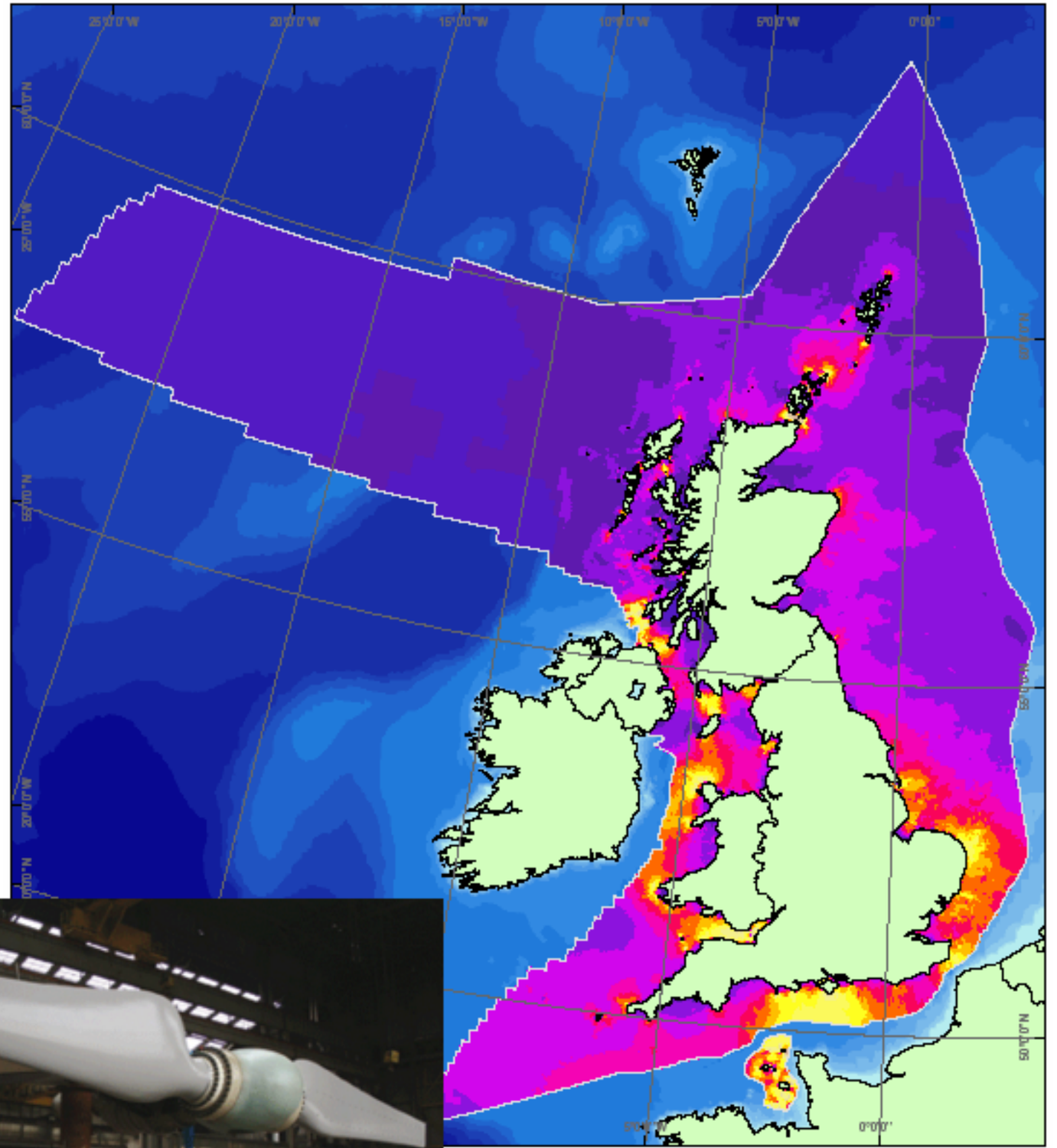
7 x Germany's

Renewables are diffuse

Power per unit land area

Wind	$2\,\mathrm{W/m^2}$
Offshore wind	$3\,\mathrm{W/m^2}$
Tidal pools	$3\,\mathrm{W/m^2}$
Tidal stream	$8\,\mathrm{W/m^2}$
Solar PV panels	$5\text{–}20\,\mathrm{W/m^2}$
Plants	$0.5\,\mathrm{W/m^2}$
Solar chimney (Spain)	$0.1\,\mathrm{W/m^2}$
Concentrating solar power (desert)	$15\text{–}20\,\mathrm{W/m^2}$
Ocean thermal	$5\,\mathrm{W/m^2}$
Rain-water (highlands)	$0.24\,\mathrm{W/m^2}$
Rain-water (lowlands)	$0.02\,\mathrm{W/m^2}$

