Strategies for Sustainable Energy

Lecture 8. Strategies for Sustainability II

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Outline

26. Fluctuation and Storage

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Energy demand fluctuates on a daily and yearly basis

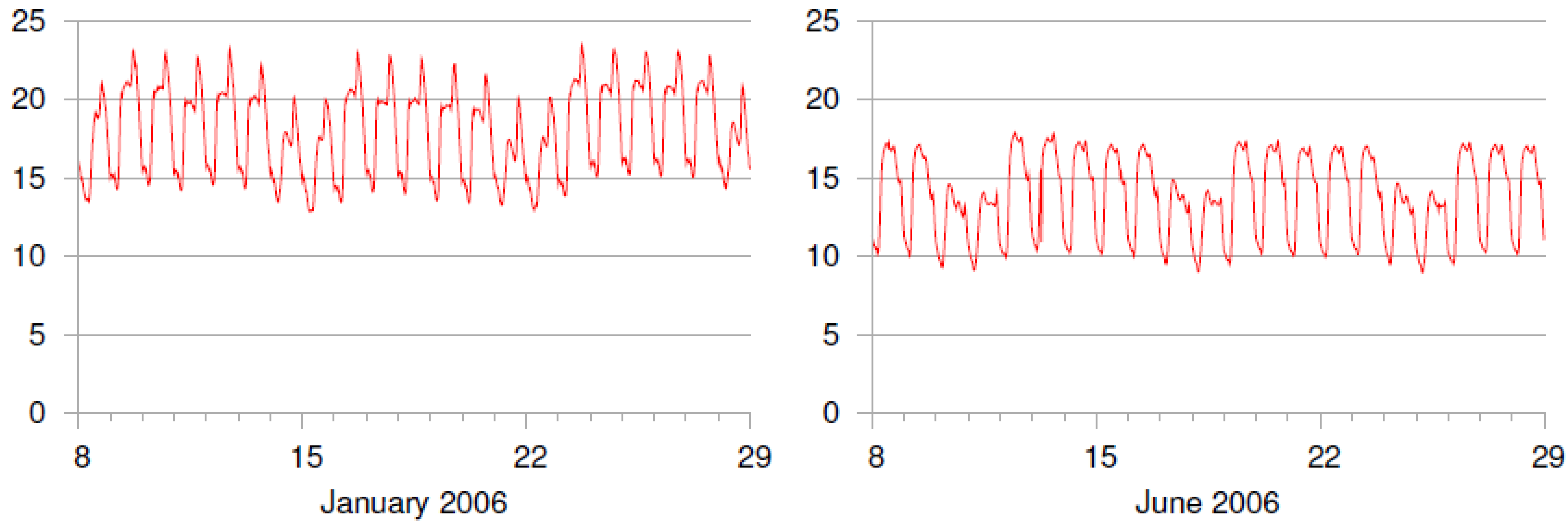

Figure 26.1. Electricity demand in Great Britain (in kWh/d per person) during two winter weeks and two summer weeks of 2006. The peaks in January are at 6pm each day. The five-day working week is evident in summer and winter. (If you'd like to obtain the national demand in GW, remember the top of the scale, 24 kWh/d per person, is the same as 60 GW per UK.)

