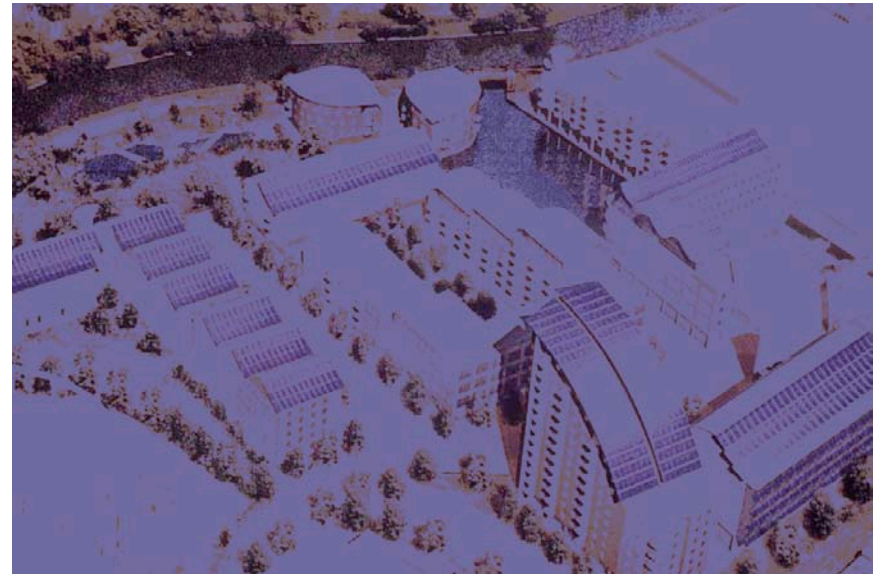


# A review of initiatives to reduce energy-related CO<sub>2</sub> emissions from the city of Oxford: Past, Present and Future



**ECEEE 2007 Summer Study**  
4-9 June 2007, La Colle sur Loup, France  
**Dr Rajat Gupta**, [rgupta@brookes.ac.uk](mailto:rgupta@brookes.ac.uk)

## Structure of presentation

**City of Oxford, United Kingdom: some facts**

**Cities and CO<sub>2</sub> emissions: need for action**

**Oxford Solar Initiative**

Feasibility study

Implementation phase

**DECoRuM® model: GIS-based carbon-counting and carbon-reduction model**

**Oxford Climate Change Action Plan**

Assessing baseline CO<sub>2</sub> emissions

Targets and action for Oxford

Implementing the Action Plan recommendations



## City of Oxford, United Kingdom

- Oxford is a city in Oxfordshire, UK. (Region: south-east England).
- Centre of academic excellence
- Population: 145,100 (mid-2004).
- Oxford is one of 24 local authorities to become part of the UK Councils for Climate Protection (CCP) Pilot Programme.
- Oxford hosted the 2<sup>nd</sup> International Solar Cities Conference in April 2006.

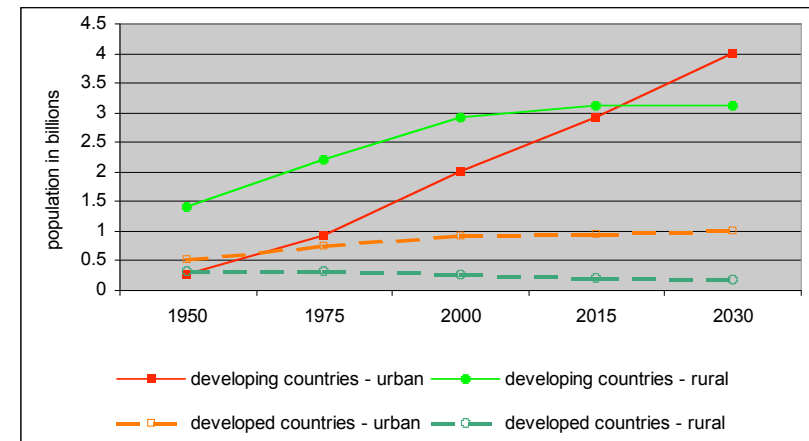


# Cities and CO<sub>2</sub> emissions: need for action



## Cities and CO<sub>2</sub> emissions: key facts

- Cities account for **75%** of total global energy demand and produce **80%** of our CO<sub>2</sub> emissions driving climate change.
- Half the global population lives in cities: three-quarters of the human population to become city dwellers by 2050.



<http://www.infoforhealth.org/pr>



## Cities and CO<sub>2</sub> emissions: key facts

However Cities have great potential to make a difference: form the very framework for development.



In fact the city of the future is just as much about providing energy as it is about consuming it.



# Oxford Solar Initiative: Strategies and programmes

[www.oxfordsolar.org.uk](http://www.oxfordsolar.org.uk)

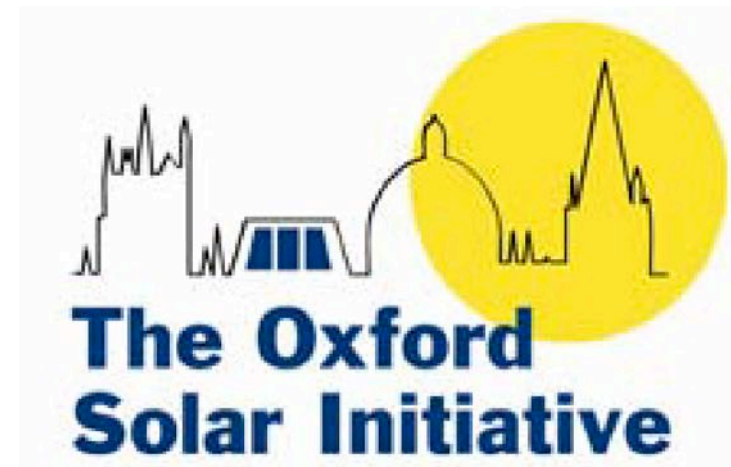




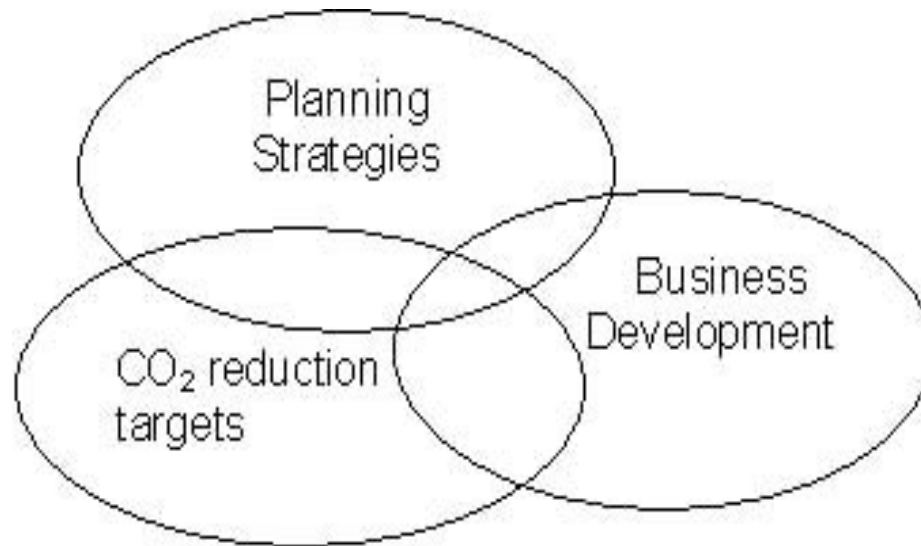
## Objectives

**To find the best ways to introduce solar energy technologies (SET) and the rational use of energy (RUE) in Oxford.**

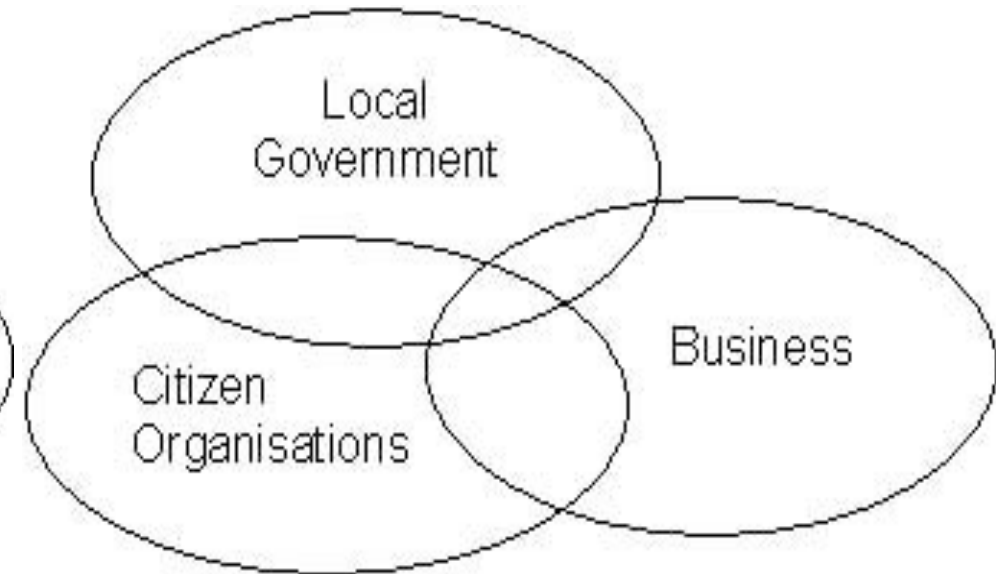
- Create Targets: 10% of all houses in Oxford to have solar systems by the year 2010
- Capacity build the local government to reduce CO<sub>2</sub> emissions.
- Establish strategic alliances to make these reductions happen.
- Initiate and implement a solar campaign.



