All “Sources” of Energy are Not Equal:

The Role of Negawatts

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Source of the word "NEGAWATTS"

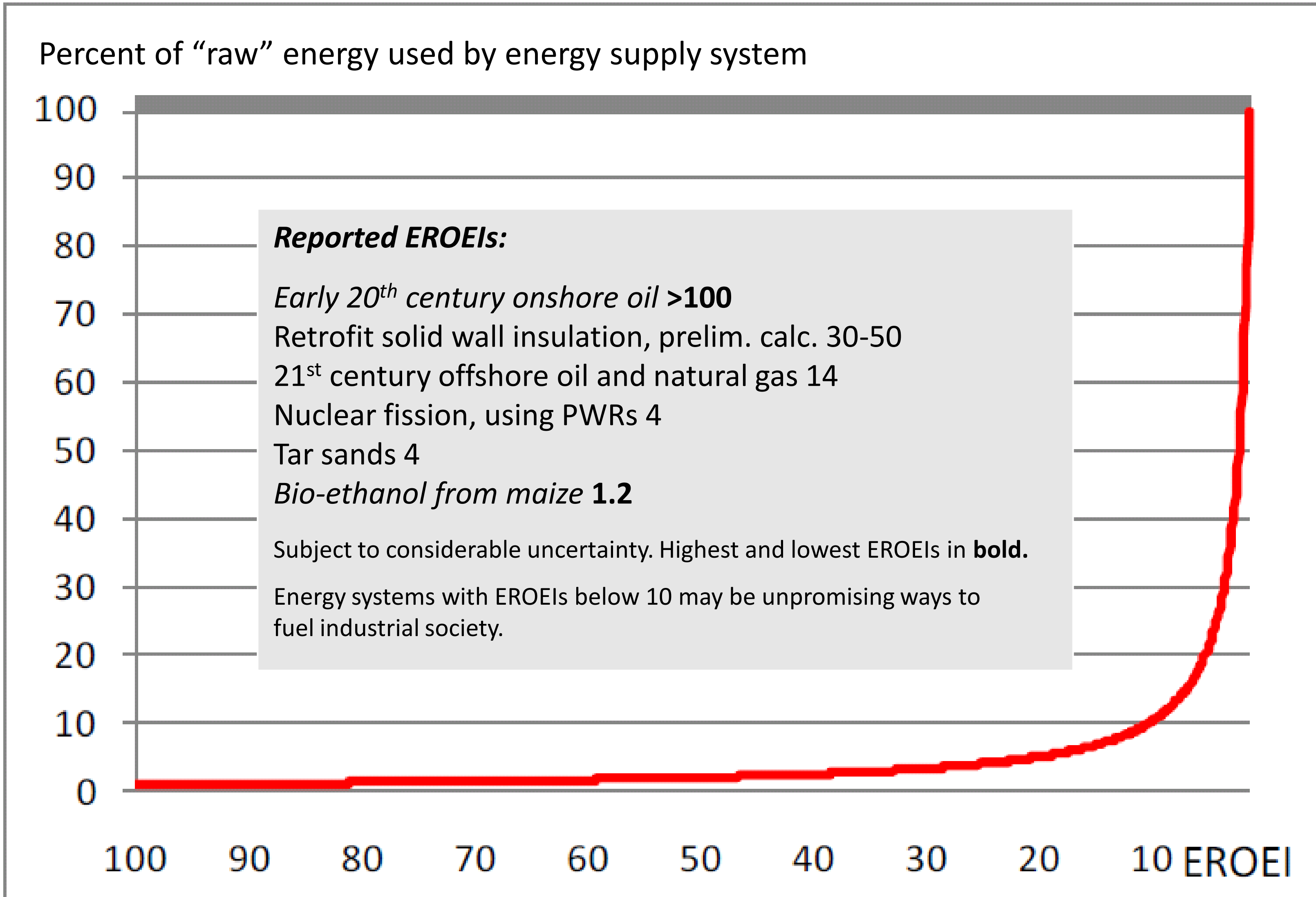
- It was a typing error in a manuscript on energy efficiency prepared by a staff member at the Rocky Mountain Institute, Colorado, USA about 25 years ago.

- It has come to mean providing the demand for energy-related services by investment in reduced demand or in more efficient energy conversion, not necessarily in increased energy supply.

