ENERGY EFFICIENCY

NEW BUILDINGS

Presented by

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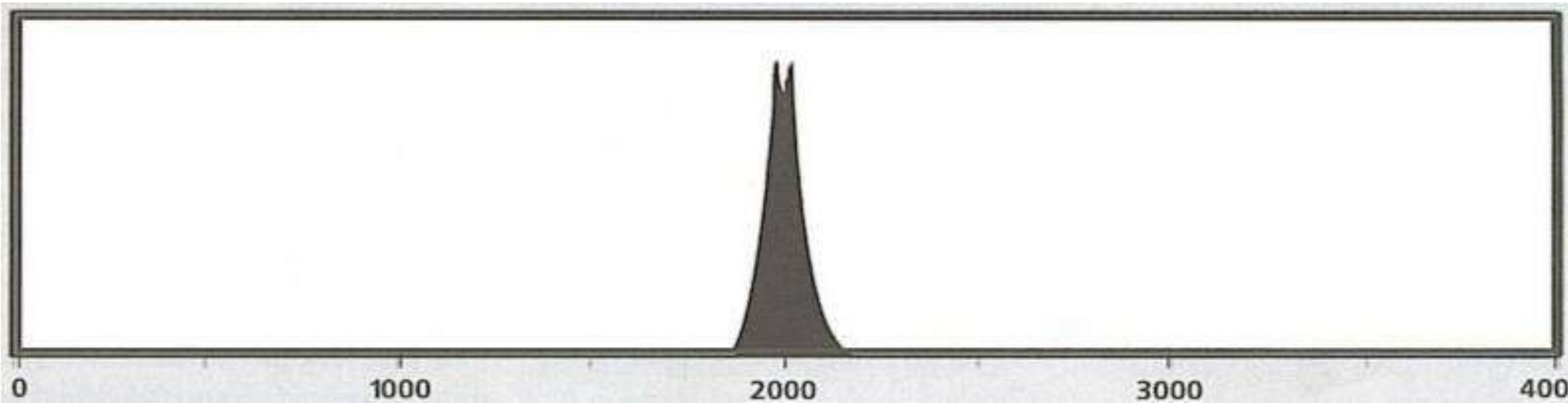
What I shall talk about

- Some major strategic issues
- Energy efficiency in new buildings
  - Mostly housing
- Some case studies
- Energy efficiency market barriers
  - How to get what we want, not what we don’t want.

Some Major Strategic Issues

Peak Oil:

Expected to be Followed by Peak Gas



Oil production & consumption in a historical context.

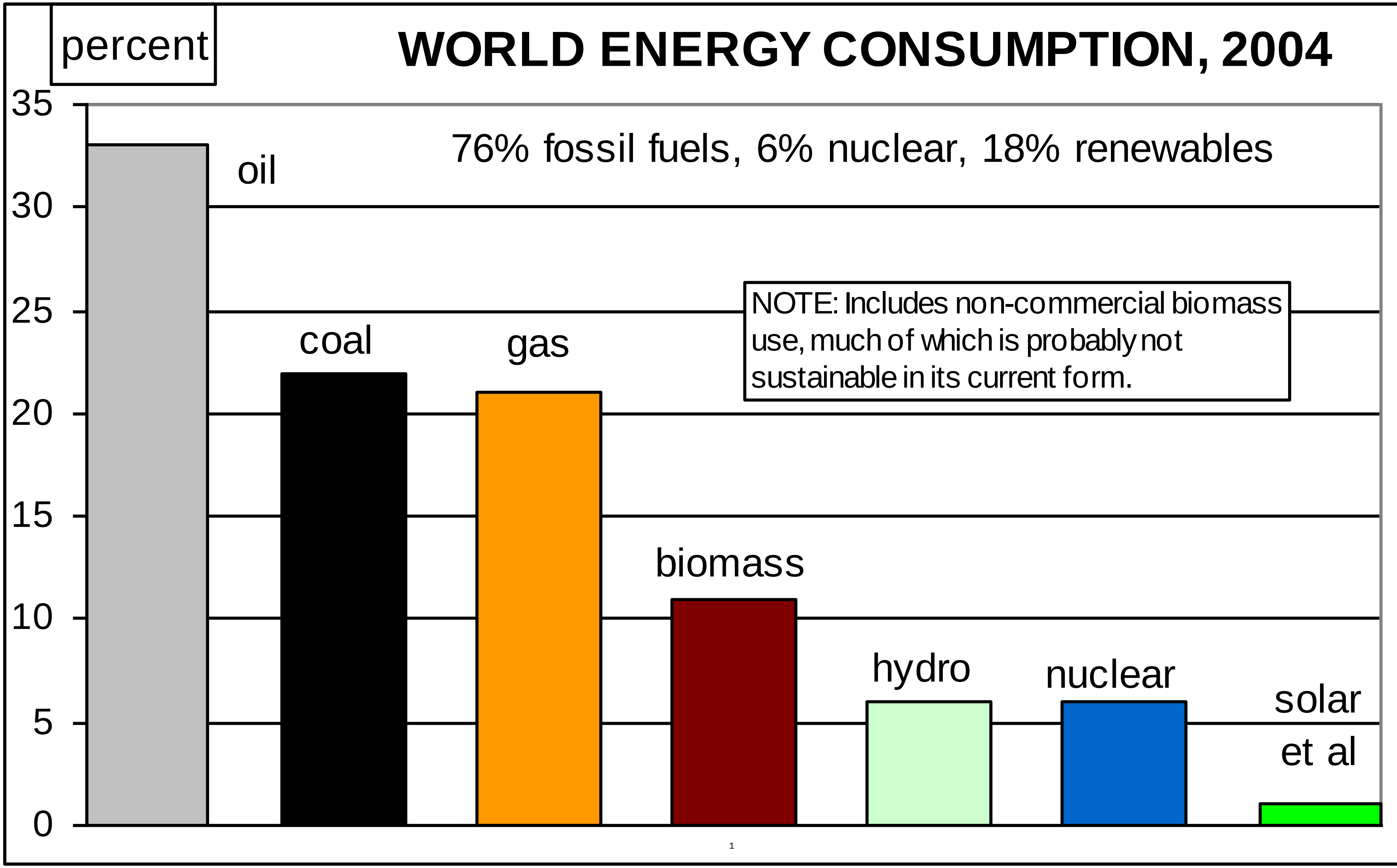
Actual profile 1870-2003 and predicted profile 2003-2130.

“The world has never faced a problem like this. Without massive mitigation more than a decade before the fact, the problem will be pervasive and will not be temporary. Previous energy transitions were gradual and evolutionary. Oil peaking will be abrupt and revolutionary."

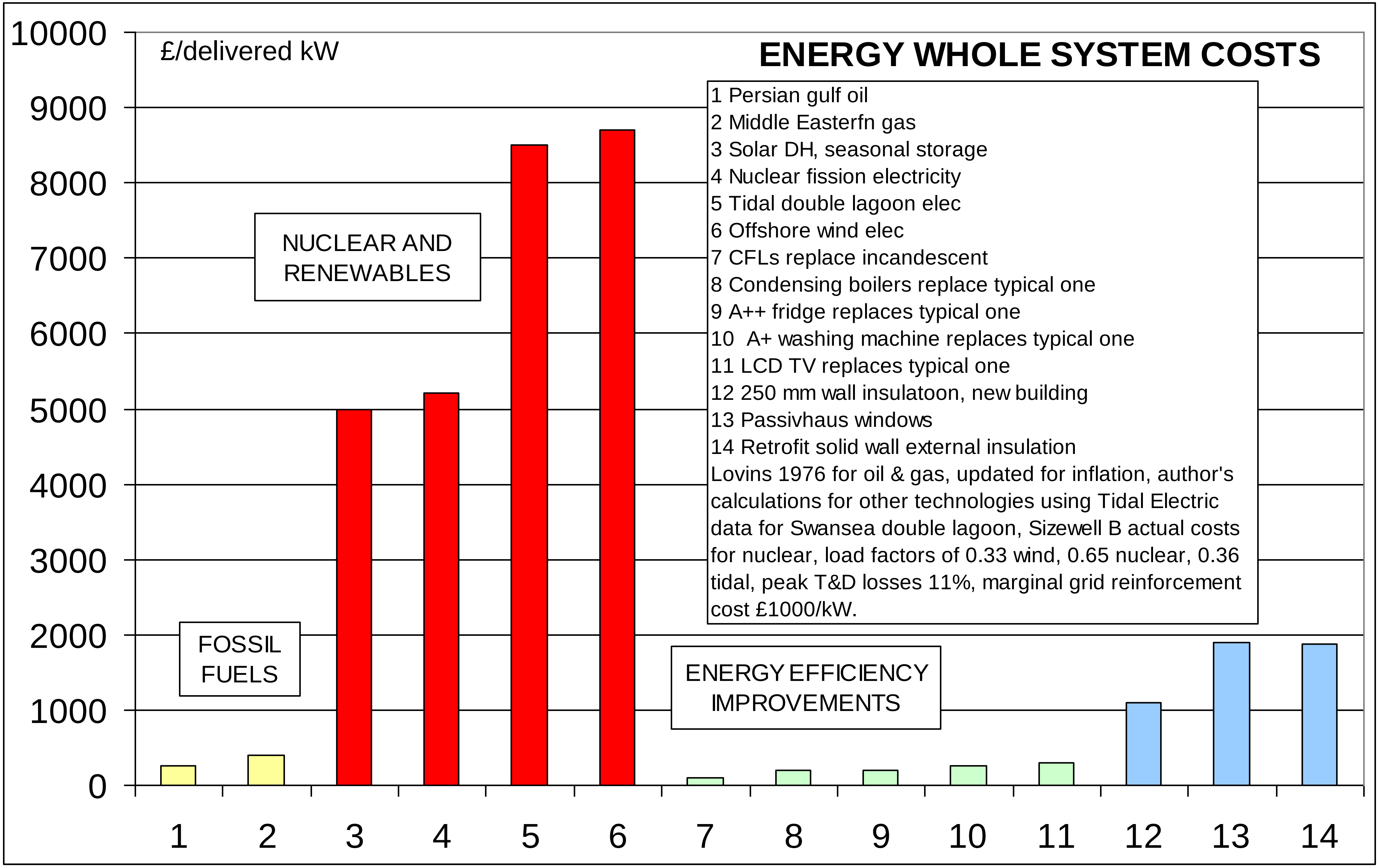
US Dept. of Energy, internal March 2005 report.

