

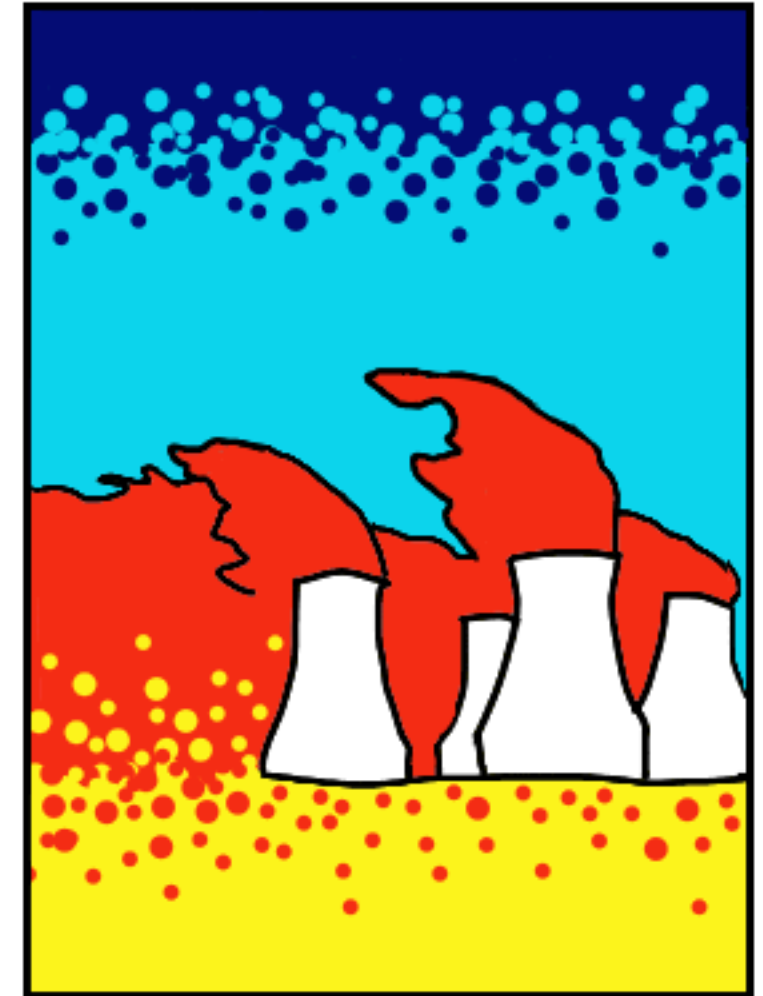
Sustainable Energy

- 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?



Britain (United Kingdom)



<http://www.maps-of-britain.co.uk/>

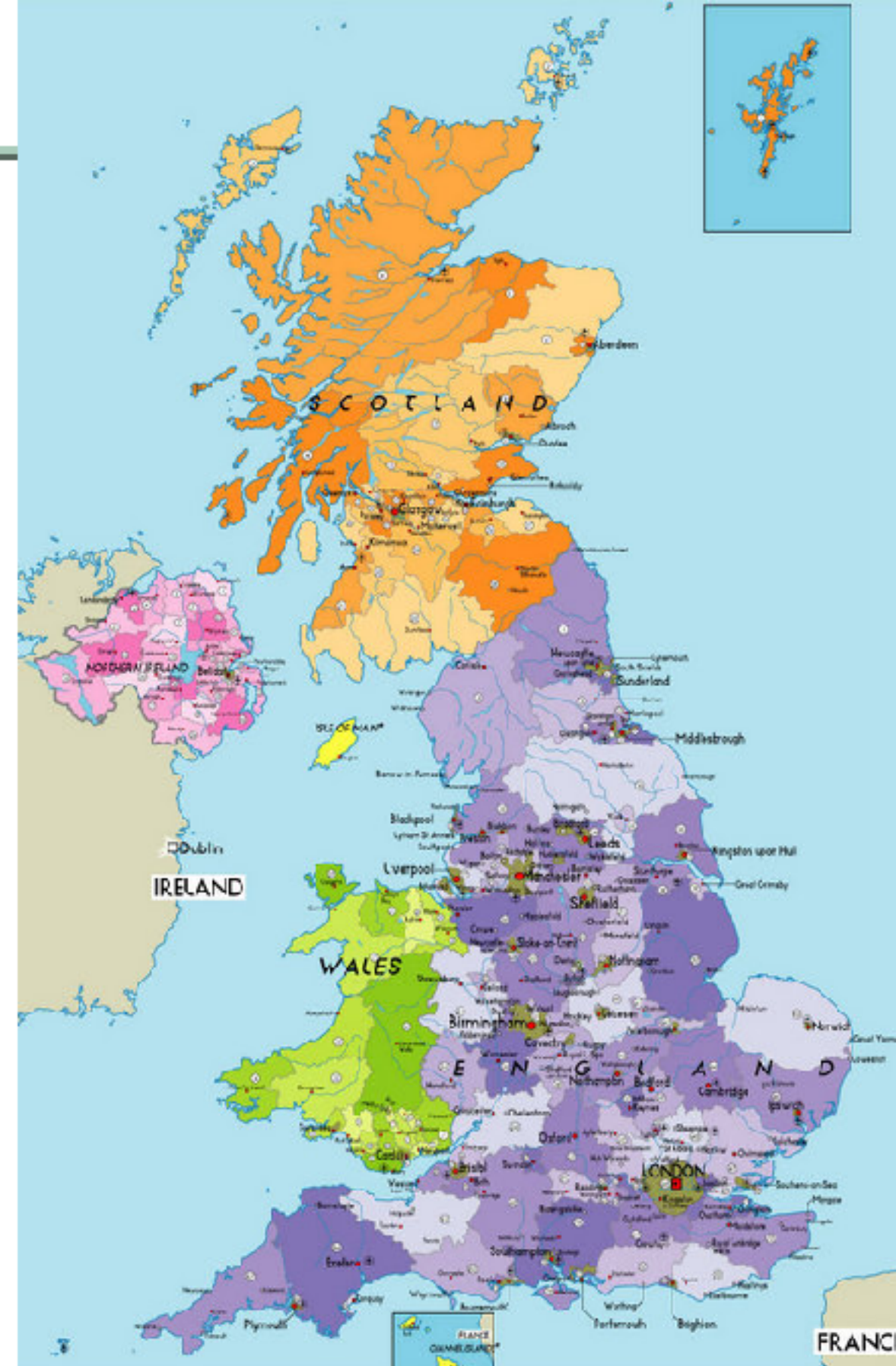
Britain (United Kingdom)

Areas:

Wales = New Jersey

England = New York

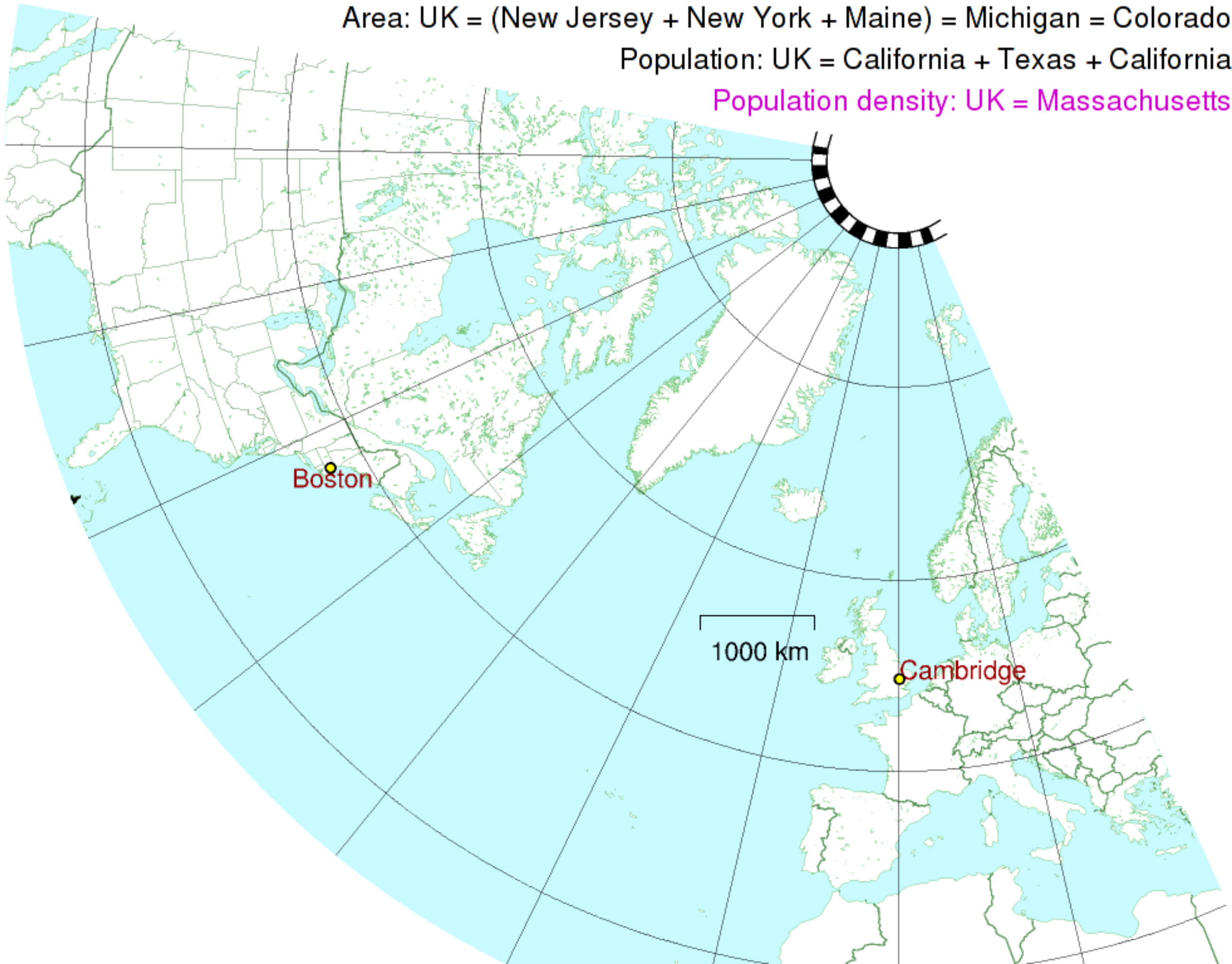
Scotland = Maine



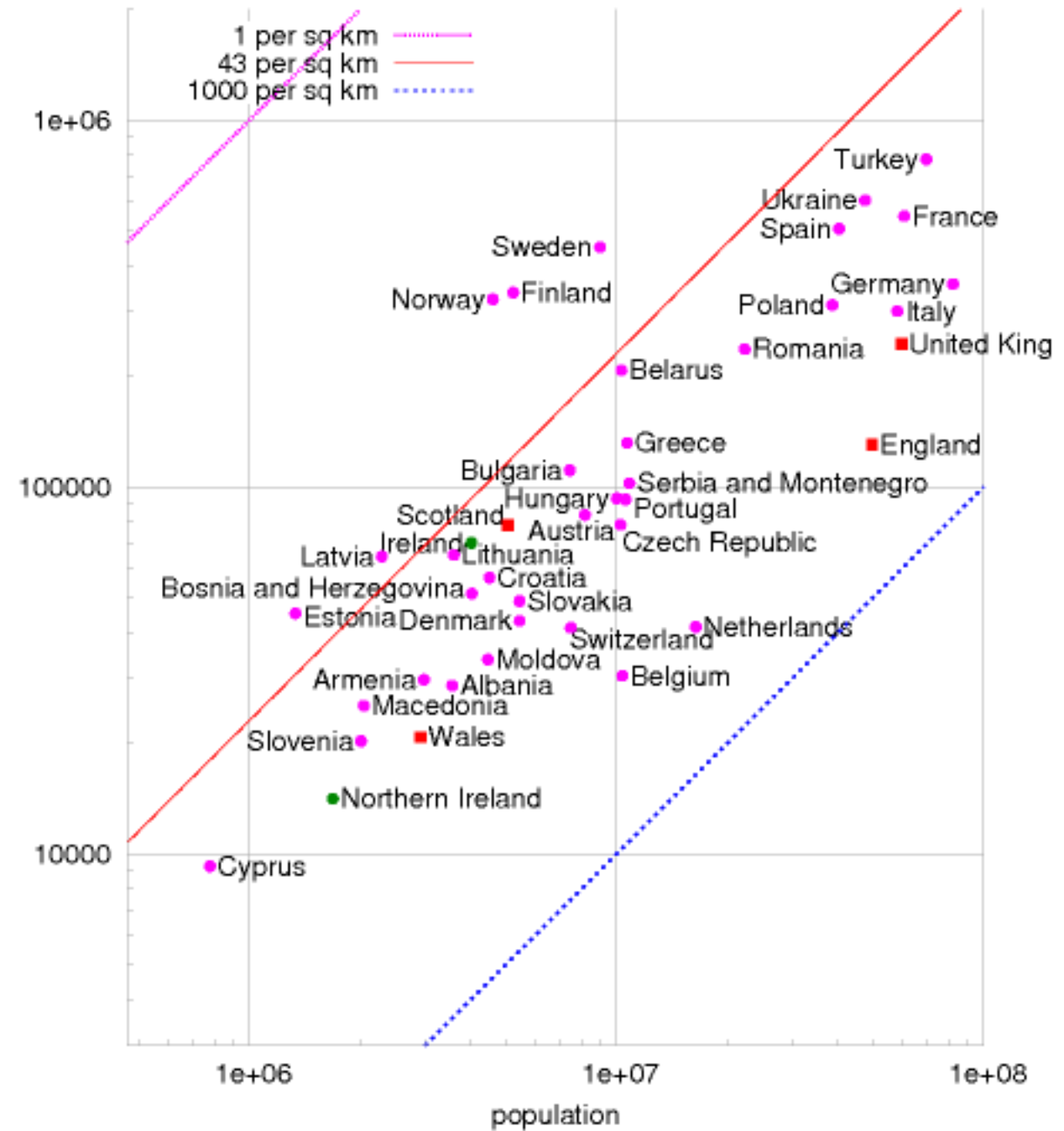
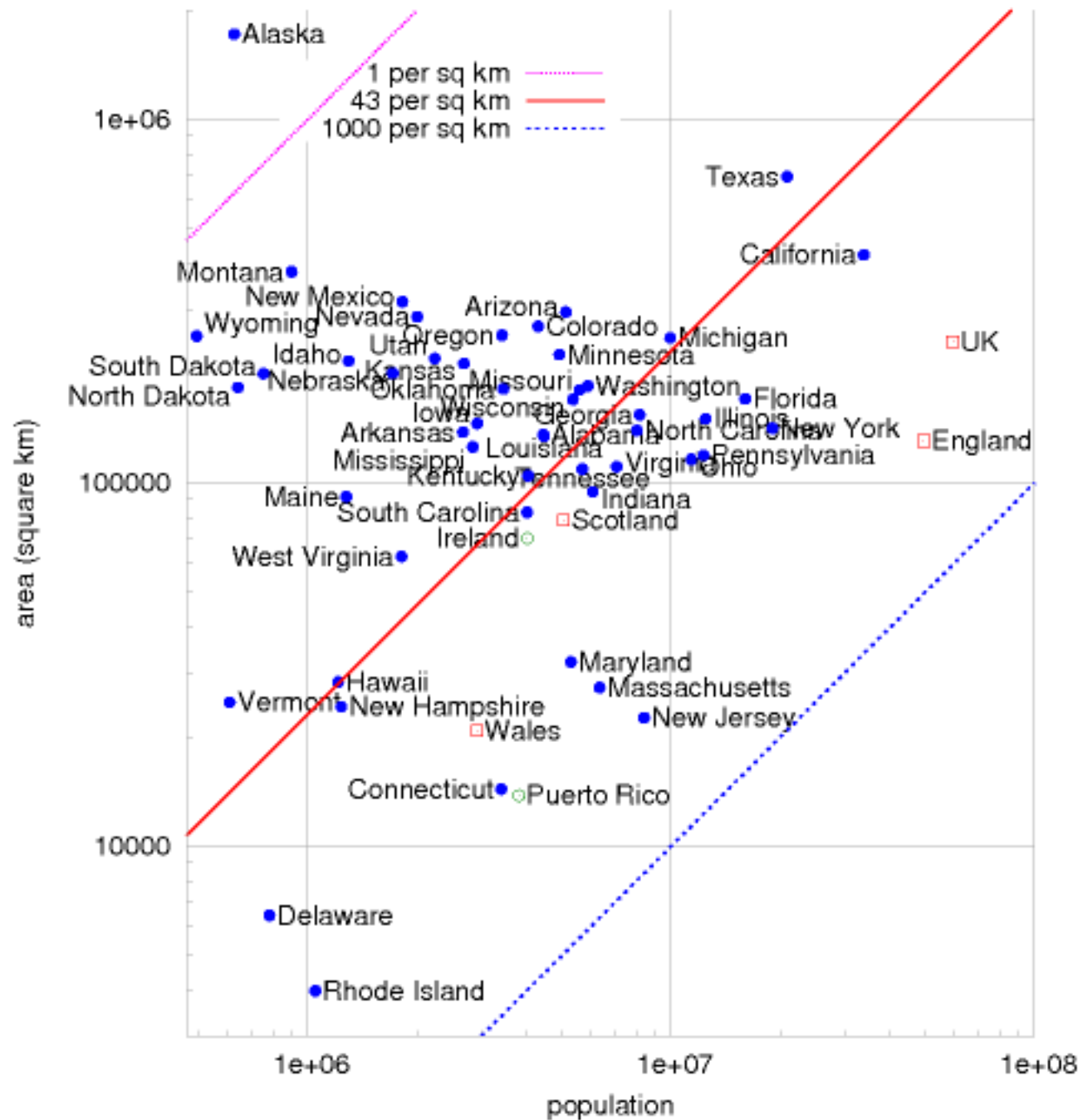
Area: UK = (New Jersey + New York + Maine) = Michigan = Colorado

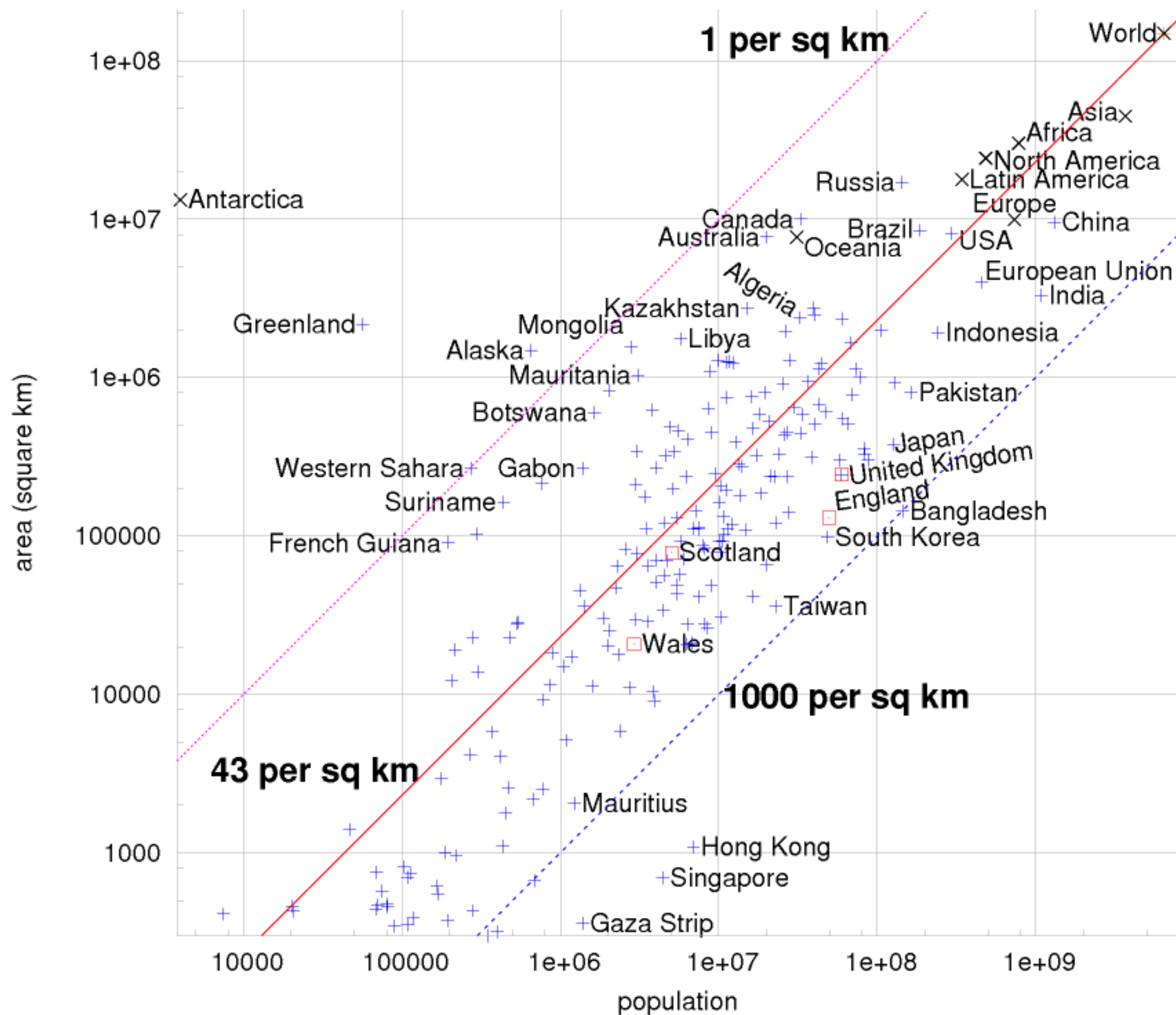
Population: UK = California + Texas + California

Population density: UK = Massachusetts



Population densities





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?

[**Britain or Massachusetts**]

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

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

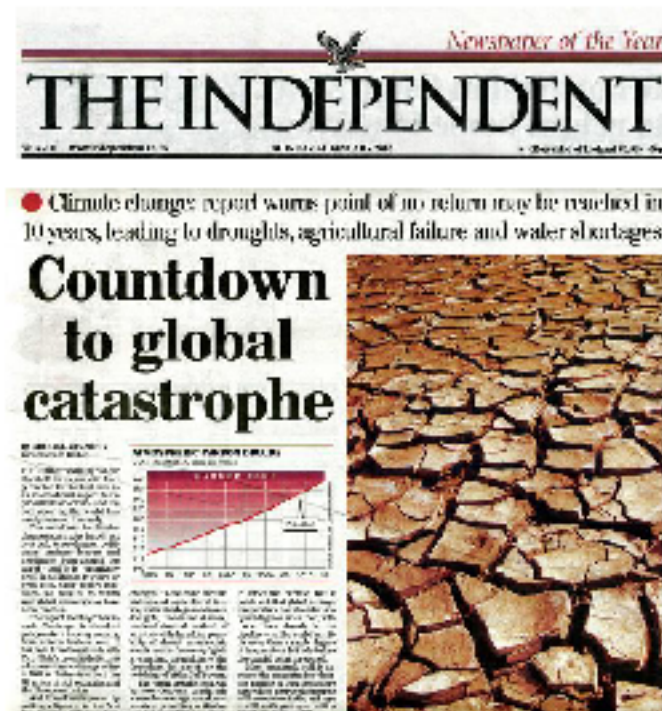
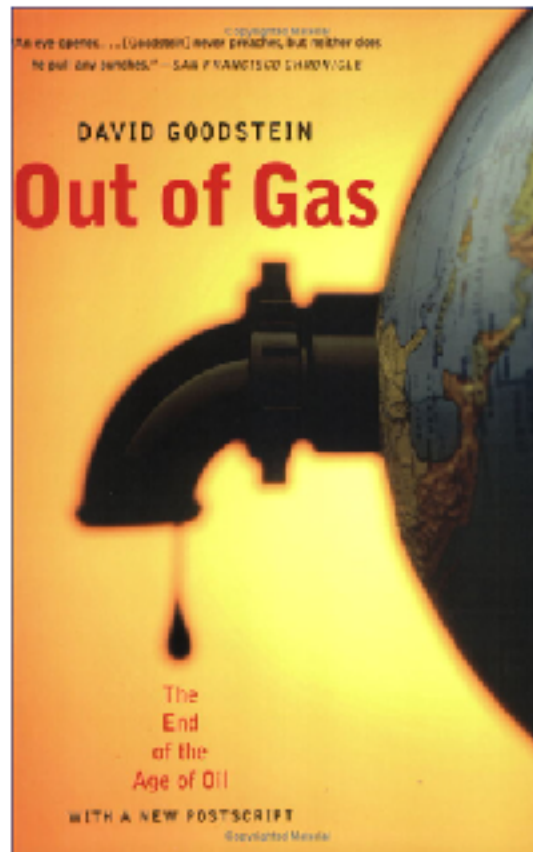
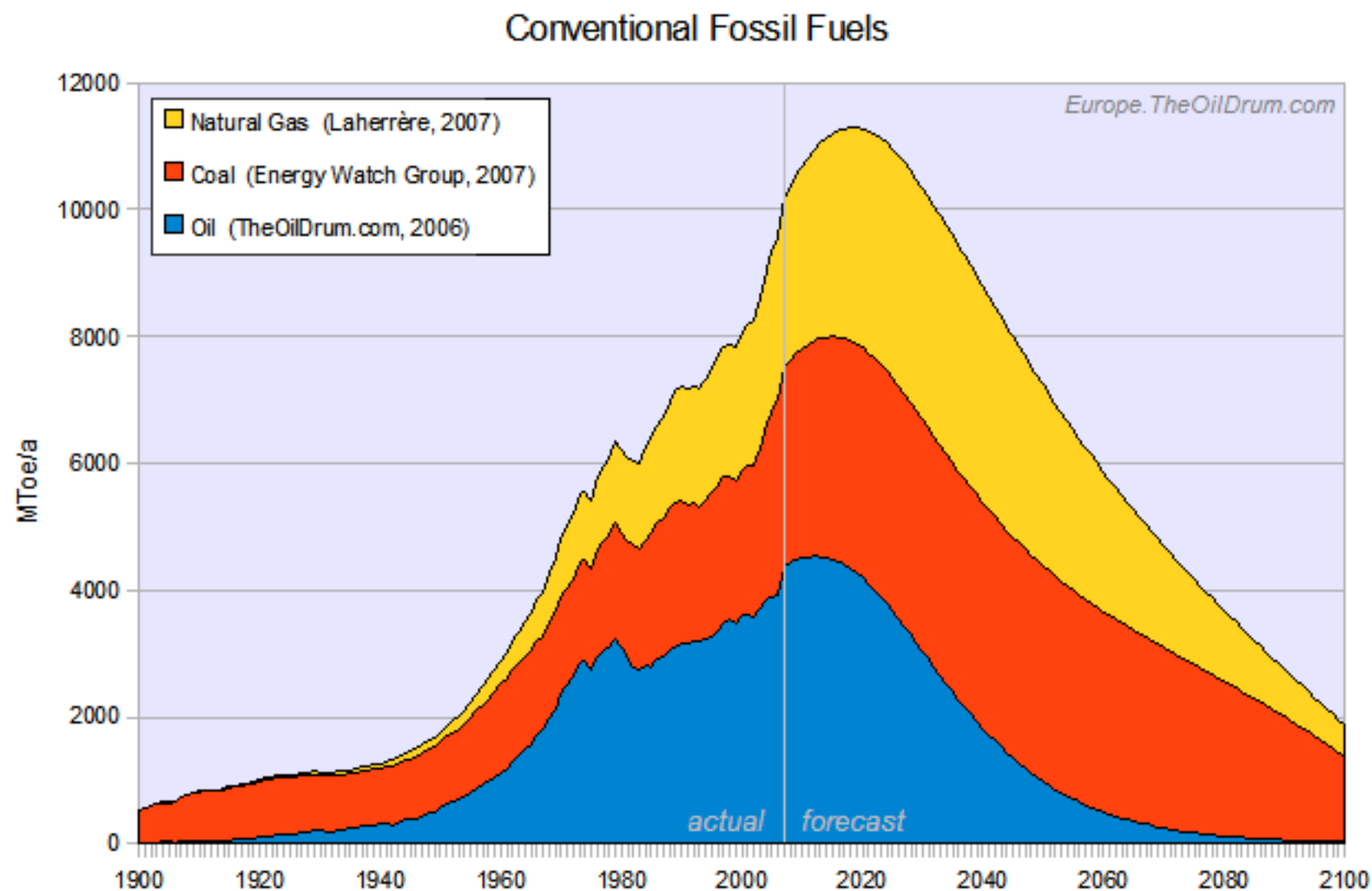
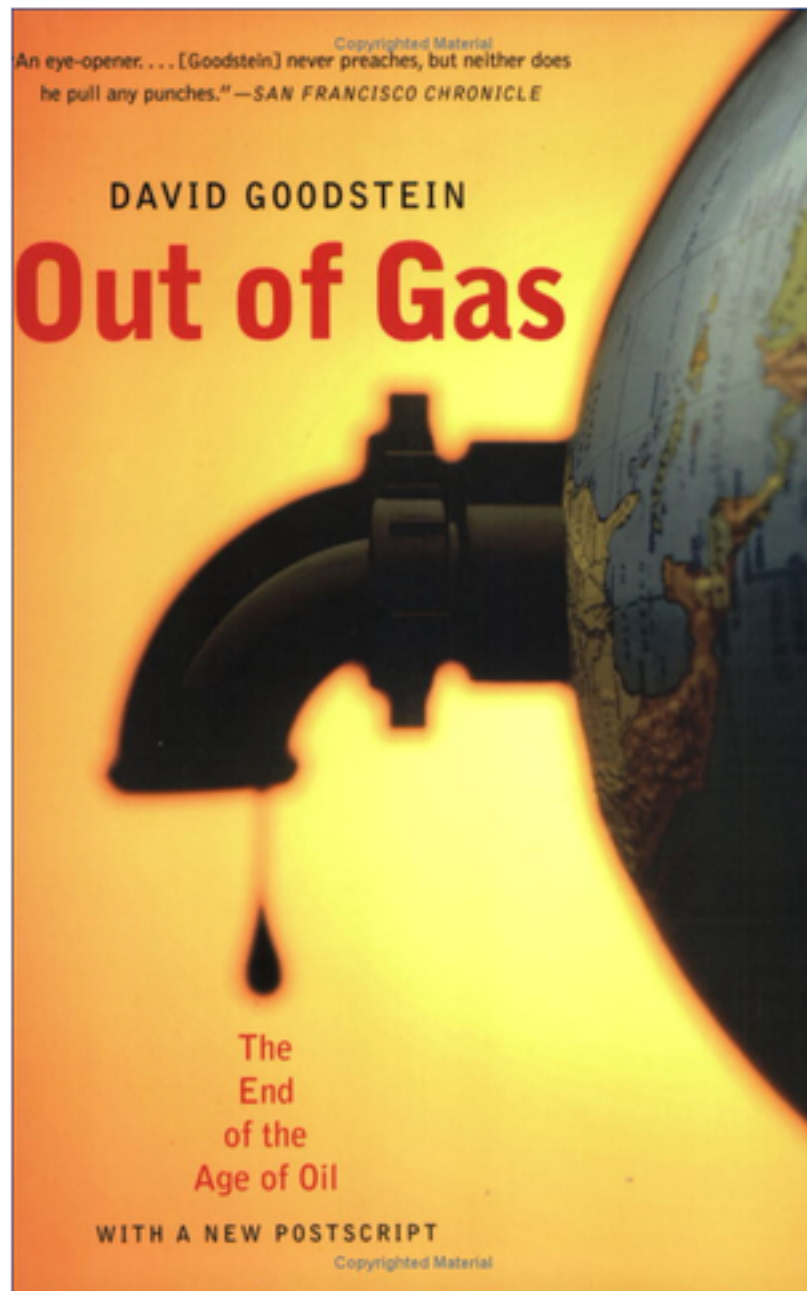


Photo by Terry Cavner





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.

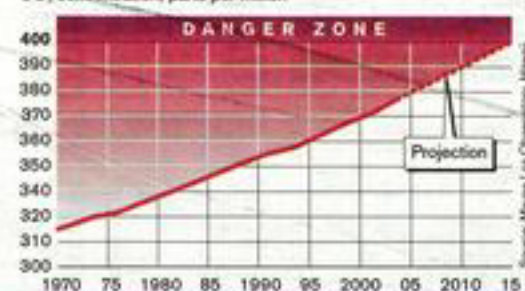
The countdown to climate-change catastrophe is spelled out by a task force of senior politicians, business leaders and academics from around the world – and it is remarkably brief. In as little as 10 years, or even less, their report indicates, the point of no return with global warming may have been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

CO₂ 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 CO₂.



'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

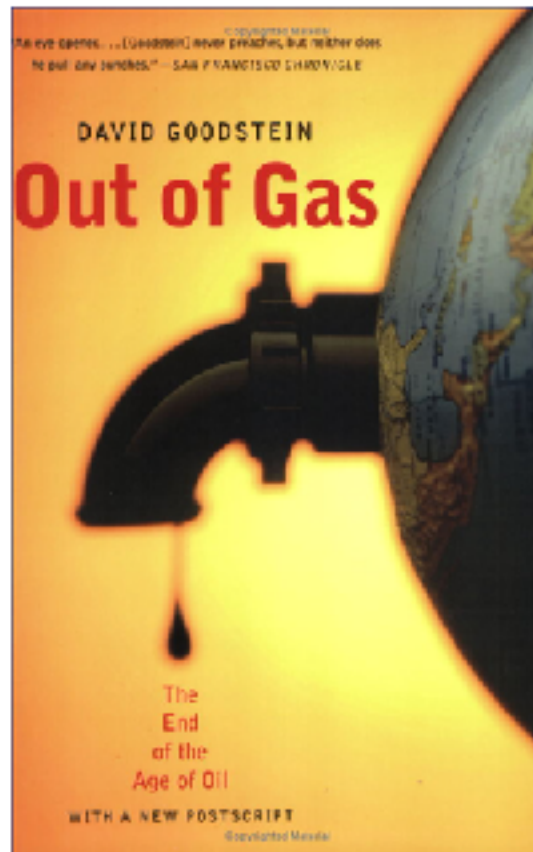
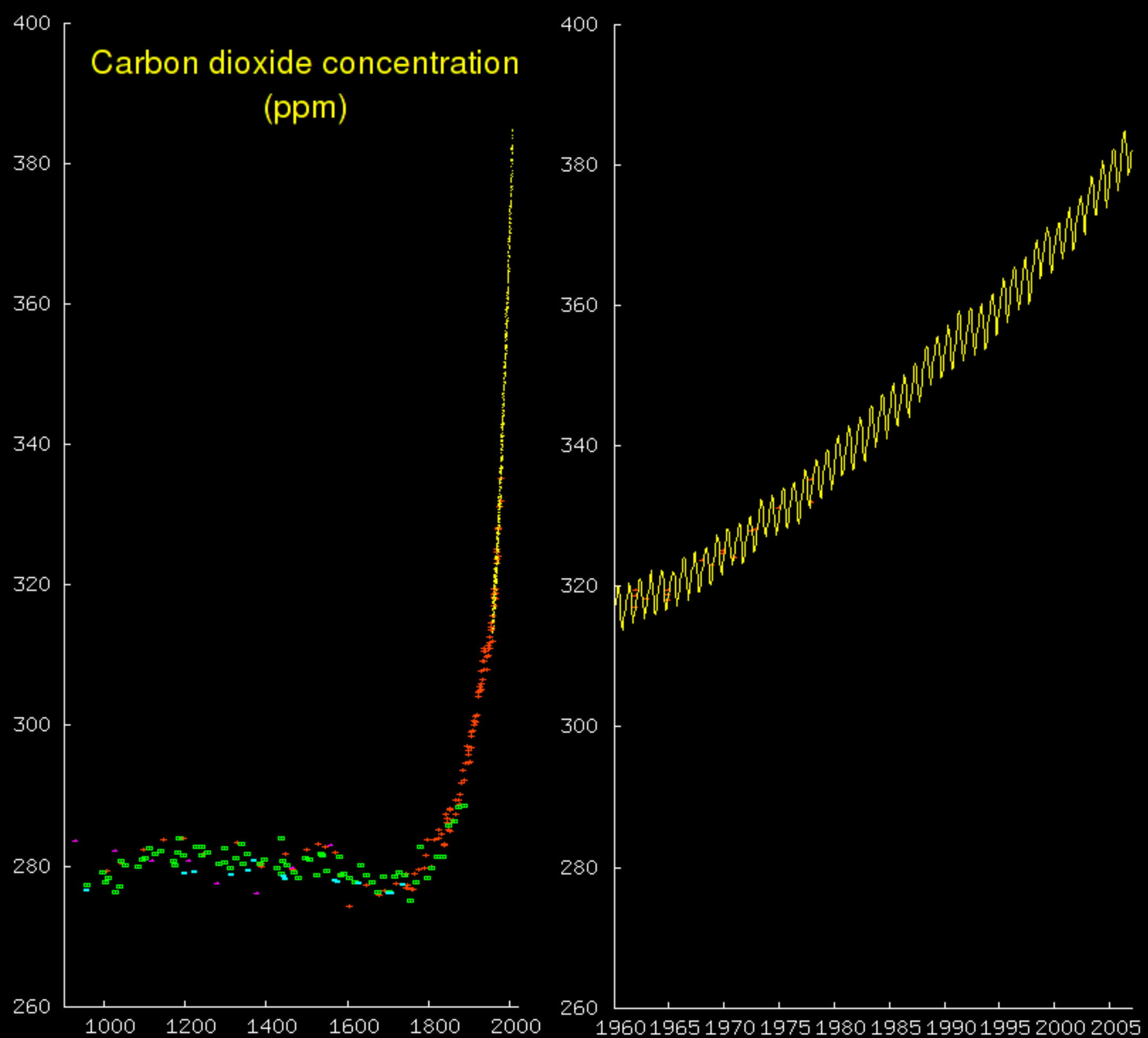
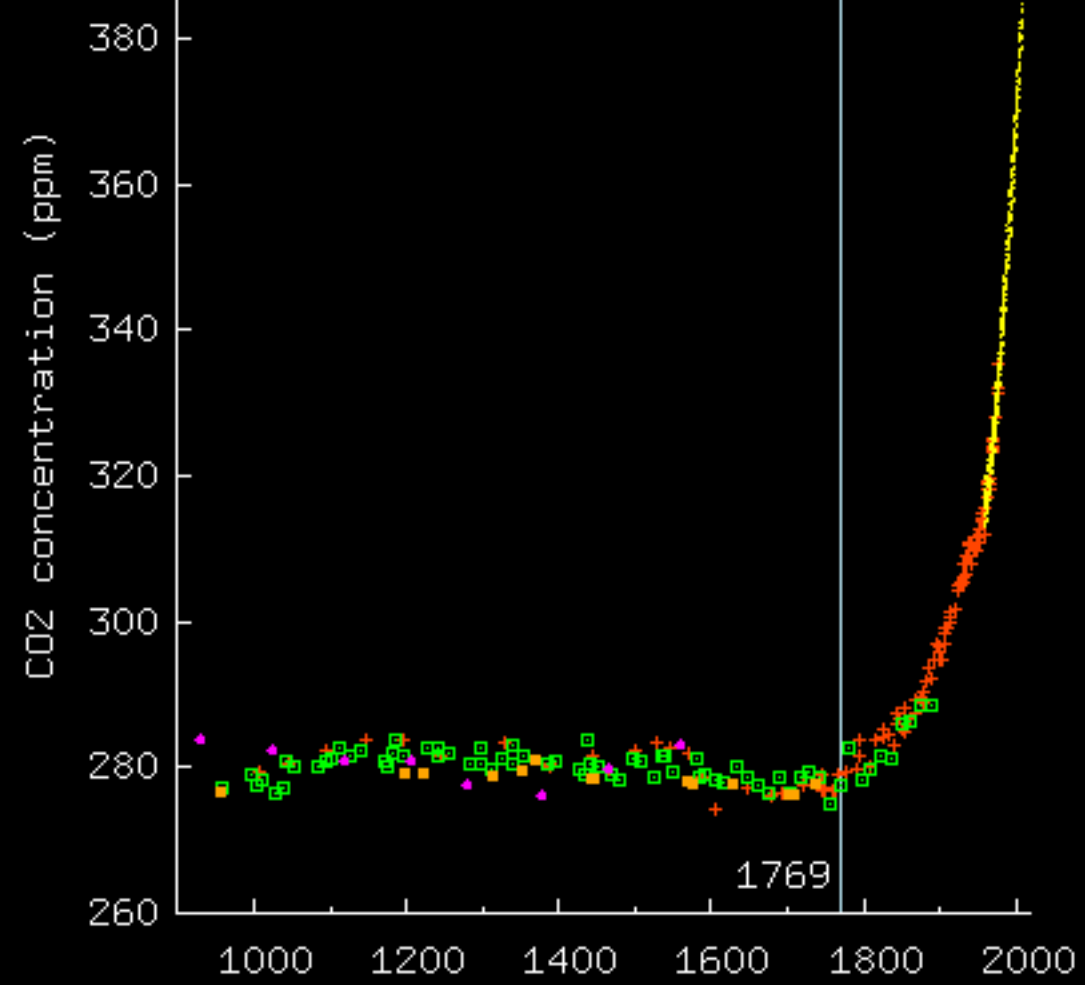
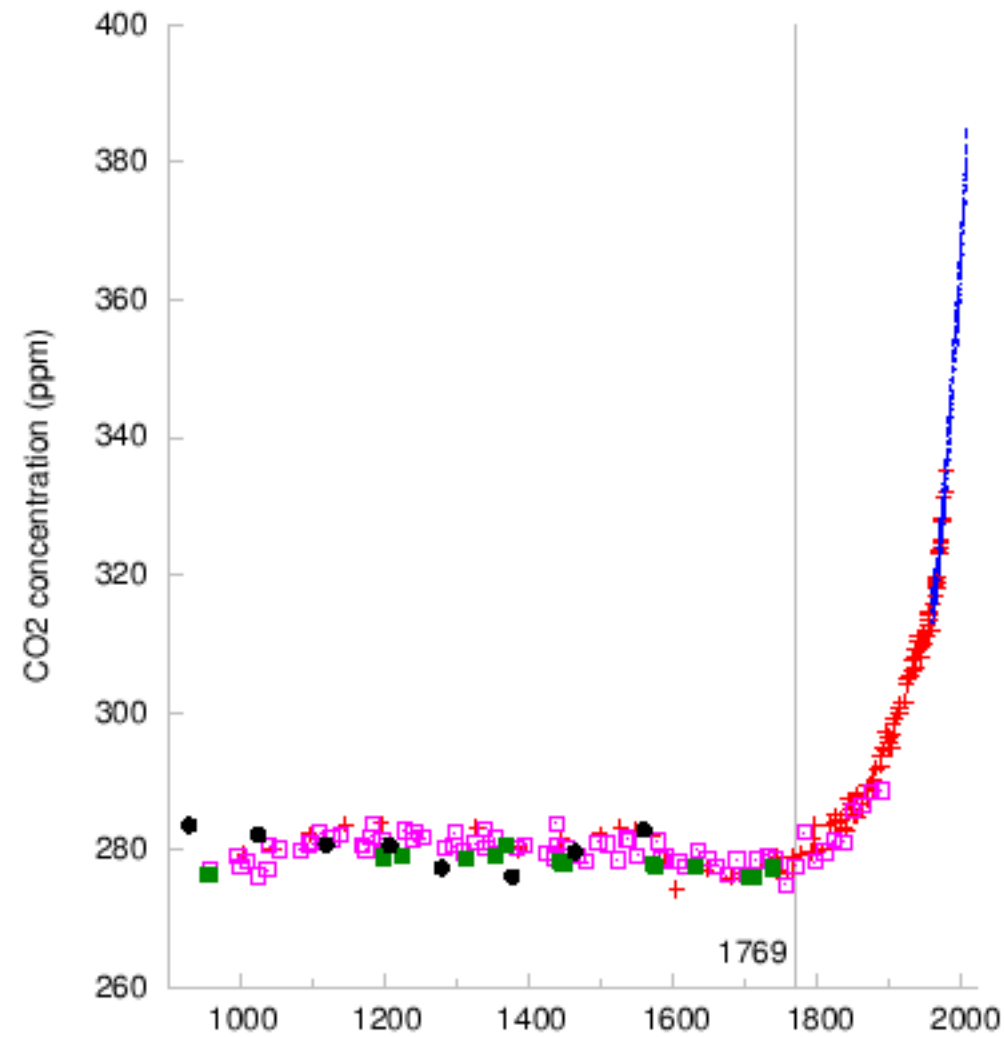


Photo by Terry Cavner

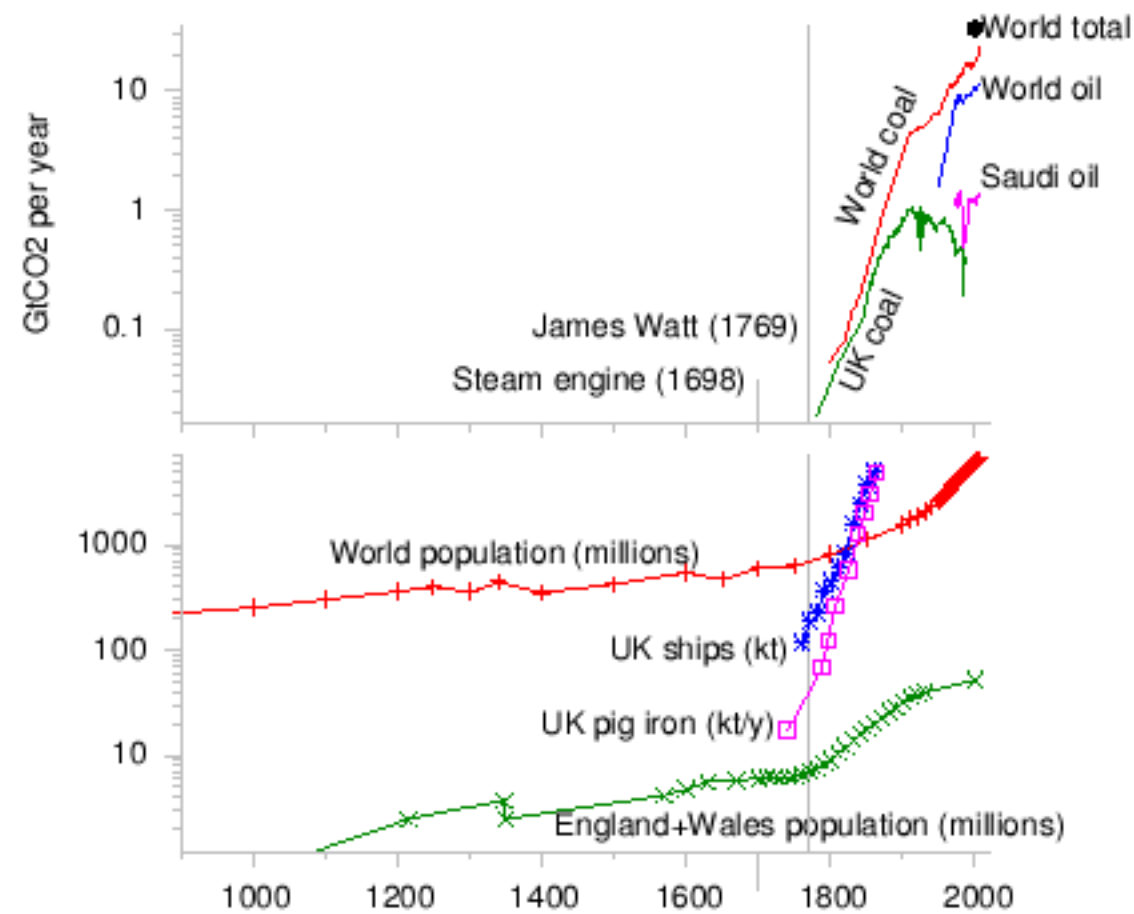


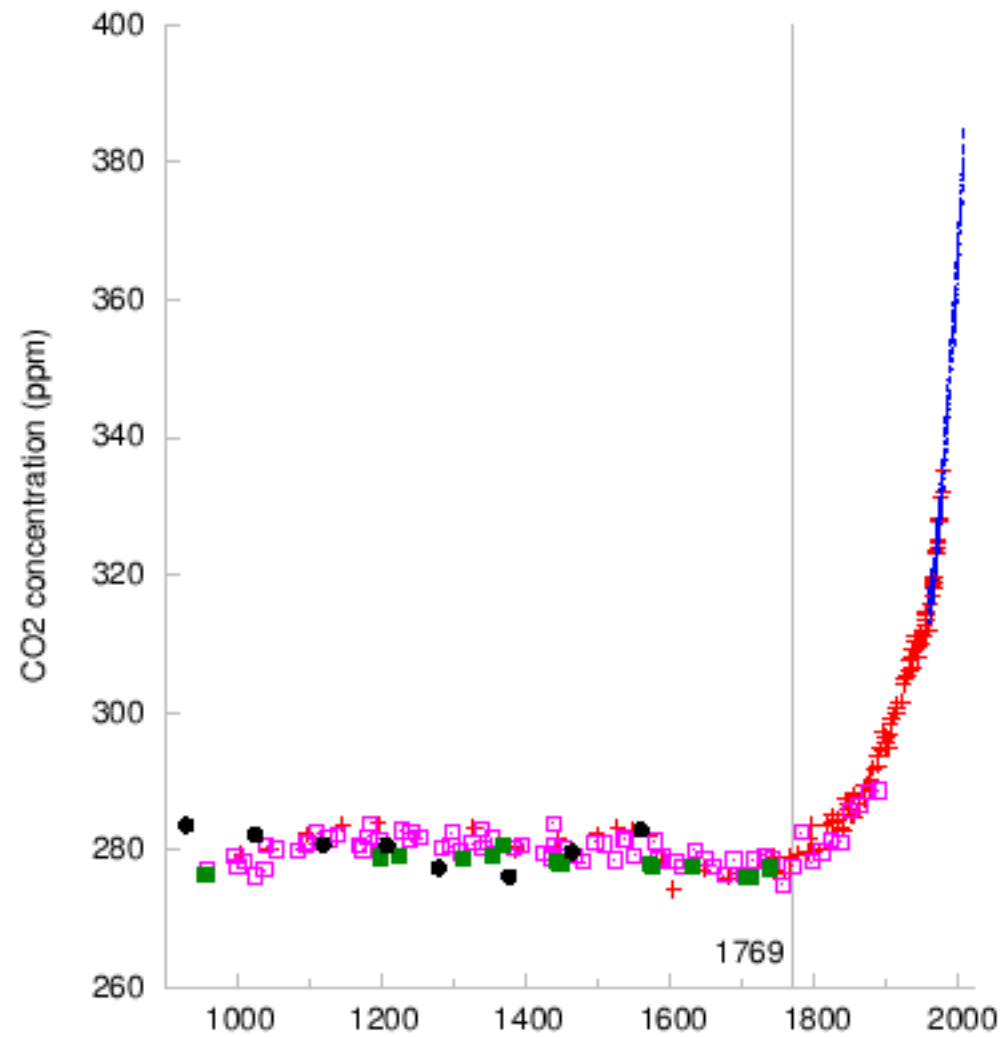
Sources: Keeling and Whorf (2005); Neftel et al (1994); Etheridge et al (1998); Siegenthaler et al (2005); Indermuhle et al (1999)



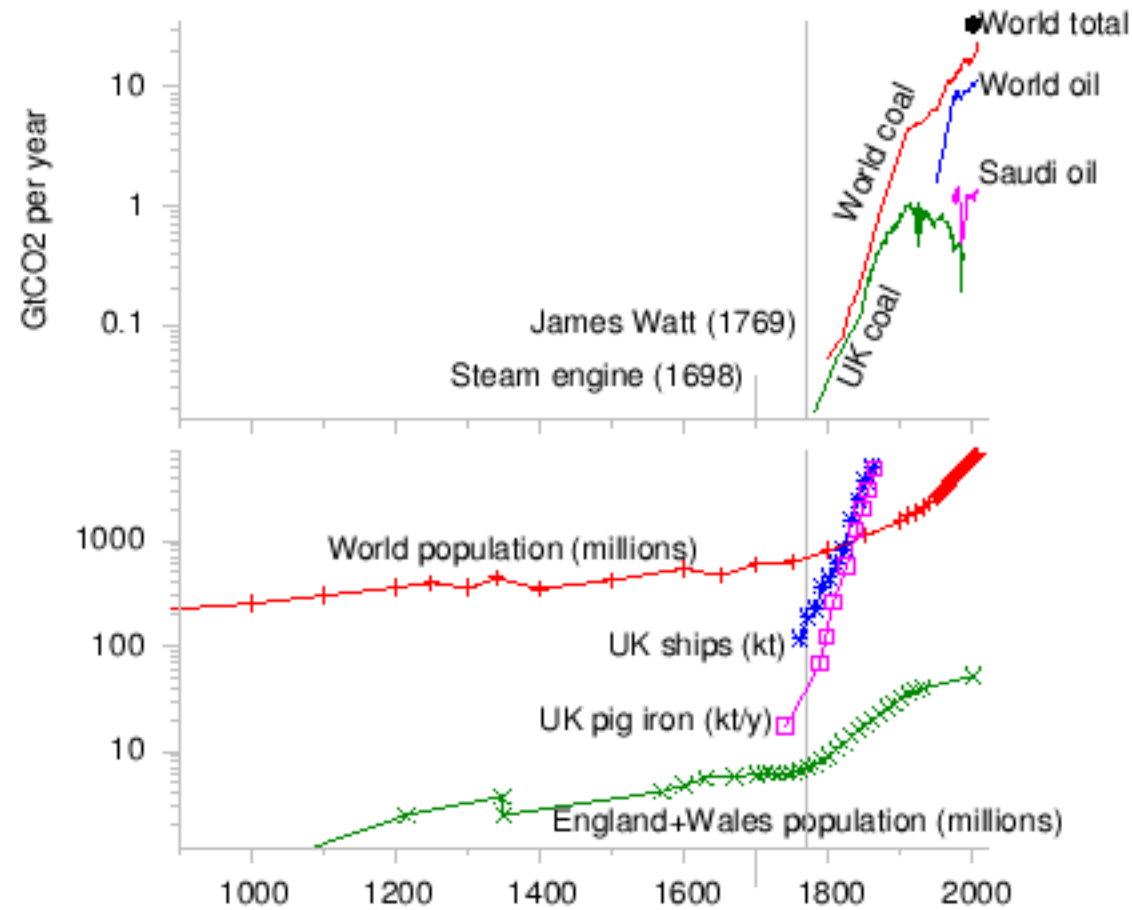


James Watt (1769)

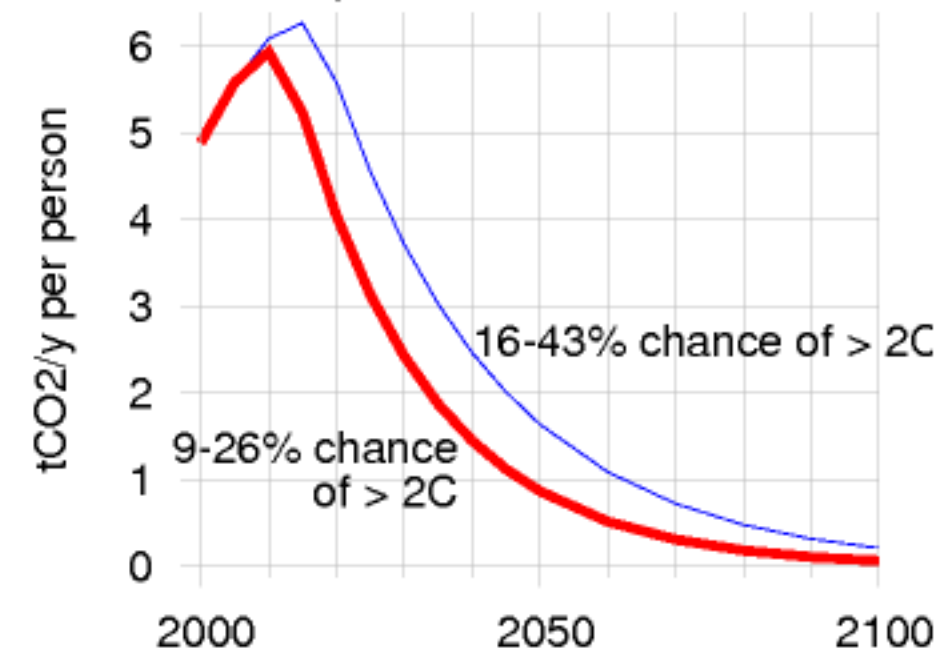




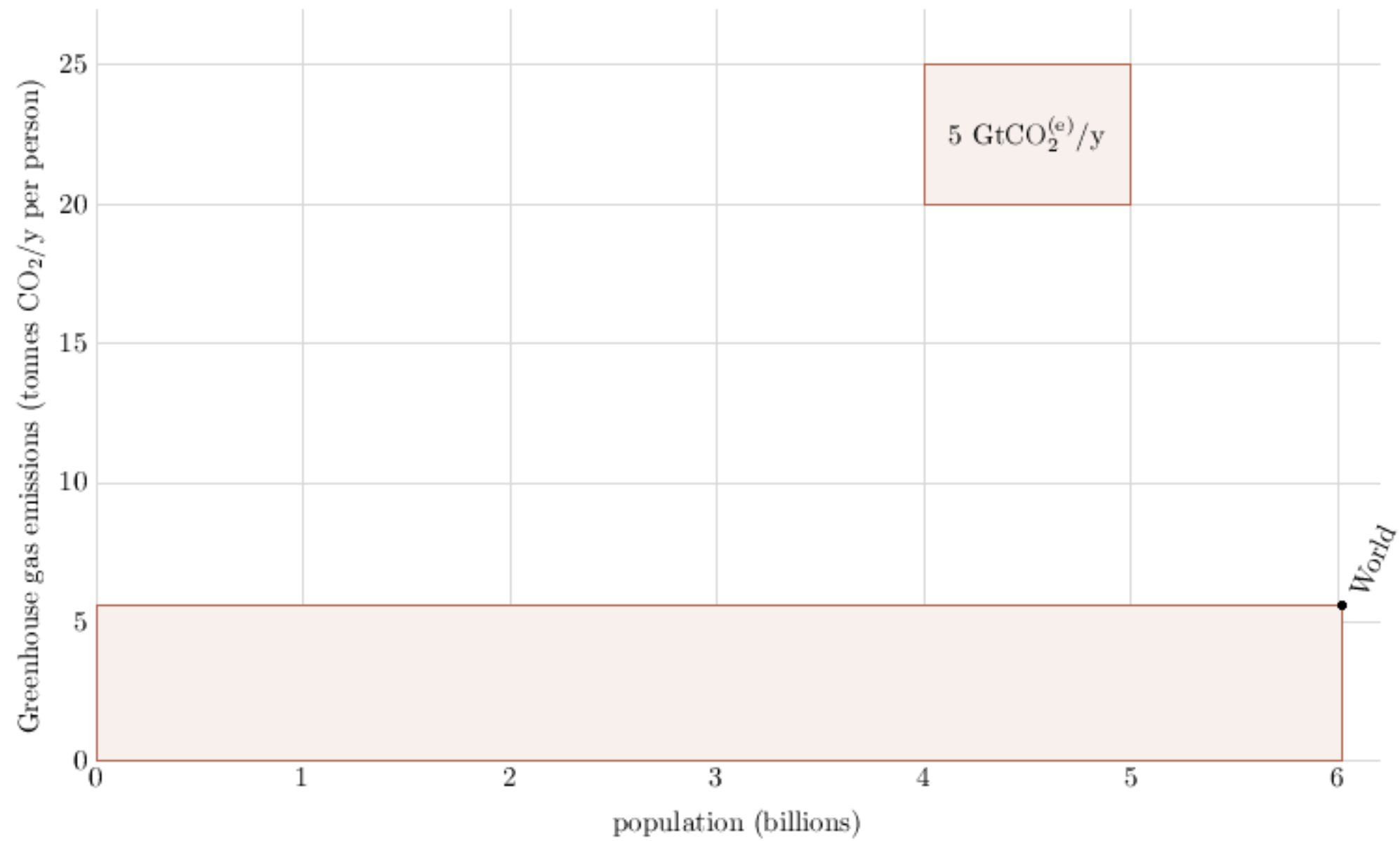
James Watt (1769)