- To make a difference, renewable facilities have to be country-sized



marineturbines.com

All renewables are diffuse

Power per unit land area	
Wind	$2\,\mathrm{W/m^2}$
Offshore wind	$3\,\mathrm{W/m^2}$
Tidal pools	$3\,\mathrm{W/m^2}$
Tidal stream	$8\,\mathrm{W/m^2}$
Solar PV panels	5–$20\,\mathrm{W/m^2}$
Plants	$0.5\,\mathrm{W/m^2}$
Solar chimney (Spain)	$0.1\,\mathrm{W/m^2}$
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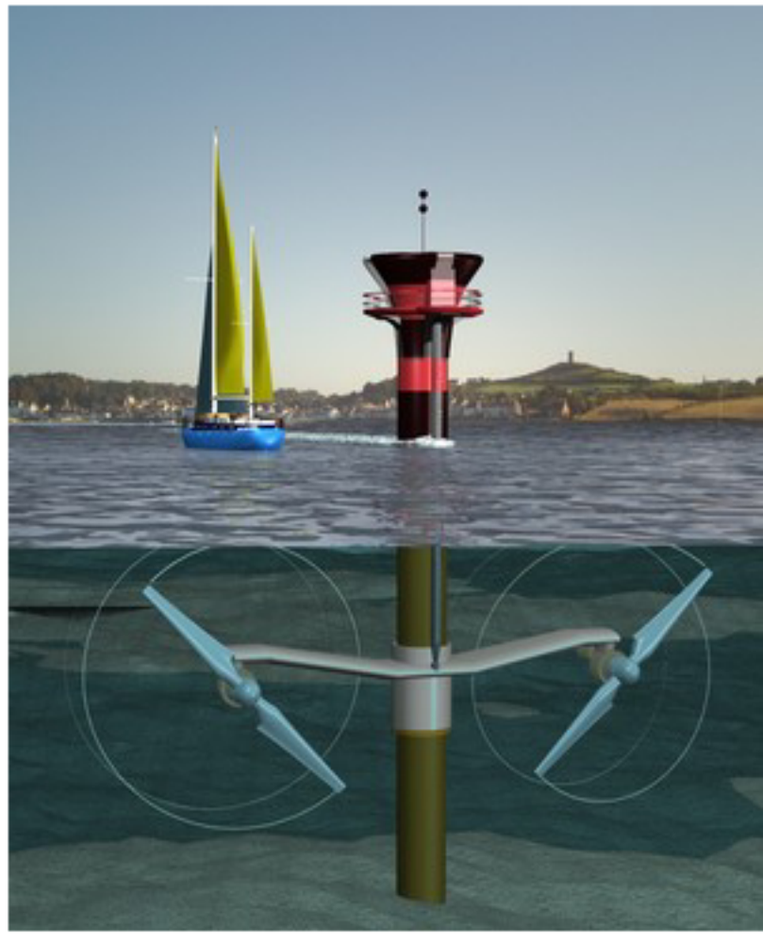

marineturbines.com

- To make a difference, renewable facilities have to be country-sized

Bavaria Solar Park: $5\,\mathrm{W/m^2}$; this picture shows $0.7\,\mathrm{MW}$ (average)

All renewables are diffuse

Power per unit la	
Wind	
Offshore wind	
Tidal pools	
Tidal stream	
Solar PV panels	
Plants	
Solar chimney (Spain)	
Concentrating solar power (des	
Ocean thermal	5 W/m²
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- To make a difference, renewable facilities have to be country-sized

Renewables are diffuse

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- To make a difference, renewable facilities have to be country-sized