## Focus Areas



## Actors involved



Success of Oxford Solar Initiative depends upon a community-based collaborative approach among all involved parties.

Creation of a local 'Solar Oxford Partnership': Oxford Brookes University, Oxford City Council, and leading UK consultants.



# Feasibility study

A survey conducted to provide evidence for the likely success of the proposed **implementation** phase.

**HOME ENERGY SURVEY: SOLAR POWER QUESTIONS**

In order to receive the free low energy light bulb, please return the questionnaires before **Monday 30<sup>th</sup> December 2002**

**ENVIRONMENTAL AWARENESS**

I am concerned about climate change due to the greenhouse effect/global warming (such as storms, floods, temperature change). Agree strongly  Agree  Disagree  Disagree strongly  Neither

I think most people could take some action to help prevent the worst impacts of climate change. Agree strongly  Agree  Disagree  Disagree strongly  Neither

I would consider taking action on Energy efficiency (using energy efficient products and having a well insulated home). Agree strongly  Agree  Disagree  Disagree strongly  Neither

I would consider taking action on Renewable energy [having renewable energy generation in the home (such as solar panels) / buying green electricity from their electricity company]. Agree strongly  Agree  Disagree  Disagree strongly  Neither

I have already taken personal action in one or more of the above fields. Yes  No  Don't know

If 'Yes' which areas.

Are there things preventing you from taking action on energy efficiency or renewable energy? Yes  No  Don't know

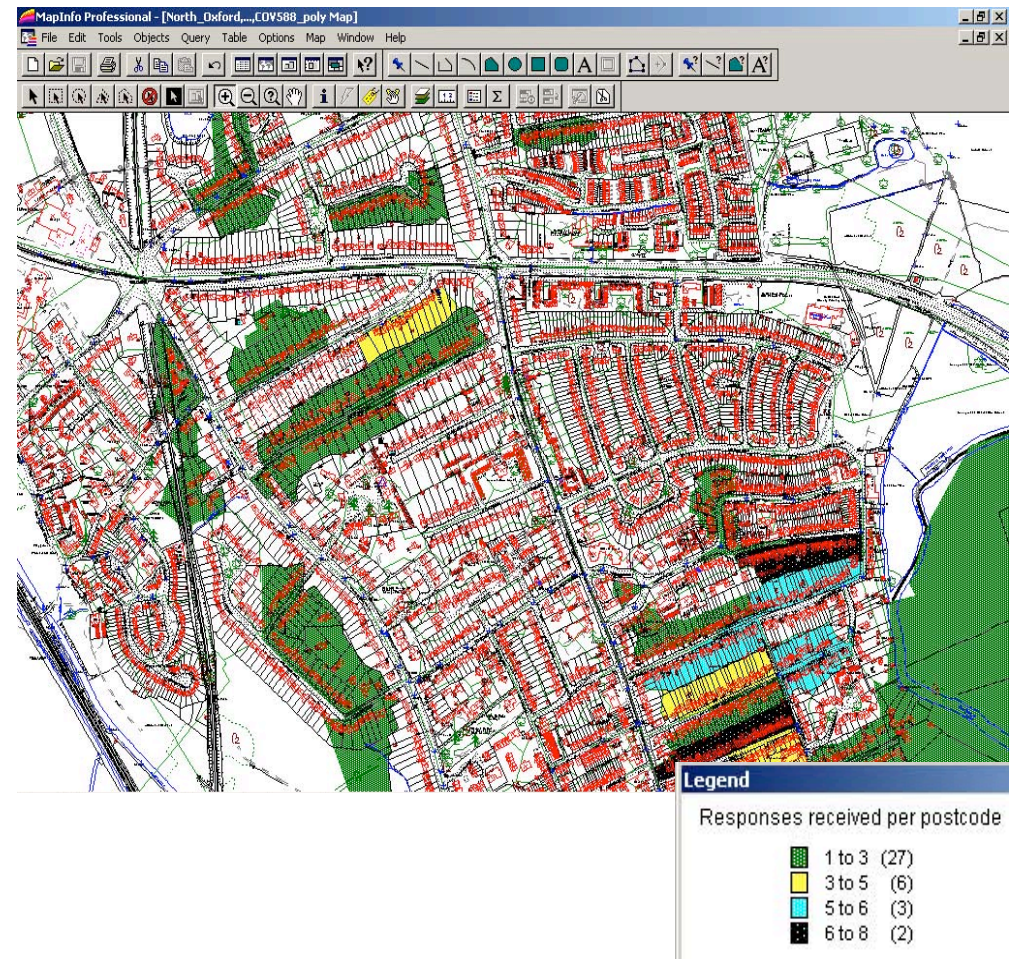
If 'Yes' please make brief comments.



## Feasibility study : main findings

600 questionnaires were distributed and 100 returns were received.

65% of respondents expressed a strong interest in both solar and energy efficiency measures with 12% of these willing to invest up to £2,500 and 63% between £1,000 and £1,500.





The campaign is initiated with two pilot projects

# Oxford Solar Campaign

## 1. The Solar Street: Harpes Road, Oxford

A street of energy efficient houses equipped with solar hot water systems, passive solar sunspaces and PV systems with a power gate to a single point of connection to grid, sized to qualify for ROC (Renewable Obligation Certificate).





**2. The Solar Suburb: Wolvercote, Oxford**





# Oxford Solar Initiative: public events organised

**Public launch**

July 2003

**Oxford Solar Fair**

October 2003

**Oxford Solar debate:**

September 2004

Does Oxford really  
have a solar future?

