LESS IS MORE:

Energy Security After Oil

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with Andy Simmonds

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Energy Security After Oil

An AECB discussion document

Puts forward the ingredients of a more secure and affordable energy future after oil. The technologies needed empirically work and are not dependent on speculative breakthroughs.

Conforms to advice from climate scientists that we need to reduce atmospheric CO_2 to 350 ppm, not just reduce CO_2 emissions by 80%.

Would be lower-cost than the present policy of high investment in energy supply, especially in electricity supply.

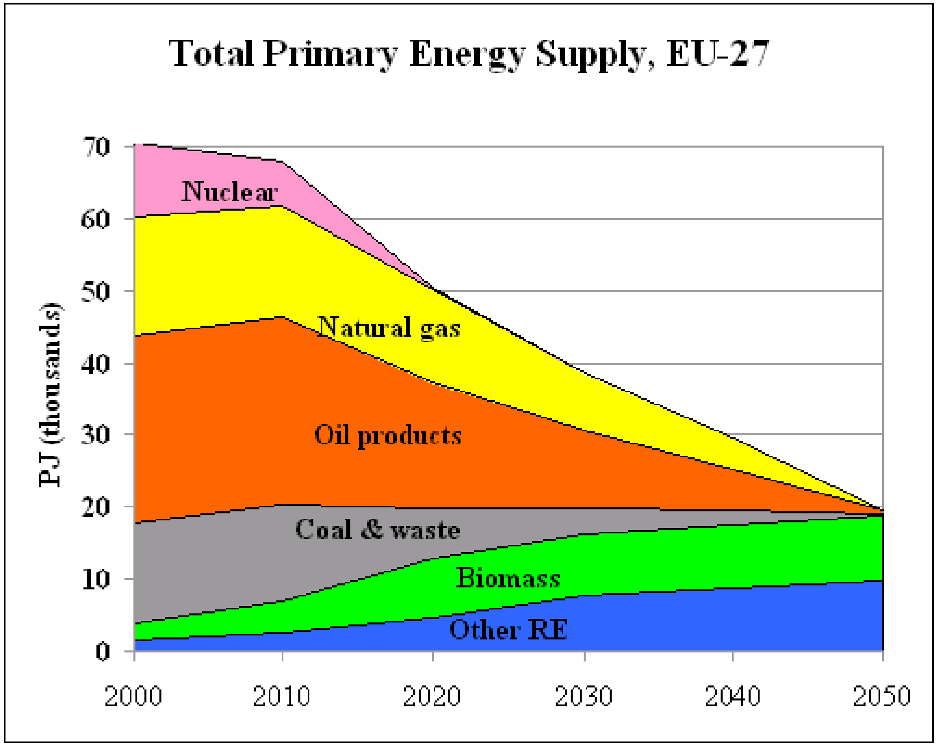
Especially fitting for the UK to take such an initiative. It was the first country to industrialise and has contributed disproportionately to CO_2 emissions.

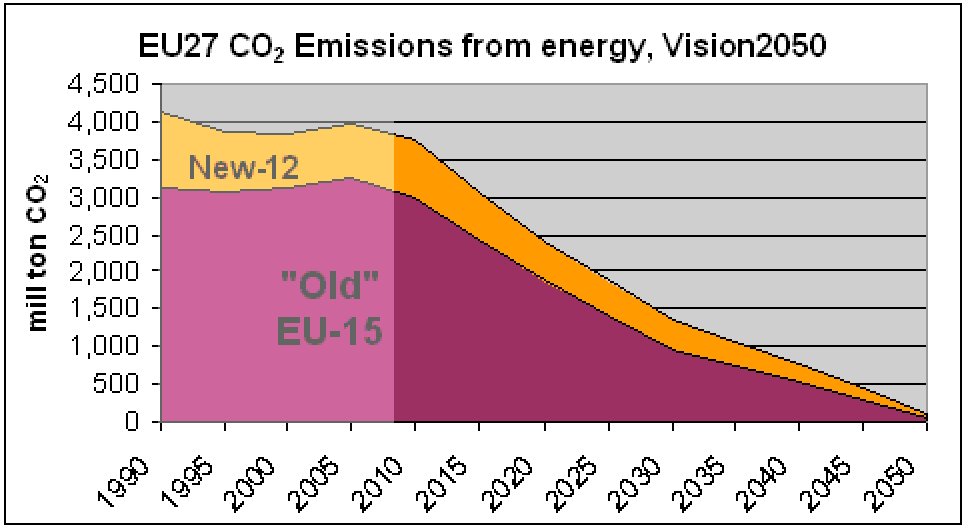
Energy Scenarios for the EU-27

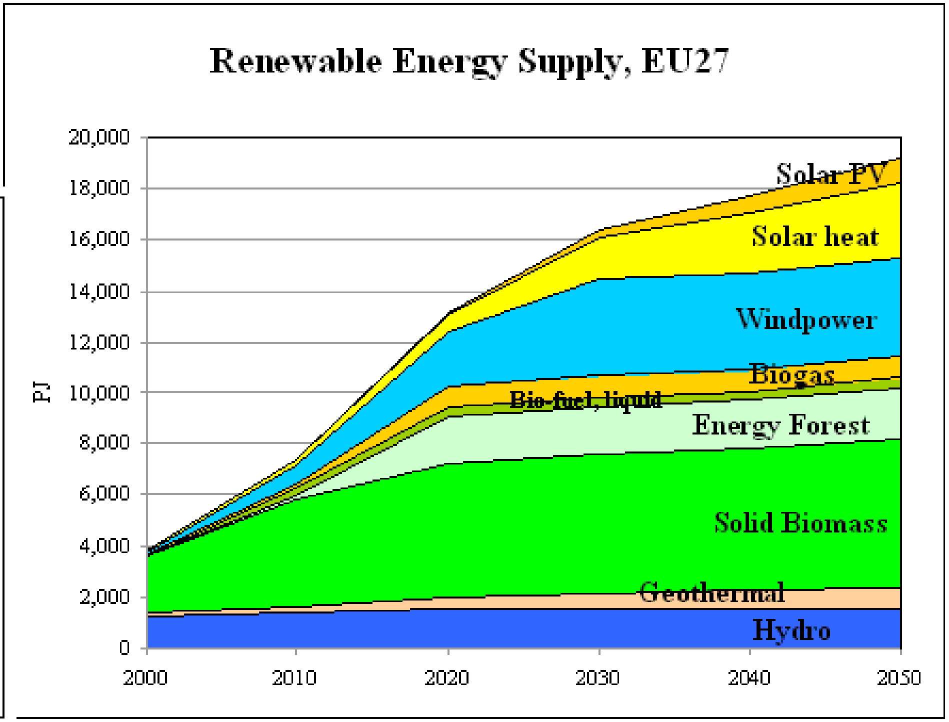
"Vision 2050"

Reproduced by courtesy of

http://www.inforse.org







What I Shall Talk About

The Energy Problem

Government Policy

A New UK Policy?