Block

News

News
England
Northern Ireland
Scotland
Wales
International
RSS feeds

PRINT
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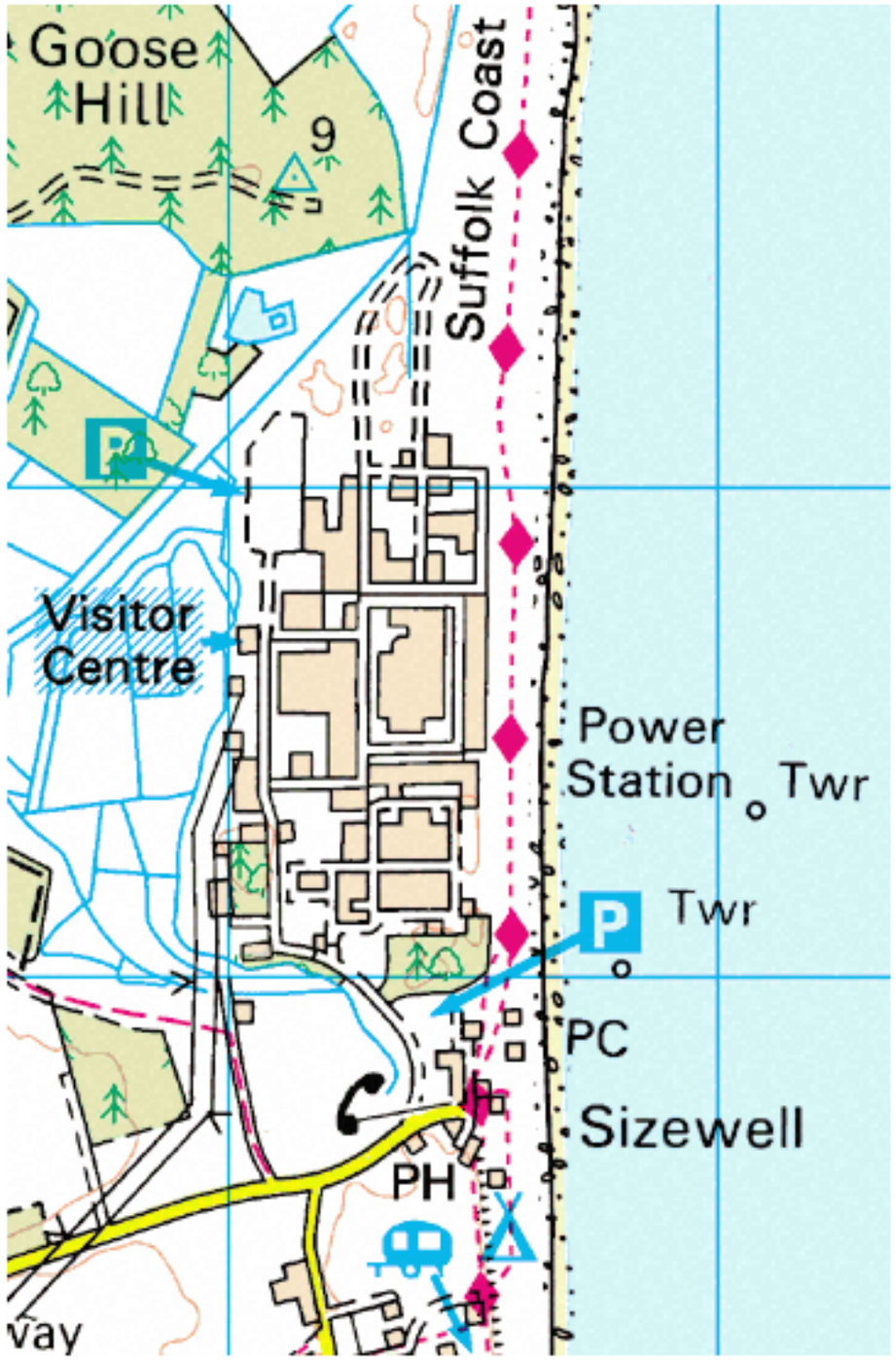
No green light for Severn barrage

Last modified: 01 October 2007

Europe's most dynamic estuary will be destroyed by the construction of a barrage across the Severn while other less striking measures would cost less and could do more to cut carbon emissions.

"other less striking measures"?