See also www.oilendgame.com

World Fossil Fuel Dependence



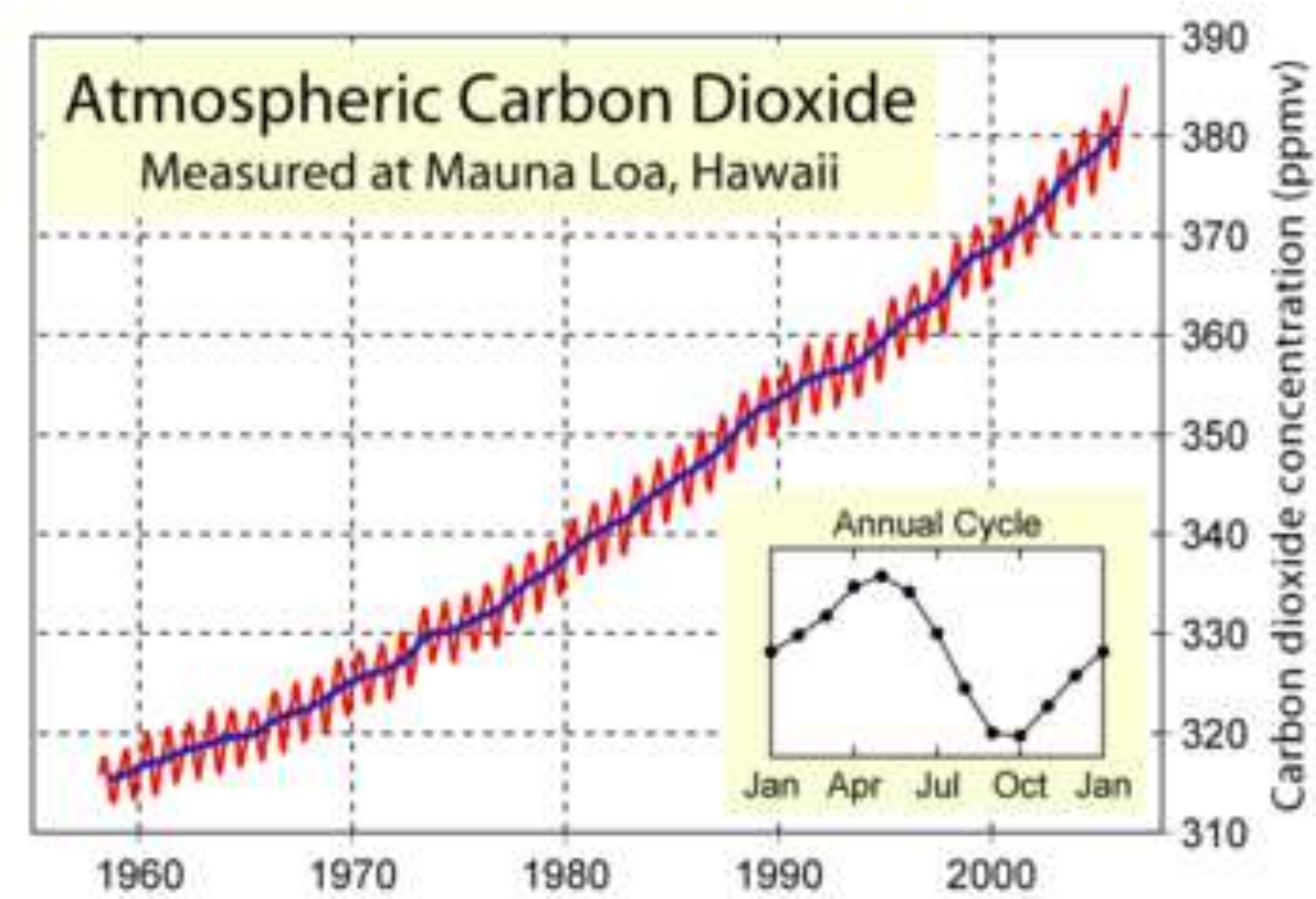
The Very High Costs of Non-Fossil Energy Supply Systems



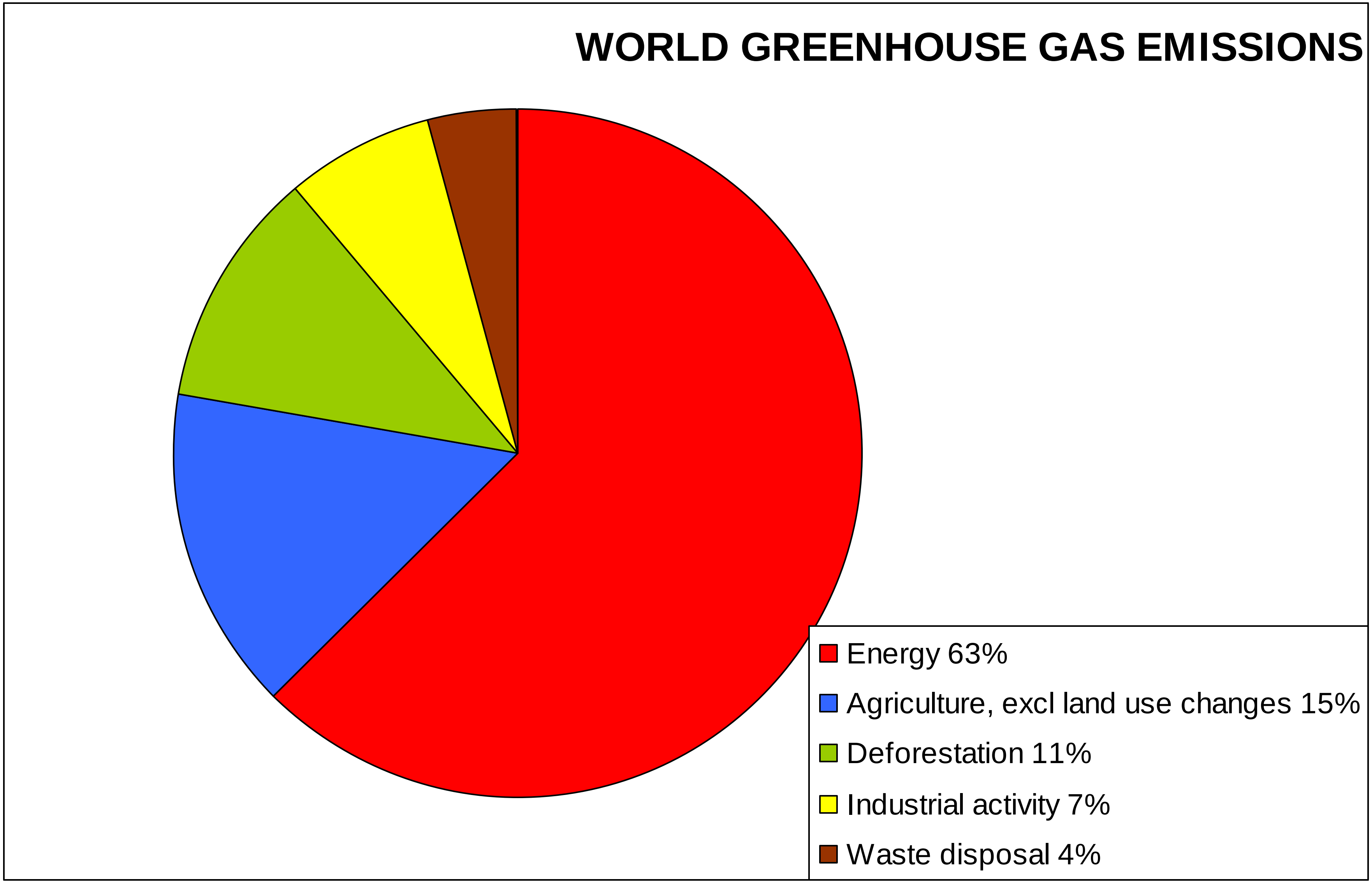
Worked Example

- External solid wall insulation is utilised to save heat in a well-heated detached house in the Birmingham area; i.e., a fairly typical UK climate.
- Work costs £50/m^2 of wall area. Sufficient insulation is used to reduce the U-value of a solid 215 mm brick wall from 2.1 to 0.2 W/m^2K.
- Calculations using the German PHPP Excel simulation package show that this measure typically saves 235 $kWh/yr.m^2$ wall area.
- Cost to "deliver" an average kilowatt of heat to final consumers
  = £ 50x8766/235 = £1,870/delivered kilowatt.
- Illustrative only, not a detailed study.