**Architects & Builders**

March 2005

**Seminar**



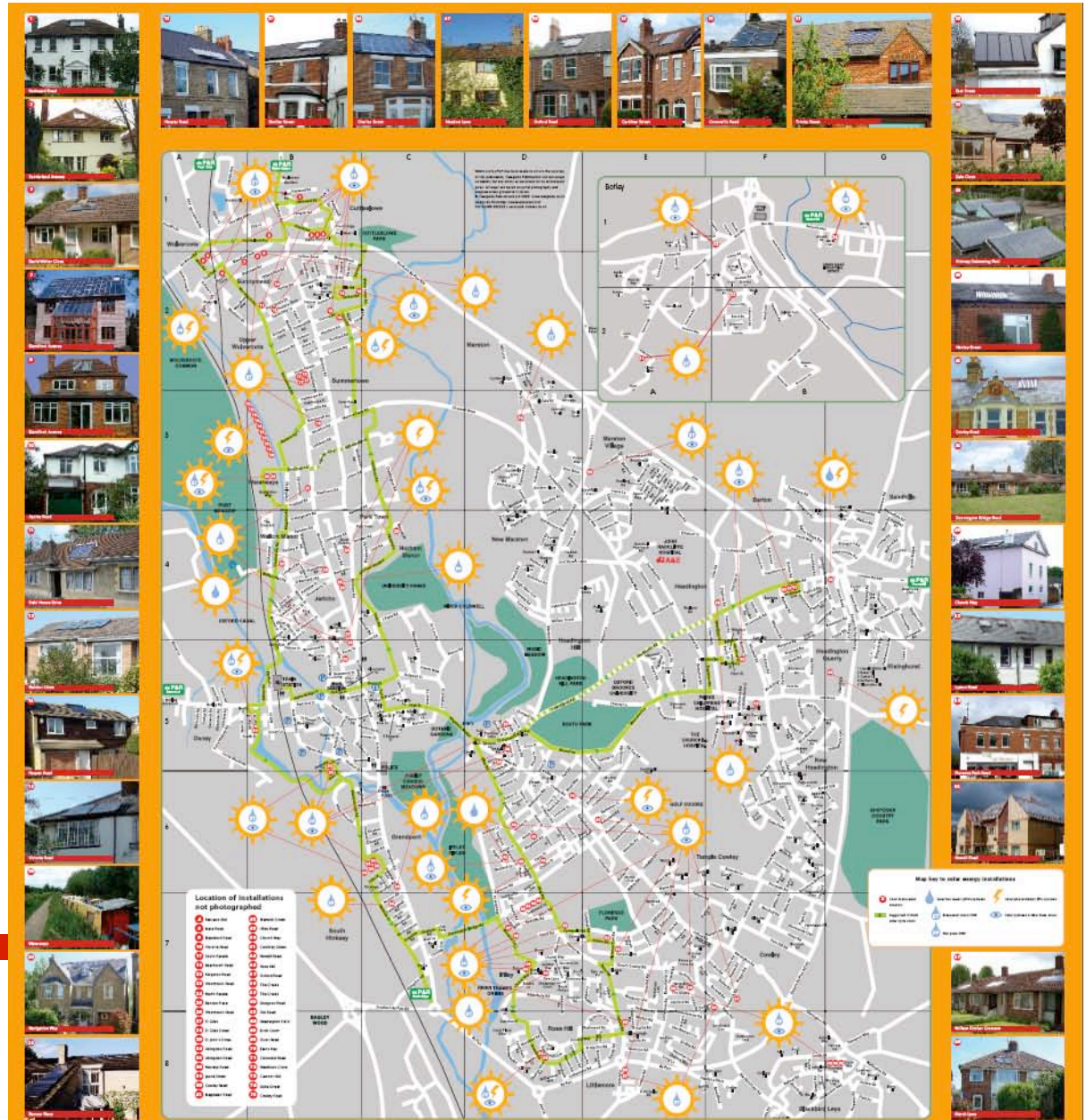
Public launch of OSI-12 July 2003



# Oxford Solar Initiative: Implementation phase

So far OSI has facilitated the installation of **80** active solar systems, over **450** energy efficiency measures and 3,000 low energy light bulbs (CFLs).

Developed an Oxford Solar Map.





**DECoRuM<sup>®</sup>:  
A GIS-based carbon-counting model**

**[www.decorum-model.org.uk](http://www.decorum-model.org.uk)**



## A GIS-based energy and emissions model: DECoRuM

Capability to estimate baseline CO<sub>2</sub> emissions from individual dwellings using a locally-relevant approach, and well-established methodologies to ensure credibility.

Aggregates these to an urban scale – street, district or city level.

This enables it to evaluate the potential for domestic CO<sub>2</sub> emission reductions from a whole range of measures on both the demand and supply sides of energy.

An additional and unique feature of assessing the cost-benefits of individual CO<sub>2</sub> reduction measures and putting a financial cost to CO<sub>2</sub> emission reduction.

A mapping tool for representing domestic CO<sub>2</sub> emissions and reductions.

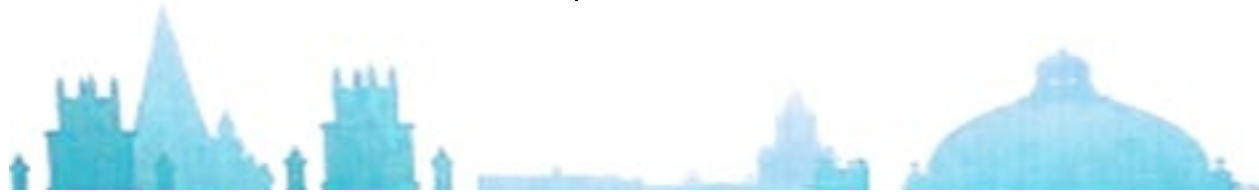


# Core methodologies used in DECoRuM

Methodology used	Details of methodology	Outputs
<b>Building Research Establishment Domestic Energy Model (BREDEM) -12</b>	<p>Industry standard to calculate energy use for different dwelling types in UK.</p> <p>Estimates annual energy requirement for space heating, water heating, lights &amp; appliances and cooking</p> <p>Requires 95 input parameters</p>	<p>Annual energy use (GJ/year)</p> <p>Annual CO<sub>2</sub> emissions (kg/year)</p> <p>Running costs (£s/year)</p>
<b>Standard Assessment Procedure (SAP) 2001</b>	<p>Government's recommended system for home energy rating based on energy costs for space and water heating.</p>	<p>SAP rating (scale of 1 - 120)</p> <p>Carbon Index (scale of 1 - 10)</p>
<b>Net annual cost method</b>	<p>Used by BRE to assess cost-effectiveness of energy efficiency measures.</p>	<p>Net annual cost/tonne of CO<sub>2</sub> saved</p>

Underlying physically-based energy models: BREDEM -12 linked to SAP 2001.

Cost-benefit analysis approach

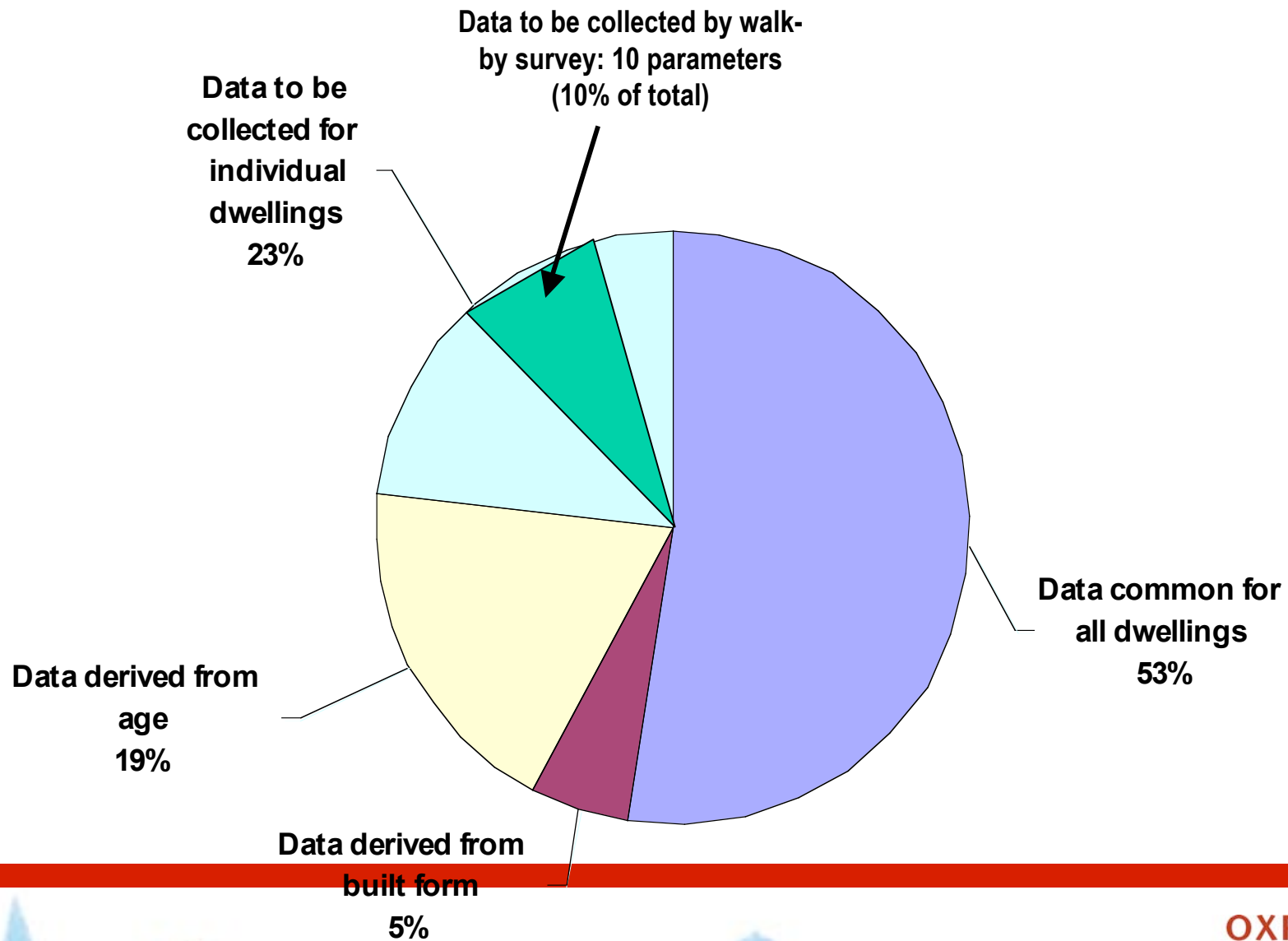


## Outputs from DECoRuM

	Outputs	Expressed as
<b>Energy use</b>	Total annual energy use	kWh/year kWh/m <sup>2</sup> /year
	Annual energy use by end use	kWh/year
<b>CO<sub>2</sub> emissions</b>	Total annual CO <sub>2</sub> emissions	kgCO <sub>2</sub> /year kgCO <sub>2</sub> /m <sup>2</sup> /year
	Annual CO <sub>2</sub> emissions by end use	kgCO <sub>2</sub> /year
<b>Fuel costs</b>	Total annual running (fuel) costs	£/year
	Annual running (fuel) costs by end use	£/year
<b>Energy rating</b>	SAP rating	Scale of 1 to 120
	Carbon Index	Scale of 1 to 10