To make a difference, renewable facilities have to be country-sized



Nuclear	
Fission	$1000\,\mathrm{W/m^2}$













Current consumption: 125 kWh/d per person

We can't live on our own renewables

- at least, not as we currently live

Geothermal: 1

Tide: **11 kWh/d**

Wave: **4**

Shallow offshore wind: **16 kWh/d**

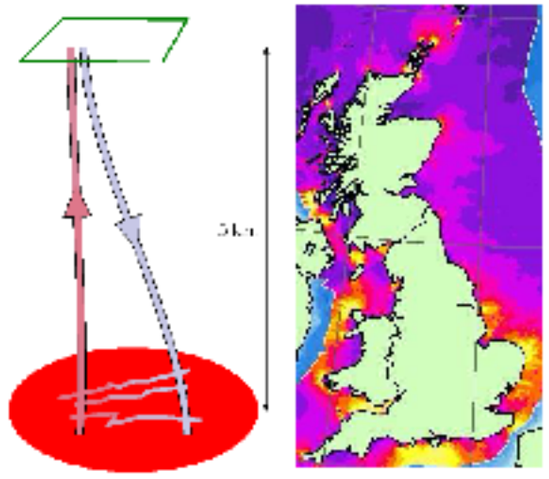
Hydro: **1.5**

Biomass: food, biofuel, wood, waste incin'n, landfill gas: **24 kWh/d**

PV, 10 m^2: **5**

Solar heating: **11 kWh/d**

Wind: **20 kWh/d**









www.withouthotair.com

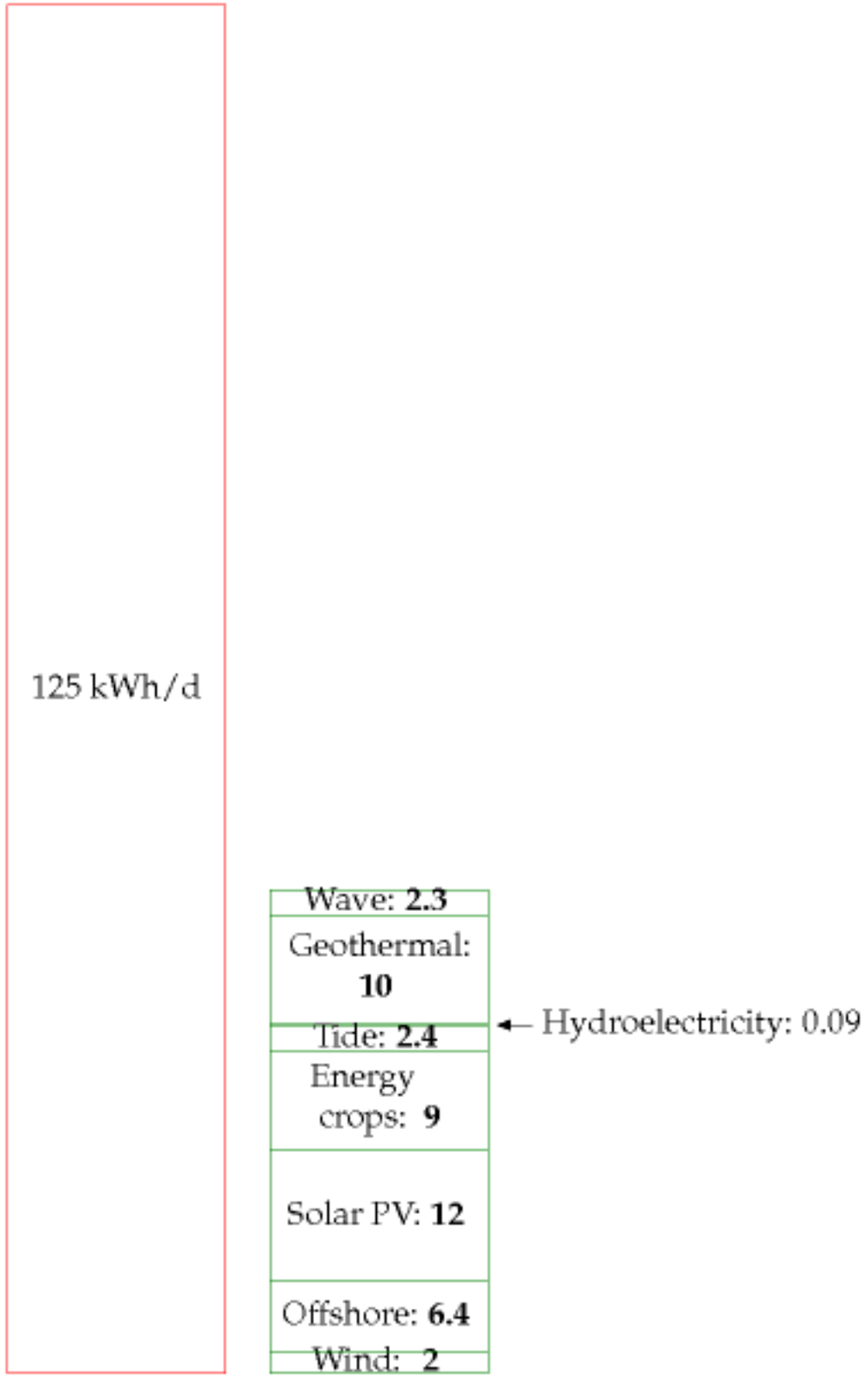
sustainable development commission

The role of nuclear power in a low carbon economy

Paper 2:
Reducing CO_2 emissions - nuclear and the alternatives

An evidence-based report by the Sustainable Development Commission

March 2006



IEE's 'technical potential' is 'an upper limit that is unlikely ever to be exceeded even with quite dramatic changes in the structure of our society and economy'.