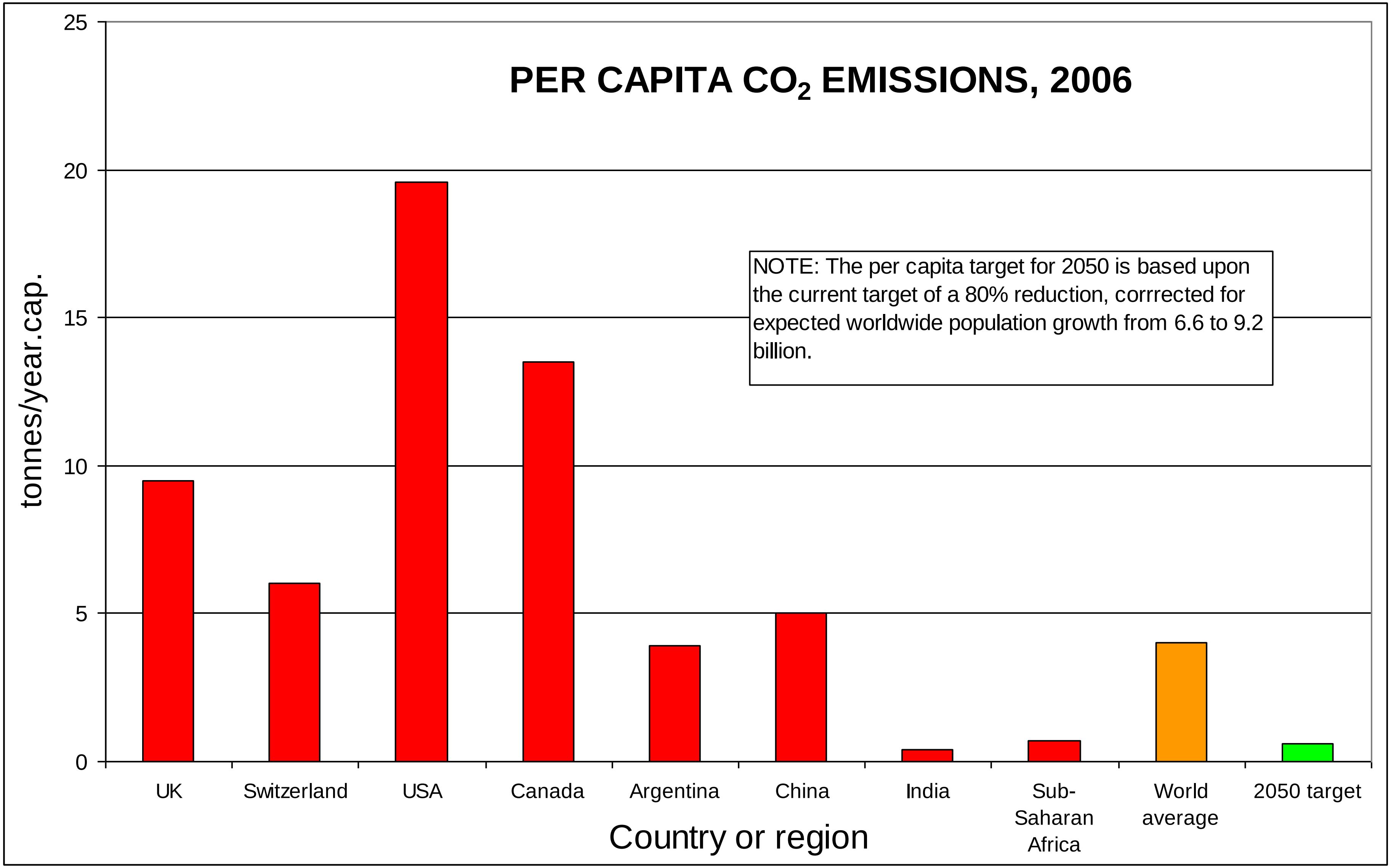
Rising Atmospheric CO_2 Equivalent



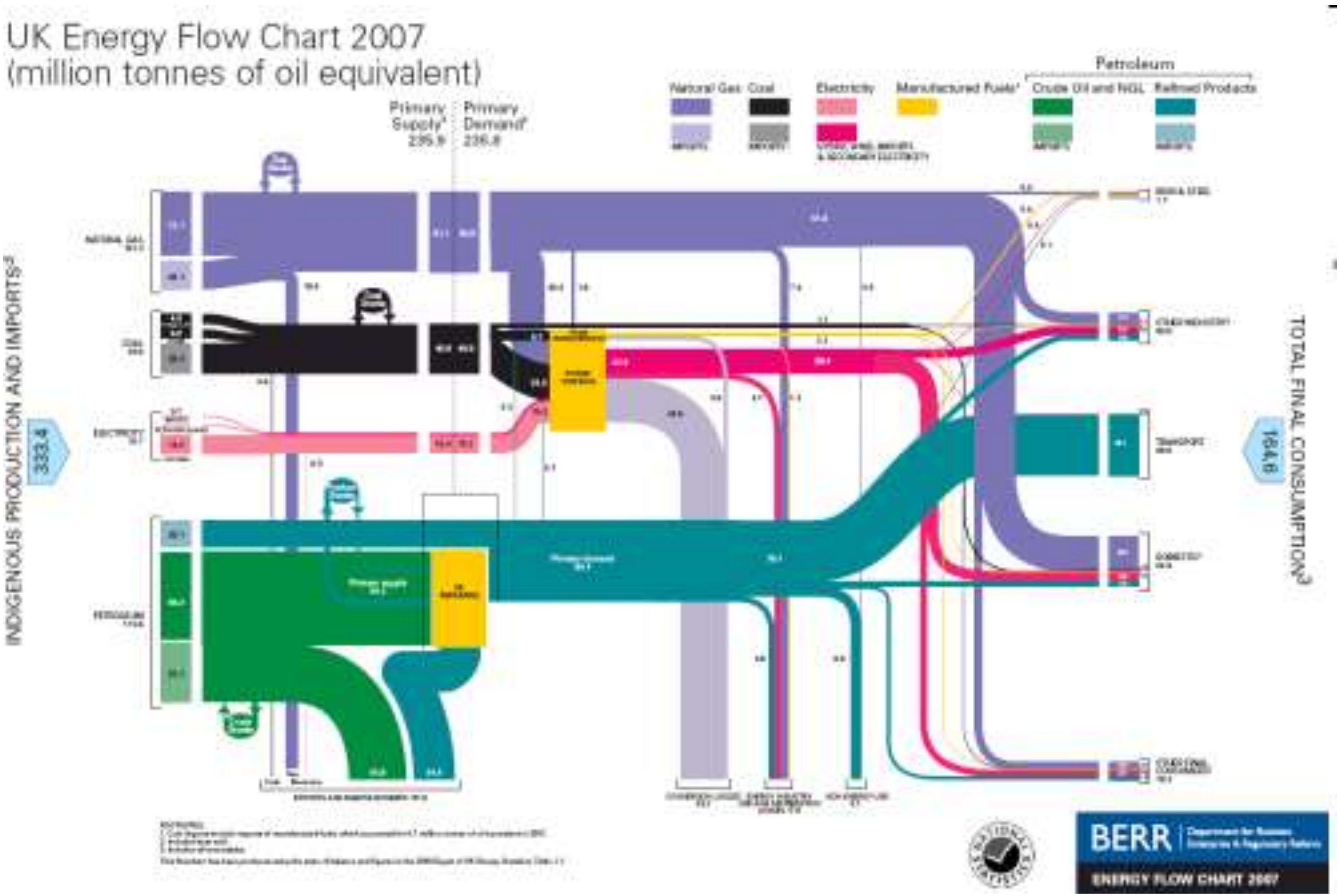
Sources of Greenhouse Gases



International CO_2 Reduction Targets

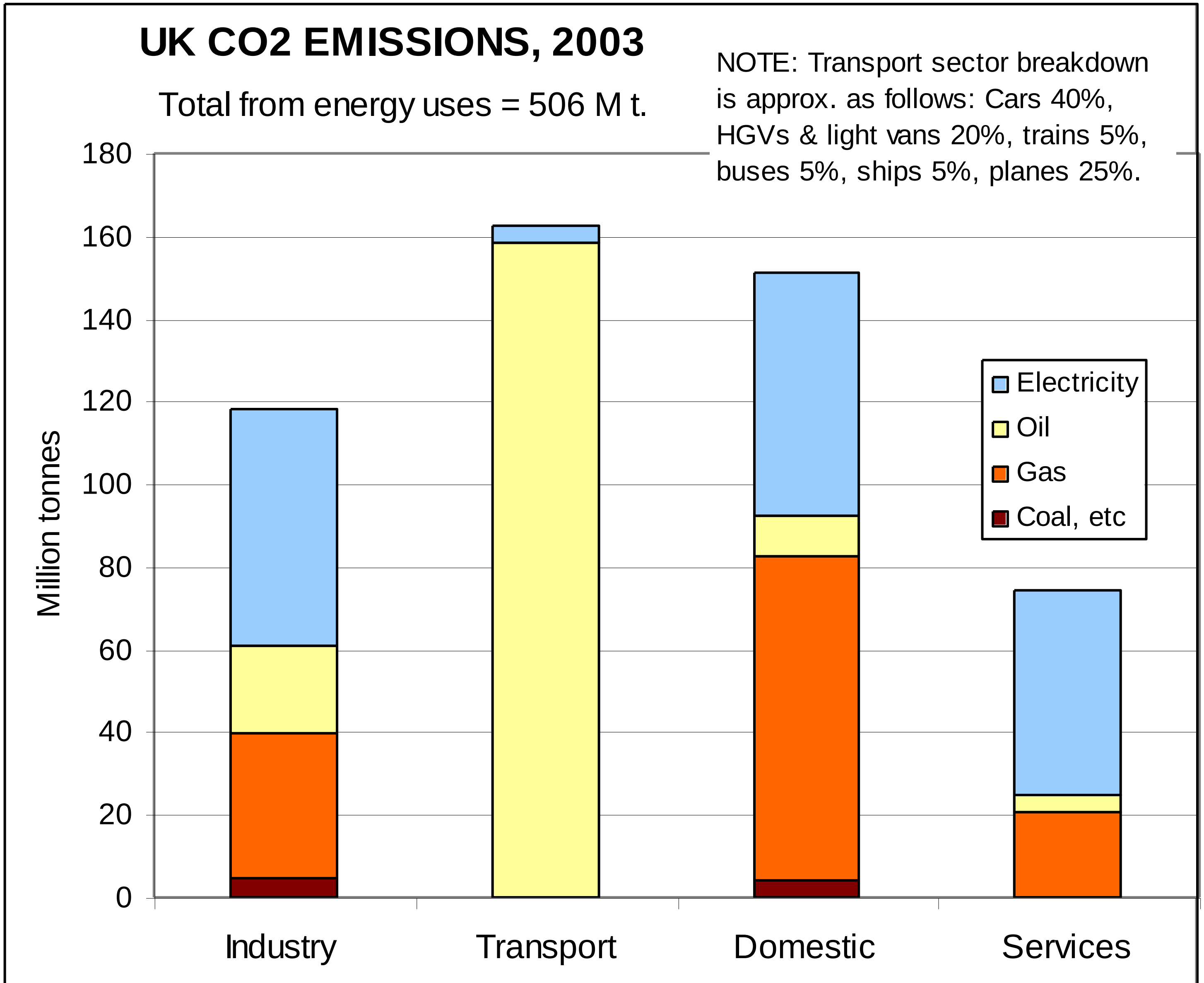


UK, Major Oil and Gas Dependence

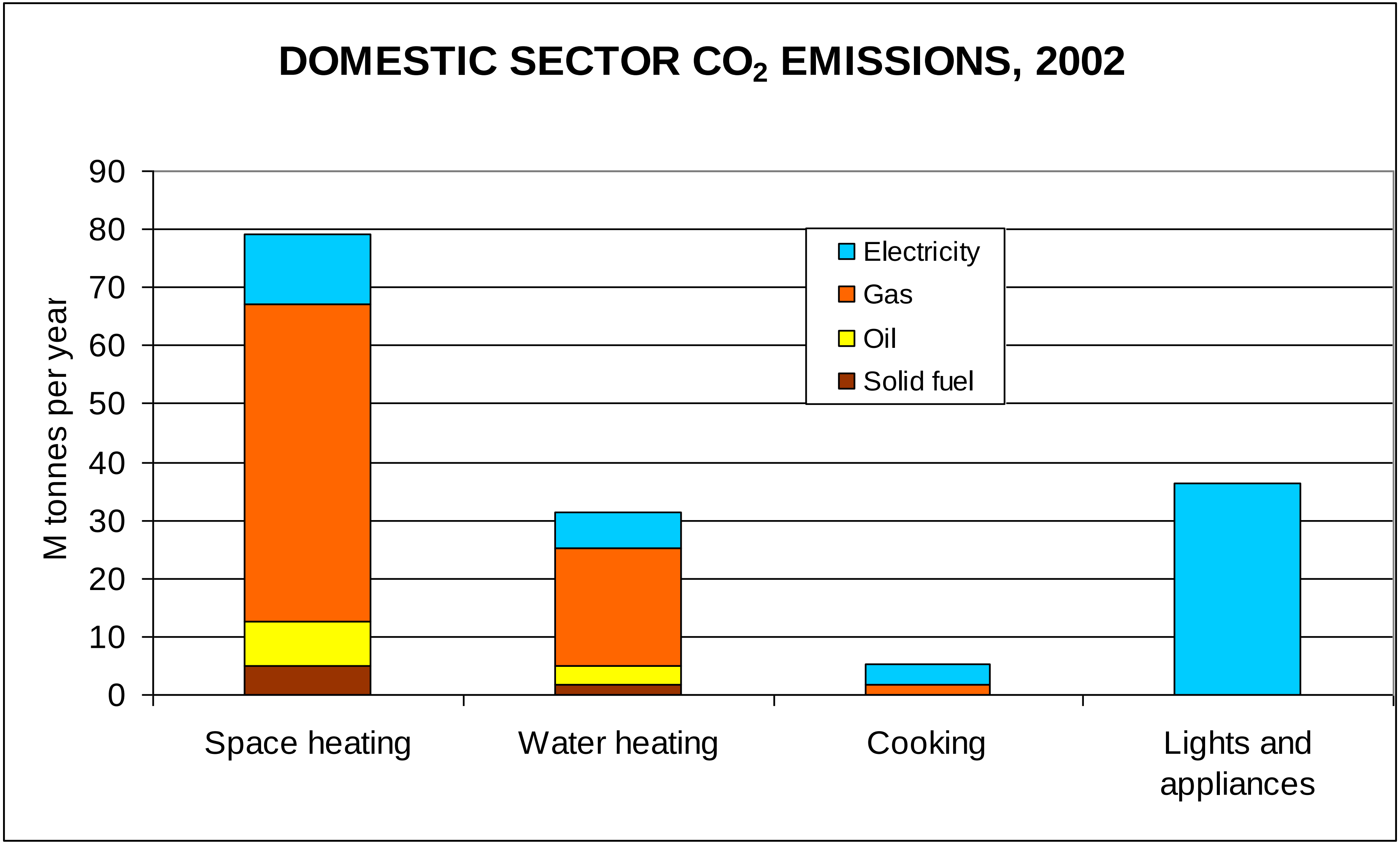


The largest energy flows are oil for transport and gas for heating. 30% more heat is rejected from gas, coal and nuclear power stations than the amount of gas used for heating buildings.

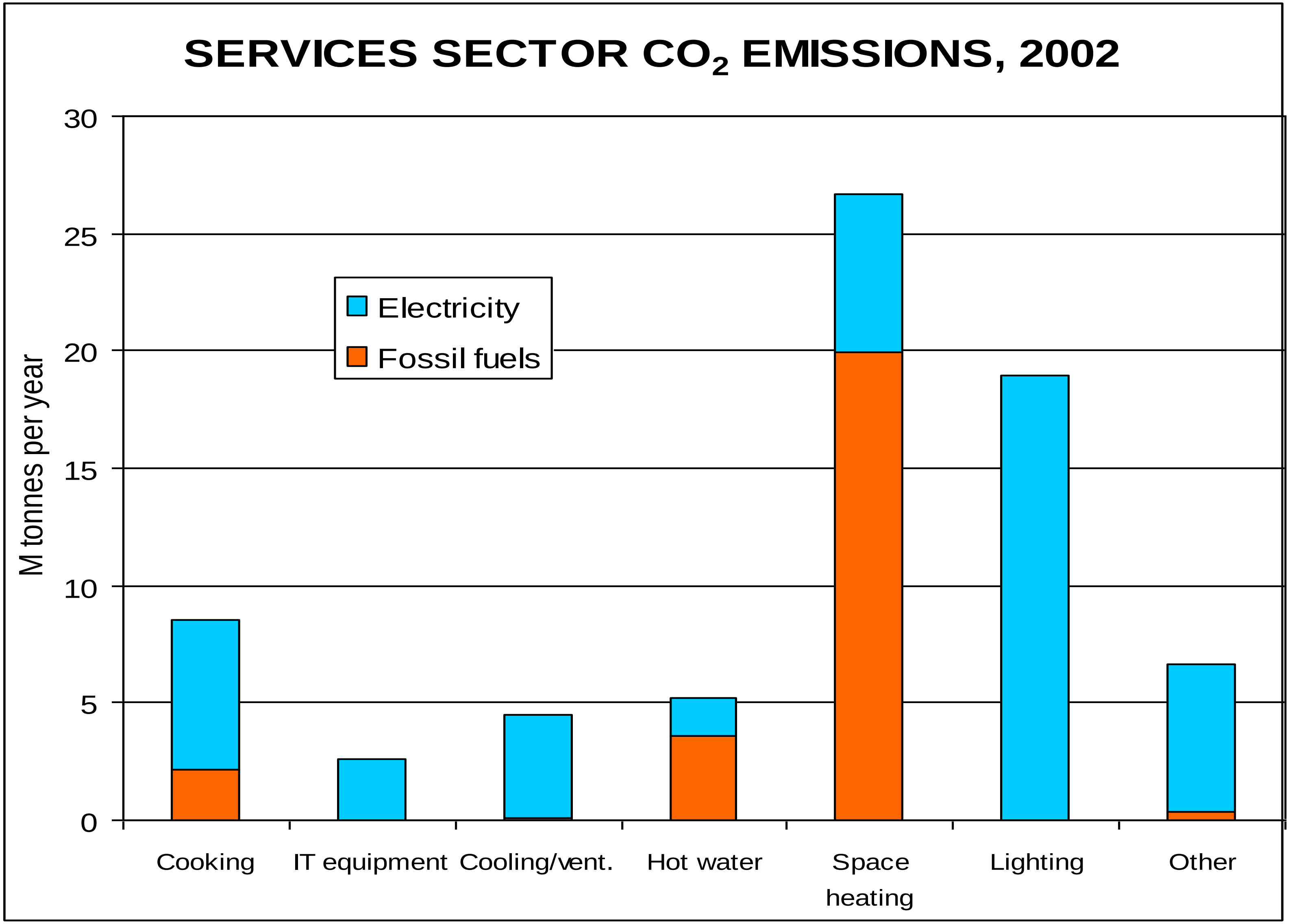
UK Situation, Energy Sector



CO_2 Emissions From the Domestic Sector



CO_2 Emissions From Non-Domestic Buildings



Possible Ways Forward

- With the rising cost of new energy supply systems, the world's energy resource costs per unit GDP could rise by an order of magnitude, with adverse economic consequences.
- Electricity supply systems used at low load factor; e.g. for heat, have particularly high costs, expressed in £ per delivered kilowatt or pence per kWh of delivered energy.
- Unlike new sources of energy supply, most energy efficiency measures studied to date compete with the resource cost of oil, let alone with the market price of oil.
- A large enough investment in energy efficiency to reduce consumption drastically could possibly keep annual costs at acceptable levels, despite the inevitable sharp rise in energy supply costs.

Energy Efficiency In Buildings

1. Dwellings - houses and flats

2. Non-domestic - schools, offices, hospitals, hotels, retail, etc.

Countries Which Lead

in Energy/Building Work

1 **Canada** - Issued guidance on air-vapour barriers >45 years ago, launched R-2000 Program 25 years ago, C-2000 Program, etc. Pioneered mass builder training on making normal new homes more airtight.