# Data reduction in DECoRuM

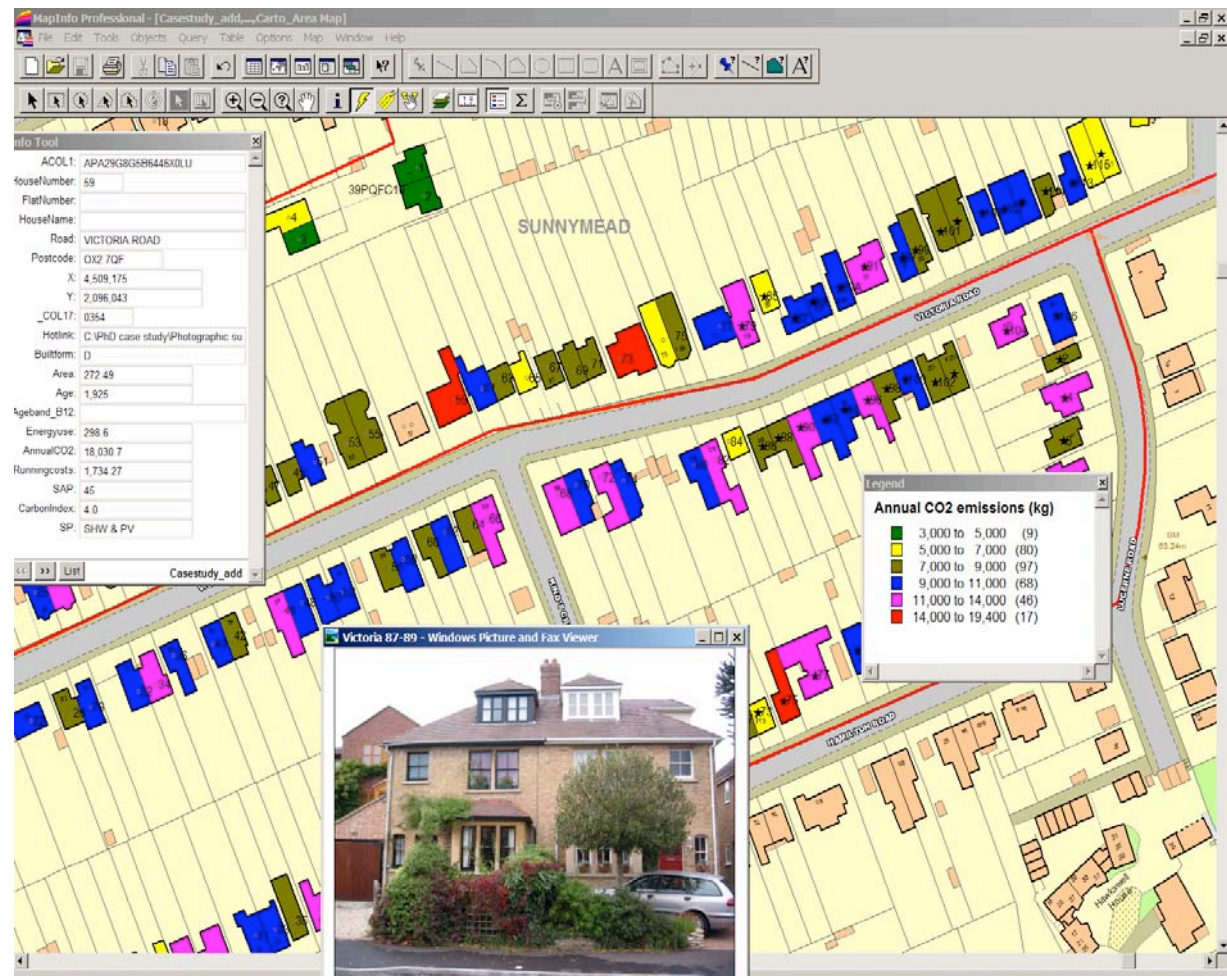


# A GIS-based energy and emissions model: DECoRuM

Provides the scientific-based platform to estimate baseline emissions of individual dwellings as well as on an urban scale.

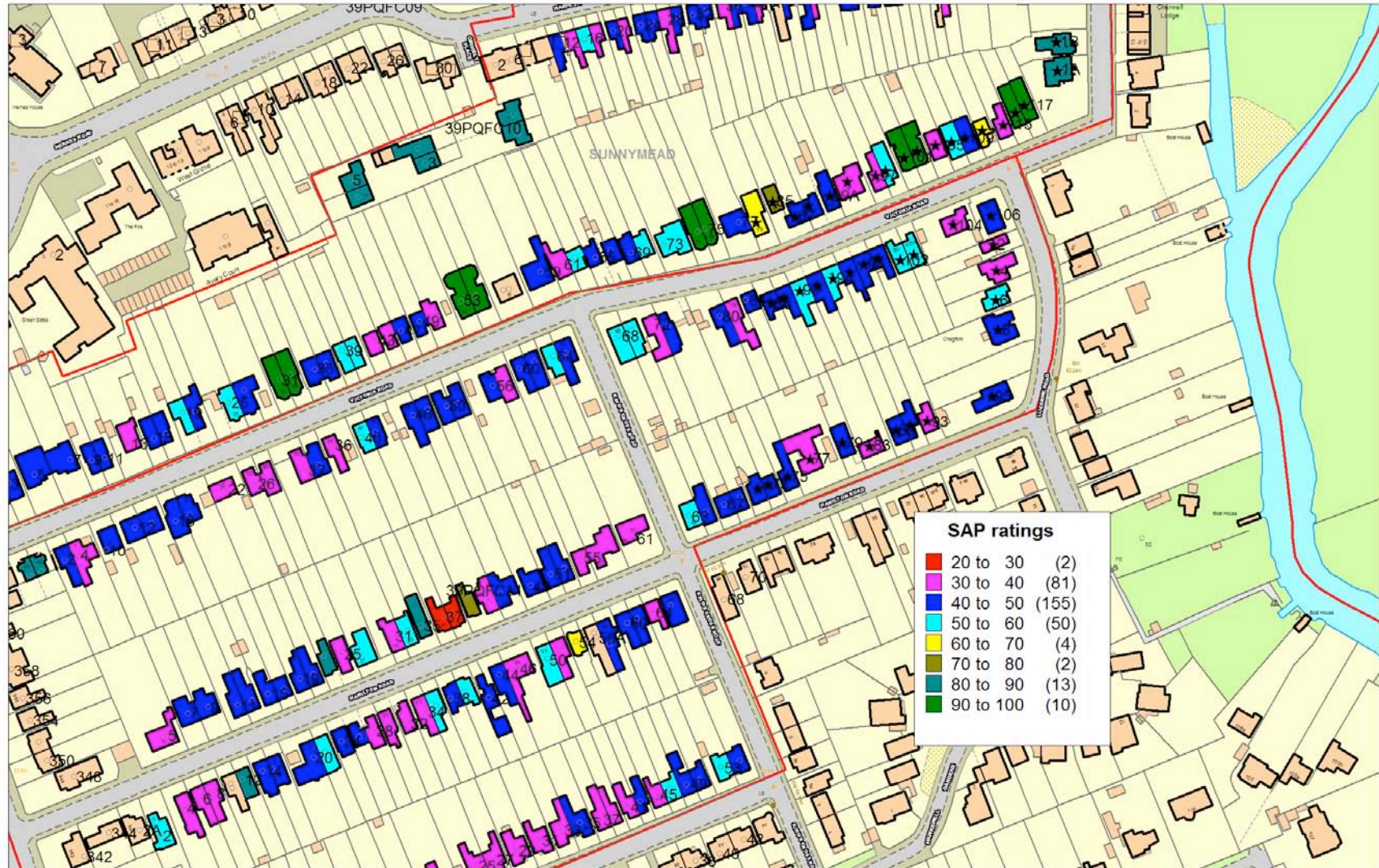
Predicts resulting CO<sub>2</sub> savings and cost-benefits of deploying energy efficiency measures and renewables in households.