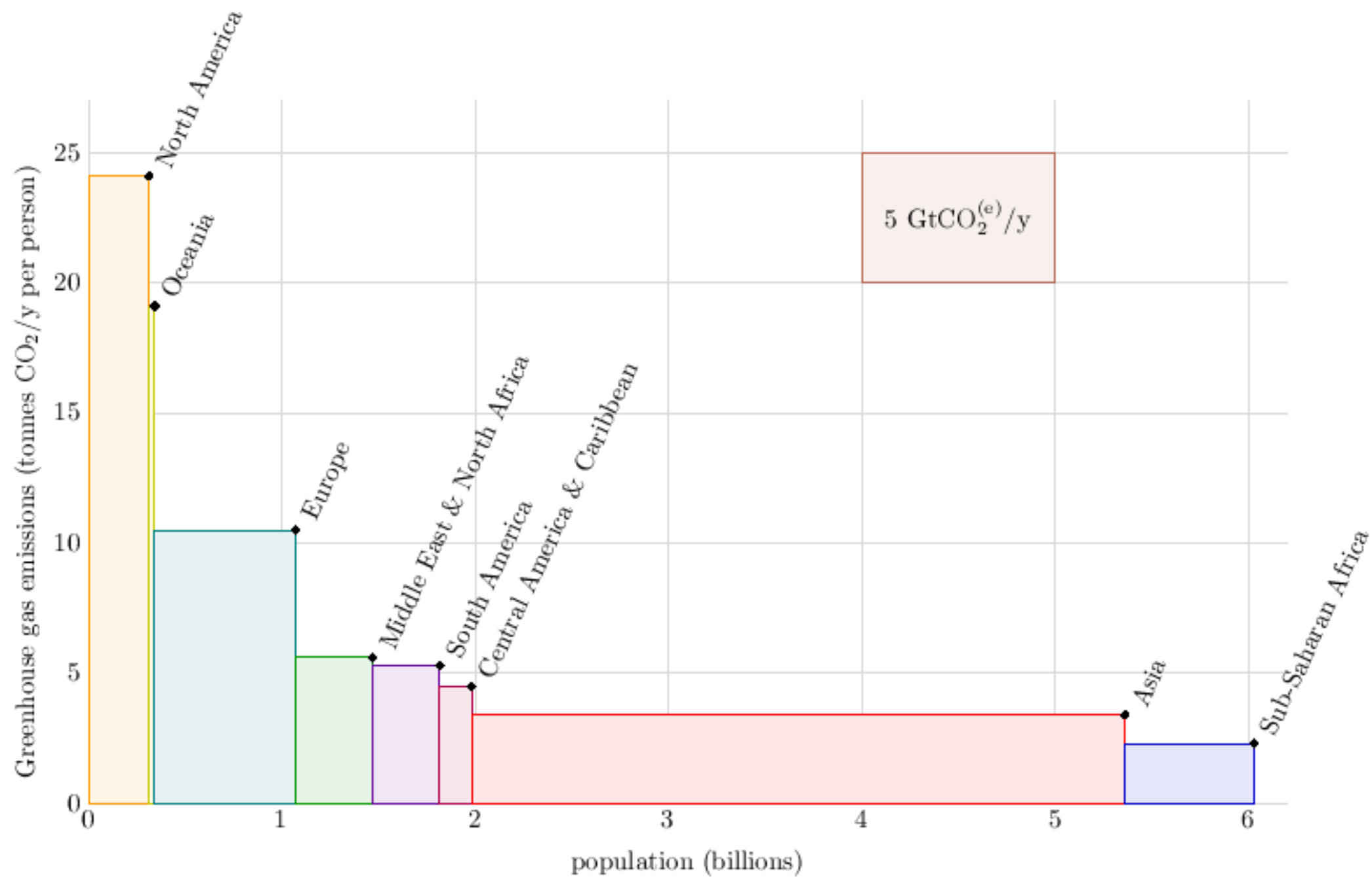
What's required:



Baer & Mastrandrea

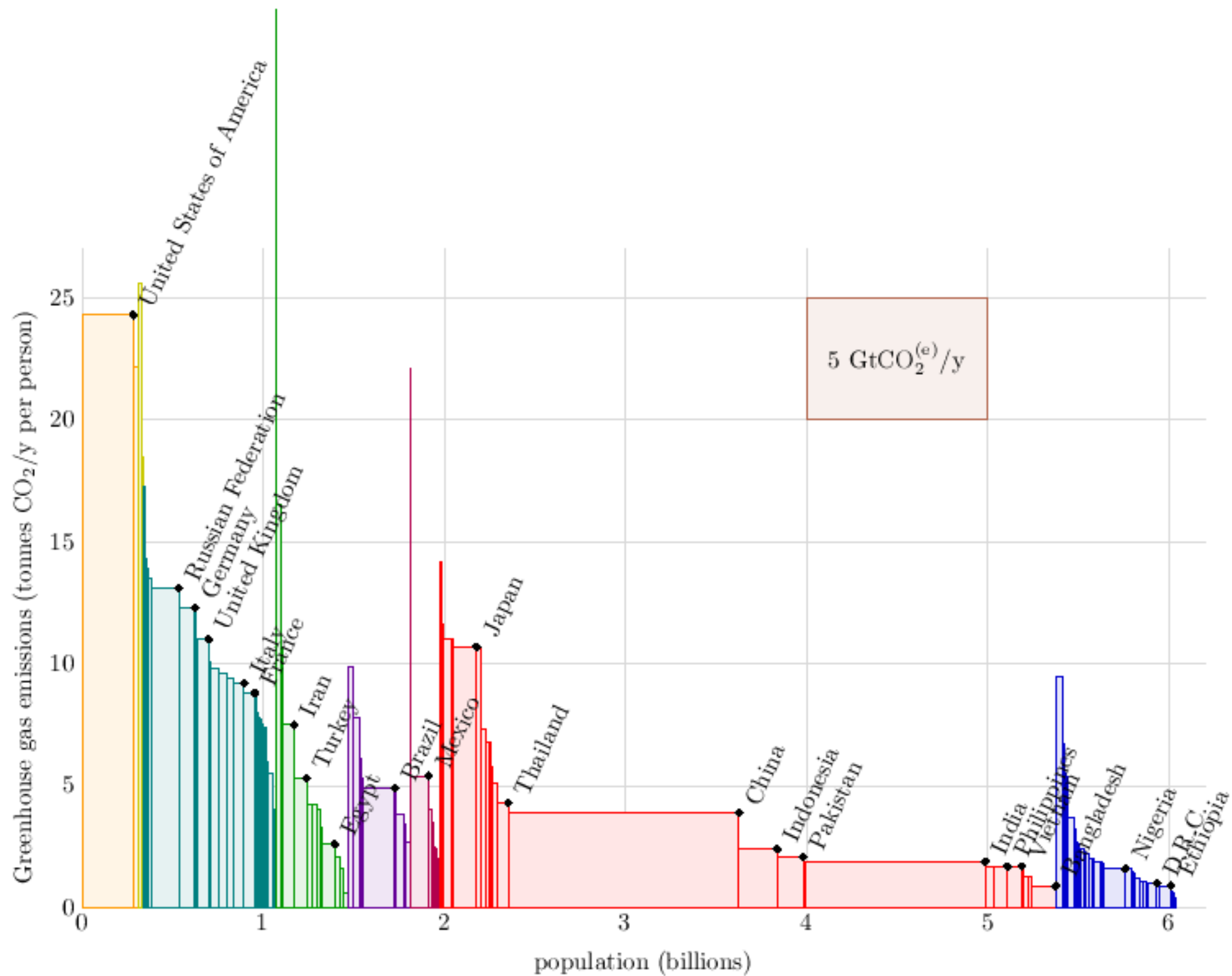


Total GHG emissions, 2000 = $34 \text{ GtCO}_2^{(e)}$



Total GHG emissions, 2000 = 34 GtCO₂^(e)

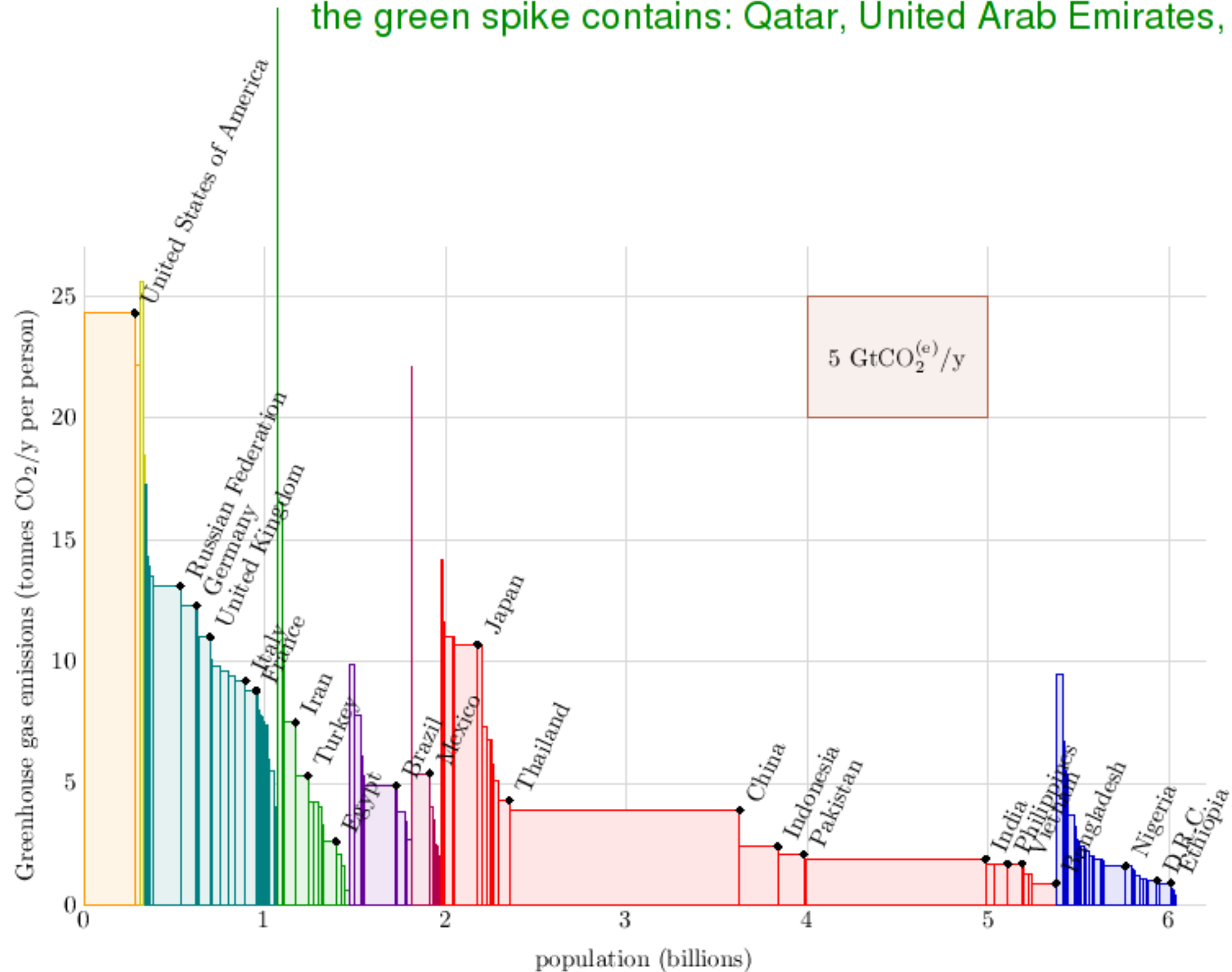
Data source: Climate Analysis Indicators Tool (CAIT)
Version 4.0. (Washington, DC: World Resources Institute, 2007).



Total GHG emissions, 2000 = 34 GtCO₂^(e)

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

the green spike contains: Qatar, United Arab Emirates, and Kuwait

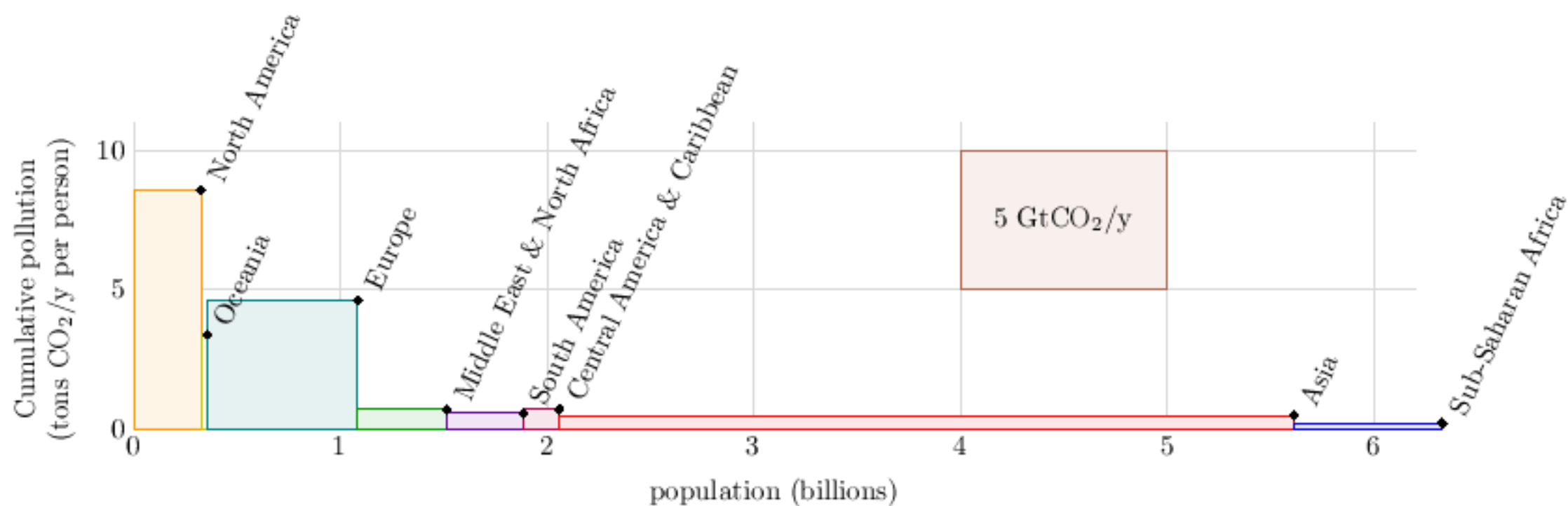
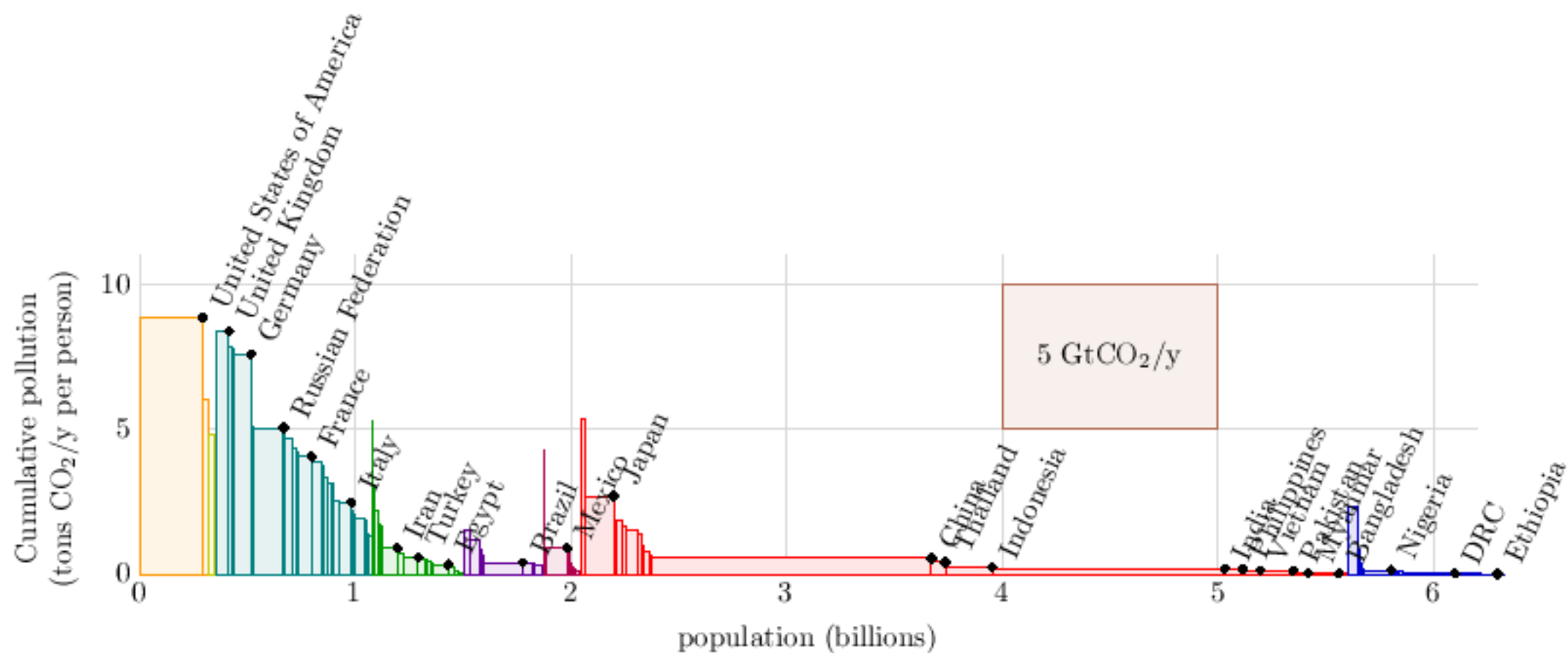


Total GHG emissions, 2000 = 34 GtCO₂^(e)

Data source: Climate Analysis Indicators Tool (CAIT)

Version 4.0. (Washington, DC: World Resources Institute, 2007).

Cumulative emissions (average for 1880–2004) – CO₂ only



1880-2004

Something must be done!

'Make a difference'

targetneutral

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 CO2 emissions
one car at a time

Brought to
you by BP



'Do your bit'!



Generating
a sustainable future

Positive Energy



Let the
power of
nature into
your home



Switch your
energy to
Powergen's
Go Green
tariff and
do your bit
for the
environment

[Click here ►](#)



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

the vehicle
ything.

HEAD

huge prob-
finding a
space and
usually re-
ing that

y like
ehi-
V3

te
no

get a decent view out.

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

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

at
R
a

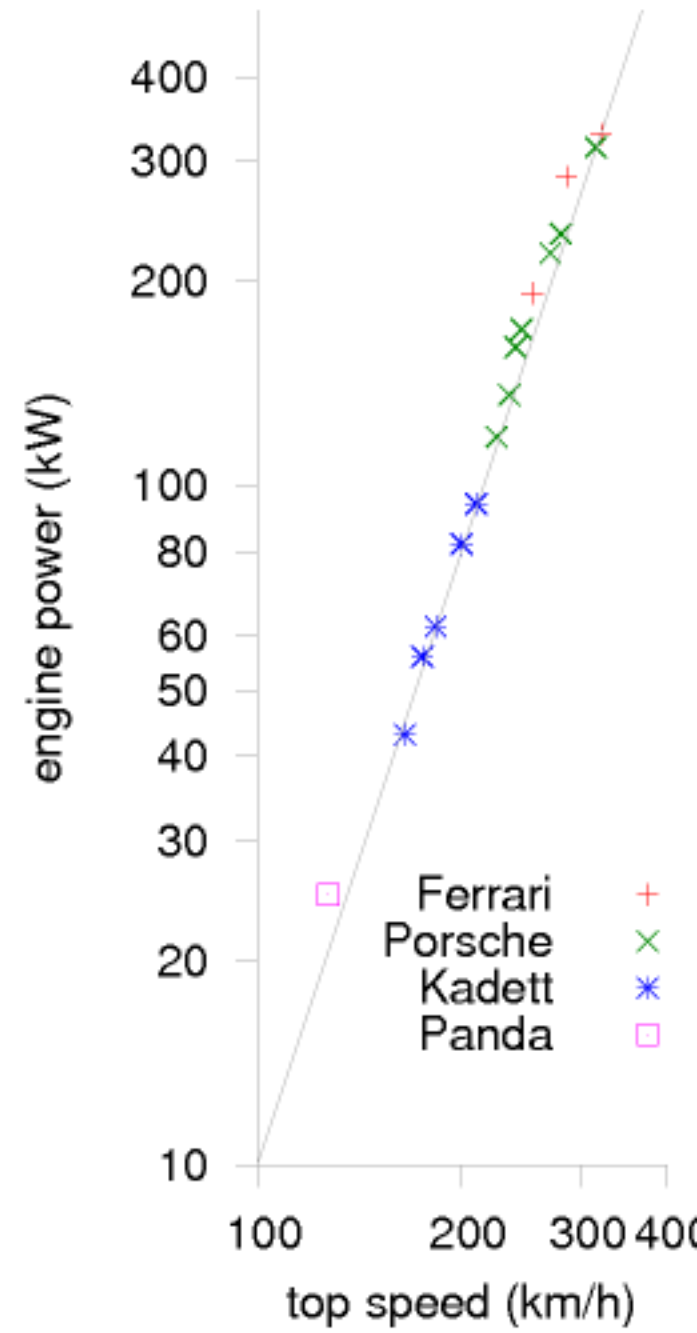
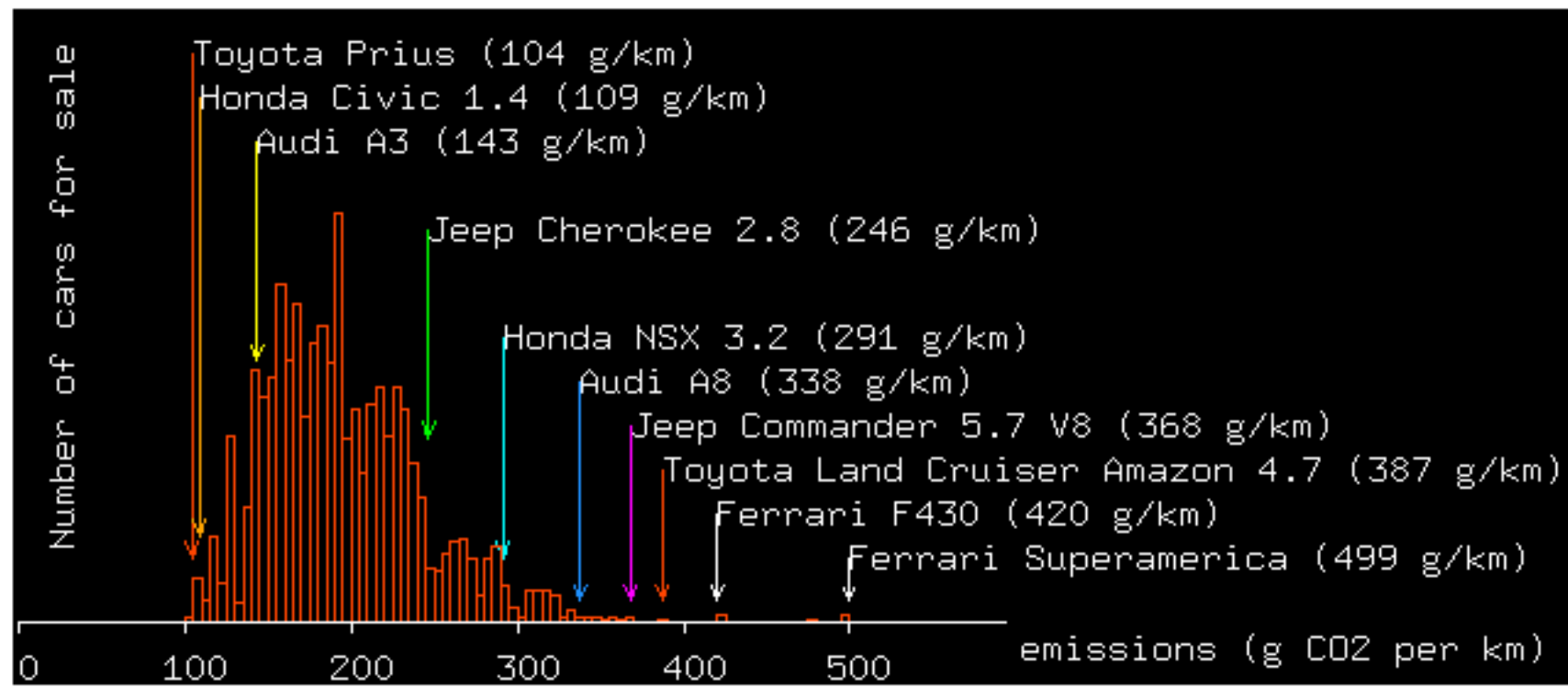


**Practically perfect:
the Volvo XC90**

Carbon emissions from cars



Polo (102 g/km)



Efficiency through technology



'a highly fuel-efficient aircraft'

Efficiency through technology



'a highly fuel-efficient aircraft'

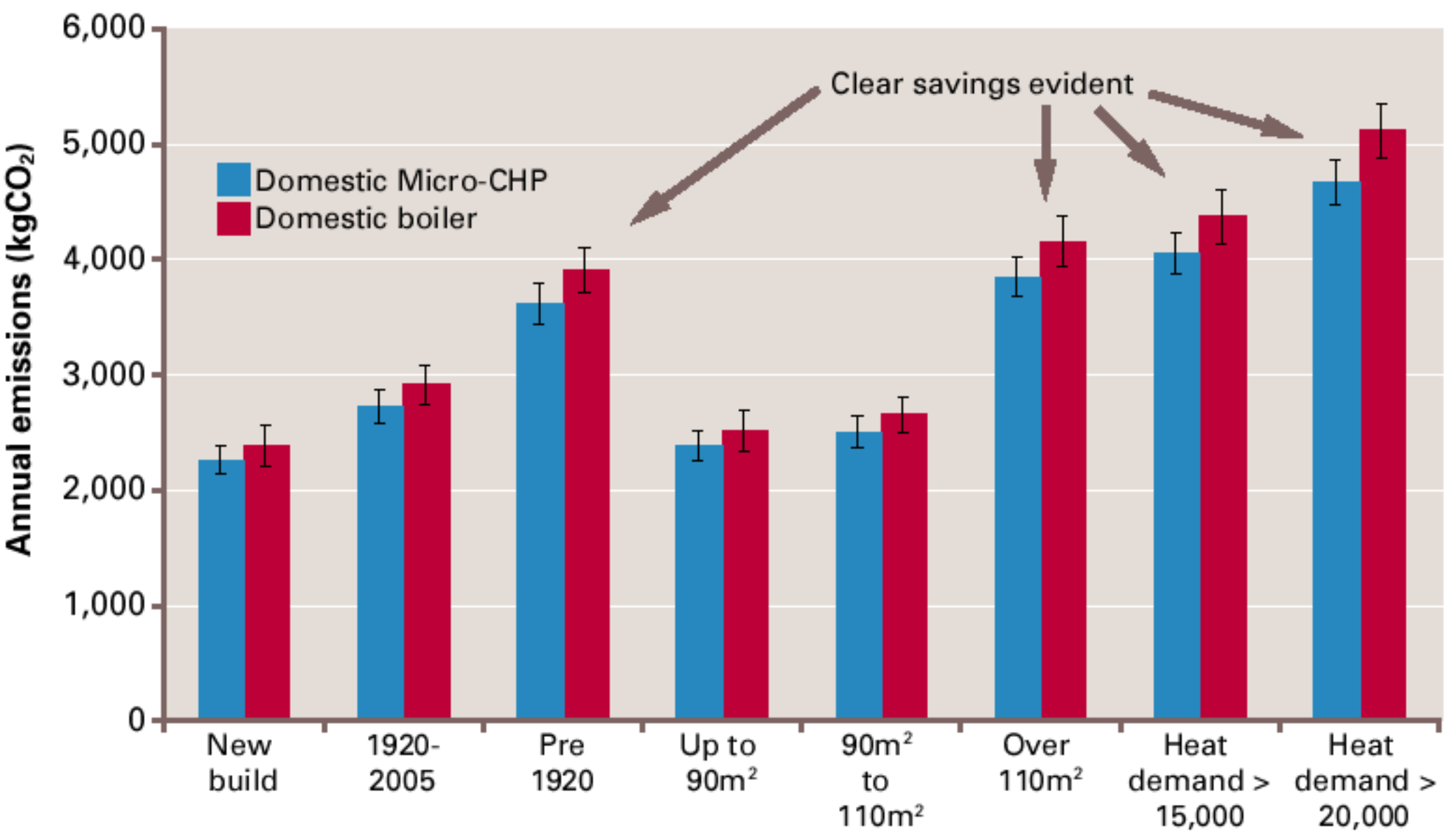
- it burns **12 percent less** fuel per passenger-km than a 747

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



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

Nuclear versus Wind



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Sir Bernard Ingham

‘We have a **huge** amount of wave and wind’.

‘Nuclear is a **money pit**’.

Ann Leslie

We need **numbers, not adjectives**

● Part I: Numbers, not adjectives

- Could Britain live on its own renewables?
- Could Massachusetts live on its own renewables?

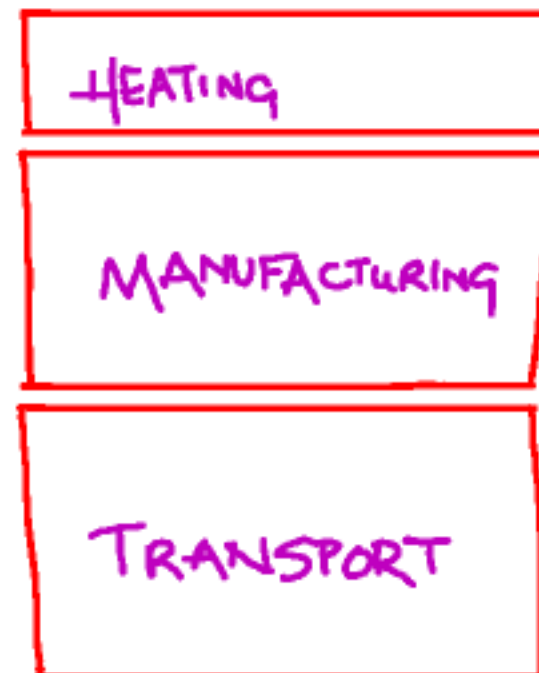
● Part II: Energy plans that add up

- Britain & Massachusetts without carbon
-

Part I: Numbers, not adjectives

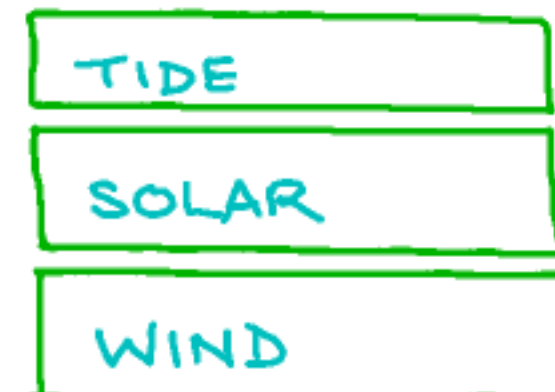
- Ignore economic, social, + environmental constraints

CONSUMPTION



PRODUCTION

[Maximum
Conceivable
Sustainable
production]



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**

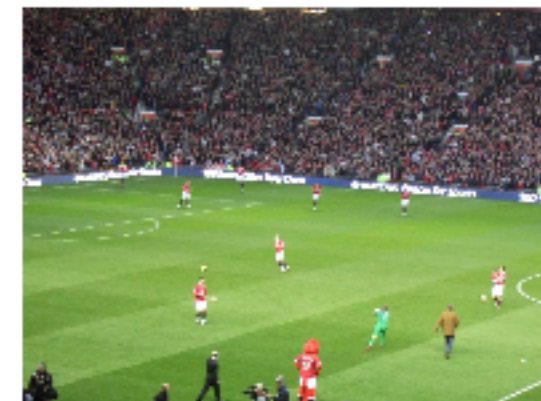
● Fluxes: **W per square metre**

● Population density: **square metres per person**

UK: **4000 m² 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



Cars



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

Car:
40 kWh/d

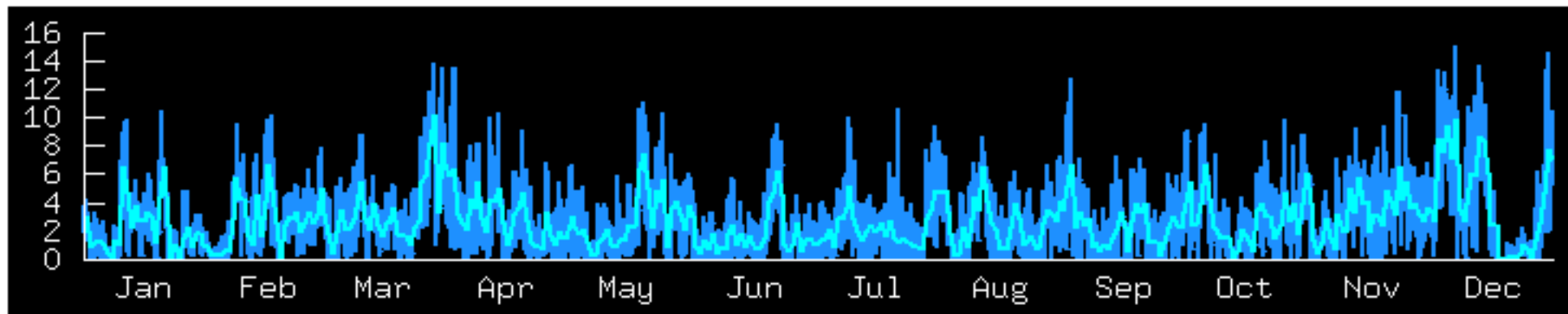
33 miles per UK gallon

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

Wind



Wind



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



Wind

$$v = 6 \text{ m/s (force 4)}$$

Wind farm 2 W/m^2 flat ground

UK: 4000 m^2 per person

Put wind farms on 10% of the country

- $400 \text{ square metres}$ each

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

50 x Denmark's



7 x Germany's



Car:
40 kWh/d

Wind:
20 kWh/d



Flight



7 600 miles: one round-trip / year:

$$\frac{2 \times 240\,000 \text{ litre}}{416 \text{ passengers}} \times 10 \text{ kWh/litre/year} = 29 \text{ kWh/day}$$

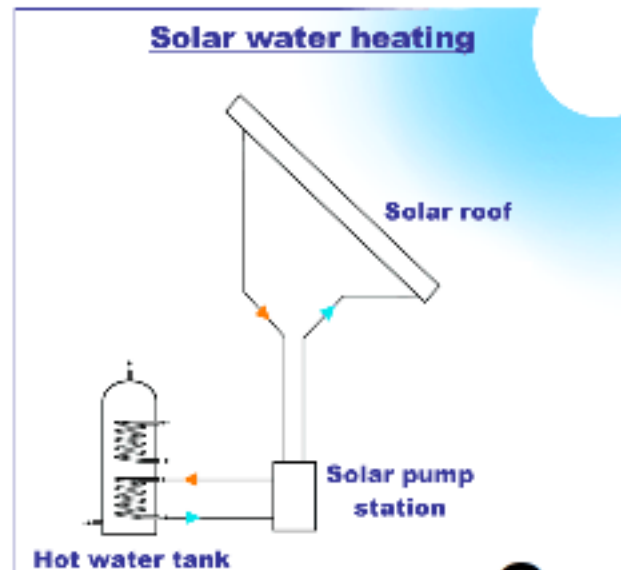
Jet flights:
30 kWh/d

Car:
40 kWh/d

Wind:
20 kWh/d

Solar

● Solar thermal



Cover every south-facing roof



Jet flights:
30 kWh/d

Car:
40 kWh/d

10 m² per person:
10 kWh/day per person

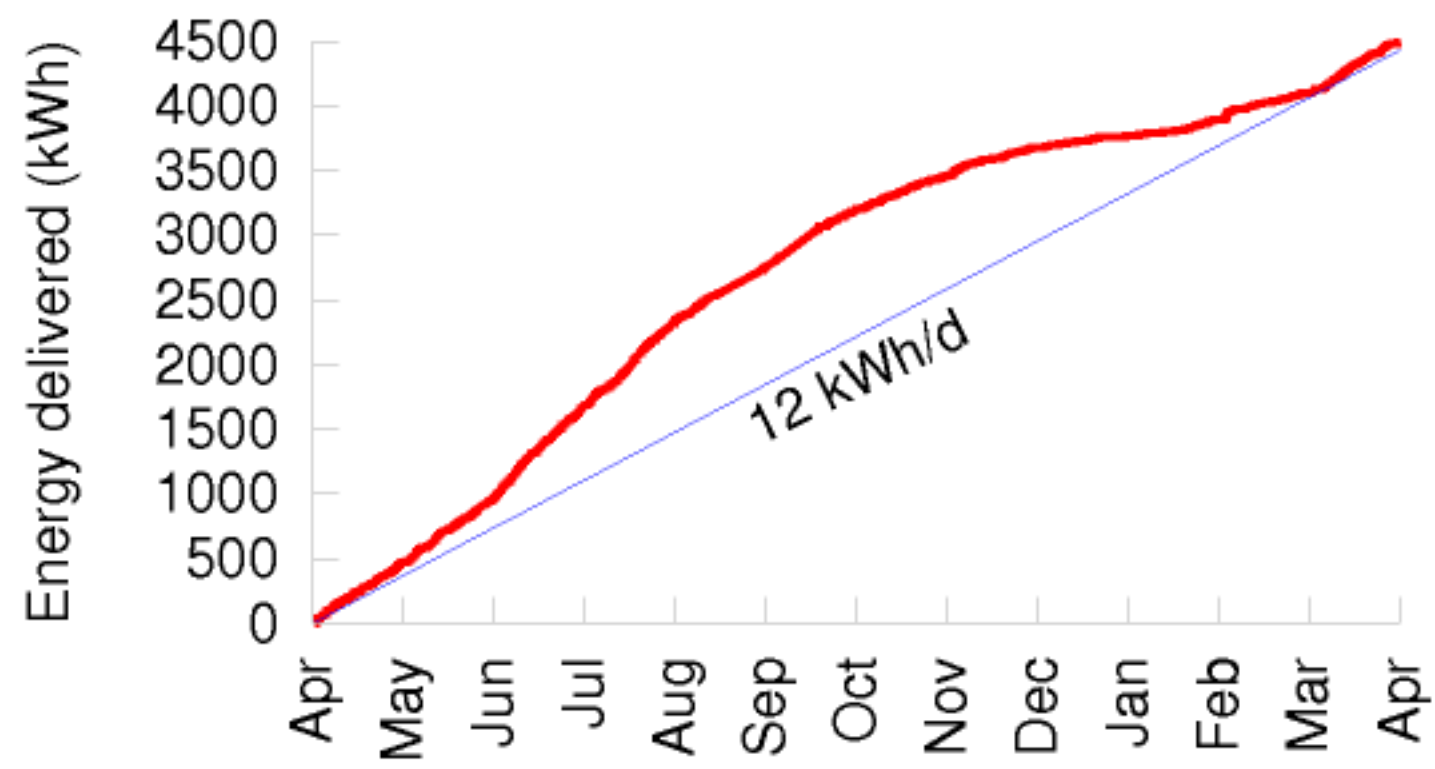
Solar heating:
10 kWh/d

Wind:
20 kWh/d

Solar electric (photovoltaics)



Solar electric



Data and photo by Jonathan Kimmitt

Cover *every South-facing roof*,
10m² per person: **4kWh/day per person**

Jet flights: 30 kWh/d	PV, 10 m ² : 4
Car: 40 kWh/d	Solar heating: 10 kWh/d
	Wind: 20 kWh/d

Solar PV farming



Bavaria Solar Park: 5 W/m^2 ; this picture shows 0.7 MW (average)

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



Jet flights:
30 kWh/d

Car:
40 kWh/d

PV farm
(400 m²/p):
50 kWh/d

PV, 10 m²: 4

Solar heating:
10 kWh/d

Wind:
20 kWh/d



Solar biomass



- Best plants (1% 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
(400 m²/p):
50 kWh/d

PV, 10 m²: 4

Solar heating:
10 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:
13

Hot air

Hot air:
24

Fridge, Airconditioning

Cooling: 1

Heating,
cooling:
38 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
(400 m²/p):
50 kWh/d

PV, 10 m²: 4

Solar heating:
10 kWh/d

Wind:
20 kWh/d



Hydro

● 1.5 kWh/d per person

(currently 0.2 kWh/d per person)

Heating, cooling: 38 kWh/d	Hydro: 1.5 Biomass: food, biofuel, wood, waste incin'n, landfill gas: 24 kWh/d
Jet flights: 30 kWh/d	PV farm (400 m ² /p): 50 kWh/d
Car: 40 kWh/d	PV, 10 m ² : 4 Solar heating: 10 kWh/d
	Wind: 20 kWh/d



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

Light

● 10 bulbs

● 5 hours per day



Light: 4

Heating,
cooling:
38 kWh/d

Jet flights:
30 kWh/d

Car:
40 kWh/d

Hydro: 1.5

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

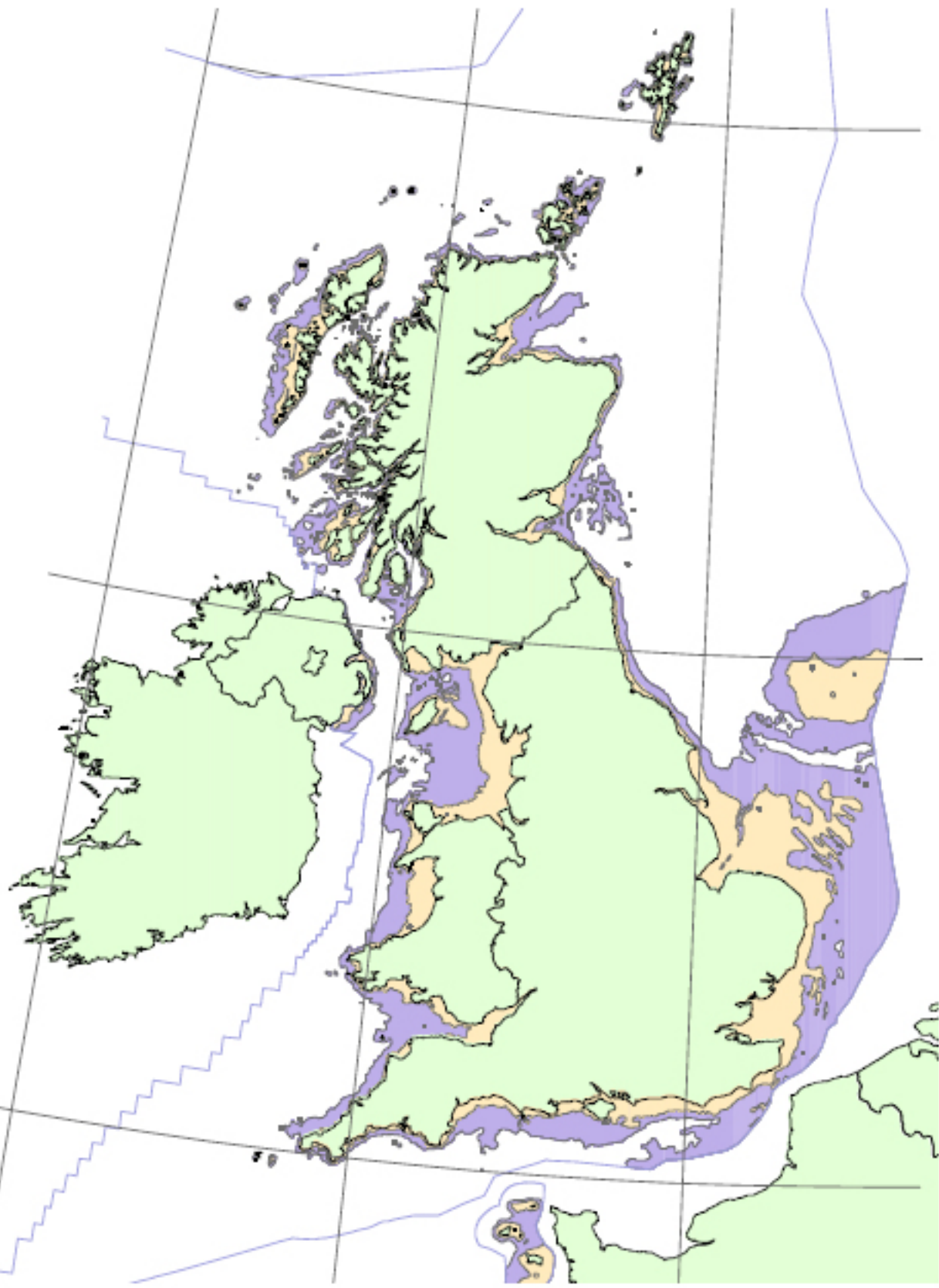
PV farm
(400 m²/p):
50 kWh/d

PV, 10 m²: 4

Solar heating:
10 kWh/d

Wind:
20 kWh/d

Offshore wind



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

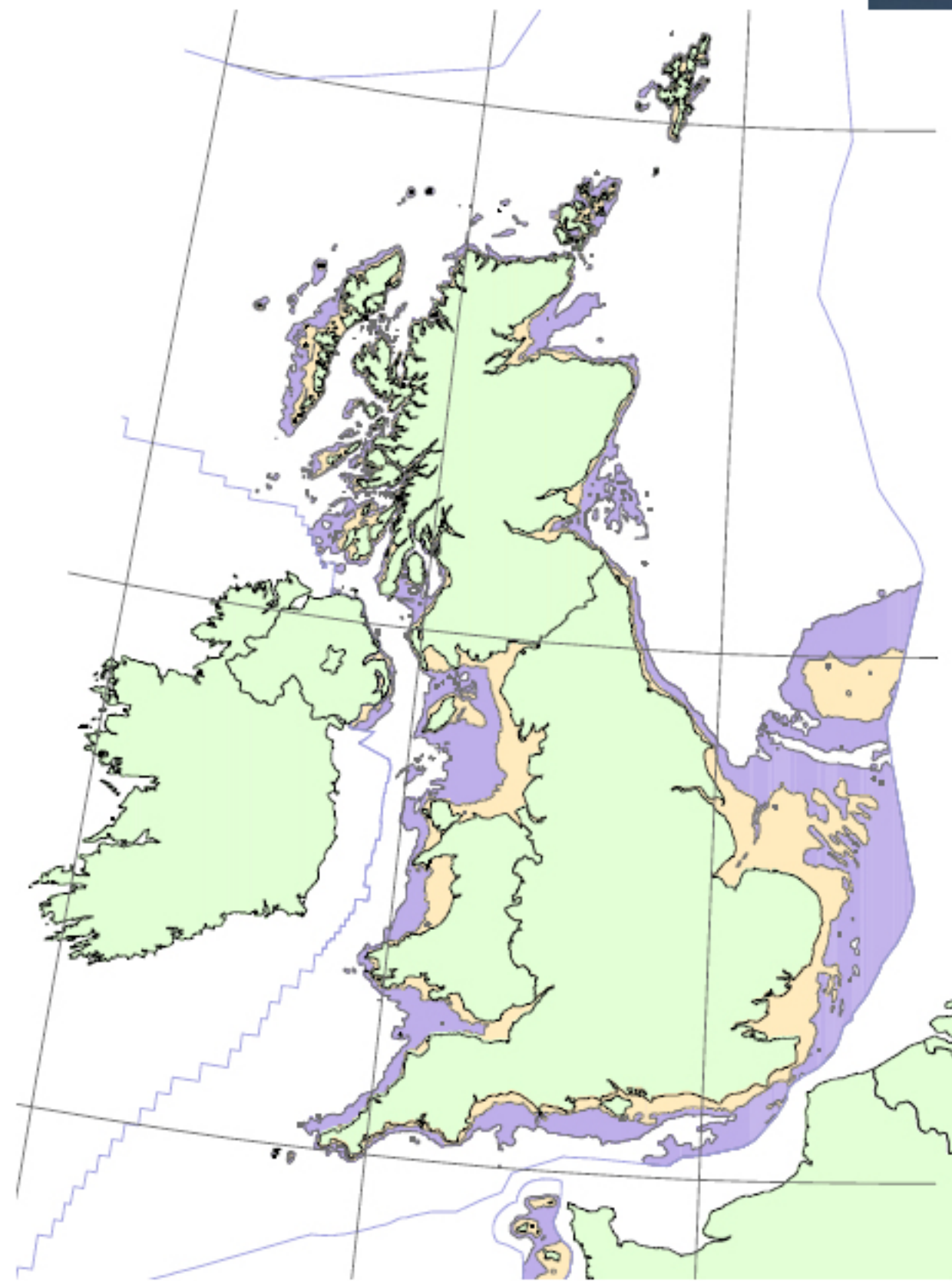
Light: 4
Heating, cooling: 38 kWh/d
Jet flights: 30 kWh/d
Car: 40 kWh/d

Shallow offshore wind: 16 kWh/d
Hydro: 1.5
Biomass: food, biofuel, wood, waste incin'n, landfill gas: 24 kWh/d
PV farm (400 m ² /p): 50 kWh/d
PV, 10 m ² : 4
Solar heating: 10 kWh/d
Wind: 20 kWh/d



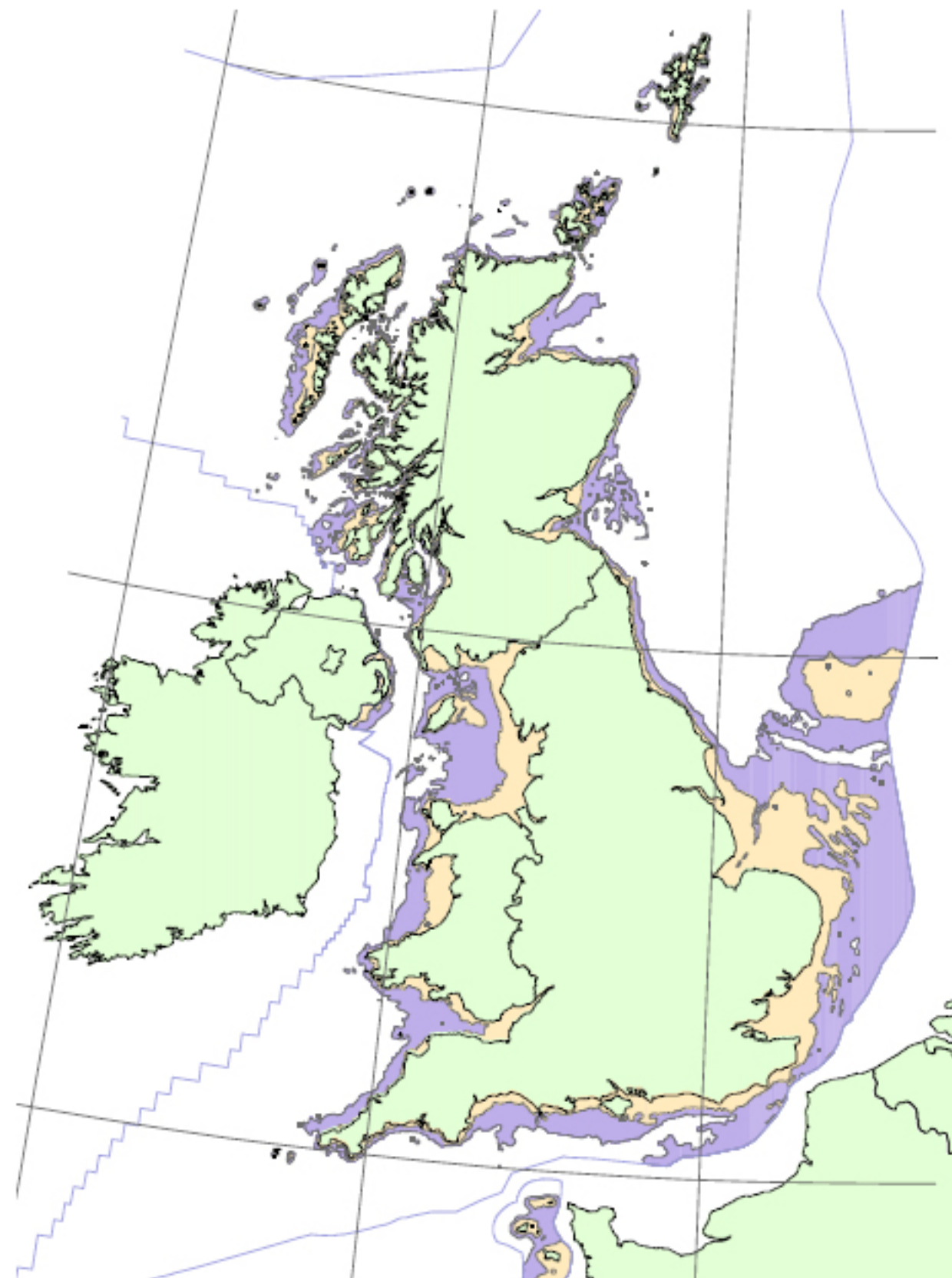
(c) Elsam (elsam.com).
Used with permission.

Deep offshore wind



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

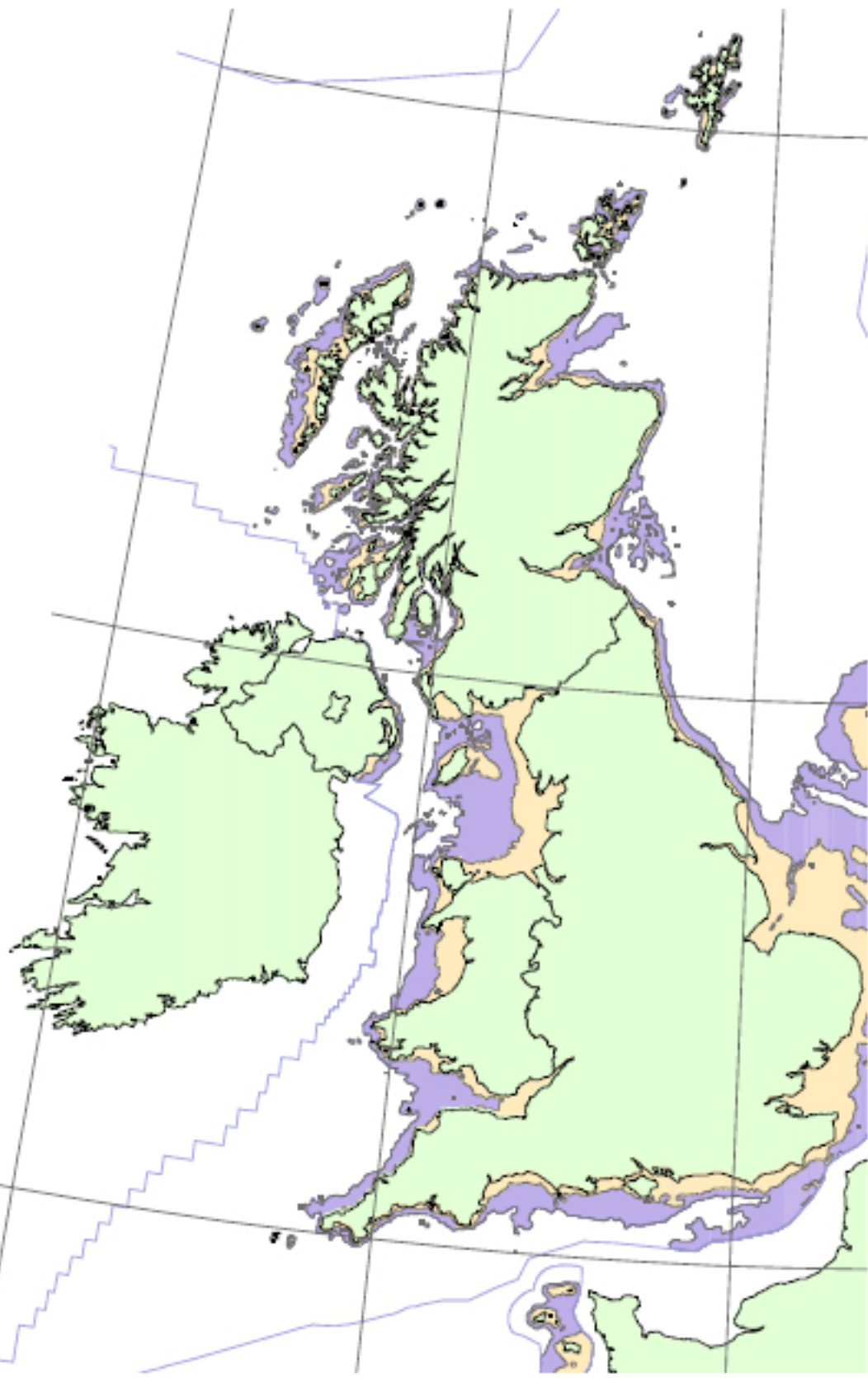
Deep offshore wind



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



Deep offshore wind



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

Light: 4
Heating, cooling: 38 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 (400 m ² /p): 50 kWh/d
PV, 10 m ² : 4
Solar heating: 10 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:
38 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

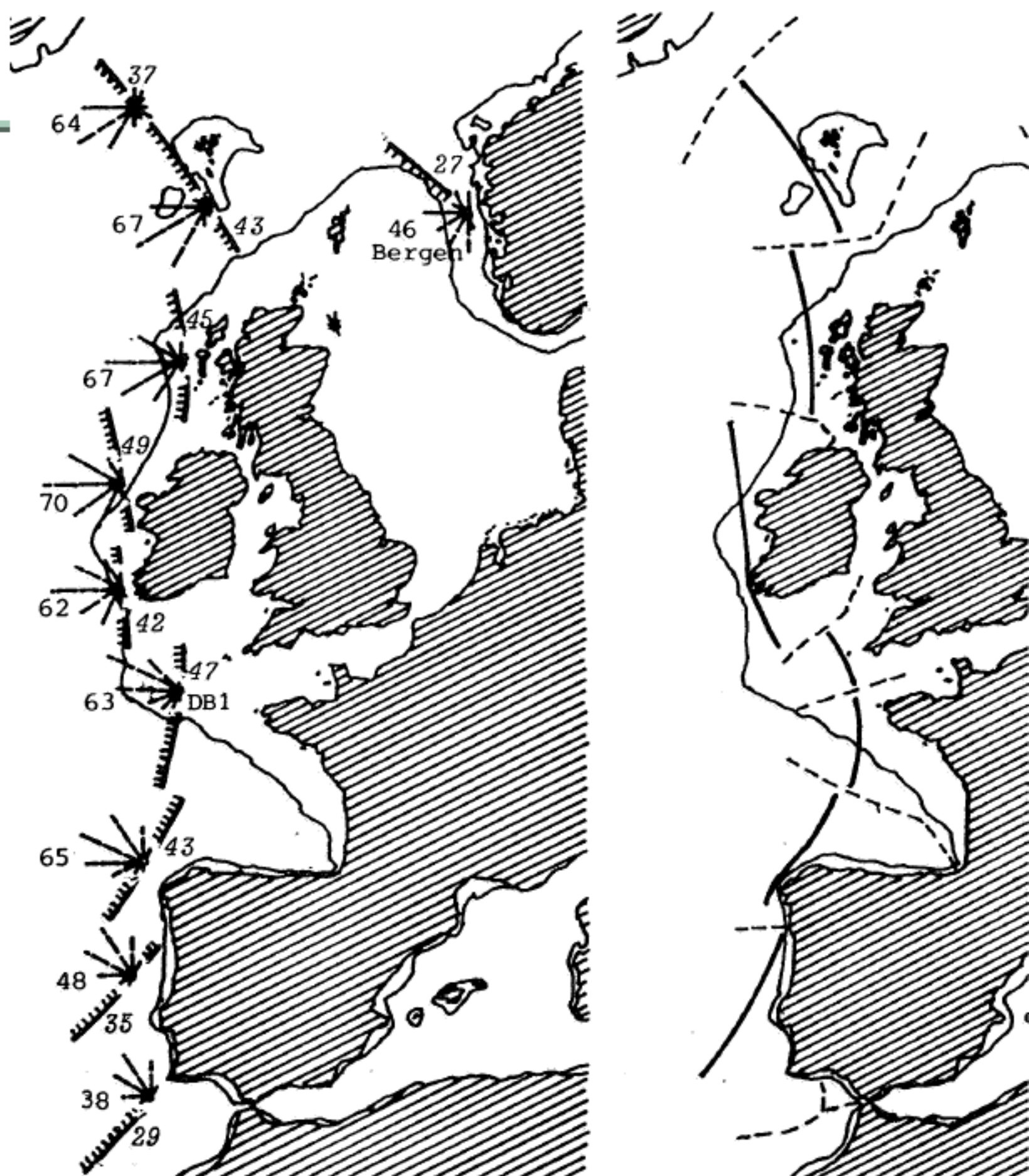
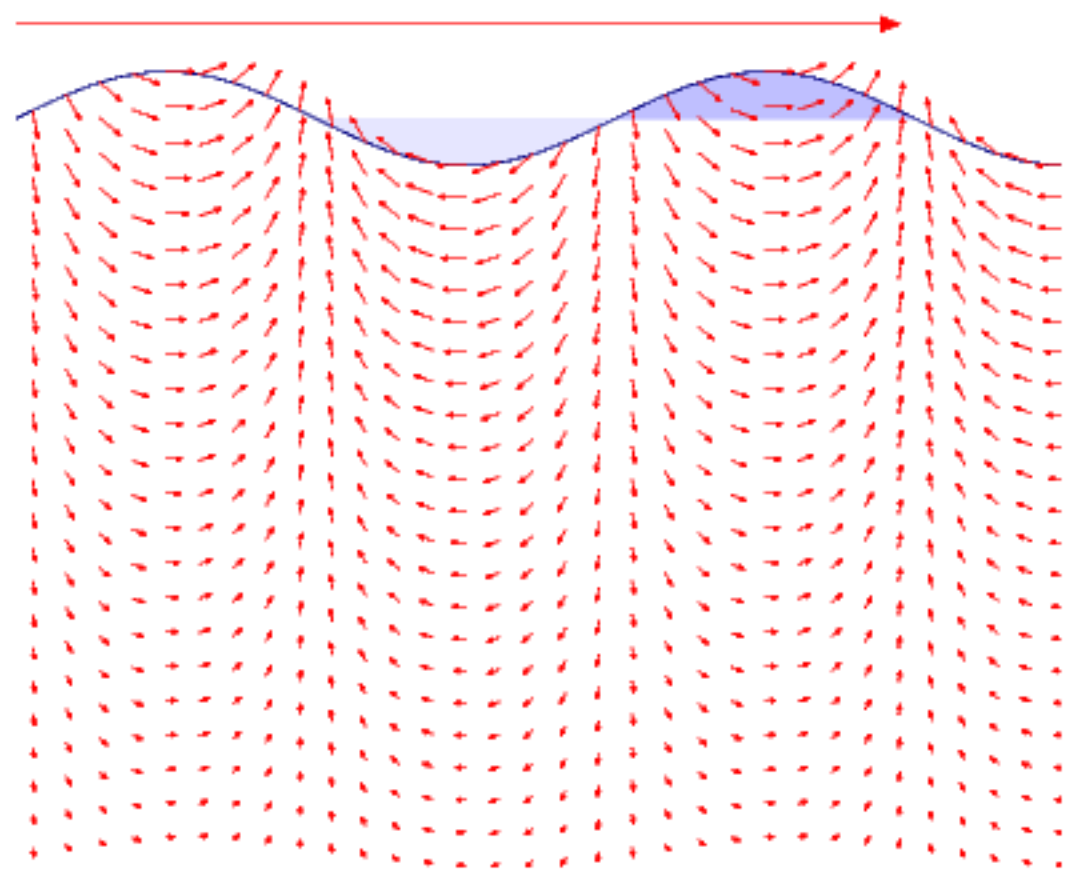
PV farm
(400 m²/p):
50 kWh/d

PV, 10 m²: 4
Solar heating:
10 kWh/d

Wind:
20 kWh/d



Wave



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

Wave

Wave Dragon, images (c) Earth-vision



'500 kW' Limpet, Islay

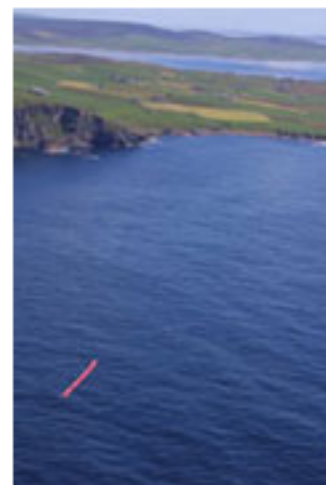


Predicted average power: 200kW. Actual: 21kW.