Energy supply from renewable sources fluctuates on a daily and yearly basis

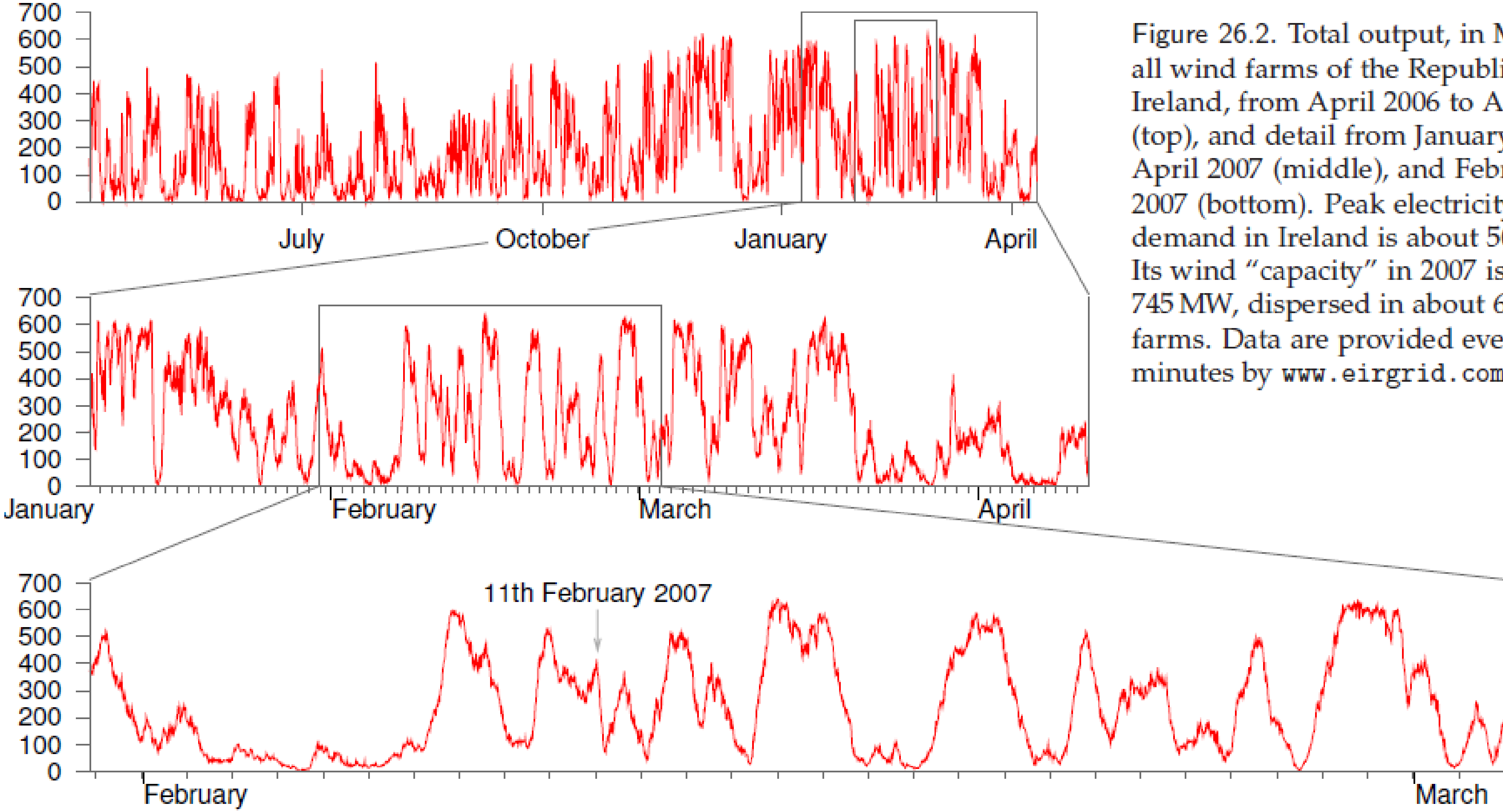

Figure 26.2. Total output, in MW, of all wind farms of the Republic of Ireland, from April 2006 to April 2007 (top), and detail from January 2007 to April 2007 (middle), and February 2007 (bottom). Peak electricity demand in Ireland is about 5000 MW. Its wind "capacity" in 2007 is 745 MW, dispersed in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

26. Fluctuation and Storage

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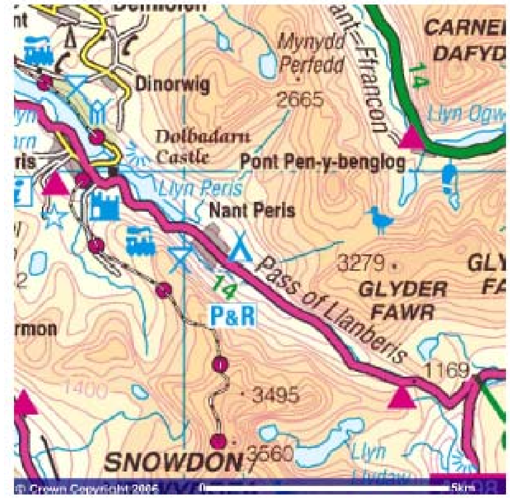
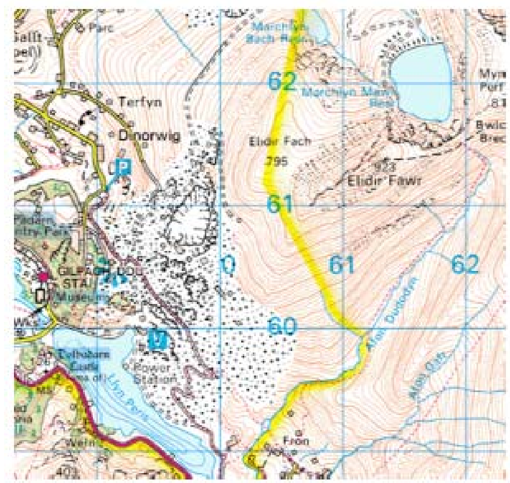
We need country-sized energy storage systems to cope with lulls in renewable energy production.

Options include

- Pumped storage
- Network of electric vehicles

Pumped storage involves using electricity to pump water from a low elevation to a high elevation, when there is excess electricity. When you need electricity and the wind turbines aren't spinning because the wind isn't blowing, you allow the water to flow back down to the lower elevation through hydroelectric turbines.





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.

26. Fluctuation and Storage

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● Network of electric vehicles (Vehicle to Grid) Technology

Vehicle-to-grid (**V2G**) describes a system in which plug-in electric vehicles, such as electric cars (BEVs) and plug-in hybrids (PHEVs), communicate with the power grid to sell demand response services by either delivering electricity into the grid or by throttling their charging rate.[1][2]