A tool to track progress of take-up of measures.





# A GIS-based energy and emissions model: DECoRuM



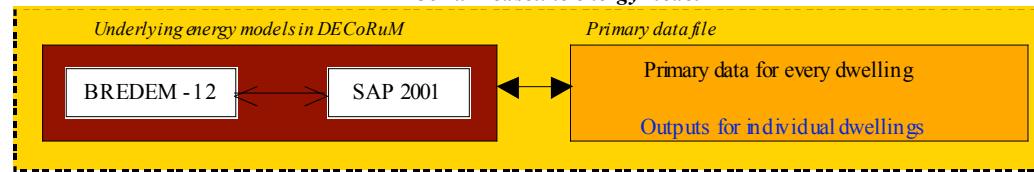


# A GIS-based energy and emissions model: DECoRuM

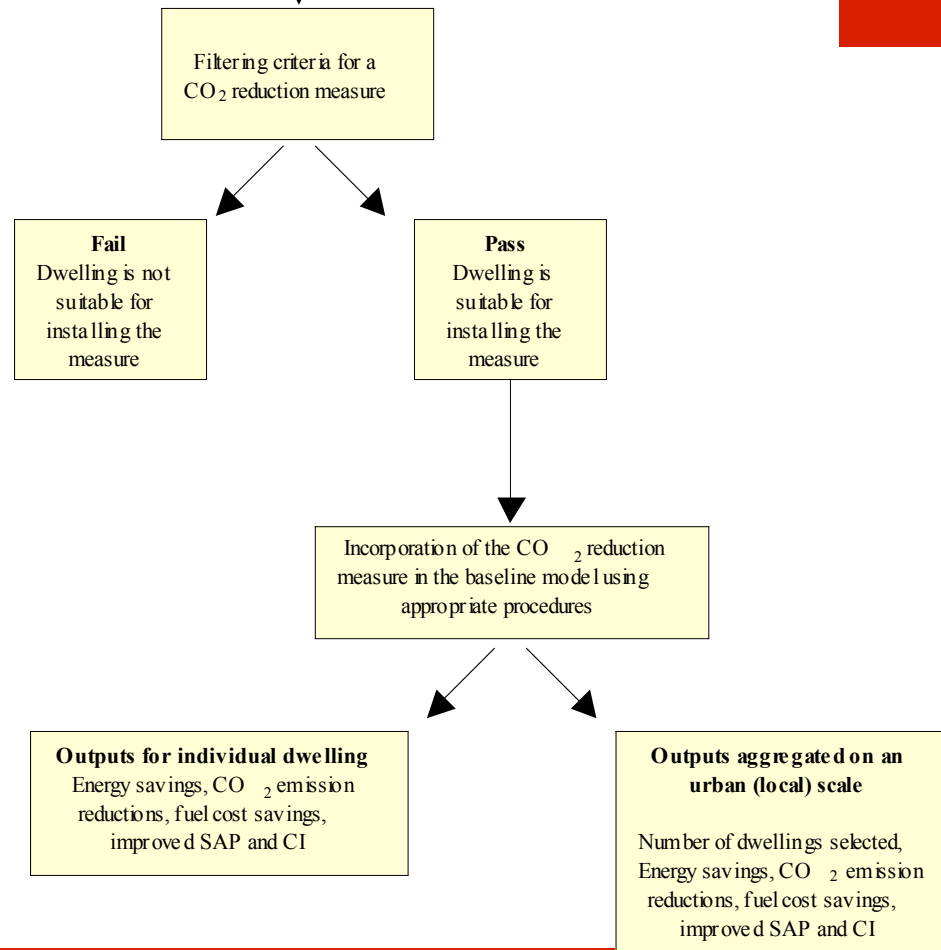




*DECoRuM baseline energymodel*



**DECoRuM CO<sub>2</sub> reduction model**



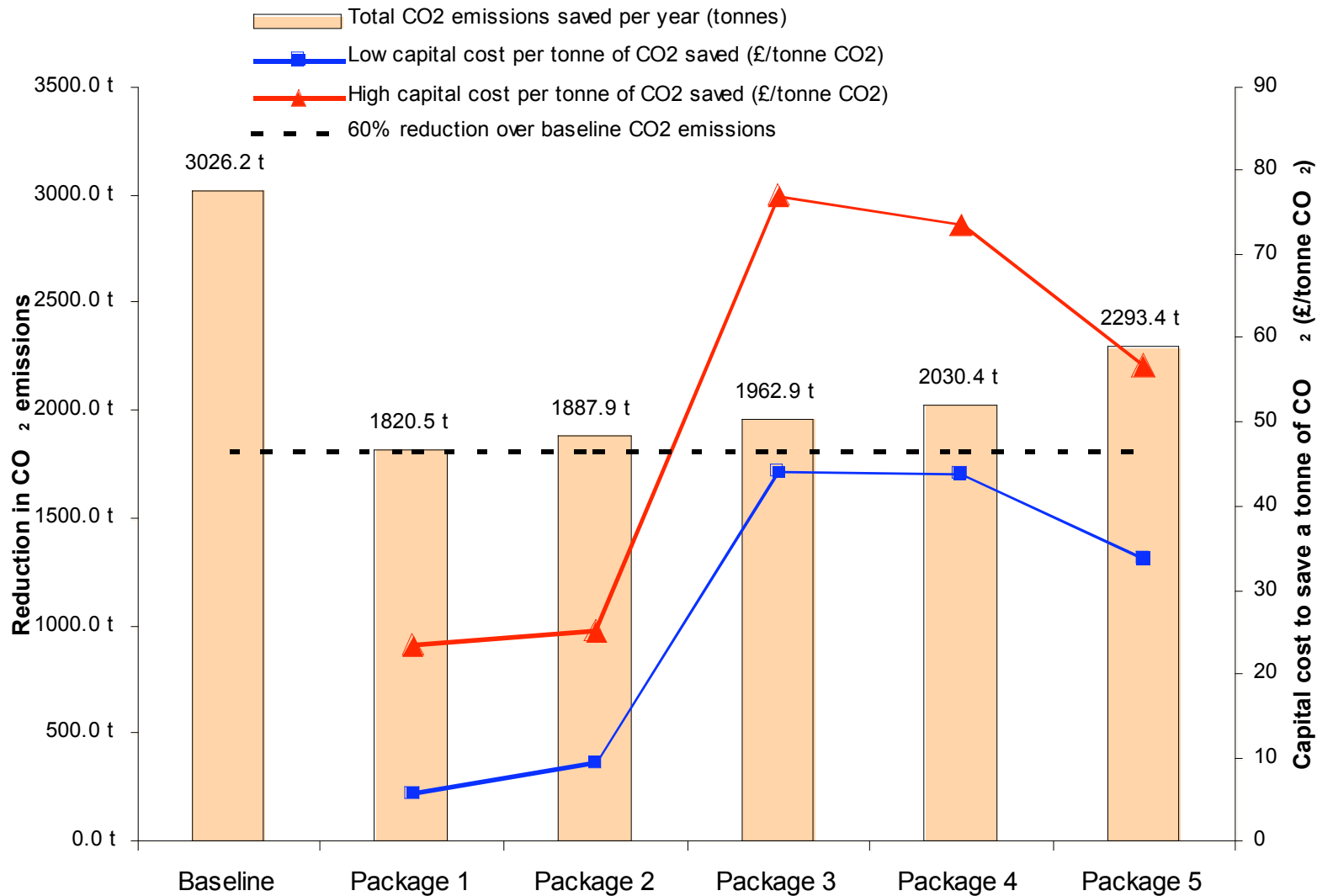
**Thematic maps in GIS showing:**  
Number of dwellings selected  
Reduced energy and CO<sub>2</sub>

# DECoRuM CO<sub>2</sub> reduction model: estimating solar potential

87% of the dwellings in the case study were suitable for installing either a SHW or a PV system or both.

Dwellings with potential for	Number of dwellings	Percentage
4 m <sup>2</sup> flat plate SHW (available roof area: 4.0 m <sup>2</sup> - 9.9 m <sup>2</sup> )	38	11.9%
PV (available roof area: 10.0 m <sup>2</sup> -13.9 m <sup>2</sup> )	46	14.5%
SHW & PV (available roof area: >13.9 m <sup>2</sup> )	192	60.4%
None	42	13.2%
<b>TOTAL</b>	<b>318</b>	<b>100.0%</b>

# Potential for CO<sub>2</sub> emission reductions above 60%



SHW and solar PV systems, individually installed cost £335 and £644/tonne of CO<sub>2</sub> saved in a low capital cost scenario. When applied in combination in package 3, the cost drops to £44 /tonne CO<sub>2</sub> saved.