A Summary of the Energy Problem

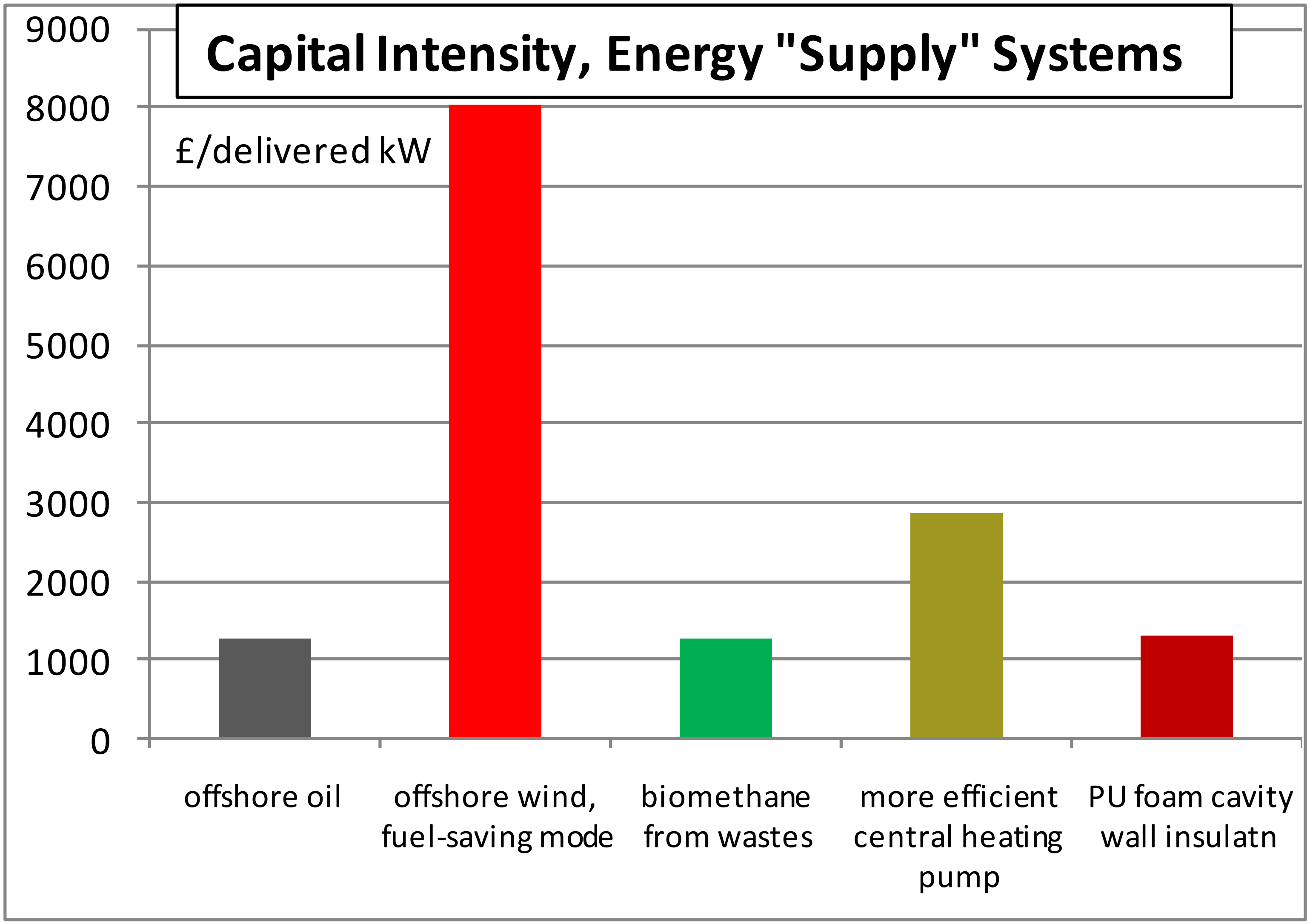
- High-grade energy is the lifeblood of industrial society. No energy, little or no economic activity.
- Rising economic prosperity in the last two centuries was associated with rapid consumption of our energy capital; i.e., fossil fuels;
- The “choicest” deposits of coal, oil and natural gas have been extracted, leaving the most difficult and expensive;
- Fossil fuel combustion is causing severe environmental problems;
- Many future “non-fossil” sources; e.g., nuclear fission and many renewables are even more costly than offshore oil;
- “Newer” resources, even “unconventional oil”, often have a low energy return on energy invested (EROEI).

