Reducing CO_2 emissions of UK non-domestic buildings – Conclusions of the Tarbase project

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Tarbase aims

tarbase
technologies for carbon reduction in existing buildings

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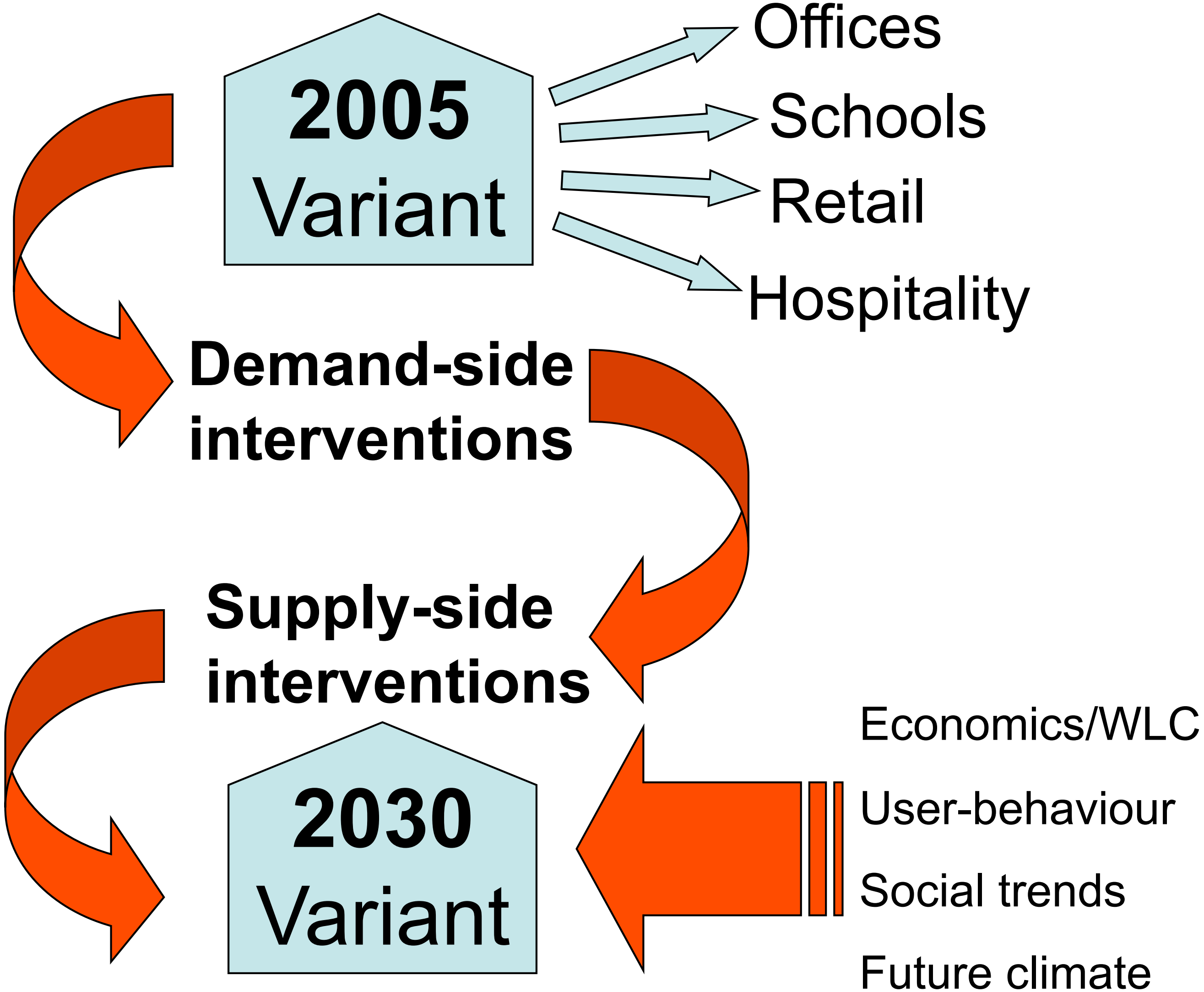
To deliver technological solutions able to reduce CO_2 emissions from *existing* buildings by 50% by 2030.

- Wide ranging assessment of CO_2-saving interventions
- Social, technical and economic issues addressed
- Domestic and non-domestic building variants

Dynamic simulation

- Steady state modelling has limitations:
  - Overheating
  - Thermal mass
  - Internal heat gain/occupancy profiles
- DSM can be used to investigate the above
- For larger non-domestic buildings this is essential
  - Due to effect of internal activity on heating/ cooling

