Technology Strategy Board

Driving Innovation

RETROFIT FOR THE FUTURE

The Energy and CO_2 Targets

Presented by

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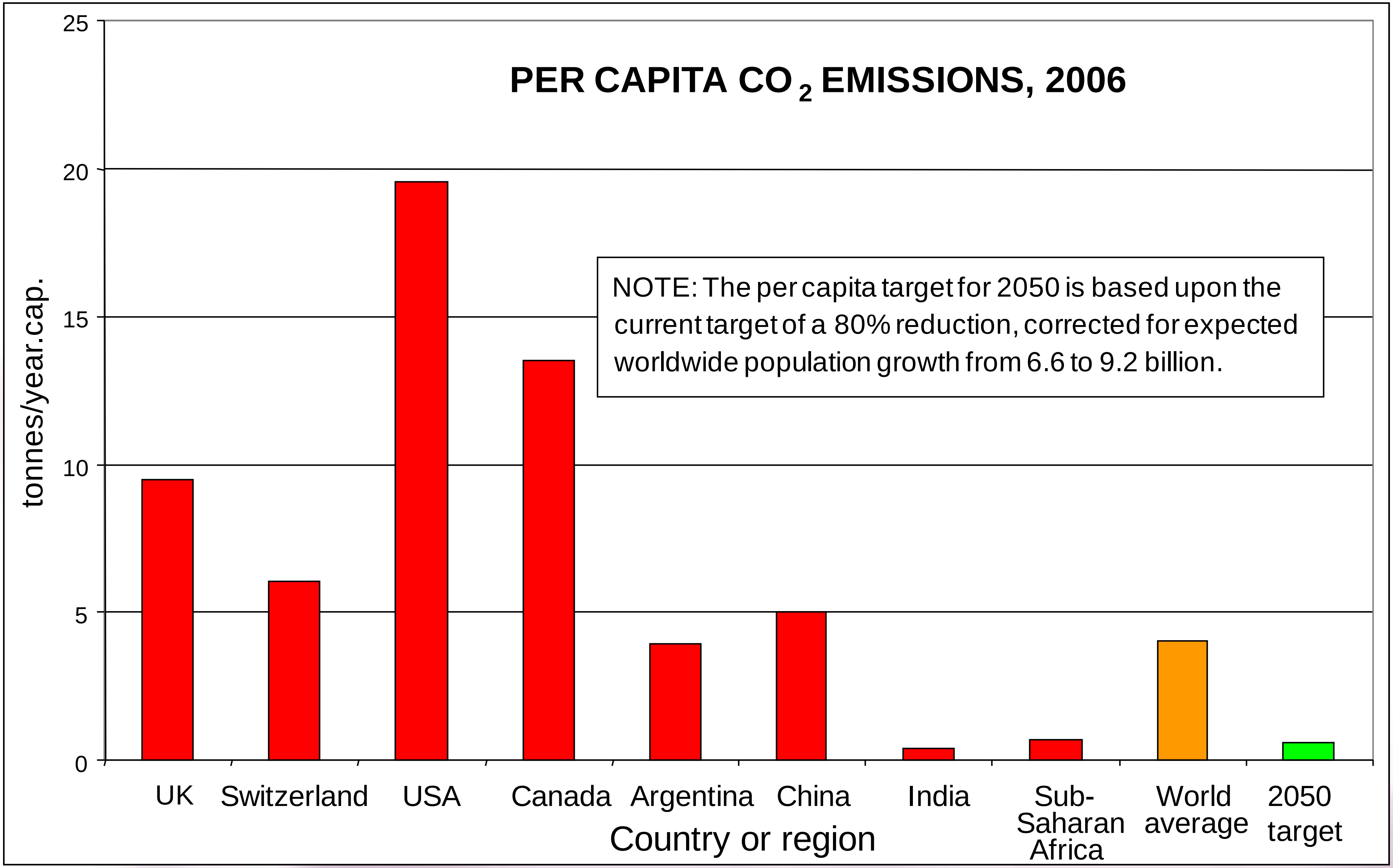
The Big Picture