Vehicle-to-grid can be used with such *gridable* vehicles, that is, plug-in electric vehicles (BEVs and PHEVs), with grid capacity. Since most vehicles are parked an average of 95 percent of the time, their batteries could be used to let electricity flow from the car to the power lines and back, with a value to the utilities of up to $4,000 per year per car.[3]

http://en.wikipedia.org/wiki/Vehicle-to-grid

The Current Situation

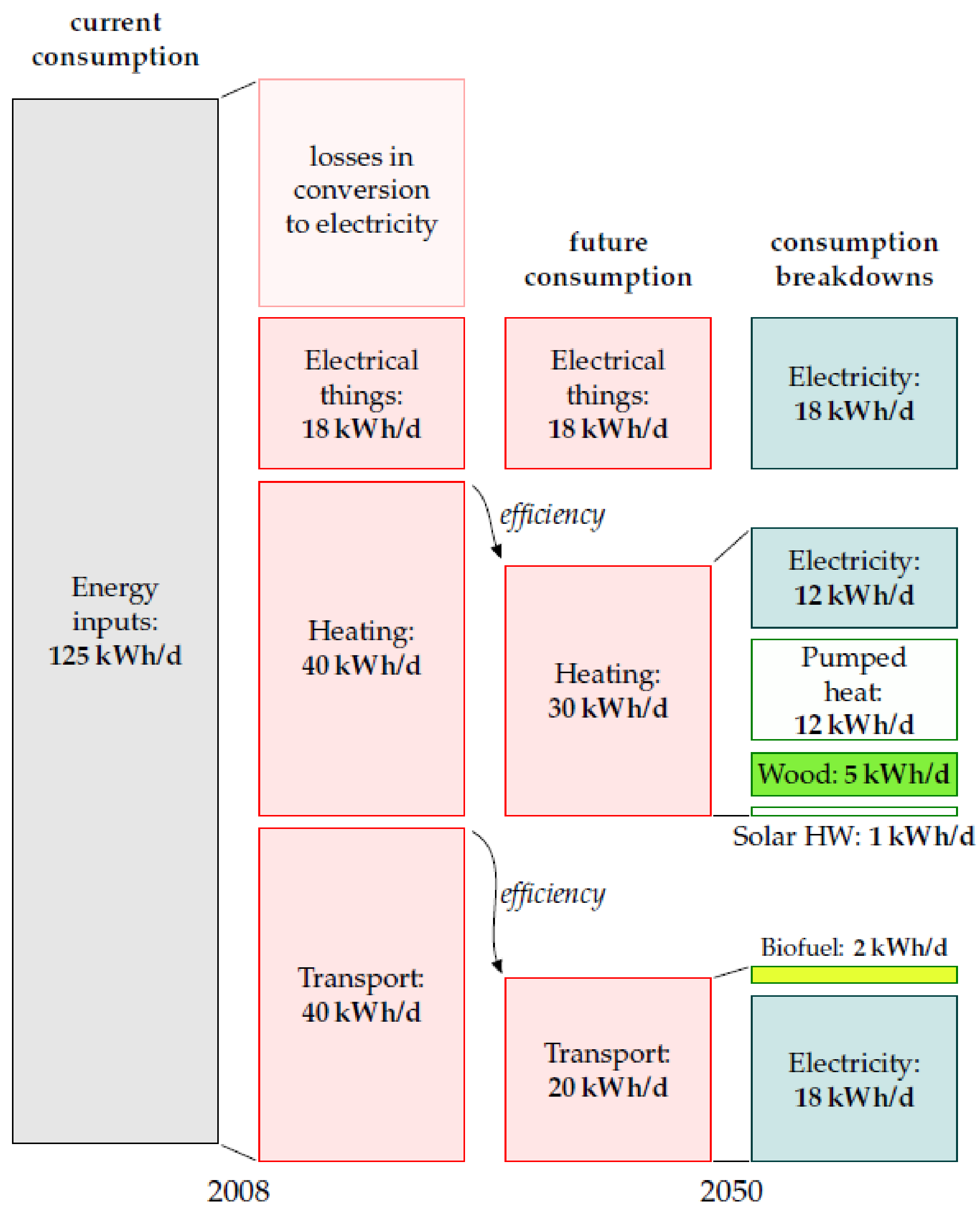

Figure 27.1. Current consumption per person in "cartoon Britain 2008" (left two columns), and a future consumption plan, along with a possible breakdown of fuels (right two columns). This plan requires that electricity supply be increased from 18 to 48 kWh/d per person of electricity.

27. 5 Plans for Britain

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Common Features of all Five Plans

transport

- transport is largely electrified.
- mass transport is more prevalent and more utilized