Tarbase methodology



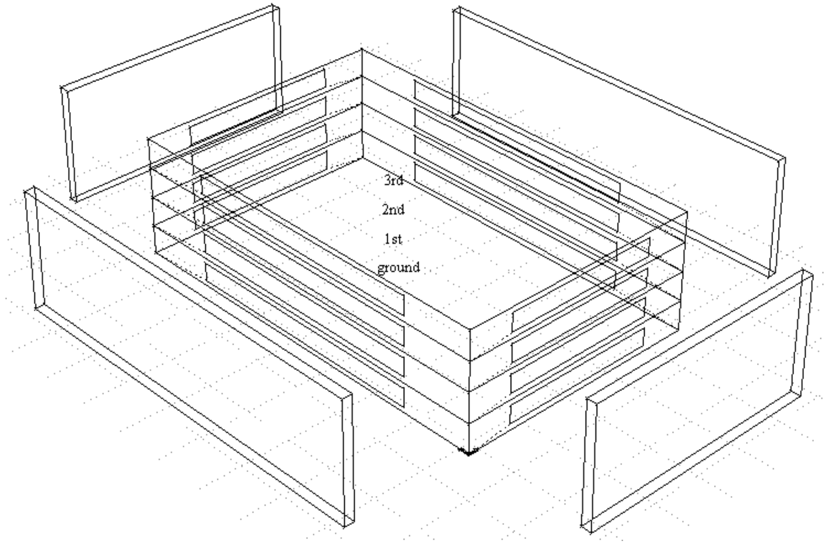
Demand-side measures

- IT/end-use equipment and appliances
- Lighting
- The effect of the above on internal gains (and heating and cooling)
- Building fabric
- Glazing
- Alternative HVAC systems
  - Tarbase HVAC models for different boiler and air-conditioning systems

Supply-side measures

- Tarbase models for:
  - Solar PV
  - micro-CHP
  - micro-Wind
  - Solar thermal
  - Air-source (and ground-source) heat pumps
  - Heat recovery
  - Battery storage

Offices – Case study

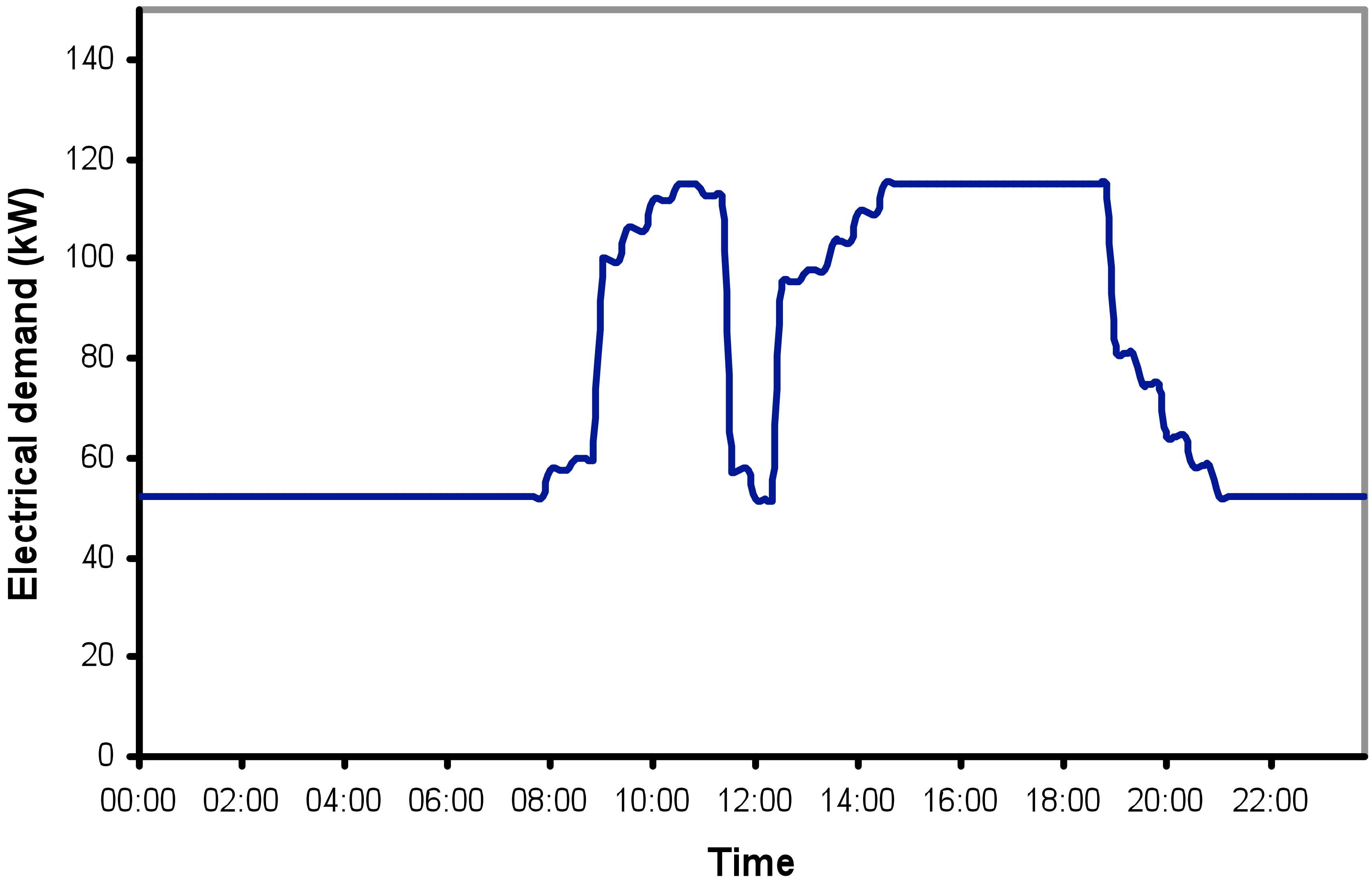


- London office
- 4000m^2 TFA
- 12m height
- 286 workers
- 1981-5 construction
- Concrete panel wall

Small power and lighting

- Bottom-up analysis of office equipment
  - Define "people per appliance"
  - Characterise equipment (PC, monitor etc)
    - Define modes of use (on, off, standby)
    - Define hours of use in these modes
  - Account for weekend operation and diversity of use (e.g. PCs switching on at different times)