Rising Energy Overheads



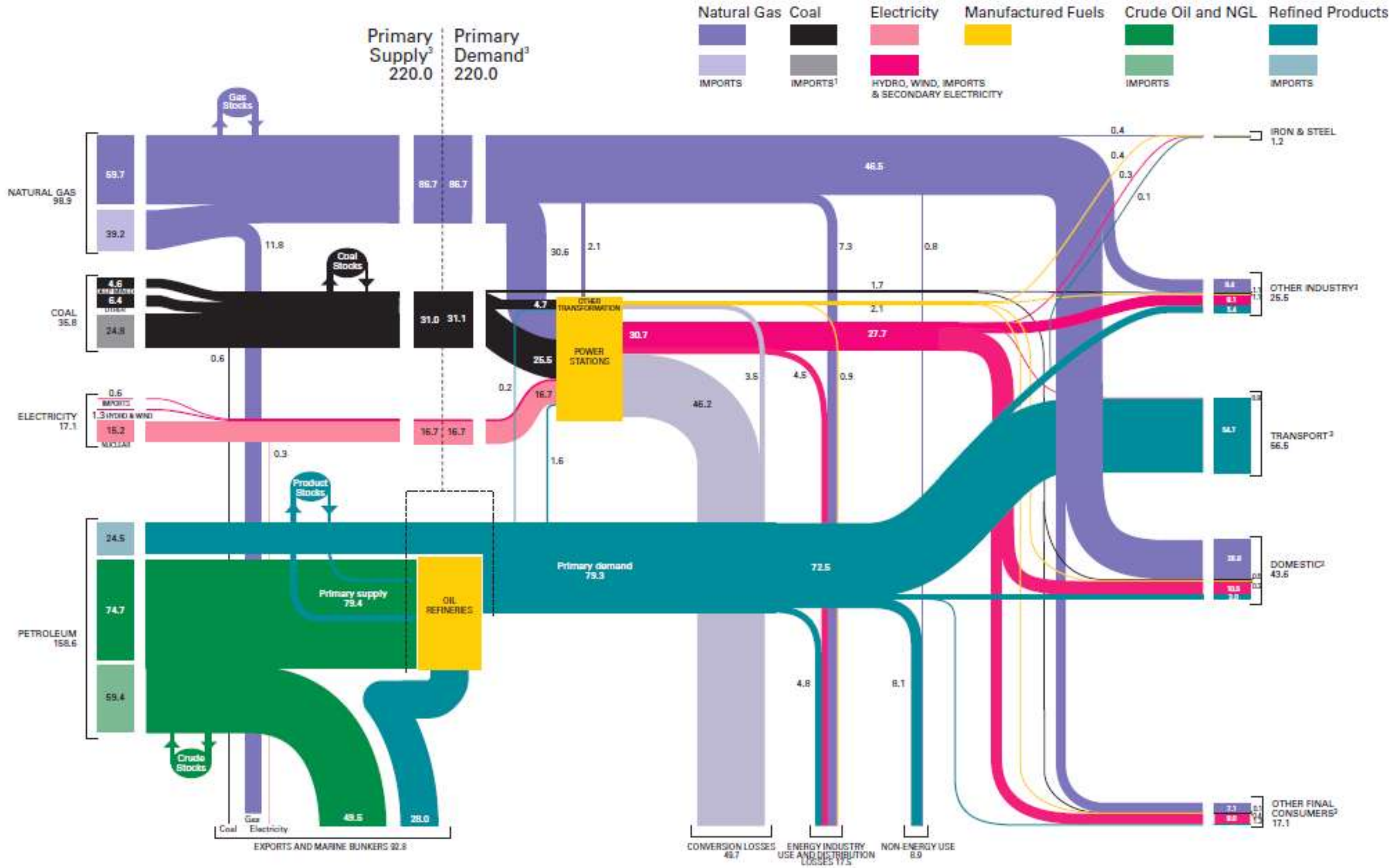
The High Cost of Future Energy Supply

NOTE: Preliminary analysis using published data. Refers to a 15% wind system with energy delivered as electricity, not a 50% or 100% wind system . Source *LESS IS MORE: Energy Security After Oil. AECB, the* Sustainable Buildings Assocn., Feb. 2012.



UK Energy Supply and Use 2009

Source: DECC.



The three largest energy flows in the UK economy:

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

The use of delivered energy in the UK economy:

1. Portable fuels for transport 45%; 2. Low-and high-temperature heat 43%; 3. “Essential electricity” 12%.

Greater Energy Efficiency in Space and Water 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%. Note the "rebound effect". If comfort becomes cheaper, people want more of it.