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 (oceanpd.com)



Wave

Wave Dragon, images (c) Ea



Ocean Power Delivery (ocea



Gadgets: 5

Light: 4

Heating,
cooling:
38 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
(400 m²/p):
50 kWh/d

PV, 10 m²: 4

Solar heating:
10 kWh/d

Wind:

'500 kW' Limpet, Islay



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

Total incident power / population of UK

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



Food'n'Farming



NUTRITION	
Typical Values	Per 100 g
Energy kJ	3080

(not including energy for food delivery)

Vegans: 3 kWh/d

Vegetarians: 4 kWh/d

Carnivores: 16 kWh/d

(260 kg of animal preparing to be eaten)

Fertilizer: 3

Food: 16

Gadgets: 5

Light: 4

Heating,
cooling:
38 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
(400 m²/p):
50 kWh/d

PV, 10 m²: 4

Solar heating:
10 kWh/d

Wind:
20 kWh/d



3 kWh/d

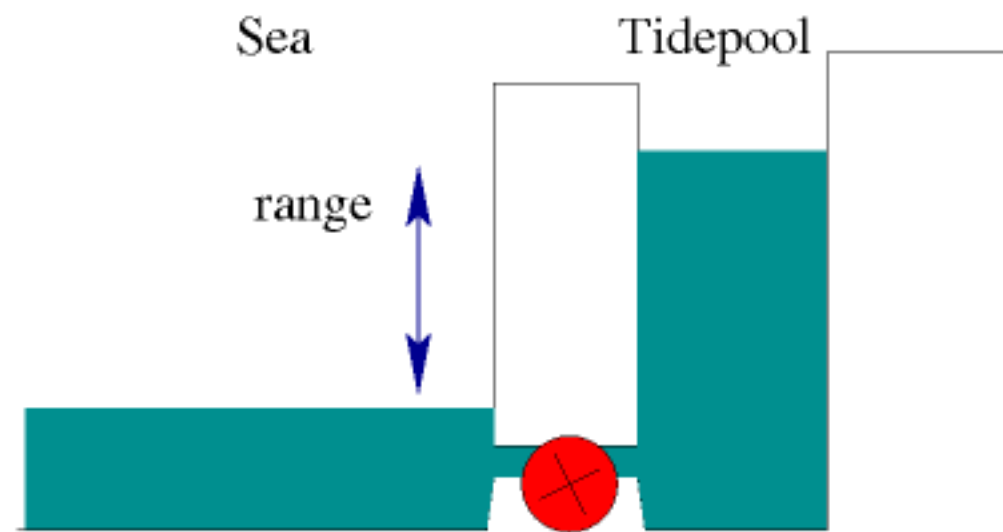


12 kWh/d



17 kWh/d

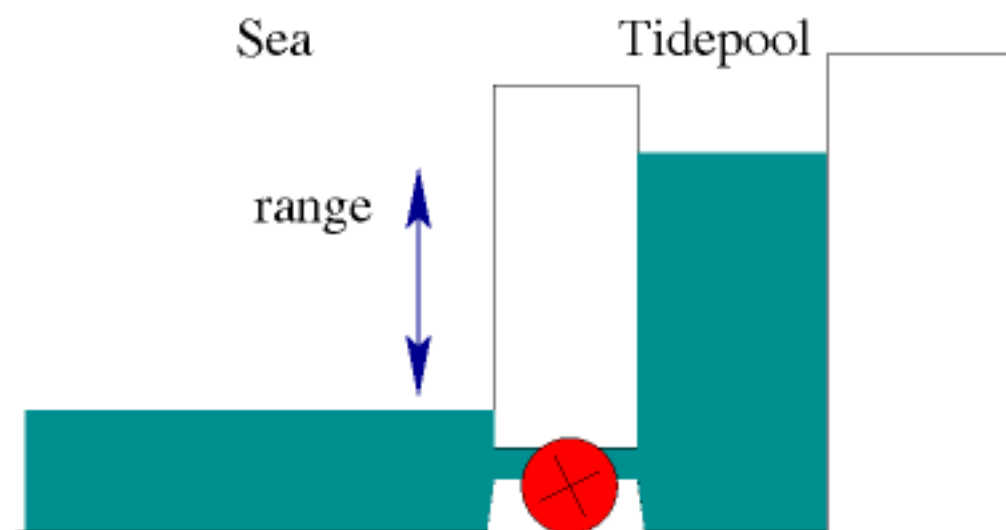
Tide - using tide pools



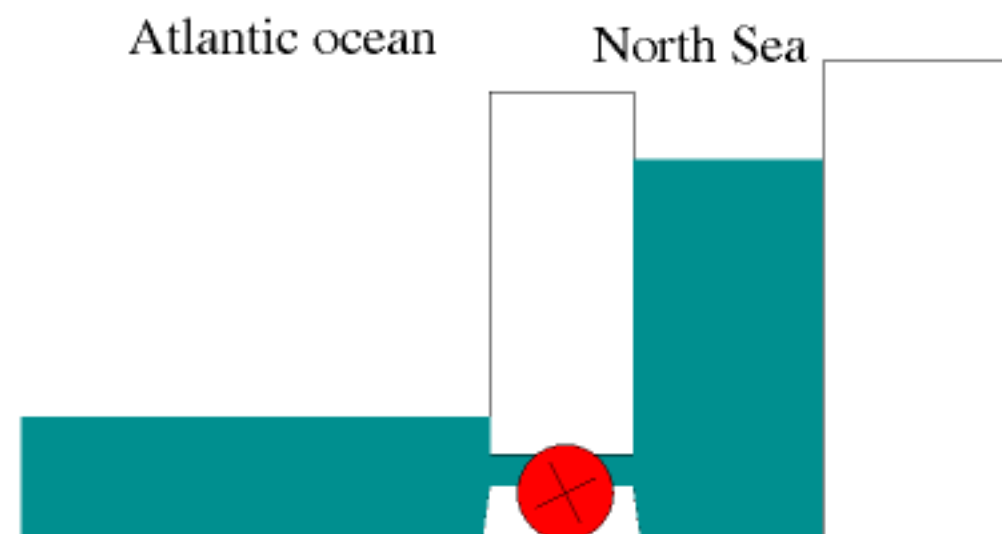
Tidal range	Power per unit area
4 m	3 W/m^2



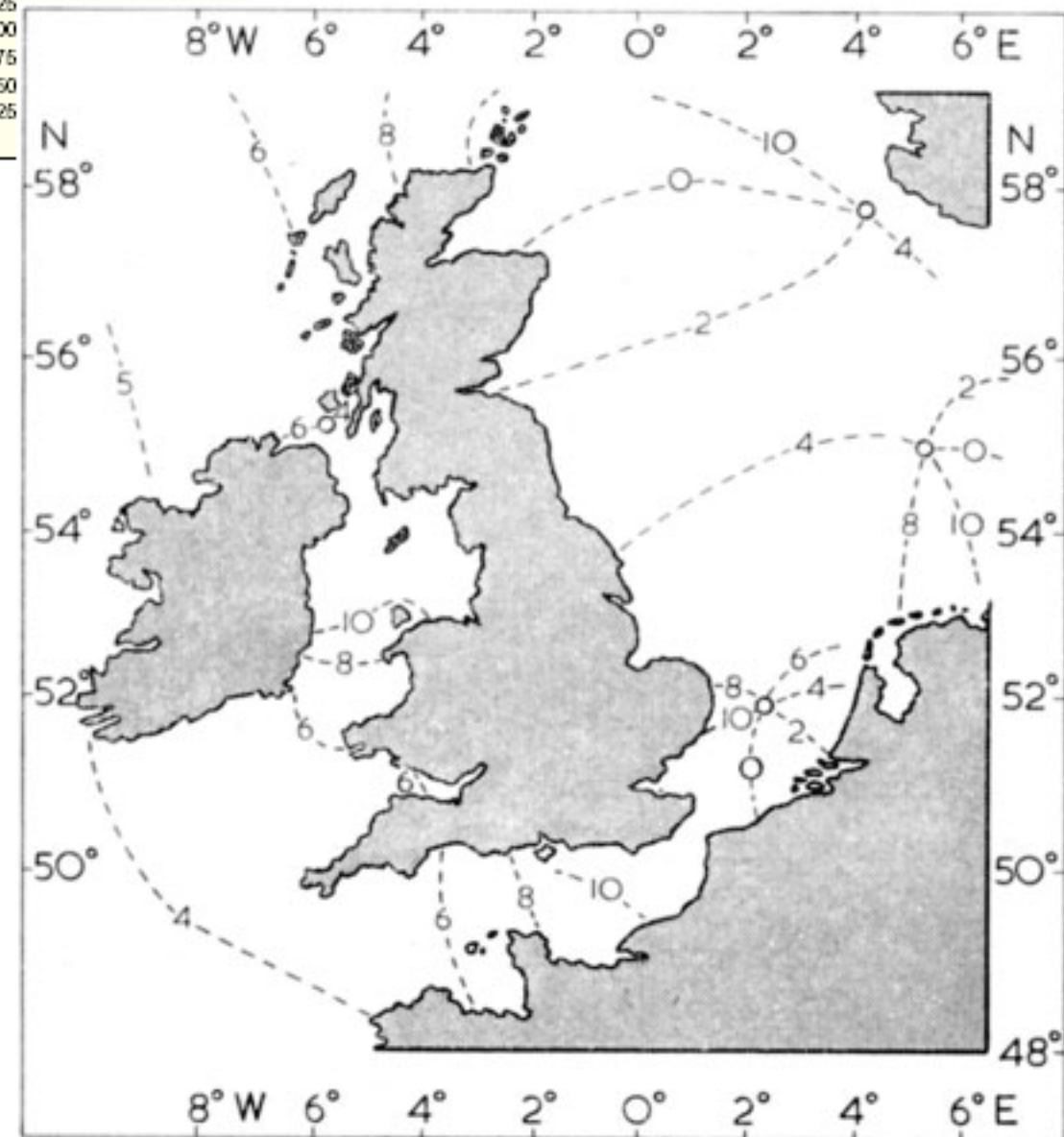
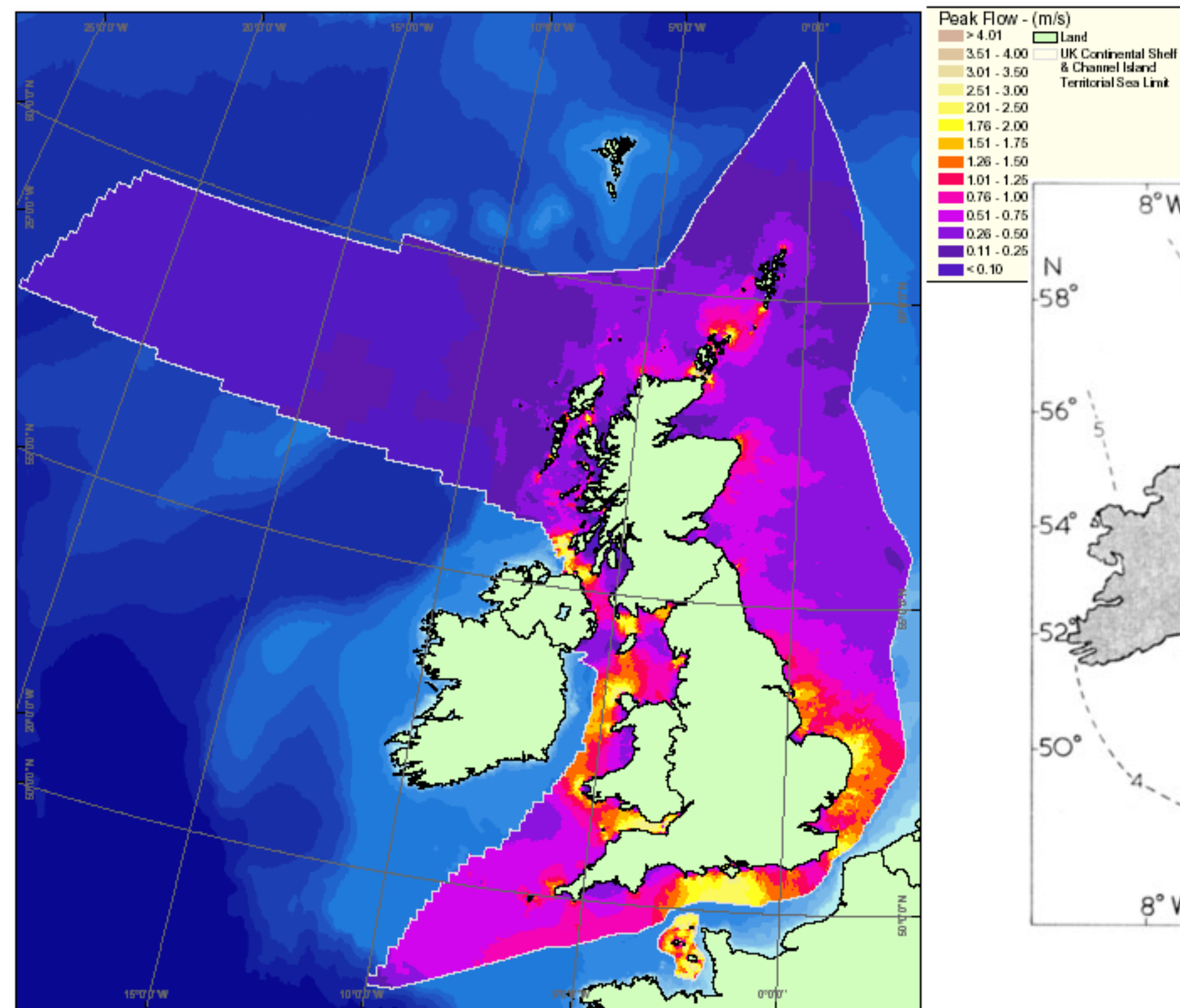
Tide - using tide pools



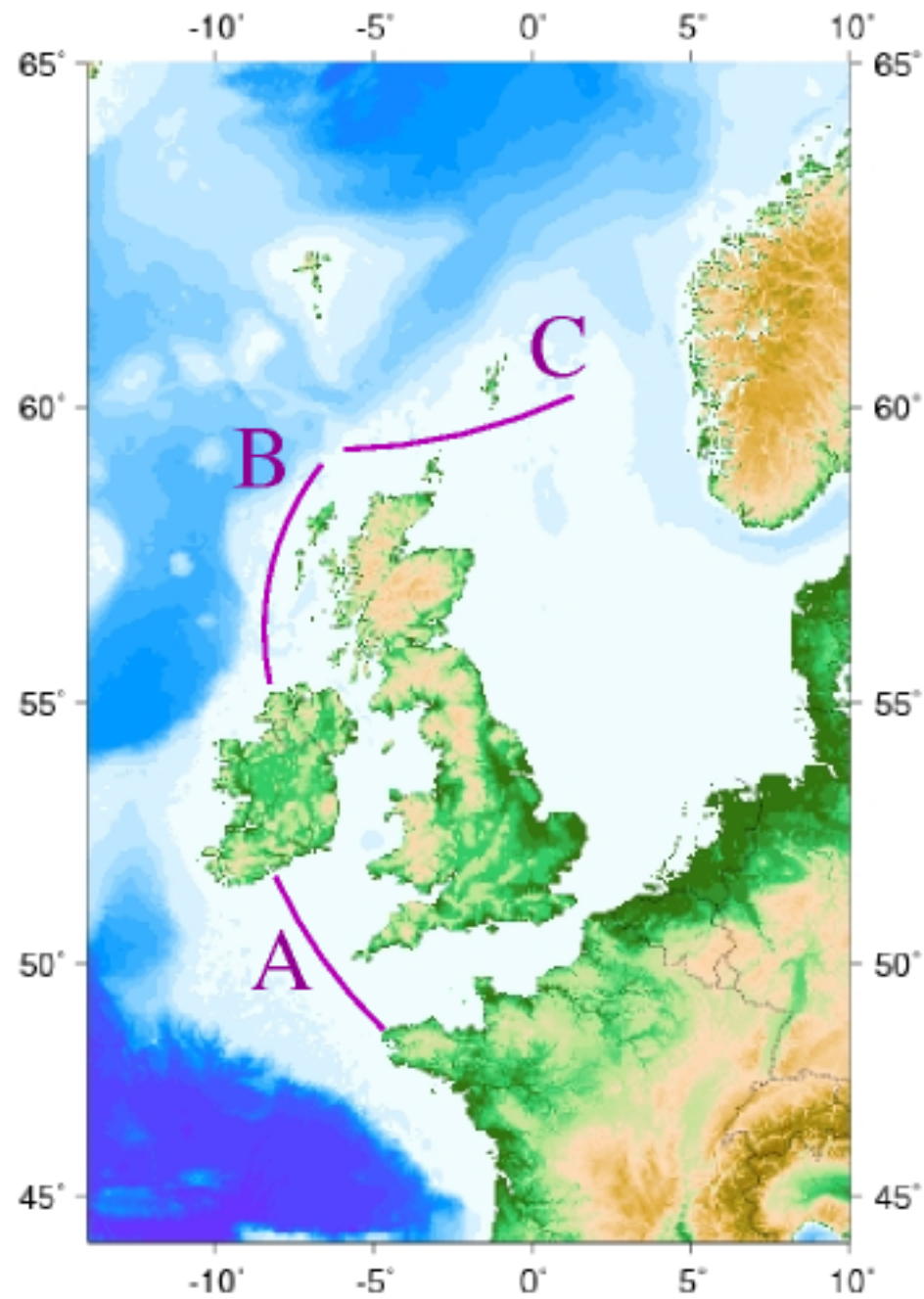
Tidal range	Power per unit area
4 m	3 W/m^2



Tide



Total incoming power in 'tidal waves'

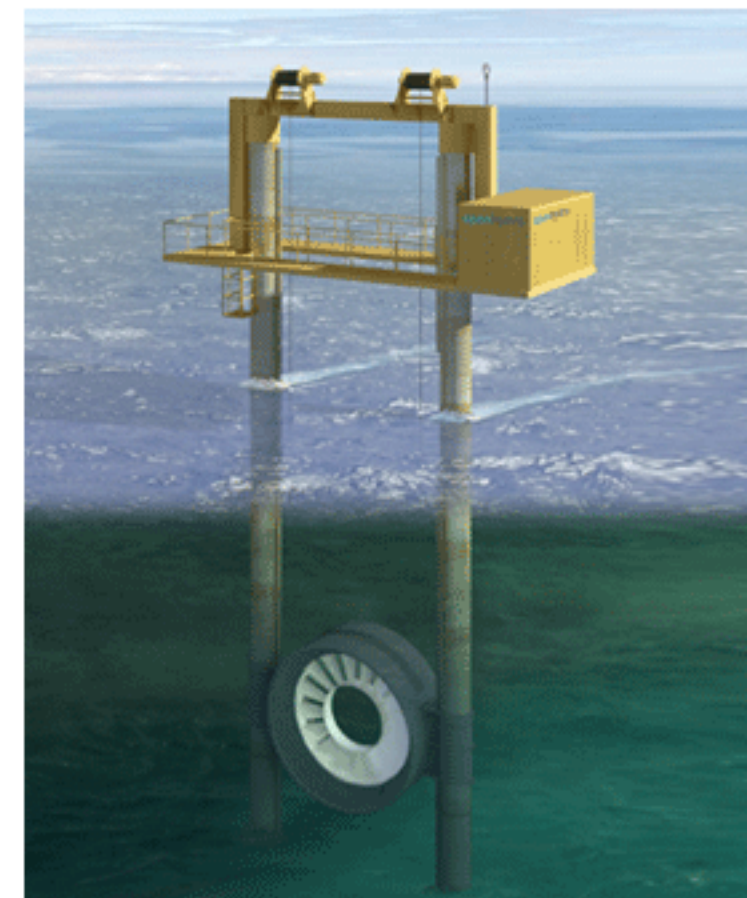
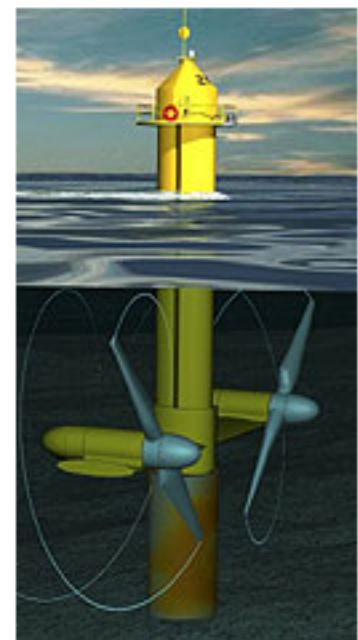


300-1000 kW per metre

Total: 750 GW
(300 kWh/d per person)

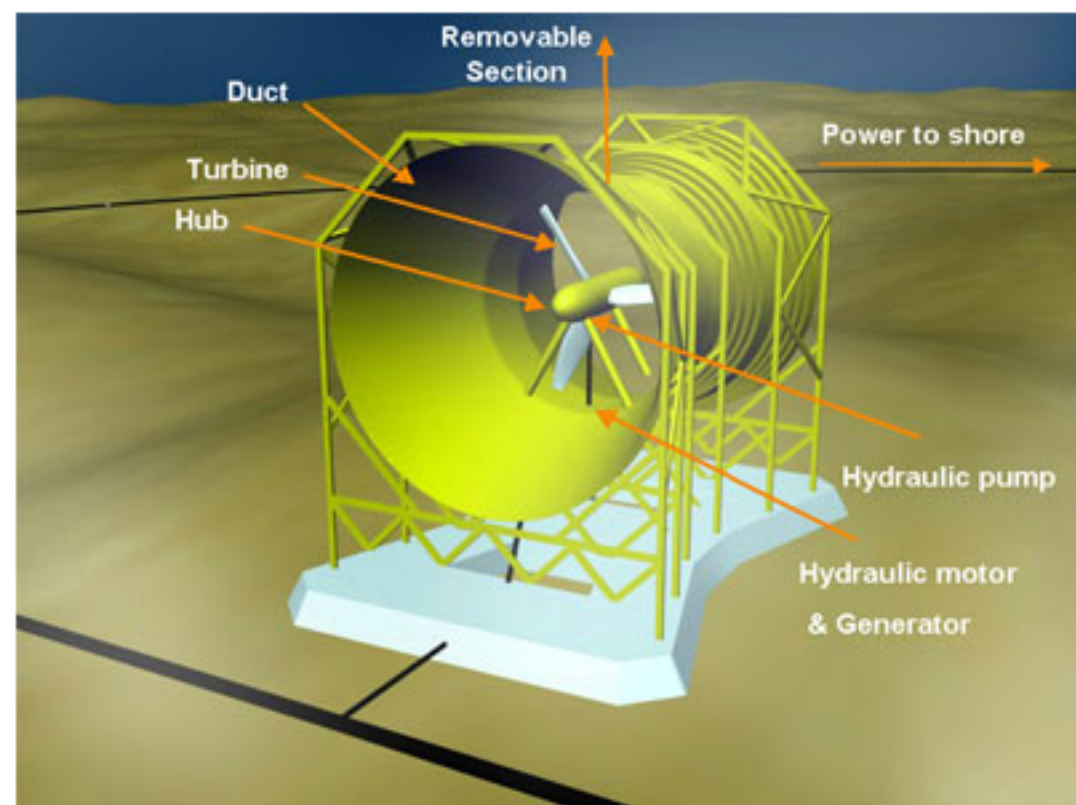
Tidal stream power

Marine Turbines (marineturbines.com)



Open Hydro

Lunar Energy (lunarenergy.co.uk)



1kWh/d/person
(DTI figure)

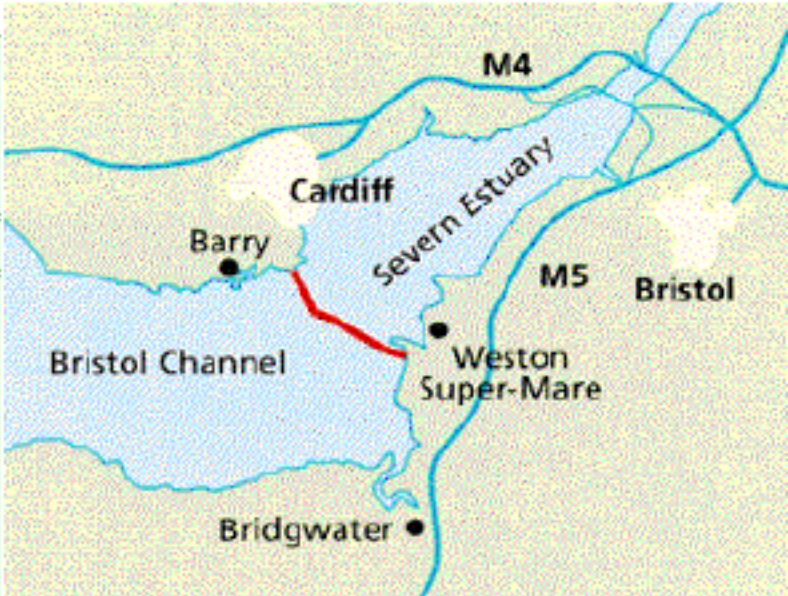
SMD Hydrovision "TidEL"



Tide

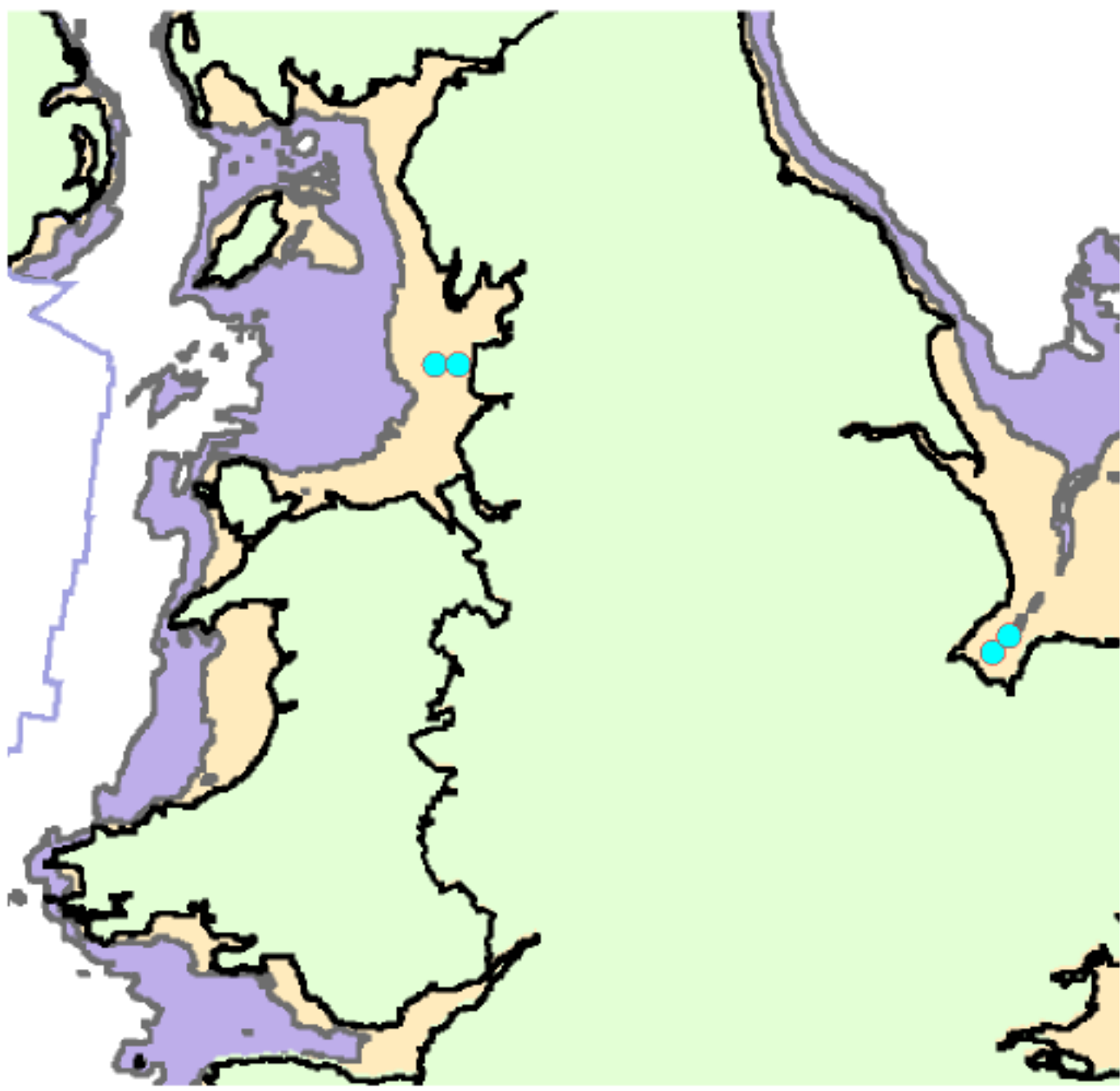
● Tide farms

● Tidal lagoons



and barrages

0.8 kWh/d per person



Fertilizer: 3	Tide: 14 kWh/d
Food: 16	Wave: 4
Gadgets: 5	Deep offshore wind: 32 kWh/d
Light: 4	Shallow offshore wind: 16 kWh/d
Heating, cooling: 38 kWh/d	Hydro: 1.5
Jet flights: 30 kWh/d	Biomass: food, biofuel, wood, waste incin'n, landfill gas: 24 kWh/d
Car:	PV farm (400 m ² /p): 50 kWh/d
	PV, 10 m ² : 4
	Solar heating: 10 kWh/d

Stuff

● One new computer every 2 years

Chips: 4
Aluminium: 3

● 5 cans per day

● Stuff made in China: 12 kWh/d/p

● Transporting rubbish around

Road freight: 7



Supermarkets:
0.5 kWh/d

Shipping: 4



Photo by Ian Boyle
www.simplonpc.co.uk

Newspapers,
junk mail,
magazines:
2 kWh/d



Transporting stuff: 12

Stuff: 48+

Fertilizer: 3

Food: 16

Gadgets: 5

Light: 4

Tide:
14 kWh/d

Wave: 4

Deep offshore wind:
32 kWh/d

Shallow offshore wind:
16 kWh/d

Hydro: 1.5

Biomass: food,



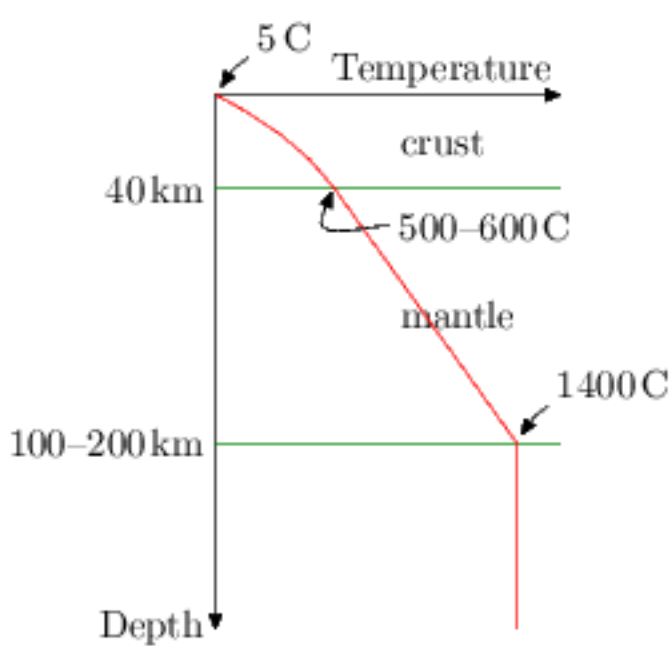
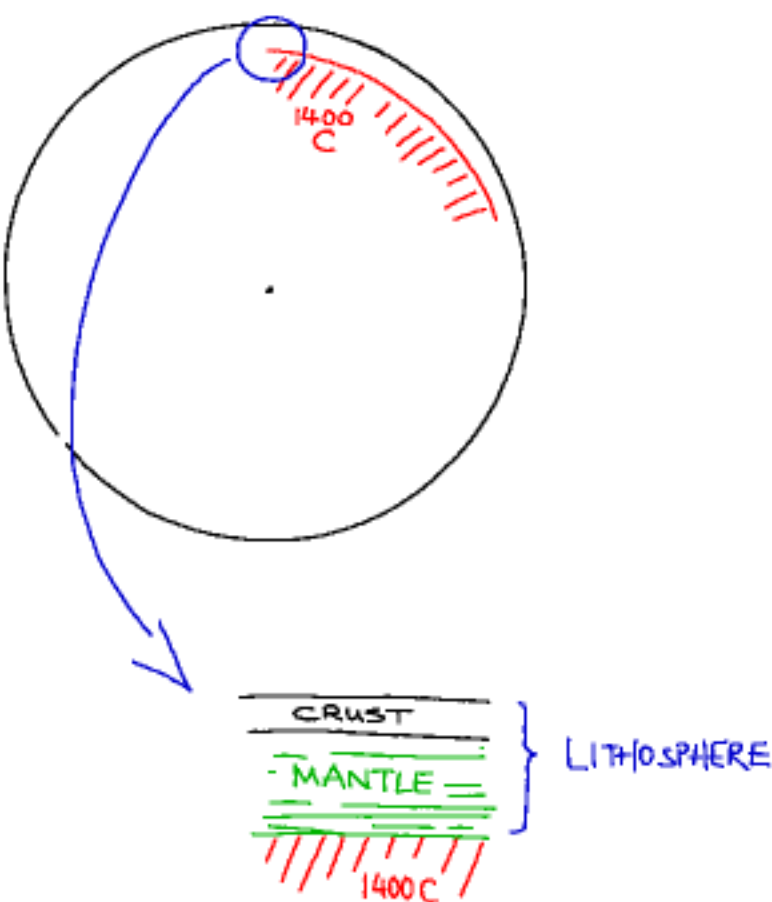
Geothermal



Nesjavellir, Iceland

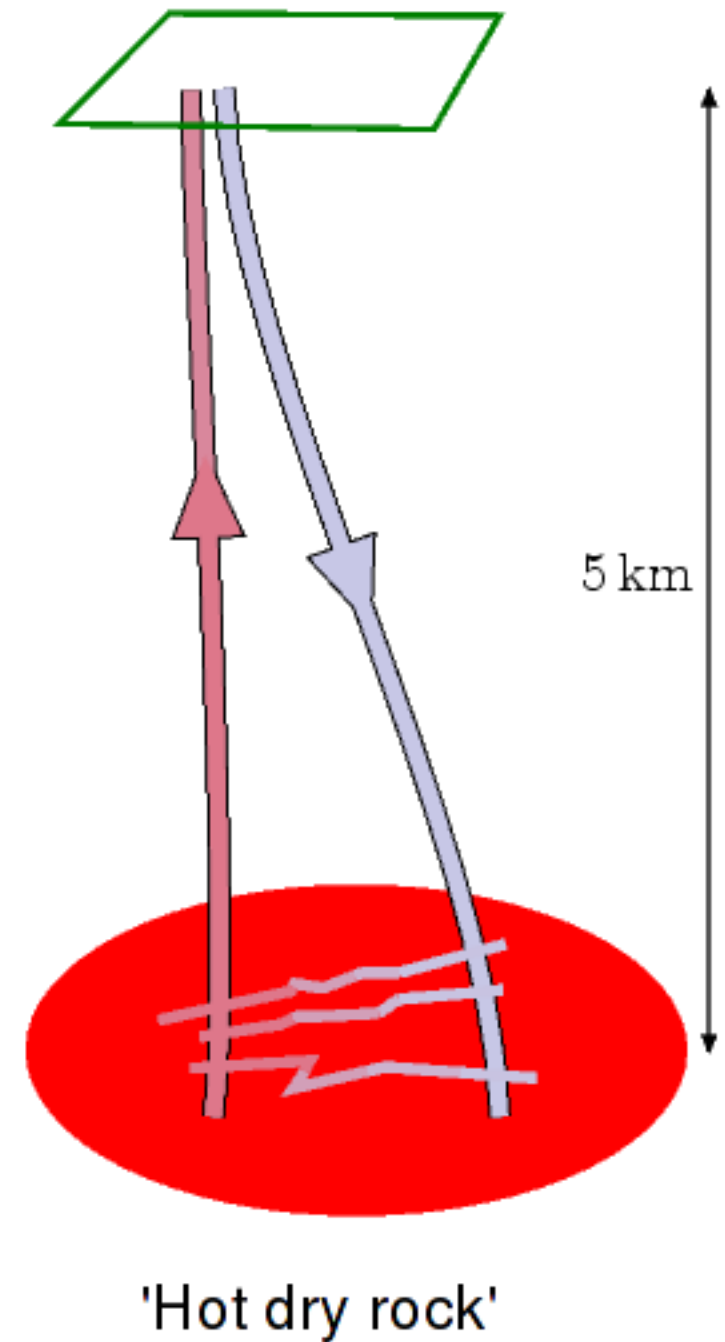


Geothermal



Transporting stuff: 12
Stuff: 48+
Fertilizer: 3
Food: 16
Gadgets: 5
Light: 4
Heating, cooling: 38 kWh/d
Jet flights: 30 kWh/d

Geothermal: 2
Tide: 14 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 (400 m ² /p): 50 kWh/d



Still to come
on the red stack:

- industry,
- road building,
- 'defence',
- hospitals, ...

Transporting stuff: 12	
Stuff: 48+	Geothermal: 2
	Tide: 14 kWh/d
	Wave: 4
	Deep offshore wind: 32 kWh/d
Fertilizer: 3	
Food: 16	Shallow offshore wind: 16 kWh/d
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Jet flights: 30 kWh/d	PV farm (400 m ² /p): 50 kWh/d
	PV, 10 m ² : 4
	Solar heating: 10 kWh/d
Car: 40 kWh/d	Wind: 20 kWh/d

**It would be
very
difficult to live
on our own
renewables**

- at least, as
we
currently live

Penicuik Environment Protection Association



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object to Midlothian Council in writing or by the eobject button on the website.

Important

During the last week of January and first week of February 2007, the Planning Department has acknowledged email objections received via the website since February 2006. The email address given to PEPA's consultant setting up the eobject site by a Planning Official was incorrect. Fortunately a backup file has been obtained but if you have not received an acknowledgement by February 8th 2007, please resubmit. A new email address has been provided and is operational. If you had already received an acknowledgement previously for objections submitted via letter / postcard, another acknowledgement would not be

SAY NO
TO WIND TURBINES
IN BENINGTON



SWAG

GROUP



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



Maer Hills Protect

Hook Moor Wind Farm Action Group



Prote
En

YMGYRCH
CEFN CROES
CAMPAIGN



SAY
NO
TO THE
WIND FARM

Now Against Tu

[www.
stopbeningtonwindfarm
.co.uk](http://www.stopbeningtonwindfarm.co.uk)



STOP



STOP Lochluichart

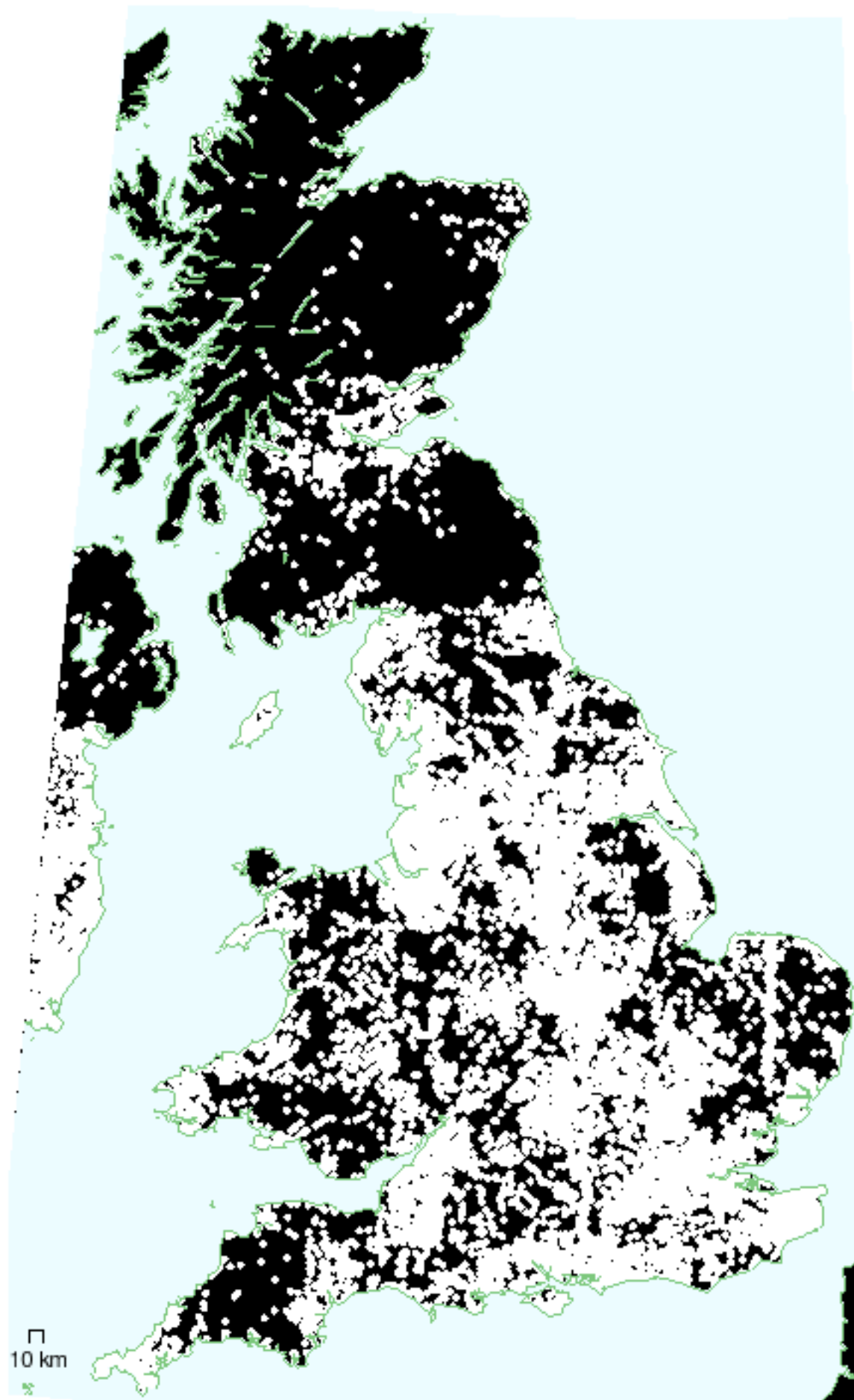
'a windfarm too far'



FS

T

SH



Save Our Scenery - Protecting Our Heritage Coastline

BEFORE



AFTER

FROM LLANDUDNO
PROMENADE



FROM COLWYN BAY
PROMENADE



saveourscenery.com



email address

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

News

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



accepted 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

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 north. Experts say a wind farm next to the defunct nuclear power station, at Brightlingsea, could cause air traffic control issues and might even interfere with radar. Airport manager Alistair Welch raised the concerns at a public inquiry which is being held in the town.

June 22, 2007 in Echo

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 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 biggest offshore wind farms on the south Wales coast met on Friday. Residents in Porthcawl gathered to highlight their opposition to the proposed 30-turbine Porthcawl Sands.

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

"The turbines will change the shape of the sandbanks and the waves," he said. "If the waves are changed and people stop sport because of the turbines then the town is going to be left behind the £100m scheme say the turbines, which will be built at sea level, will generate enough power for 86,000 homes. The site, which is to the west of Porthcawl, is approximately 10 miles from the nearest household.

Project - Is This A New Klondyke?

The *Wrexham Herald* (linked above) talks about the views and disappearing as we used to know them - vast open spaces as they had been for hundreds of years and a rural landscape and industrial scene. As we watch the first massive turbines on the Caithness and Sutherland coast are we watching the loss of another aspect of our scenery - the coastal views? Another hazard for fishing boats and vessels to be in the view now of anyone on the east of Caithness are the oil rigs as we face up to rising oil prices and the threat of a new oil spill. We already see oil rigs with in view. Will wind turbines be out at sea then on our hills and mountains?

BBC NEWS

WATCH LIVE BBC News 24

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.

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.



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

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

Wind power 'a security risk'

02 November 2007 08:15

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

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

EXPLORE UK NEWS

> CRIME NEWS

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 Trimmingham on the Northumberland, Yorkshire and Norfolk coasts.


GREEN CENTRAL BLOG



Guilt-free flying? Are biofuels the future for aviation?



20 green ideas for Valentines day



*Miles from the nearest shore,
Cape Wind will use the clean,
inexhaustible power of wind to
provide three-quarters of the
Cape and Islands' electricity*

...helping to clean our environment and the air

...reducing our dependence on foreign energy

...creating new jobs

...lowering electric costs



**THE TRUE DANGER OF CAPE WIND IS BECOMING CLEAR
EVERYDAY**

BUSINESS WEEK

THE DANGERS OF WIND FARMS

Europe August 24, 2007, 12:05PM EST

**As wind turbines multiply around the globe, the
number of dangerous accidents is also climbing, causing
critics to question overall safety**

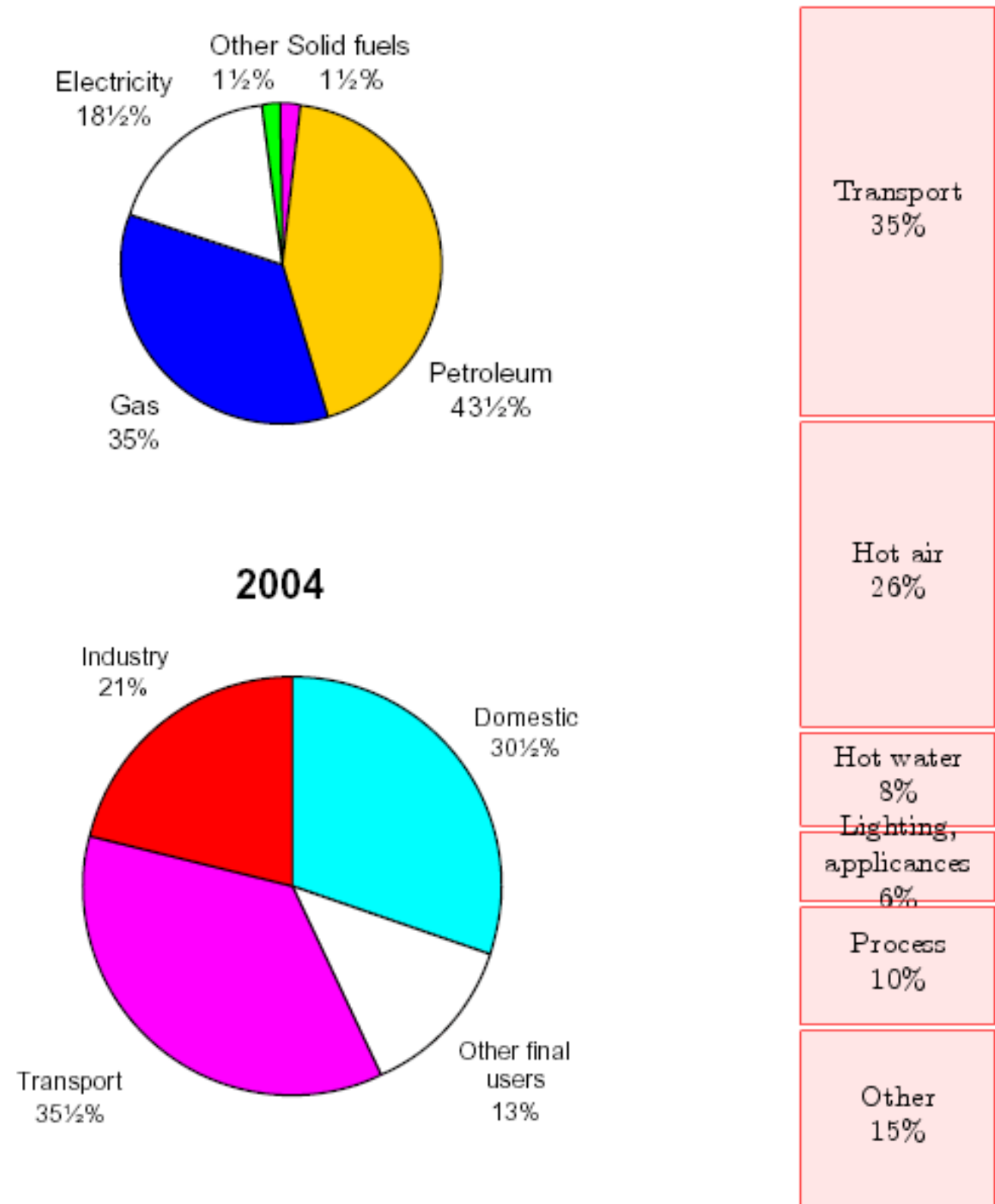
Transporting stuff: 12		
Stuff: 48+	<div>Geothermal: 2</div> <div>Tide: 14 kWh/d</div> <div>Wave: 4</div> <div>Deep offshore wind: 32 kWh/d</div>	too expensive!
Fertilizer: 3		
Food: 16	Shallow offshore wind: 16 kWh/d	not near my birds!
Gadgets: 5	Hydro: 15	not in my valley!
Light: 4		
Heating, cooling: 38 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 (400 m²/p): 50 kWh/d	too expensive!
Car: 40 kWh/d	<div>PV: 10 m²: 4</div> <div>Solar heating: 10 kWh/d</div> <div>Wind: 20 kWh/d</div>	<div>too expensive!</div> <div>not on my street!</div> <div>not in my back yard!</div>

Transporting stuff: 12		
Stuff: 48+	Geothermal: 2	too immature!
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	Waves: 4	too expensive!
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Gadgets: 5	Hydro: 4.5	not in my valley!
Light: 4		
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Car: 40 kWh/d	PV: 10 m²: 4	too expensive!
	Solar heating: 10 kWh/d	not on my street!
	Wind: 20 kWh/d	not in my back yard!

after the great British consultation exercise...



Average Power consumption, UK: 125 kWh/d each



www.dti.gov.uk



'primary consumption'
125 kWh/day (Europe)
300 kWh/day (USA)

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

For CO₂ pollution, divide by 10:
100 kWh/day \simeq 10 tonnes CO₂/yr

Conclusions - part I

We can't live on
our own renewables
- at least,
not as we currently live

To make a difference,
renewables have to be
country-sized

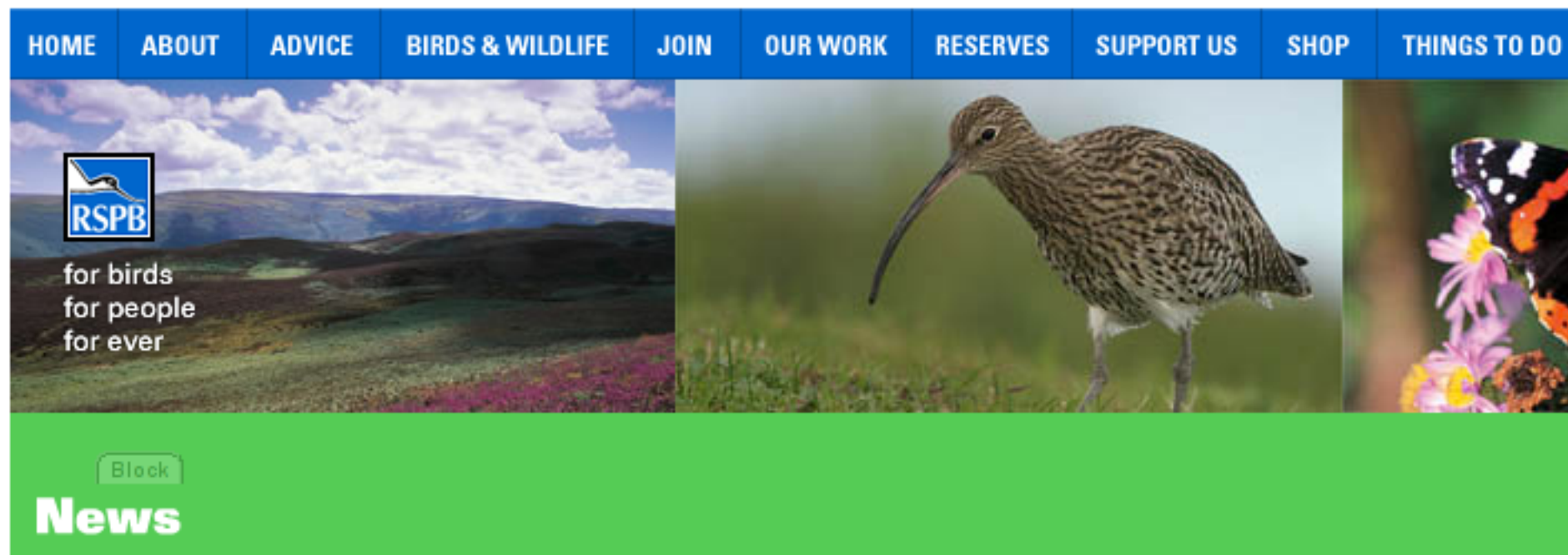
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Car: 40 kWh/d	PV 10 m²: 4	too expensive!
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	Wind: 20 kWh/d	not in my back yard!