Electrical demand



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Small power/lighting

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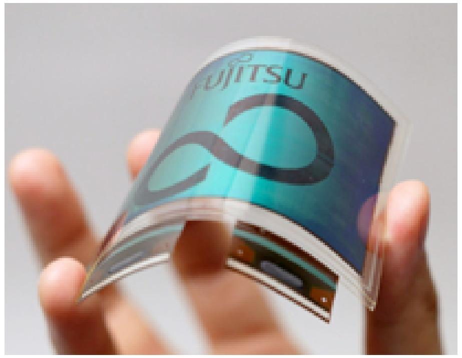
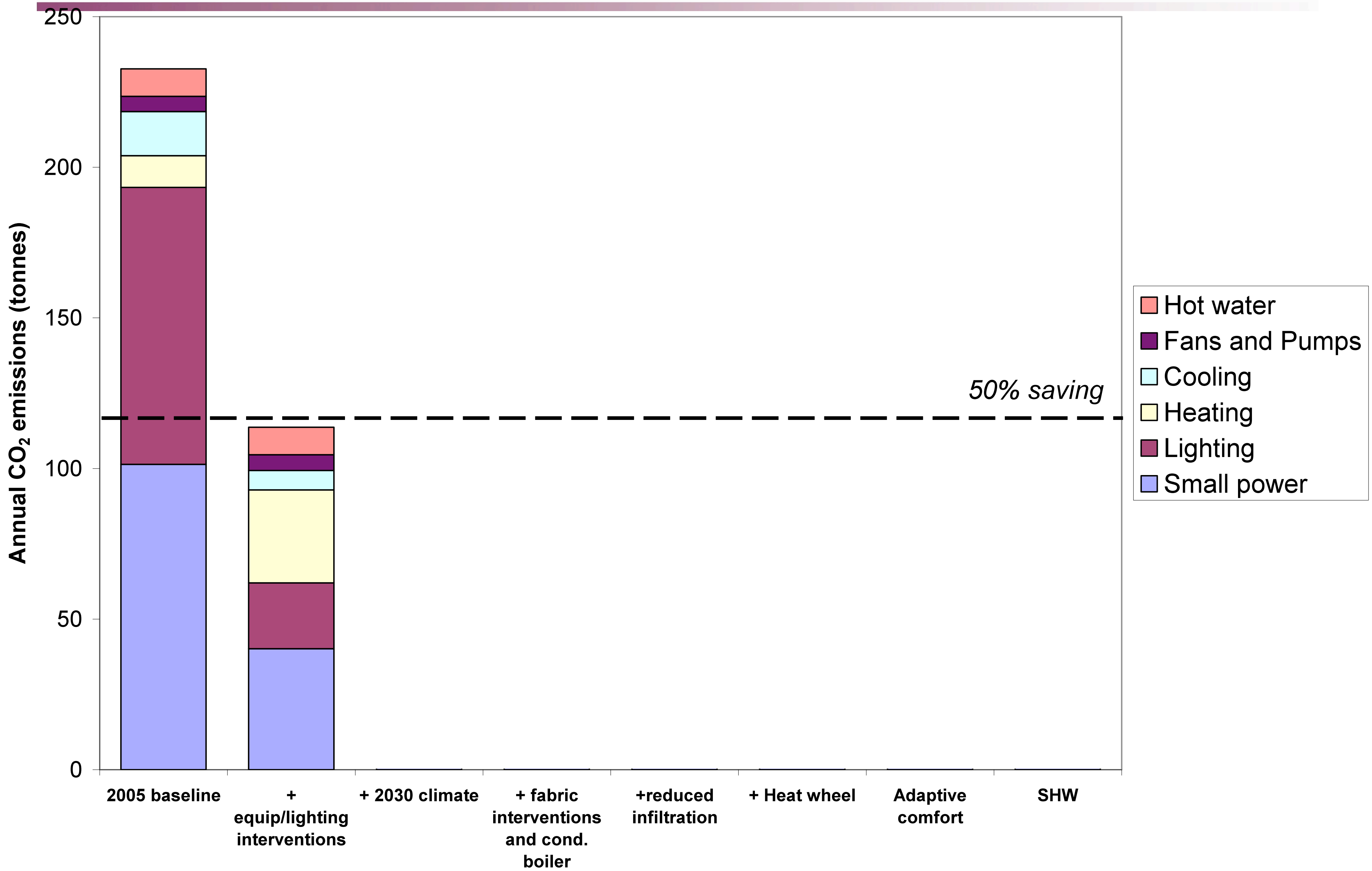


- Energy management
- Low-power display technology
- Small decrease in PC processor power
- LED lighting (150lm/W)