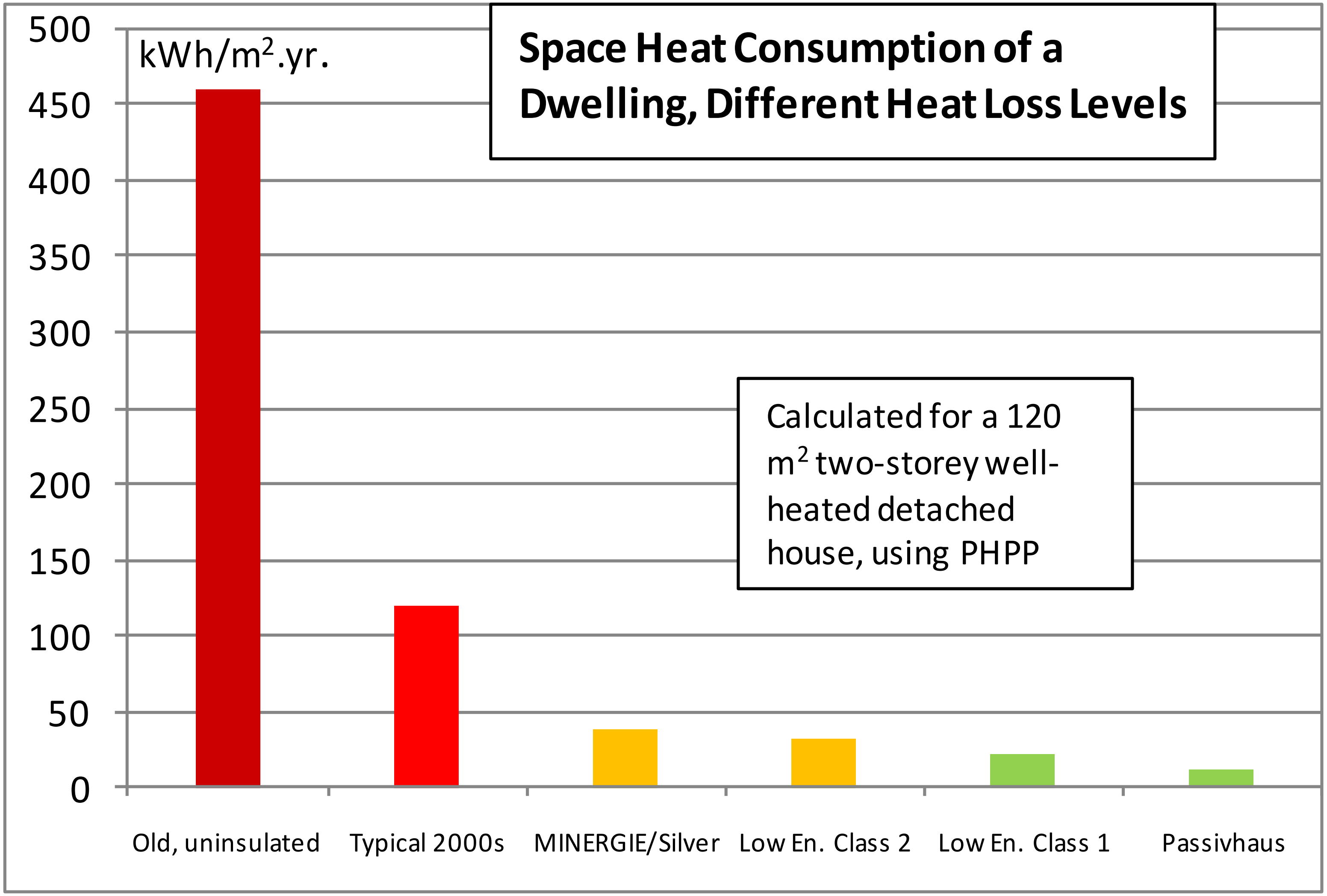
Reduce the quality of energy consumed; e.g., replace a gas-fired heat-only boiler or electric resistance heating by waste heat from gas CHP or possibly by an electric heat pump. May reduce consumption of high-grade energy and CO_2 emissions by 80% or even 95%. Sometimes a "rebound effect" too.

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

Other impacts. Try to reduce other air pollution when replacing one heating system by another; e.g., soot, PM-2.5 particles and NO_x.

Lower Heat Consumption

Good and best practice reduces emissions 95-97% versus "worst practice" and 70-88% vs. "2000s average practice".



Sources:

Old uninsulated and 2000s construction - author's calcs

MINERGIE - a Swiss government standard.