Renewables are diffuse

POWER PER UNIT LAND AREA

Wind	2 W/m ²
Offshore wind	3 W/m ²
Tidal pools	3 W/m ²
Tidal stream	6 W/m ²
Solar PV panels	5 W/m ²
Plants	0.5 W/m ²
Solar chimney (Spain)	0.1 W/m ²
Concentrating solar power (desert)	15 W/m ²
Ocean thermal	5 W/m ²
Rain-water (Scotland)	0.24 W/m ²
Rain-water (England)	0.02 W/m ²

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



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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 W/m^2



How to make an energy plan that adds up

● Demand-side

- Reduce population
- Change lifestyle
- Technology, efficiency

Current
consumption:
125 kWh/d
per person

● Supply-side

- 'Clean coal'
- Nuclear power
- Use other countries' renewables

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

← Hydro: 0.3

'Sustainable fossil fuels'

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

Coal:
6 kWh/d

Carbon capture and storage

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

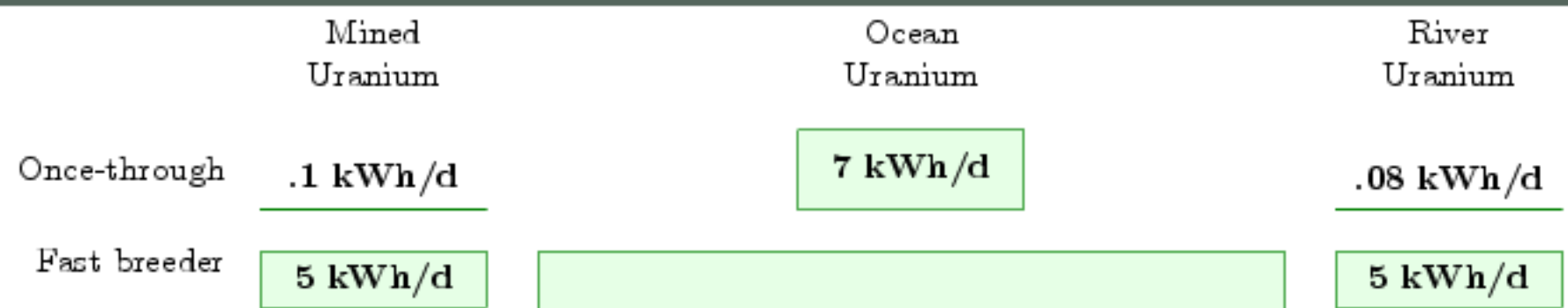
Sustainable Fossil Fuels

The Unusual Suspect in the Quest for Clean and Enduring Energy

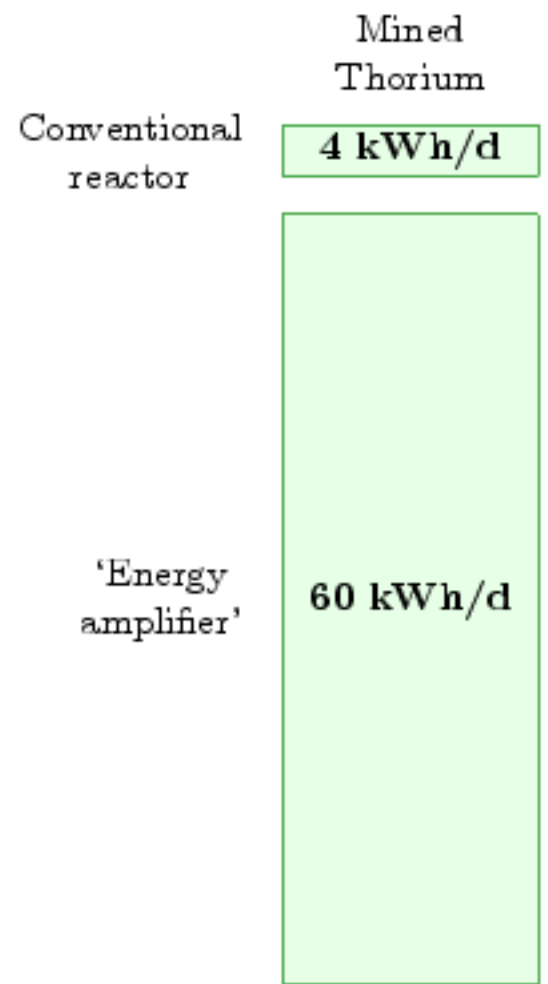


Nuclear Fission ('sustainable' = 1000 years)

● Uranium

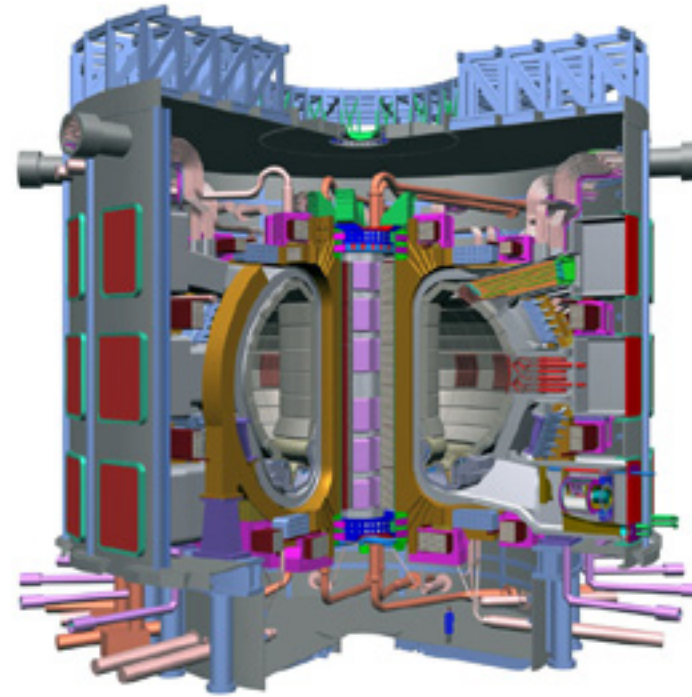


● Thorium



Nuclear Fusion

- Not a sure thing
 - a gamble



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

Lithium
fusion:
110 kWh/d

DD reaction

D lasts ~ 1 billion years

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per person

● Supply-side

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- Nuclear power
- Use other countries' renewables

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

← Hydro: 0.3

Area / km²

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

Antarctica
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

India

Greenland

Canada
Australia

Kazakhstan

Alaska
Mongolia

Libya

Mauritania

Namibia

Botswana

Western Sahara

Gabon

Guyana

Suriname

French Guiana

Iceland

23 000 m² per person

Scotland

England

South Korea

1000 m² per person

Taiwan

Wales

Mauritius

Hong Kong

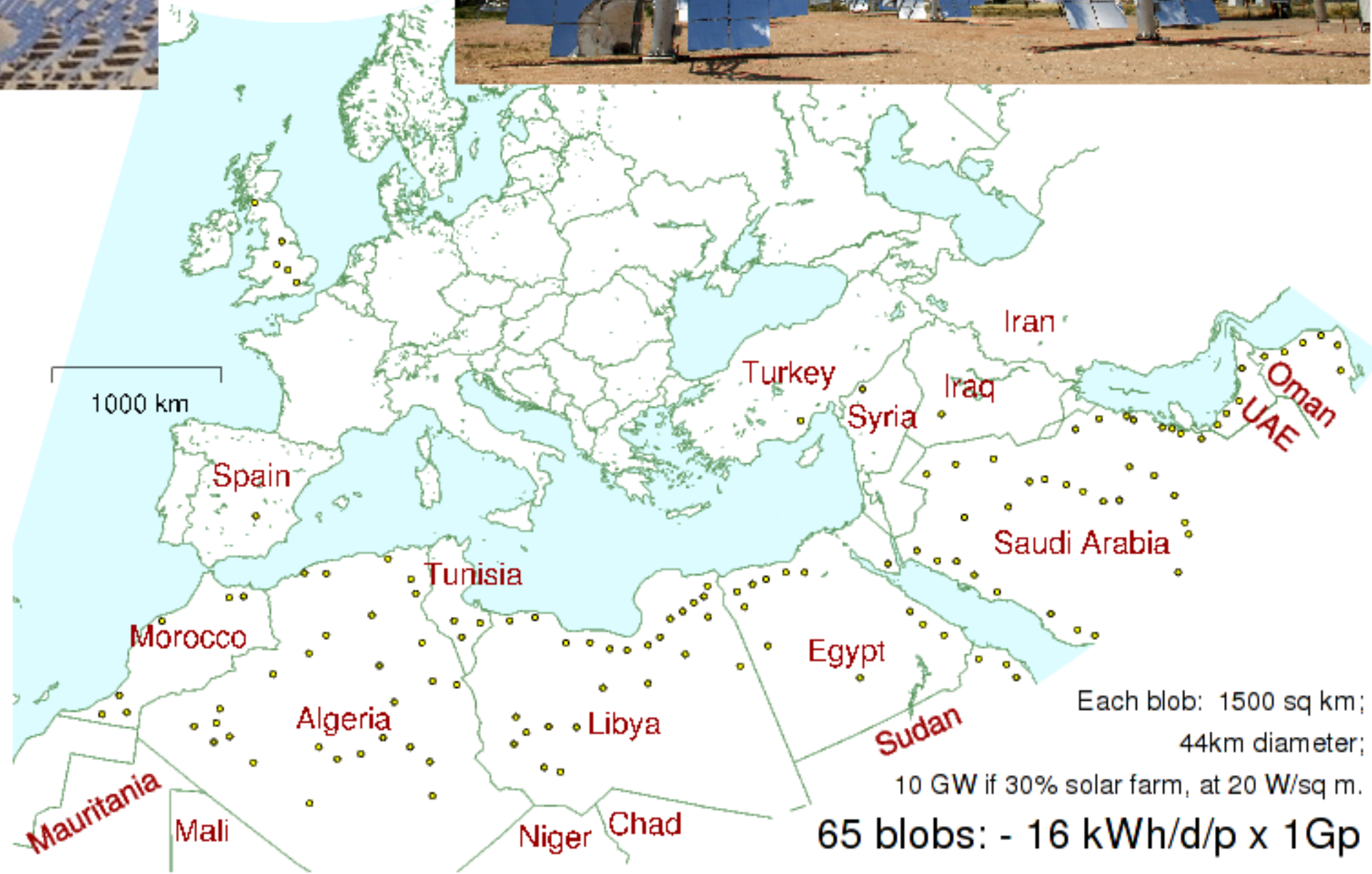
Singapore

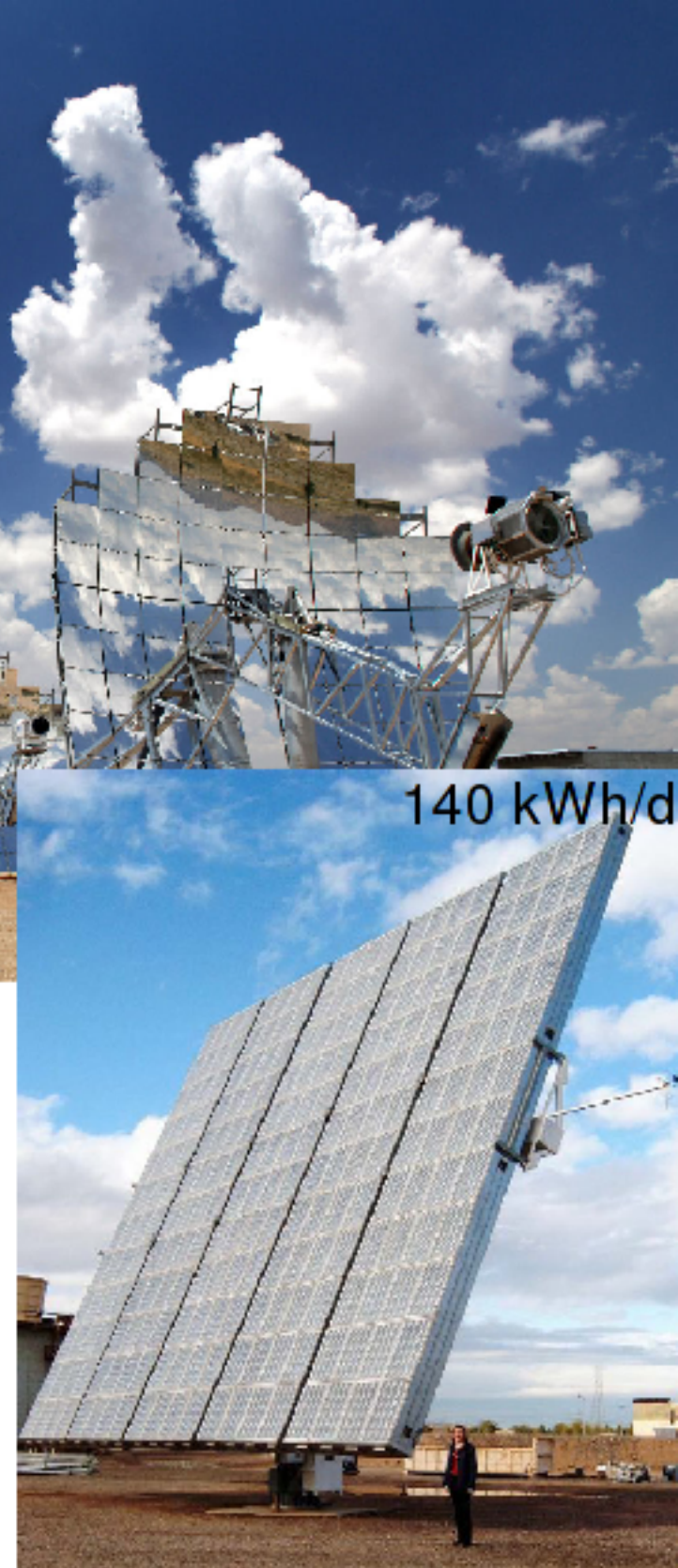
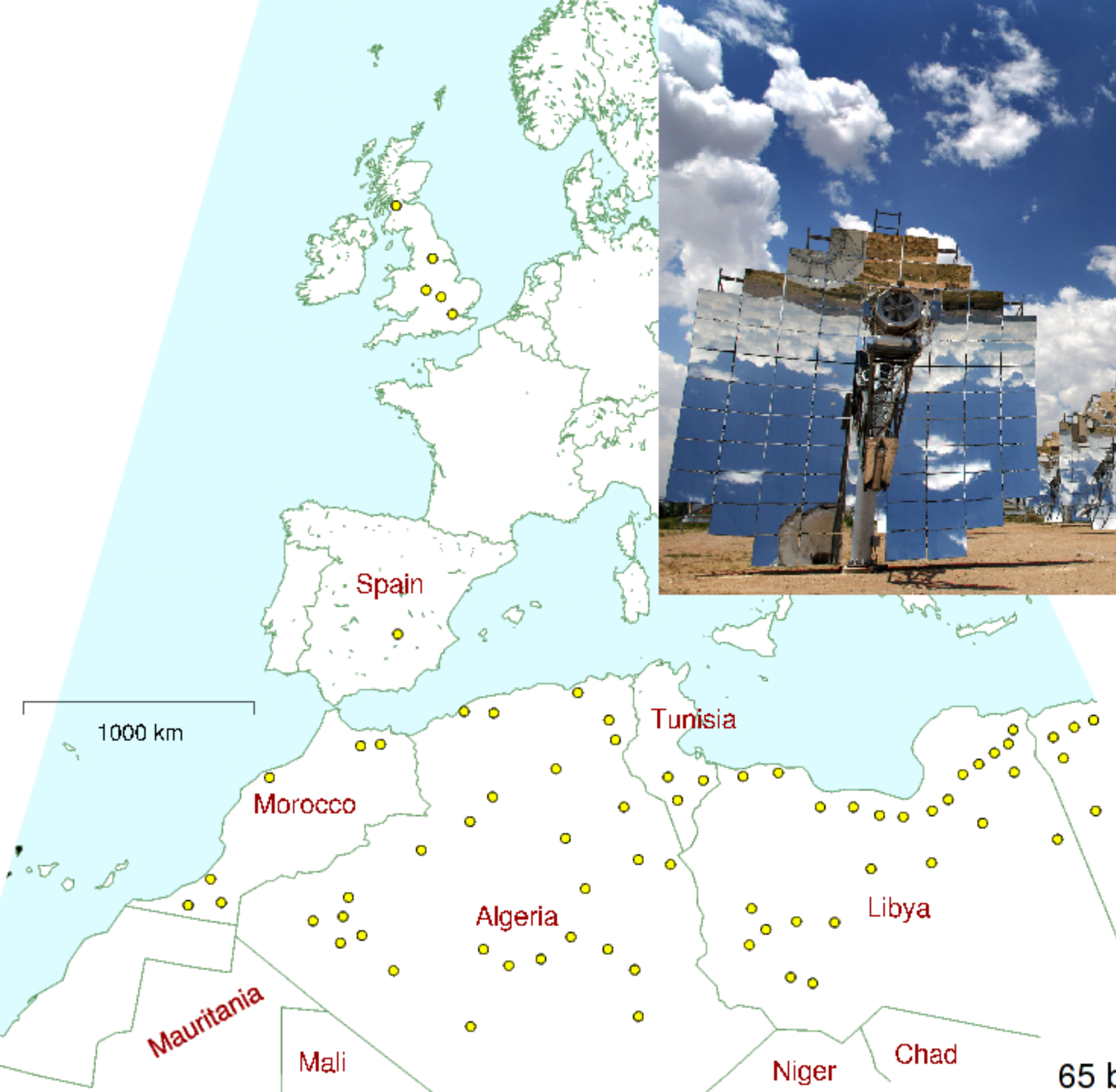
Gaza Strip



Population

International options





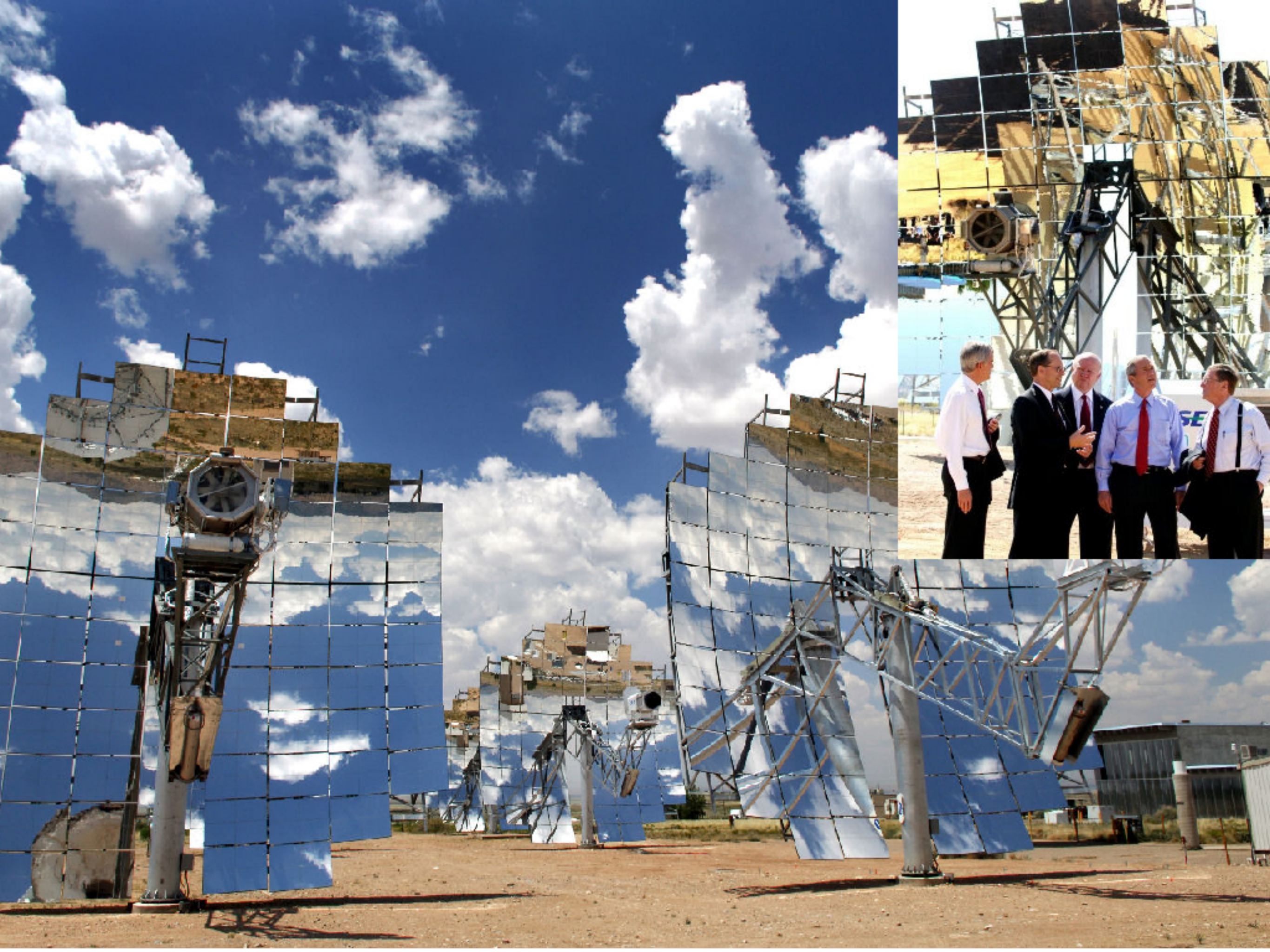
140 kWh/d

Each blob: 1500 sq km;

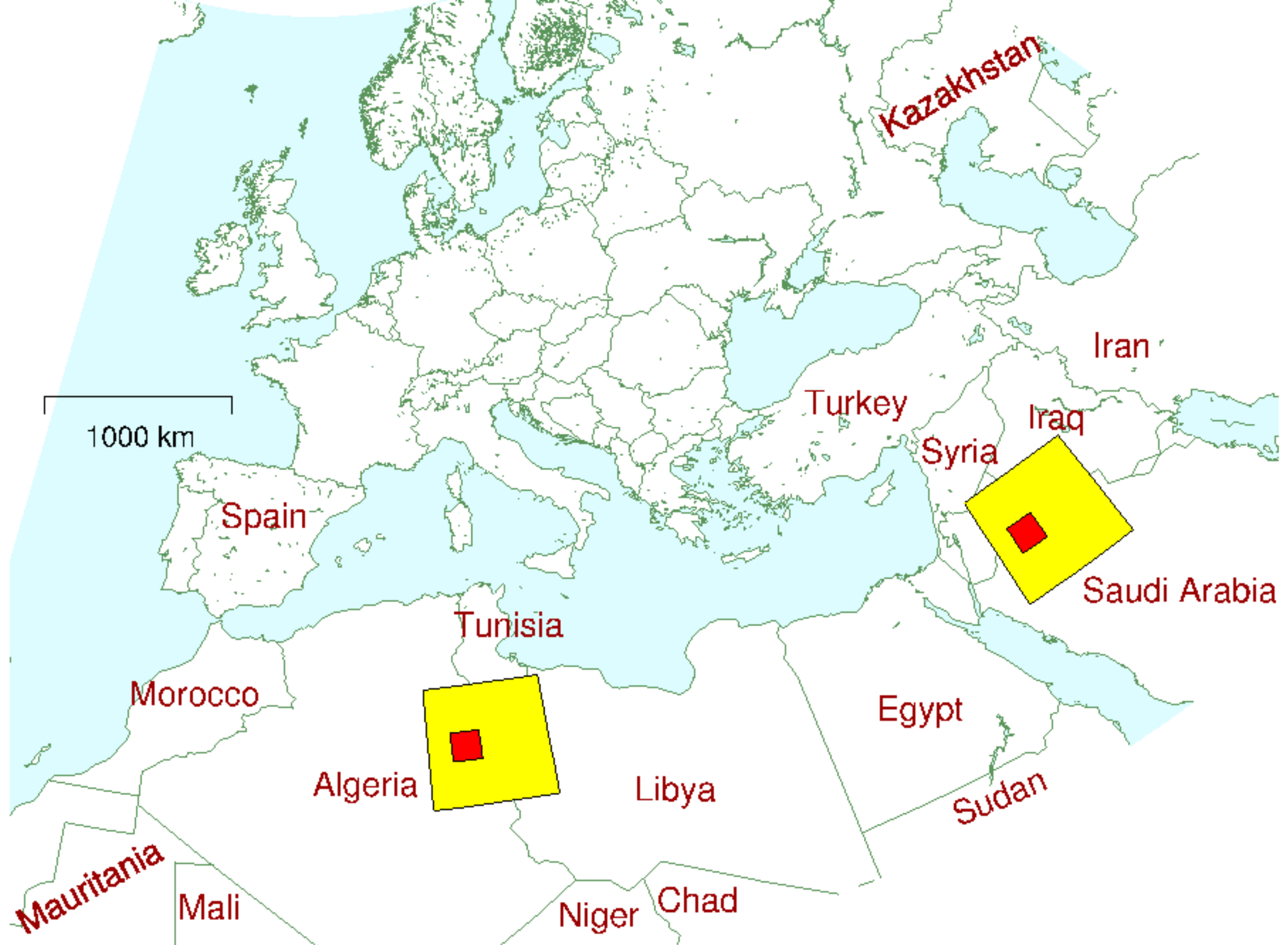
44km diameter;

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

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

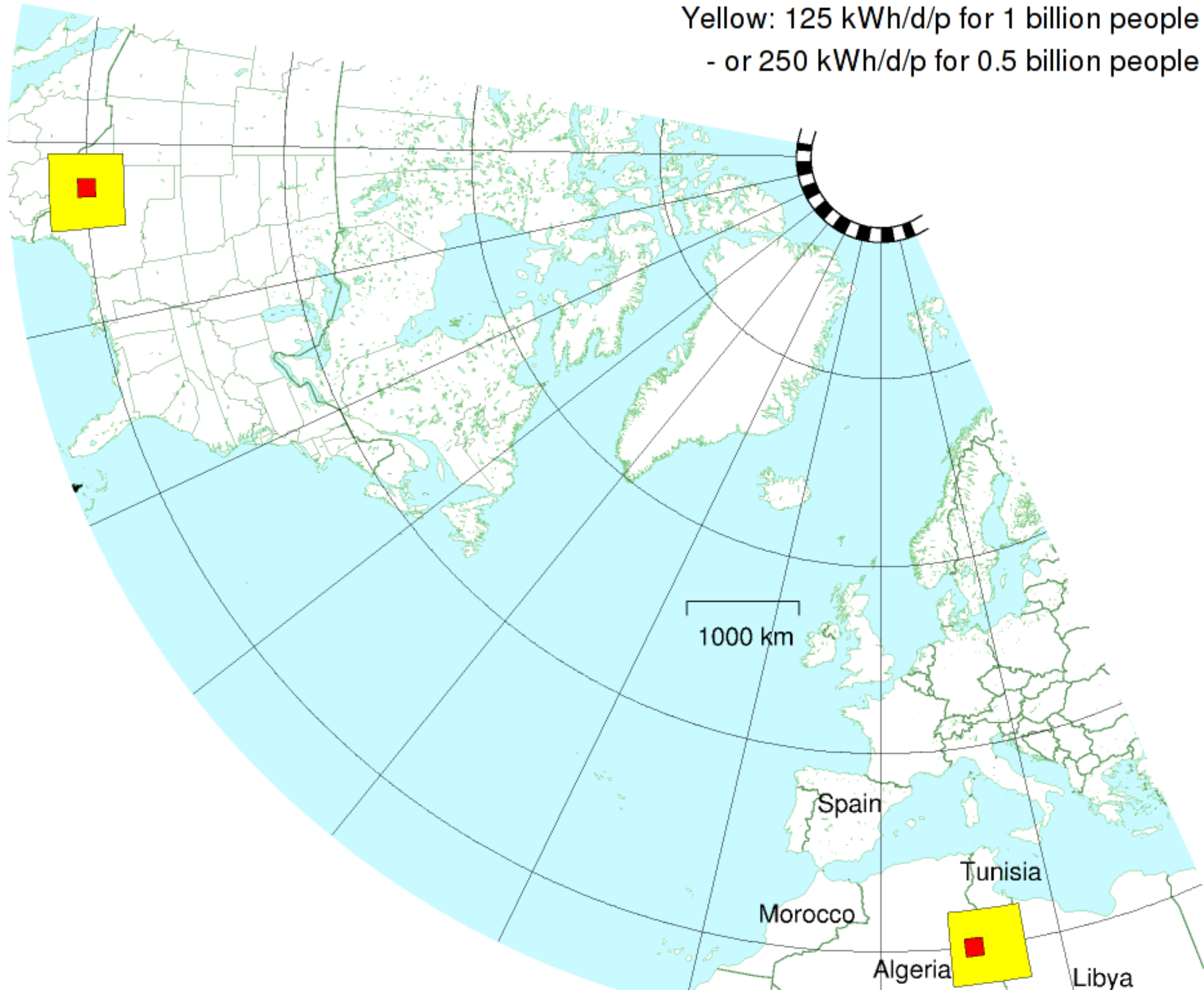






Yellow: 125 kWh/d/p for 1 billion people; Red: 125 kWh/d/p for 60 million people

Yellow: 125 kWh/d/p for 1 billion people
- or 250 kWh/d/p for 0.5 billion people



Andasol, Spain

10 W/m^2

Photo: ABB



(c) FLAGSOL



Kramer Junction



How to make an energy plan that adds up

● Demand-side

- Reduce population
- Change lifestyle
- Technology, efficiency

Current
consumption:
125 kWh/d
per person

● Supply-side

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- Nuclear power
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Tide: 3
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← Hydro: 0.3

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

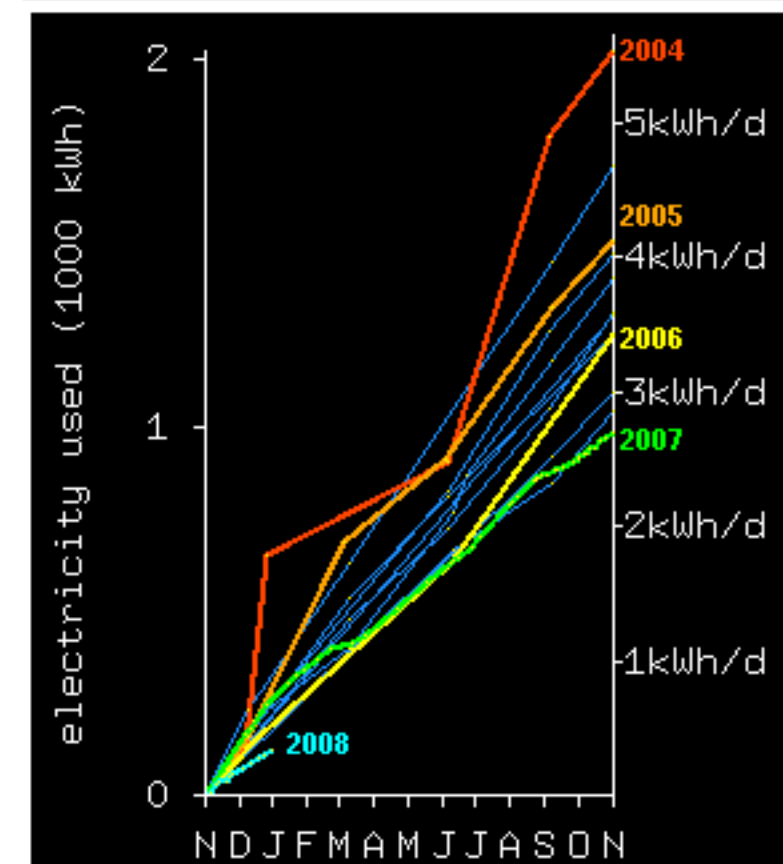
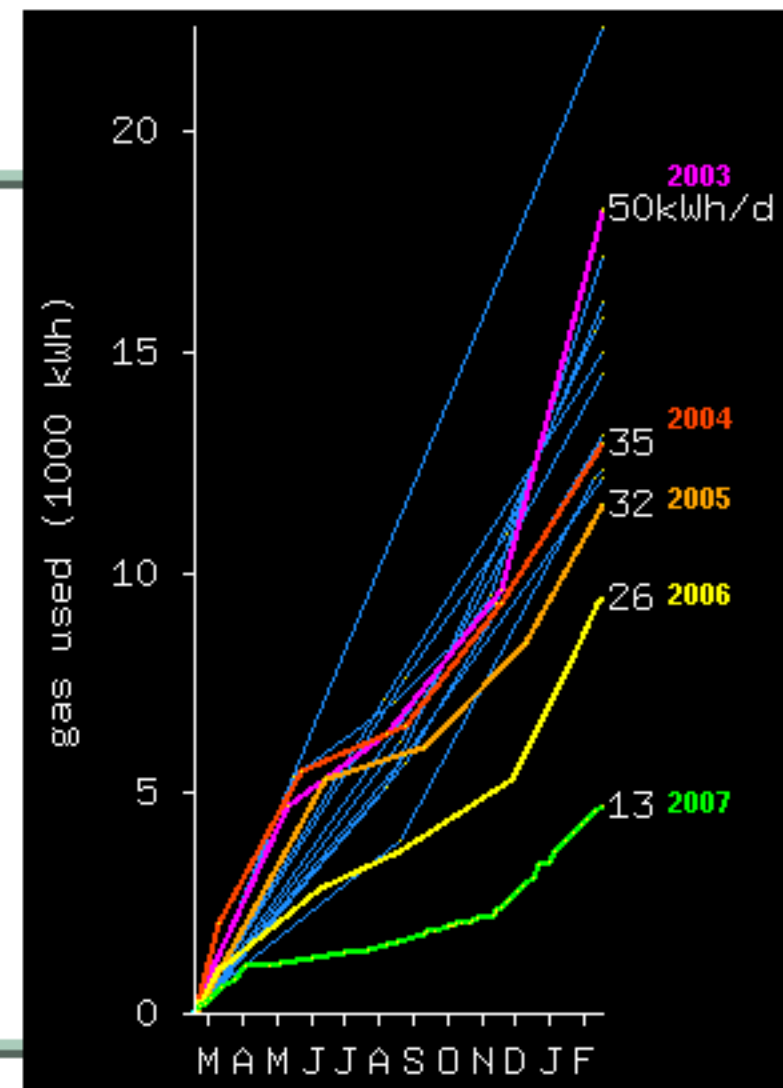


What society must do

- 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:

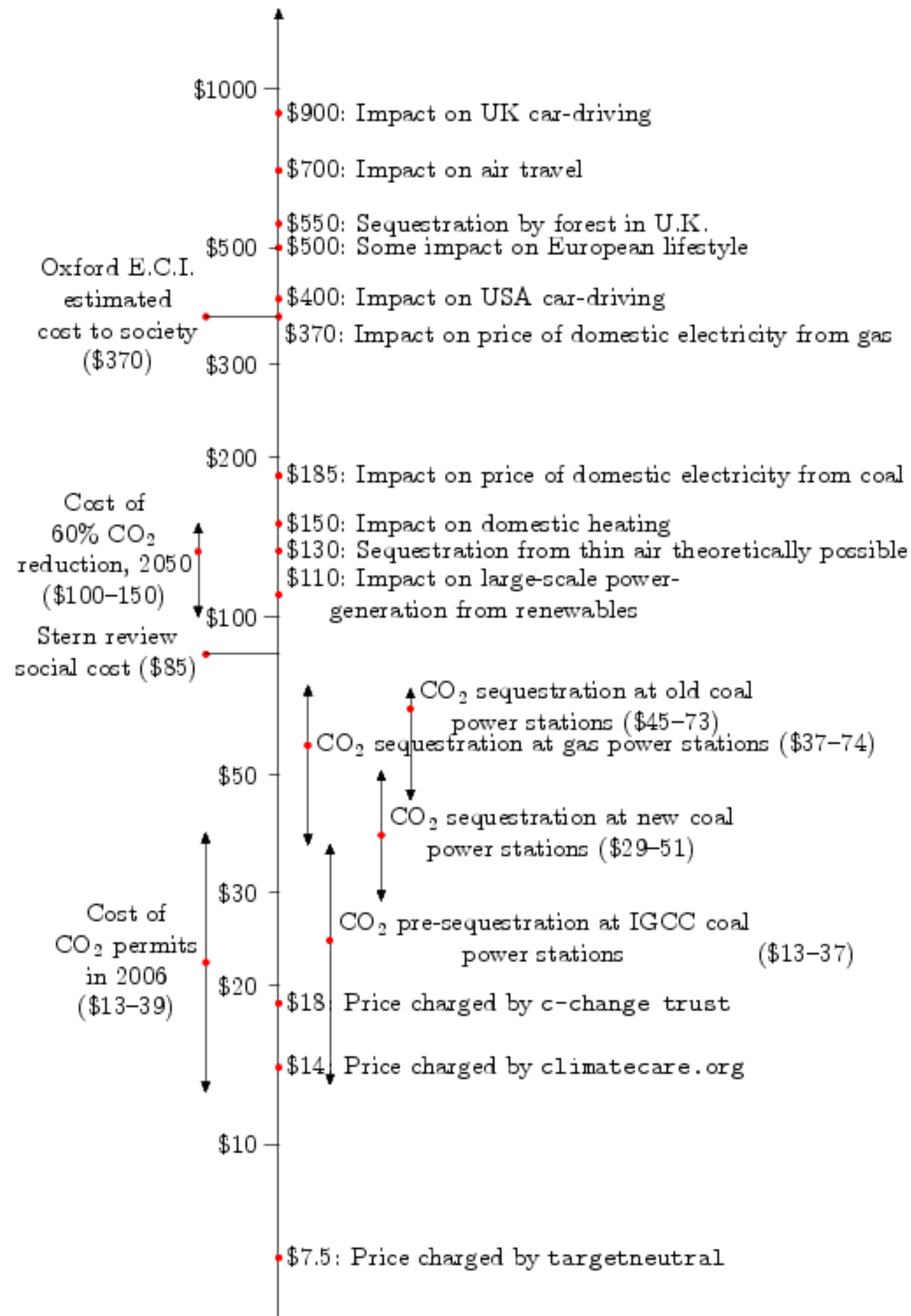
- country-sized renewable facilities
- renewables from other people's countries
- lots of nuclear power

● 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...'

What should carbon cost?





A Mitsubishi Warrior, yesterday

Amazing acts of testosterone-fuelled bravery

Efficiency

● Jevons' paradox

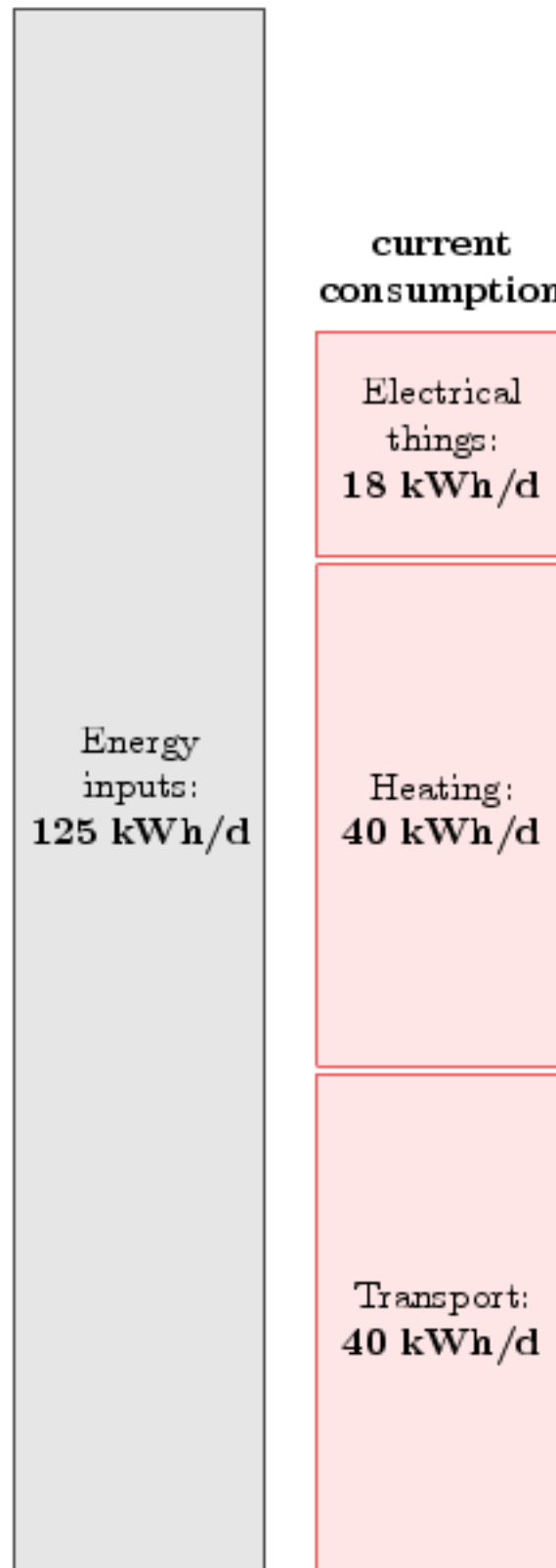
"as technological improvements increase the efficiency with which a resource is used, total consumption of that resource may increase, rather than decrease."

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.

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'



B5 is 5% biodiesel and 95% fossil fuel



A pump full of B5

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.

"Baby on board"



80 kWh per 100 person-km (1 person)
or 24 kWh per 100 person-km (3 people)

How can this consumption be reduced?

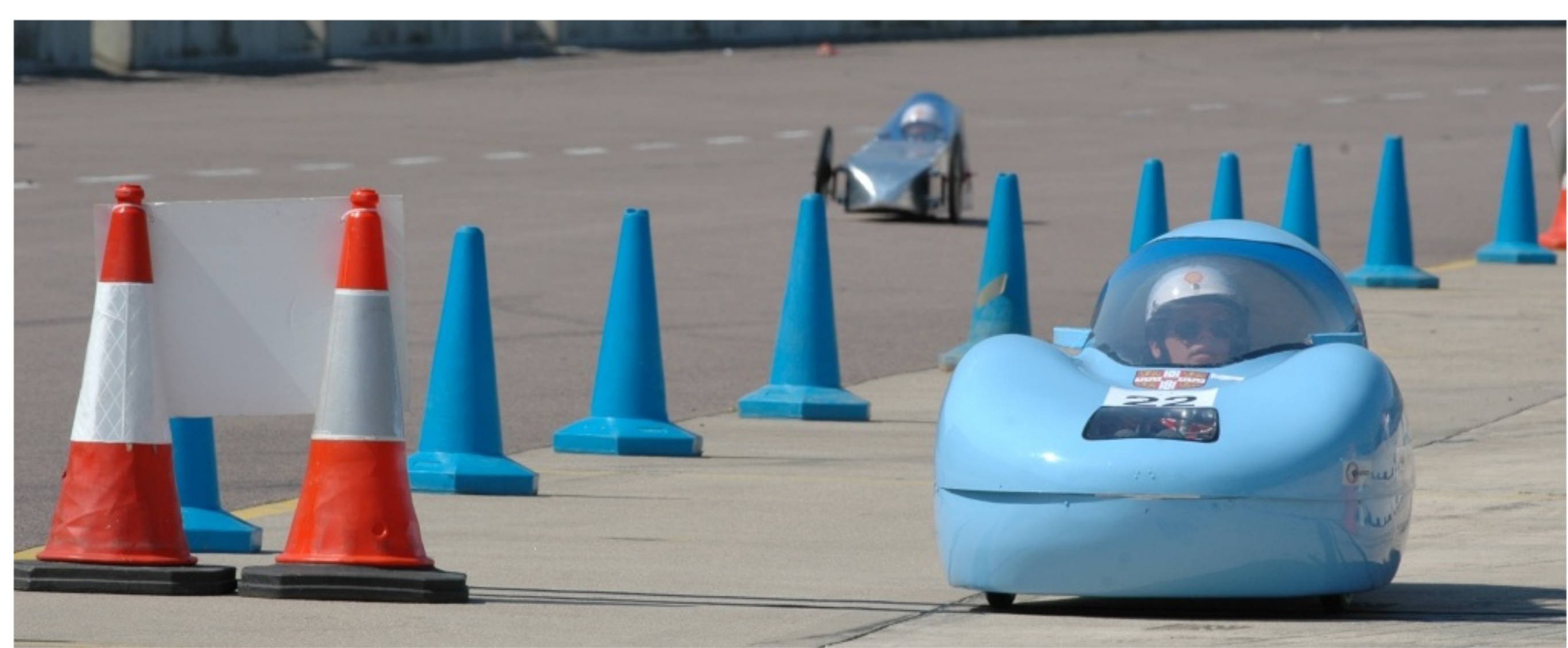


1 kWh per 100 person-km (3 people)



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



G-Wiz

- 11 kWh per 100 km (solo); 3 kWh per 100 pkm (3 p)
- equivalent to 225 miles per gallon
- or 90 miles per gallon
 - ▶ (depending whether we say 1 kWh(e) = 2.5 kWh)

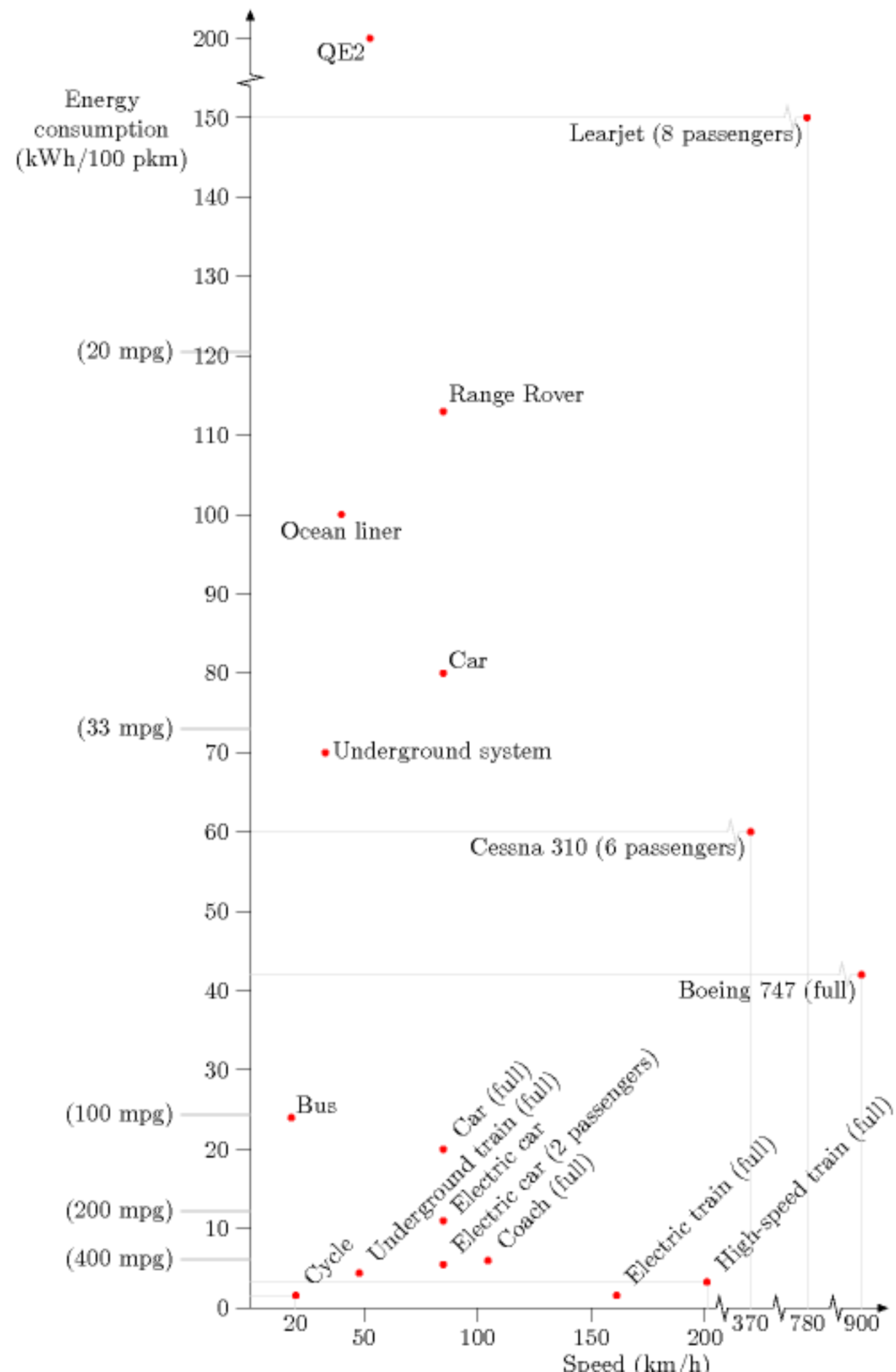
Electric scooters

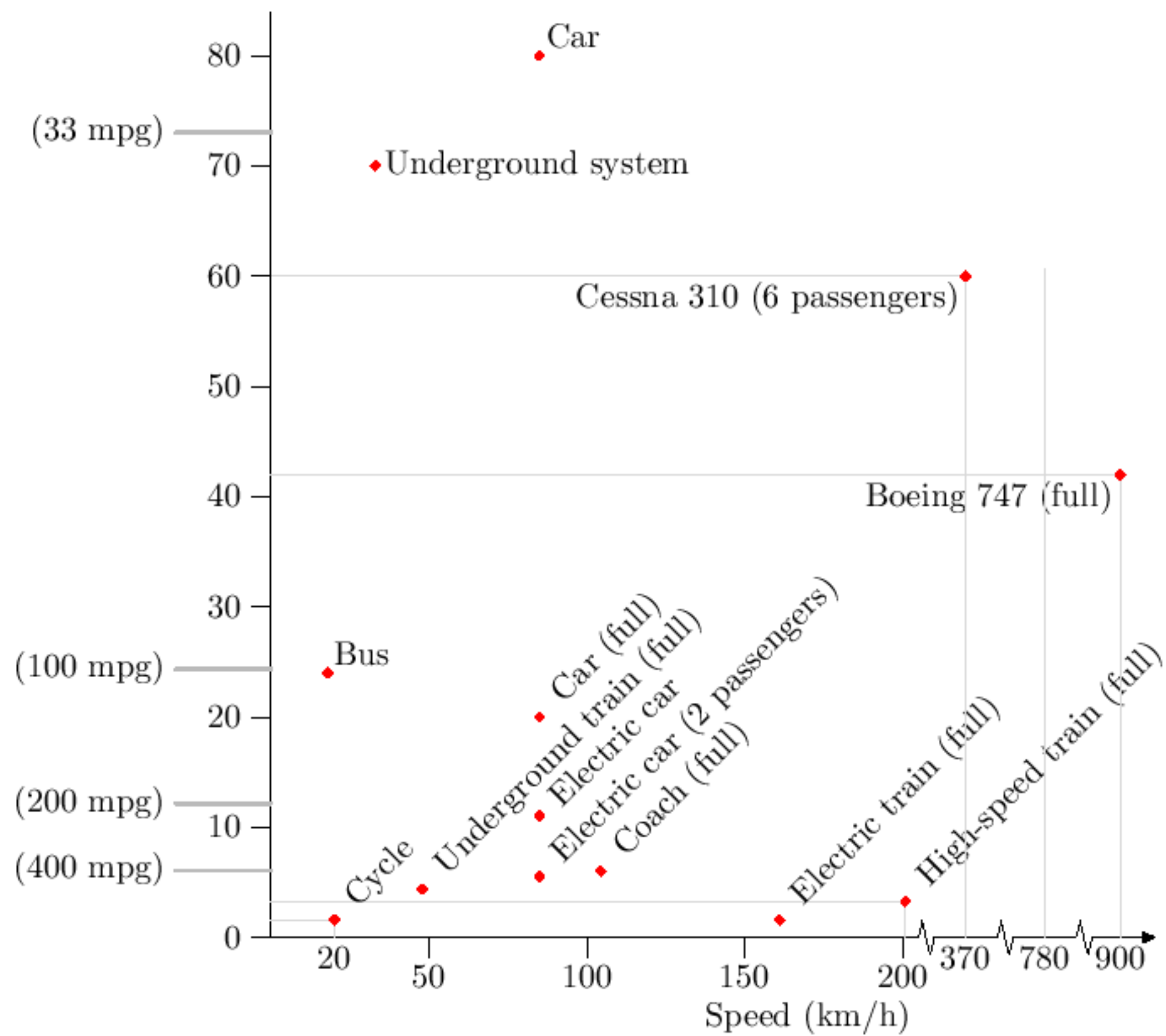


3 kWh per 100 km

<http://www.vectrix.com/>







Efficiency II

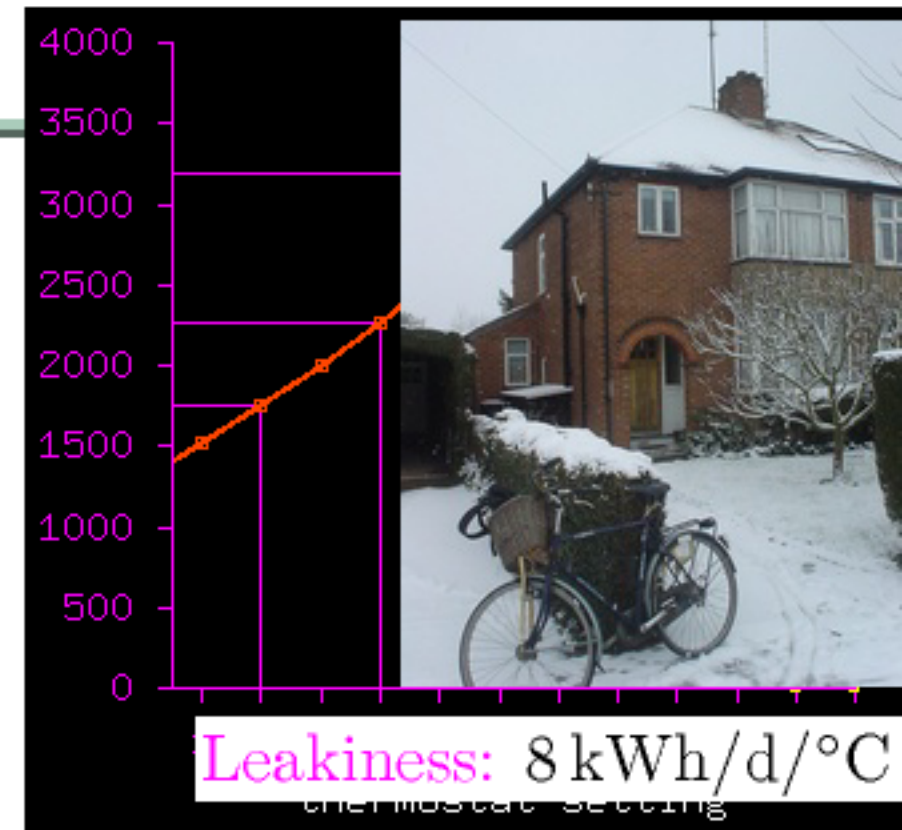
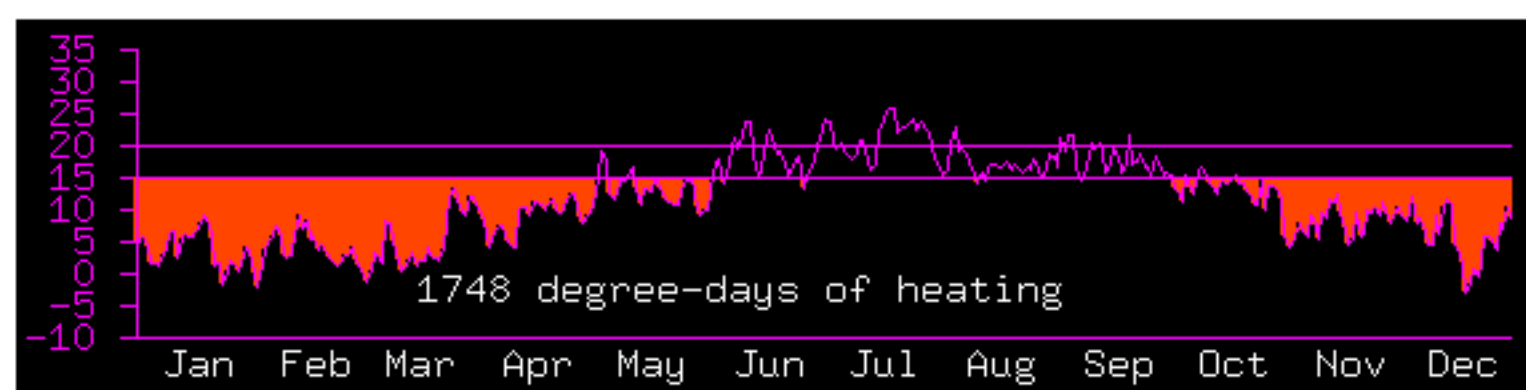
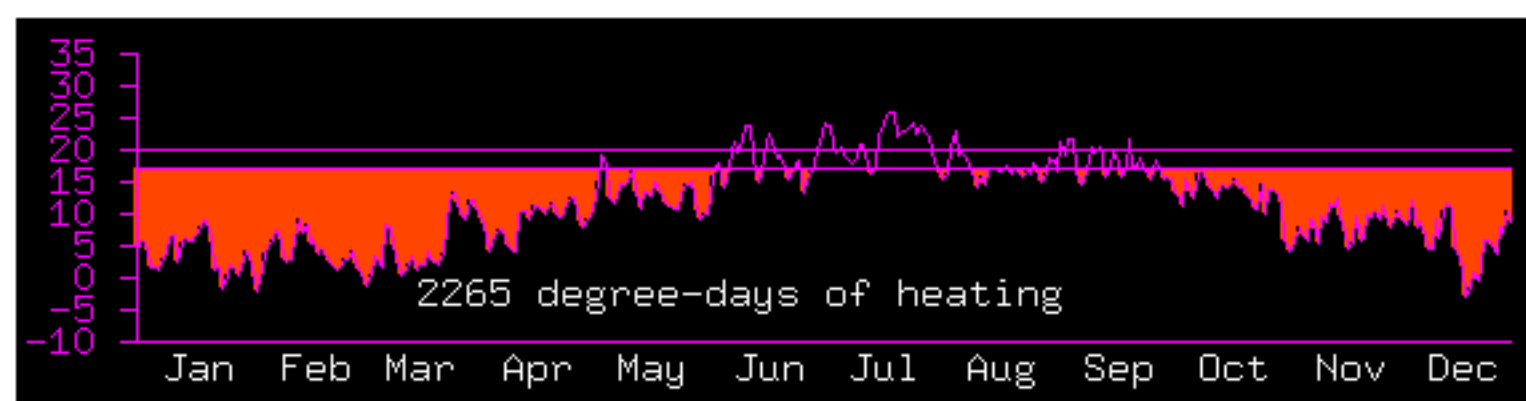
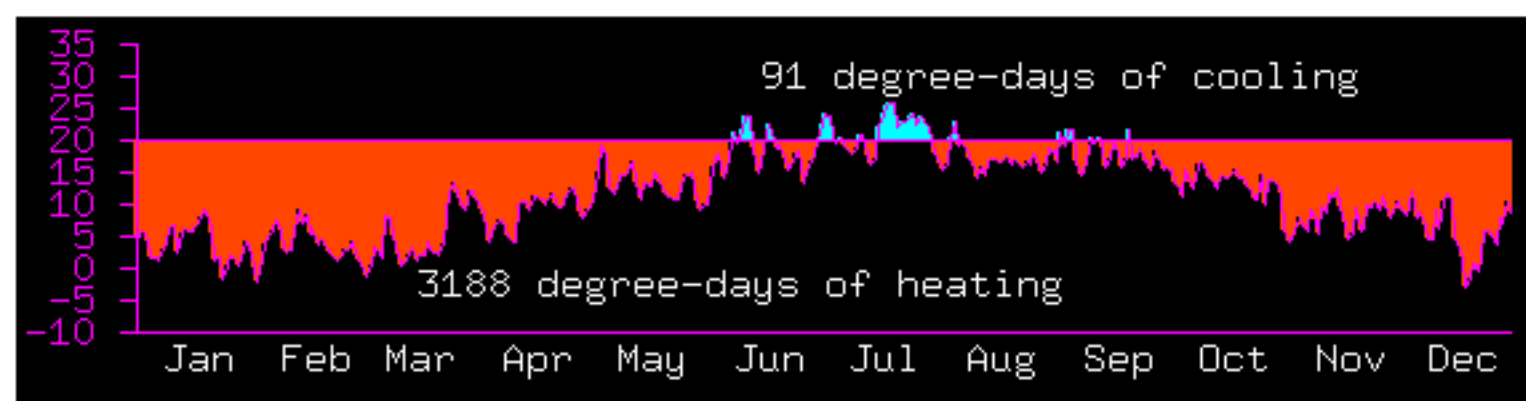
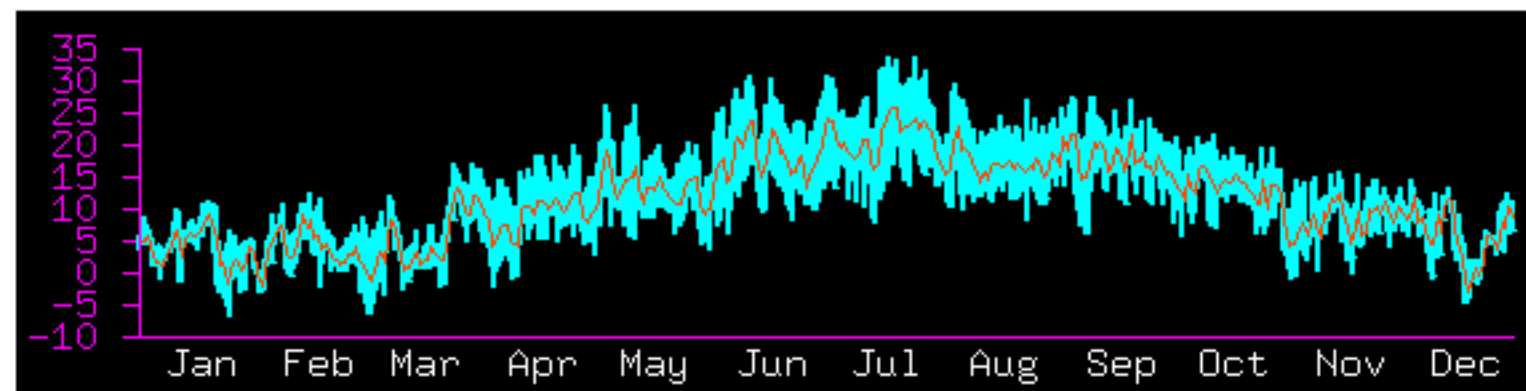
● Heating



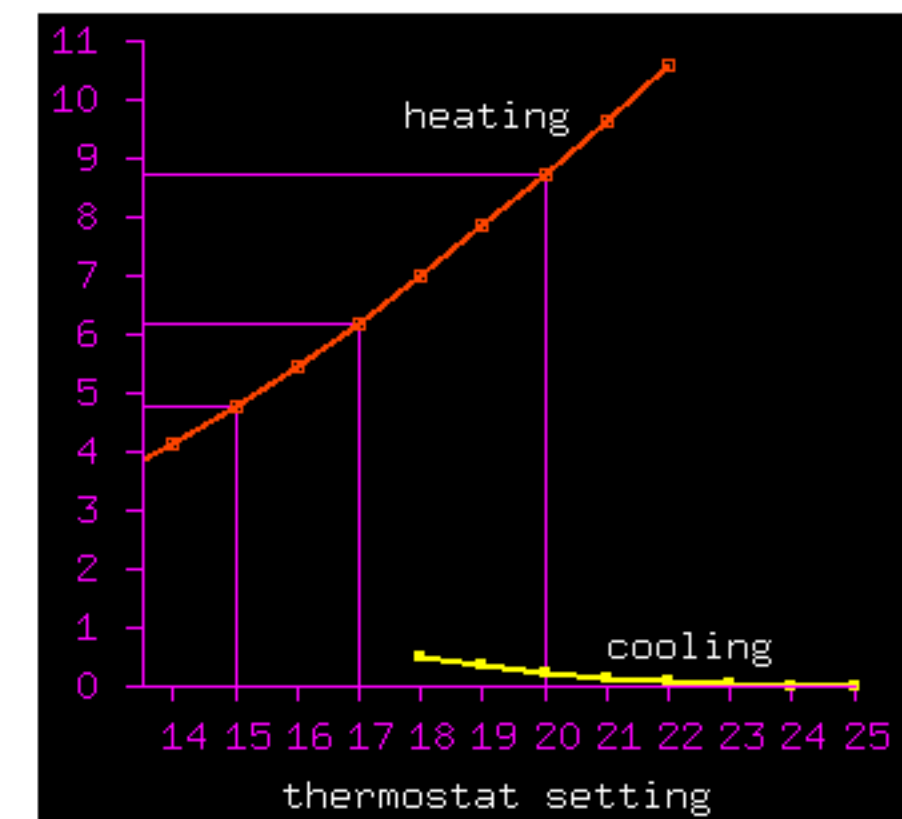
$$\begin{array}{l} \text{Heat loss} = \text{Leakiness} \times \text{Average temperature difference} \\ (\text{kWh/d}) \quad (\text{kWh/d/}^{\circ}\text{C}) \quad (^{\circ}\text{C}) \end{array}$$

Turn the thermostat down

$$\text{Heat loss (kWh/d)} = \text{Leakiness (kWh/d/}^{\circ}\text{C)} \times \text{Average temperature difference (}^{\circ}\text{C)}$$



Average temperature difference



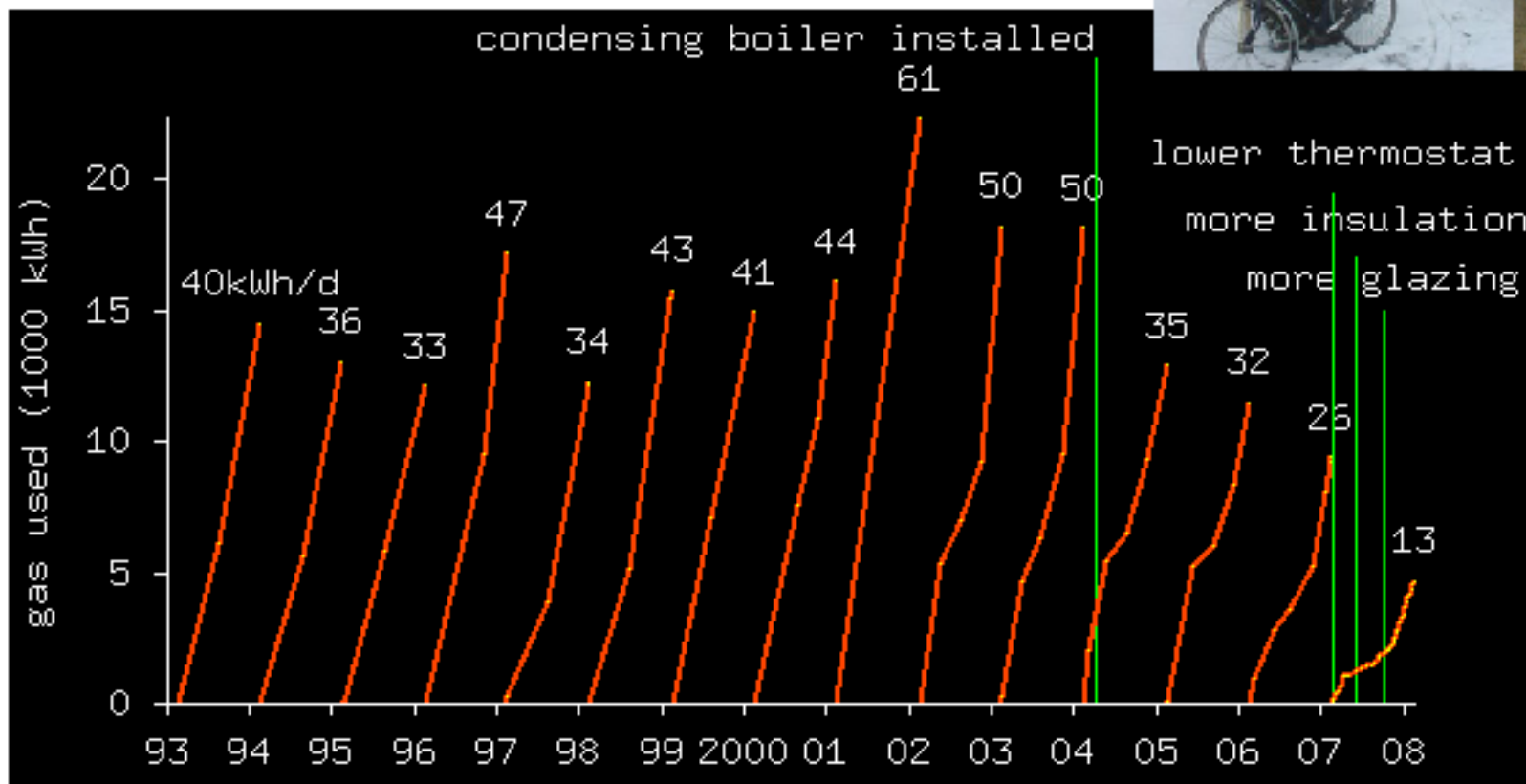
Reduce leakiness



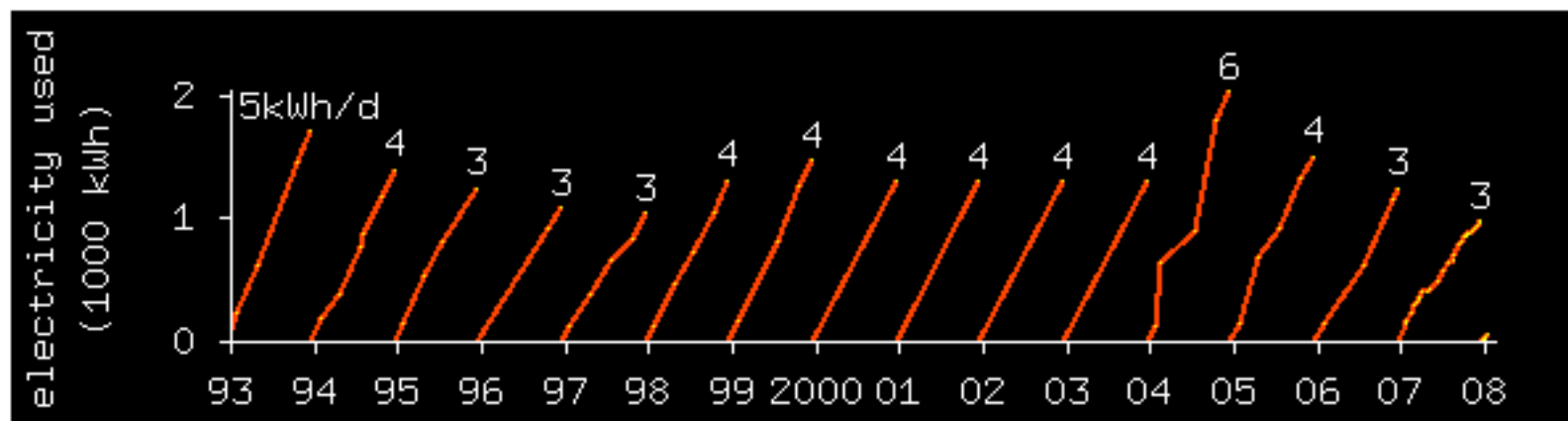
New leakiness: $6 \text{ kWh/d/}^{\circ}\text{C}$

Read your meters!