PER CAPITA CO 2 EMISSIONS, 2006
NOTE: The per capita target for 2050 is based upon the current target of a 80% reduction, corrected for expected worldwide population growth from 6.6 to 9.2 billion.
tonnes/year.cap.
25
20
15
10
5
0
UK
Switzerland
USA
Canada
Argentina
China
India
Sub-Saharan Africa
World average
2050 target
Country or region

The UK

Energy and CO_2 Trends Since 1970

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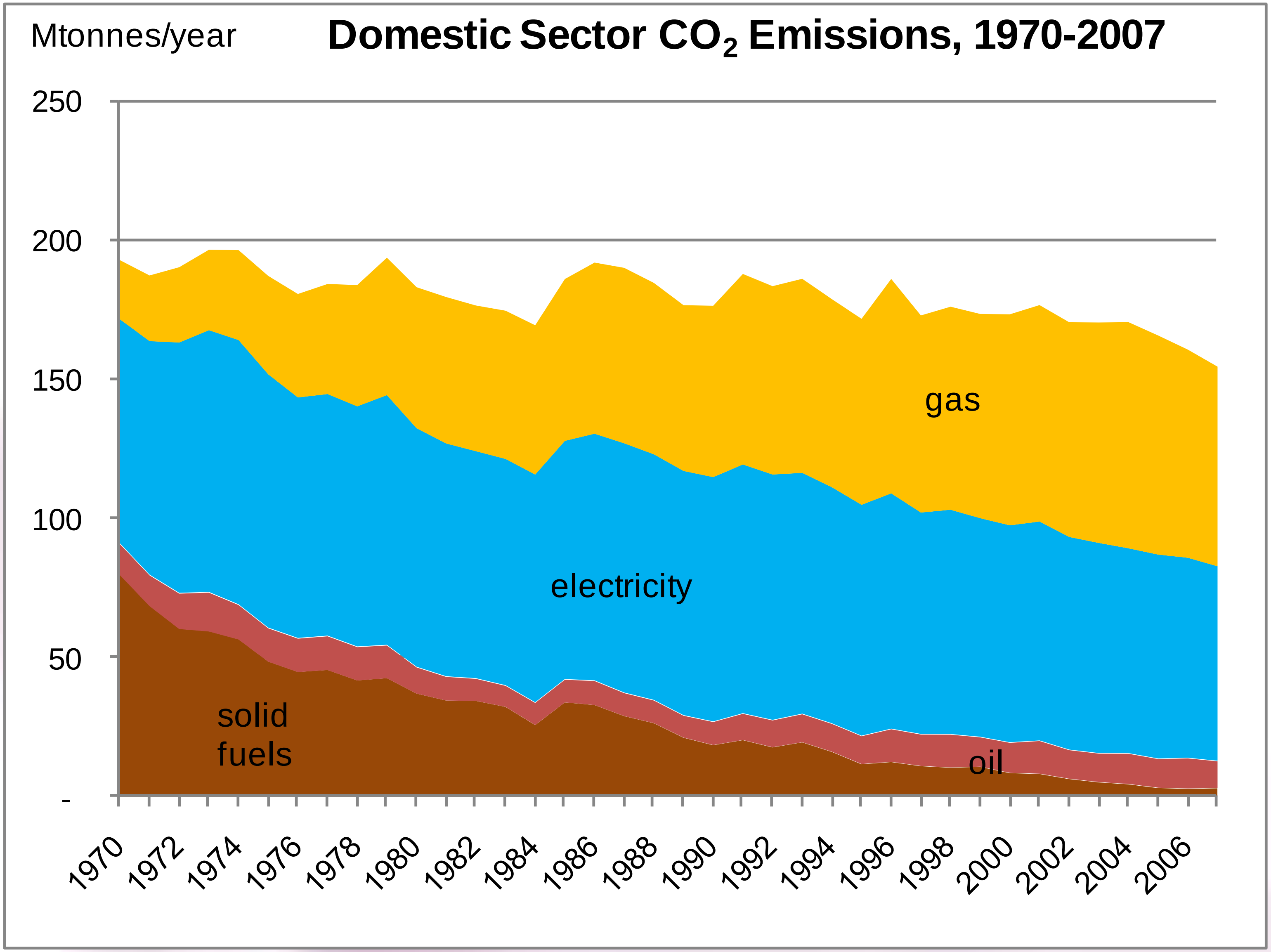
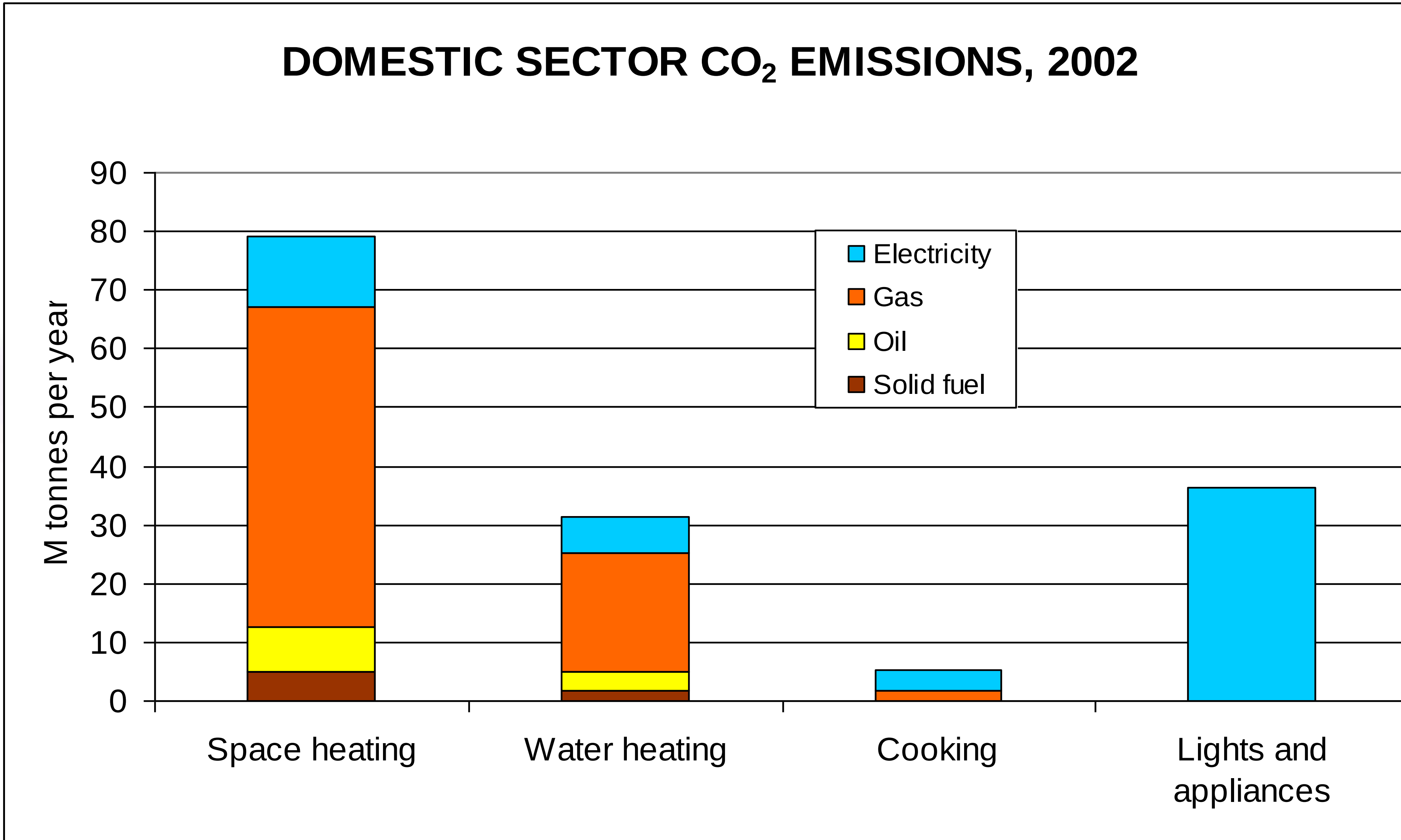
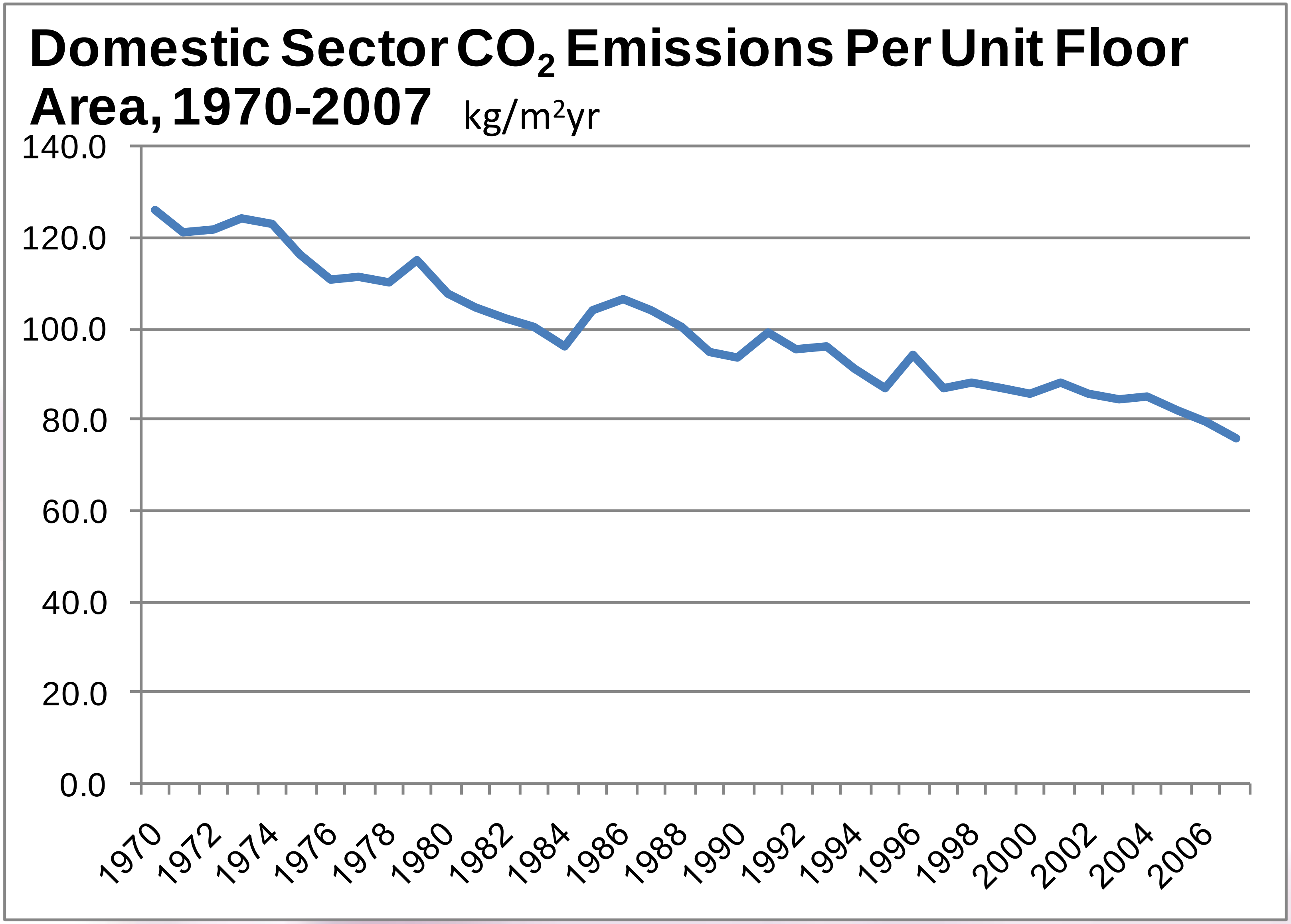
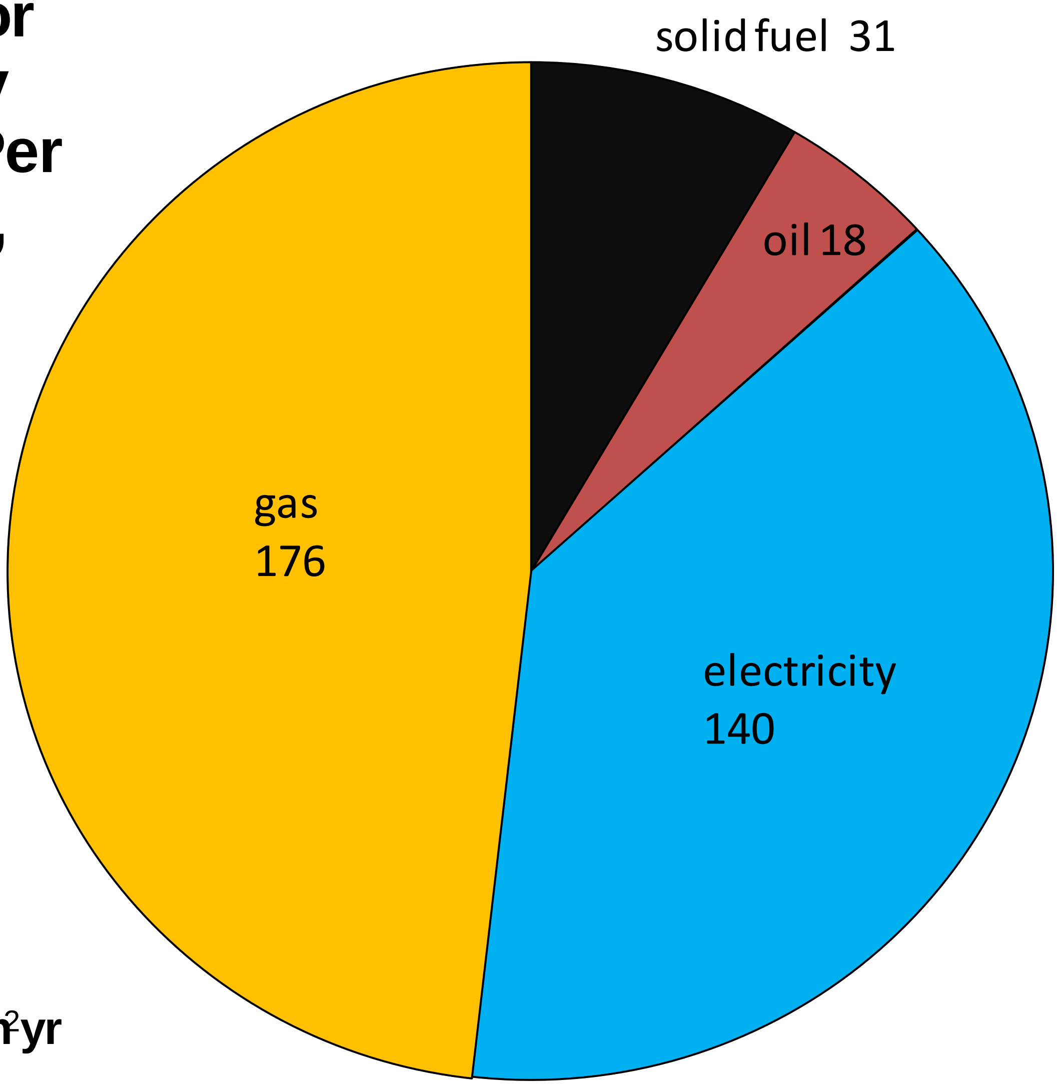