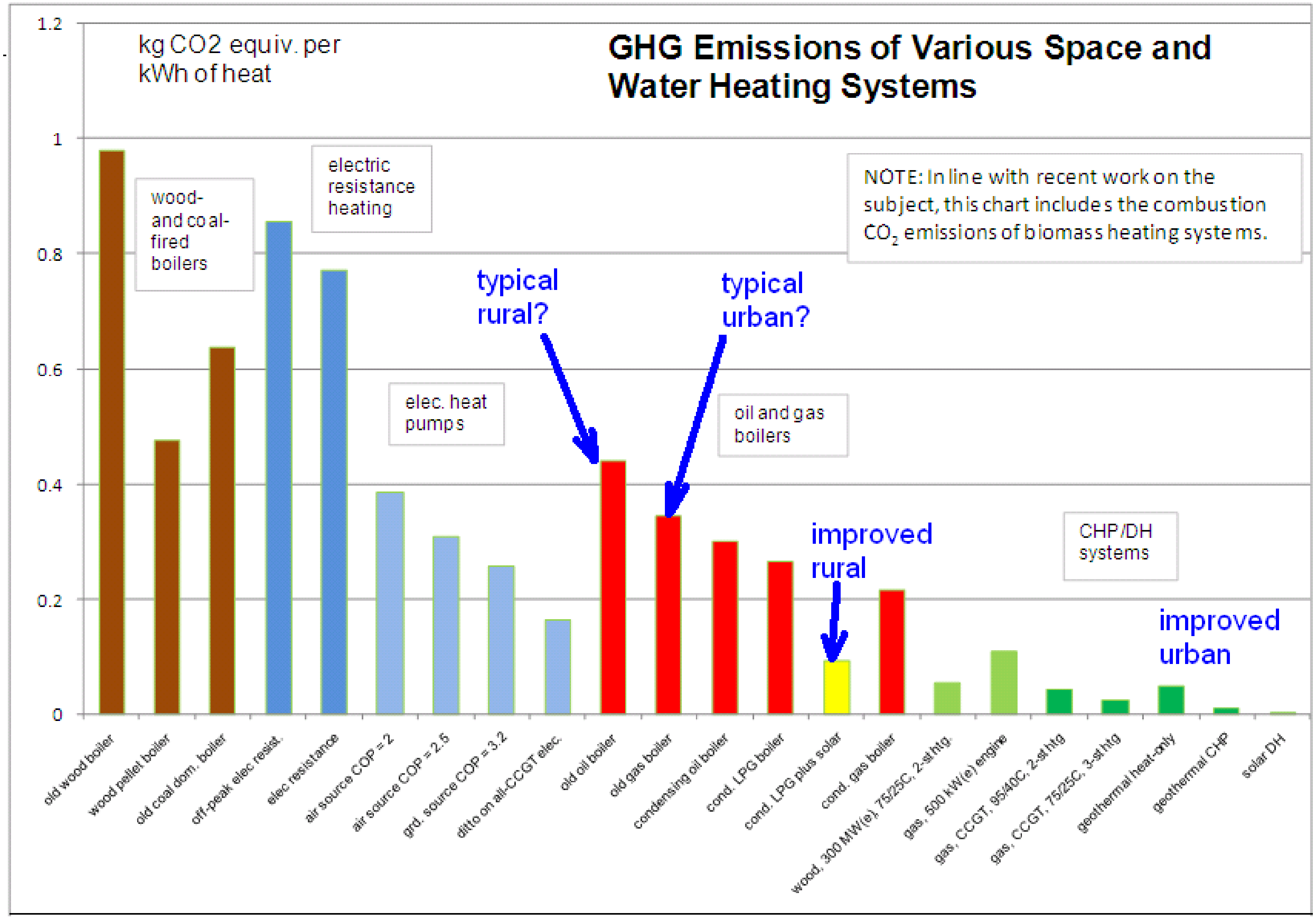
Silver - AECB, the Sustainable Bldgs. Assocn.

Low Energy Class I and II – the Danish government.

Passivhaus - standard - PHI, Germany

Lower-CO_2 Heat

Good practice reduces emissions 75-90%. Until power generation is non-fossil; e.g., maybe in 2040, electric heat pumps do not give dramatically lower emissions than gas- or oil-fired condensing boilers. The latter give significantly lower heating system capital costs..



CHP and/or District Heating

Top right - typical PEX twin pipe for low-density areas and small systems; i.e., with low pressures

Bottom left - suburbia in the city of Aarhus, Denmark supplied by piped heat

Bottom right - typical Danish connection to piped heat for detached houses.