● Gas

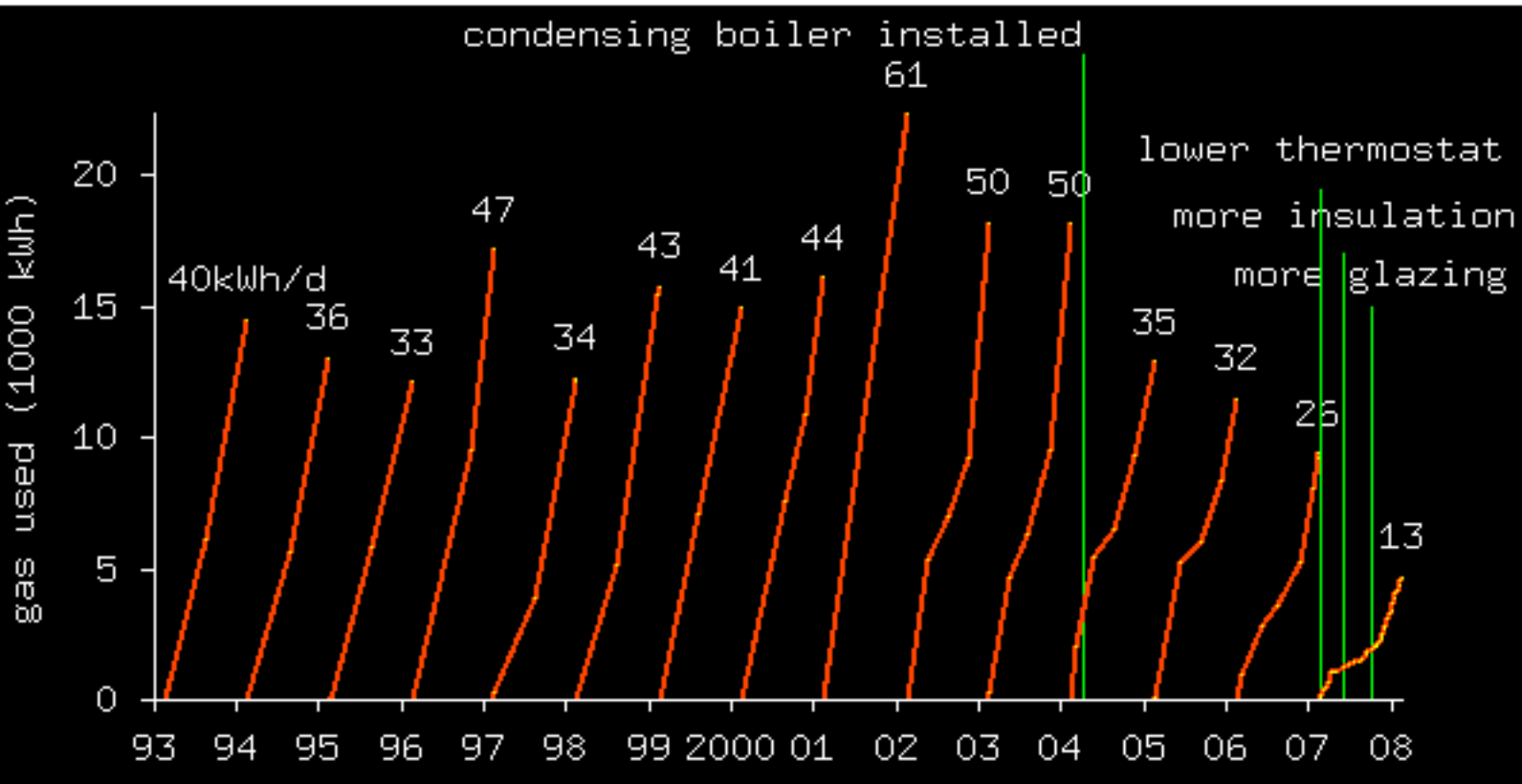


● Electricity

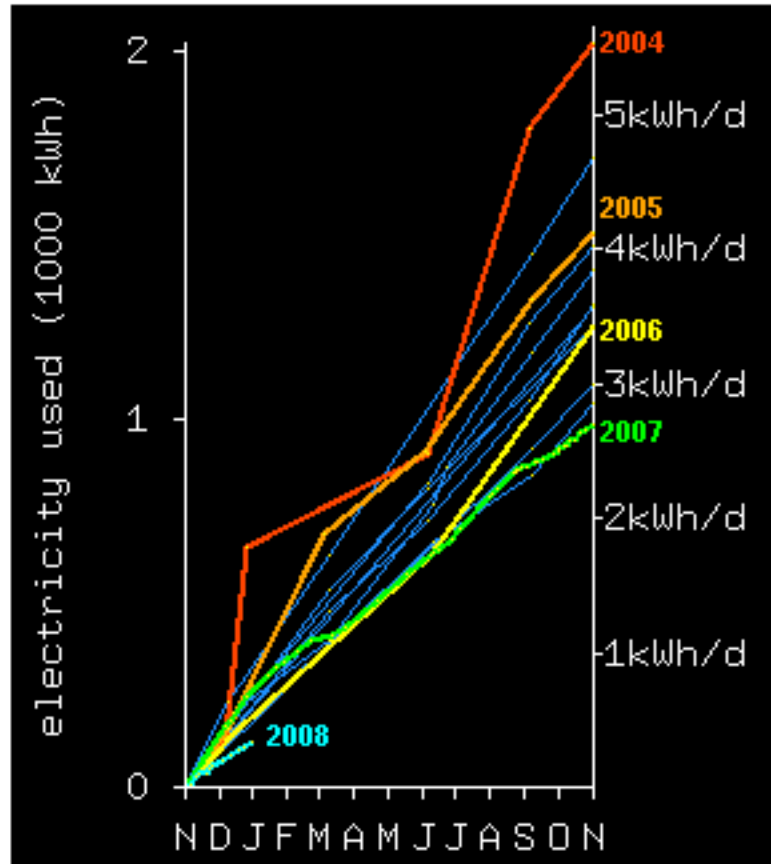
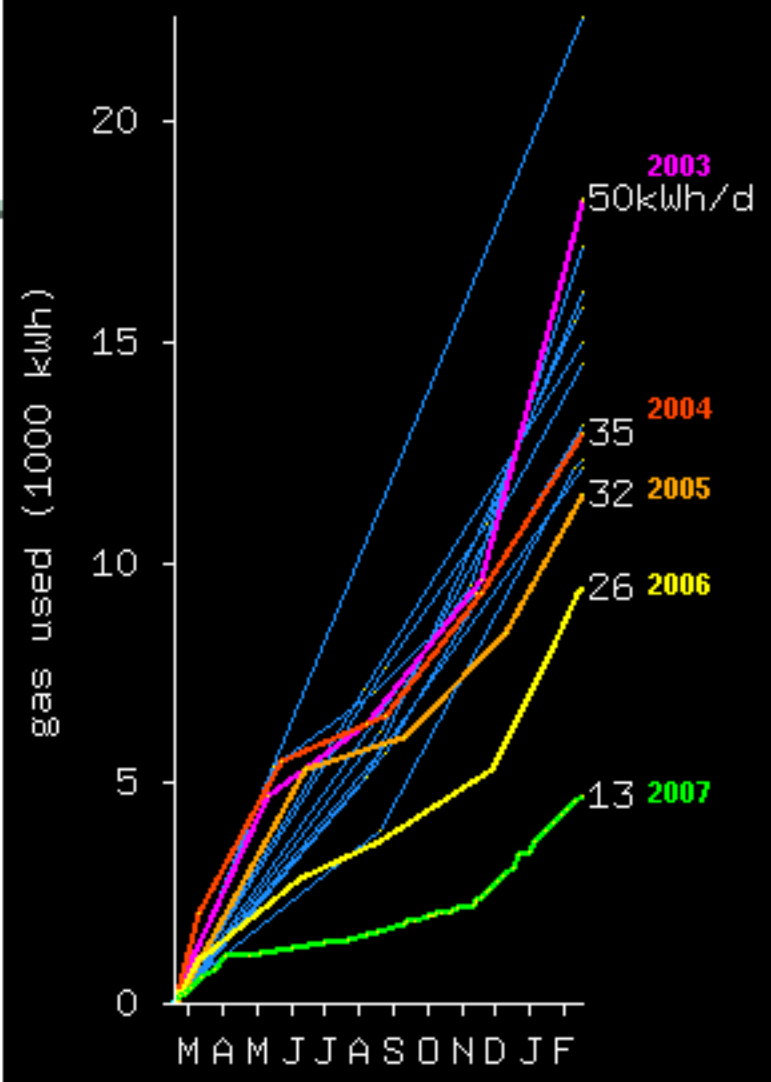
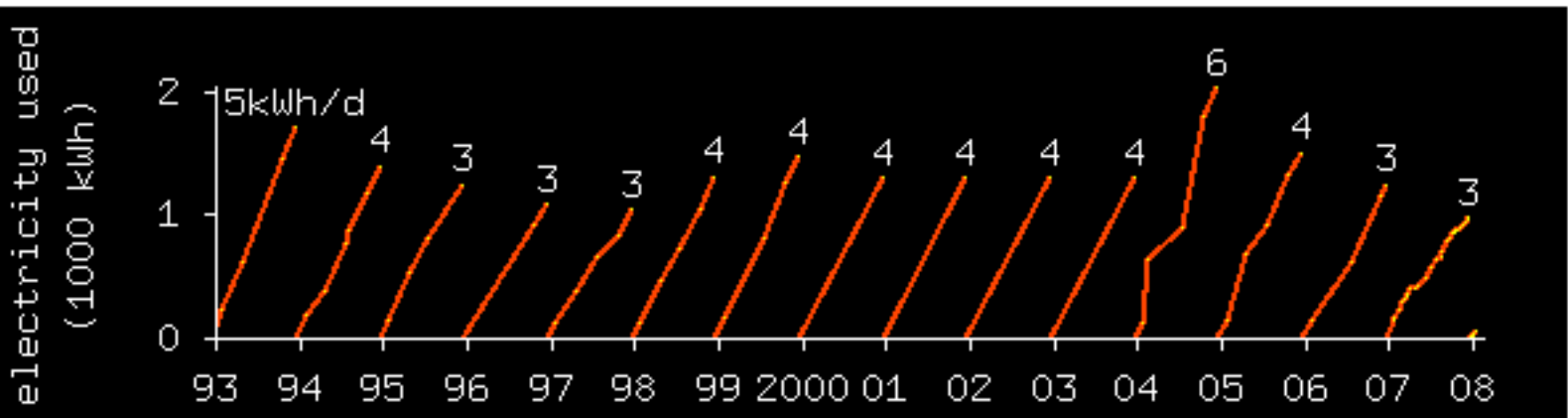


Read your meters!

Gas



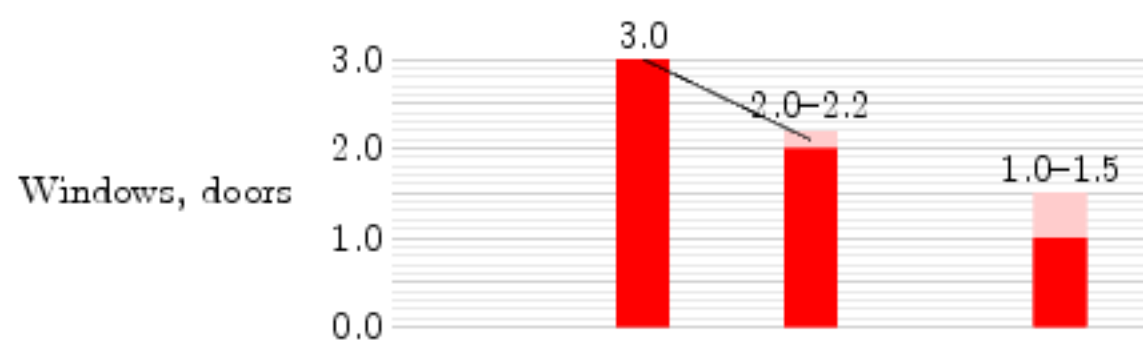
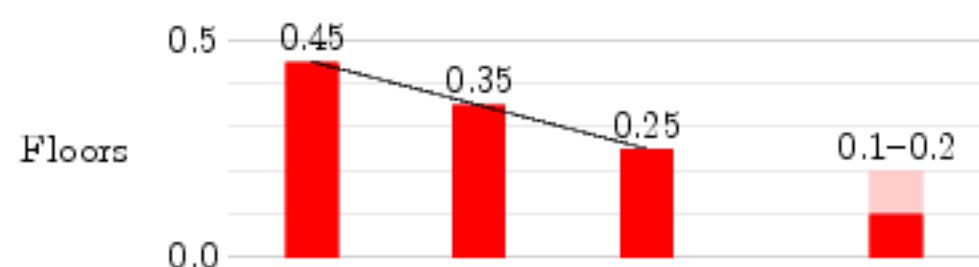
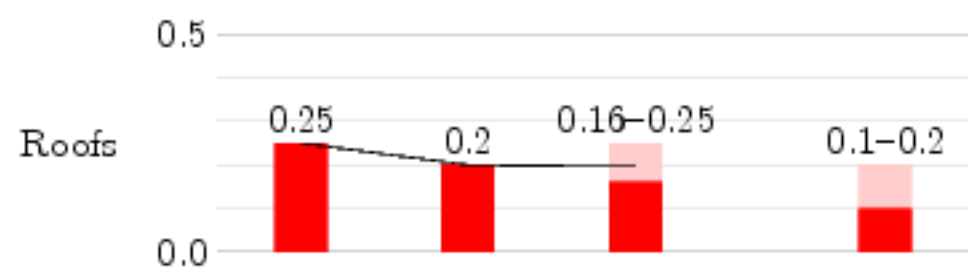
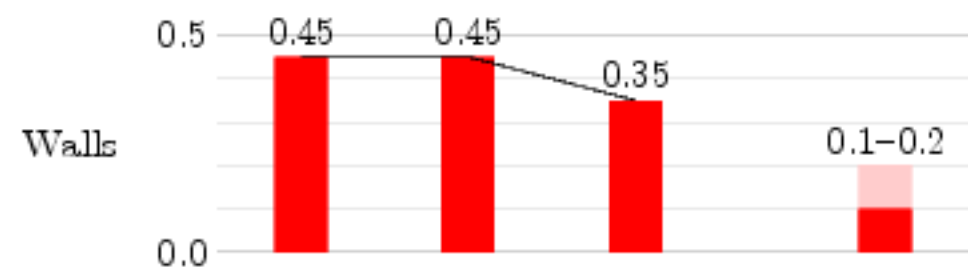
Electricity



Maximum
U-values
(W/m²/K)

England and Wales
1985 1991 2002

Sweden



Heating without fossil fuels

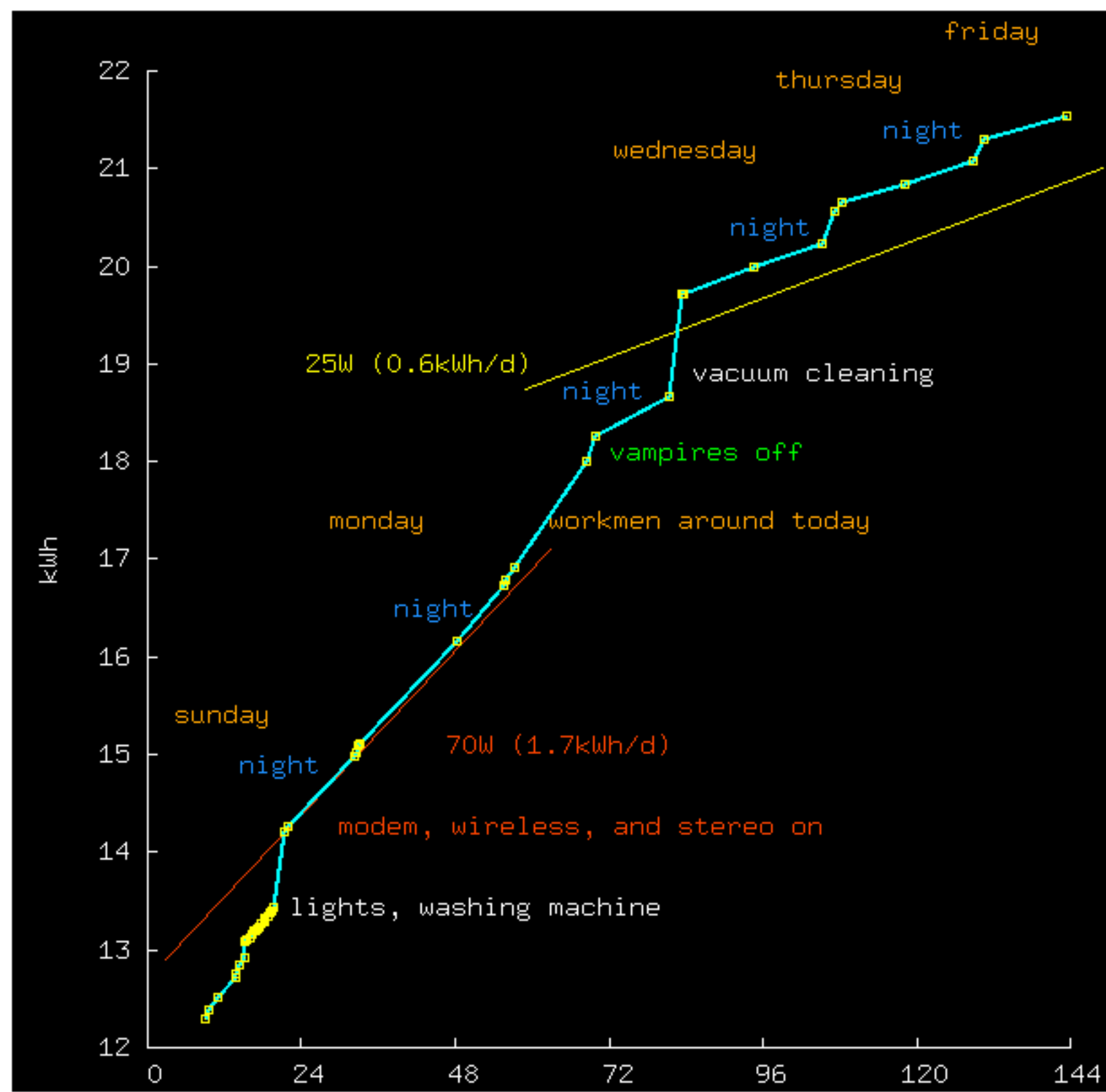
- Heat pumps, powered by electricity
 - Ground-source heat pumps
 - Air-source heat pumps



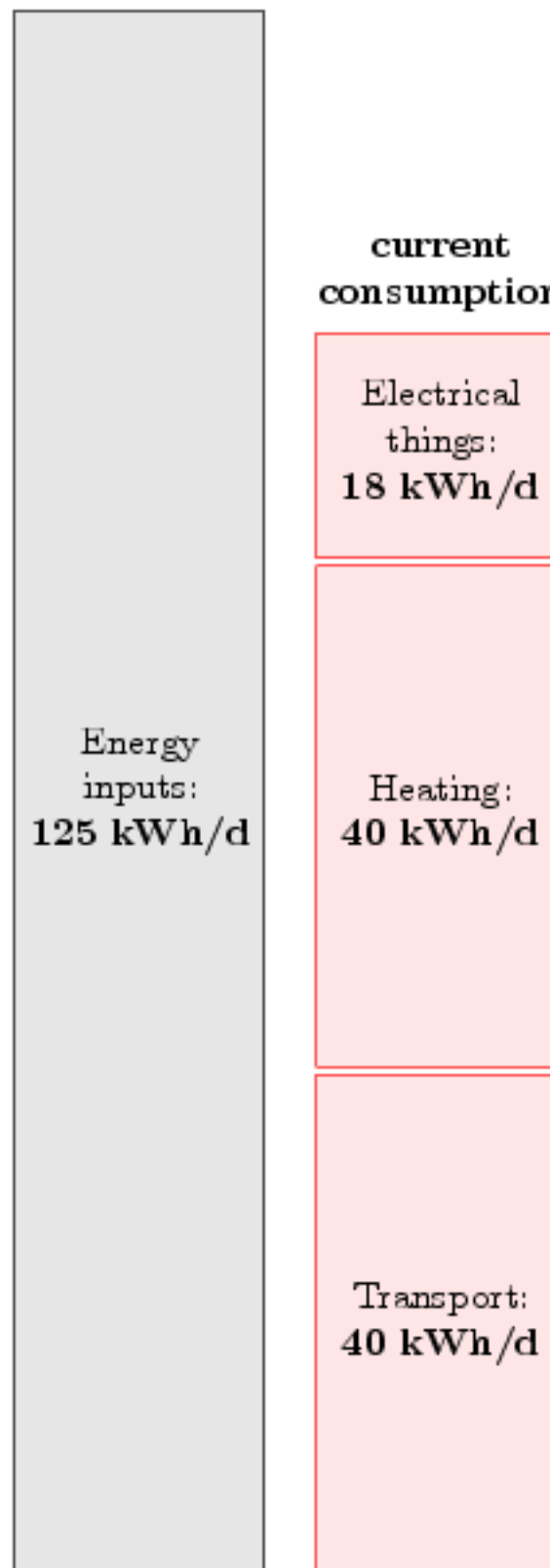
4 times better than ordinary electric heating

Efficiency in the offing

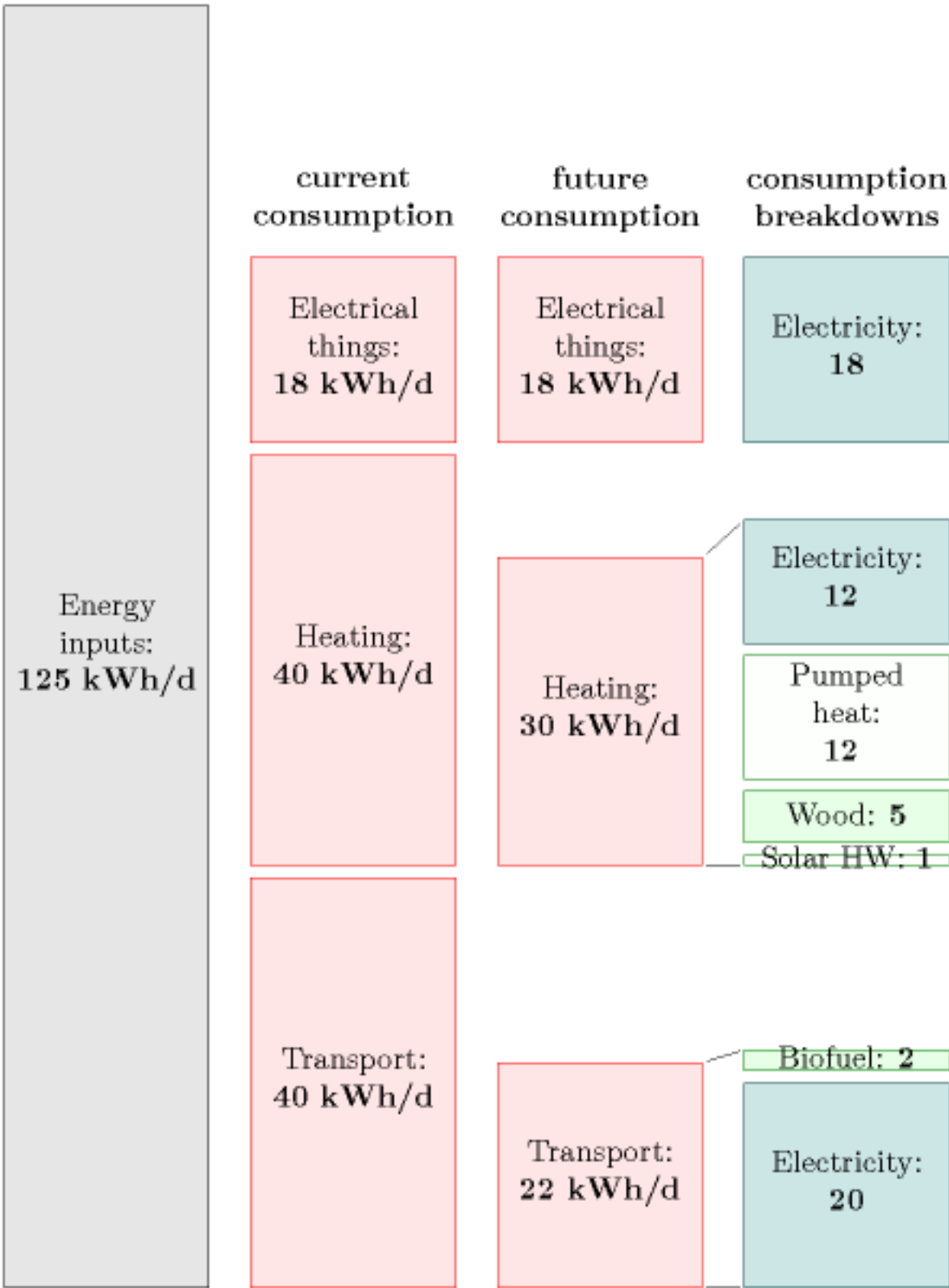
● Electricity



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

Plan D: 'Diversity'



40GW; triple coal imports



7 sq m / p

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



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



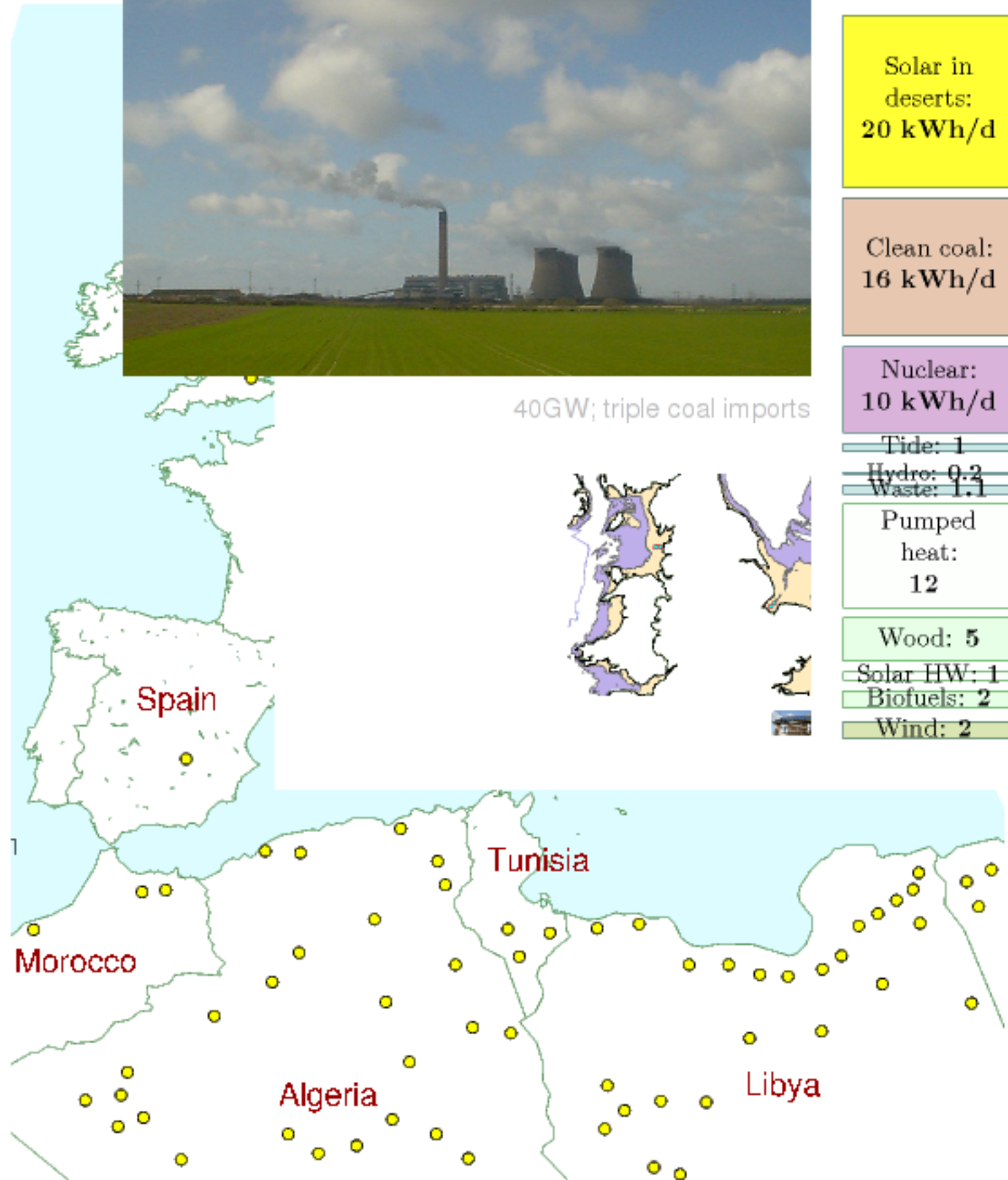
upgrade all current sites



all municipal waste incinerated, and equal agri. waste



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



Plan L: 'Libdem'



40GW; triple coal imports



7 sq m / p

- 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



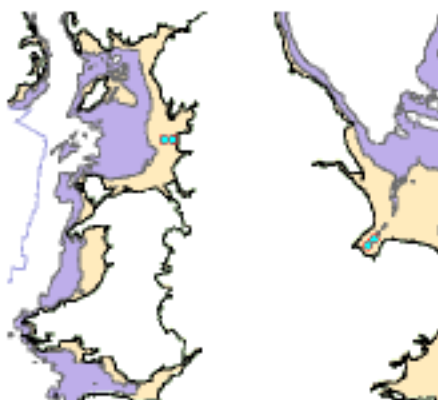
all municipal waste incinerated, and equal agri. waste



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: 9.2
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



Tidal lagoons (providing storage too)

Nuclear:
44 kWh/d

Tide: 0.7
Hydro: 0.3
Waste: 1.1

Pumped
heat:
12

Wood: 5

Solar HW: 1

Biofuels: 2

Wind: 4



110GW - twice France's nuclear



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

plan D	plan N	plan L	plan G	plan E
Clean coal: 16 kWh/d	Solar in deserts: 20 kWh/d	Solar in deserts: 16 kWh/d	Solar in deserts: 7	Nuclear: 44 kWh/d
Nuclear: 16 kWh/d	Clean coal: 16 kWh/d	Clean coal: 16 kWh/d	Tide: 3.7	
Tide: 3.7	Nuclear: 10 kWh/d	Tide: 3.7	Wave: 3	
Wave: 2	Tide: 1	Wave: 2	Hydro: 0.2	
Hydro: 0.2	Hydro: 0.2	Hydro: 0.2	Pumped heat: 12	Waste: 1.1
Waste: 1.1	Waste: 1.1	Waste: 1.1	Wood: 5	Tide: 0.7
Pumped heat: 12	Pumped heat: 12	Pumped heat: 12	Solar HW: 1	Hydro: 0.2
Wood: 5	Wood: 5	Wood: 5	Biofuels: 2	Waste: 1.1
Solar HW: 1	Solar HW: 1	Solar HW: 1	PV: 3	Pumped heat: 12
Biofuels: 2	Biofuels: 2	Biofuels: 2	Wind: 32	Wood: 5
PV: 3	Wind: 2	PV: 3		Solar HW: 1
Wind: 8		Wind: 8		Biofuels: 2
				Wind: 4
Diversity	NIMBY	Libdem	Green	Economist

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?

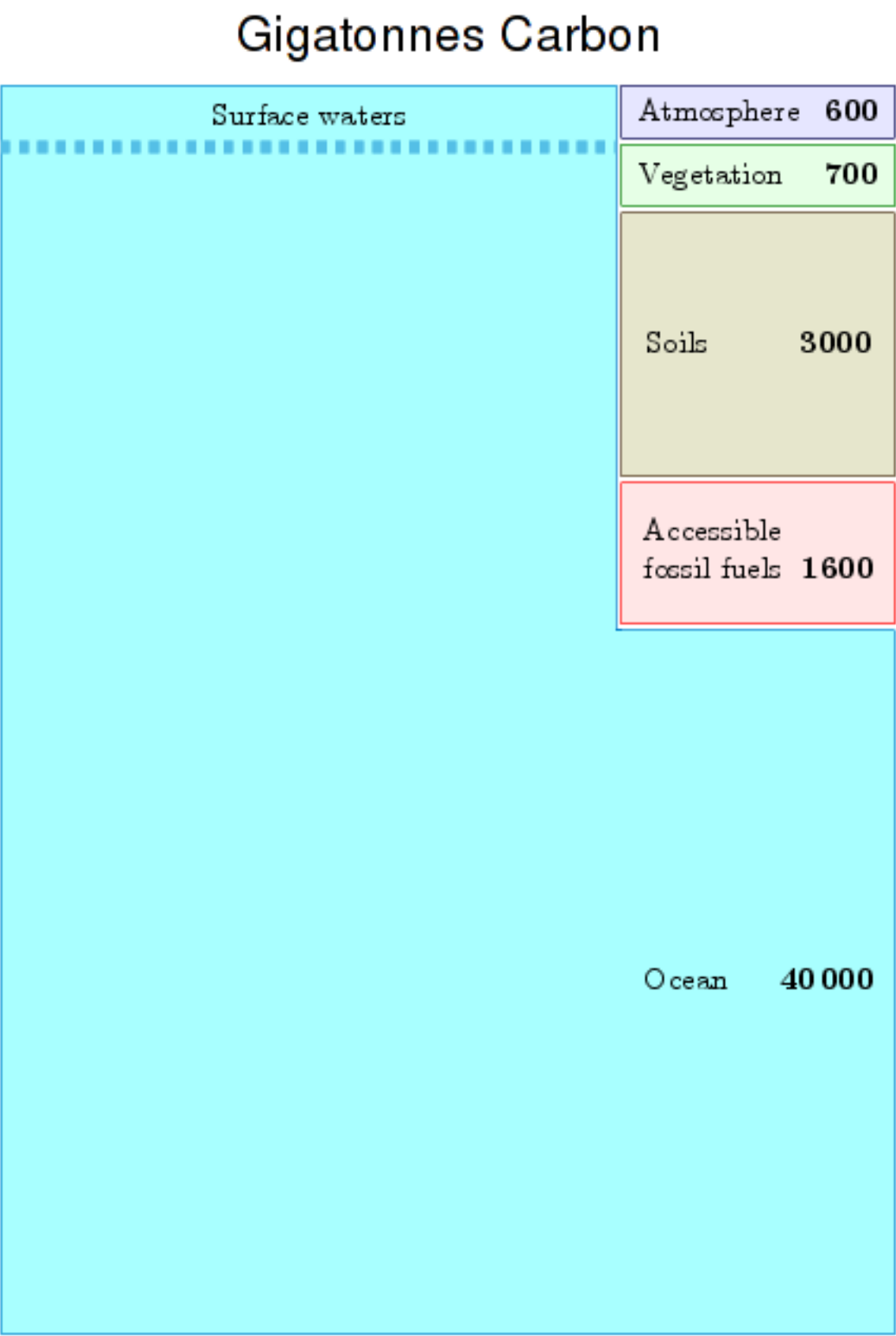


● Legislation

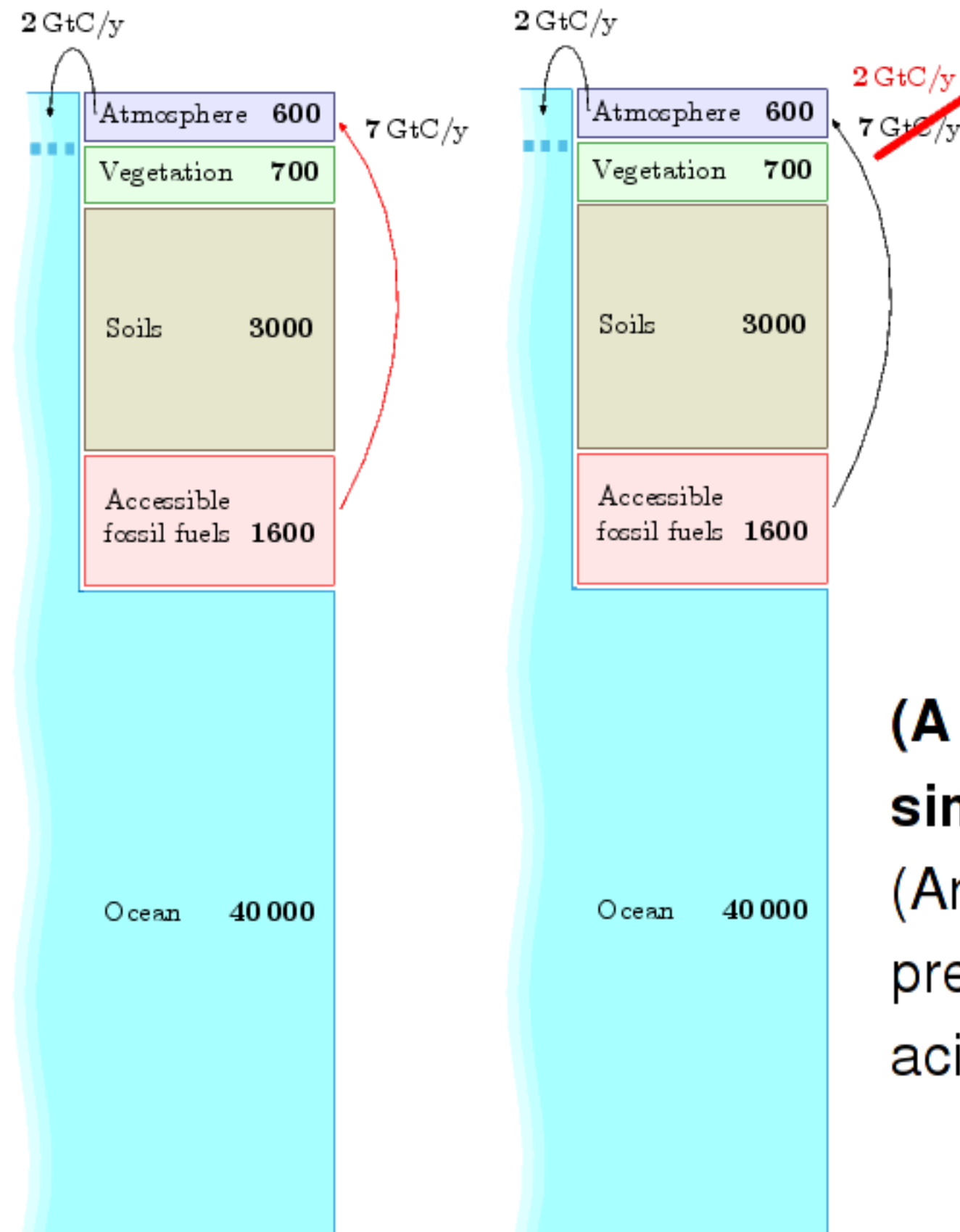
- Promotion of consumption bill
- Carbon tax to replace VAT
- Glorification of travel act

$$2 + 2 \neq 120$$

Carbon - where is it?

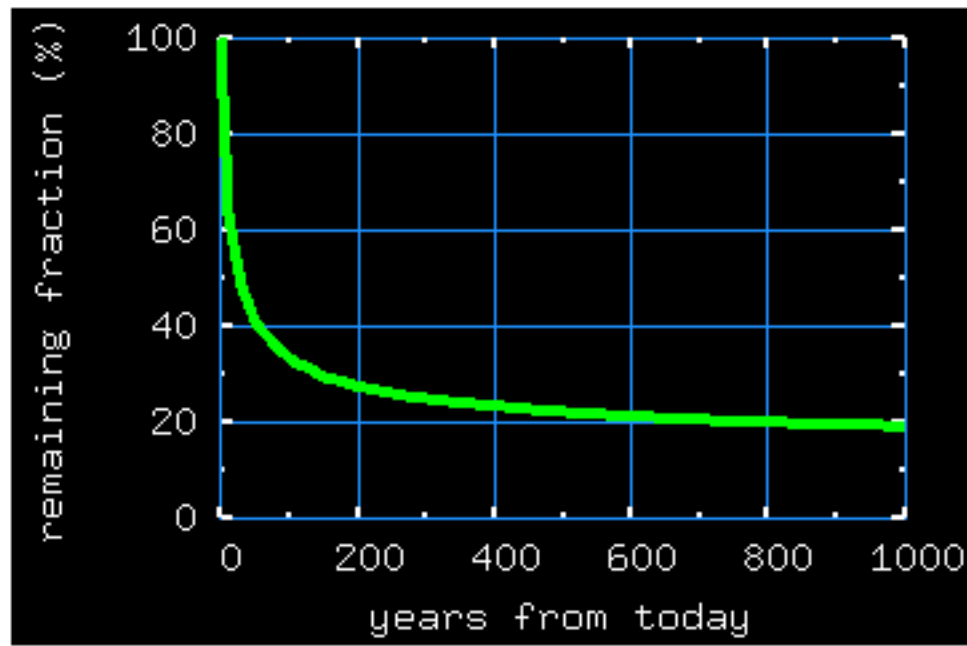
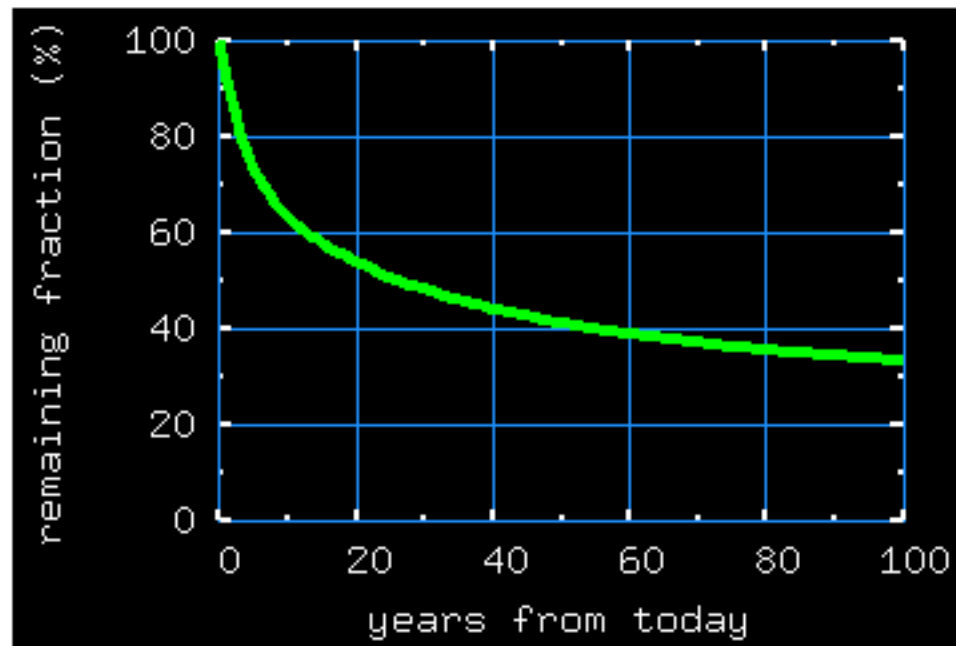


Carbon - where is it going? How to fix climate change

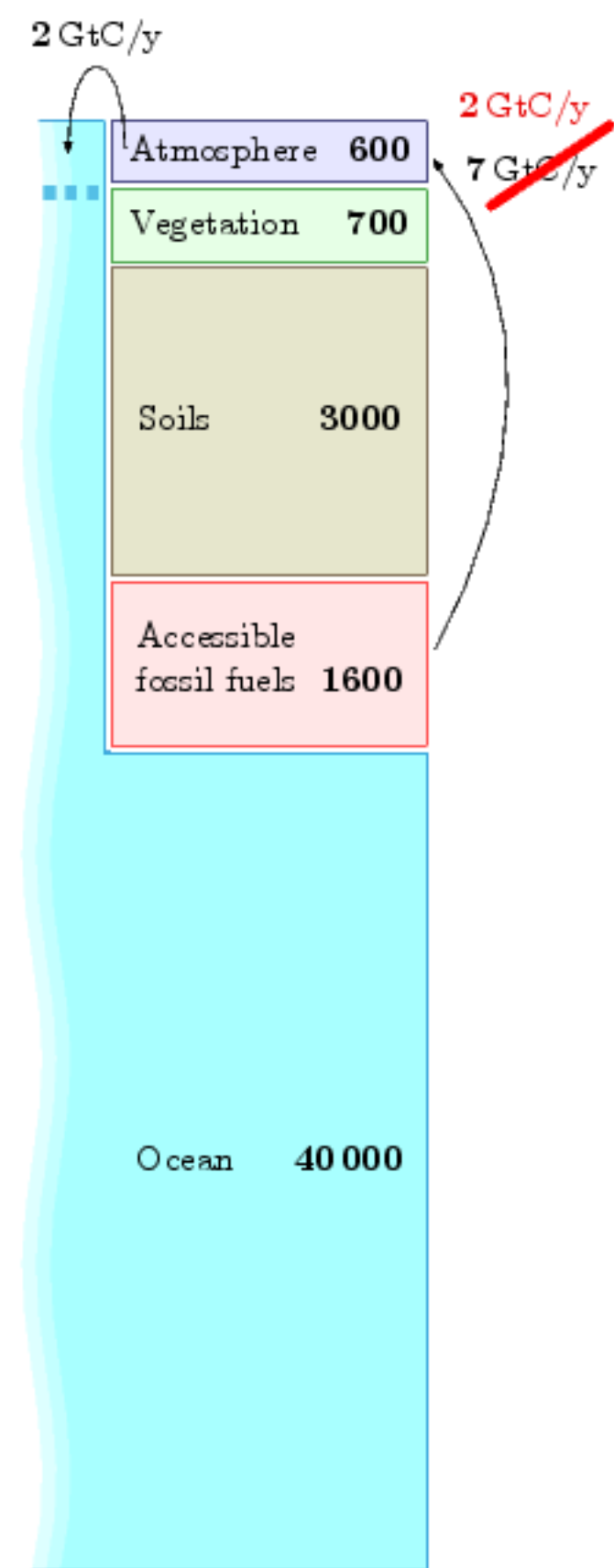
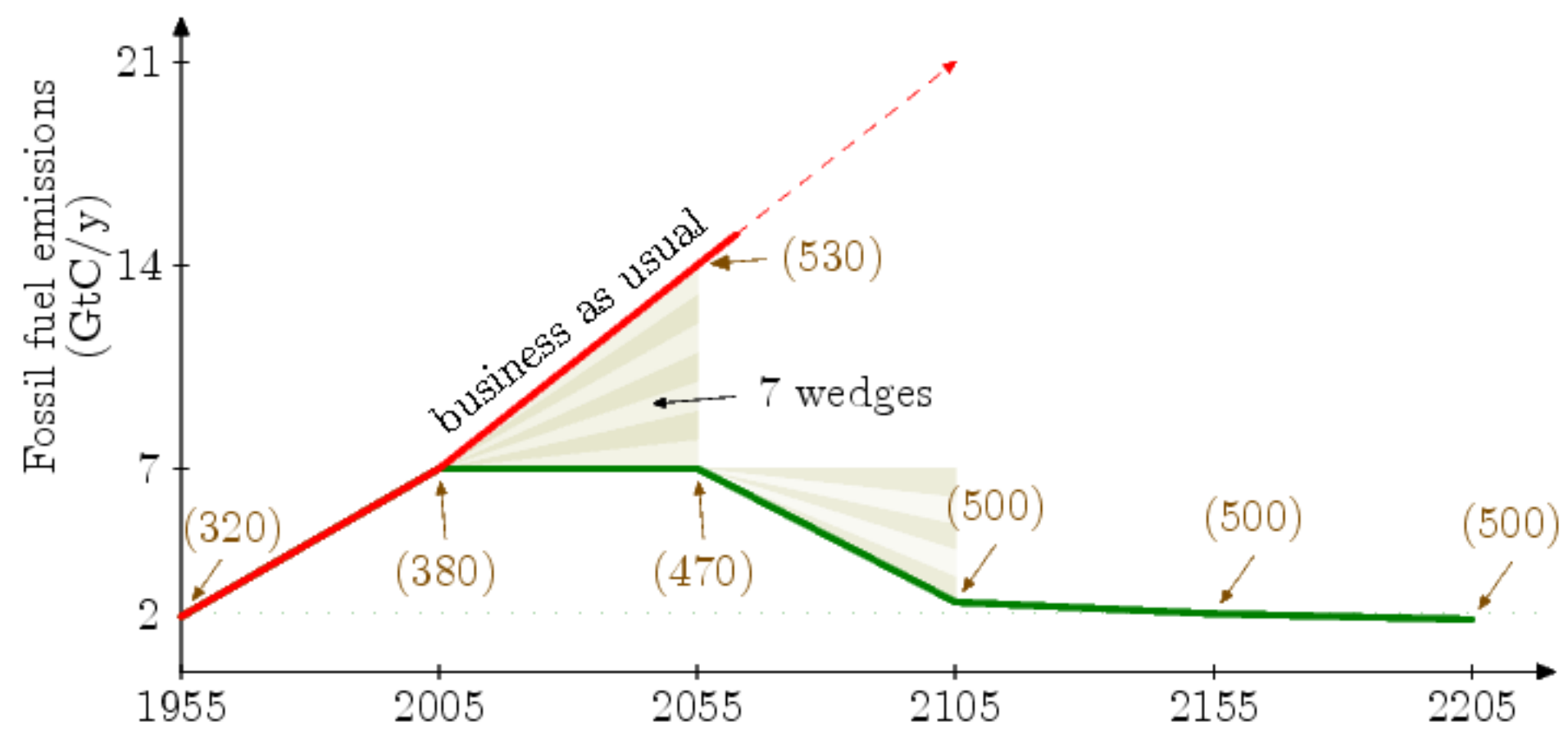


(A big simplification!)
(And this doesn't prevent ocean acidification)

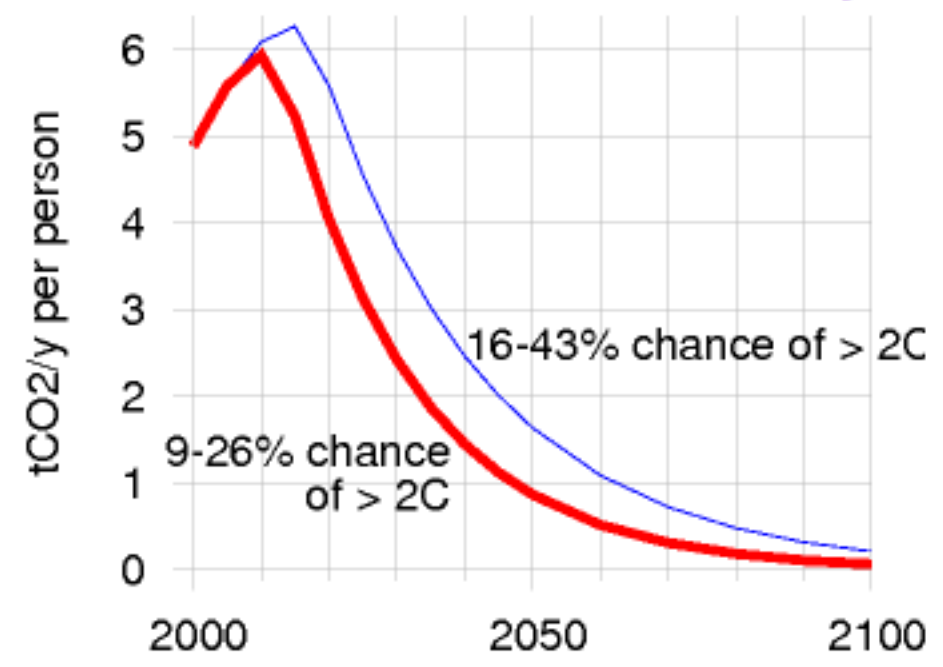
When does it go away?