## DECoRuM model: key benefits

- Individual dwelling is represented as the base level of resolution but results can be displayed up to a street, district and city level.
- Pollution hotspots can be spatially located and targeted for improvement.
- Assessment requires no access to the property.
- A robust data filtering process provides accurate and reliable results.
- Cost-benefits analysis enables cost comparison of different measures.
- Helps to estimate the potential for citywide application of solar energy systems.
- A useful visual aid when encouraging householders to install energy efficiency measures



# DECoRuM received RIBA President's medal for outstanding research 2006

The screenshot shows a Microsoft Internet Explorer browser window displaying the Oxford Brookes University website. The address bar shows the URL [http://www.ox.ac.uk/business\\_employers/news/articles/research\\_award](http://www.ox.ac.uk/business_employers/news/articles/research_award). The page features the Oxford Brookes University logo and a navigation menu with links to Home, Studying at Brookes, International, About Brookes, Research, Business and employers, Alumni, and Students and staff. A search bar is located in the top right corner.


## RIBA Research Award 2006

The Royal Institute of British Architects (RIBA) is pleased to announce that Dr Rajat Gupta from Oxford Brookes University (Oxford, United Kingdom) has been awarded the RIBA President's Research award for 2006: outstanding PhD.

This award was made on 6 December 2006 at the prestigious President's Medals ceremony held at the RIBA, 66 Portland Place, London.

The judges' citation for the winner of the Outstanding PhD is as follows:

This PhD research describes the development and validation of a domestic energy, carbon-counting and carbon-reduction model (DECoRuM) for urban scale assessments of the cost benefits of a wide range of energy efficient and renewable energy options. The thesis deftly handles the complex and contentious literature on climate change. The novelty of the approach lies in the ability to reliably aggregate results for individual houses up to an urban scale. This is an extremely impressive study both in terms of its scope and detail. It is also very timely, and should be taken up by local authorities and housing agencies around the country. This is an issue of widespread importance and interest to many architects, and one which the RIBA champions.



Judging panel:

- Jane Rendell - chair of judges - Director of Architectural Research at the Bartlett School of Architecture UCL
- Richard Coyne - Edinburgh University, Architecture Department
- Andrew Ballantyne - University of Newcastle, School of Architecture
- Brian Ford - Head of School of the Built Environment, Director of the Institute of Architecture, University of Nottingham
- Simon Allford - AHMM, and RIBA Vice President for Education

[editor login](#)

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Internet

[www.decorum-model.org.uk](http://www.decorum-model.org.uk)



## Oxford Climate Change Action Plan



Final Report for  
**Oxford City Council**

November 2005

Prepared by:  
**Dr Rajat Gupta**  
Department of Architecture  
School of the Built Environment  
Oxford Brookes University, Oxford OX3 0BP  
Tel: 01865 484049, Fax: 01865 483298  
Email: [rgupta@brookes.ac.uk](mailto:rgupta@brookes.ac.uk)

# Oxford Climate Change Action Plan (OCCAP)

OXFORD  
**BROOKES**  
UNIVERSITY



## Oxford Climate Change Action Plan (OCCAP)

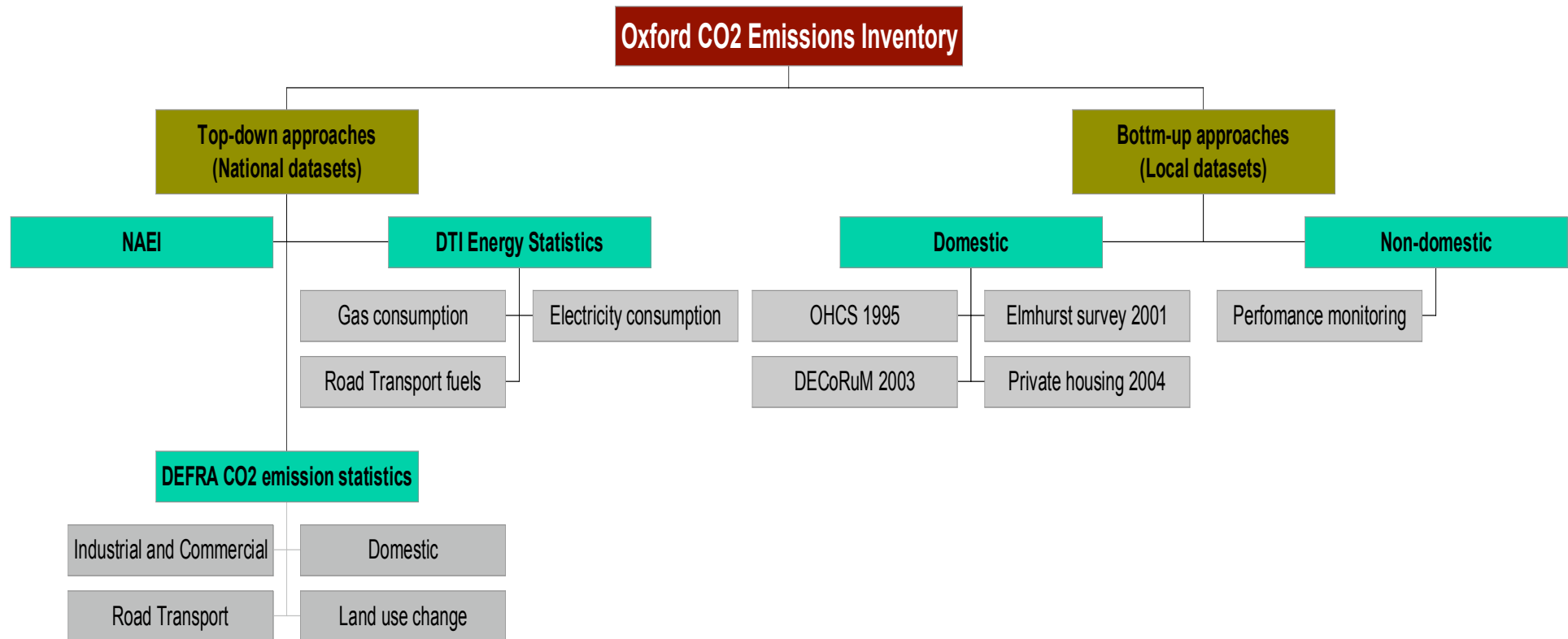
Within such a context, the **OCCAP** has been developed:

- Constructs an accurate CO<sub>2</sub> emissions inventory for Oxford city for a baseline year.
- Establishes CO<sub>2</sub> emissions reduction targets
- Proposes action to meet those targets.

**OCCAP is currently being implemented by the Oxford City Council.**



# CO<sub>2</sub> inventory for Oxford: Top-down and bottom-up approaches



**Top-down approaches provide an overall picture of Oxford sectoral emissions.**

**Bottom-up approaches provide disaggregated figures for taking actions.**

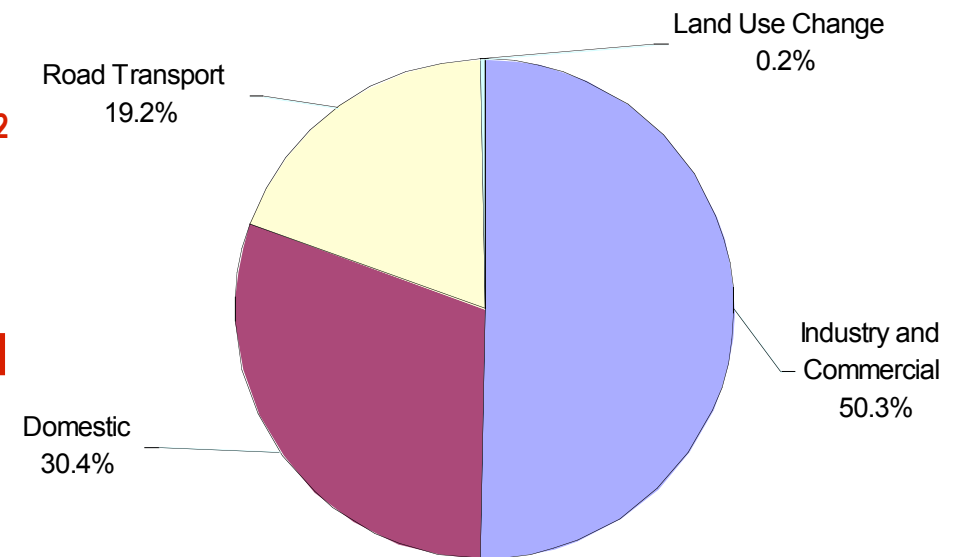
# DEFRA CO<sub>2</sub> emission figures by LA for 2003