Greater Energy Efficiency in Heating

Greater Energy Efficiency in the Use of Electricity

Important Technologies in *LIM*

Case Study

The Energy Problem

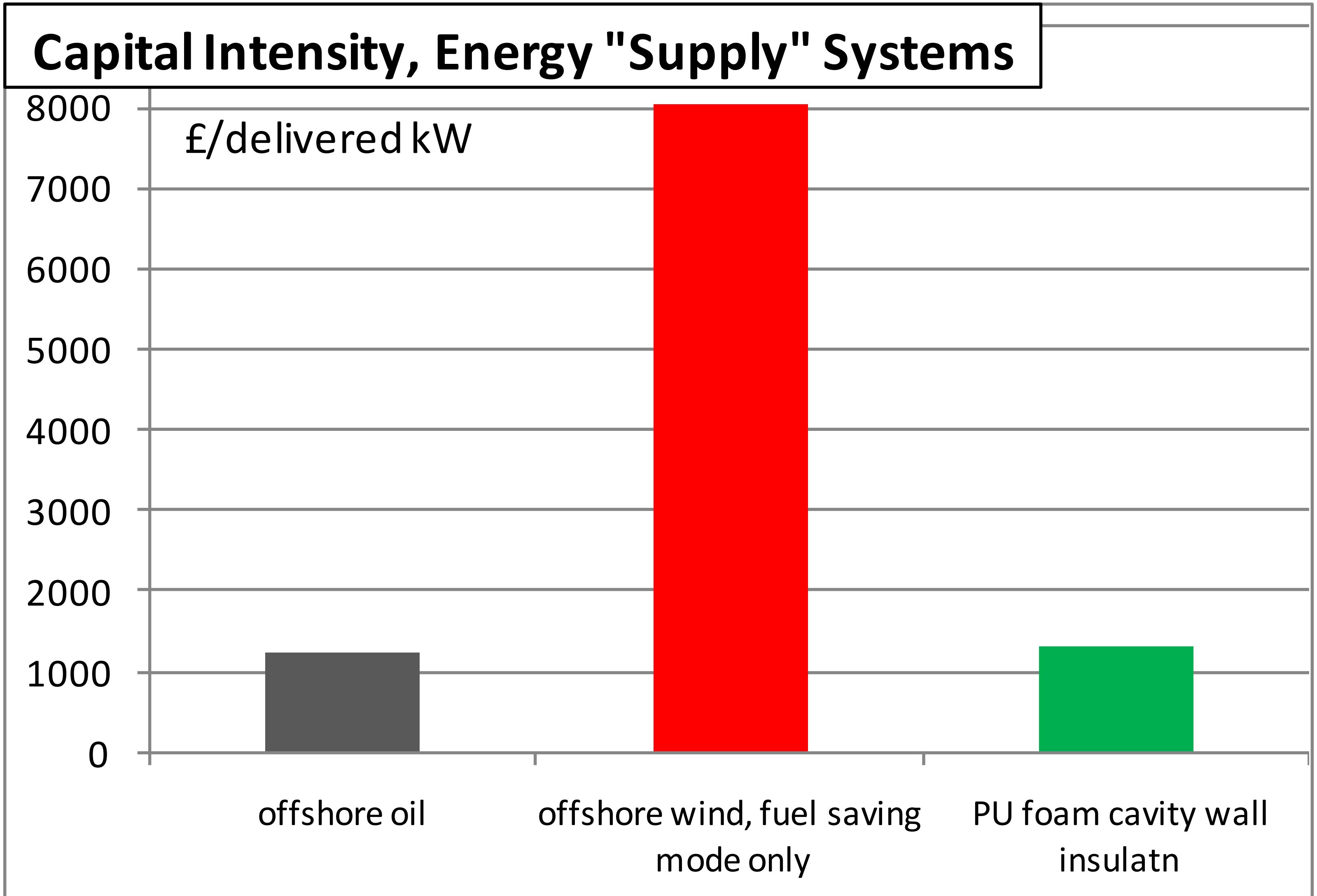
The Energy Problem

- Energy is the lifeblood of industrial society. Cheap fossil fuels have brought a better life to billions of people over last 50-100 years.
- Most future energy sources cost *much* more to produce than fossil fuels.
- UK production of coal, oil and natural gas peaked from ten to 100 years ago and continues to fall. An oil company representative stated at the UK Peak Oil Summit that world conventional oil production peaked/plateaued in 2004. The UK’s balance of payments deficit limits its ability to afford fuel imports.
- With the rising cost of energy supply, energy costs per unit of GDP could rise by an order of magnitude, with very adverse economic consequences.

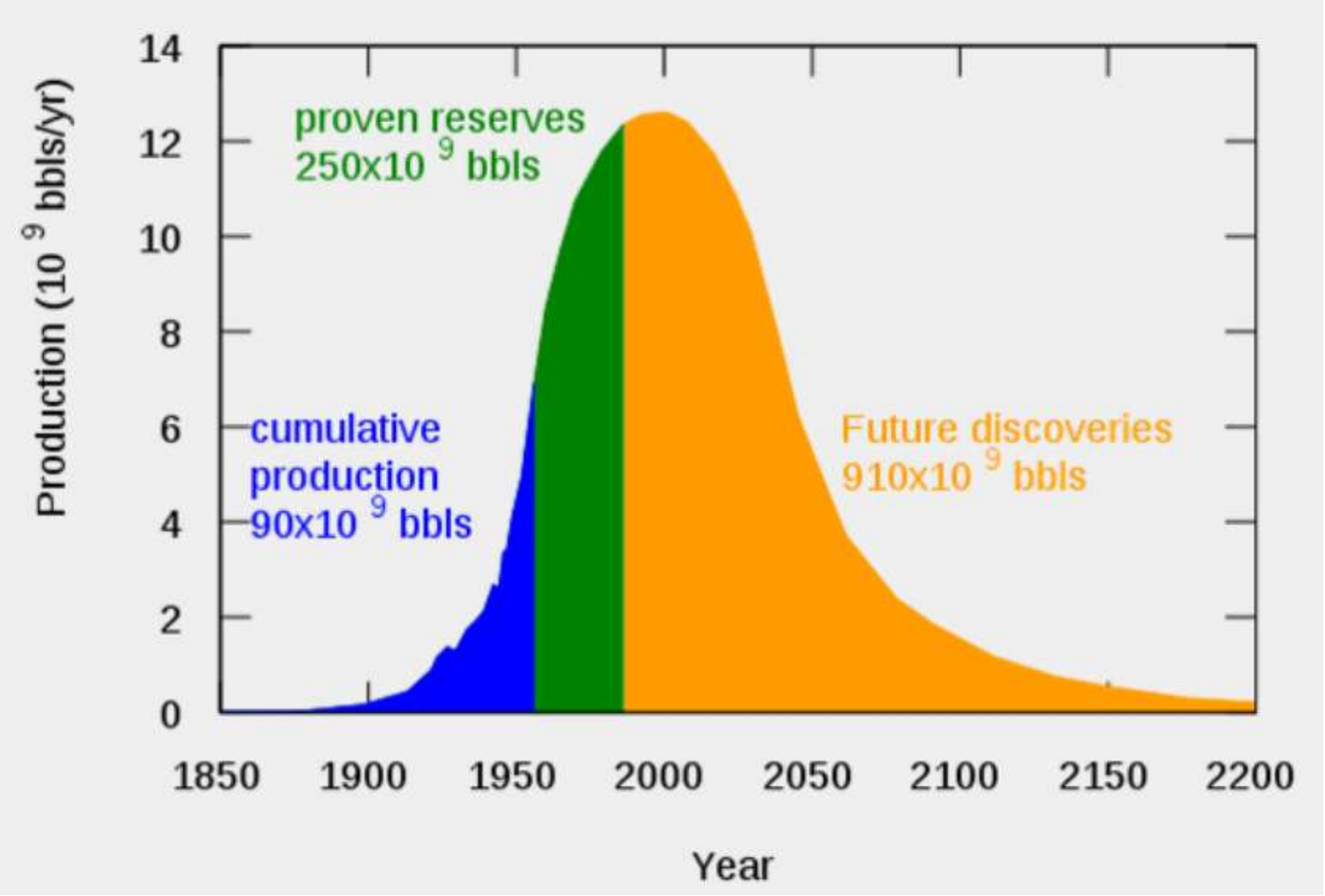
NOTE: The world price of energy is weakly related to the cost of extracting, refining and transporting fossil fuels. It mostly reflects a combination of high demand and limited supplies.

The High Cost of Future Energy Supply

NOTE: Preliminary analysis using published data.

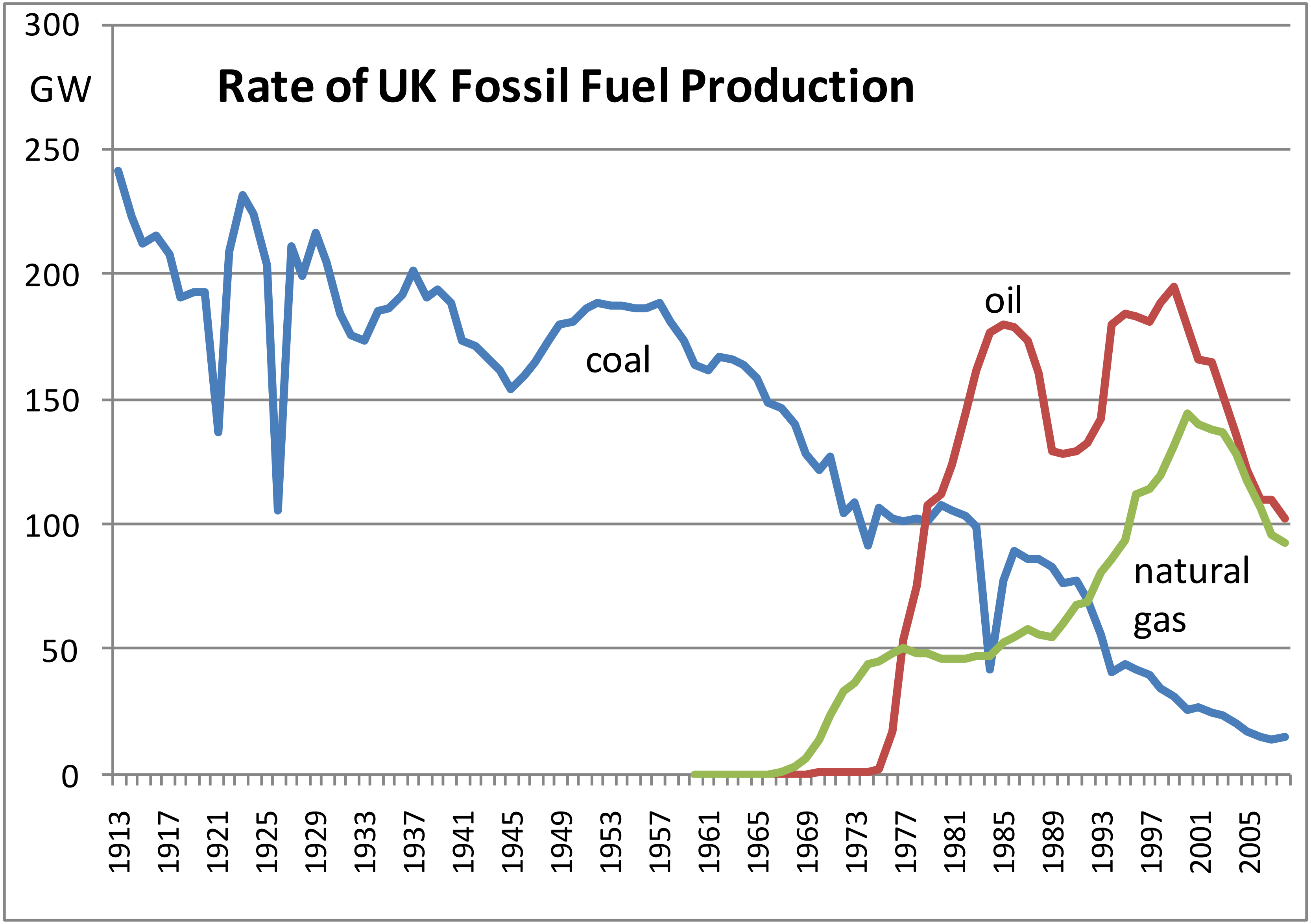


Peak Oil as Forecast in 1956



SOURCE: M King Hubbert, chart as published on Wikipedia.