2 **USA** - Participates in most IEA Tasks related to energy-efficient solar buildings. Superb government websites; e.g., the Office of Energy Efficiency and Renewable Energy of the US Dept of Energy.

3 **Germany** - Work by independent institutes and state governments. German and Swedish experts developed the Passivhaus standard in 1988. Passivhaus buildings can obtain 30 year fixed rate mortgages at 3.4%/yr or 25 year at 3.2%/yr.

4 **Austria** - Much grassroots action. 60% of all new dwellings are self-build one-offs. More Passivhaus buildings per capita than Germany.

5 **Switzerland** - Federal government MINERGIE and MINERGIE-P Standards. Superb technical documents produced by Swiss Institute of Architects and Engineers.

6 **Sweden** - Even its Building Code is close to the Passivhaus Standard.

7 **Denmark** - New buildings *in 1975* had 100 mm wall insulation. 65% of all buildings are heated by CHP or by industrial waste heat.

8 **Norway** - State Housing Bank wrote two voluntary low-energy standards for dwellings. Main window producer makes a Passivhaus window.

Countries Which Lag

in Energy/Building Work

1 **UK** - In heat loss terms, the England & Wales Building Regulations of 2006 are at best on a par with the Swedish or Norwegian Building Codes of 1965-75 and their actual building practice in 1950. But we are not alone …

2 **France** - Has land borders with Switzerland, Germany and Belgium,. Strangely, many insulation measures which are now compulsory in those regions are voluntary or even unknown on the French side of the border.

3 **Ireland** - Independent work showed that housing built in the late 1990s and the 2000s uses more energy per unit floor area than pre-1990 housing. But at least Ireland has made measurements. Since 1999, UK authorities have consistently declined to fund such work.

4 **Japan** - Imported US & Canadian wooden housing, with walls of 38 x 90 mm timbers, and 90 mm glass fibre insulation, is revered for its thermal comfort compared to traditional Japanese timber buildings, which have only one warm room. Yet the climate of Japan resembles that of the eastern & north-eastern USA, where walls with this little insulation are now rare or even illegal.

5 **China** - Minimal insulation standards. Yet the winters of the NE interior are as cold as those of central Canada or Siberia. Harbin's January temperature is -20^{o}C; i.e., the same as in Winnipeg, they are the two coldest major cities on earth.

Summary - Passivhaus Standard

- Opaque U-values <0.15 W/m^2K, usually <0.10 W/m^2K.
- "Thermal bridge-free" construction.
- Glazing U-value <0.8 W/m^2K.
- Air leakage <0.6 air changes/hour @ 50 Pa
- Peak space heating load <10 W per m^2 floor area
- Space heating useful energy <15 kWh/m^2yr.
- Consequently no separate heating system, only water-air heat exchanger(s); i.e., plumbing coil(s), in ventln. ductwork.
- Ventilation system specific fanpower <1.44 W per l./s.
- Ventln. system equiv. heat recovery >75% as seasonal average, excl. fan heat gains and the benefit of the earth tube heat exchanger if used.
- Highly energy-efficient lighting systems, electrical appliances & office equipment.
- Primary energy consumption <120 kWh/m^2yr.
- Pushes energy efficiency far beyond existing UK awareness, custom or practice.
- Germany has 100 times as many retrofits to the Passivhaus standard as the UK has *new* Passivhaus buildings.
- See www.passiv.de

AECB Silver and Gold Standards

* Developed in UK from 2003 onwards for application by all 1,400 members in their own projects.
* Lead to energy consumption respectively 75% and 85% lower than the UK building stock.
* Lead to CO_2 emissions respectively 70% and 95% lower than the building stock.

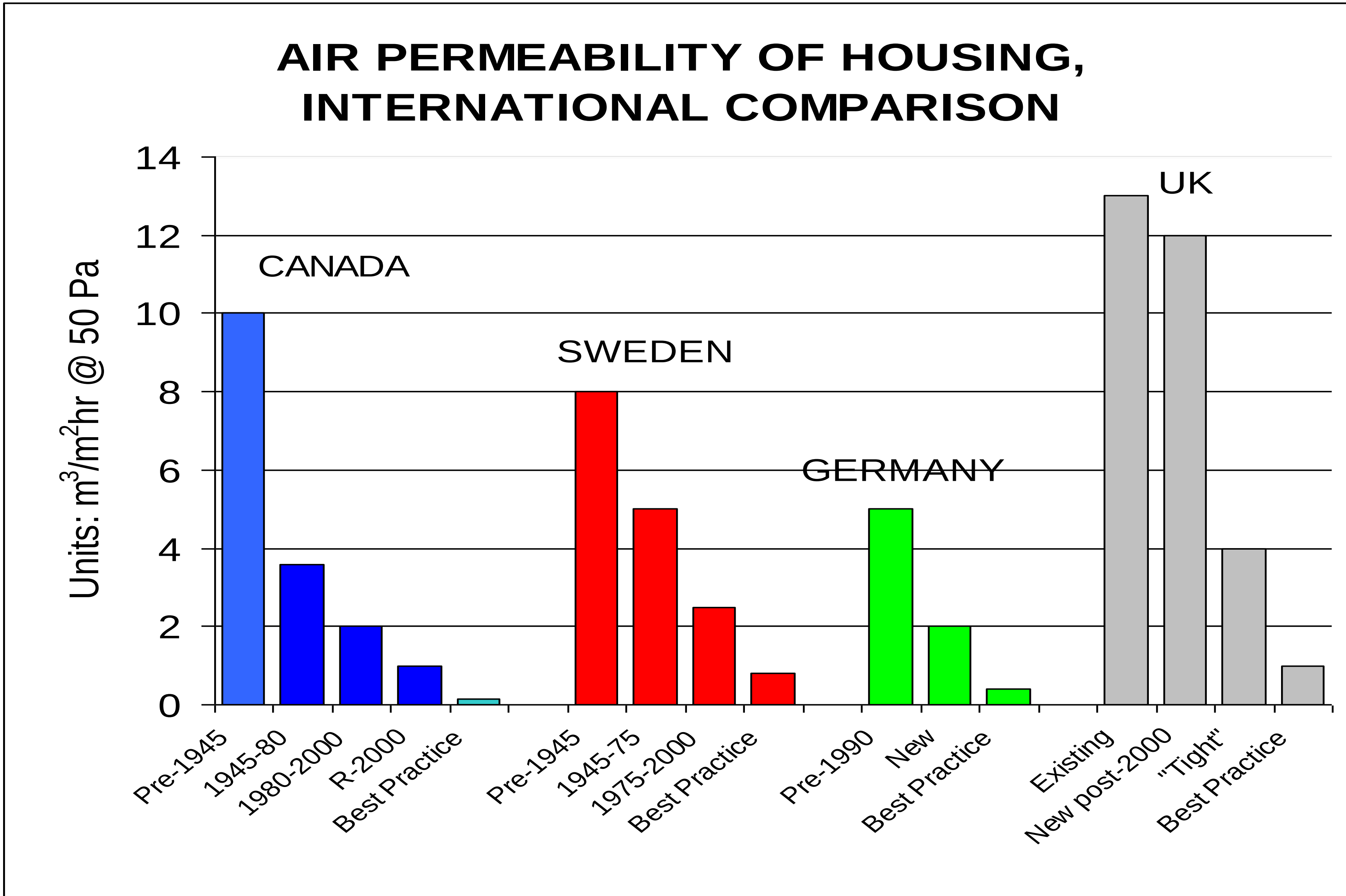
See www.aecb.net.

Summary - AECB Gold Standard

- Opaque real U-values <0.15 W/m^2K, usually <0.10 W/m^2K
- Minimal thermal bridging
- Glazing U-values <0.8 W/m^2K
- Air permeability <0.75 m^3/m^2hr @ 50 Pa
- Peak space heating load <10 W per m^2 floor area
- Space heating useful energy <15 kWh/m^2yr.
- Vent. system specific fanpower <0.8 W per l./s
- Vent. system equiv. heat recovery >85% as seasonal average excluding fan heat gains, including benefit of earth preheating tube(s) if used
- The most energy-efficient lighting systems, domestic appliances & office electrical equipment on the market
- Elec. generated from on-site or dedicated renewables; e.g., PV, micro-hydro or community wind turbine helps to offset CO_2 emissions from the elec. consumption for lights & appliances.

The UK builds in ways which fail to keep the heat in.

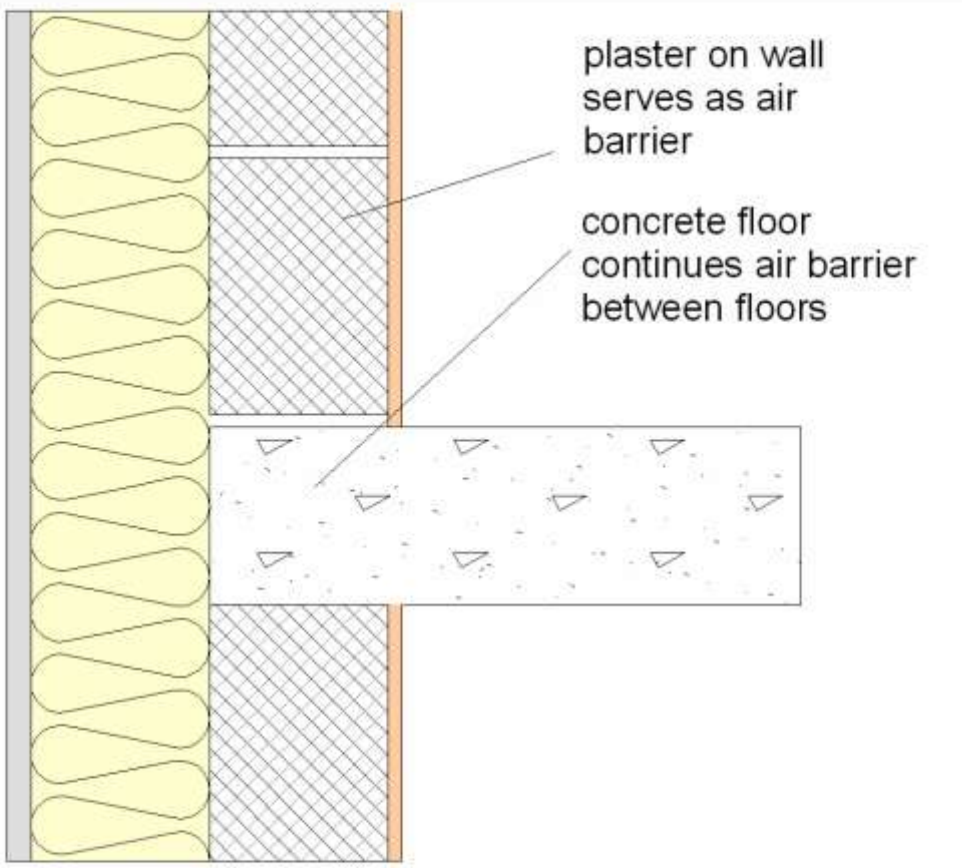
New UK dwellings are leakier than those built in Canada, Sweden or Germany 60 years ago.