Pictures courtesy: www.pipesystems.com Google maps. www.danskfjernvarme.dk

More Efficient Use of Electricity

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

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

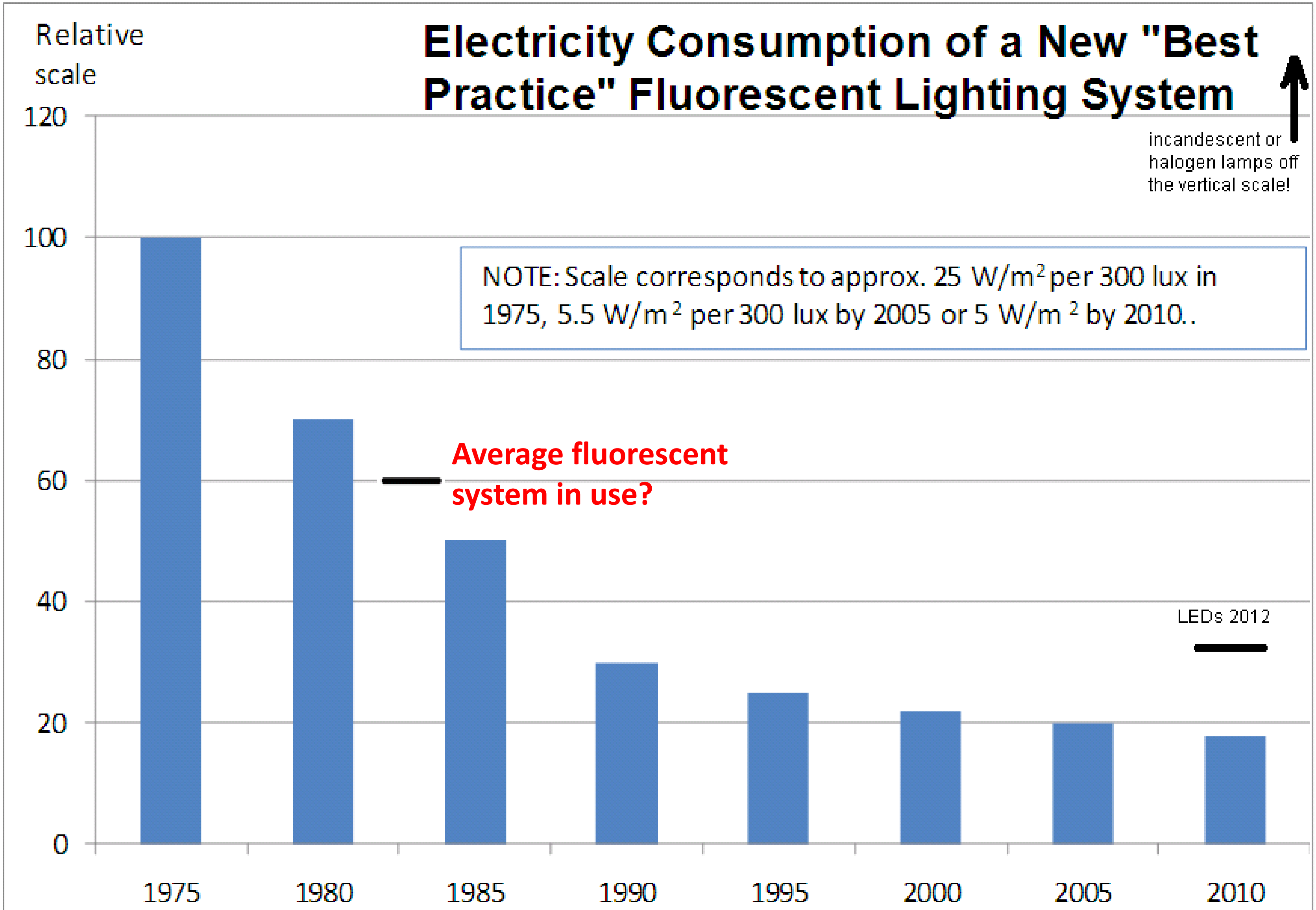
- *Legislate* to mandate a maximum standby power consumption of about 0.1 W per appliance, as achieved for instance by most TVs.

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

- Savings quite often as high as 75-90%.

- Much higher returns on capital than most retrofit insulation. It is cheaper to save electricity than to operate most offshore wind farms! Why are we not doing it?

Fluorescent Tube Lighting Efficiency



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 = 3 p per kWh.