UK Peak Coal, Oil and Natural Gas



Government Policy

Summary

Much more electricity

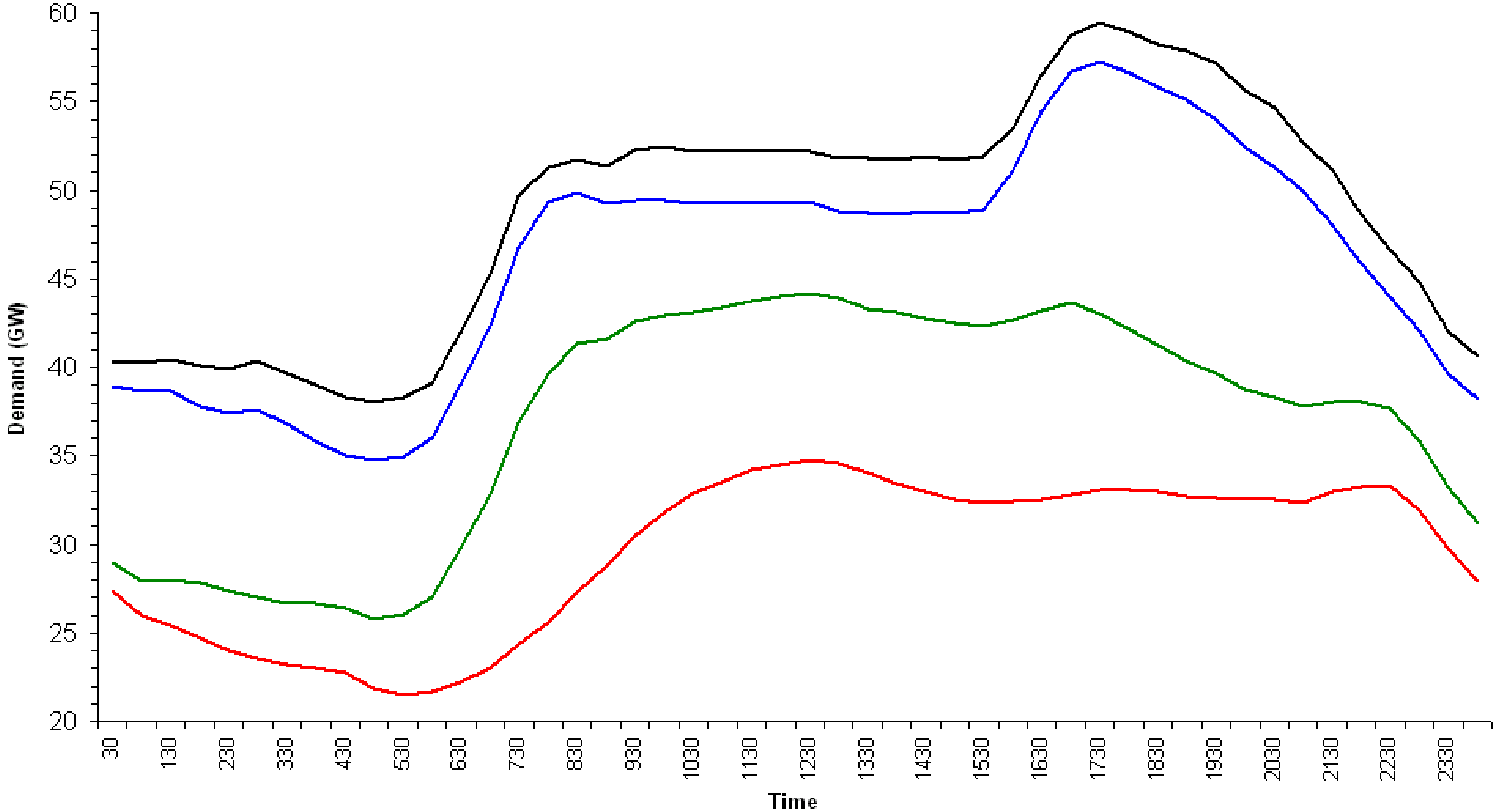
Sources include wind, nuclear, coal with CCS, until about 2040 natural gas-fired plant for periods with no wind.

The national grid is increased in capacity by about six-fold.

Electric cars, vans and lorries replace petrol and diesel ones.

Electric heating, including heat pumps, replaces natural gas, oil and coal in buildings and industry.

Great Britain, Hour-to-Hour Rate of Electricity Consumption, 2005-06.



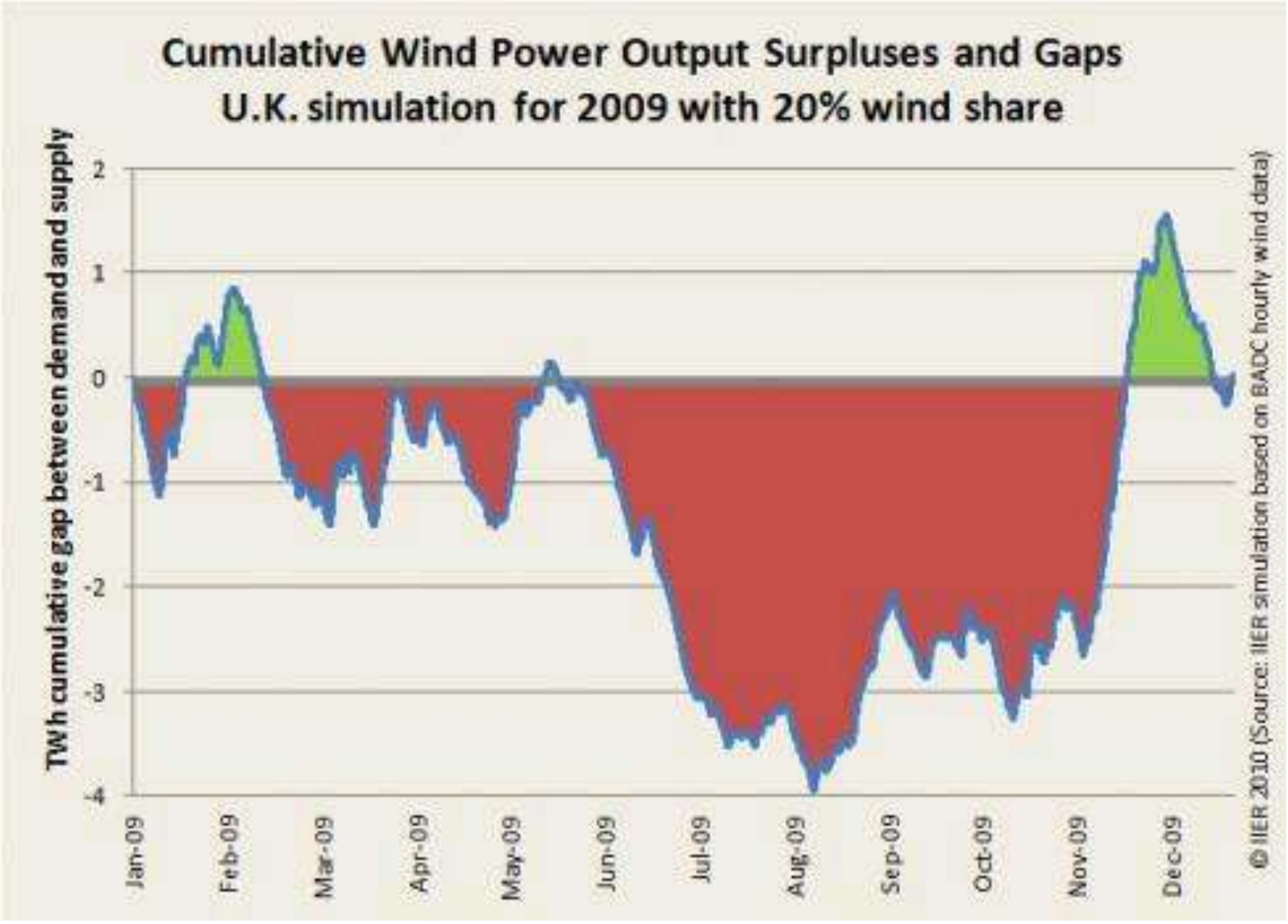
SOURCE: National Grid PLC. Black = maximum winter weekday, blue = typical winter, green = typical summer, red = minimum summer weekend, etc.

Note that unlike fuel and heat, electricity cannot be stored. It must be generated exactly when it is needed.

Wind Energy Availability in 2009

Compared to UK Electricity Demand

Analysis by Institute of Integrated Economic Research, Switzerland, www.iier.ch.