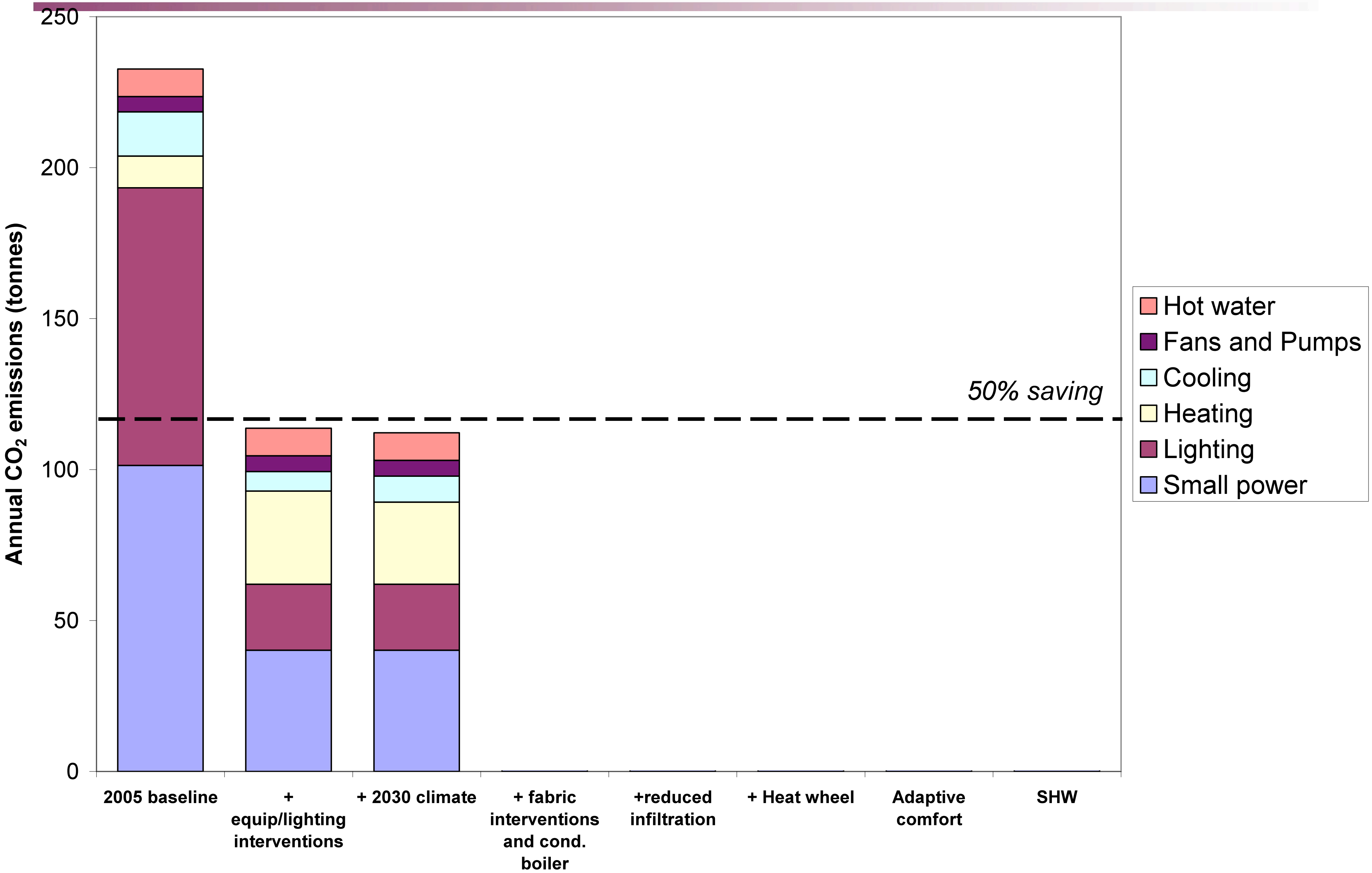
	Annual energy use (MWh/yr)		Peak internal gain (W/m^2)	
	2005	2030	2005	2030
Small power	236	93	11.4	4.4
Lighting	214	51	15.2	6.3