	Industry and Commercial	Domestic	Road Transport	Land Use Change	Total	Population (2001)	Per capita CO <sub>2</sub> (tonnes)	Domestic per capita CO <sub>2</sub> (tonnes)
<b>Oxford</b>	496,992	299,960	189,365	1,535	<b>987,853</b>	142,500	<b>6.9</b>	<b>2.1</b>

**Total CO<sub>2</sub> emissions for 2003 = 987,853 tCO<sub>2</sub>**

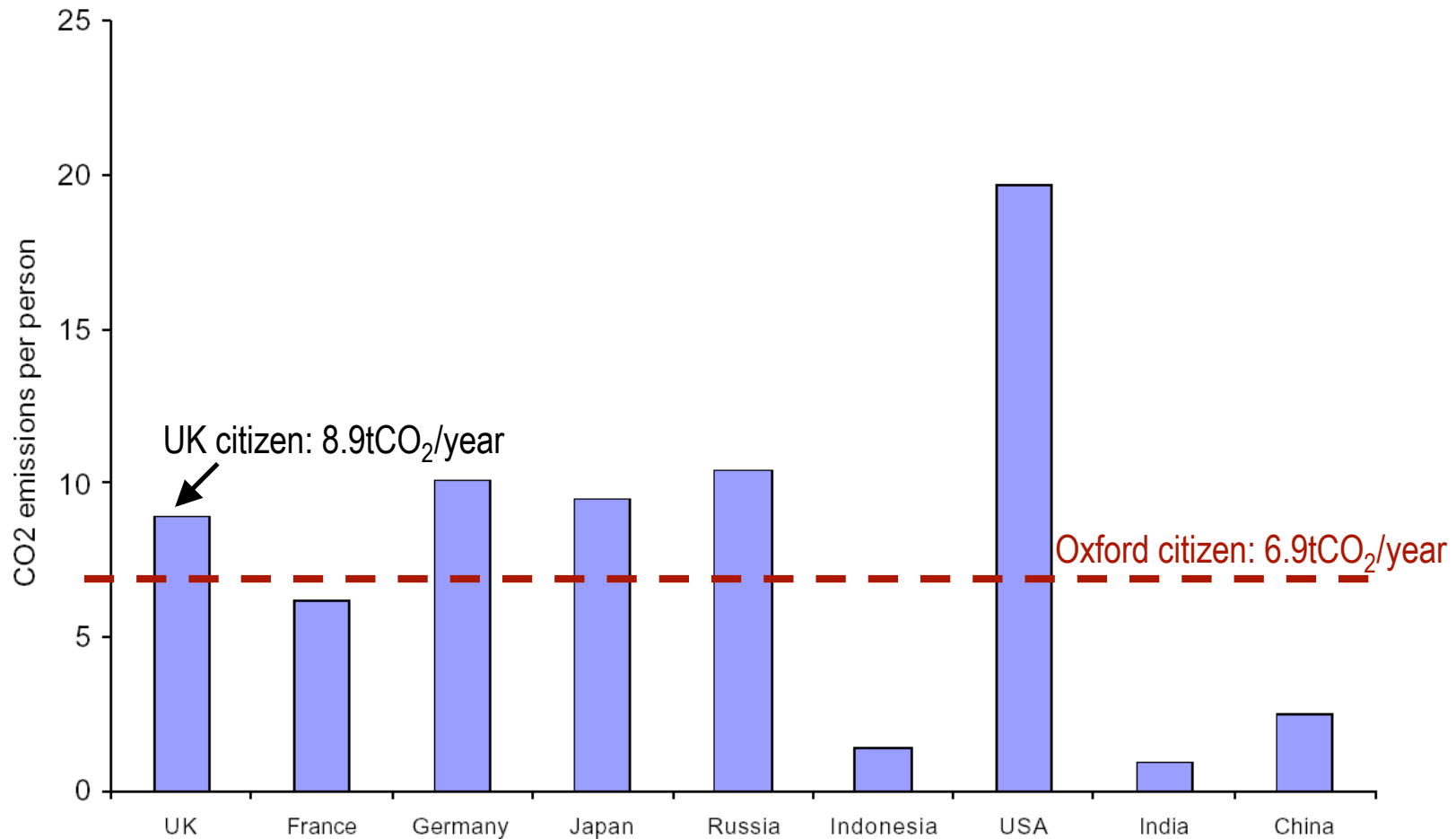
**Oxford population 2001 Census = 142,500**

**CO<sub>2</sub> emissions ( gas, electricity and road transport) of average Oxford citizen:  
6.9 tCO<sub>2</sub>/year**