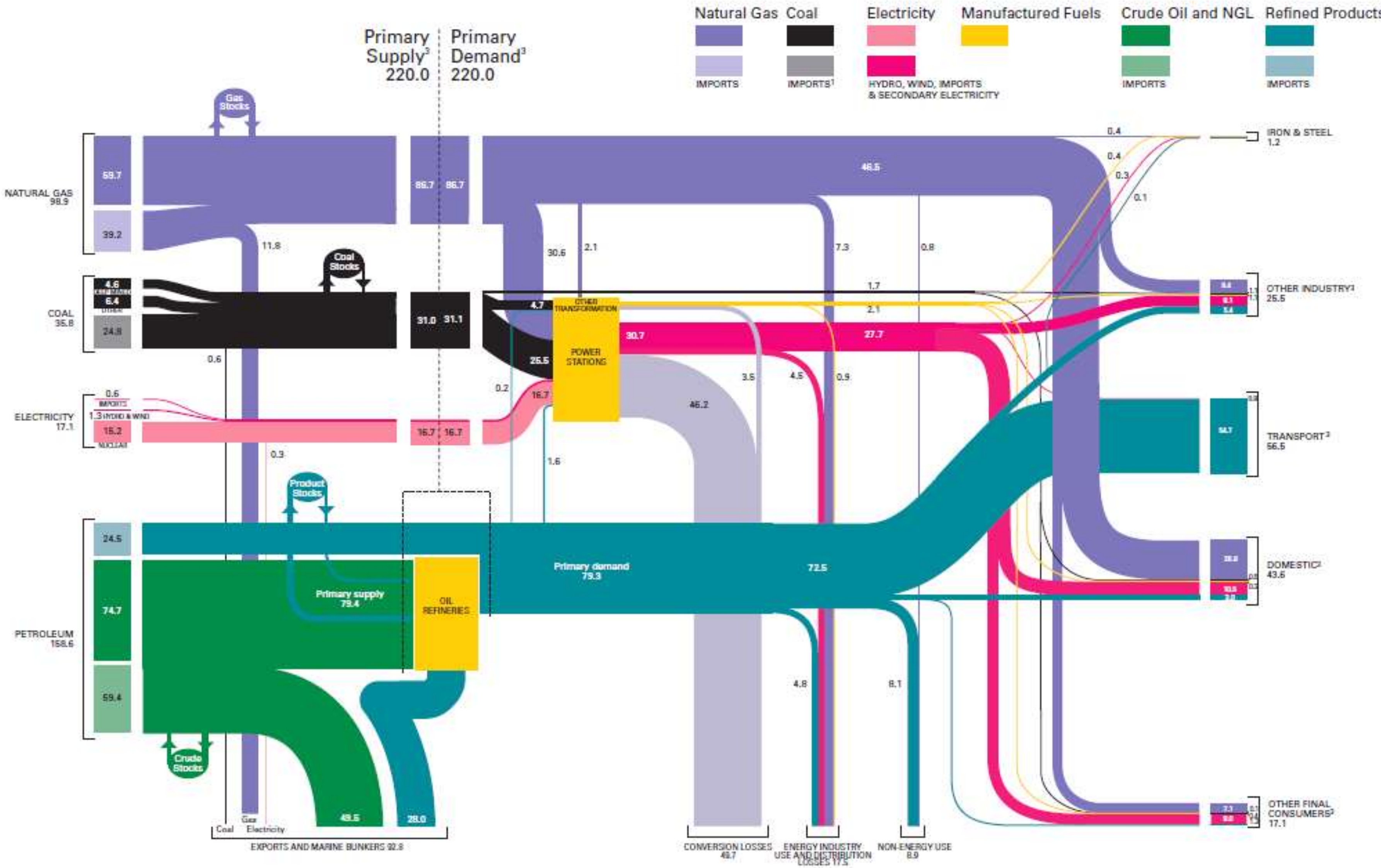


NOTE: The availability of wind energy is poorly matched to the UK's pattern of electricity consumption. Wind energy also varies from year to year.

For possible solutions, see; e.g.,

http://www.uni-kassel.de/hrz/db4/extern/dbupress/publik/abstract.php?978-3-89958-798-2.

UK Energy Supply and Use 2009



The three largest energy flows in the economy:

1 Natural gas for heating; 2 Oil for transport; 3 Power station cooling water.

A New UK Policy?

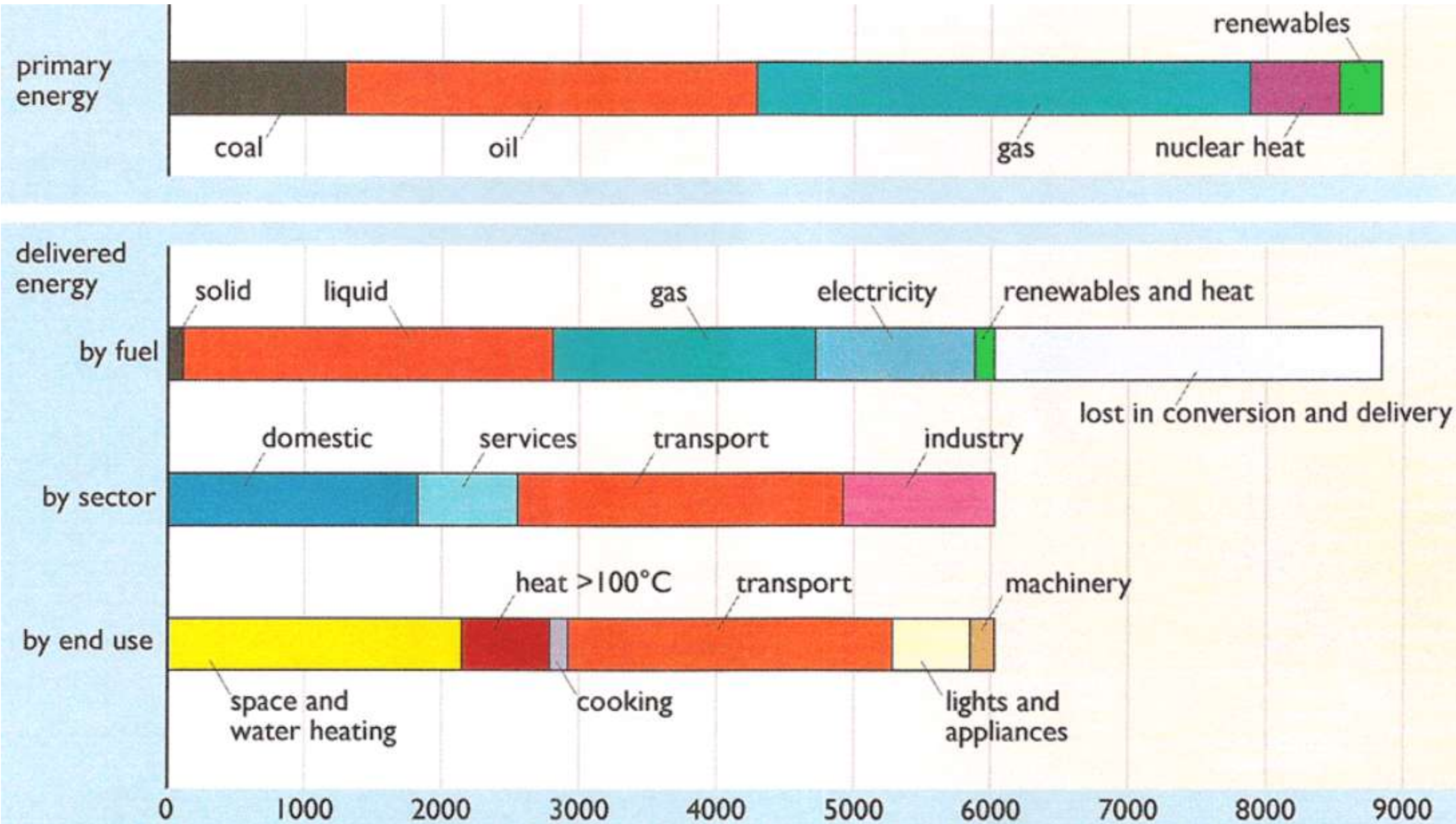
Potential Ways Forward

- Lavish investment in energy efficiency wherever it costs less than new energy supply. This could keep energy bills affordable, despite a rise in energy supply costs in pence per kWh.
- Sequester CO_2 via changed farming/forestry practices and pre-combustion sequestration; e.g., anaerobic digesters. Technically appears more straightforward than post-combustion “CCS”.
- Minimise electricity consumption so that it can mainly be supplied by despatchable sources; e.g. tidal, hydro, biomethane or geothermal CHP.
- Convert wind energy surpluses which would de-stabilise the national grid to synthetic fuel or to hot water for heat networks, maintaining security of supply. Both these forms of energy are storable.
- Renewable energy sources whose economics are reasonable versus fossil fuels. Examples: passive solar, daylighting, large-scale solar district heating, geothermal heat or electricity, some hydro, biomethane from large anaerobic digestion plants, tidal lagoons.

Uses of UK Delivered Energy

- •35% heat below 100°C
- •13% heat at or above 100°C
- •40% transport energy
- **•12% essential electricity**

NOTES:
UK policy appears to place too much stress on electricity and too little on heat and fuel.
If more industrial goods were made here, high-temperature heat would be higher than 13% of delivered energy.