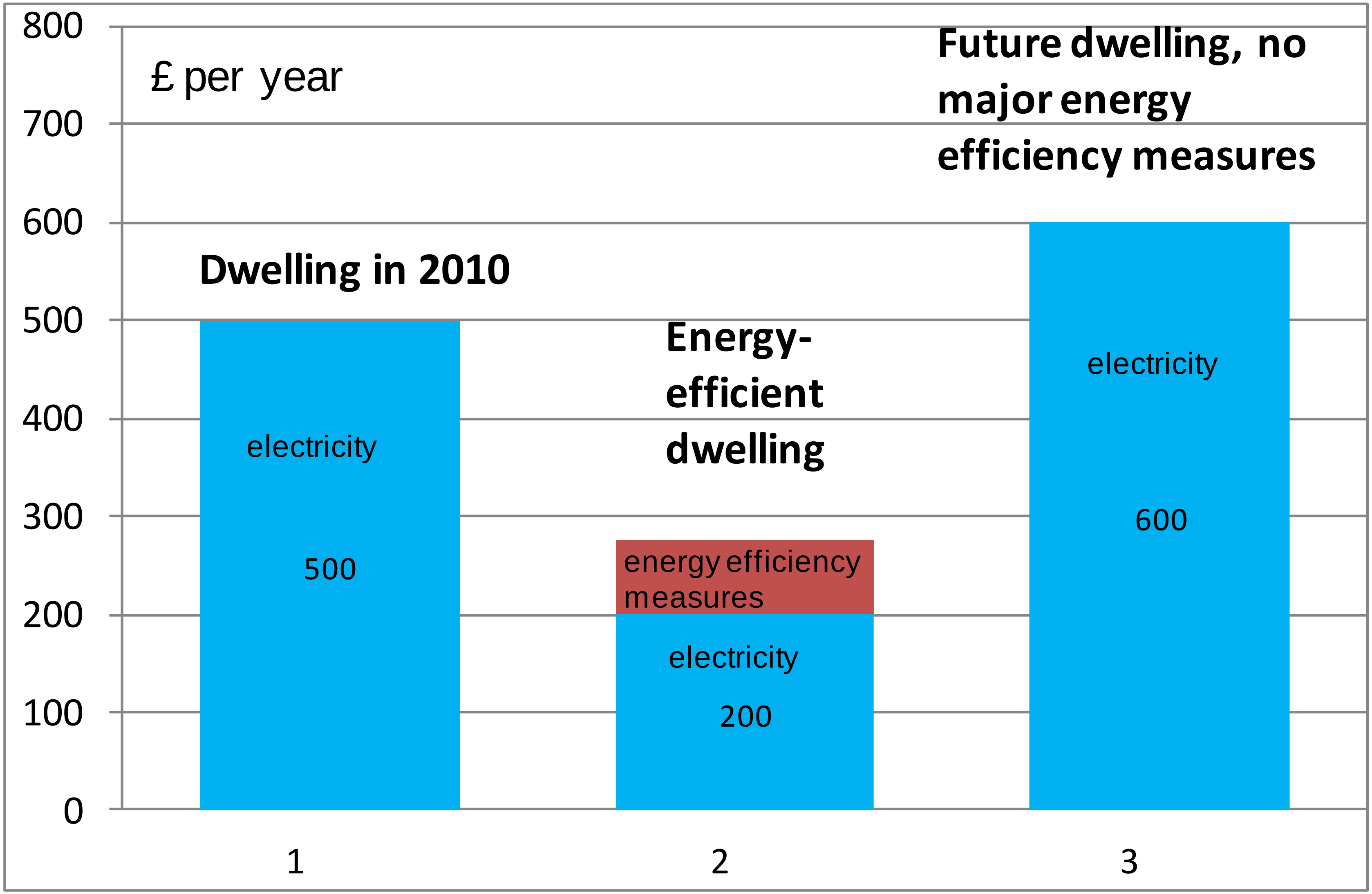
Results of US test at 32°C and 21°C are interpolated linearly to calculate consumption in a CEN test at 25°C.

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

Domestic Electricity Bills

With and without major energy efficiency investment

Figures 2 and 3 are for a dwelling with more appliances than today.



Energy Supply: Where From?

- Hydro power, albeit within UK limits
- Geothermal heat and electricity
- Solar heat
- Tidal power, as electricity
- Bio-energy, after conversion to cleanly- and efficiently-burning fluid fuels; i.e., gases and liquids, with surplus C sequestered.
- Wind, both as electricity and with unwanted surpluses converted to heat or fuel for long-term energy storage/security of supply
- Solar electricity. Unwanted surpluses treated as for wind power.

Case Studies

Small Hydropower, Germany

A run-of-river plant on the River Neckar at Kiebingen. Germany produces 21 TWh/yr of hydropower and water power comprises 23% of renewable electricity. It may set a model for what the UK could achieve with greater investment.

Picture courtesy of Energie Baden-Württemburg AG.
http://www.erneuerbareenergien.de/english/renewable_energy/hydropower/doc/42608.php

Hydropower, the Netherlands

A 12 MW(e) low-head, run-of-river plant at Linne on the River Meuse, built in 1990.
The flat Netherlands has 37 MW of hydropower capacity; i.e., more than England has.

Picture courtesy of www.microhydro.net.

Geothermal Heat, UK

Well being drilled in central Newcastle-upon-Tyne in 2011.

Picture courtesy of BBC.

Tidal Power, France

The 240 MW(e) barrage at La Rance, Brittany. Built in 1966 and still working successfully.

Northern France, the Channel Islands, southern and western England and Wales have over 50% of the EU's tidal energy potential. Construction of tidal lagoons should have a lower environmental impact than damming estuaries.

Interlinked lagoons or barrages can provide power on demand and pumping between basins can increase the total output. Tidal streams cannot do this.

Picture courtesy of DECC.