A consultation exercise in full swing

Penicuik Environment Protection Association

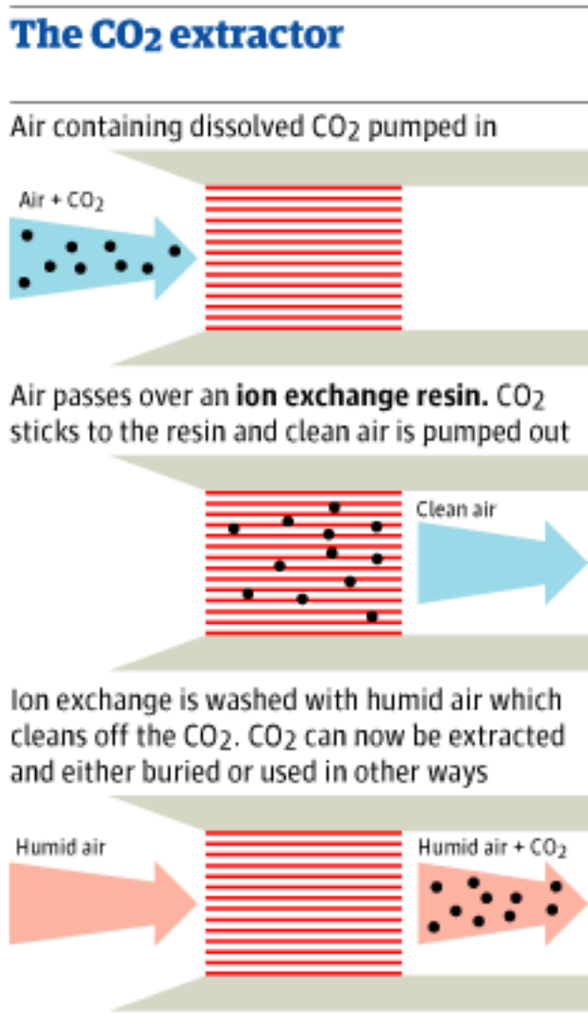
http://www.auchencorth.org.uk/

Go to page 61 or 70

FIXING CLIMATE

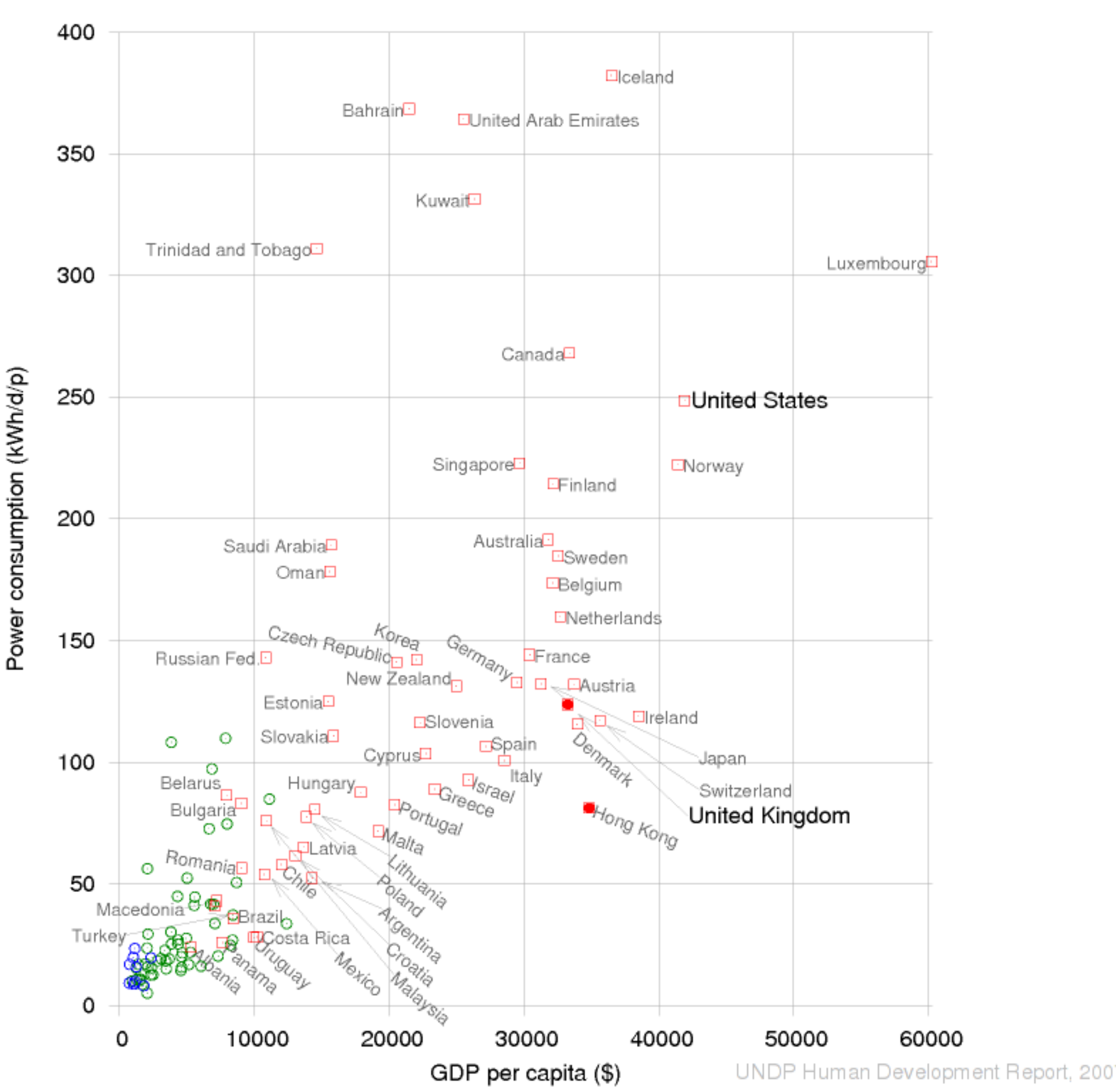
WHAT PAST CLIMATE CHANGES REVEAL ABOUT THE CURRENT THREAT—AND HOW TO COUNTER IT

WALLACE S. BROECKER and ROBERT KUNZIG



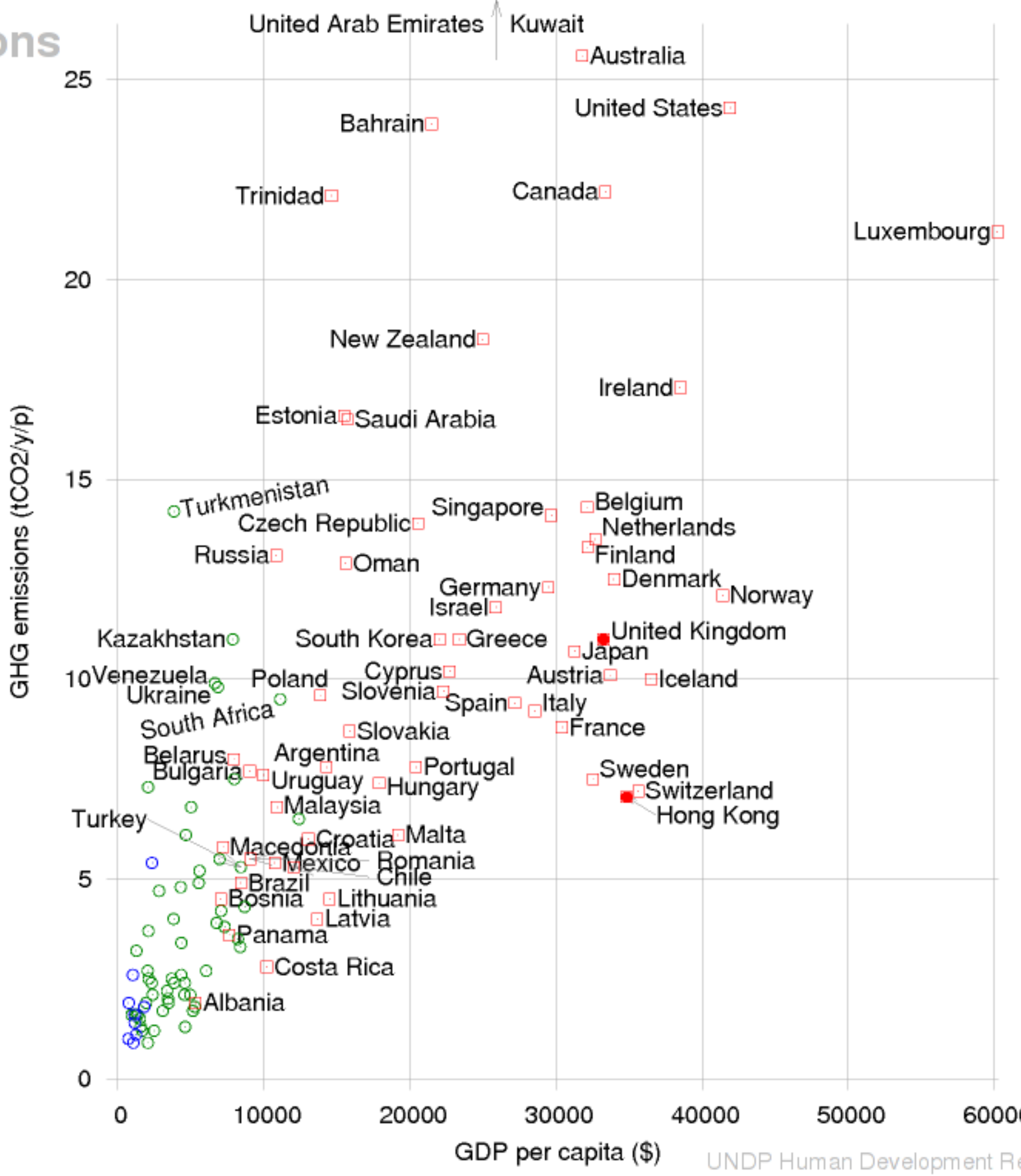
Lackner's method (June 2007): $1.3\,\mathrm{kWh}^{(e)}$ per kg of CO_2:
To capture $30\,\mathrm{kg}$ per day per person, need $40\,\mathrm{kWh}^{(e)}$ per day.

Energy use versus GDP - linear scale



UNDP Human Development Report, 2007

GHG emissions versus GDP



UNDP Human Development Report, 2007; CAIT, 2007

GHG emissions versus energy use

GHG emissions (tCO2/y/p)

Energy use (kWh/d/p)

Australia
Kuwait, UAE
United States
Bahrain
Canada
Trinidad and Tobago
Luxembourg
New Zealand
Ireland
Estonia
Saudi Arabia
Netherlands
Czech Republic
Turkmenistan
Belgium
Singapore
Russia
Oman
Finland
Denmark
Germany
Norway
Israel
United Kingdom
Greece
Korea
Japan
Venezuela
Cyprus
Austria
Iceland
Poland
Slovenia
Spain
Italy
Slovakia
France
Argentina
Portugal
Belarus
Uruguay
Bulgaria
Hungary
Sweden
Uzbekistan
Switzerland
Malaysia
Hong Kong
Croatia
Malta
Macedonia
Romania
Chile
Mexico
Brazil
Bosnia
Lithuania
Turkey
Latvia
Panama
Costa Rica
Albania

UNDP Human Development Report, 2007; CAIT, 2007

1 kW (24 kWh/d)