Some UK Programs and Organisations Involved

Affordable Warmth Program; All-Wales Fuel Poverty Scheme; Carbon Emissions Reduction Target; Carbon Trust; Community Energy Saving Program; Community Energy Scheme; Carbon Reduction Commitment; CRC Energy Efficiency Scheme; Decent Homes Standard; Energy Company Obligation; DCLG, DECC, DEFRA, Energy Efficiency Advice Centres; Energy Efficiency Action Plan; Energy Efficiency Standards of Performance; Energy Efficiency Commitment; Energy Saving Trust; Enhanced Capital Allowances Scheme; Feed-In Tariff; Fuel Poverty Strategy; Fuel Poverty Monitoring and Technical Group; Green Deal; Green Investment Bank; Home Energy Efficiency Scheme (Wales); Landlord’s Energy Saving Allowance; London ReNew; Low Carbon Buildings Program; Office of Energy Efficiency; Renewable Heat Incentive; Scottish Energy Assistance Package; Stamp Duty Land Tax Exemption; Warm Front Scheme; Warm Homes Discount; Welsh National Energy Efficiency and Savings Plan.

Redesign Financial Incentives

Cut support for “eco-bling”

•Micro-wind: largely discredited by the poor energy yield and the high cost per kWh produced.

•Electric heat pumps. Sound in theory but real performance very modest. Need field trials and development so that COPs are reliably as high as in other countries; e.g., air source 2.8 and ground source 3.5.

•Solar thermal on small house roofs: return on investment = 1-1.5 %/year in buildings with gas-fired condensing boilers and well insulated tanks & pipes.

•Wood-fired boilers or stoves: the NO_x and soot damage the climate and the PM-2.5 particle emissions are a public health hazard.

•Gas micro CHP - no CO_2 saving versus using a condensing boiler for heat and CCGT electricity for lights and appliances.

•Photovoltaics; scope may be limited outside niche markets and summer-peaking electricity systems. In Germany, a PV market share of 1% has led to worries over grid stability.

Redesign Financial Incentives

Transfer support to sound, proven measures

New cavity wall in Denmark 1977, but UK similar in 2007.

Energy efficiency

•Insulation and draughtproofing beyond Part L, plus proper compliance and guidance.

•Retrofit insulation where cost-effective against the heat supply method. Solid wall external insulation can be roughly five times better value than solar thermal on roofs.

•Modify heating controls and insulate DHW tanks and pipes. Saves roughly as much CO_2 as doubling building thermal insulation levels from 150-200 to 300-400 mm.

Redesign Financial Incentives

Transfer support to sound, proven measures

Energy efficiency

•Fossil and bio-methane CHP/DH, low supply temperatures; e.g., 75ºC flow and 25ºC return. Equivalent to using an electric heat pump with a COP of 12-13. 75% lower emissions than a heat pump.

•Large-scale solar.

•Mechanical exhaust ventilation (MEV) in many buildings. Poorly-understood, but in fairly airtight buildings it uses little more energy than MVHR and is easier and cheaper to retrofit.

•Balanced MVHR in extremely draughtproof buildings which are heated by expensive heat sources; e.g., oil, LPG, elec. heat pumps.

•Major improvements in energy-efficient heating pumps, fans, controls, lighting, domestic appliances and office equipment. No support today.

Redesign Financial Incentives

Transfer support to sound, proven measures

- *Lower-cost renewables*

- Passive solar heat. No support.

- Daylighting. Solar light = 5-10x more valuable than solar used as heat. No support.

- District-scale solar thermal. Crane into place. Cost = 1.6 p and not 20 p/kWh, meet renewable heat target(s) more affordably. A heat network is needed. Low or no support.

- Geothermal. Southampton is in part heated by a 1981 well, but more areas could be used. One just drilled in Newcastle. Also needs a heat network. Low or no support.

- Anaerobic digestion. Large digesters are more cost-effective than small ones. Modest support for small ones.

Reform UK Utilities

Adopt policies which have worked elsewhere

- Under "retail deregulation", UK gas and electricity suppliers have a financial incentive to emit more CO_2. They profit from each kWh sold. In this situation, they do not want lower consumption.
- Return to "retail regulation" of mains electricity, gas & heat. It happens in; e.g., Denmark and most of the USA. It applied to UK gas and electricity between 1988 and 1999. It applies to water in England and Wales. "Issue" with EU directives.
- Denmark zones heat supply methods to achieve the most economic and environmentally beneficial result and to reduce dependence on oil. Urban areas are zoned for piped heat or piped gas, rural areas for other methods, like heat pumps. Piped gas is being replaced by piped heat.
- In California and 10-15 other US states, privately-owned gas and electricity utilities must invest in energy efficiency measures which cost less than investing in new energy supply.

The Proposed Green Deal

Needs major amendments:

•Key technologies are excluded.

•The maximum support levels are too low.

•The "Golden Rule" is wrongly-defined.

•It is planned to repay the loan account on the electricity bill. 93% of UK space heating comes from gas, LPG, oil or solid fuel.

•The proposed interest rate exceeds utility borrowing costs or mortgage interest rates, so the repayments would be excessive.

•The organisations charged with delivering it are mostly experts on retailing and know less about domestic energy use.

Financing Thermal Improvements to Existing Buildings, Including Use of Waste Heat

Key to affordability:

•Regulated, low-risk utility-level returns on capital.

•Life-cycle costing; e.g., 30 year loans, as offered in Germany.

•Index linking, to reduce the repayments in the early years.

•No limit to sum borrowed, as long as measures are cost-effective. Help to deal with low incomes/fuel poverty.

•Tie loans to buildings and not to owner-occupiers, lessees, landlords or tenants.

•A binding obligation to make repayments, cf service charges, ground rent, etc. Not a problem with cost-effective measures.

•Rural buildings using LPG and oil (and maybe solar) would need loans from public funds or similar for very extensive retrofits.

Greater Energy Efficiency in Heating

Greater Energy Efficiency in Heating

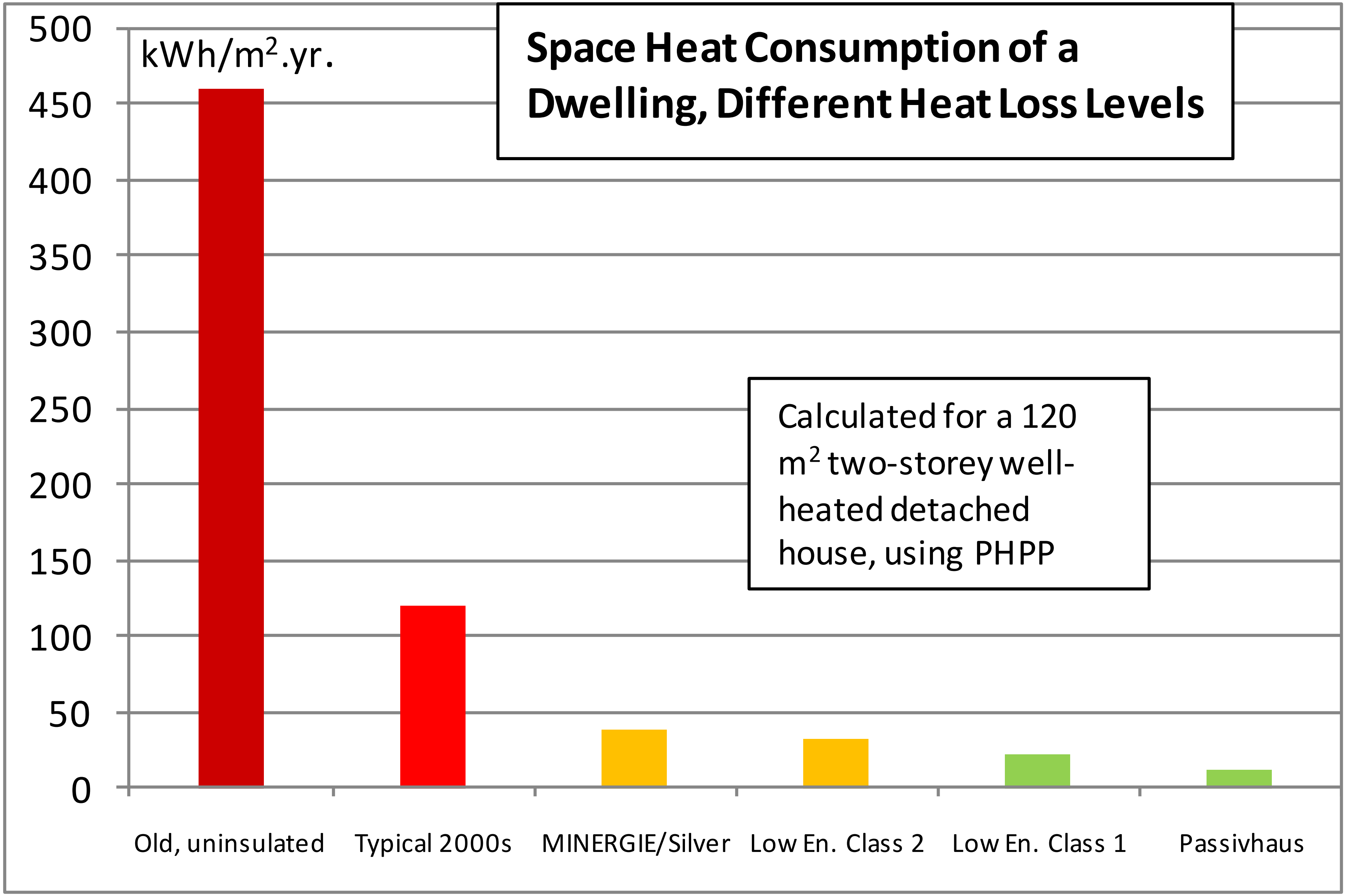
Reduce the quantity of energy consumed; e.g. insulate the walls, improve the windows and draughtproof a building to reduce its heat loss. May reduce heat consumption and CO_2 emissions by 80%, even 98%. But beware of the “rebound effect”.