Ref: *Jenkins, Liu & Peacock, Energy and Buildings 40, 874-881 (2007)*

Small power and lighting



2030 climate

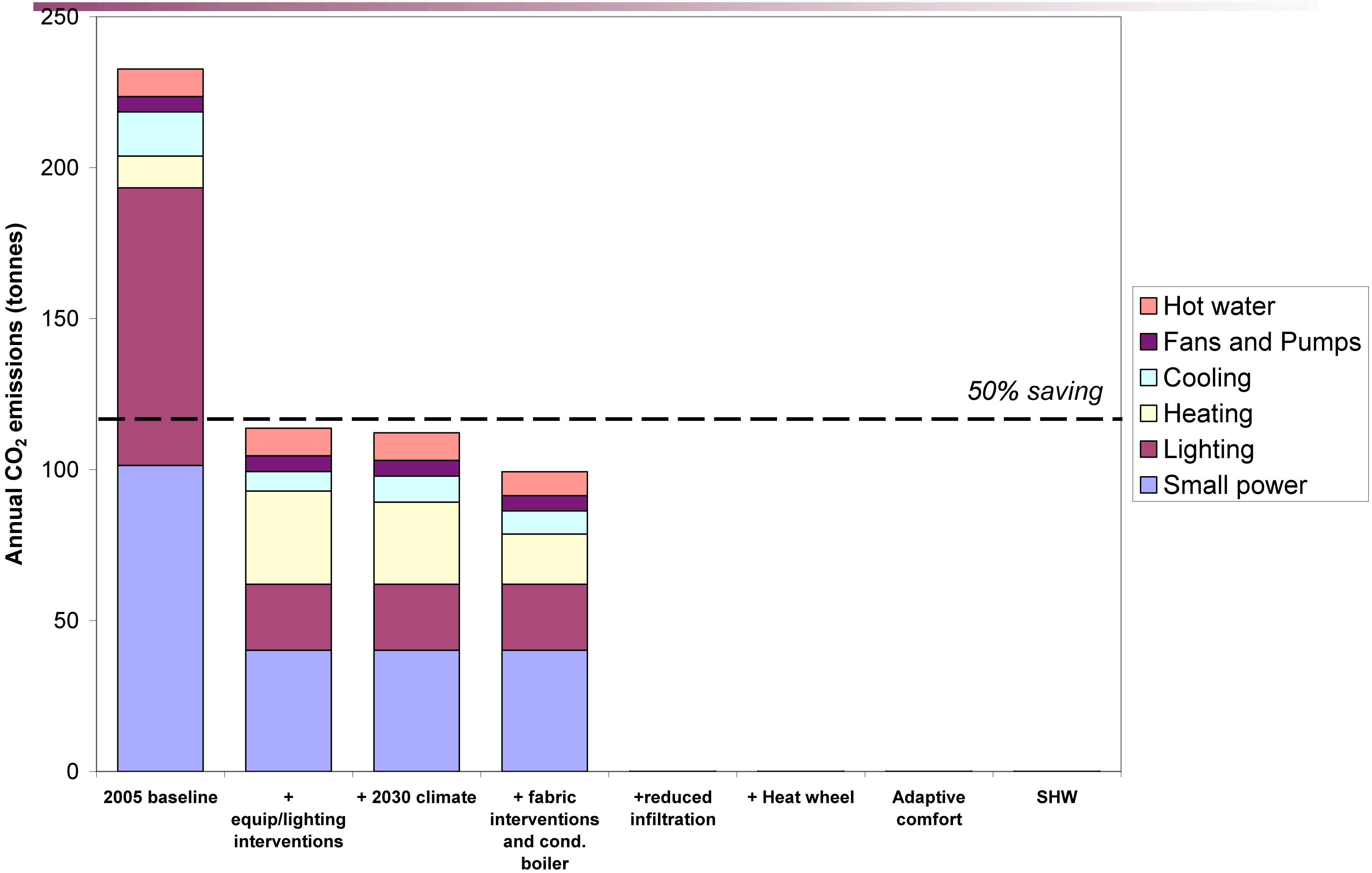


Fabric/glazing

- Increased fabric/glazing insulation
  - Can be detrimental for high-gain offices
  - For lower gain offices, often beneficial when combined with reduced solar gain

	U-values (W/m^2K)			
	Walls	**Floor**	**Roof**	**Glazing**
2005 construction	0.65	0.27	0.87	2.75
2030 construction	0.15	0.22	0.14	0.78