heating

- better insulated buildings
- heat pumps for heating

electricity

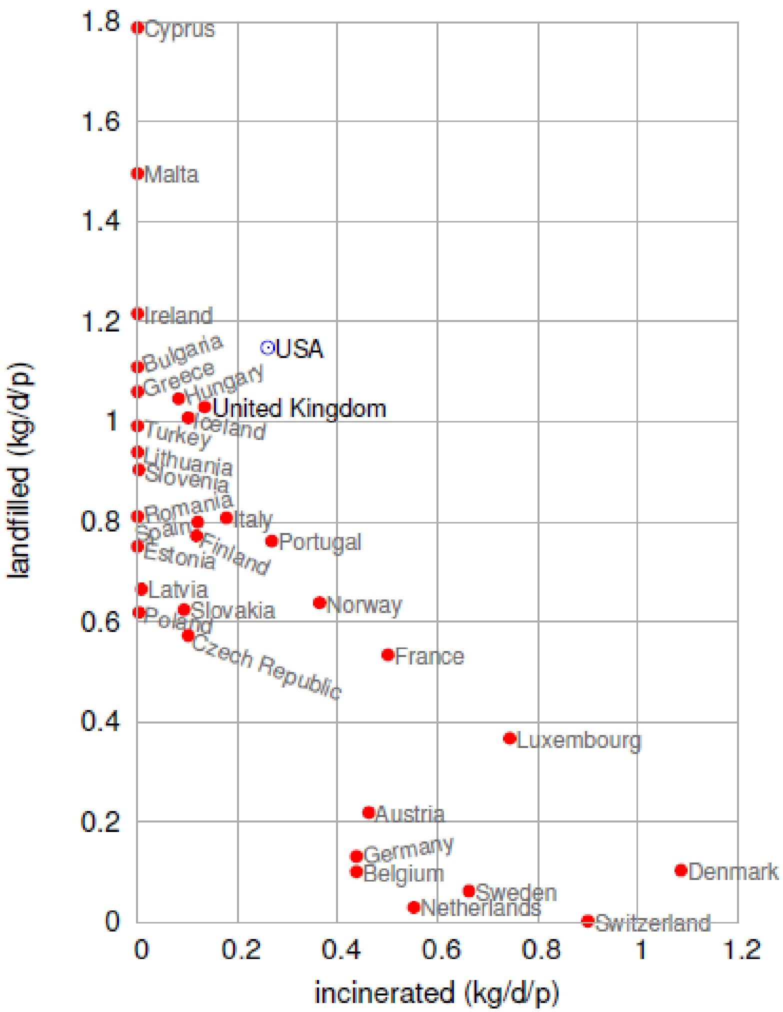
- increased from 18 kWh/d/p to 48 kWh/d/p

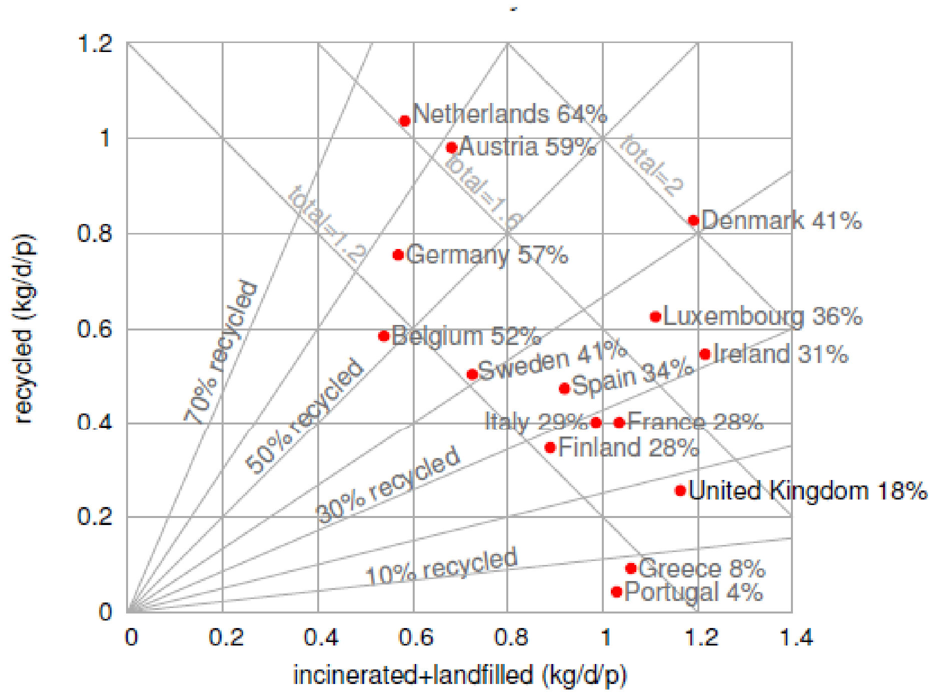
Waste incineration

- all waste that cannot be recycled is burned for energy

27. 5 Plans for Britain

Waste Incineration



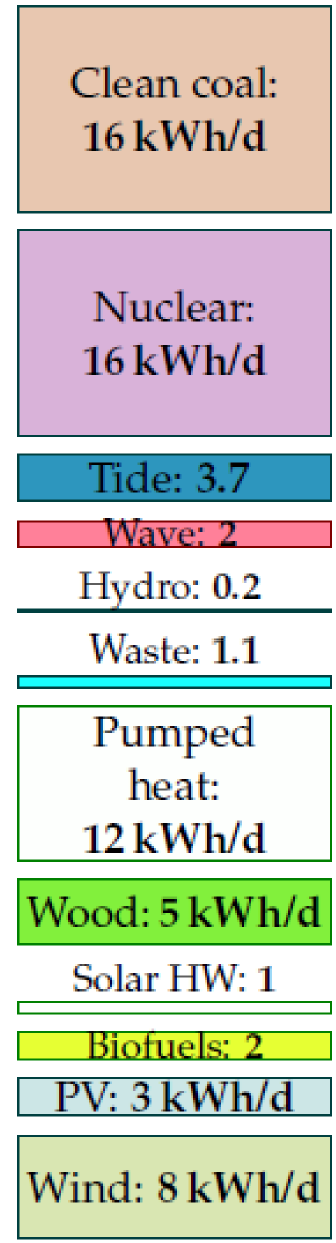


27. 5 Plans for Britain

Plan D: Domestic Diversity

Make as much energy as possible domestically.