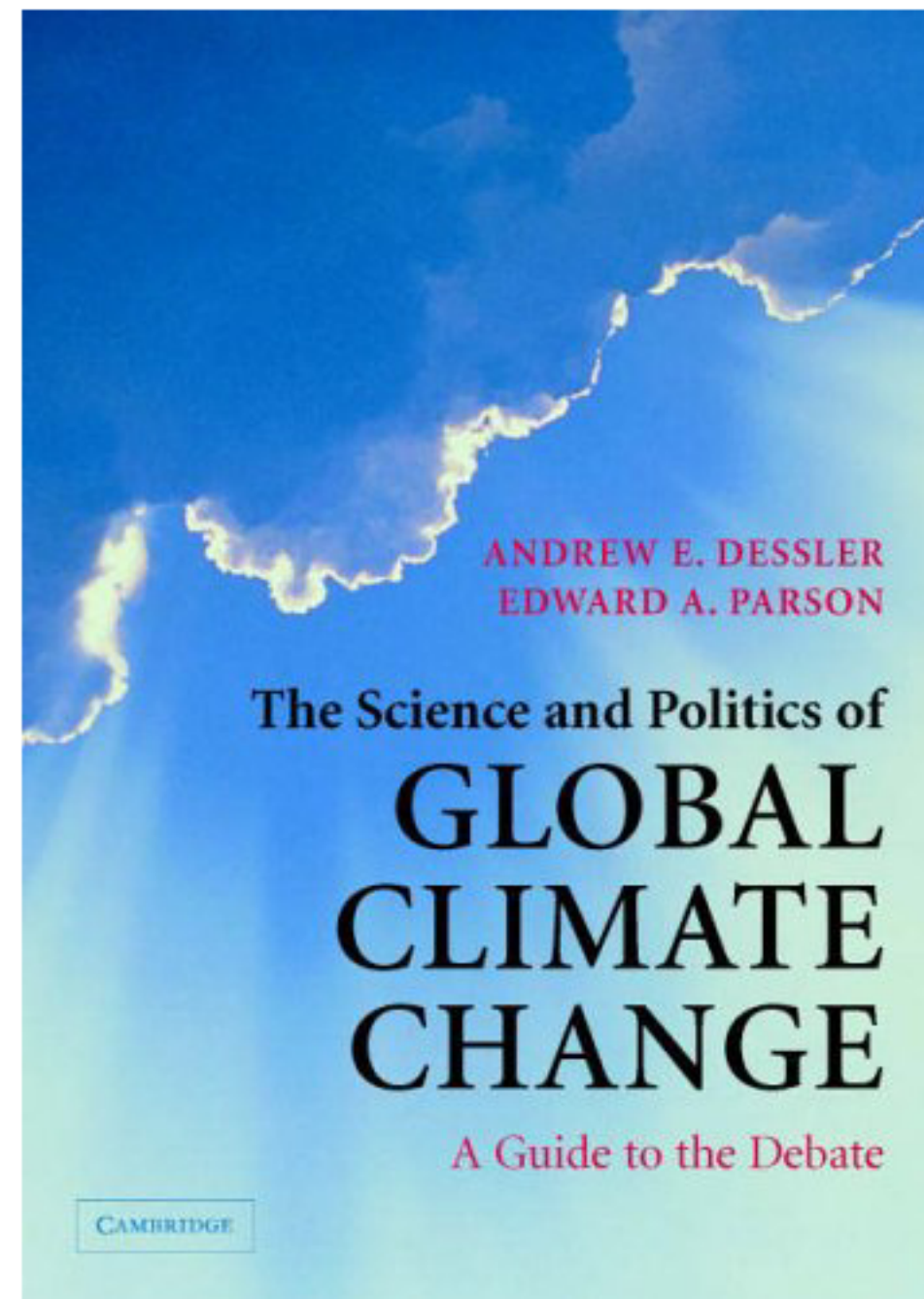
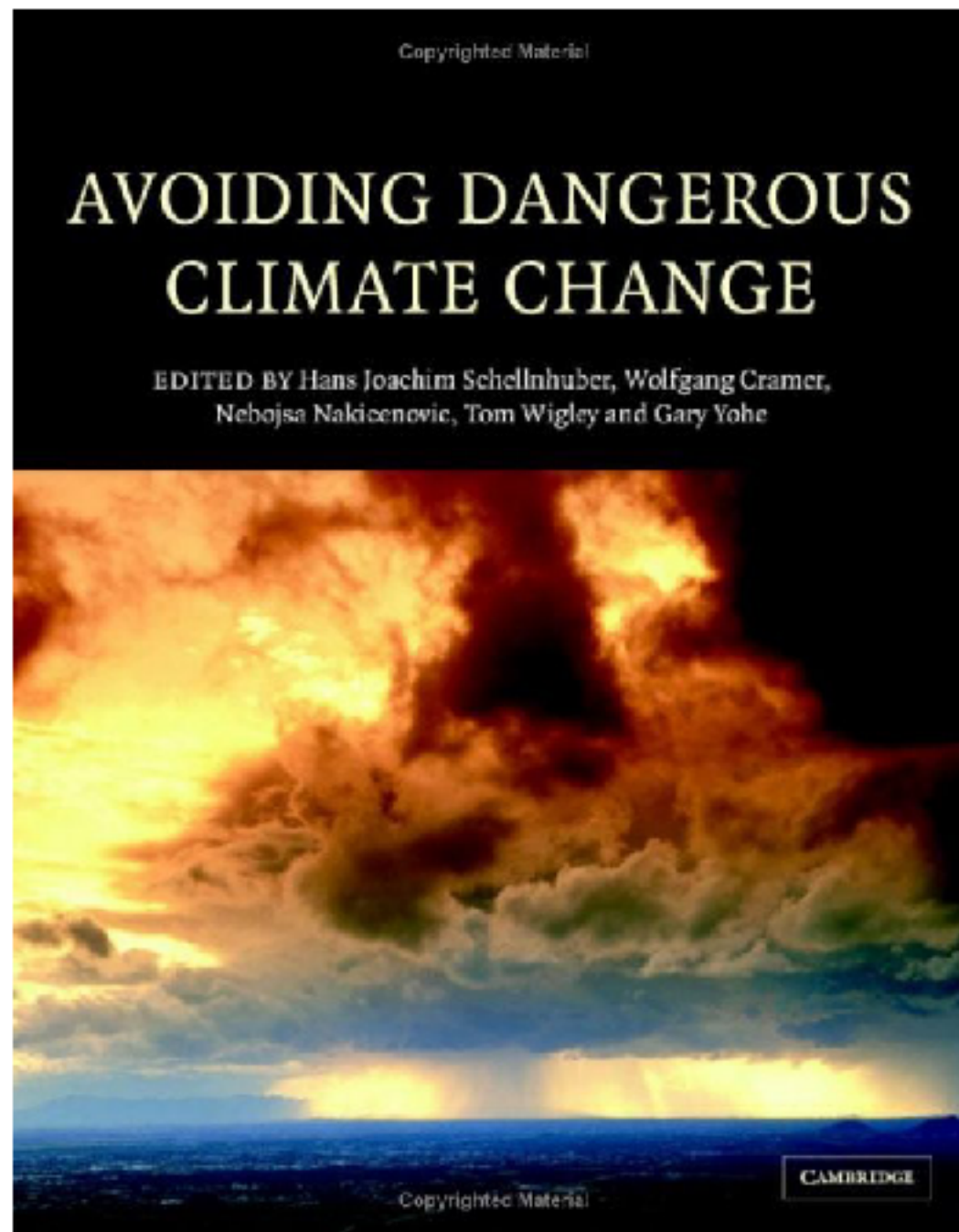
Socolow's model of CO2 emissions



Baer & Mastrandrea: Socolow's trajectory not good enough



Good books



Carry on burning

- Sequestration

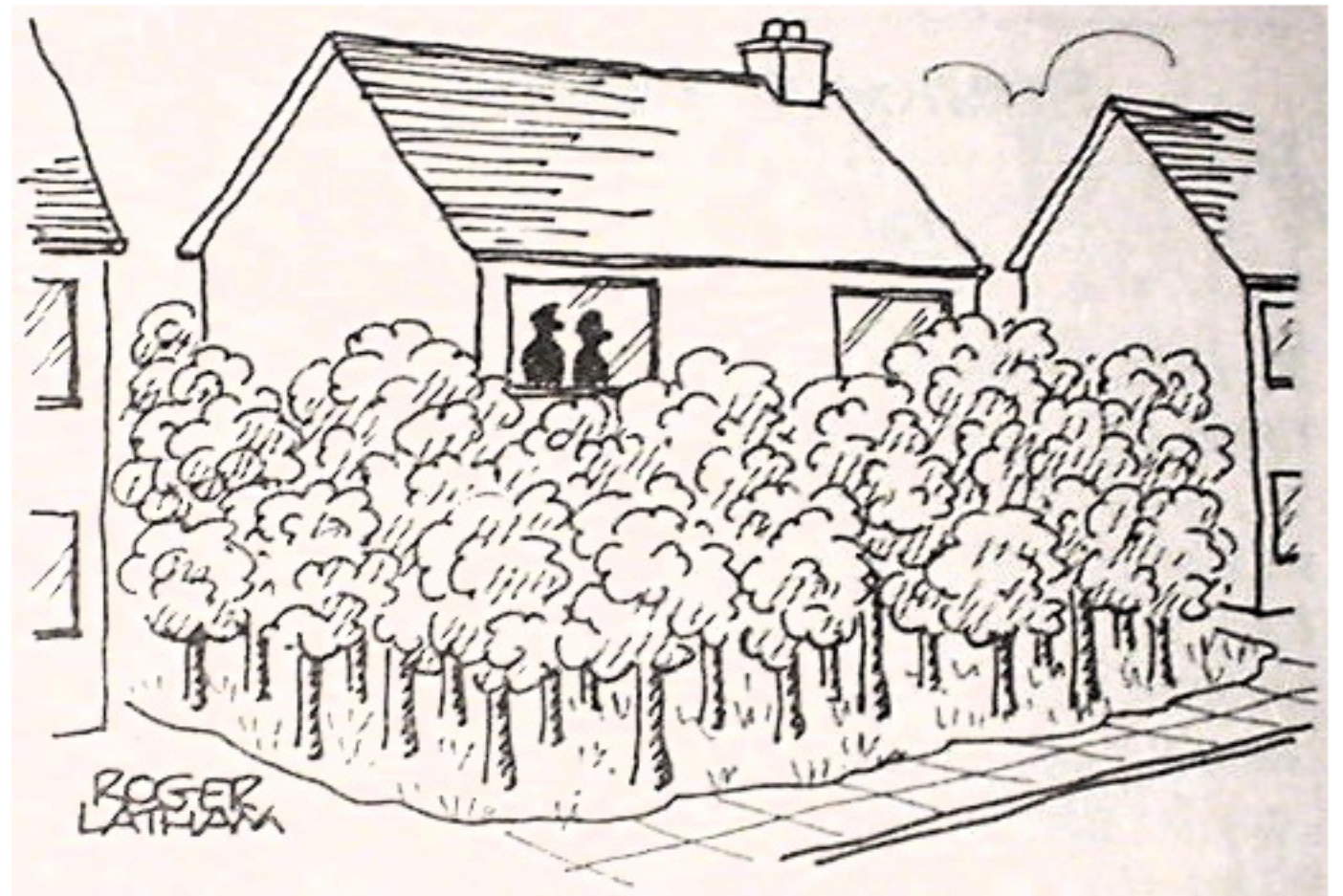
(This is NOT sustainable!)

- 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 m³ of dry wood per hectare per year,
i.e., 0.05 kg of Carbon per m² per year. So to balance
pollution associated with 100 kWh per day, need

50 000 m² of forest

and a permanent storage place to put

12 m³ of dry wood per year.

[UK's area is 4 000 m² per person.]

The company has a 10 acre plot. That is only 40,000 m².

● Alternative model

- take barren land and produce forest on it

● Mature forest contains

25 kg/m² of 'standing phytomass',
i.e., 5 kg of Carbon per m².

To balance pollution associated with 100 kWh per day,
need

100 m² of new forest
created per year.

[UK's area is 4 000 m² per person.]

The company has a 10 acre plot. That is only 40,000 m².
So they can service 400 customers for one year in their 10 acres.

Sequestration cost per molecule (from thin air)



Ideal concentration machine

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

Ideal liquifaction machine

$$kT \ln \frac{V_1}{V_2} = kT \ln 1000 = 7 kT$$

Total

$15 kT$ per molecule

Ideal sequestration cost

$15 kT$ per molecule
is 0.24 kWh per kg of CO_2 .

Compare with energy created when emitting CO_2 :

$$\frac{1}{3} \text{ kg of petrol} \longrightarrow 4 \text{ kWh} + 1 \text{ kg CO}_2.$$

What's efficiency of generator and compressor?

Realistic sequestration cost

Production:

$$1 \text{ kg of CO}_2 \quad \longleftrightarrow \quad 4 \text{ kWh heat} \quad \longleftrightarrow \quad \frac{1.3 \text{ kWh useful energy}}{3}$$

Sequestration:

$$1 \text{ kg of CO}_2 \quad \longleftrightarrow \quad 0.24 \text{ kWh ideal cost} \quad \longleftrightarrow \quad 0.7 \text{ kWh actual cost} \times 3$$

USEFUL IDENTITIES

$$1 kT \text{ per molecule} = 2.5 \text{ kJ/mol}$$

$$1 \text{ kWh} = 3600 \text{ kJ}$$

● 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.

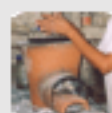
You can click on the calculator button to calculate your share of the emissions created during your journey and the cost of neutralising the impact of those emissions. If you decide to pay this cost, the money raised will be used by Climate Care to fund sustainable energy projects around the world on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



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

CO₂ 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 CO₂

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

BRITISH AIRWAYS

CO₂ Emissions calculator

Climate Care

Click here
to calculate/offset
your CO₂

- ⌘ When you fly, drive or heat your home, your CO₂ emissions add to global warming.
- ⌘ Climate Care lets you offset these emissions by funding sustainable energy and reforestation projects.

Stamp out

global warming

● "Offsetting"

If true cost of “neutralizing” 2 tonnes of CO₂ 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



make a donation

Every £10 buys 1 tree and offsets 1 tonne of CO₂

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



Reducing CO2 emissions

"I feel bad that using my car contributes to climate change, but now I've found there's a way we can all start to redress the balance"

► Become a CO2 neutral driver at targetneutral.com



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.



targetneutral

targetneutral

What it is
How it works→

Projects

How CO2 emissions
are reduced→

Your Environment

Climate change & other
ways you can help→

Advisory Panel

Independent advice
& third party views→

Action

Become CO2 neutral→
[Log in](#)

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 CO2 emissions
one car at a time

Brought to
you by BP



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Glossary

FAQ

Contact us

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.

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

Lifestyle change?



Changing energy consumption



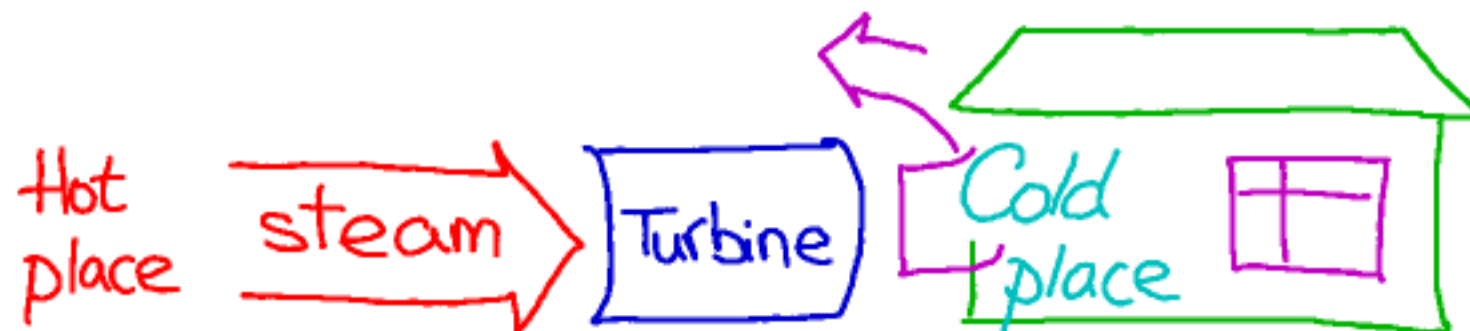
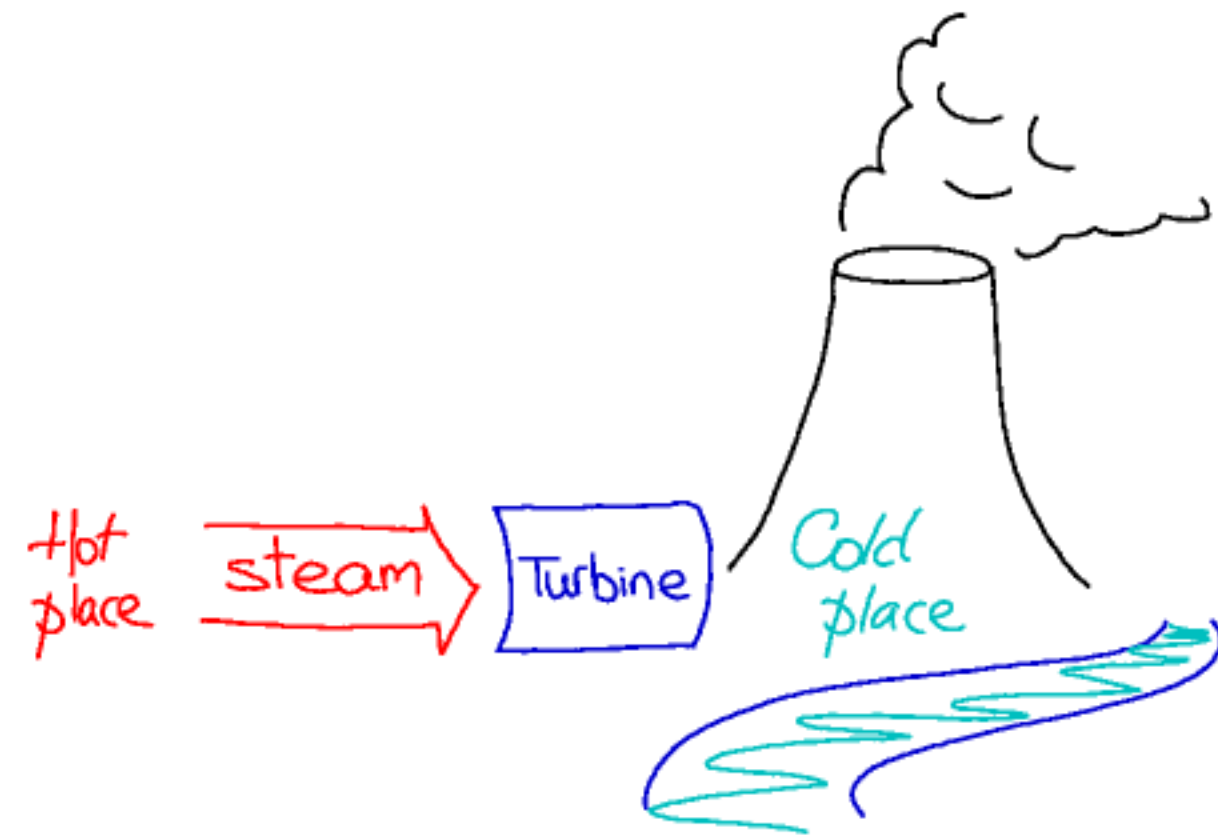


"A reduction in growth is not an acceptable path to a lower-carbon world."

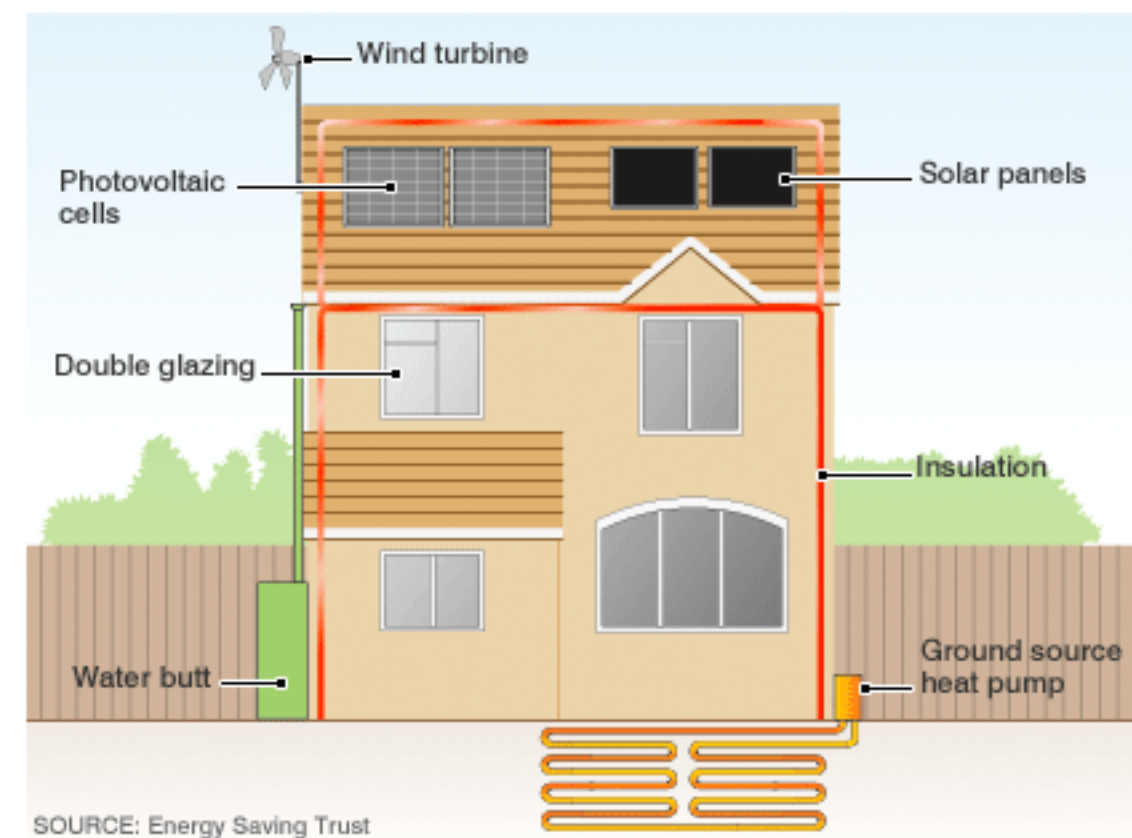


"the truth is no country is going to cut its growth or consumption substantially in light of a long-term environmental problem"

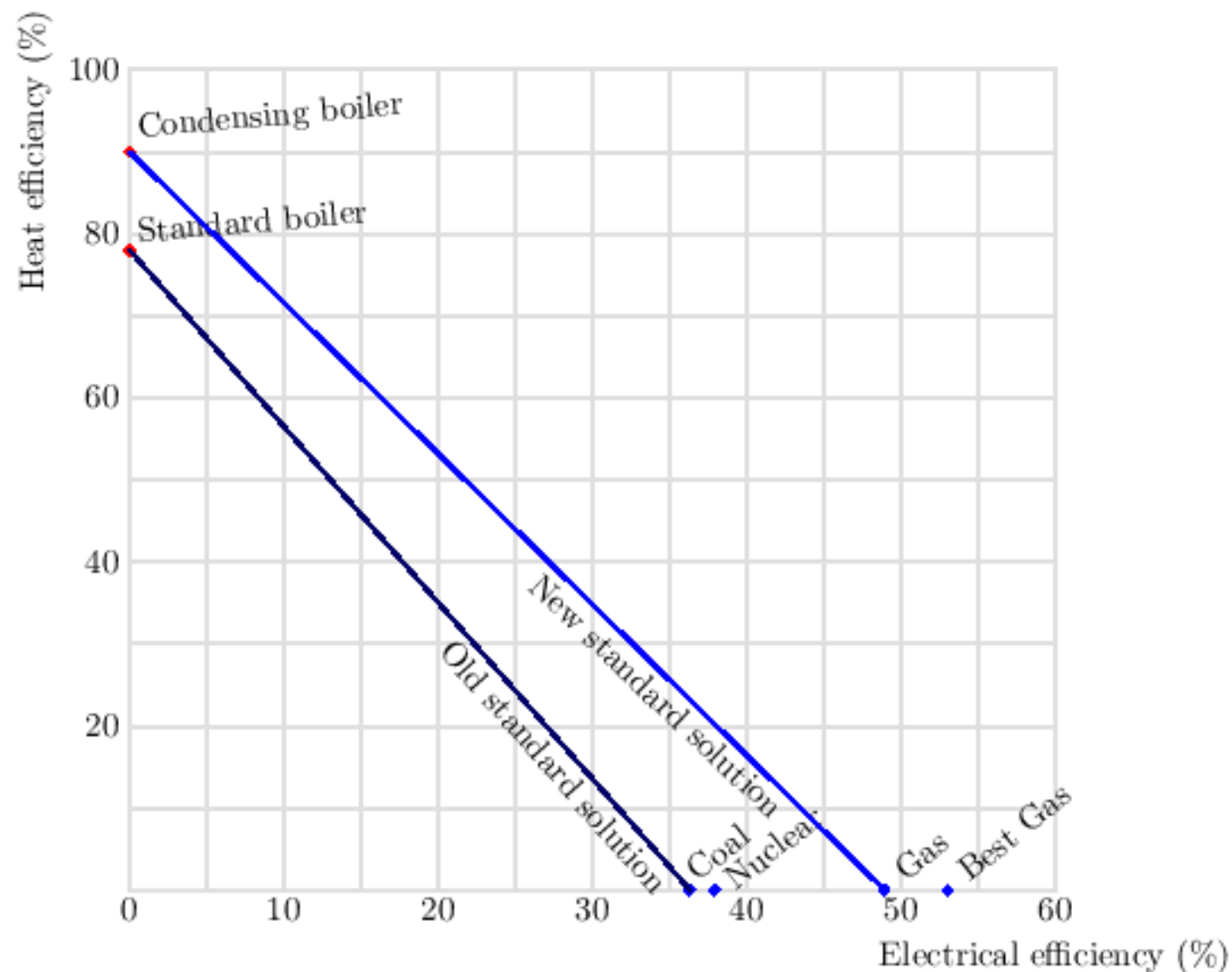
Combined heat and power?

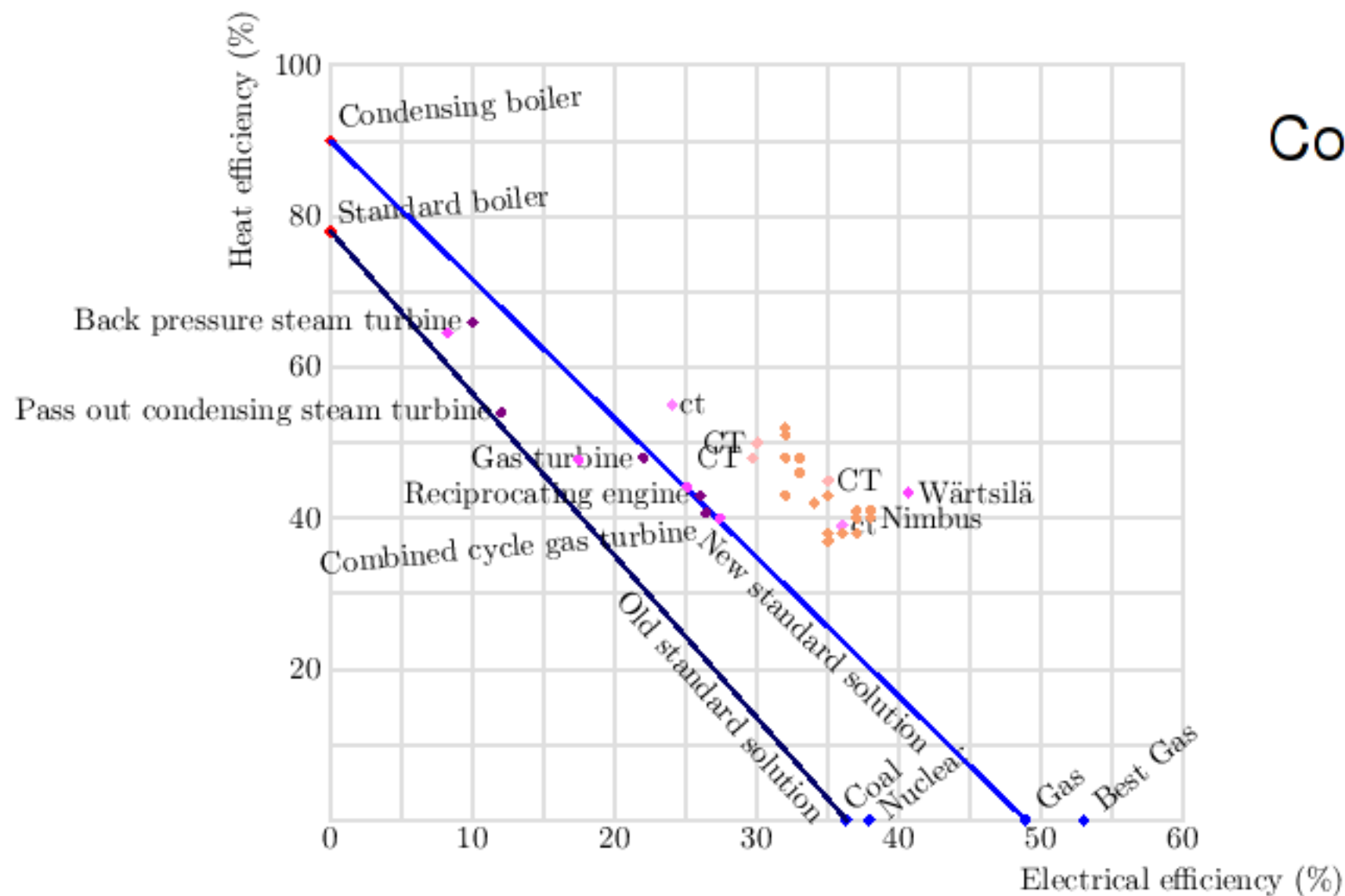
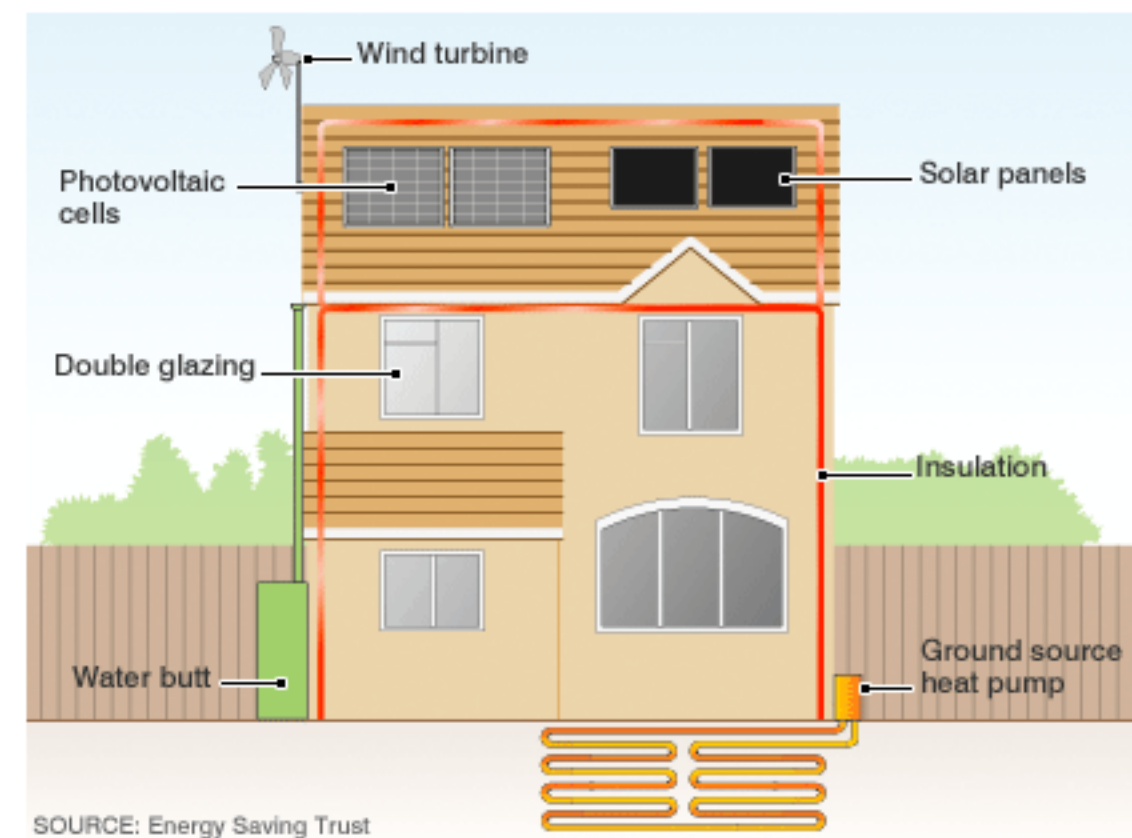


'Microgeneration', 'Decentralization'



Can we do better than
Combined Heat and Power?
- Heat pumps





Can we do better than Combined Heat and Power?
- Heat pumps



A world Leader in Air Conditioning Technology
Australia and New Zealand

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[home](#) > [products](#) > [Domestic](#) > [Single Split Systems](#) > [Reverse Cycle](#) > [FTXS25E](#)

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.

[Overview](#)[Features](#)[Specifications](#)[Controllers](#)[Downloads](#)**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

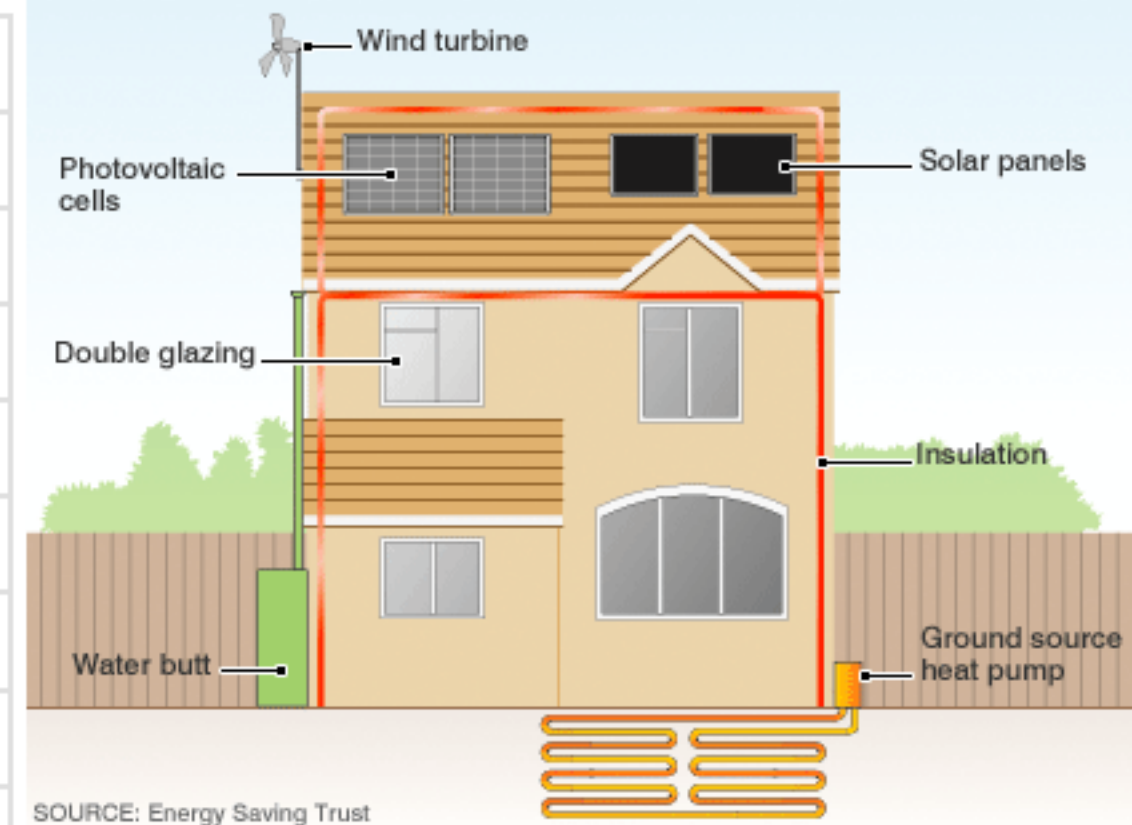
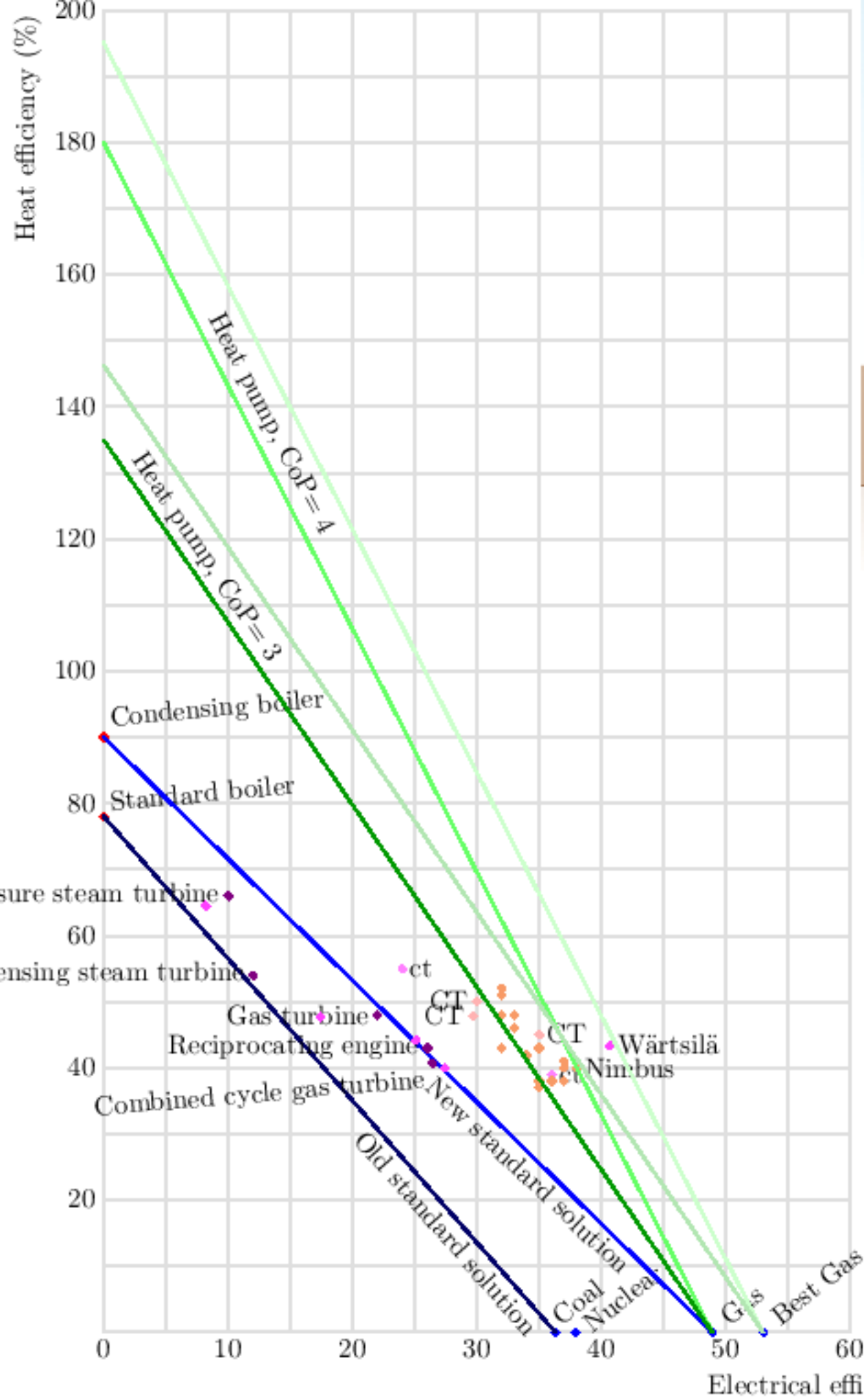
4.17/4.10

Front Panel Colour

White

Power Supply

1 phase, 220-240V, 50Hz



Can we do better than
Combined Heat and Power?
- Heat pumps

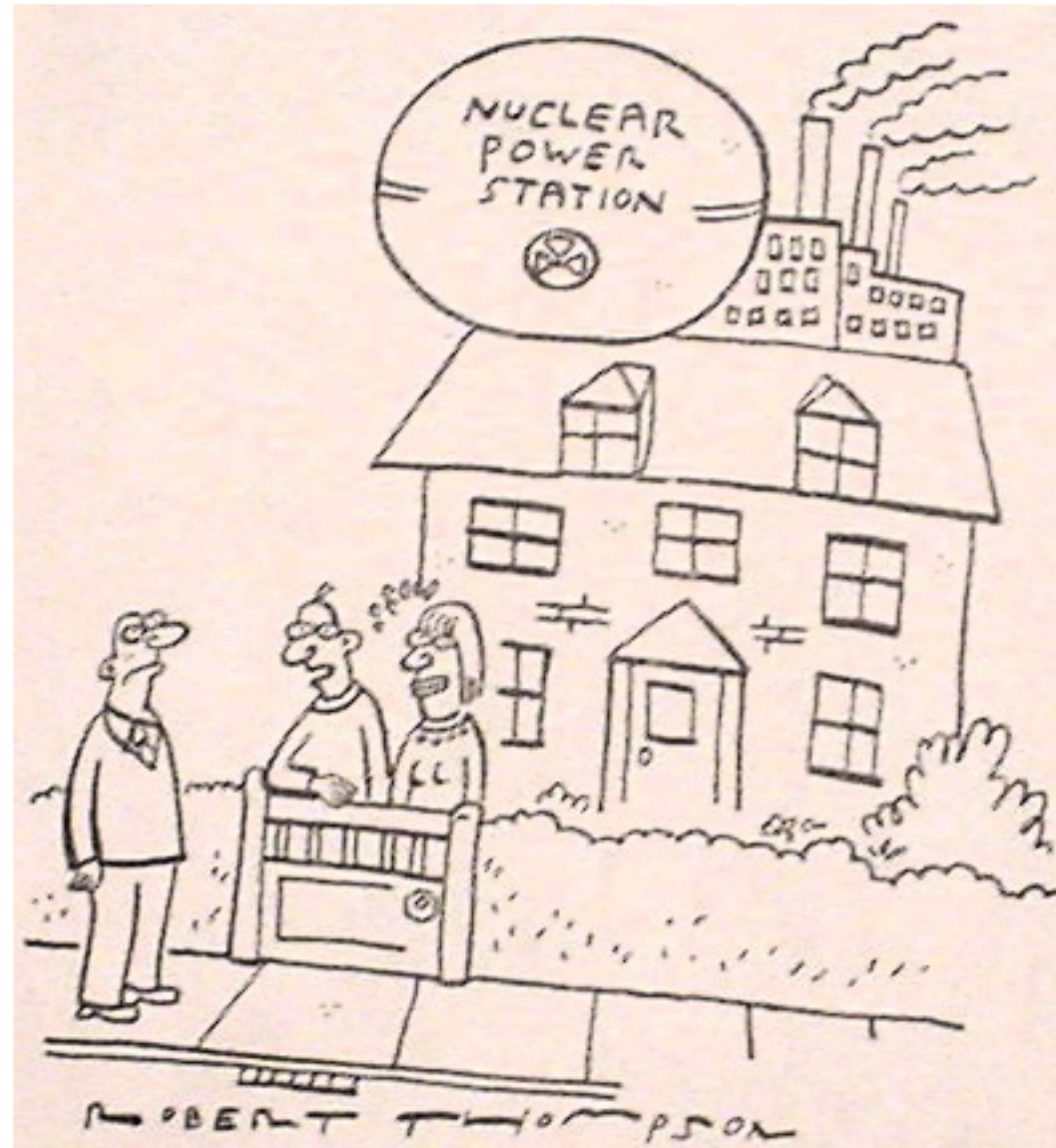
Carbon tax



What's the best way to suck CO₂ from thin air?

Energy cost \geq 700 kWh per tonne

How to make a difference?



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

From Private Eye, April 2007

Ocean thermal

- Not available in the UK

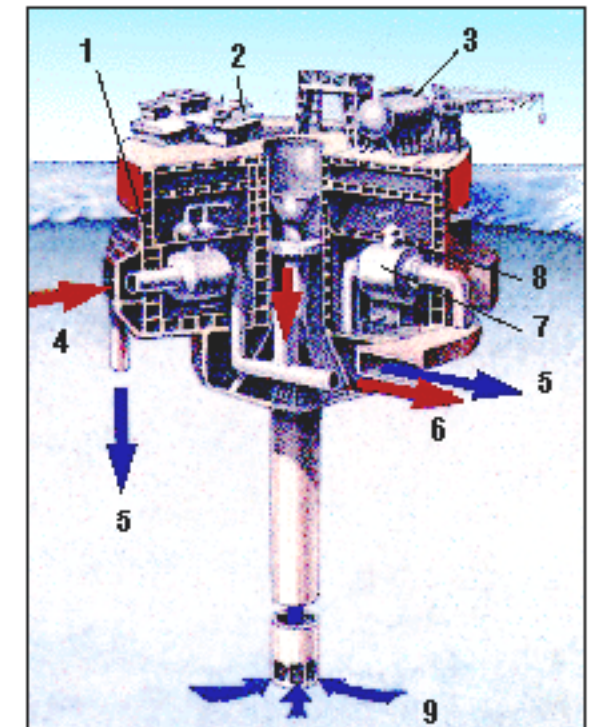
- Theoretical limit: 5 W/m^2

- Spin-offs:

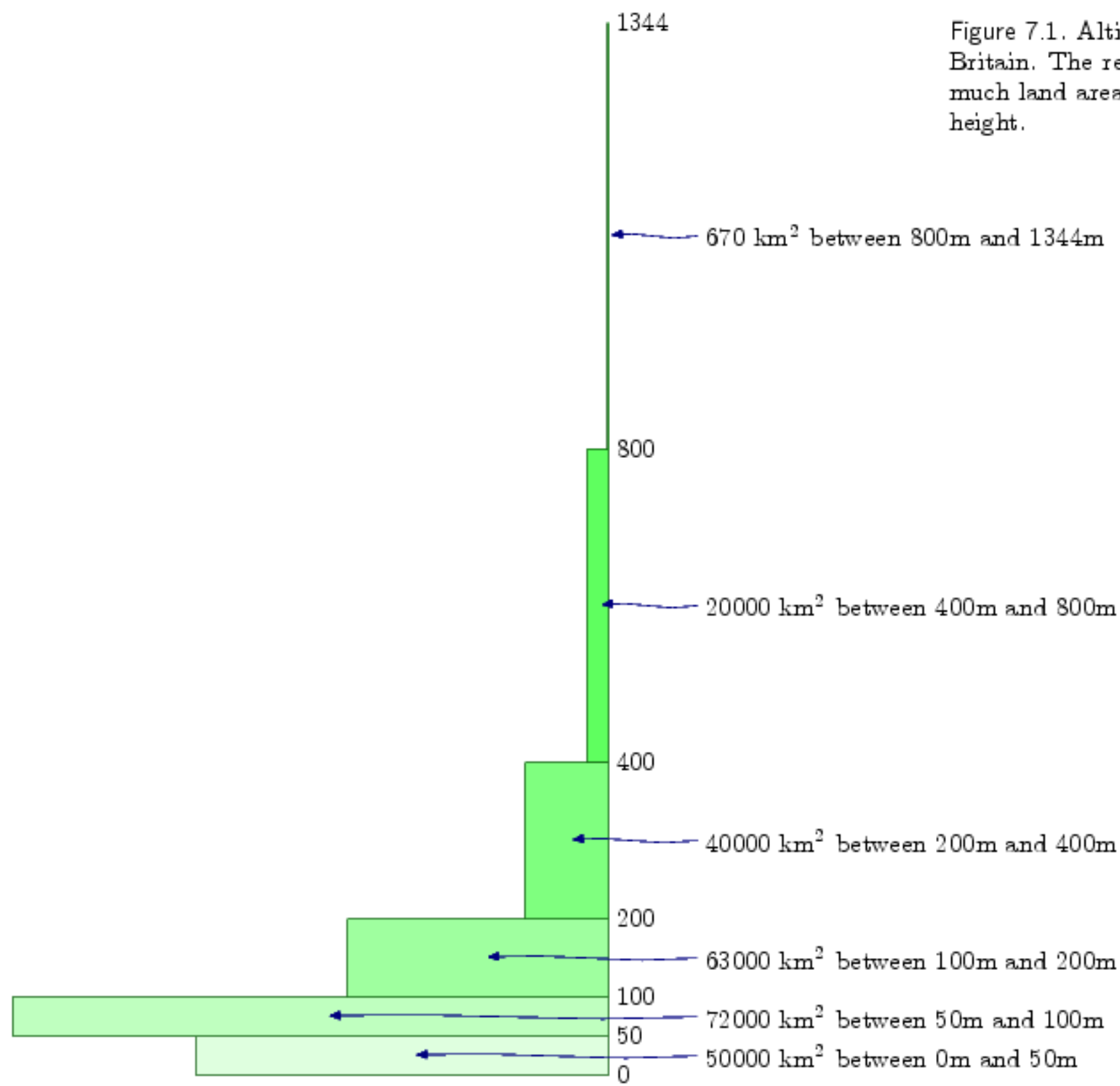
- Uranium extraction
- Desalinated water
- Air-conditioning

- Fantasy:

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



Altitudes in the UK



Birds killed by windmills

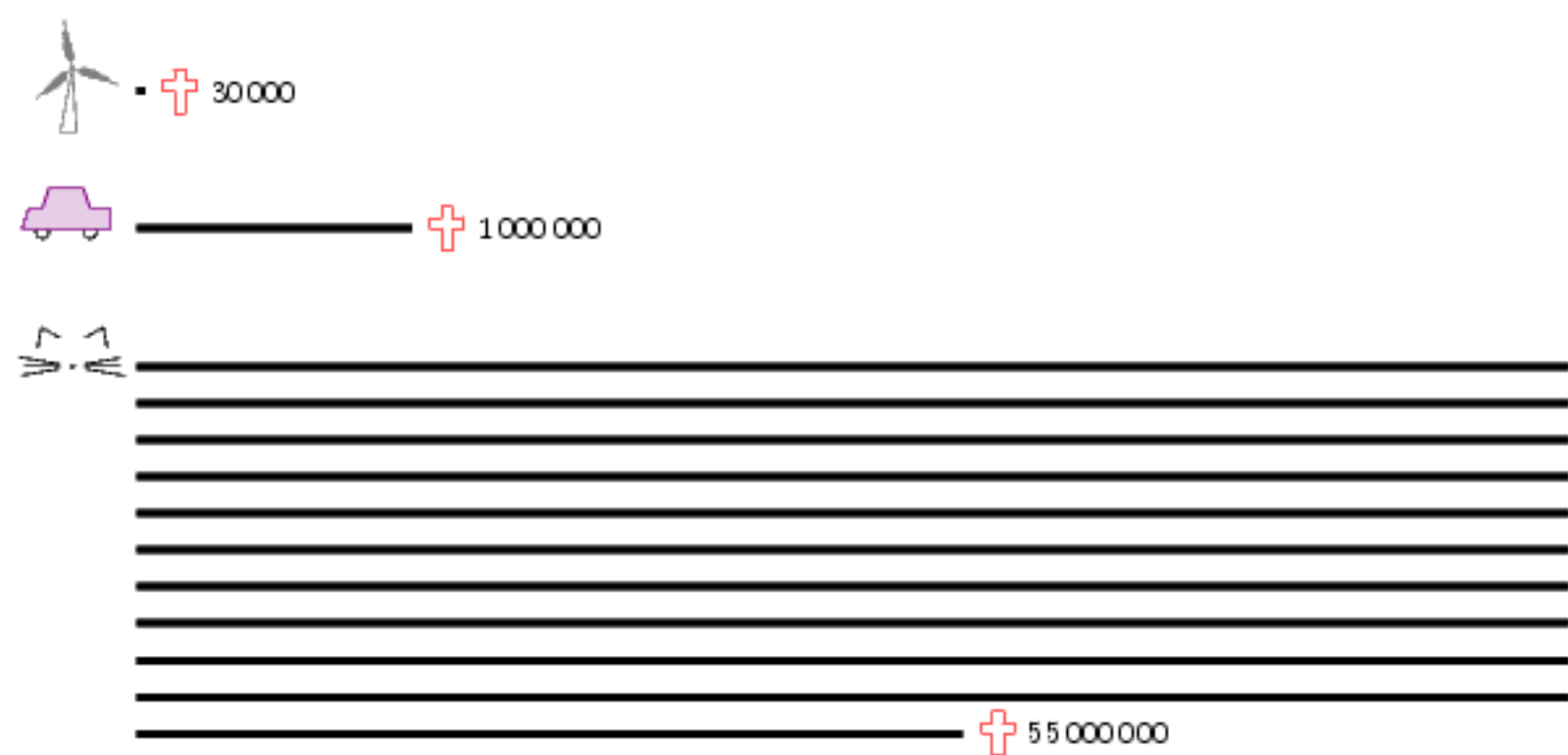
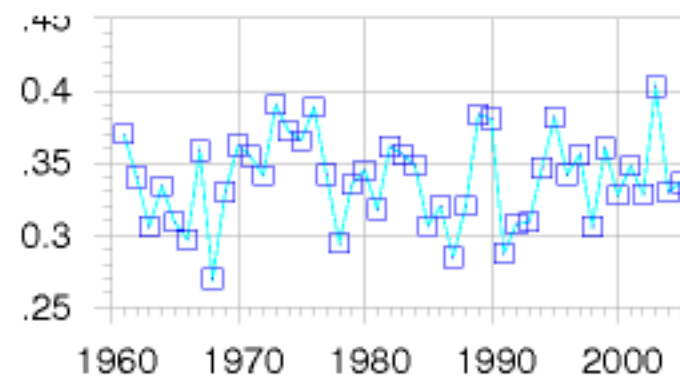


Figure 9.4. Birds lost in action.