Reduce the quality of energy consumed; e.g., replace a gas-fired heat-only boiler or electric heating by waste heat from gas CHP or a heat pump. May reduce consumption of high-grade energy and CO_2 emissions by 80% or even 95%. Sometimes a “rebound effect” too.

The combination. Can in theory reduce consumption of high-grade energy and CO_2 emissions by 99%. But “merely” 90-95% would be very acceptable!

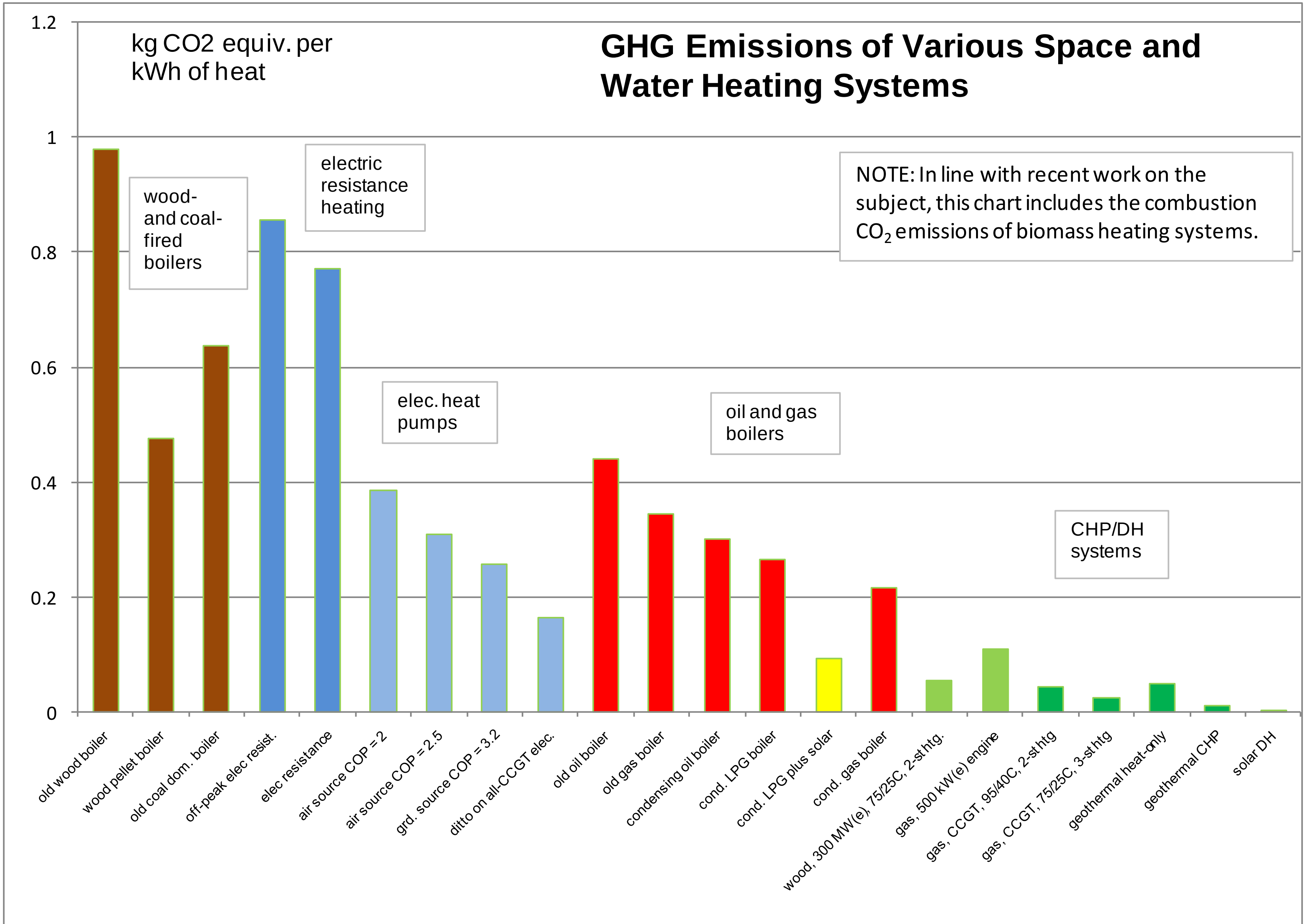
Other impacts. Try to reduce other air pollution when replacing one heating system by another.

Lower Heat Consumption



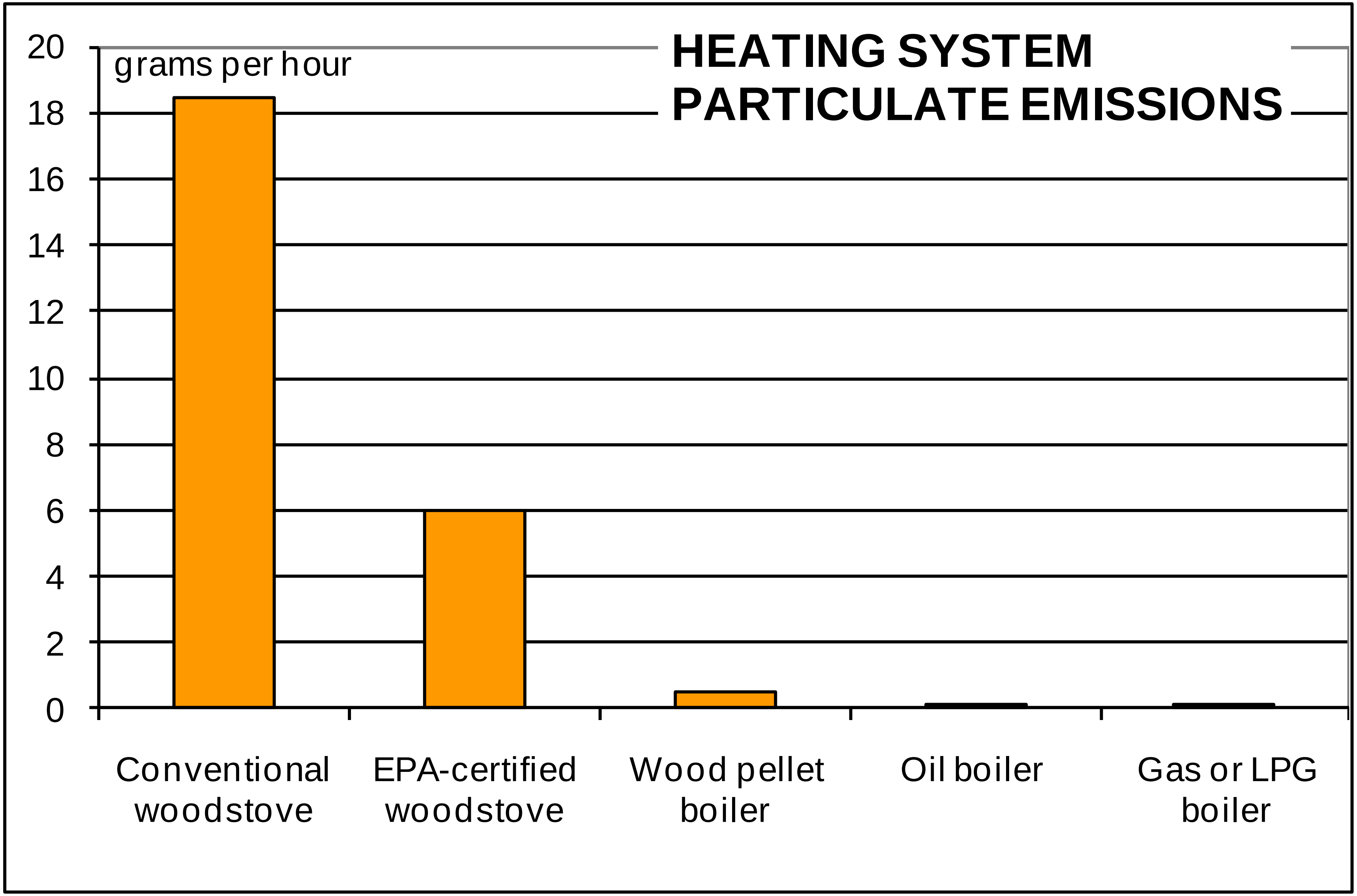
Lower-CO_2 Heat

Good practice reduces emissions 80-90% compared to current practice.



Cleaner Heat

UK air quality consistently breaches EU law.
It is undesirable to make matters worse.