- 30 fold increase in wind power
- 6 m^2 of 20% efficient PV cells per person in England
- Waste incineration 2 kg/d/person
- Wave power 16,000 pelamis wave devices
- Tidal stream installation, a barrage & tidal lagoons
- 4 fold increase in nuclear
- Increase coal-fired power plant capacity
- Use imported coal
- 32% of the energy from other countries (coal)

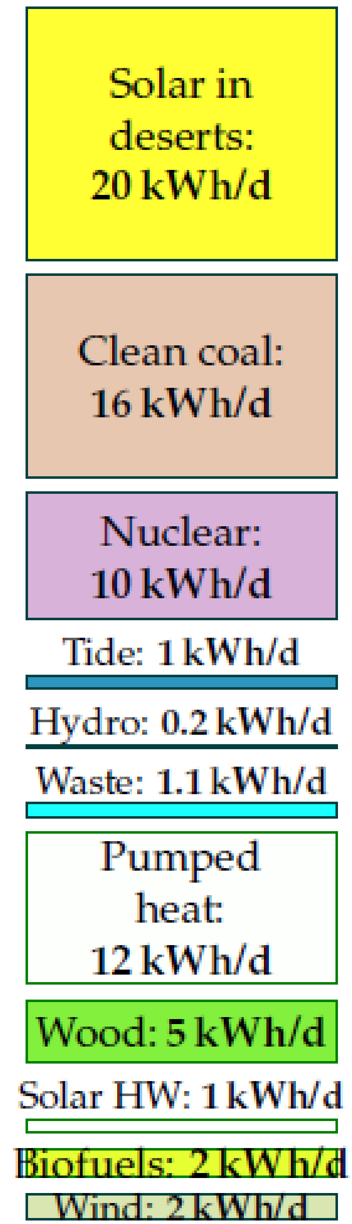


27. 5 Plans for Britain

Plan N: NIMBY: Not In My Back Yard

Don’t industrialize the countryside.
Minimize nuclear.

- 8 fold increase in wind power
- No solar PV cells per person
- Waste incineration 2 kg/d/person
- No Wave power
- modest increase in nuclear (no new plants)
- Increase coal-fired power plant capacity
- Use imported coal
- solar power stations in North African deserts
- 72% of the energy from other countries



27. 5 Plans for Britain

Plan L: Liberal Democrats

No nuclear

- Same as plan D, but swap nuclear for solar.
- Solar power farms in North African deserts
- 64% of the energy from other countries

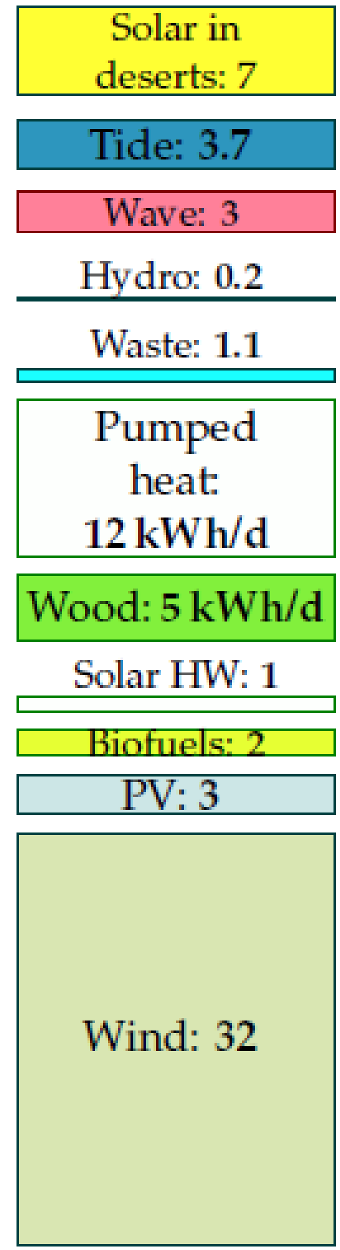
- 30 fold increase in wind power
- 6 m^2 of 20% efficient PV cells per person
- Waste incineration 2 kg/d/person
- Wave power 16,000 pelamis wave devices
- Tidal stream installation, a barrage & tidal lagoons
- Increase coal-fired power plant capacity
- Use imported coal

27. 5 Plans for Britain

Plan G: Green Party

No nuclear
No coal.

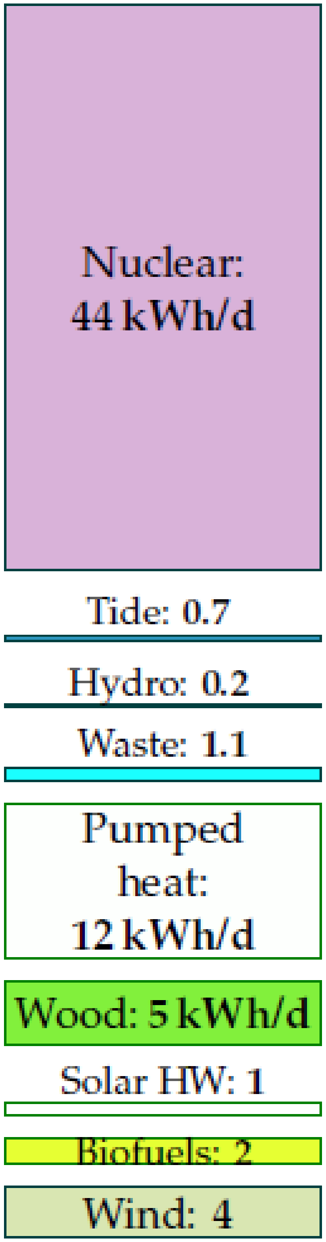
- 120 fold increase in wind power
- Solar power farms in North African deserts
- Waste incineration 2 kg/d/person
- Wave power 16,000 pelamis wave devices
- Tidal stream installation, a barrage & tidal lagoons
- Increase coal-fired power plant capacity
- Use imported coal
- 14% of the energy from other countries