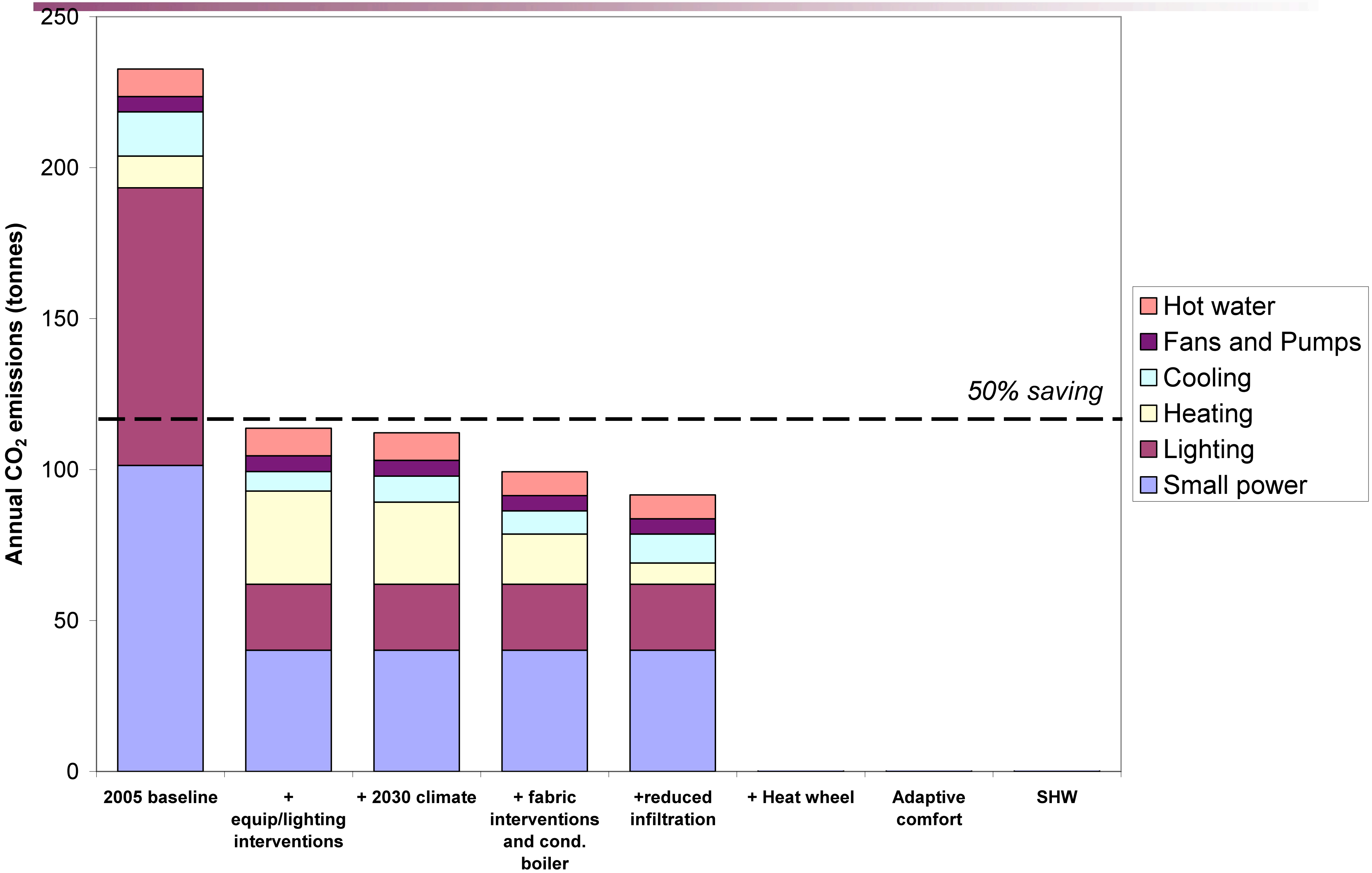
Fabric/condensing boiler



Infiltration

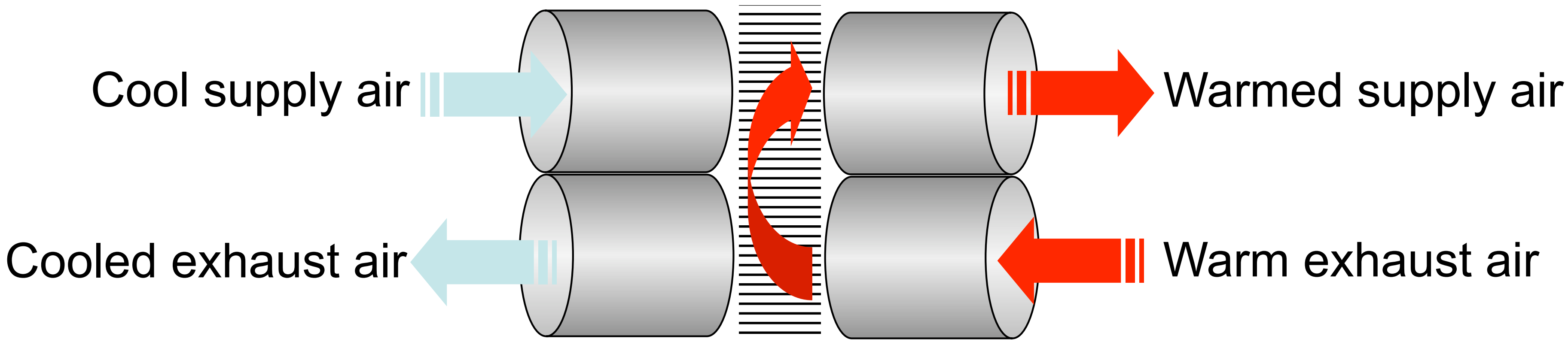
- Infiltration reduced from 1ach to 0.5ach
  - Not necessarily of benefit for carbon savings – depends on internal gains
  - Fabric-based intervention (draughtproofing etc)