DOMESTIC SECTOR CO2 EMISSIONS, 2002
M tonnes per year
90
80
70
60
50
40
30
20
10
0
Electricity
Gas
Oil
Solid fuel
Space heating
Water heating
Cooking
Lights and appliances


Domestic Sector CO_2 Emissions Per Unit Floor Area, 1970-2007 kg/m²yr
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006

Domestic Sector Primary Energy Consumption Per Unit Floor Area, Average c.1990



total = 365 kWh/m²yr

This Competition

The Energy and CO_2 Targets

The Energy and CO_2 Targets

CO_2 emissions down 80% from 97 to 20 kg/m^2.yr. Primary energy consumption down 75% from 365 to 90 kWh/m^2.yr. A whole-house target covering space & water heating, HVAC pumps, fans and controls, cooking, lighting and appliances. Same target applies to detached, semi-detached and mid-terraced houses. Without the energy target, scarce but in theory low-CO_2 energy resources could be wastefully used

Emissions & energy use are calculated using Derby (SAP) or Manchester weather data (PHPP) and standard occupancy conditions as appropriate to future low-energy dwellings. Corrections needed when monitoring.

Uses today's emissions coefficients; see SAP-2009 and guidance for using PHPP. Emissions will fall further if energy carriers such as gas, hot water or electricity are "decarbonised".

Flexibility

The 80/75% CO_2 & primary energy targets are presented as a challenge for teams to meet if they feel able to do so on their particular project.

Teams can meet more ambitious targets than 80/75% if they consider this to be feasible in their individual circumstances, bearing in mind the typically high cost of additional measures in terms of £ per tonne saved.

Teams can choose to meet less ambitious targets if they consider their situation to be abnormally restrictive. See; e.g., the factors listed on the next slides.

Proposals will be assessed in the light of the projected average cost of a project, measured in £ per tonne saved, the percent CO_2 saving and the cost of the most expensive measures in £/tonne.

Energy & CO_2 Targets: Some Practical Restrictions

The application of some technologies may be restricted if a dwelling is legally-protected and/or is located in a designated area:

Listed Grade I, II* and II buildings (England)

Conservation Areas

Green Belts (about 11% of England and Wales)

Areas of Outstanding Natural Beauty (18% of England and Wales)

National Parks (7% of England, 20% of Wales and 7% of Scotland)

Sites of Special Scientific Interest

Scheduled Ancient Monuments

Energy & CO_2 Targets: Some Other Restrictions

Some technologies face restrictions over where they could be applied. For instance:

Ground source electric heat pumps could significantly cool the ground if large numbers were used in urban/dense suburban areas, setting in effect an upper limit to heat load density.

Heat mains are not feasible in low-density areas. In any case this competition is only able to fund the marginal costs of extending to extra house(s) a DH scheme which already exists or is being constructed.

Thick external wall insulation does not appear feasible in areas where its bulk could obstruct pavements, footpaths, etc. External insulation of a gable wall may not be feasible if the wall is on the property boundary.

Feasibility of the Energy and CO_2 Targets

How Low Can We Go?

Energy & CO_2 Targets: Feasibility

Two particular dwellings were modelled using PHPP to explore the feasibility of a 80% CO_2 reduction and a 75% primary energy reduction:

1. A suburban or urban semi-detached solid-walled house
2. A rural detached cavity-walled bungalow with space available for increasing the footprint significantly via added wall and roof insulation

Dwelling 2, with a very high surface area-to-volume ratio, is particularly challenging. The main purpose was to evaluate whether such reductions could be feasible with low or modest cost measures, without recourse to more costly technologies.

Energy & CO_2 Targets
Summary of Measures Examined

Urban solid-walled semi.

Gas-fired engine CHP, solar in summer

75 mm external insulation, phenolic foam or equiv. internally

Top-up loft insulation to 250 mm

Ar-filled low-e DG windows

Solid ground floor carpeted

New air permeability = 3 m/h @ 50 Pa, as per Swedish Bldg. Code 1978

MEV

New space heat load 78 kWh/m^{2}yr.

CFLs, A++ and hot-fill appliances

Rural detached bungalow

“Passivhaus” retrofit, incl. MVHR & PH-certified windows or similar in insulated frames & air permeability = 0.75 m/h @ 50 Pa. New space heat load 23 kWh/m^{2}yr.

LPG cond. boiler plus active solar and LPG cooking ***or*** elec. Grd source heat pump, COP=3.3 and elec. induction cooking

CFLs, A++ and hot-fill appliances

NOTE: Summaries only and presented as hypothetical cases. See briefing doc.