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

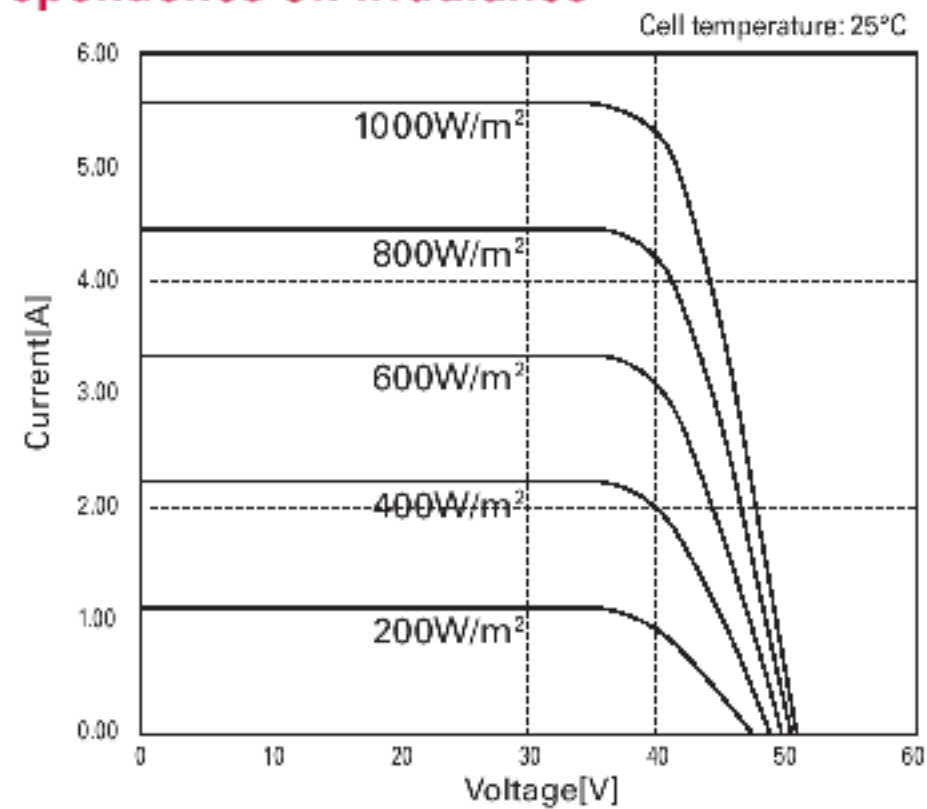
Sunniness



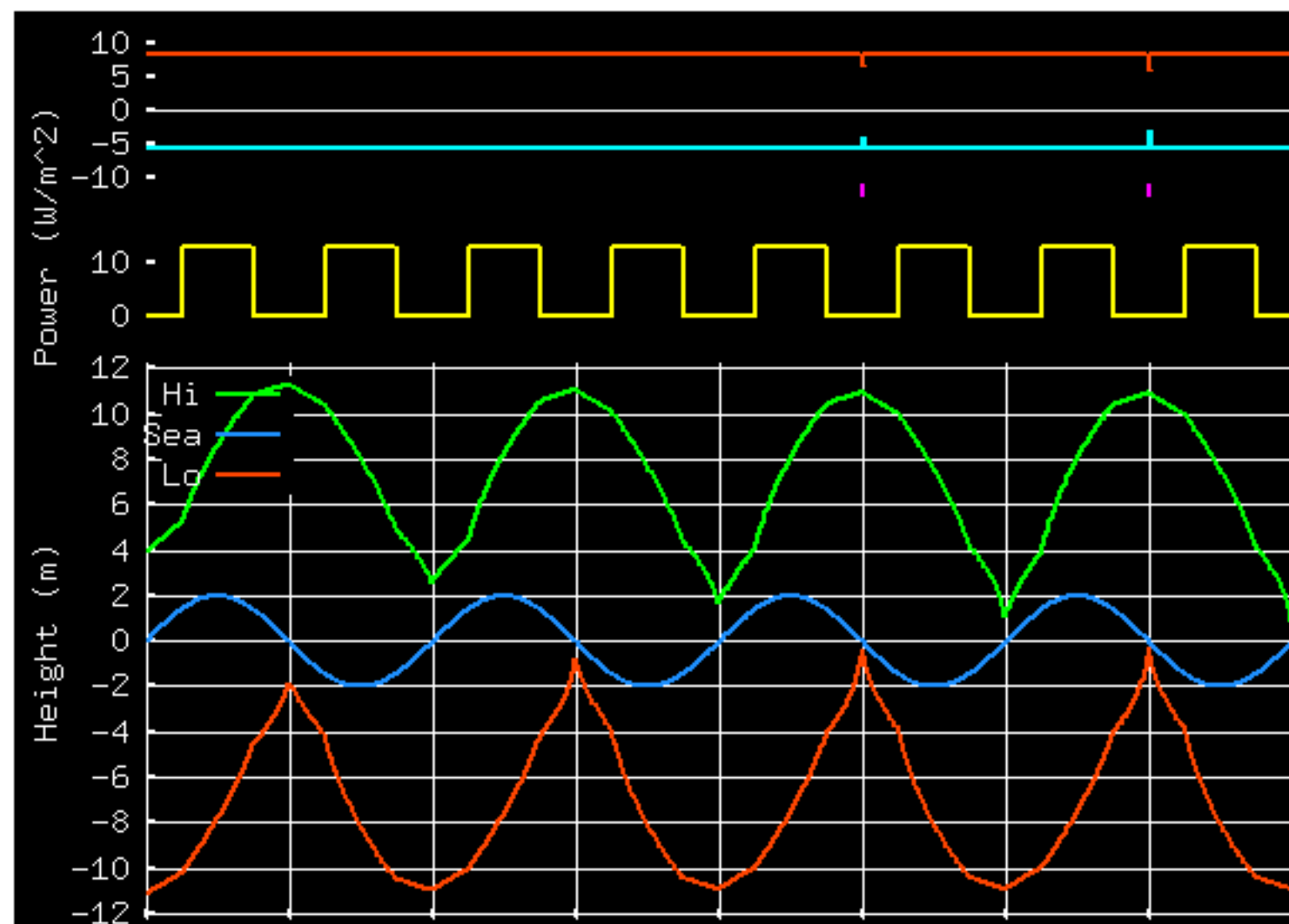
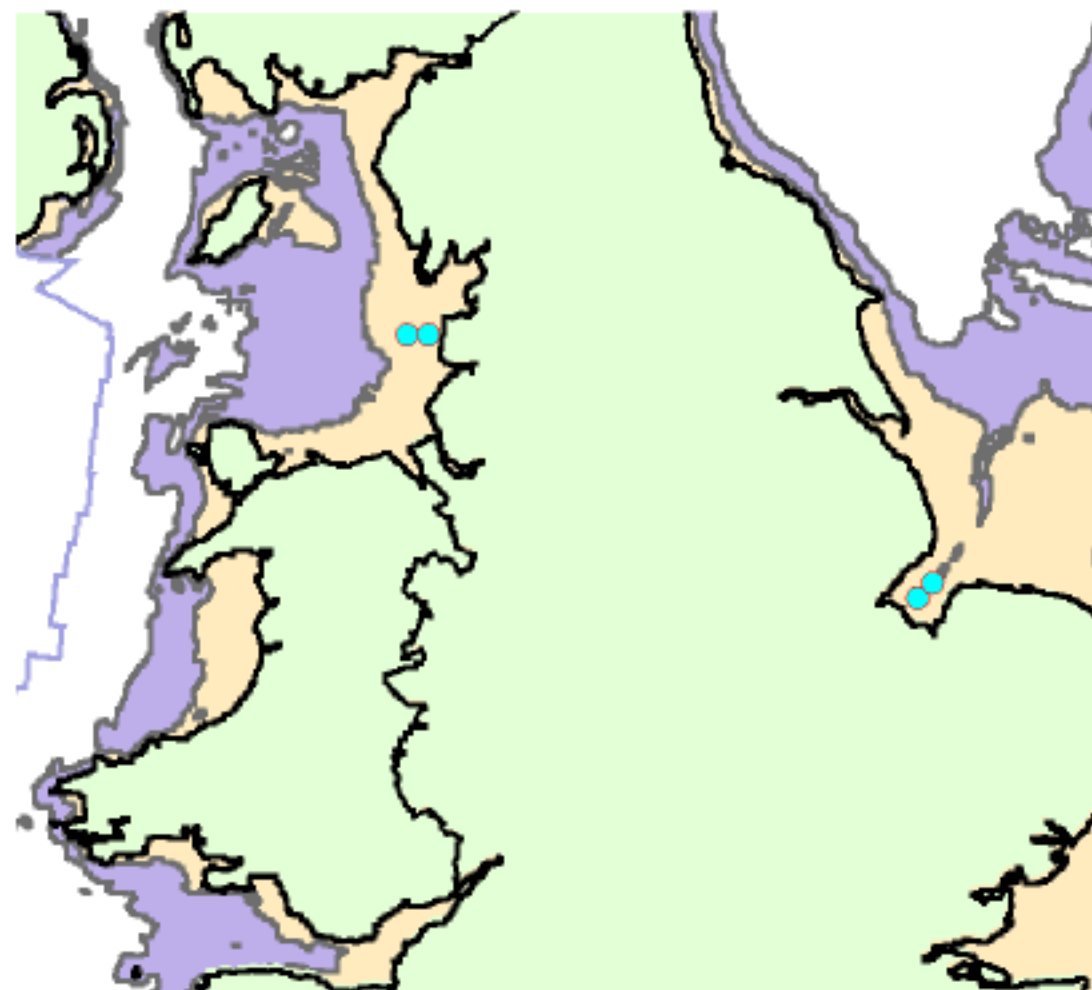
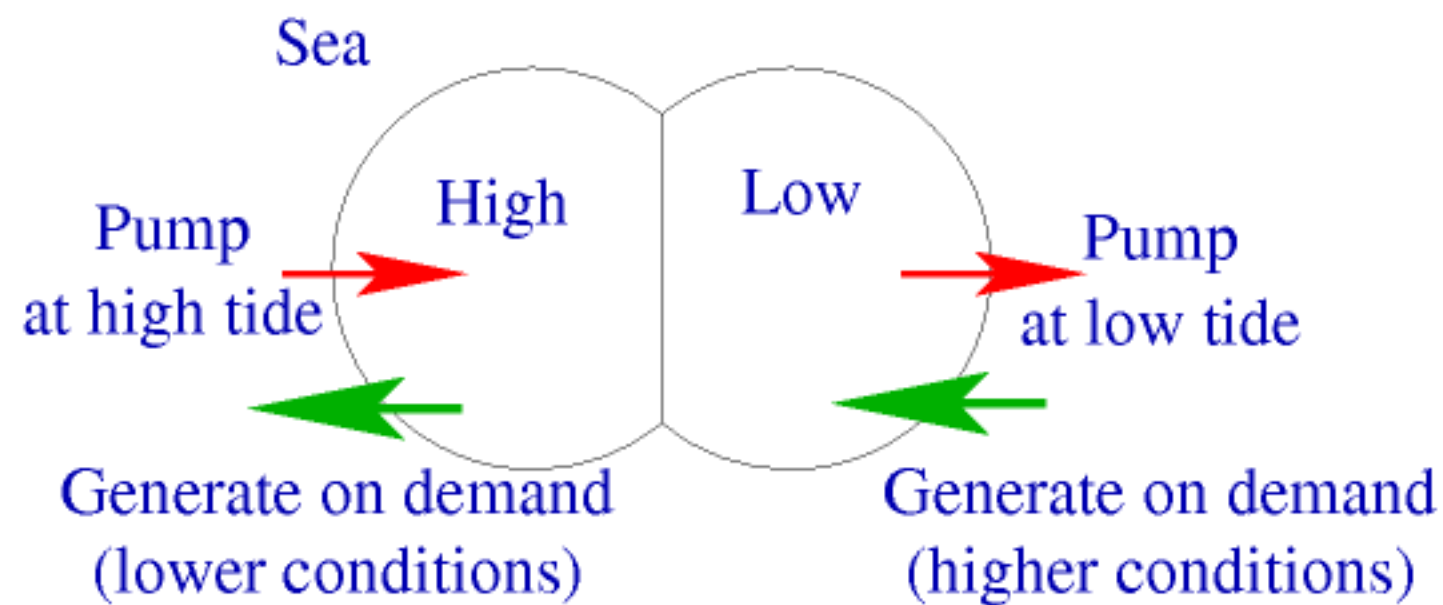
Cambridge

and its effect on PV

Dependence on irradiance



Pumped storage and tide combined



The role of nuclear power in a
low carbon economy

Paper 2: Reducing CO₂ emissions - nuclear and the alternatives

An evidence-based report by the
Sustainable Development Commission

March 2006

125 kWh/d

Wave: 2.3
Geothermal: 10
Tide: 2.4
Energy crops: 9
Solar PV: 12
Offshore: 6.4
Wind: 2

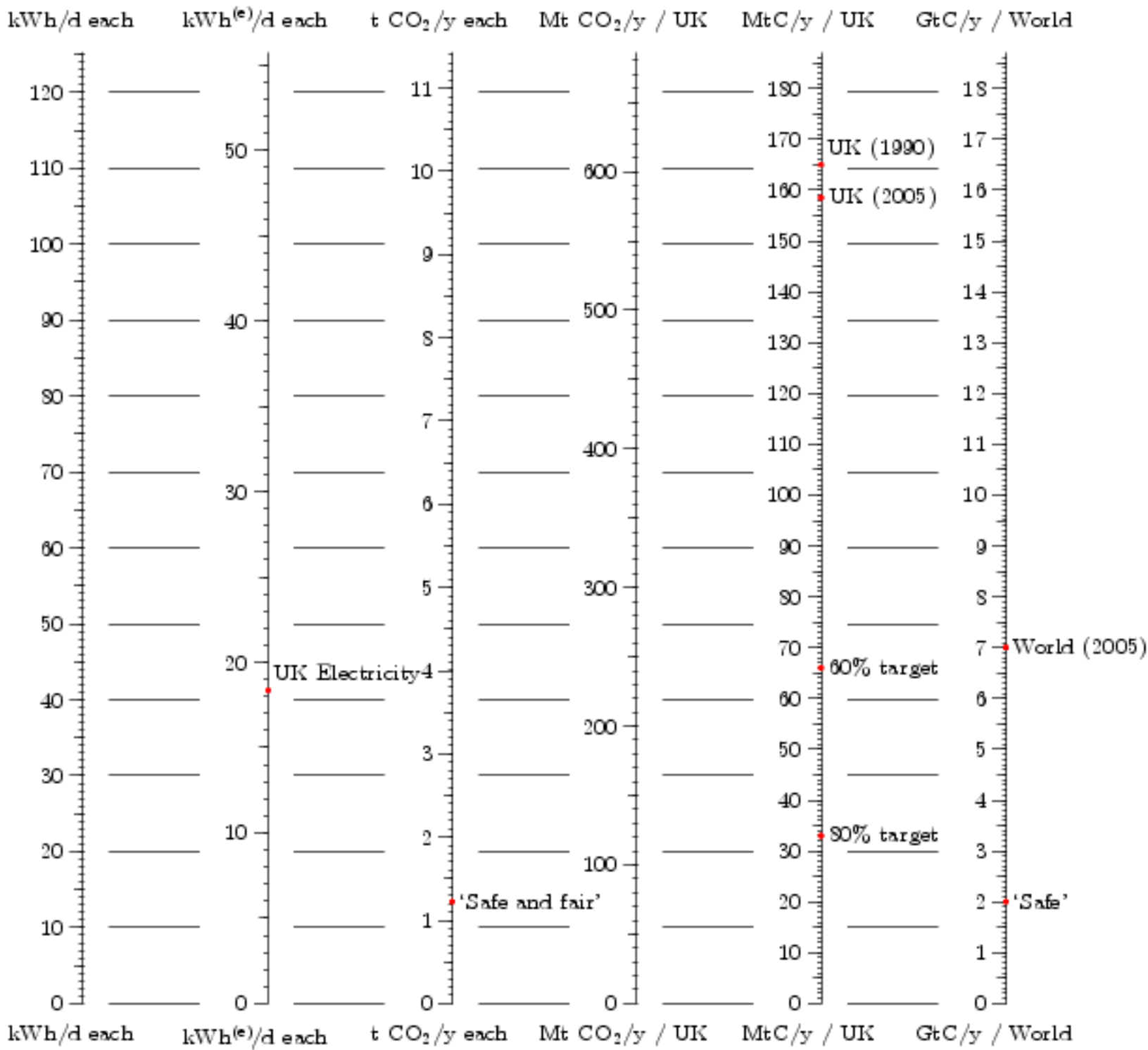
← Hydroelectricity: 0.09

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'.

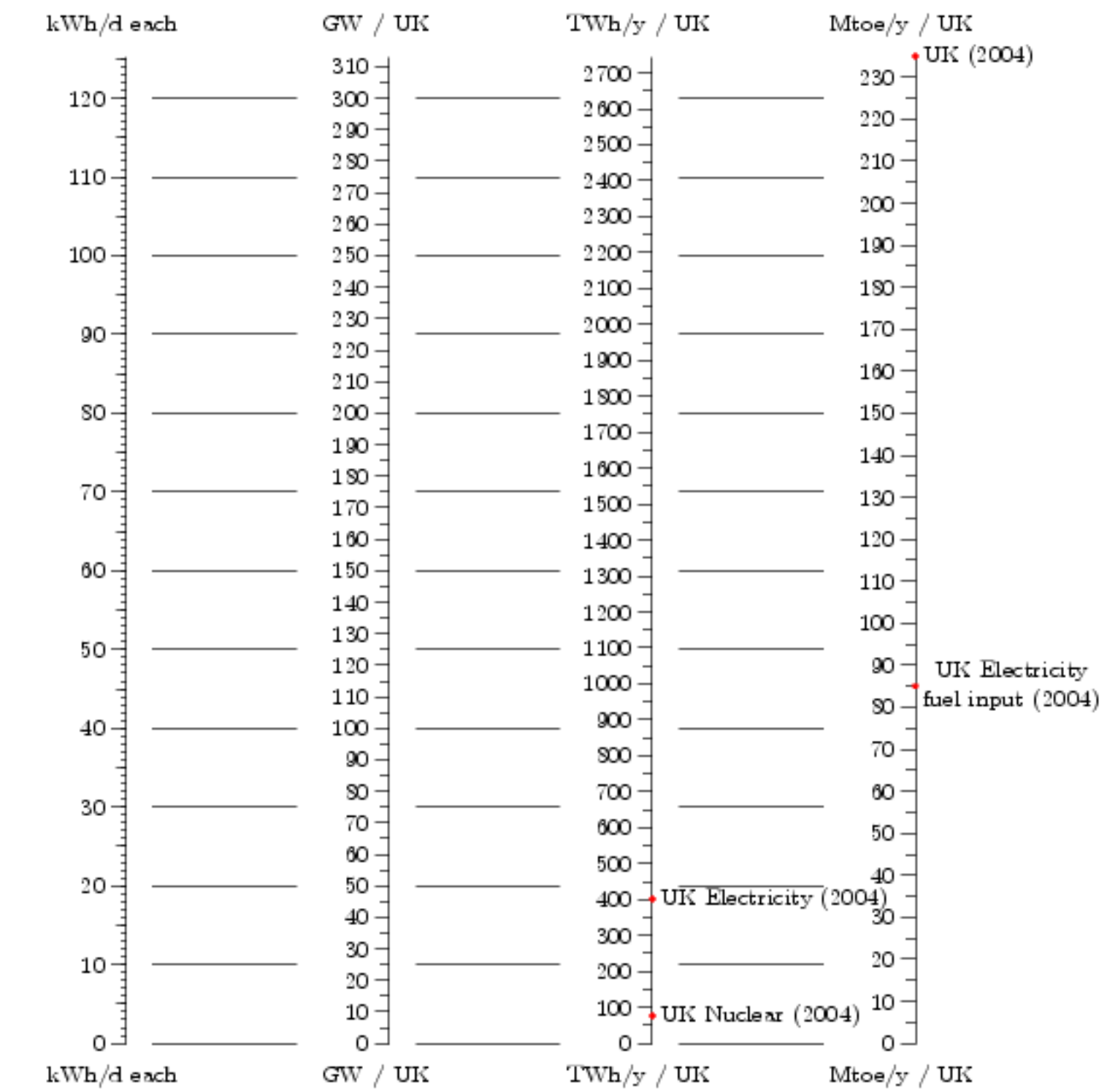
Estimates of theoretical / practical resources

My estimates	IEE	Tyndall	LAG	PIU	CAT
Geothermal: 2	Geothermal: 10				
Tide: 14 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 kWh/d	Energy crops, waste incin'n, landfill gas: 31 kWh/d	Biomass fuel, waste: 8
PV farm (400 m ² /p): 50 kWh/d				PV: 12	
PV, 10 m²: 4		PV: 0.3	PV: 0.02		PV: 1.4
Solar heating: 10 kWh/d					Solar heating: 1.3 kWh/d
Wind: 20 kWh/d	Wind: 2	Wind: 2.6	Wind: 2.6	Wind: 2.5	Wind: 1

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



[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

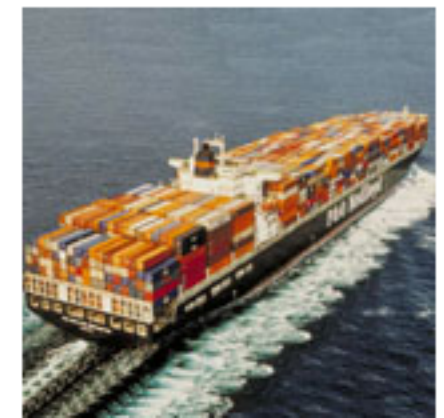
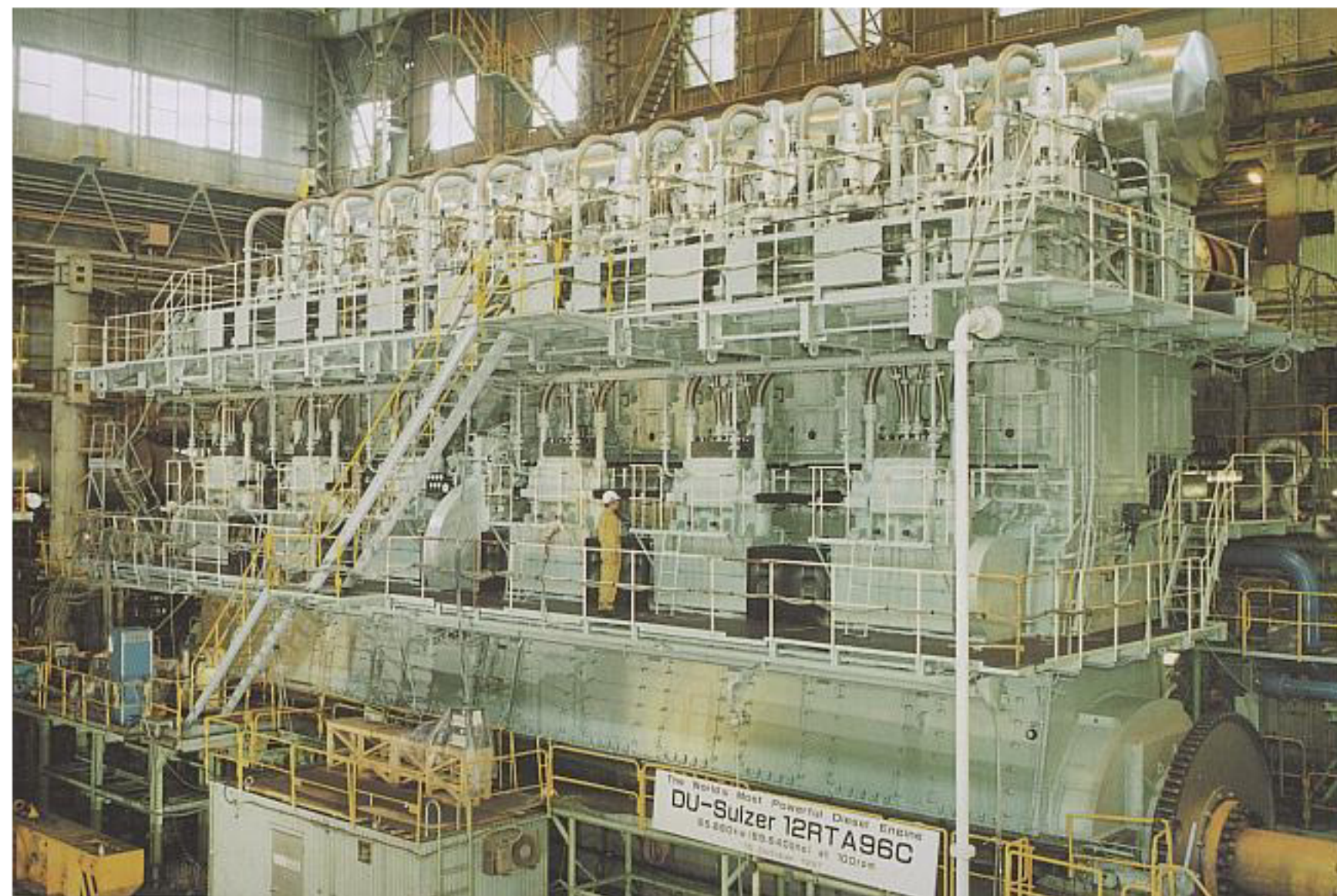
TIMES RECOMMENDS

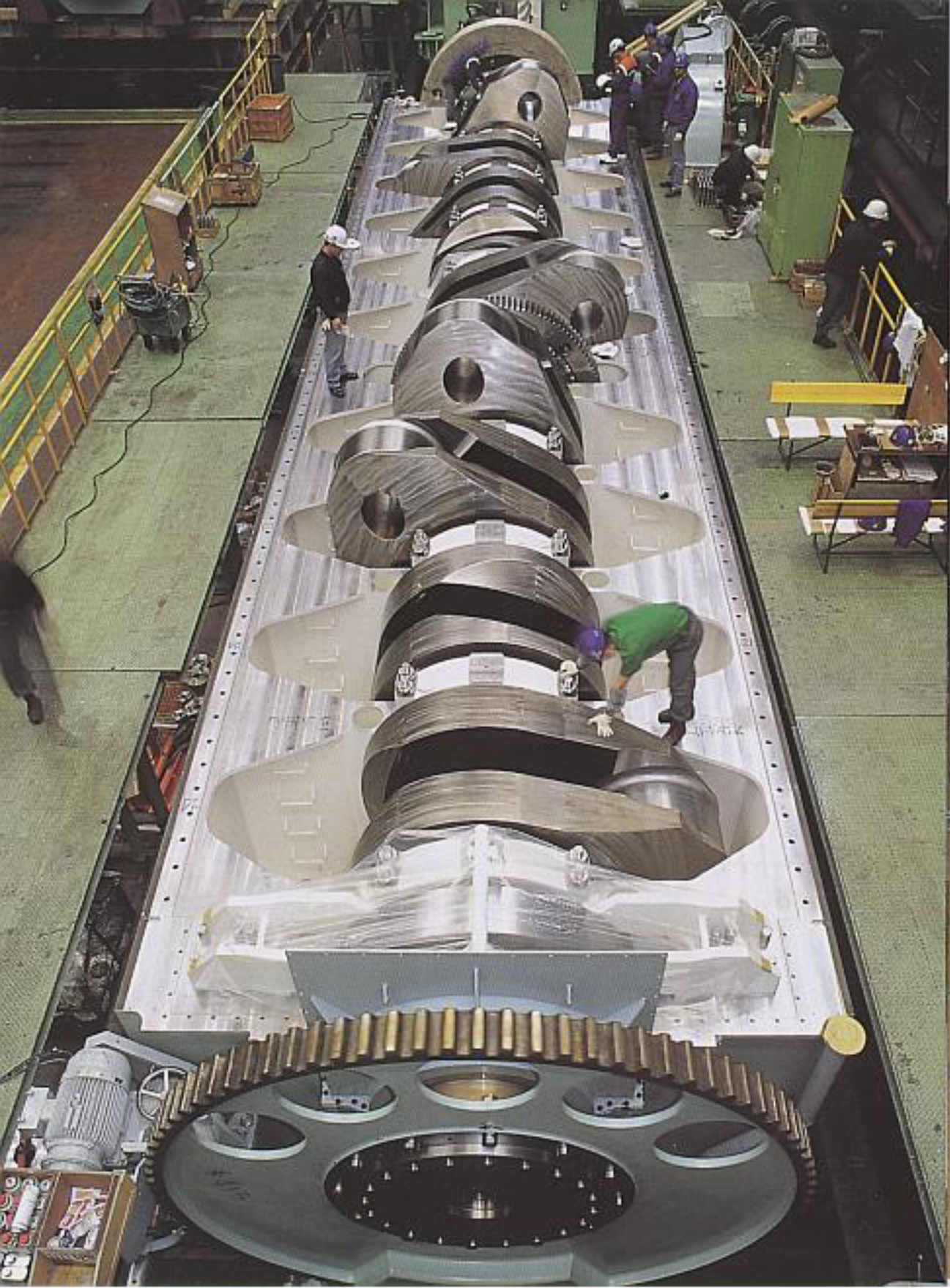
- ▶ [Labour aide quits after C-word rant](#)
- ▶ [The latest accessory for a dog with everything](#)
- ▶ [Was Noah's flood a sign of climate change?](#)

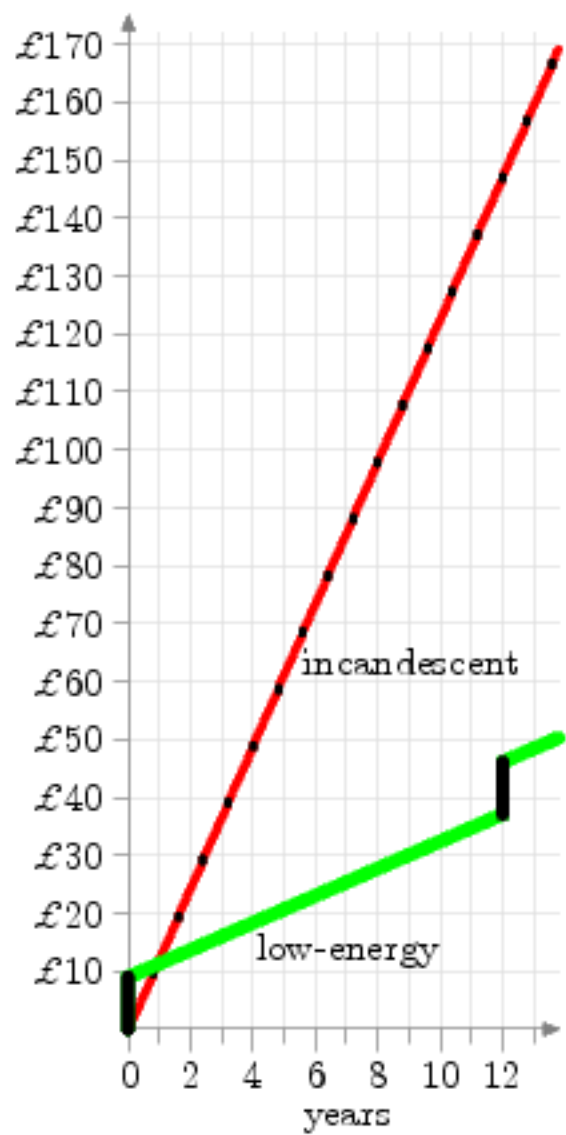
COMMENT CENTRAL



Don't knock centralization







Micro-wind (one per person?)

David Cameron's chimney ->



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

2000 pounds for that!

Cars



- Engine inefficiency

 - internal combustion is 25% efficient

- Drag

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

No viscosity!

- Acceleration/deceleration

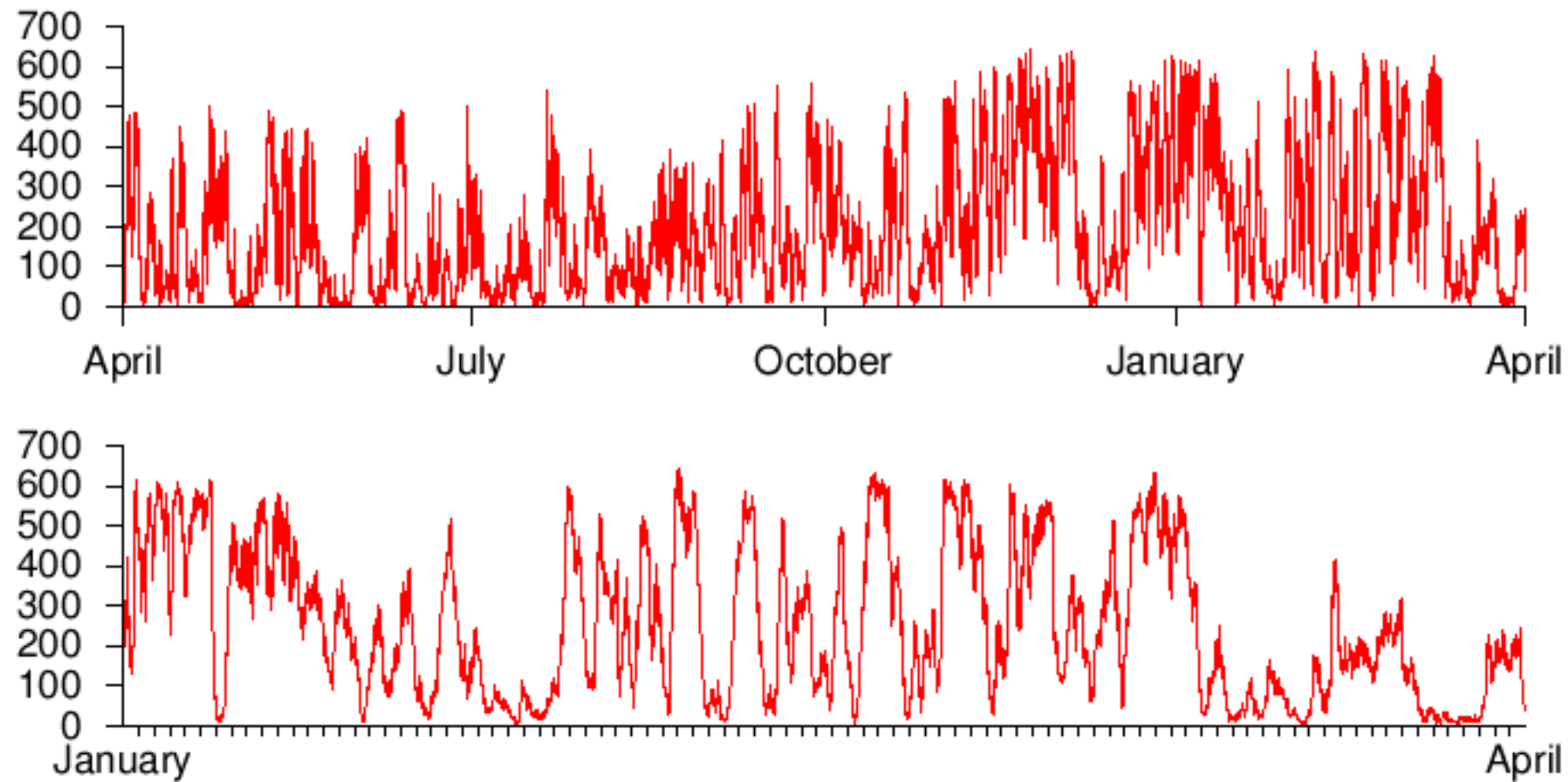
$$\text{Power} = \frac{1}{2} \rho A v^3 c_d + \frac{1}{2} \frac{m v^3}{D}$$



Car:
40 kWh/d

Wind fluctuates

- Even when added over a whole country



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

www.eirgrid.com

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



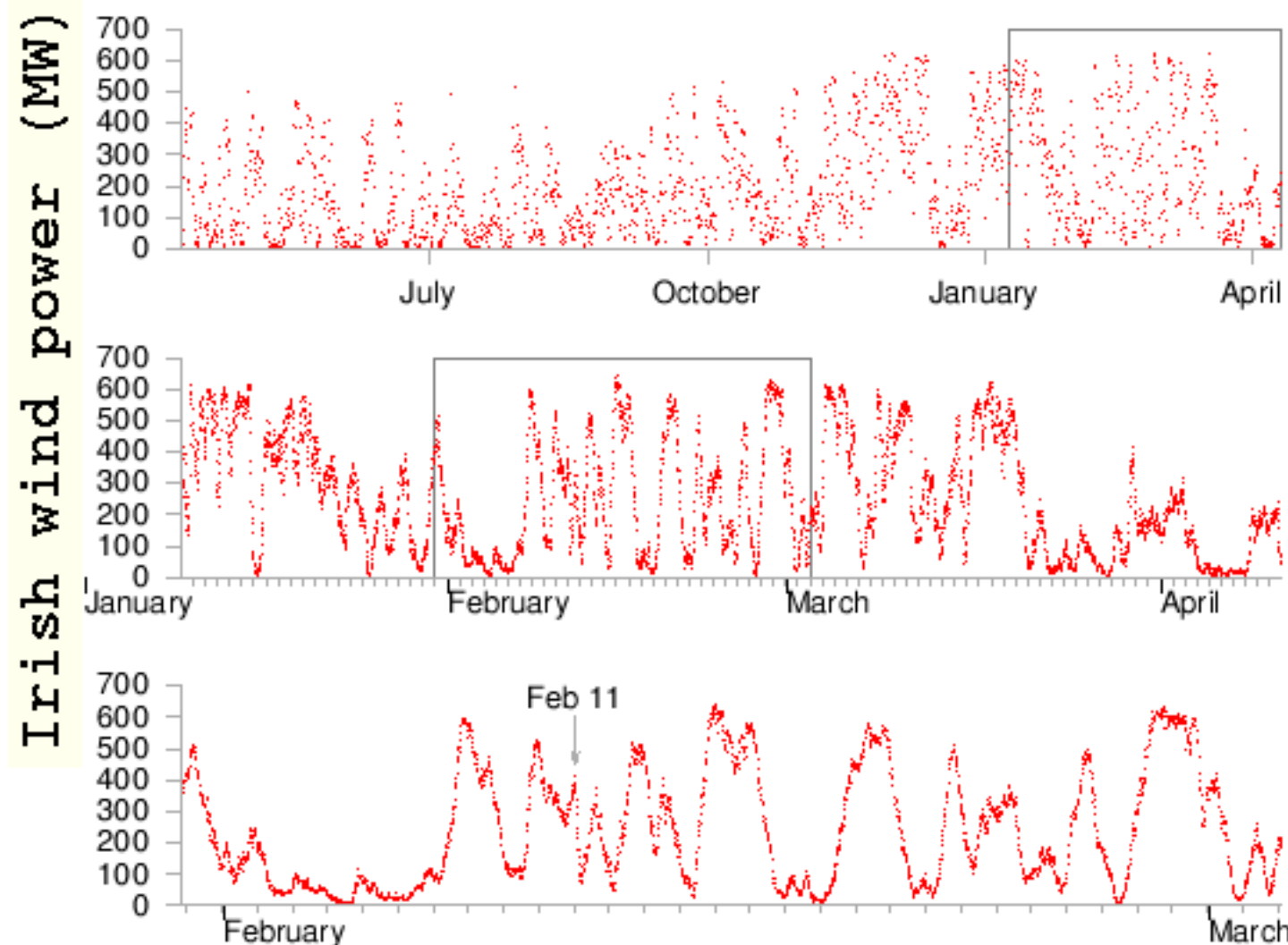
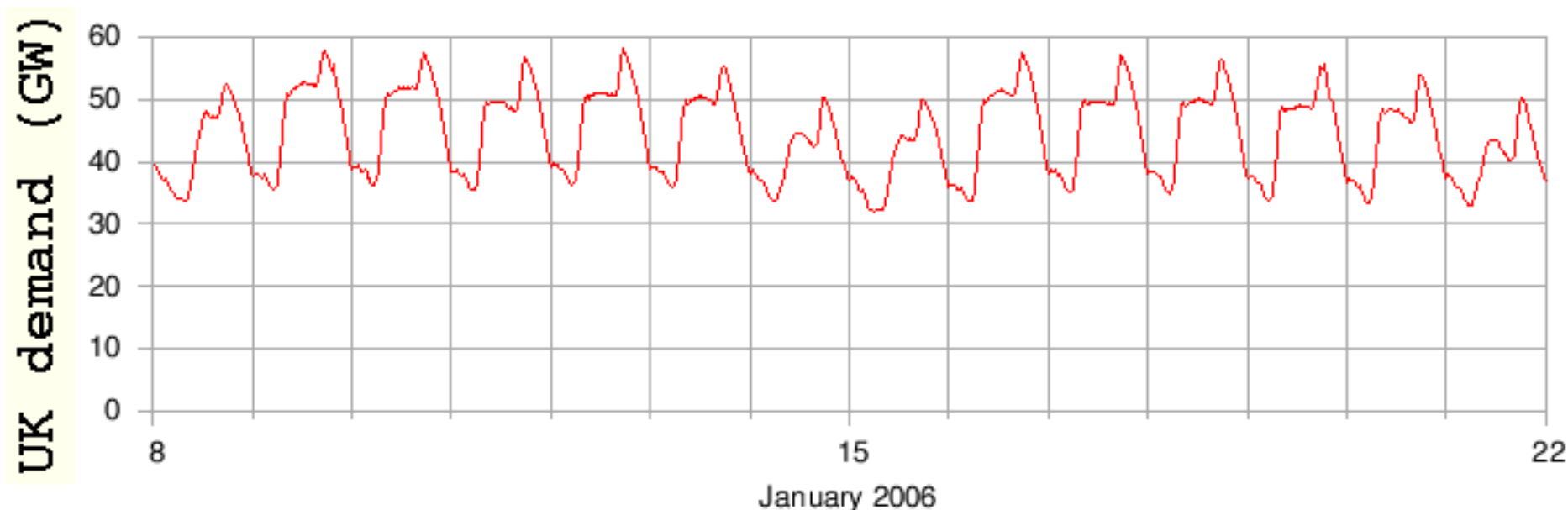


Figure 26.2. Total output, in MW, of all windfarms of the Republic of Ireland, from April 2006 to April 2007 (top), and detail from January 2007 to April 2007 (middle), and February 2007 (bottom). Peak electricity demand in Ireland is about 5000 MW. Its wind 'capacity' in 2007 is 745 MW, dispersed in 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?

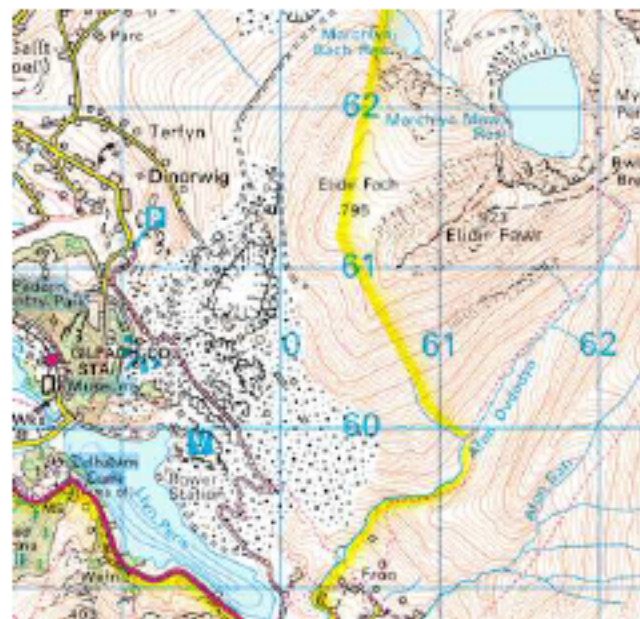


Every morning, demand rises at a slew rate of 6.5 GW per hour

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

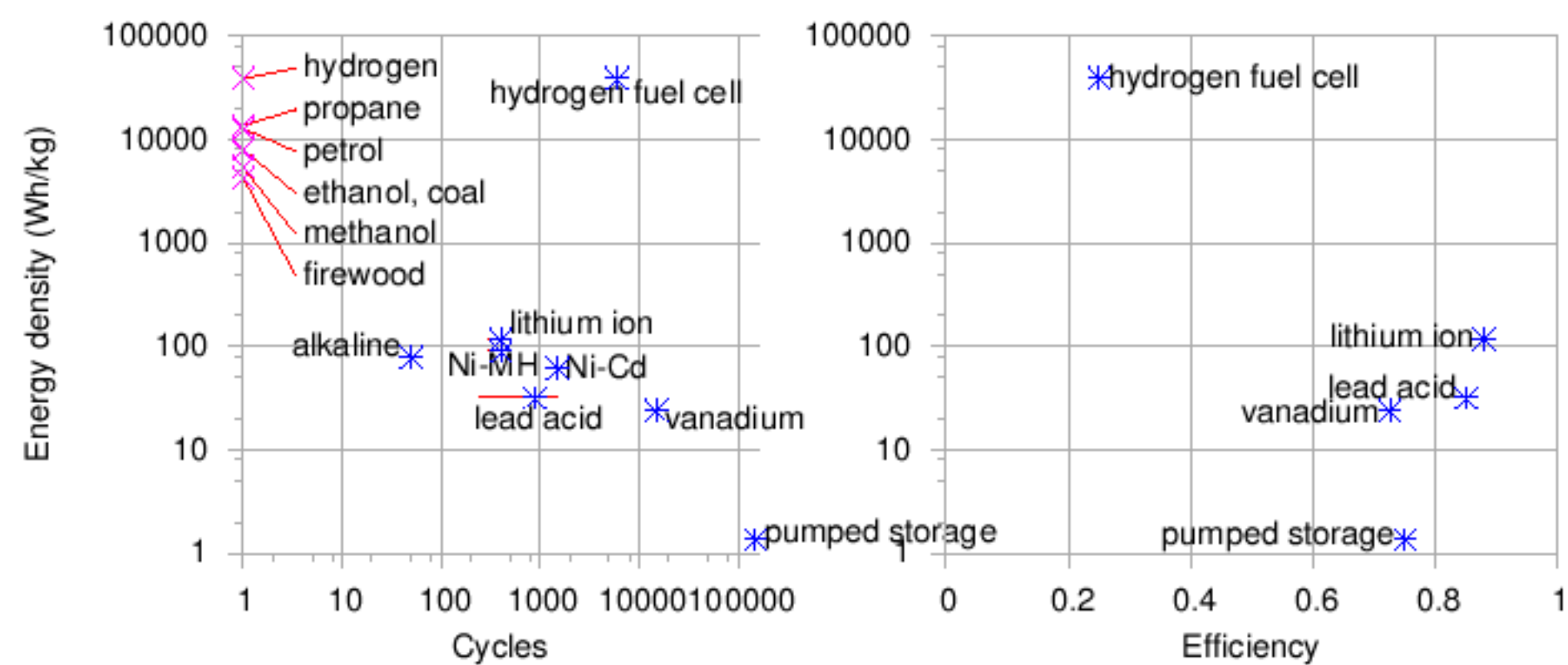


Kannagawa Power Plant (29 GWh)

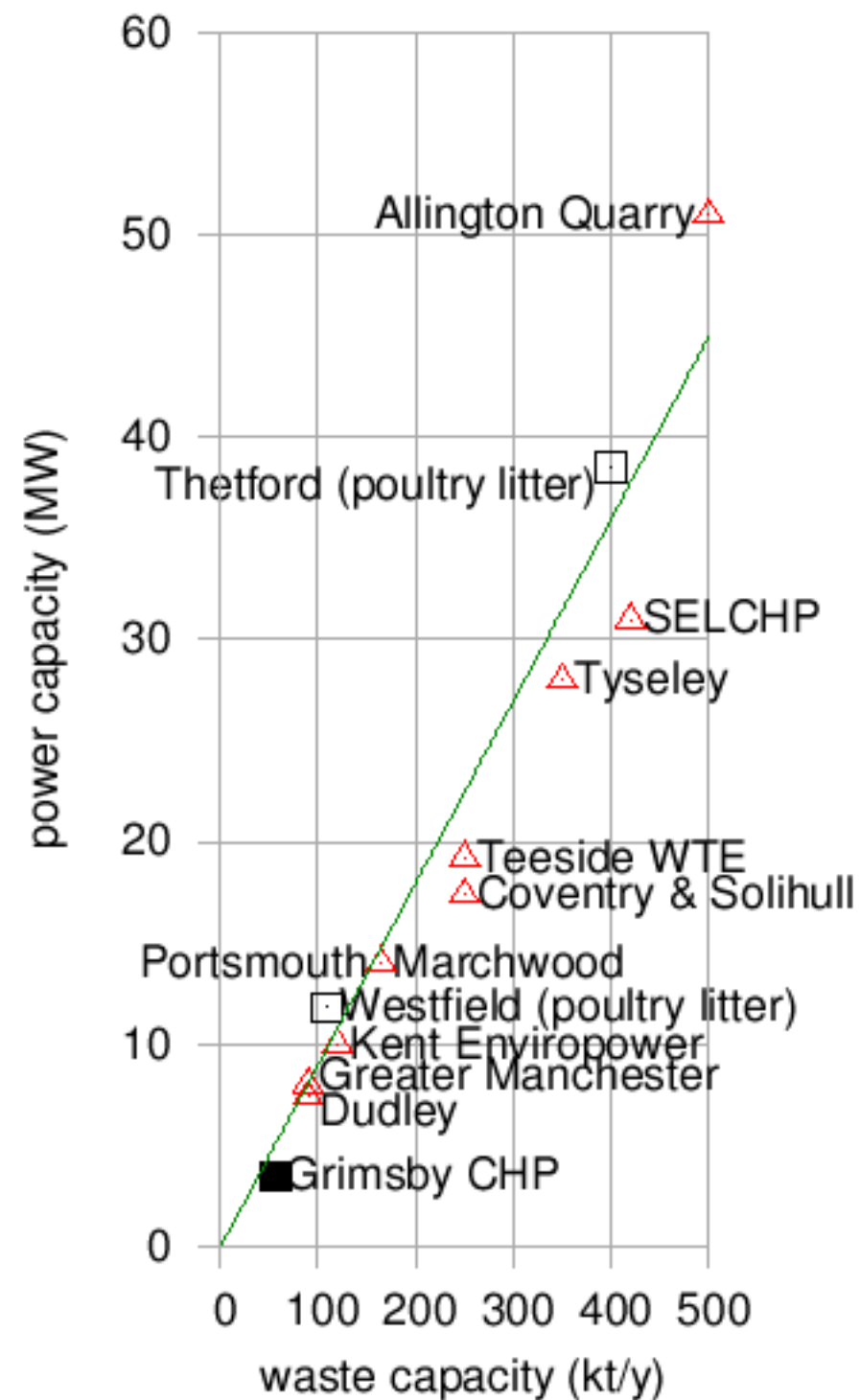
www.ieahydro.org

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

Energy storage

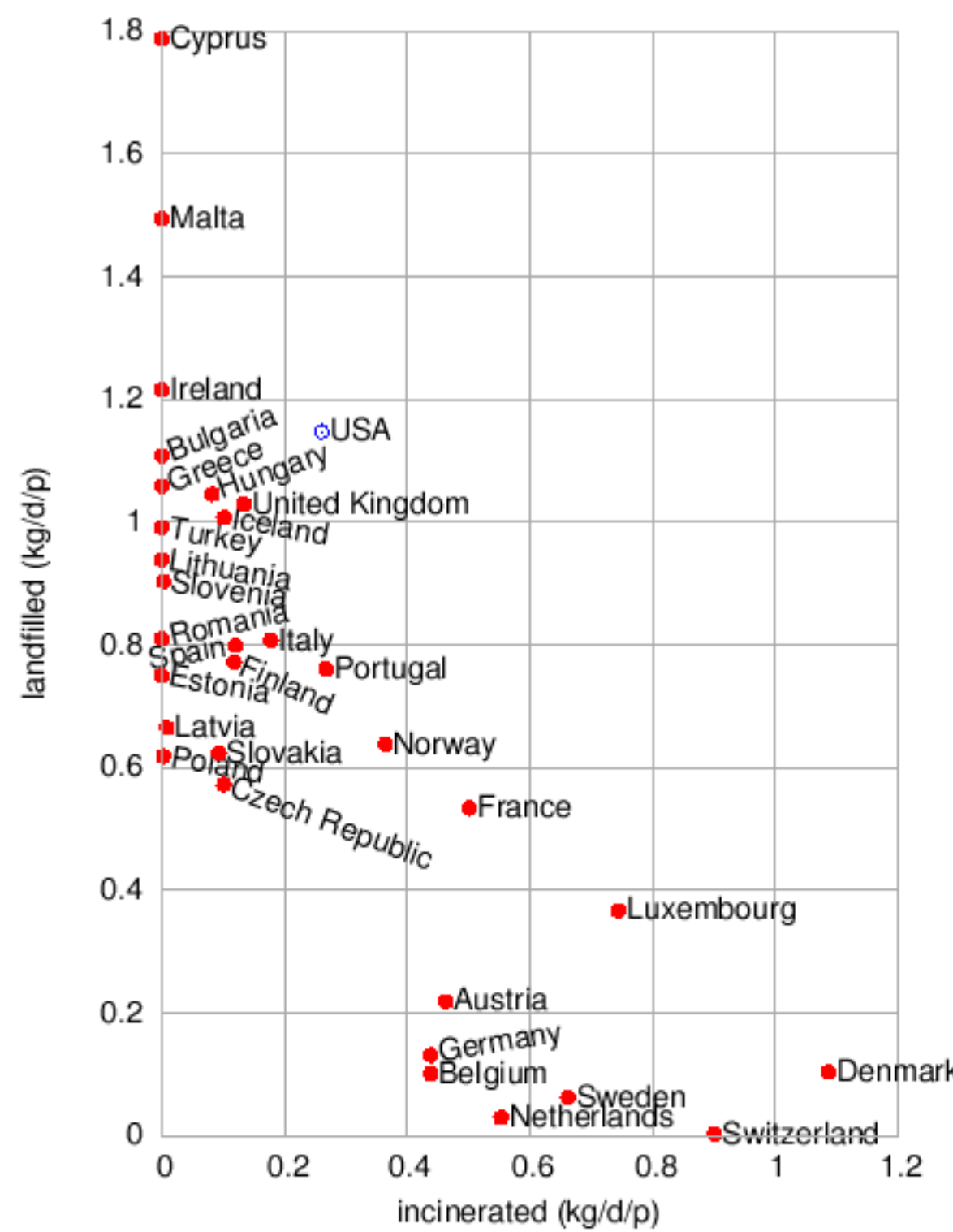


Waste incinerators

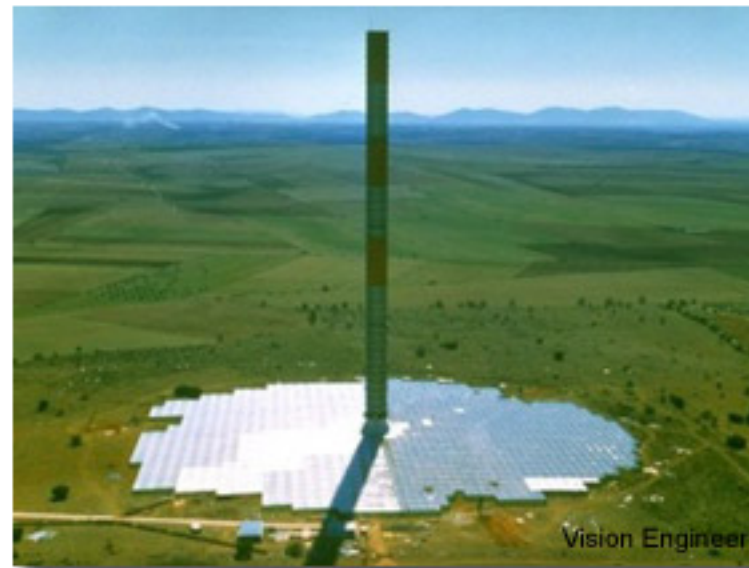


1 kg of waste - 0.8 kWh of electricity

Municipal solid waste



Solar chimney



● No mirrors!

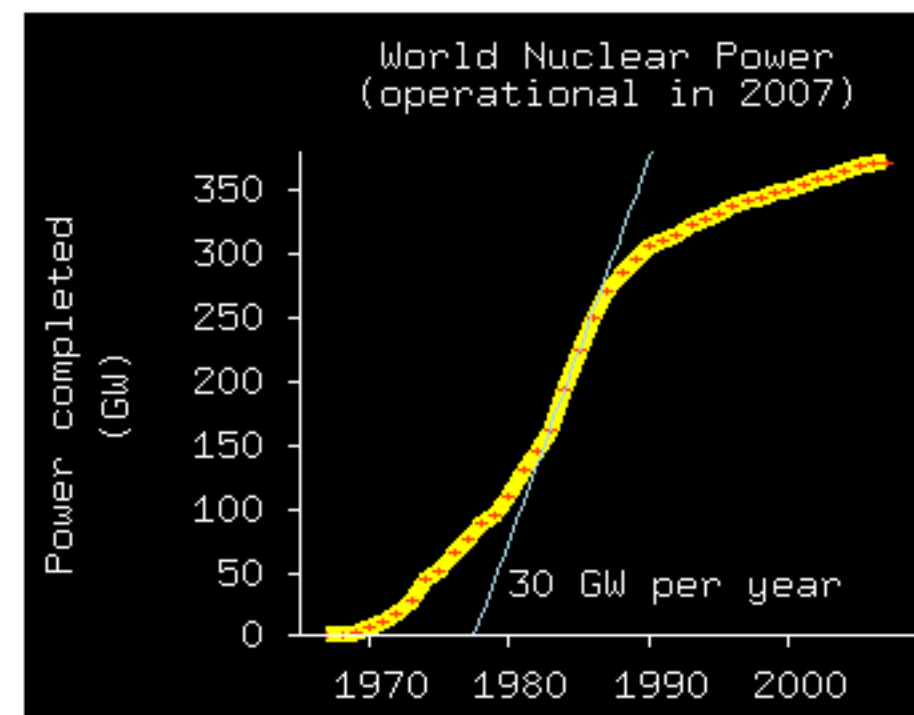
Nuclear power 'completely infeasible'?

"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.



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.

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

4 kWh/d

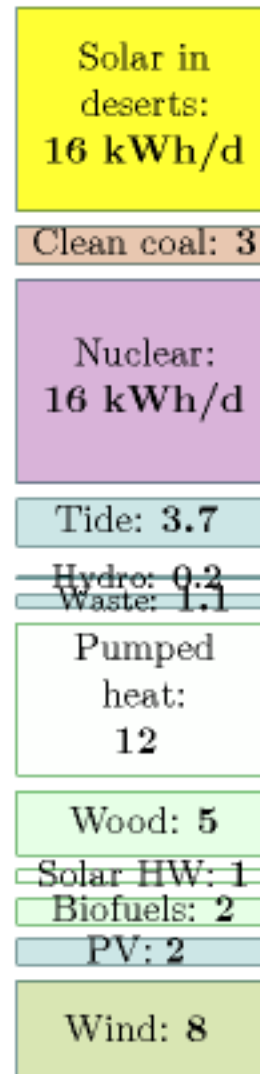
4 kWh/d

'all homes'

10 GW nuclear

33 GW wind

My mix



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

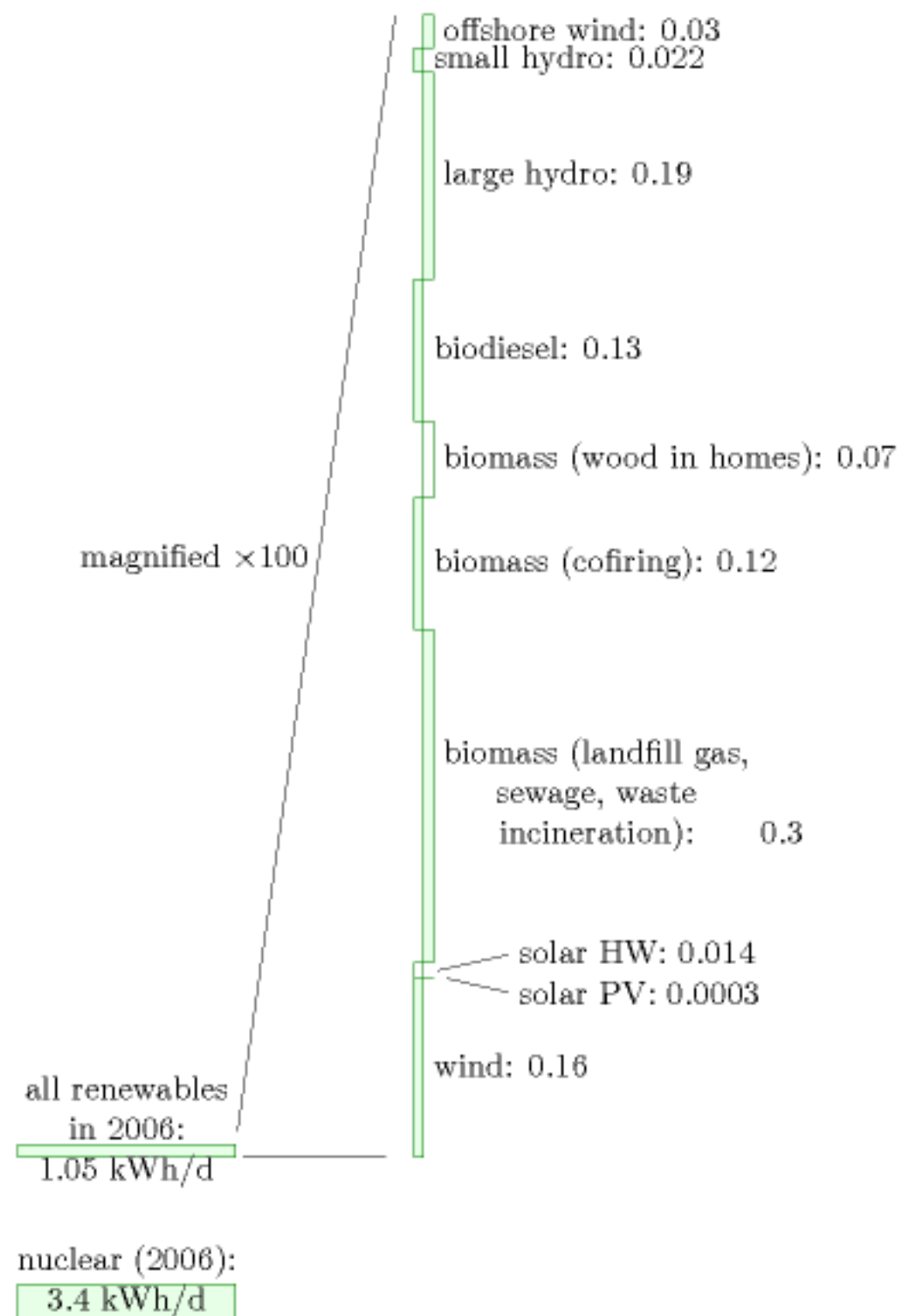
12% of UK for biofuels

Half of all roofs

33-fold increase in wind capacity, mainly offshore.