Reduced infiltration

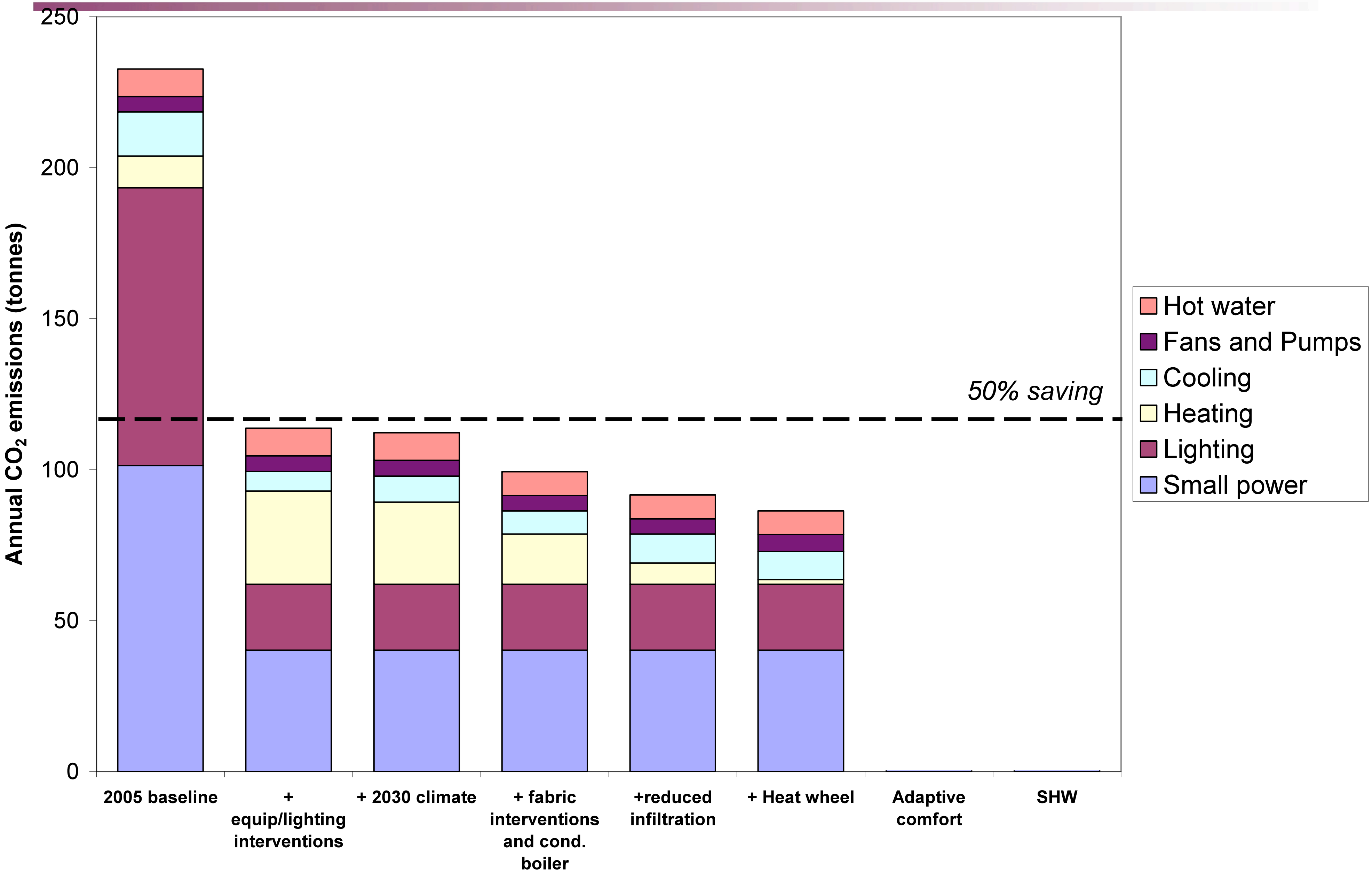


Heat recovery

- Mechanical ventilation heat recovery
  - Heat wheel used with existing ventilation system
  - Modelled every hour accounting for:
    - Hourly thermal demand
    - External and internal temperatures
    - Ventilation rate



Heat recovery



Adaptive comfort

- Instead of static (21-23°C) comfort temperatures:

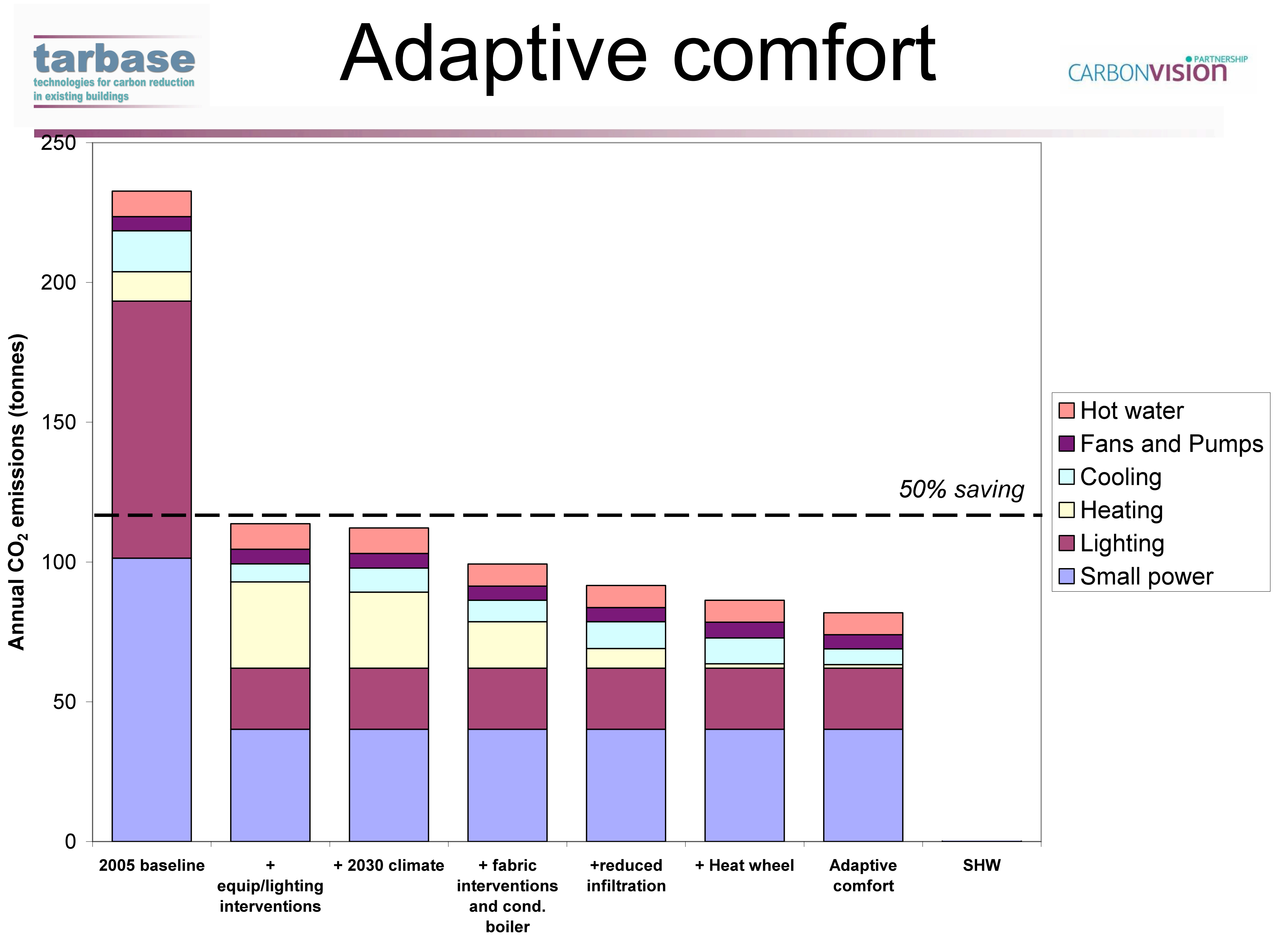
$$\text{for } T_{\text{rm}} > 10\,^{\circ}\text{C}: \quad T_{\text{comf}} = 0.33 T_{\text{rm}} + 18.8$$