Urban 80 m^2 semi-detached house

Gets very close to the primary energy target of 90 kWh/m^2yr.
Achieves the CO_2 target of 20 kg/m^2yr

	Summary: roof and wall insulation, horiz. perimeter floor insulation under external paving, low-e double-glazed windows, air permeability 3 m/h @ 50 Pa, gas-fired CHP supplemented by solar to give 30% of annual heat consumption and heat storage replacing peak boilers, electric induction cooking, MEV, hot -fill major appliances, clothes dried in ventilation system.					
Energy Use	Delivered Energy kWh/m^2yr		Primary Energy kWh/m^2yr		CO2 Emissions kg/m^2yr	
	Heat	Electricity	Heat	Electricity	Heat	Electricity
Space heating	78		29		5.8	
Water heating	19		7		1.4	
Total	*97*		*36*		*7.2*	
HVAC fans and pumps		2.1		6		1.3
Lights, appliances and cooking		18.3		51		11.2
Total		*20.4*		*57*		*12.5*
TOTAL	**117**		**93**		**19.7**	

Rural 75 m^2 detached bungalow

(a) Gets extremely close to the primary energy target of 90 kWh/m^2yr and to the CO_2 target of 20 kg/m^2yr

(b) Gets close to the primary energy target of 90 kWh/m^2yr and very close to the CO_2 target of 20 kg/m^2yr

System (a).	80% solar water heating plus LPG condensing boiler for rest of annual space and water heat demand, LPG cooking, 90% efficient MVHR system, hot-fill major appliances, clothes dried in ventilation system.						
Energy Use	Delivered Energy kWh/m^2yr			Primary Energy kWh/m^2yr		CO2 Emissions kg/m^2yr	
	LPG	Solar heat	Electricity	LPG	Electricity	LPG	Electricity
Space heating	24			27		6.2	
Water heating	6			7		1.5	
Total	*30*			*34*		*7.7*	
HVAC fans and pumps			3.9		10.9		2.4
Lights and appliances			15.1		42		9.2
Cooking	4			4		1.0	
Total	*34*		*19*	*38*	*53*	*8.6*	*11.6*
TOTAL	**53**			**91**		**20.2**	

System (b).	Using an electric ground source heat pump with overall COP = 3.3 for space and water heating. Also uses electric cooking.		
Energy Use	Delivered Energy kWh/m^2yr	Primary Energy kWh/m^2yr	CO2 Emissions kg/m^2yr
	Electricity		
Space heating	7.1	19.7	4.3
Water heating	6.7	18.6	4.1
Total elec for heat	*13.8*	*38.3*	*8.4*
HVAC fans and pumps	2.5	6.9	1.5
Lights, appliances & cooking	18.3	50.8	11.2
Total elec for other uses	*20.8*	*57.8*	*12.7*
TOTAL	**31.2**	**97.3**	**21.1**

Some Technologies In Use

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Pictures courtesy Danish Board of District Heating, www.logstor.com, www.pipesystems.com and www.isoplus.de

CHP, Denmark

Left - transmission line from plant to nearby town

Centre right - PEX twin pipe

Solar district heating, Sweden

Top right - 10,000 m^2 collectors at Kungalv, Gothenburg

Geothermal district heating, Italy

Bottom right - extension to a distribution system

Pictures courtesy John Cantor Heat Pumps Ltd.

Ground source heat pumps

Below left and top right -10 kW(t) spring source system, Wales with a 700 ltr buffer store.

Bottom right - ground coil under construction, Germany.

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

Energy-efficient "cold" appliances

Below left: energy-efficient 259 litre larder refrigerator, USA, 76 kWh/yr. Plus optional external condenser.

Below right: A++ 195 litre chest freezer, Europe, 113 kWh/yr

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

Energy & CO_2 Targets: Preliminary Conclusion

From modelling several dwelling types, it appears that the target could often be met or approached by combining:

1. Fabric thermal improvements
2. Very energy-efficient lights/appliances
3. Very energy-efficient HVAC fans/pumps
4. More efficient supply of low-temperature heat using CHP or elec. heat pumps as appropriate

If fabric improvements are constrained, the low-temperature heat supply must be extremely low-carbon. Otherwise extra measures such as PV &/or solar thermal would be needed.