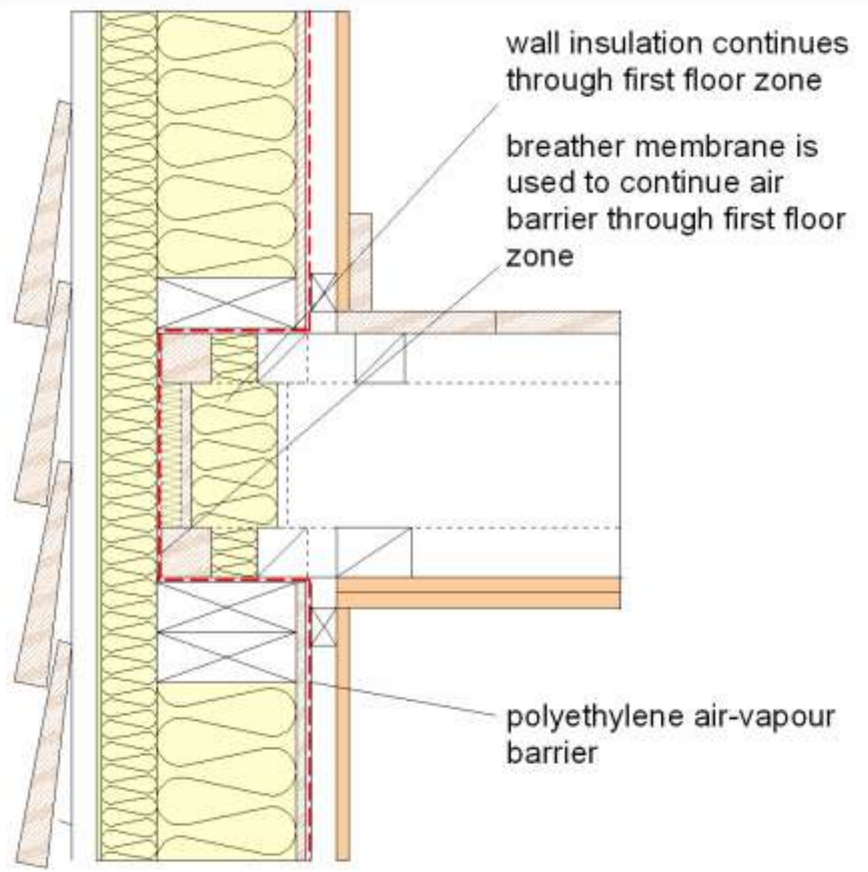
Better design guidance and builder training is needed.

Examples of sound thermal envelope design. www.carbonlite.org.uk.