Greater Energy Efficiency in the Use of Electricity

Greater Energy Efficiency in the Use of Electricity

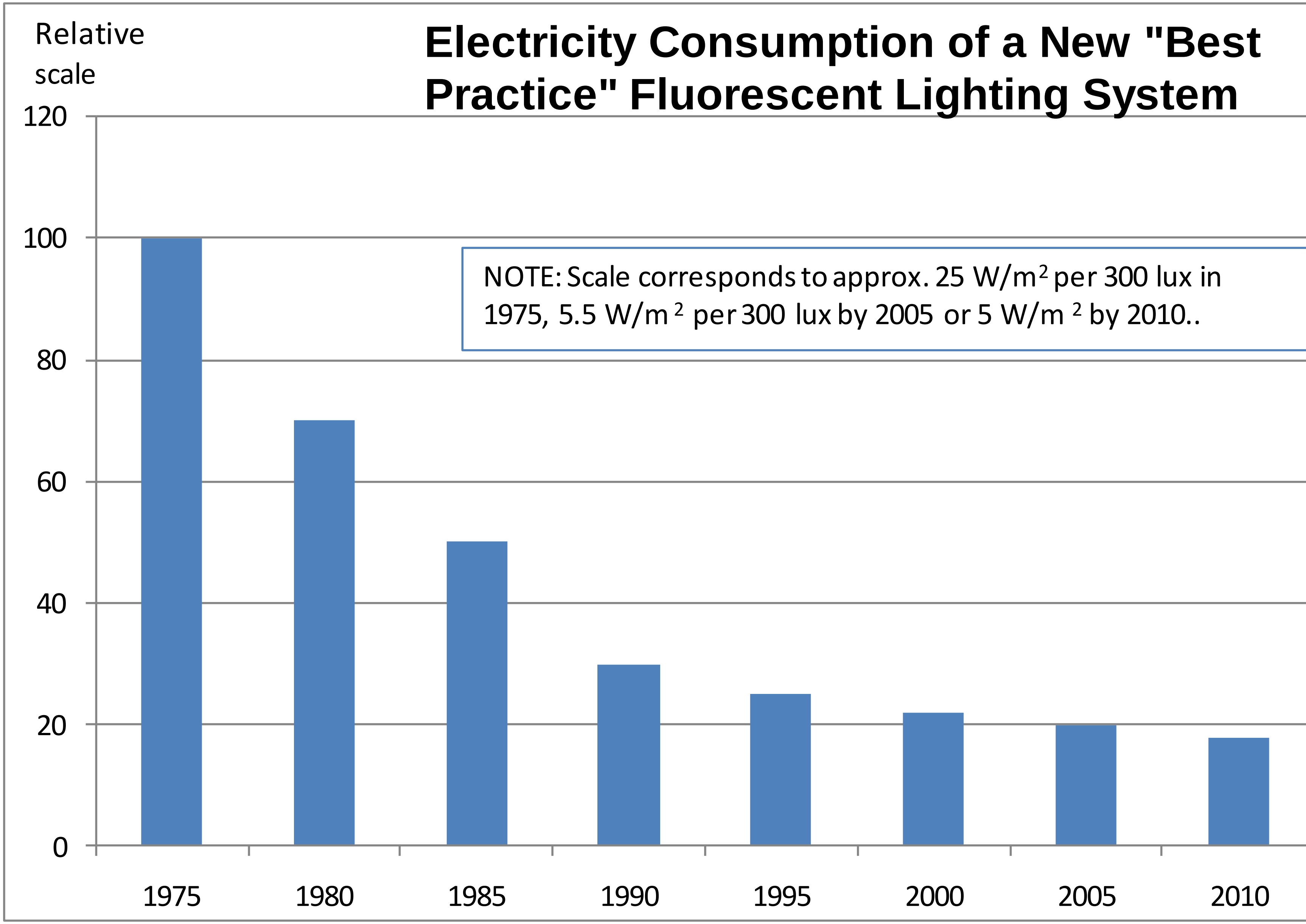
Reduce the *quantity* of electricity consumed for lighting; e.g., by *good-quality* LEDs, T5 tubes, reflector luminaires, better controls, more use of daylighting.

Reduce the *quantity* of electricity consumed for domestic and office electrical equipment, by replacing existing stock by A++ models, etc.

Use energy-efficient motors, pumps, fans and controls in HVAC systems, to reduce the quantity of electricity consumed.

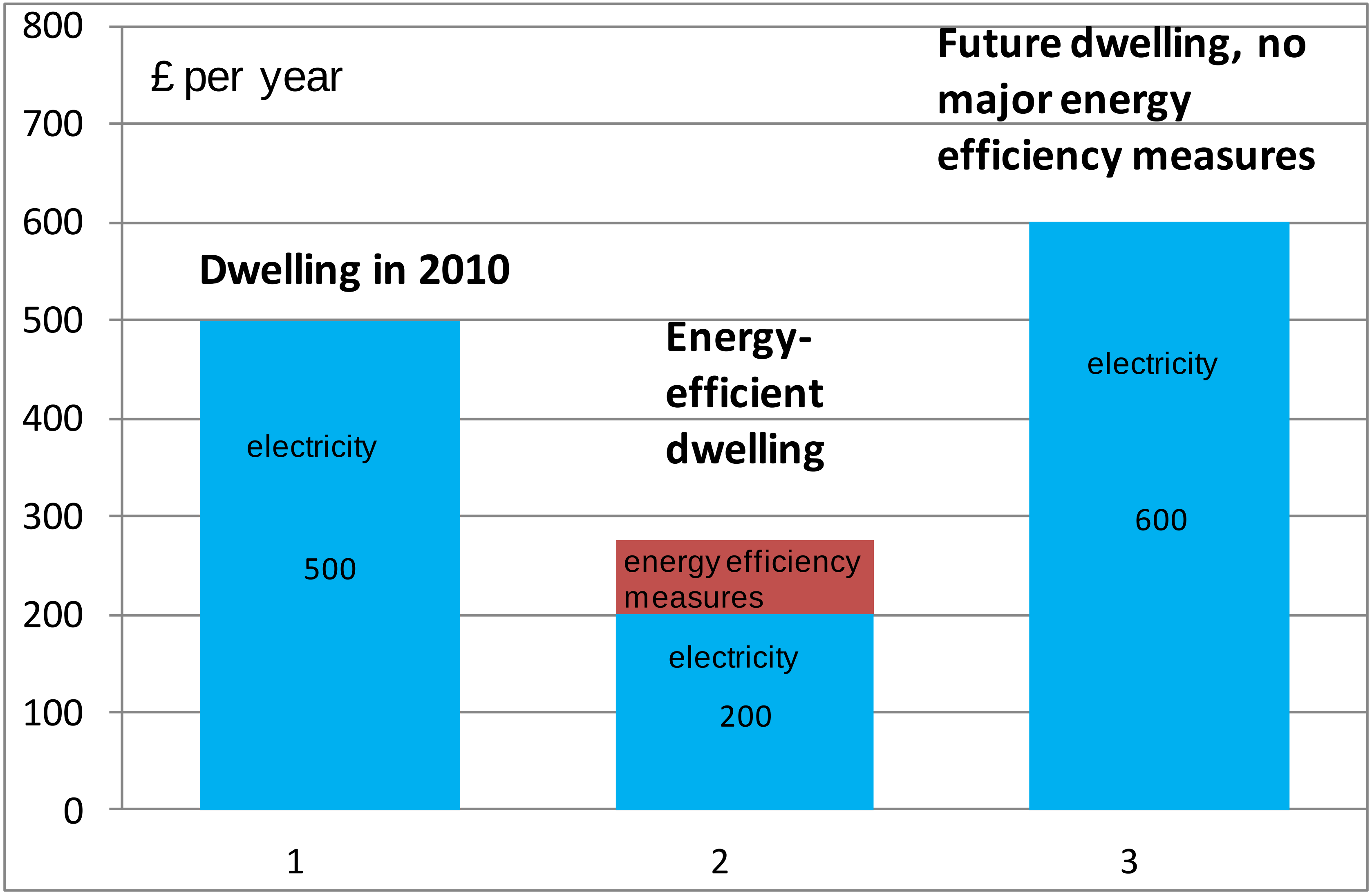
Savings often, although not always, as high as 75-90%.

Fluorescent Lighting Efficiency



Domestic Electricity Bills

With and without major energy efficiency investment



Important Technologies in *LIM*

CHP and District Heating

Bottom left - Danish heat transmission line

Right - PEX twin pipe, low-cost technology for DH in suburbia

Bottom right - Italian geothermal DH extension

Pictures courtesy www.logstor.com, www.pipesystems.com www.isoplus.de

District Heating in Practice

Kalundborg, Denmark (population 20,000) was converted to piped heat from a CHP plant in the late 1980s and early 1990s. These low-density houses were built in the late 1970s. Picture courtesy Google Streetview.

Solar Collectors, Denmark

1996/2002 –

18,000 m^2 of ground-mounted solar collectors and a seasonal heat store help to heat the small coastal town of Marstal. Heat net-work temperatures were dropped to 70/40^{o}C to raise the solar fraction.

Large collectors are being widely connected to Danish district heating systems.

Picture courtesy Leon Miller.