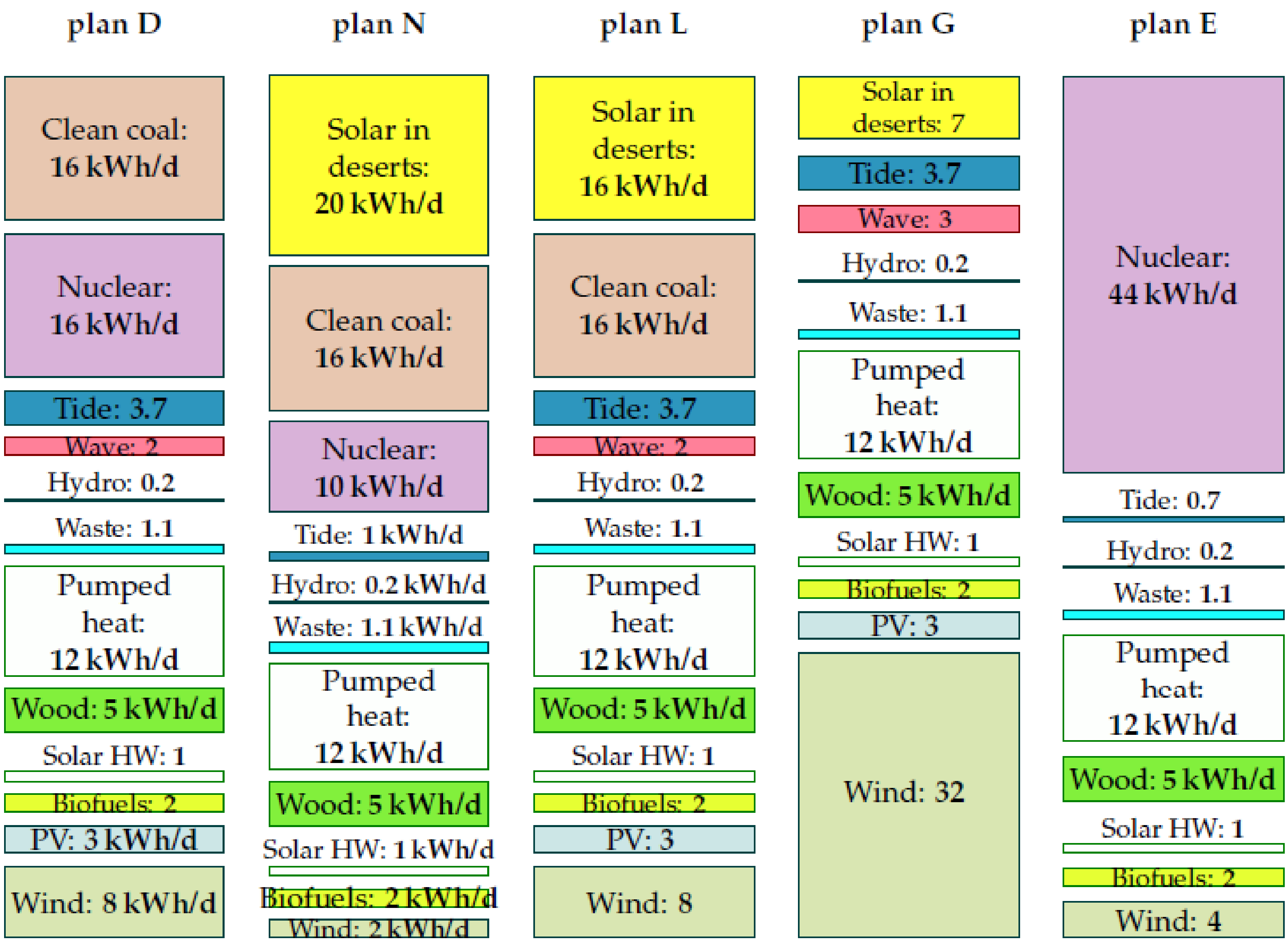
Plan E: Economics

Energy market with a strong carbon price.
Cheapest solution wins.
Nuclear is cheaper than "clean coal".

- 15 fold increase in wind power
- Waste incineration 2 kg/d/person
- 0% of the energy from other countries, if you don't count uranium



27. 5 Plans for Britain



All these plans are absurd. If so, think of a better one.