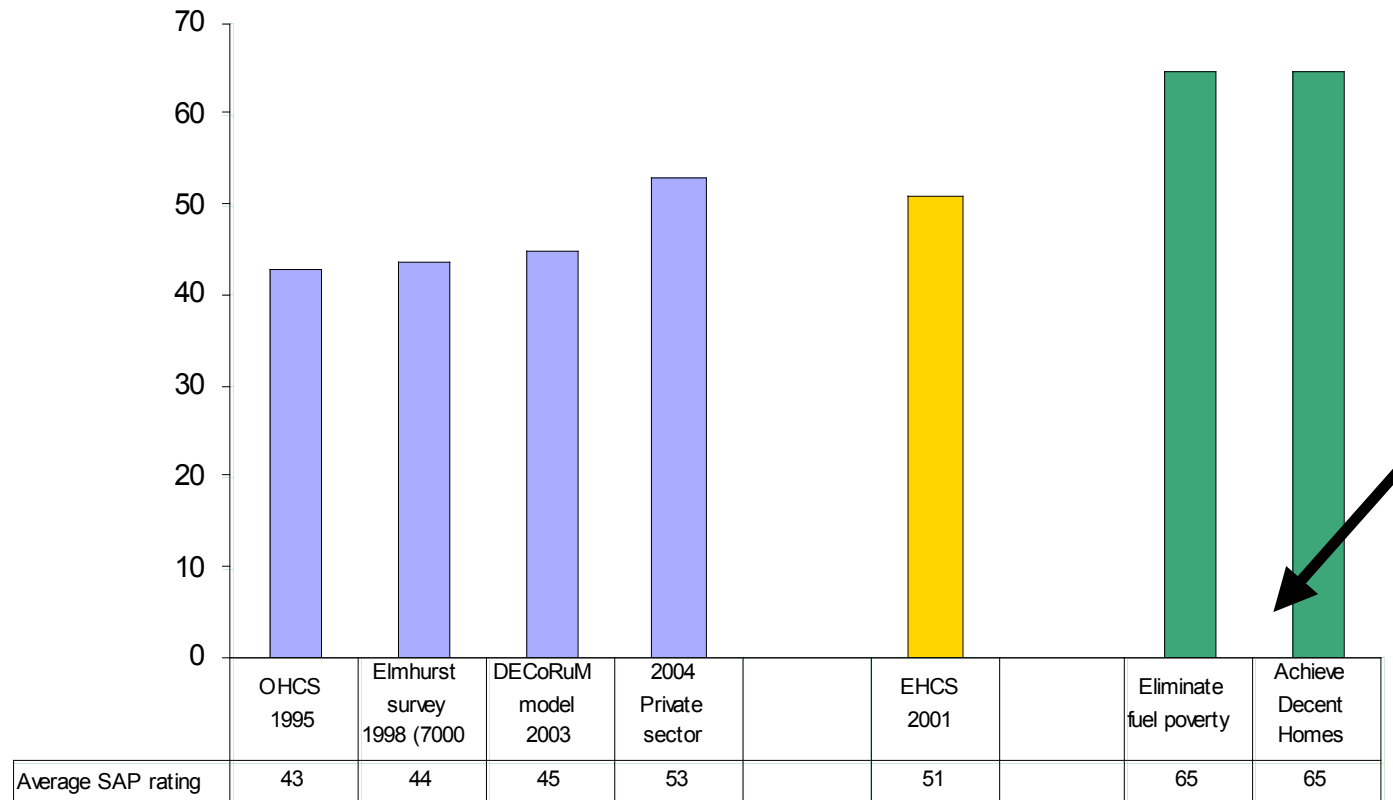




# Comparison: National and International figures

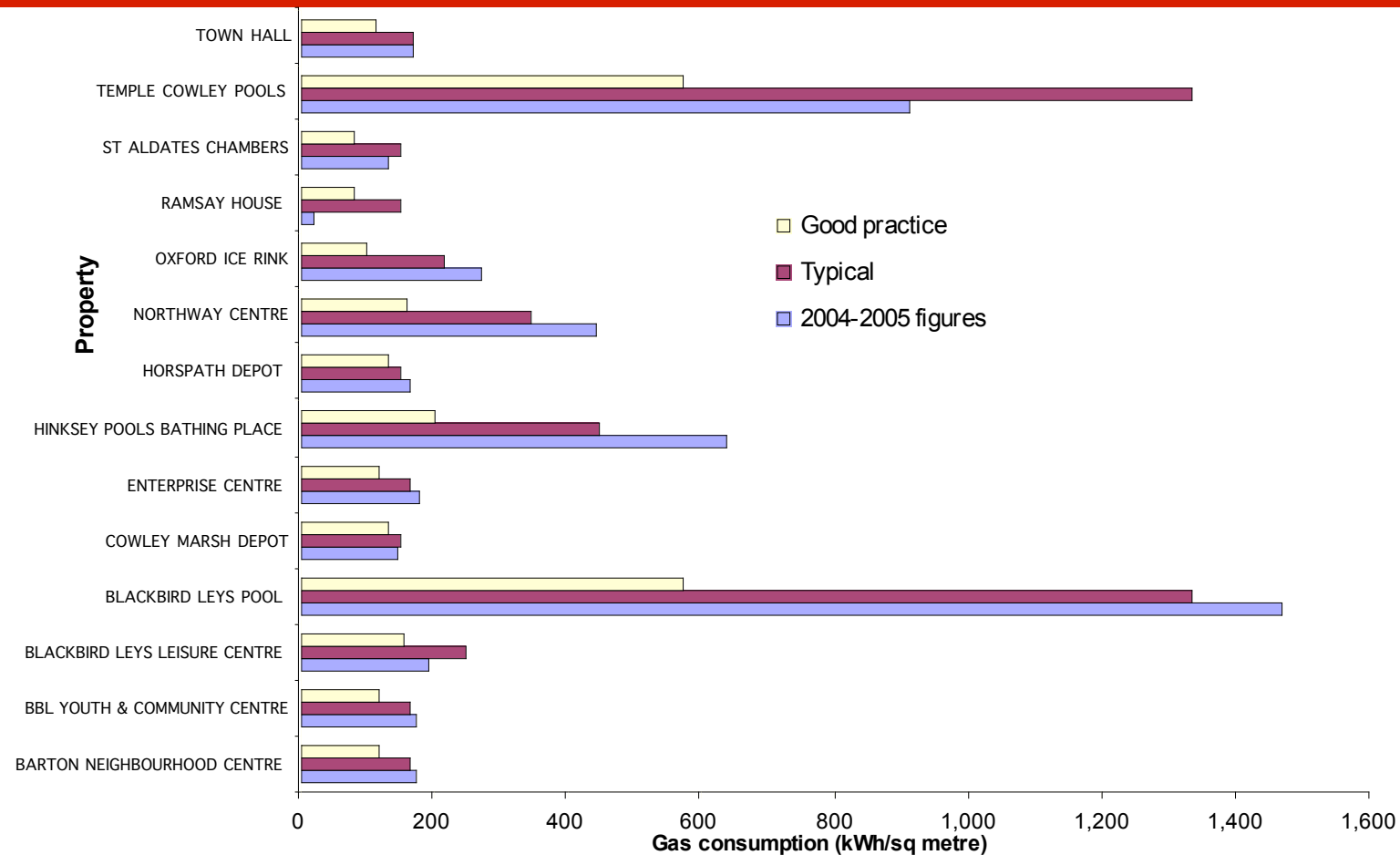


## Bottom-up approach: Local datasets for Domestic sector



**Almost 50% of dwellings in Oxford have a SAP rating of 52 or less – So there is considerable scope of improvement!**

# Bottom-up approach: Local datasets for Non-domestic sector



Performance monitoring of gas and electricity consumption of 16 high-energy consuming non-domestic buildings owned by the City Council.



## Oxford: setting CO<sub>2</sub> emission reduction targets

In line with national goals, the overall aim for Oxford should be to ultimately achieve CO<sub>2</sub> emission reductions in Oxford **above 60%** by 2050 over 2000 baseline emissions, with the following intermediate goals.

- 15% reduction in CO<sub>2</sub> emissions by 2010 (2000 baseline)
- 20% reduction in CO<sub>2</sub> emissions by 2015 (2000 baseline)
- 30% reduction in CO<sub>2</sub> emissions by 2020 (2000 baseline)
- 40% reduction in CO<sub>2</sub> emissions by 2030 (2000 baseline)

## Ten actions to meet the targets

1. Raising awareness and understanding
2. Develop a citywide GIS-based energy and emissions model.
3. Promote energy conservation + local generation of energy.
4. Improving average SAP of Oxford dwellings to 65 by 2010.
5. Improve household energy efficiency by 15% by 2010 and 30% by 2020.
6. Reduce CO<sub>2</sub> emissions from all council-owned non-domestic buildings by at least 25% on 2005 levels by 2010.
7. By 2010 all new developments to be built to best practice standards.
8. Increasing the uptake of low carbon systems.
9. Minimising the transport impact of new developments.
10. Transform Oxford into a solar (sustainable) city.

# City Council's implementation plan: Raise awareness

6 Months	Year 1	Year 2	Year 3	Year 4	Available Resources
Promote good practice and its benefits, including regular <i>Your Oxford/ Paper/Media</i> messages and expanded use of intra/internet to promote messages related to climate change ( <b>EH</b> )	Expand promotion of good practice and its benefits ( <b>EH</b> )	Continue promoting good practice and its benefits			S&R Officer working part -time on sustainability initiatives, including energy and climate change
Oxford Solar Cities Congress Citizen's Day to raise awareness of climate change amongst Oxford residents ( <b>EH</b> )	Follow -up efforts to expand climate change awareness in Oxford ( <b>EH</b> )  Save energy information leaflets for tenants (Council housing) - £10K committed ( <b>OBS, EH</b> ) Defra climate change communications bid funding (potential) to raise awareness among businesses, residents and Council staff) ( <b>SR</b> )	Information leaflets continued - £2K committed Defra climate change funding available for continued awareness raising (potential)	Information leaflets continued - £2K committed		
		Oxford Inspires: "Climate Change, The Opportunity" event (possible)			
		HECA work to target homeowners	HECA work to target homeowners	HECA work to target homeowners	Existing HECA work – 1.5 FTE

# City Council's implementation plan: Energy Audits of council bldgs

6 Months	Year 1	Year 2	Year 3	Year 4	Available Resources
Year One of energy audits of 8 (total over 3 years) Council buildings by Oxford Brookes Students ( <b>BE</b> )	Examine outcomes of Year One energy audits and make recommendations for action ( <b>BE</b> )	Year Two of energy audits of 8 Council buildings by Oxford Brookes Students – make recommendations for action  Implement actions from Year One	Year Three of energy audits of 8 Council buildings by Oxford Brookes Students – make recommendations for action  Implement actions from Year Two	Implement actions from Year Three	Possible resources from Building Maintenance Backlog where energy conservation works can be included as part of a larger scheme  (Fraction of) FTE Climate Change Officer (new)
Educate Leisure and Parks staff regarding energy use in buildings – “Turn it off” ( <b>LCS</b> )					
Procurement decisions to be made for fleet replacement and fuel use, including emission audit for fleet ( <b>CW</b> )  Alternative fuels being used/trialled ( <b>CW</b> )	Decisions implemented ( <b>CW</b> )  Continue and potentially expand use of alternative fuel vehicles ( <b>CW</b> )	Continue and potentially expand use of alternative fuel vehicles			
Electric vehicles brought into use in Council ( <b>CW</b> )  Promotion of solar hot water use at Hinksey Pool and Nursery ( <b>EH</b> )	Electric vehicles in use ( <b>CW</b> )  Consider expanding such pilot projects based on success and emission reductions ( <b>EH, BE, others</b> )				





## Conclusions

- Develop the Historical city of Oxford as a pioneering Solar (low carbon) City in Britain, Europe and the World.
- Build local partnerships to implement actions to reduce CO<sub>2</sub> emissions from the buildings of the city by up to 90%.
- Stimulate local industry.
- To turn EU and UK regional policy on the implementation of renewable energy into a successful local strategy.
- Ensure that the citizens of Oxford are future-proofed, in safe and comfortable homes, against the twin challenges of climate change and increasingly expensive fossil fuels.

In conclusion...

**"If you do not change direction,  
you may end up where you are  
heading."**



Lao Tzu (604-531 BC) Chinese Artist and Taoist philosopher

(Source: [www.cred-uk.org](http://www.cred-uk.org) )