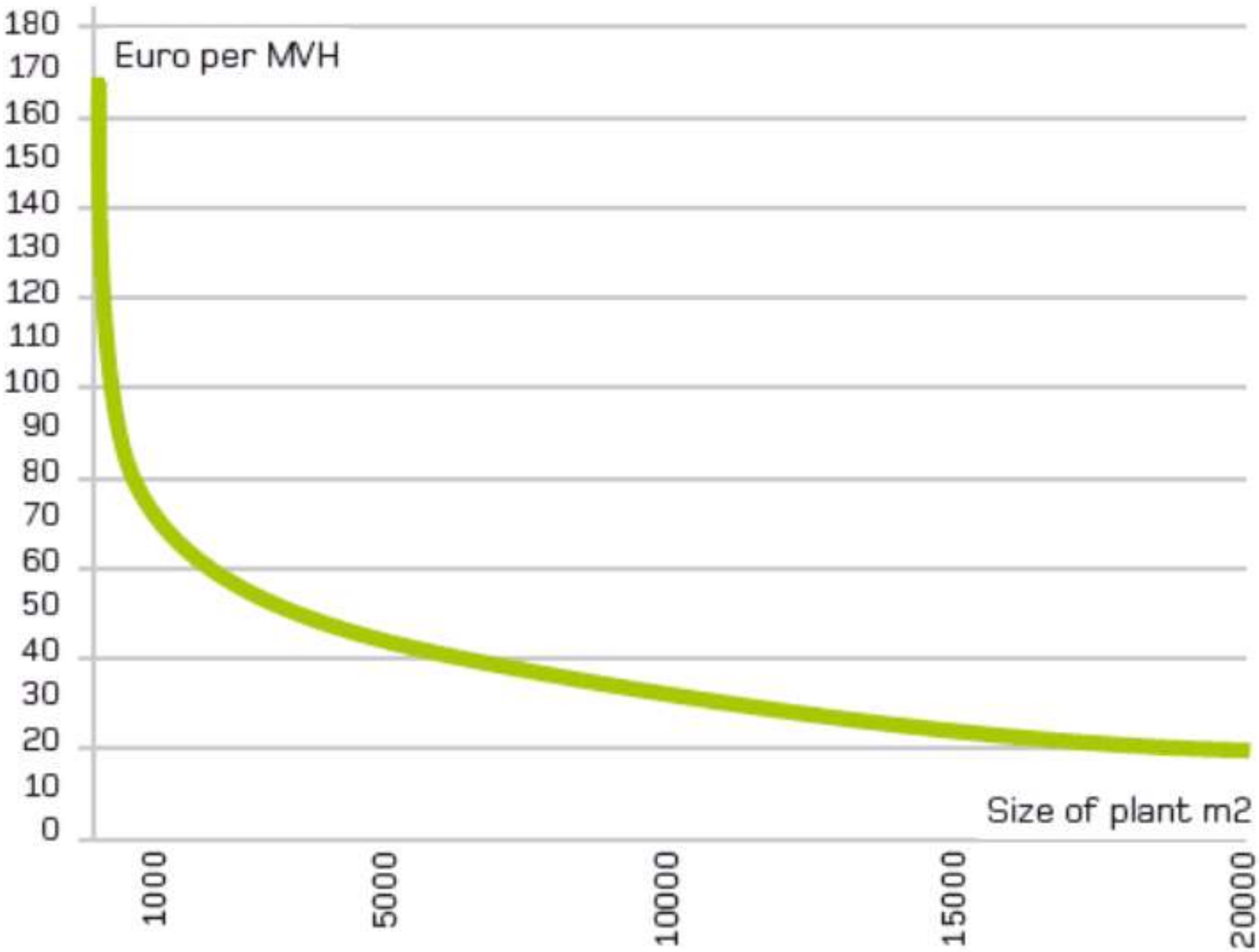
Large-Scale Solar Heat, Denmark

- The small town of Marstal, popn. 4,600
- Soon to have 33,000 m^2 of solar collectors linked to the heat network
- Saving 8.5 GWh/y or 850 m^3/y of oil
- Where sheep may safely graze.

Pictures from Marstal Fjernwärme AMBA.

Cost of Solar Heat Versus System Size

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



Heat production cost falls from 17 to 1.6 pence per kWh as system size rises from 50 to 20,000 m^2.

50 Plants in Europe >700 kW(t)

Left	-	typical solar collectors
Right	-	seasonal heat store for use in soft ground

Pictures from DH section of www.solarthermalworld.org

Wind Power, Denmark

Offshore turbines near Copenhagen.

Picture courtesy of Wikipedia.

Biomethane CHP, Germany

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

Digesters show economies of scale up to a capacity of at least 1 MW. The largest in Germany is 20 MW.

Picture courtesy of:

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

Summary

- The cheaper energy efficiency measures abate greenhouse gas emissions at negative cost, in £/tonne. They are not just a free lunch, but a lunch that we are paid to eat;
- With the rising cost of energy supply, negawatts are as important an opportunity for energy policy as the discovery of new giant oil or gas fields, few of which are being discovered any more;
- They come without the global warming impact;
- Policy-makers need to focus on the lowest-cost options, even if they are unfamiliar;
- Policy-makers should pursue energy efficiency in all its forms as seriously as geologists have explored the earth's crust for oil and natural gas deposits;
- To implement "downstream" measures which are invisible to current energy suppliers needs a sea change in government policy.

Further reading

LESS IS MORE:

Energy Security After Oil

David Olivier
with Andrew Simmonds

Downloadable free from www.aecb.net
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AECB

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