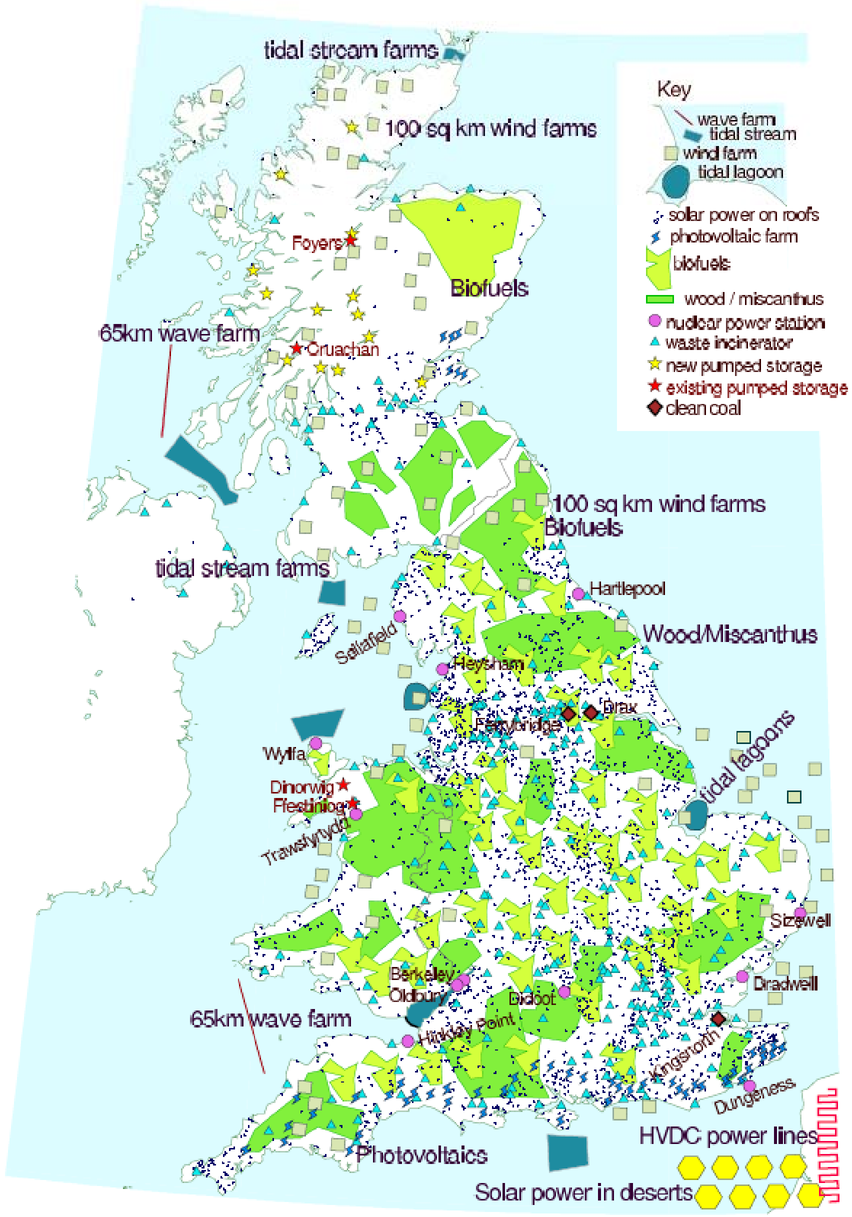
28. Putting Costs in Perspective

Plan M: the Middle plan

Combine elements of the five previous plans.

This model contains all technologies.

It is physically feasible. There is enough area around England for each of the technologies.



Solar in deserts: 16 kWh/d

Clean coal: 3

Nuclear: 16 kWh/d

Tide: 3.7

Wave: 0.3

Hydro: 0.2

Waste: 1.1

Pumped heat: 12 kWh/d

Wood: 5 kWh/d

Solar HW: 1

Biofuels: 2

PV: 2

Wind: 8

28. Putting Costs in

Plan M: the Middle plan

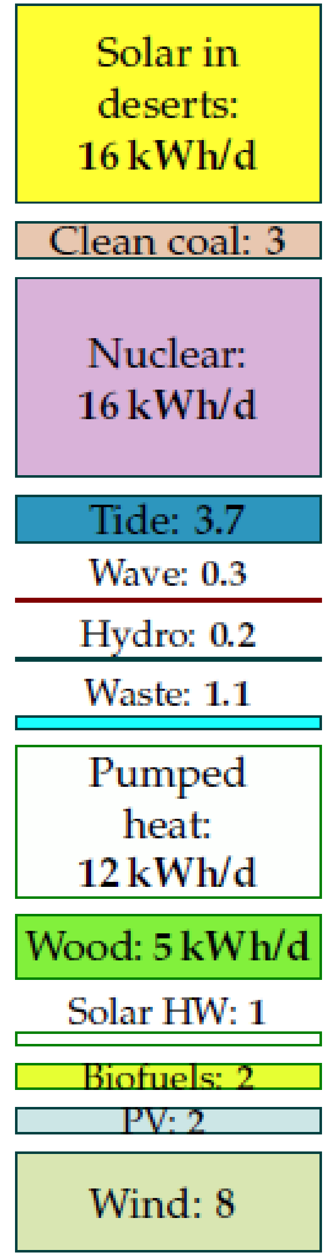
	Capacity	Rough cost total	Rough cost per person	Average power delivered
52 onshore wind farms: 5200 km^2	35 GW	£27bn – based on Lewis wind farm	£450	4.2 kWh/d/p
29 offshore wind farms: 2900 km^2	29 GW	£36bn – based on Kentish Flats, & including £3bn investment in jack-up barges.	£650	3.5 kWh/d/p
Pumped storage: 15 facilities similar to Dinorwig	30 GW	£15bn	£250	
Photovoltaic farms: 1000 km^2	48 GW	£190bn – based on Solarpark in Bavaria	£3200	2 kWh/d/p
Solar hot water panels: 1 m^2 of roof-mounted panel per person. (60 km^2 total)	2.5 GW(th) average	£72bn	£1200	1 kWh/d/p
Waste incinerators: 100 new 30 MW incinerators	3 GW	£8.5bn – based on SELCHP	£140	1.1 kWh/d/p
Heat pumps	210 GW(th)	£60bn	£1000	12 kWh/d/p
Wave farms – 2500 Pelamis, 130 km of sea	1.9 GW (0.76 GW average)	£6bn?	£100	0.3 kWh/d/p
Severn barrage: 550 km^2	8 GW (2 GW average)	£15bn	£250	0.8 kWh/d/p
Tidal lagoons: 800 km^2	1.75 GW average	£2.6bn?	£45	0.7 kWh/d/p
Tidal stream: 15 000 turbines – 2000 km^2	18 GW (5.5 GW average)	£21bn?	£350	2.2 kWh/d/p
Nuclear power: 40 stations	45 GW	£60bn – based on Olkiluoto, Finland	£1000	16 kWh/d/p
Clean coal	8 GW	£16bn	£270	3 kWh/d/p
Concentrating solar power in deserts: 2700 km^2	40 GW average	£340bn – based on Solúcar	£5700	16 kWh/d/p
Land in Europe for 1600 km of HVDC power lines: 1200 km^2	50 GW	£1bn – assuming land costs £7500 per ha	£15	
2000 km of HVDC power lines	50 GW	£1bn – based on German Aerospace Center estimates	£15	
Biofuels: 30 000 km^2		(cost not estimated)		2 kWh/d/p
Wood/Miscanthus: 31 000 km^2		(cost not estimated)		5 kWh/d/p