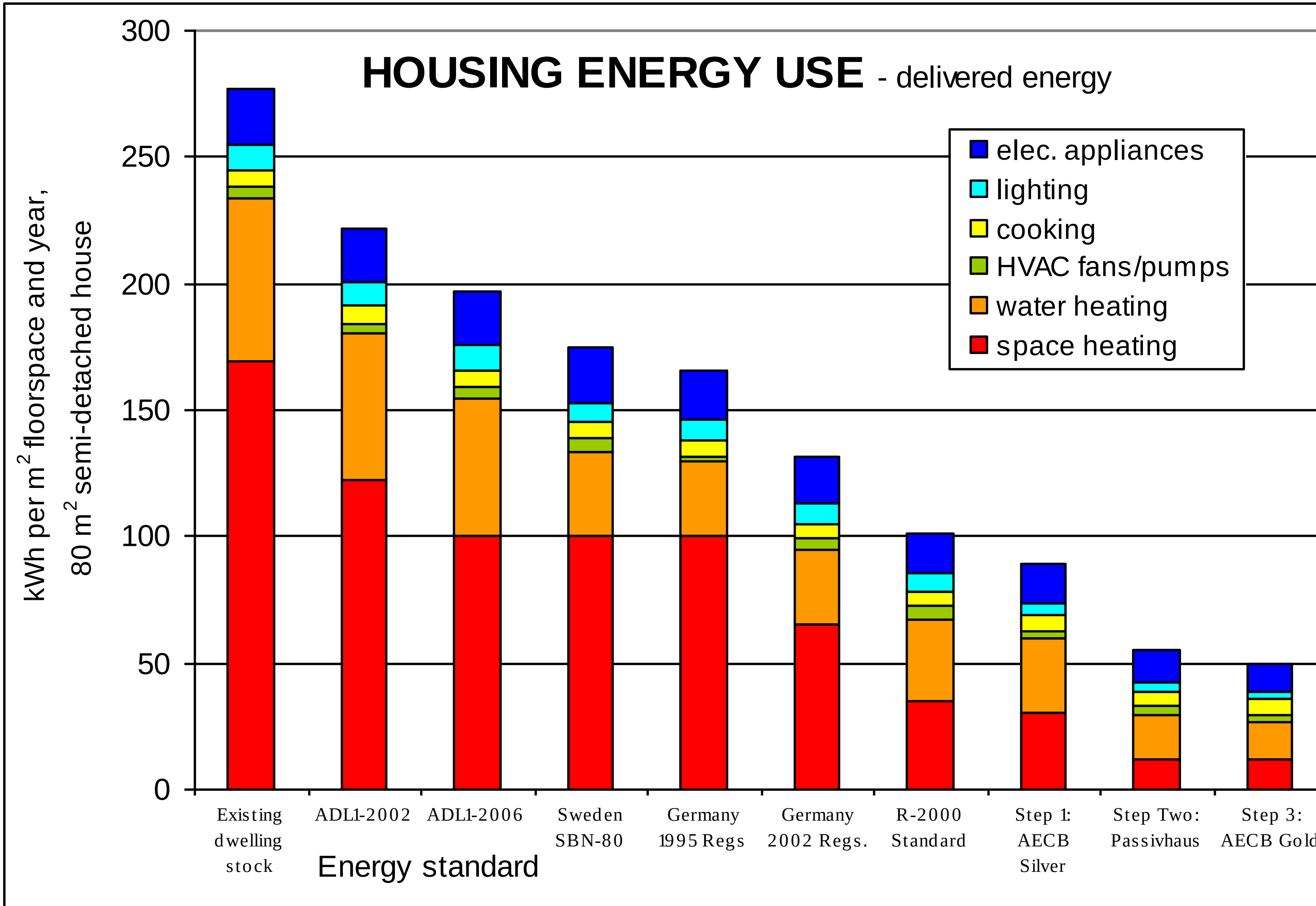
SOLID MASONRY, EXTERNAL INSULATION



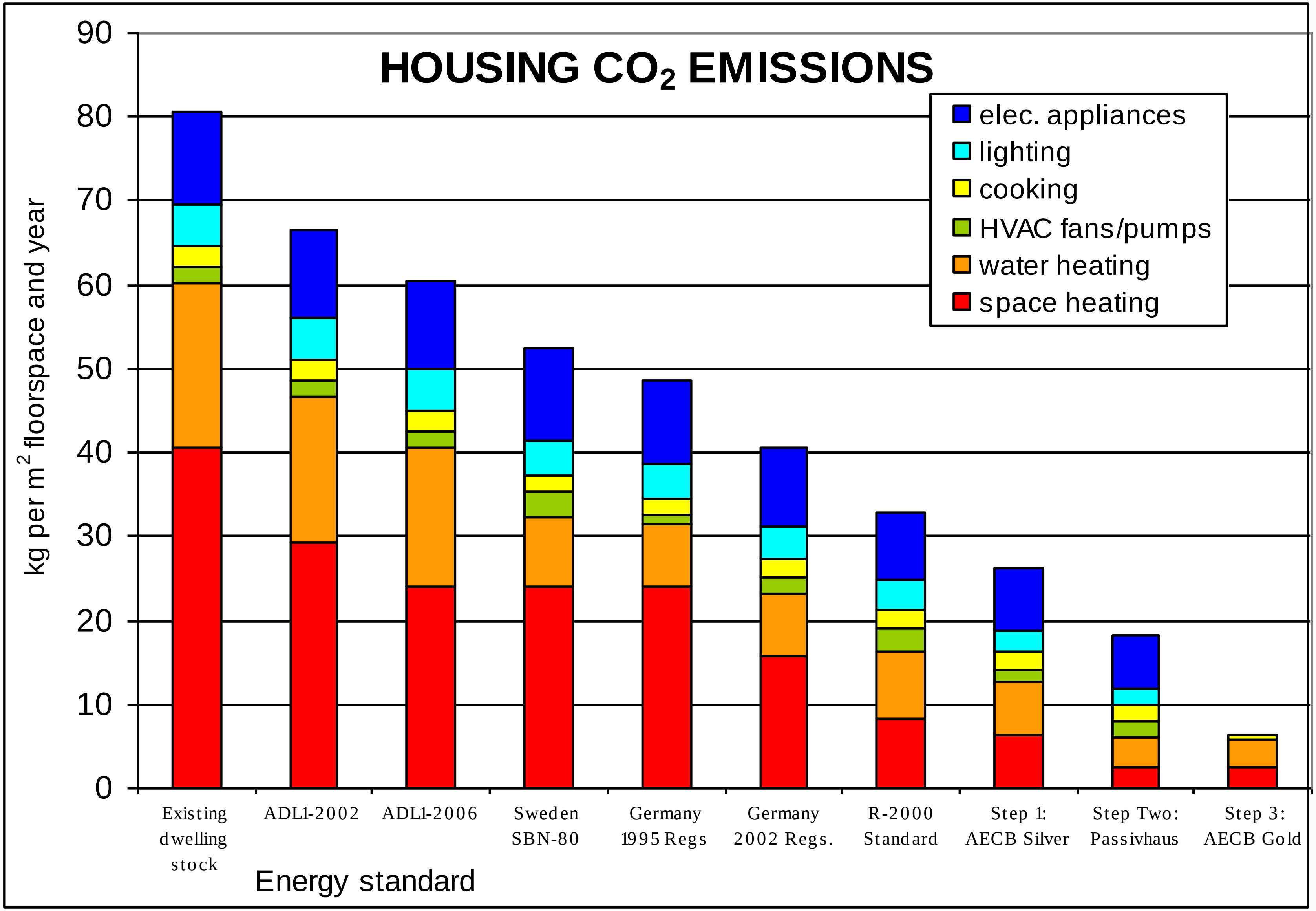
TIMBER-FRAME



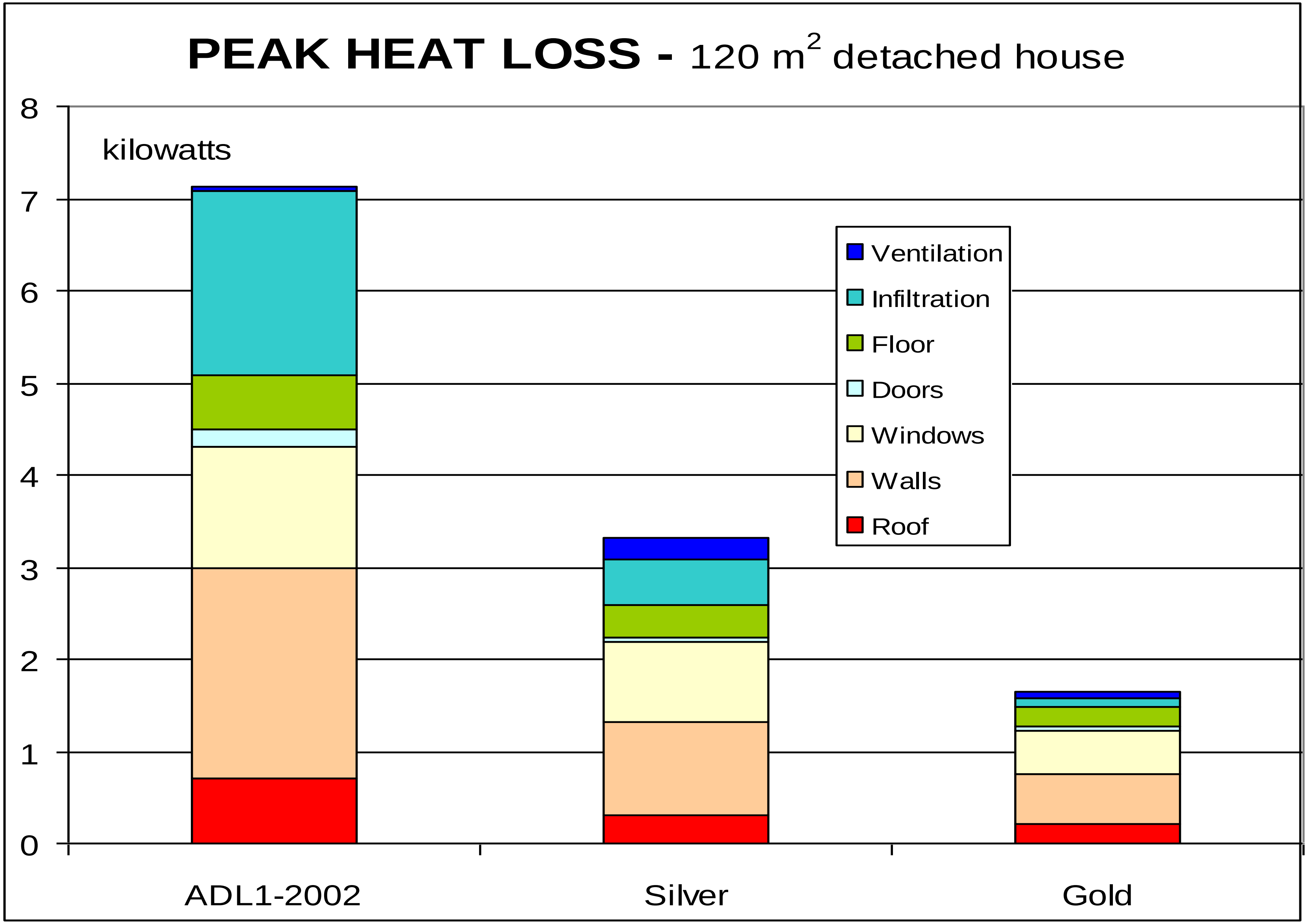
The Impact of Effective Energy Performance Standards on Energy Consumption.



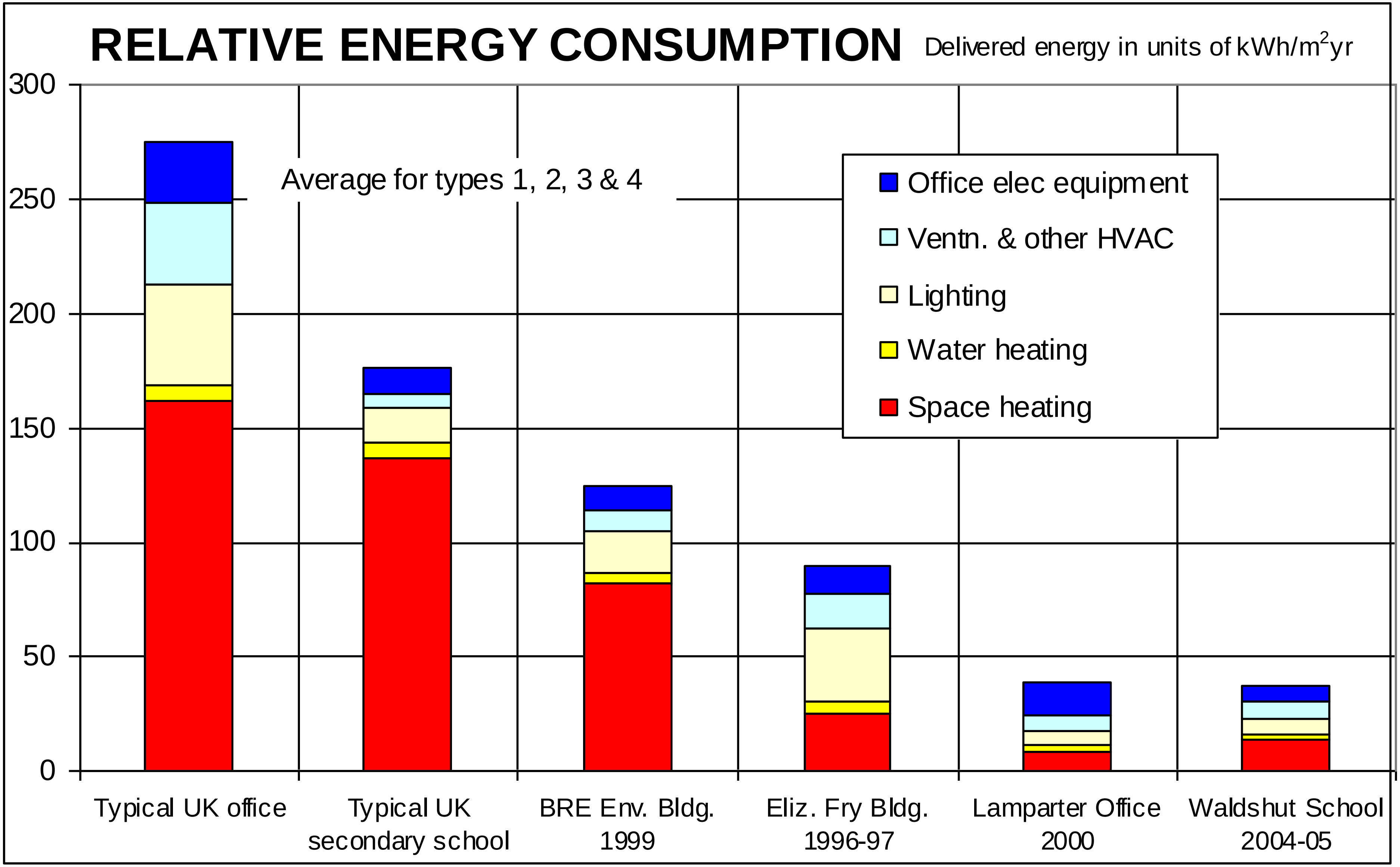
The Impact of Effective Energy Performance Standards on CO_2 Emissions.