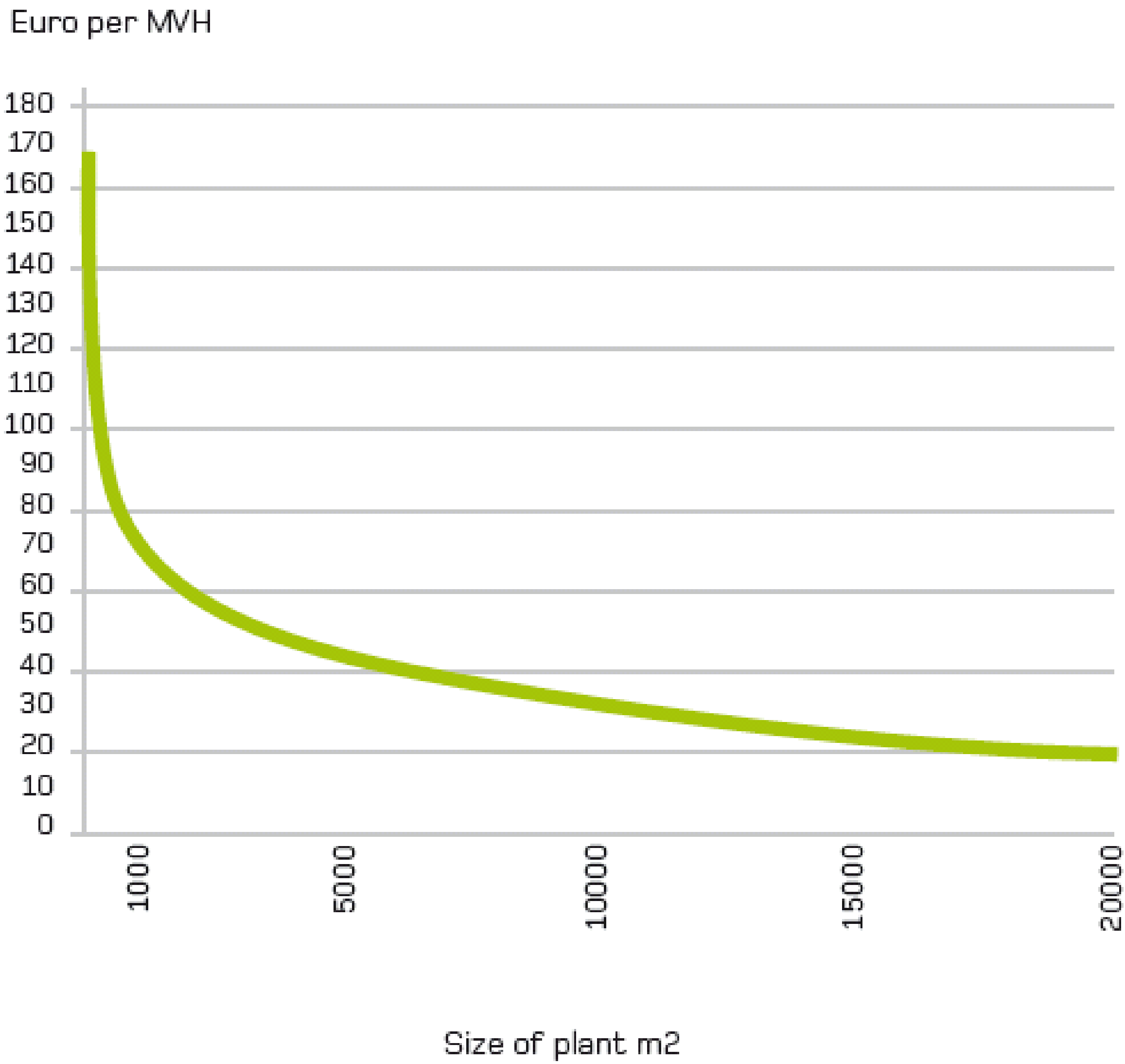
More Solar Collectors, Denmark

Top - 8,000 m^2 of ground-mounted solar collectors help to heat the small town of Strandby, Jutland.

Bottom right - solar collector field being craned into place.

Pictures courtesy http://www.solarthermalworld.org/node/766

Falling Cost of Solar Heat as System Size Increases



The heat cost falls from approx.**17 to 1.6 pence/kWh** as the system size increases from 50 to 20,000 m^2. Costs refer to heat produced at a high enough temperature for heat networks, usually 70-85^{o}C.

SOURCE:

http://dbdh.dk/images/uploads/pdfbladet/EU%20aim%20at%20great%20expansion%20of%20large-scale%20solar%20thermal%20plants.pdf

Biomethane CHP, Germany

The picture shows a gas production and storage system, not the CHP plant. Germany's target is an average biomethane output of 11.5 GW by 2030.

Picture courtesy of:

http://www.farmworldonline.com/general/meggiegermanyblog.asp

Electric Heat Pumps

Ground source heat pump under construction in Wales.

Picture courtesy John Cantor Heat Pumps Ltd.

Energy-Efficient 'Cold' Appliances

Below left - energy-efficient 259 litre larder refrigerator, USA, 76 kWh/yr. Plus optional external condenser. Old UK models about 500 kWh/yr. Saves 85%. *Below right* - A++ 195 litre chest freezer, Europe, 113 kWh/yr. Old UK models about 700-850 kWh/yr. Saves 84-87%.

Typical cost of saved electricity to go from so-called "good practice" to above levels = 2 p per kWh.

Results of US test at 32°C and 21°C are interpolated linearly to calculate consumption in a CEN test at 25°C.

Pictures courtesy www.liebherr.com and www.sunfrost.com

Case Study

Case Study: Existing Building Stock

1960s cavity-walled, solid ground-floored housing in London before and after proposed retrofit. CO_2 emissions would fall 82% at low cost.

- CWI and roof insulation with airtight material
- Gas 500 kW(e) engine CHP, extend existing scheme, add summer solar
- Reglaze existing windows when sealed units wear out
- MEV
- Highly energy-efficient lights, appliances & pumps, including use of CHP heat for clothes drying
- Highly-insulated new DHW tank and piping

The Starting Point

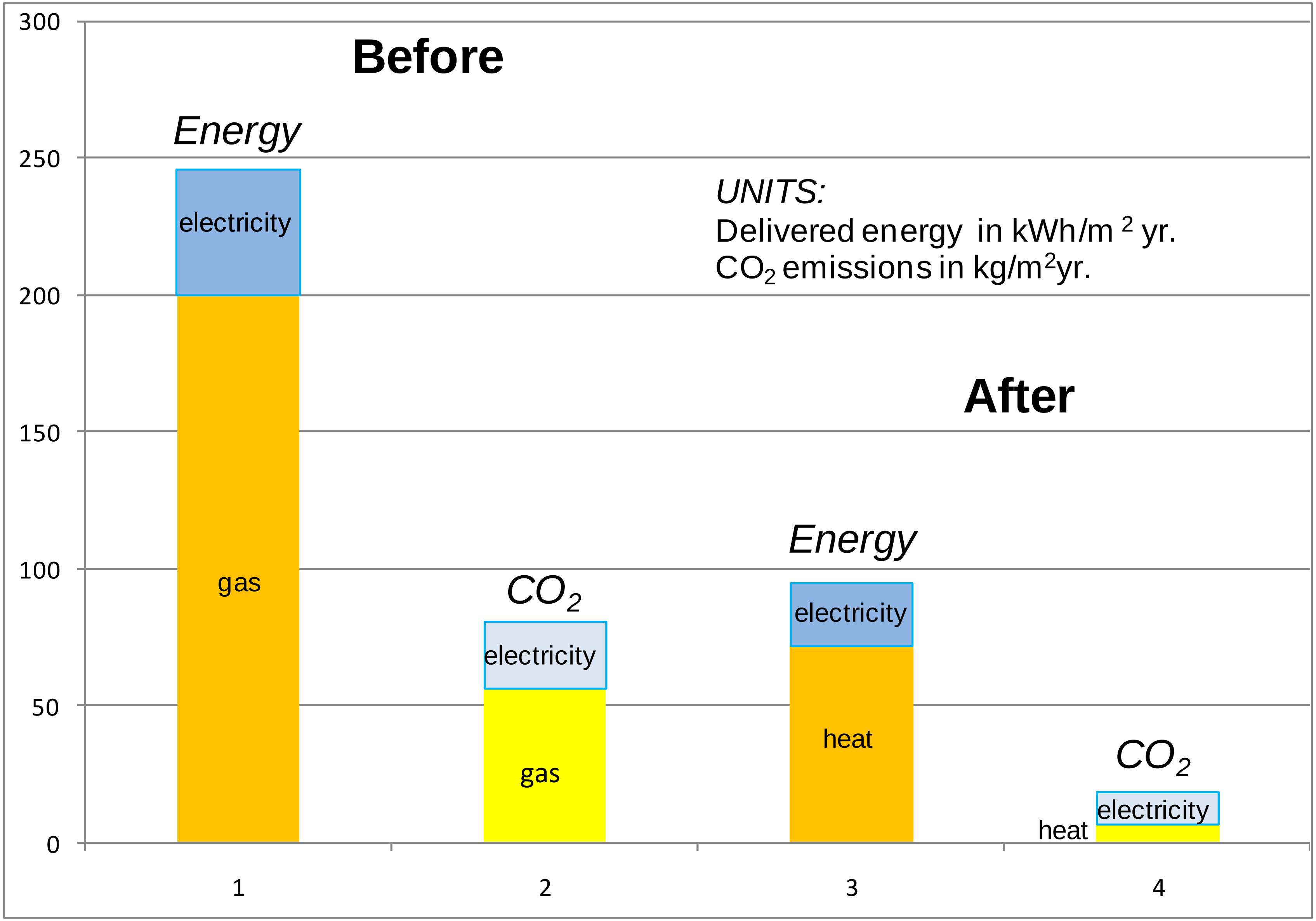
TARGETS:

Space heat down from 200 to 72 kWh/m²yr .

CO_2 intensity of heat down from 0.28 to 0.09 kg per kWh

Electricity for lights and appliances down by 50%.

Delivered Energy and CO_2 Emissions



Cost of Some Measures Analysed

Existing Urban/Suburban Semi-Detached House