28. Putting Costs in Perspective

Plan M: the Middle plan

Installation cost per kWh/day/person.

	cost (billion pounds)	power kWh/d/p	cost/power (billion pounds/kWh/d/p)
onshore wind	27	4.2	6.428571
offshore wind	36	3.5	10.28571
photovoltaic farms	190	2	95
solar hot water	72	1	72
waste incinerators	8.5	1.1	7.727273
heat pumps	60	12	5
wave farms	6	0.3	20
tidal barrage	15	0.8	18.75
tidal lagoons	2.6	0.7	3.714286
tidal farm	21	2.2	9.545455
nuclear power	60	16	3.75
clean coal	16	3	5.333333
concentrating solar power in deserts	340	16	21.25



28. Putting Costs in Perspective

Other things that cost a billion

\$46 billion/year – US war on drugs
\$700 billion/year – US expenditure on foreign oil
\$120 billion/year – US wars in Iraq and Afghanistan
\$40 billion/year – US federal highway maintenance
£10 billion/year – UK spent on food that is not eaten
\$40 billion/year – Exxon profits (2006)

The global cost of averting dangerous climate change (if we act now) is \$440 billion/year

£ 0.012 billion/per year: UK government investment in renewable energy research and development

There is money out there.
We spend it on short-sighted endeavors.

29. What to do now?

Carbon Pollution
The price of carbon dioxide must be set sufficiently high that people stop burning coal without capture.

Energy Supply
We cannot rely on the free market to drive energy sustainability.
The free market makes short-term decisions for short-term investments.
We need government legislation and green taxes.

Greening the tax system
It is cheaper to buy a new microwave or dvd player than it is to have the old one repaired. In part because labor is taxed higher than material goods. If the tax on goods was higher, the option of repairing a device would be more economically attractive.

Investment in Research and Development
Energy technologies take decades to develop. An increase in research money is needed immediately.

29. What to do now?

Simple action	possible saving
Put on a woolly jumper and turn down your heating's thermostat (to 15 or 17 °C, say). Put individual thermostats on all radiators. Make sure the heating's off when no-one's at home. Do the same at work.	20 kWh/d
Read all your meters (gas, electricity, water) every week, and identify easy changes to reduce consumption (e.g., switching things off). Compare competitively with a friend. Read the meters at your place of work too, creating a perpetual live energy audit.	4 kWh/d
Stop flying.	35 kWh/d
Drive less, drive more slowly, drive more gently, car-pool, use an electric car, join a car club, cycle, walk, use trains and buses.	20 kWh/d
Keep using old gadgets (e.g. computers); don't replace them early.	4 kWh/d
Change lights to fluorescent or LED.	4 kWh/d
Don't buy clutter. Avoid packaging.	20 kWh/d
Eat vegetarian, six days out of seven.	10 kWh/d

32 *Saying yes*

Because Britain currently gets 90% of its energy from fossil fuels, it's no surprise that getting off fossil fuels requires big, big changes – a total change in the transport fleet; a complete change of most building heating systems; and a 10- or 20-fold increase in green power.

Given the general tendency of the public to say "no" to wind farms, "no" to nuclear power, "no" to tidal barrages – "no" to anything other than fossil fuel power systems – I am worried that we won't actually get off fossil fuels when we need to. Instead, we'll settle for half-measures: slightly-more-efficient fossil-fuel power stations, cars, and home heating systems; a fig-leaf of a carbon trading system; a sprinkling of wind turbines; an inadequate number of nuclear power stations.

We need to choose a plan that adds up. It *is* possible to make a plan that adds up, but it's not going to be easy.

We need to stop saying no and start saying yes. We need to stop the Punch and Judy show and get building.

If you would like an honest, realistic energy policy that adds up, please tell all your political representatives and prospective political candidates.