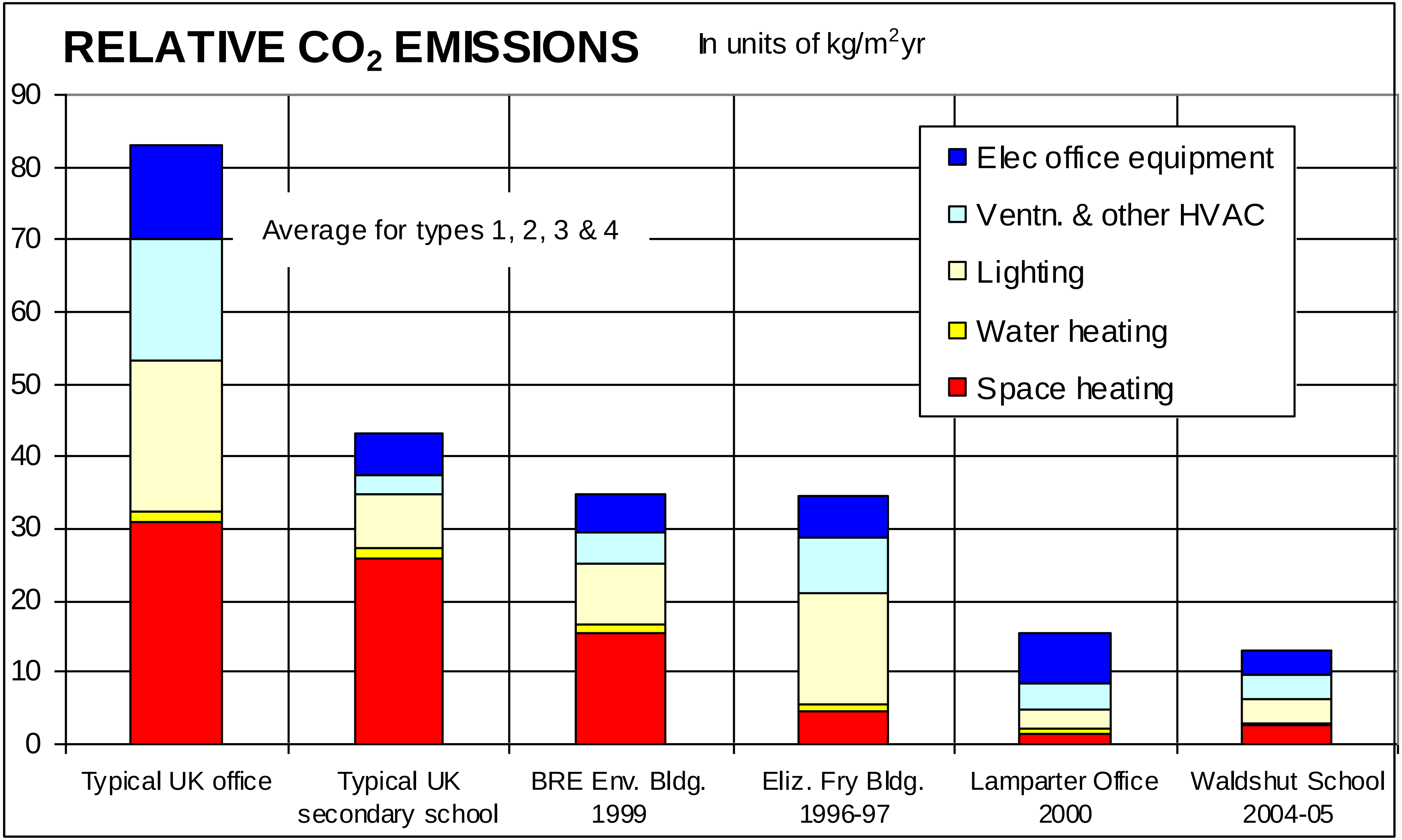
The Impact of Effective Energy Performance Standards on Peak Heat Loss.



Figures for Non-Domestic Building Energy Use



Figures for Non-Domestic Building CO_2 Emissions



Case Studies

Some Buildings of High Energy and Environmental Performance

Headquarters of the Rocky Mountain Institute *Old Snowmass, Colorado, USA* (built in 1983, photovoltaics added in 1992). Picture courtesy RMI.

The Elizabeth Fry Building.

UEA, Norwich (designed 1992-93, built 1994-95).

3,500 m^2 of floorspace on four floors. Heated by two 24 kW(t) domestic wall-hung condensing boilers. No cooling provided or needed, only automated summer night ventilation using hollow-core concrete floors. High score in PROBE user survey. Large lecture theatres in basement, seminar rooms and offices on other floors. Gas usage 25-30 kWh/m^2yr since 1997. Pictures courtesy John Miller & Partners.

A Detached House to the Passivhaus Standard.
Hohen Neudorf, Brandenburg, Germany (2004).

Picture courtesy Ralf Lenk.

The first School to the Passivhaus Standard. *Waldshut, Germany* (designed 2000 onwards, finished 2003). Picture courtesy PHI.

A Detached
100% Solar House.
Herefordshire, UK.

North roof

South roof

The project will eventually produce all its energy from solar, mainly passive gains, an experimental solar water heating system and roof-integrated photovoltaics.

/ …

The windows are imported from Canada. If such glazing is located on a south wall, it can gain more solar heat than it loses in a Welsh or southern English winter.

Energy Market and Policy Failures

Insurmountable Opportunities?

Energy Market Failures

•The UK spends over £100 billion/year on energy, slightly more than it spends on the National Health Service. Both figures have risen since 1998.

•Energy users are often unmotivated or unable to find the necessary information on energy efficiency. It can be too much trouble and effort for a person or small organisation.

•Except for activities such as cement, steel and aluminium manufacture, and for commercial airlines in the periods 1973-81 and 2007-8, energy has been a small fraction of organisations' input costs.

•Anyone who runs a business or works for a government department is faced with apparently established and mature suppliers of gas, oil or electricity, but they don't supply energy efficiency on an equal basis and some measures are forbidden or unavailable.

Energy Market Failures

The UK domestic markets for gas and electricity are each worth over £10 billion/year.

•No-one wants to buy energy *per se*. They want energy-related services; e.g., hot showers, cold drinks, warm homes, well-lit offices, mobility and access to facilities.

•Using a uniform financing basis, numerous energy efficiency measures cost “UK PLC” less in p/kWh than buying gas, oil or electricity at present prices, let alone at future prices. Where possible, costings reported in this paper employ lifecycle costing and the UK Treasury’s prescribed real rate of return.

•But end-users lack access to low-cost capital and often apply real discount rates of 25-100%/year or more, while large organisations can borrow money at real rates of 3-5%/year or less. The “social” discount rates in the USA and UK are 2-3%/yr. See; e.g., *Treasury Green Book*. Historic real rate on bank savings accounts is at most 1-2%/yr.

Energy Market Failures

Lay consumers are subject to a torrent of conflicting claims and "green-wash", which may defeat them. Some seek out professional advice, often failing to find it.

•If we wished to minimise the resource cost of CO_2 reductions, we would systematically invest in the best buys first; i.e. starting with technologies which save CO_2 for £2/tonne, not £15/tonne, and we would buy measures at £15/tonne before agreeing to buy those costing £80/tonne.

•Economists would define this as a functioning "market". The consequence of pursuing the cheaper options first is that capital and other scarce resources are efficiently-allocated.

•Investment capital in the UK is going into CO_2-saving measures in the cost range £50-100/tonne long before measures costing £2, £5 or £10/tonne have been exhausted … or even assessed!

Energy Market Failures

•UK utilities are weakly-regulated. Any consumer can buy his/her electricity or gas from the six major suppliers, or from other minor ones. No company has a defined customer service territory.

•*De facto*, utilities earn more profits if energy sales grow at the expense of their competitors; i.e., if they emit more CO_2.

•Not surprisingly, despite “energy efficiency commitments” et al *ad nauseam*, sales rise.

•Instead of paying companies to emit more CO_2, why not pay them and their shareholders to do what we want; i.e., to emit *less* CO_2, and to achieve this via the cheapest means, whether these be renewables, energy efficiency and/or a mixture?

How to Overcome Them

•California made energy efficiency a strategic alternative to new energy supplies in c.1990. It ordered the state's regulated monopoly utilities, SCE, SDGE, SCG and PG&E, to invest in energy efficiency wherever this cost no more than new fossil fuel power stations or new gas supplies; i.e., nearly always. Many new fossil-fuelled power plants were cancelled.

•**The skill, knowledge and experience hitherto used to increase sales were now directed instead at marketing "negawatts".**

•The learning process was severely disrupted by the prevailing philosophy of "de-regulation", which the US federal government encouraged from about 1996 to 2004.

•Attempts at "re-regulation" began in the mid-2000s. But after a decade of de-regulation, much momentum in least-cost planning was lost and new fossil-fuelled power stations are being ordered.

How to Overcome Them

•California has wholesale competition; e.g. between power generators, but each franchisee has a monopoly on sales of gas and electricity in its service territory. Prices are regulated by the state public utility commission as they were before 1996.

•All 50 US states are different and each public utility commission sets its own policy. But as a rule, investor-owned utilities are *much* more closely-regulated and -controlled than their UK counterparts. The rate of return on capital, allowable expenses and price per kWh are usually all controlled and foreign ownership would not normally be allowed.

•The basis for utility regulation is that the pipes or wires in the ground - but nowadays, not always the power plants - are a *natural monopoly*. Utility companies are seen as long-term, low-risk investments and can borrow more cheaply - Wall Street permitting! - than most of the private sector.

How to Overcome Them

•There have been very few US utility failures in the last 50 years. A major one was Public Service Co. of New Hampshire, in 1988. It suffered major nuclear cost overruns and was declared bankrupt after being sued by creditors for unpaid bills.

•In 2008, the American Council for an Energy-Efficient Economy awarded prizes for the ten best utility energy efficiency programs to California, Vermont, Oregon, Connecticut, New York, Washington state, Minnesota, Massachusetts, Wisconsin and New Jersey. New York state's target is for per capita electricity consumption to be 15% lower in 2015 than in 2008.

•Municipally-owned utilities in a state - California has five - have tended to pursue similar investments.

•Despite very stop-go policies with its private utilities, California's per capita electricity consumption is the same as it was in 1975, despite 33 years of economic growth.

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