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

Today's supply of renewables

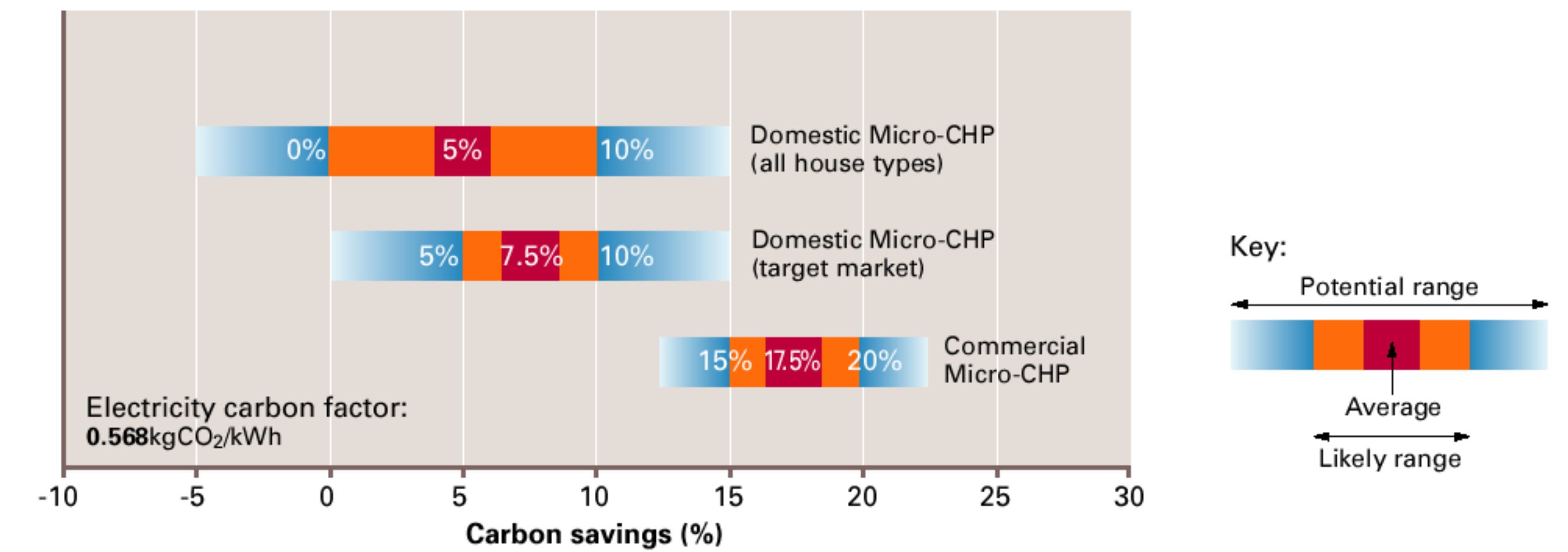


Carbon Trust on Micro-CHP

Executive summary

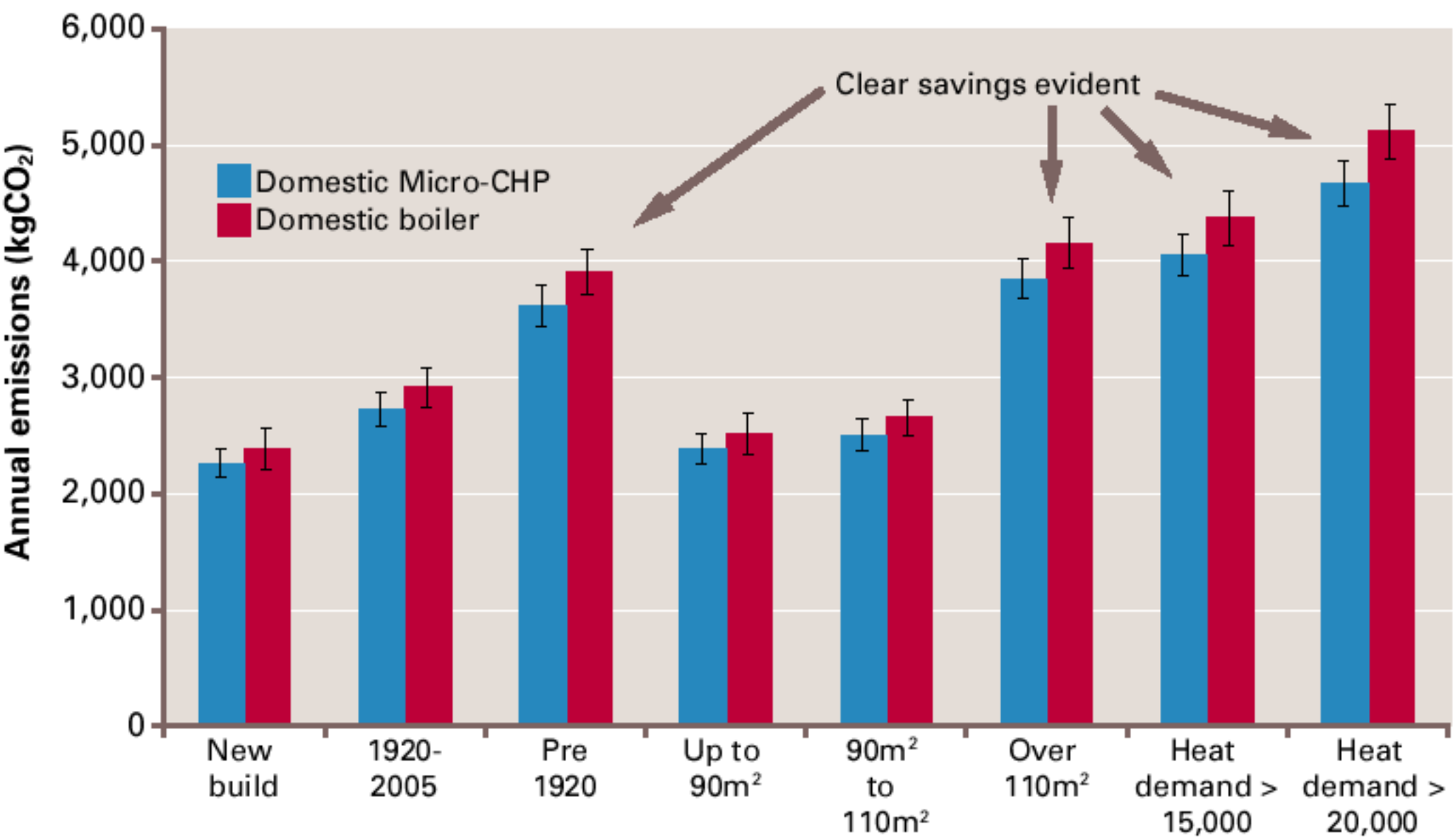
Micro-CHP is an emerging set of technologies with the potential to provide carbon savings in both commercial and domestic environments. Combined Heat and Power (CHP) systems provide potential reductions in carbon emissions and costs by generating both heat and electricity locally with efficient use of 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 0.568kgCO₂/kWh for displaced electricity)



Carbon Trust on Micro-CHP

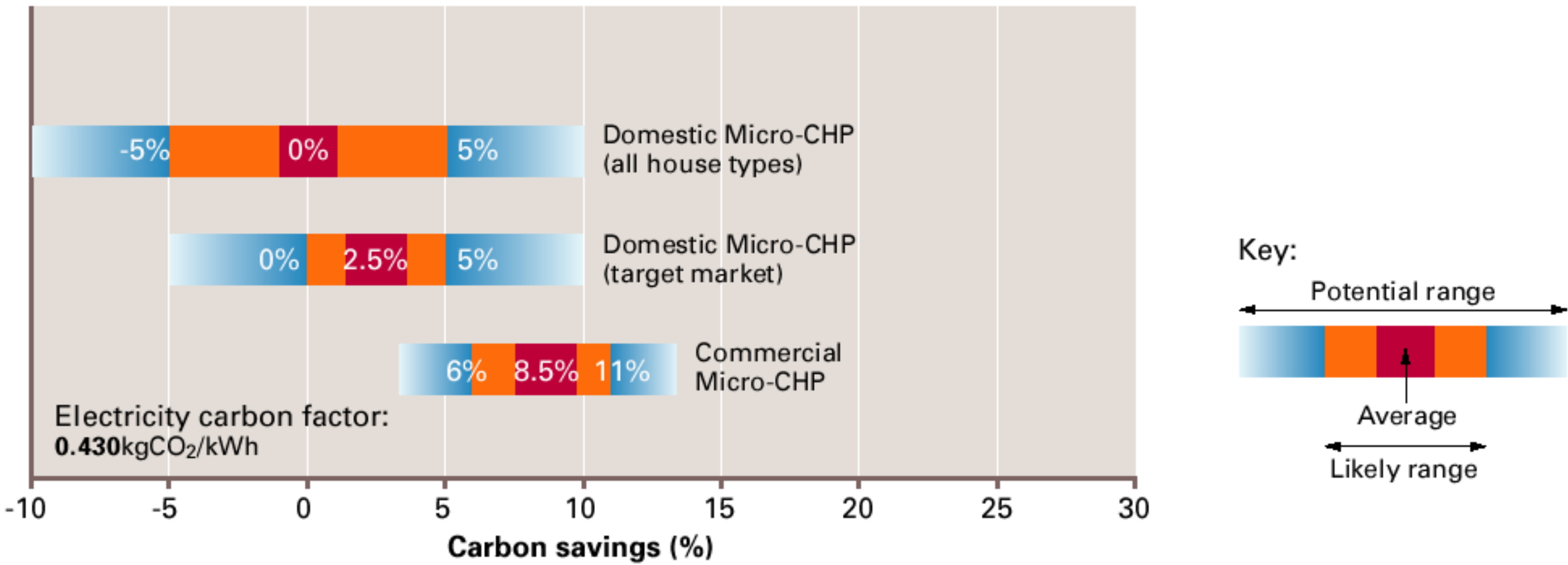
Figure 50 Annual Micro-CHP and boiler emissions for cluster scenarios



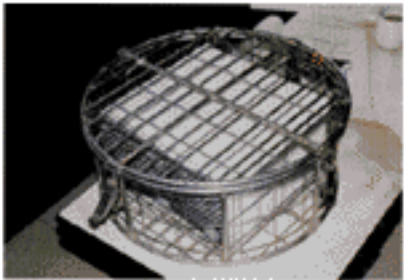
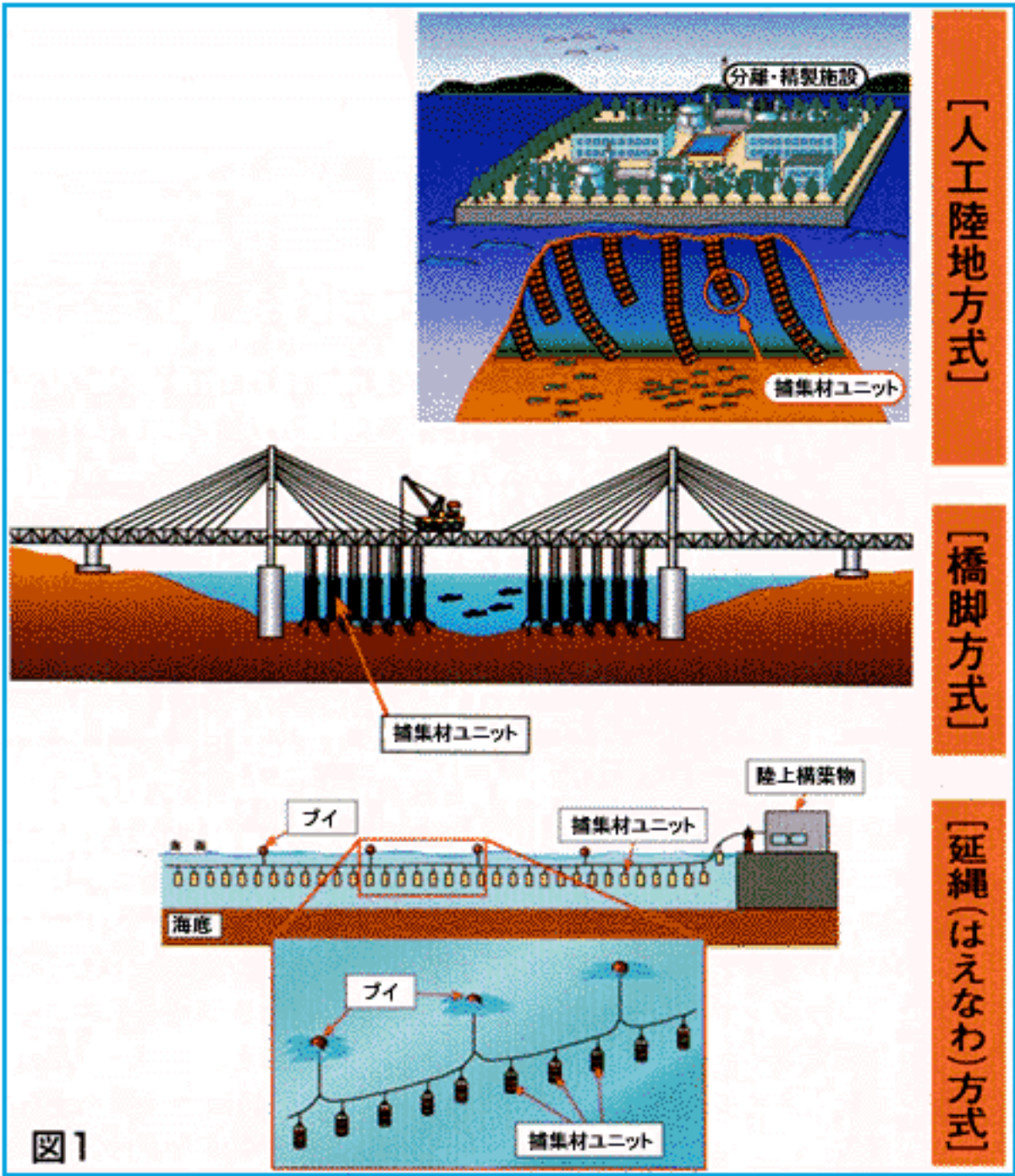
Carbon Trust on Micro-CHP

If they used 0.43 kgCO₂/kWh instead...

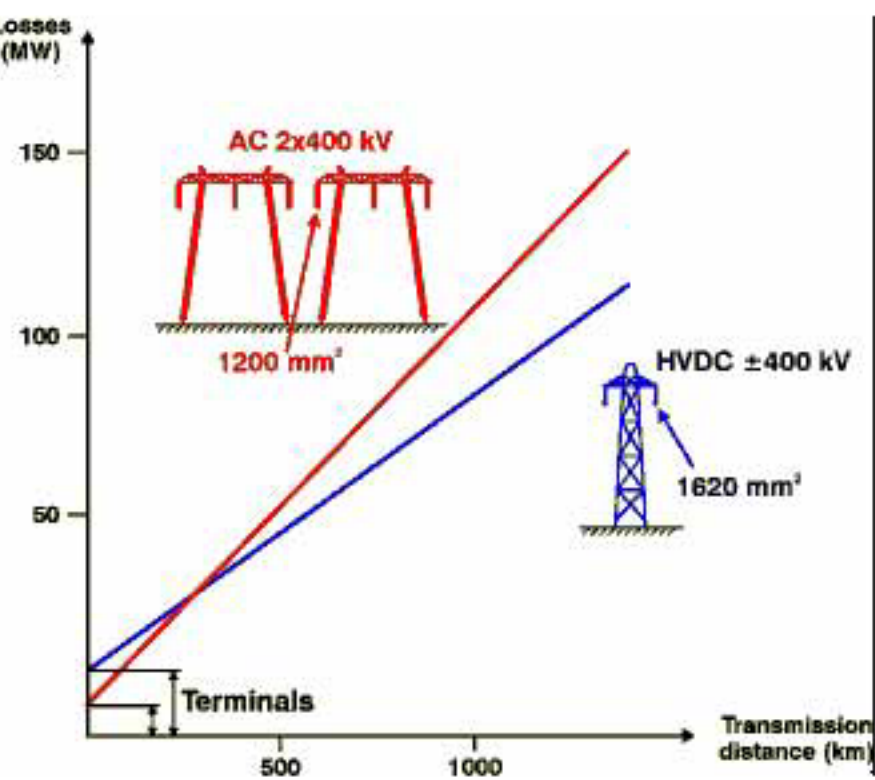
Figure 53 Range of carbon savings expected for domestic and commercial Micro-CHP
(based on carbon emissions factor of 0.43kgCO₂/kWh for displaced electricity)



Ocean Uranium



HVDC transmission



Photos and diagrams: ABB 2GW -->



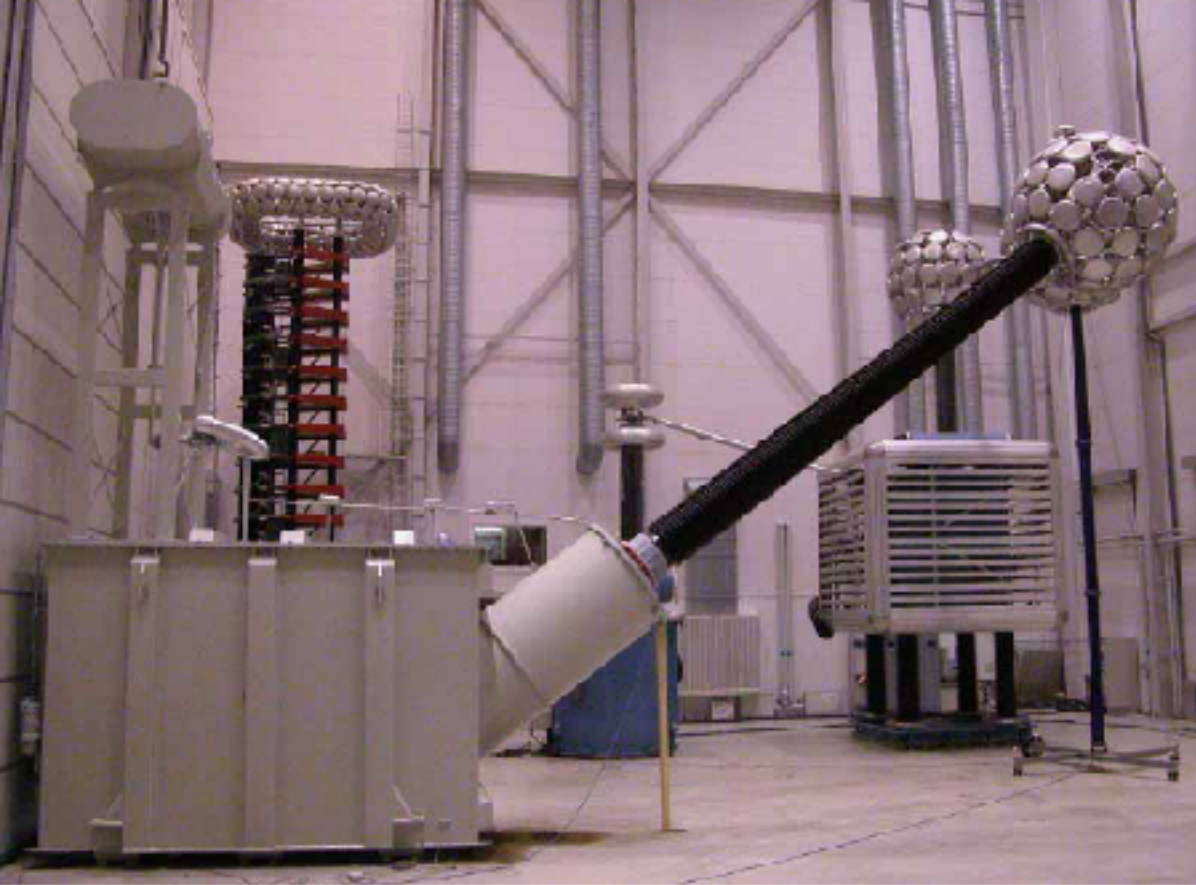
3.1GW, 1360km



1.9GW, 1420km

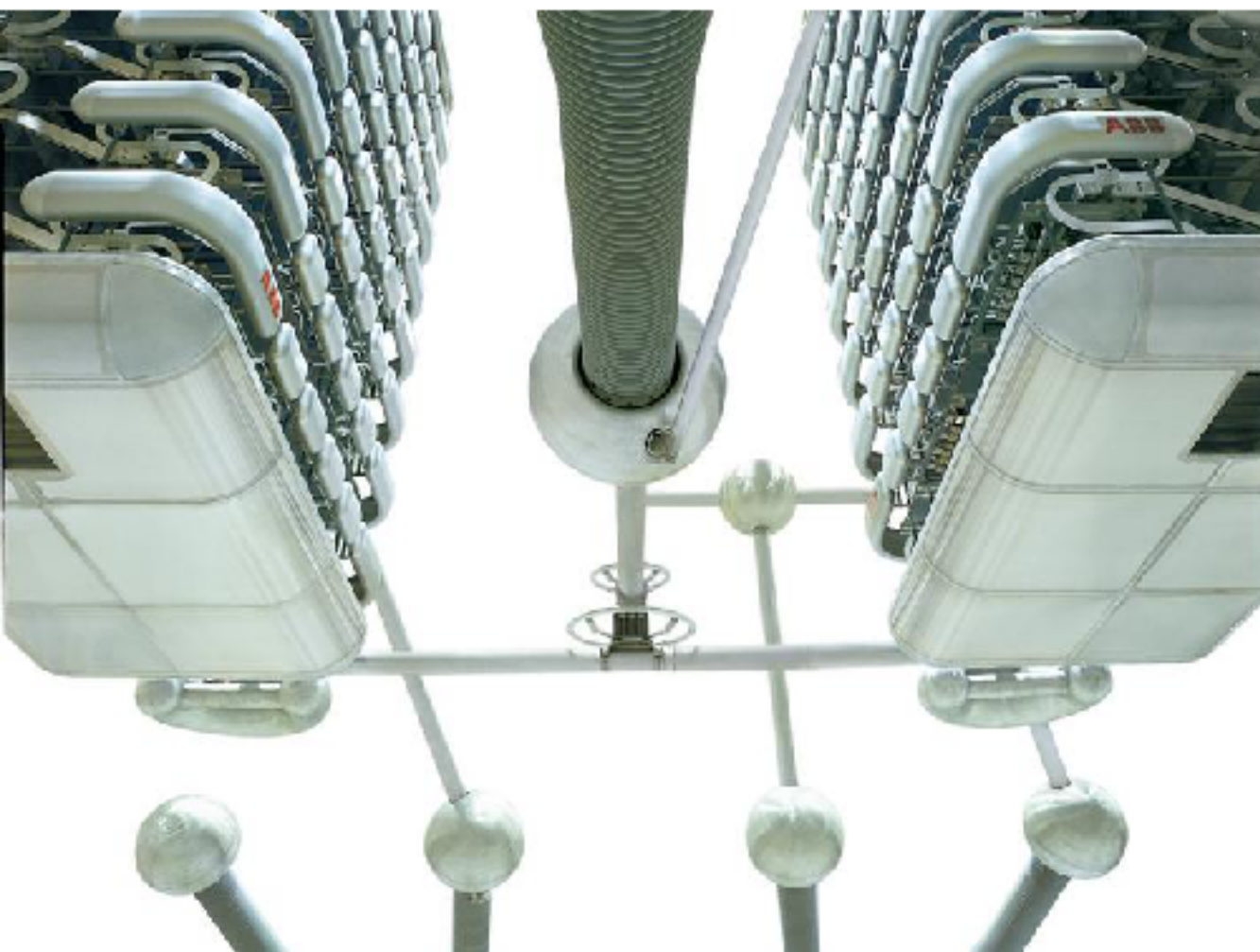


0.7GW, 580km



Finland - Estonia:
One pair of cables
transmit 350 MW

Photos: ABB



Sustainable Energy

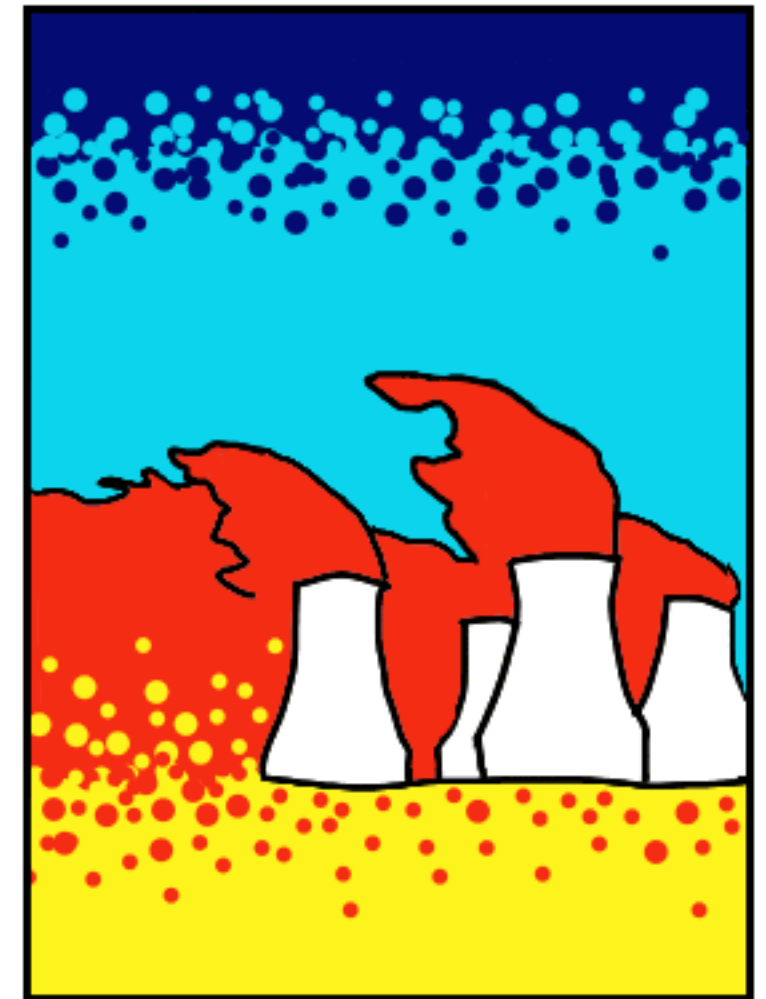
- without the hot air

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.

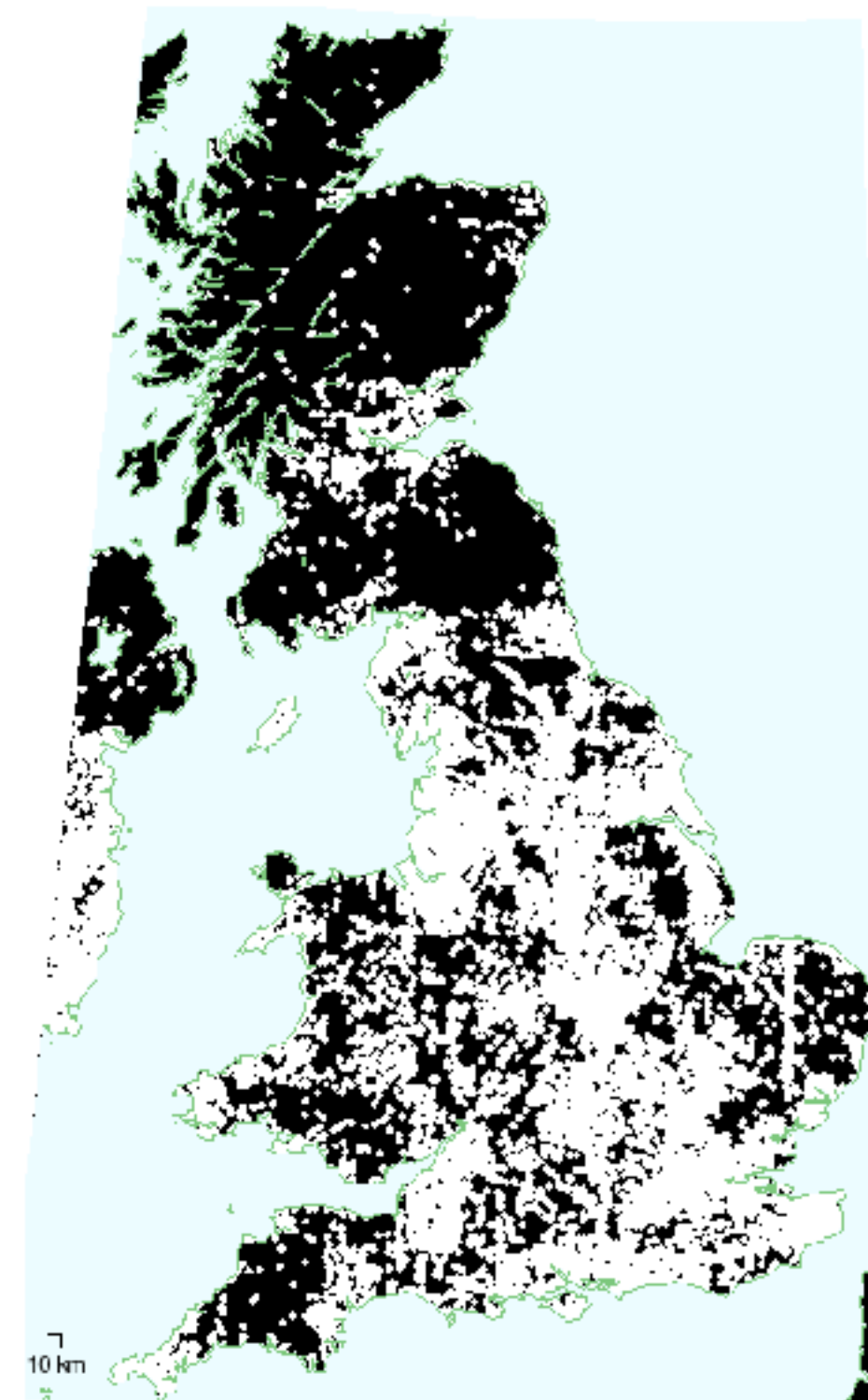
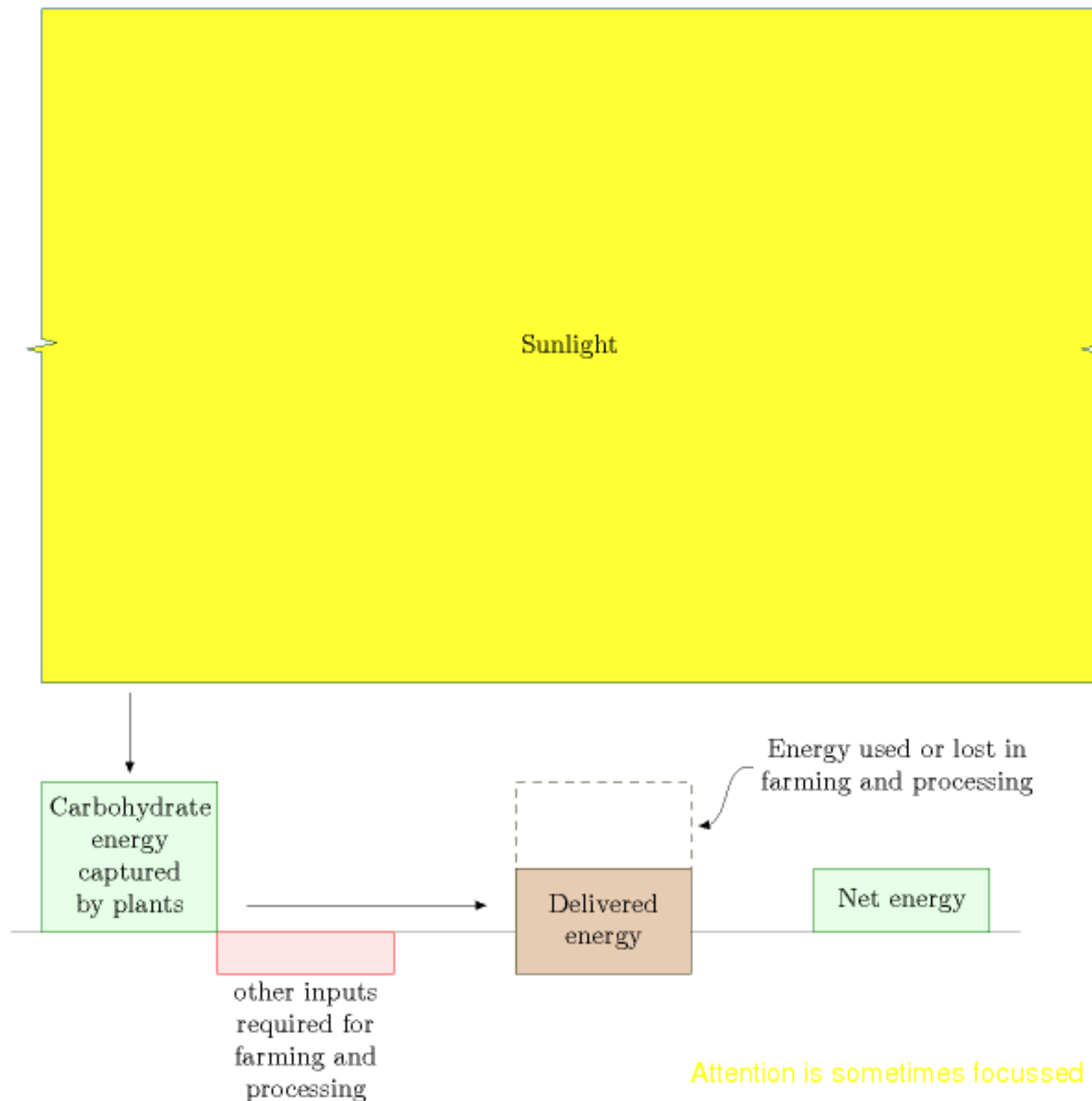
Biofuels worsen global warming

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

How much power could Britain get from biofuels?

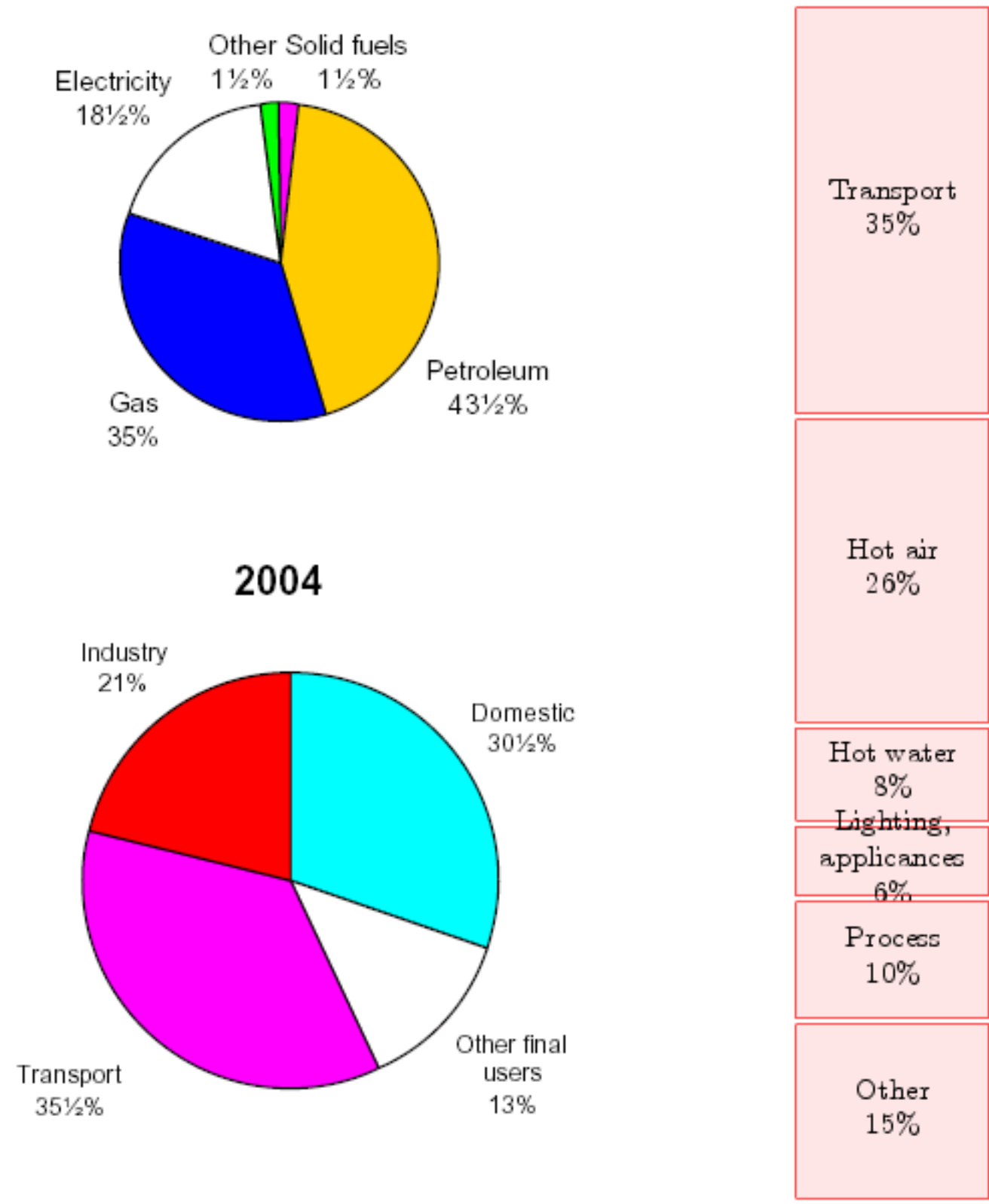
Power per unit area

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!

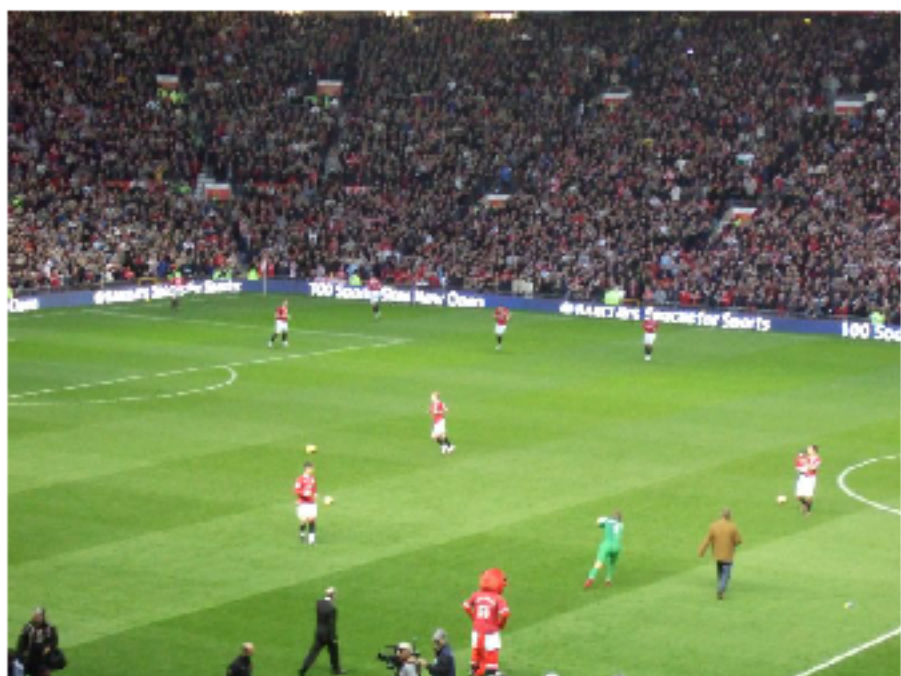
Average Power consumption, UK: 125 kWh/d each



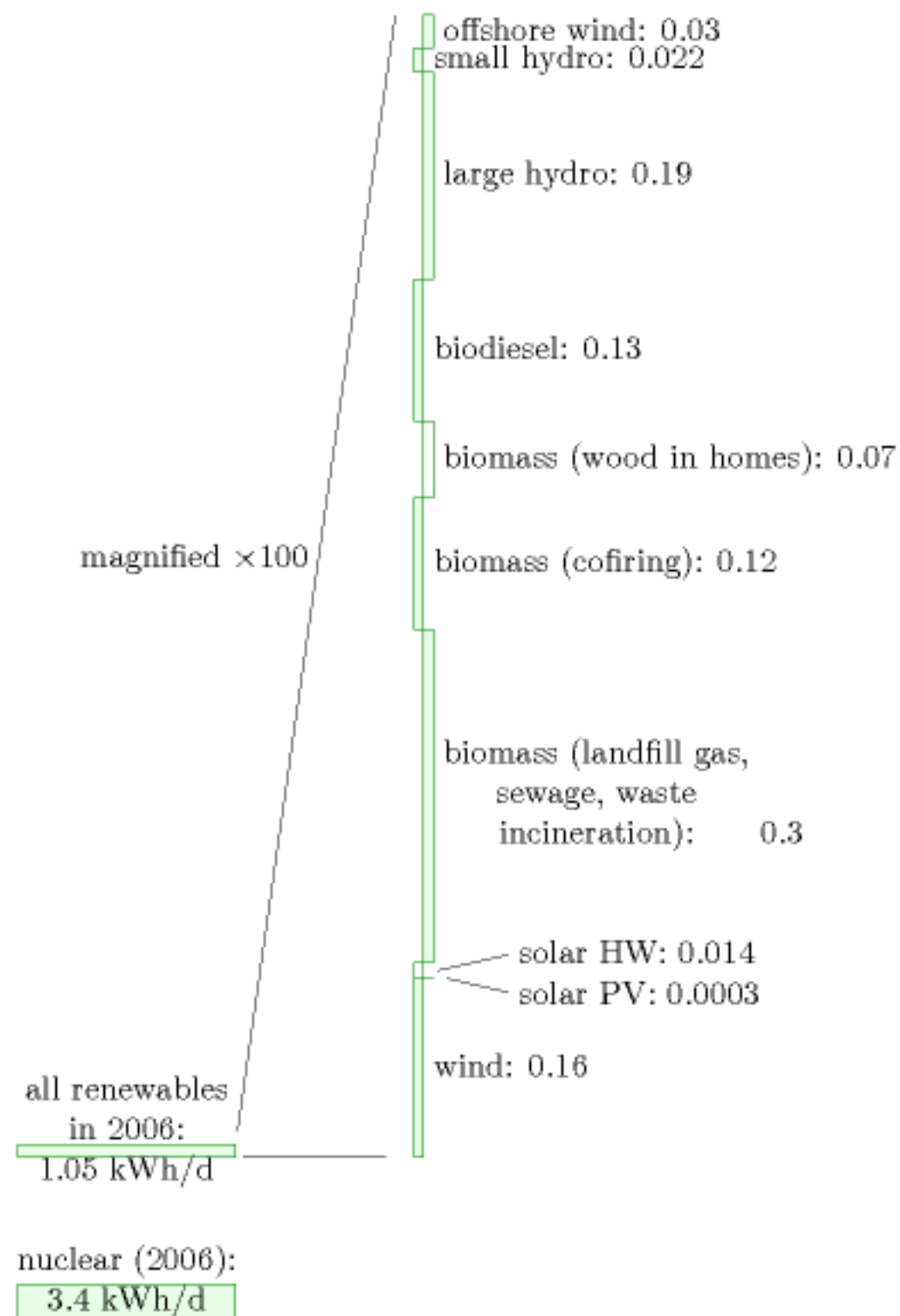
www.dti.gov.uk

'primary consumption'
125 kWh/day (Europe)
300 kWh/day (USA)
(doesn't include imports,
nor solar energy in food)

Area
UK: 4000 m² per person

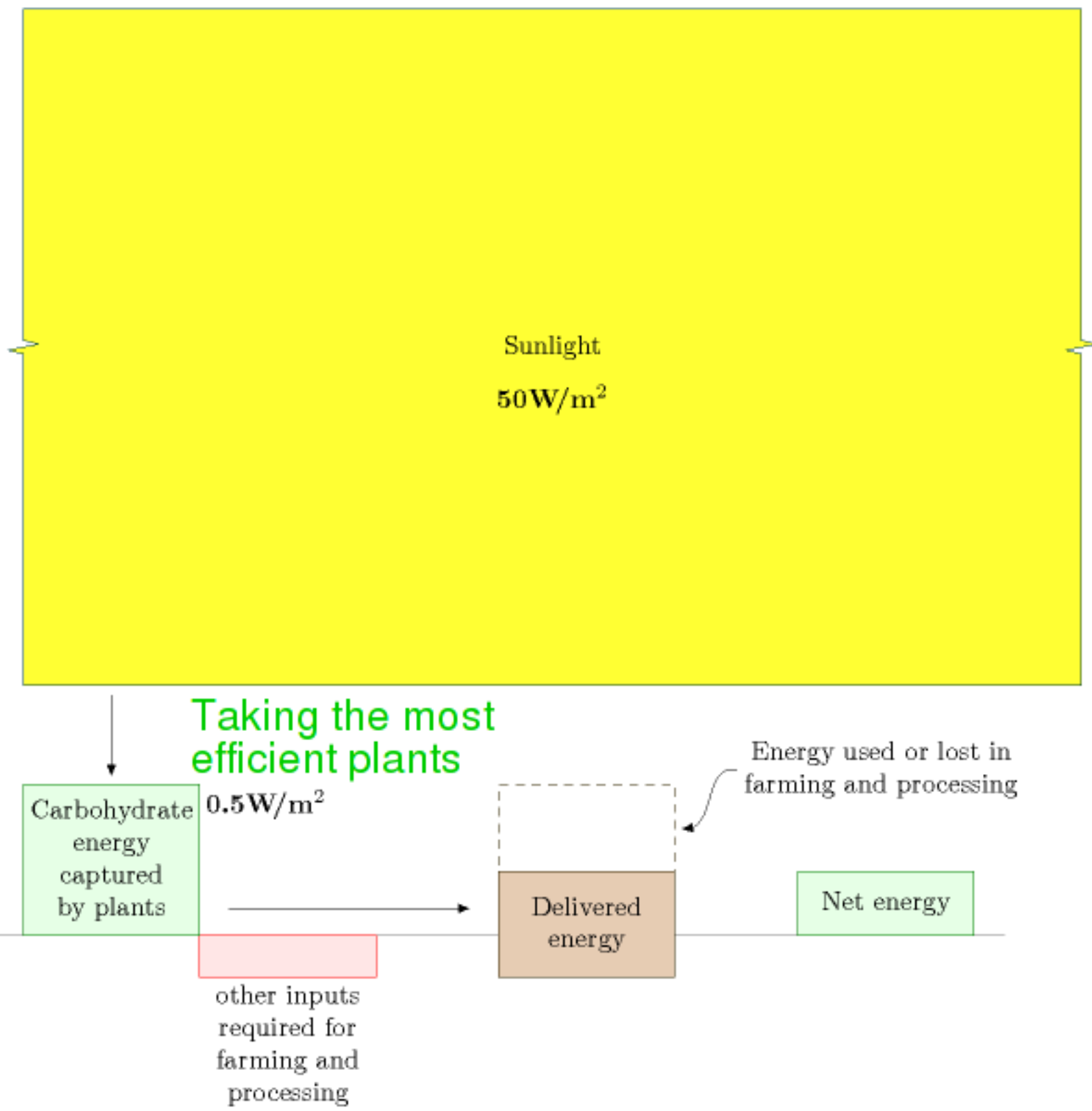


Today's supply of renewables

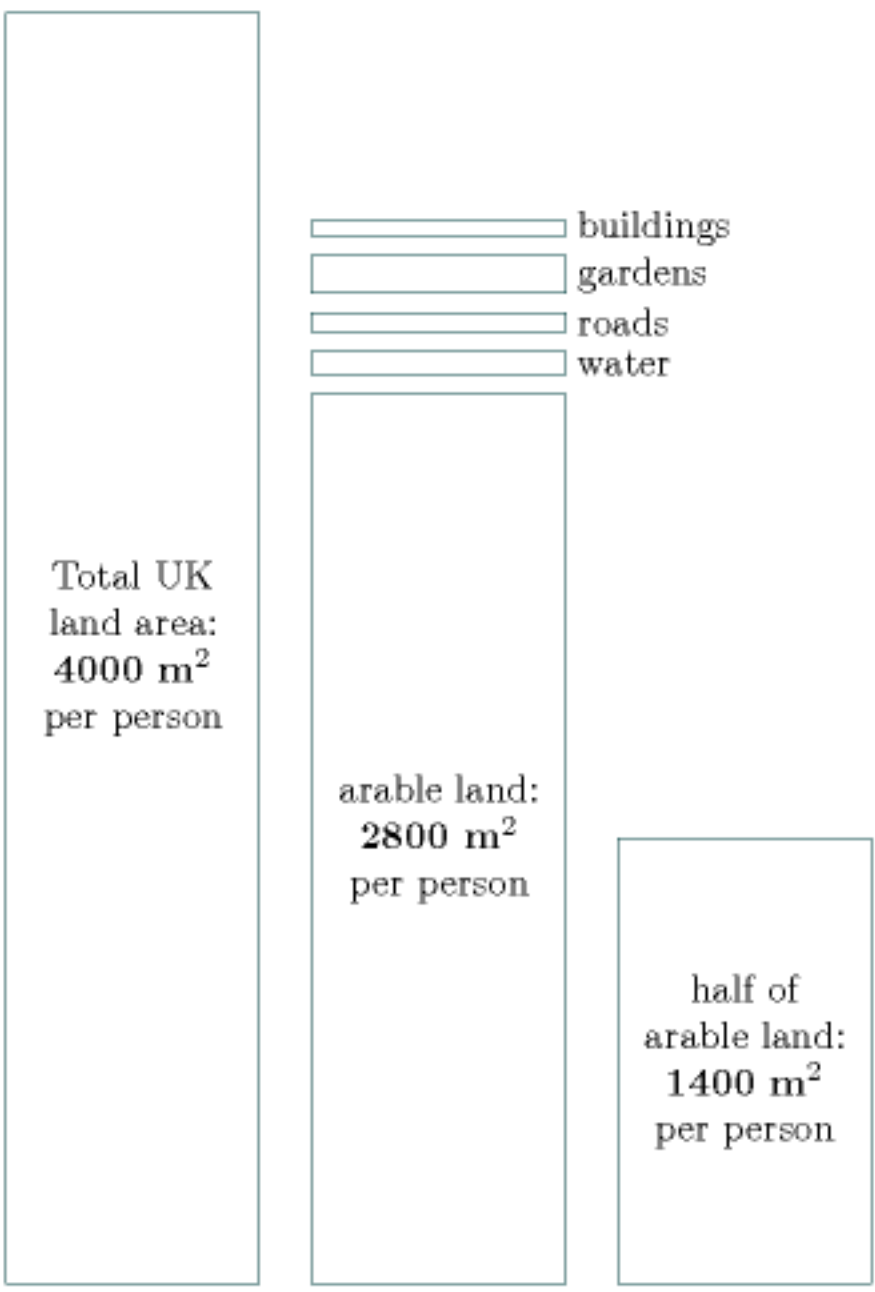


How much power could Britain get from biofuels?

Power per unit area

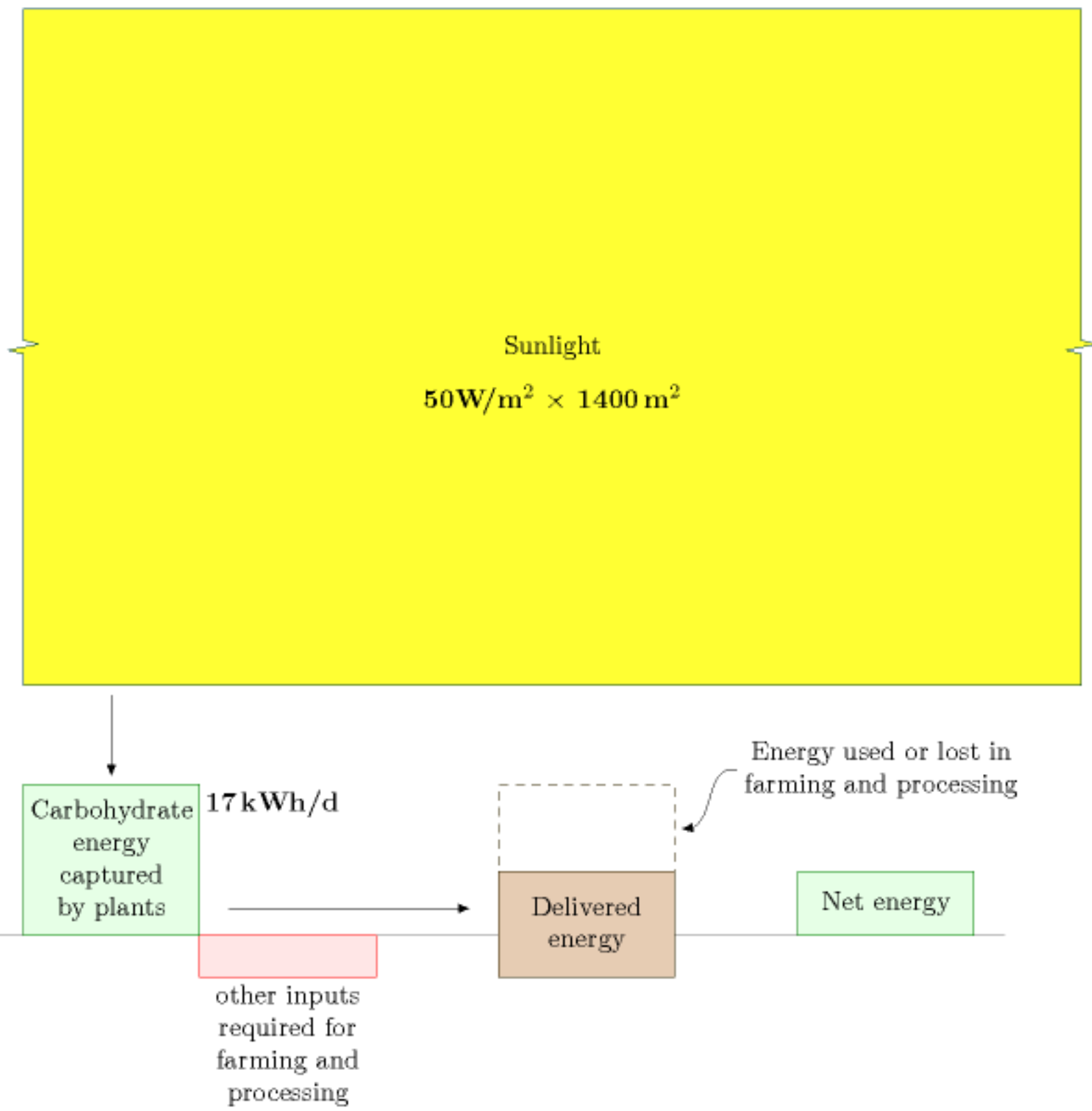


x Area

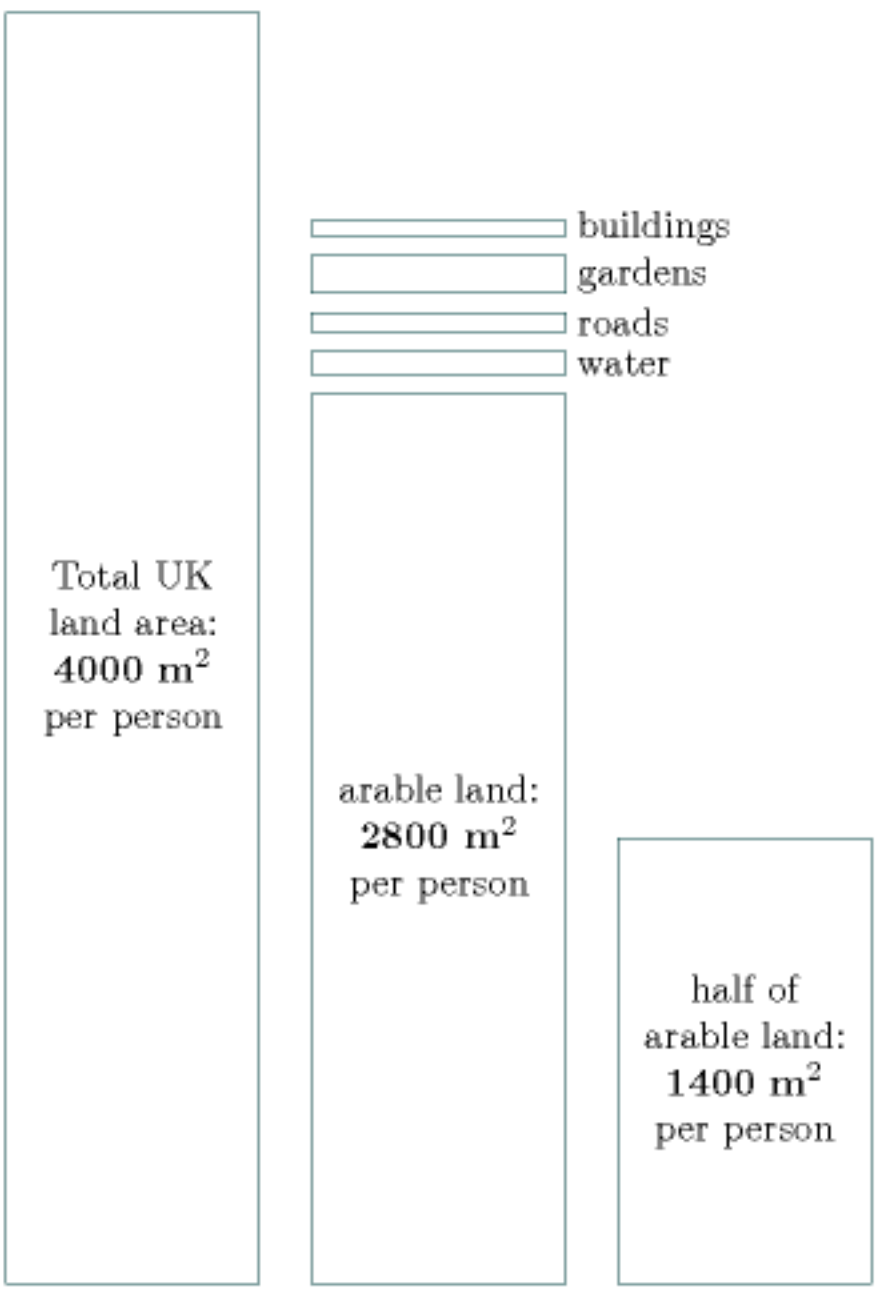


How much power could Britain get from biofuels?

Power per unit area

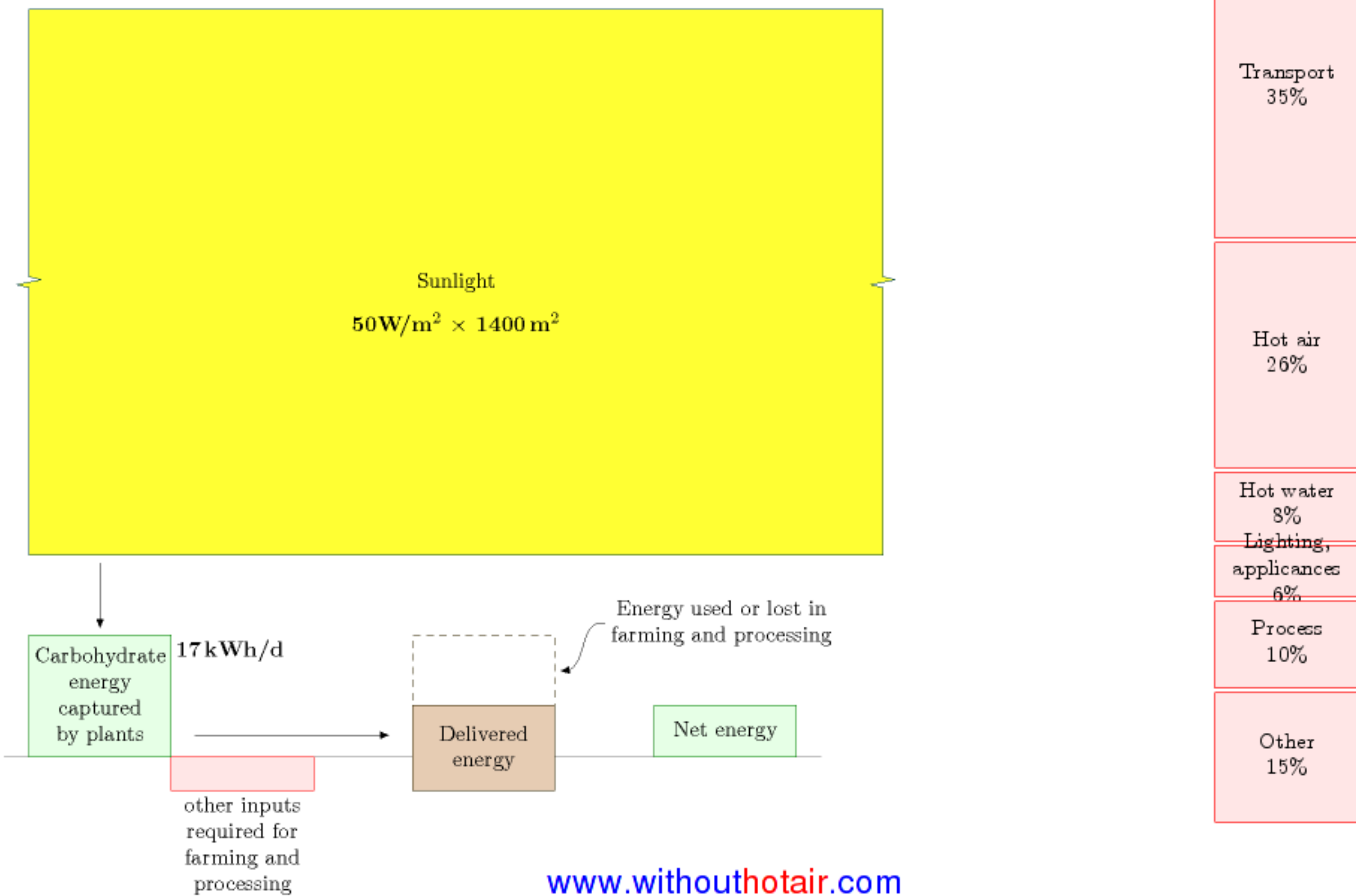


x Area



Even if all the other issues were resolved

● Biofuels could make only a small contribution



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,
Estimating the Net Energy Balance of Corn Ethanol
United States Department of Agriculture,
Agricultural Economic Report Number 721



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