$$\text{for } T_{\text{rm}} \leq 10\,^{\circ}\text{C}: \quad T_{\text{comf}} = 0.09 T_{\text{rm}} + 22.6$$

- where T_{rm} is an external running mean temperature

Ref: *Comfort driven adaptive window opening behaviour and the influence of building design, Proc. Building Simulation 2007, Tuohy et al (2007)*

Adaptive comfort



Onsite generation

- Solar thermal panel meeting 50% of "domestic" hot water demand
- 200m² of monocrystalline PV (27kW)
  - 30deg tilt, South-facing
- 10No, 1.5kW turbines (rooftop – 10.8m high building with 2m mast)
  - Average annual wind speed of 2.3m/s (low) and 5.6m/s (high); extrapolated from collected data

For other info: *DCLG/UK Green Building Council, "Report on carbon reductions in new non-domestic buildings", December 2007*

Onsite generation

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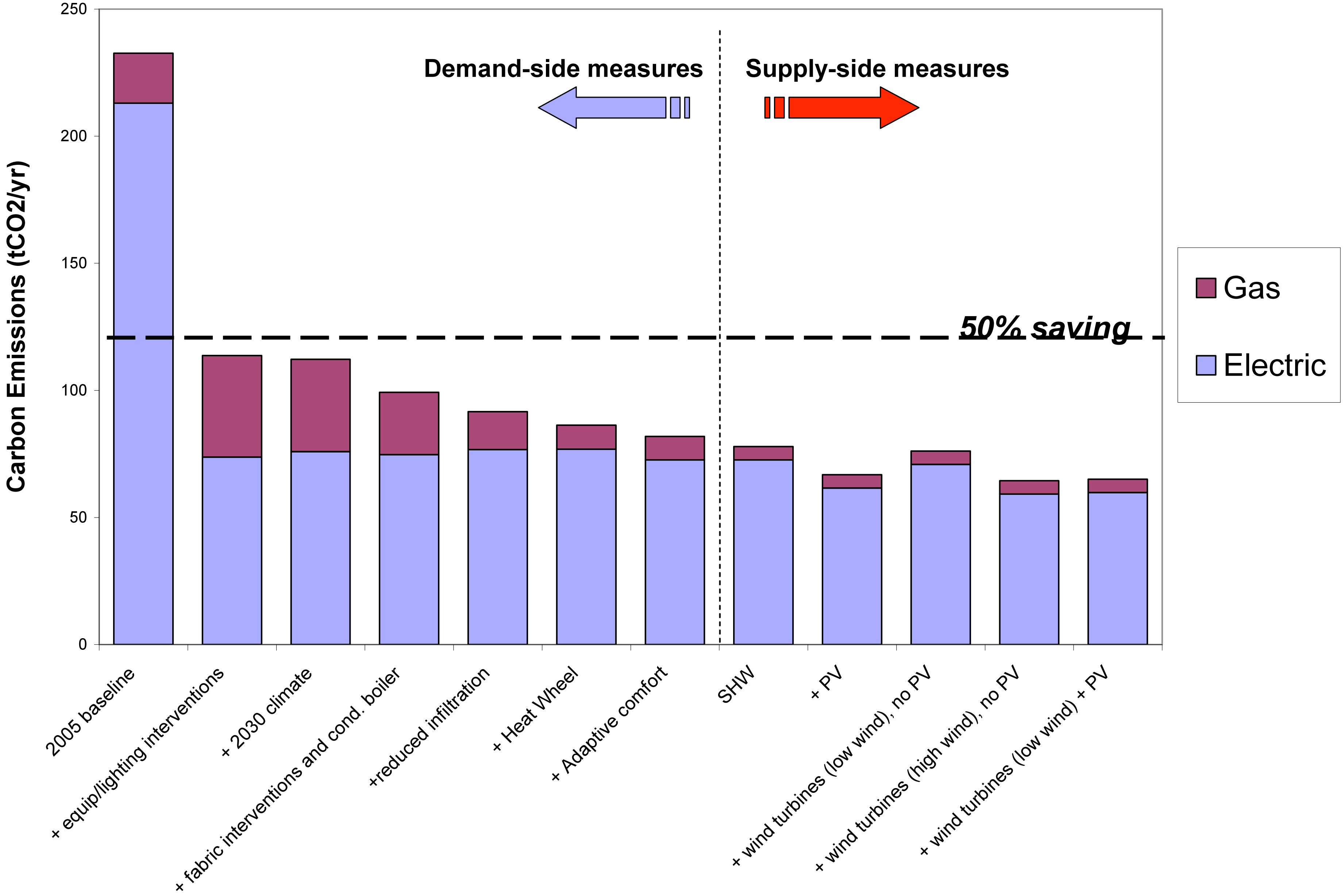
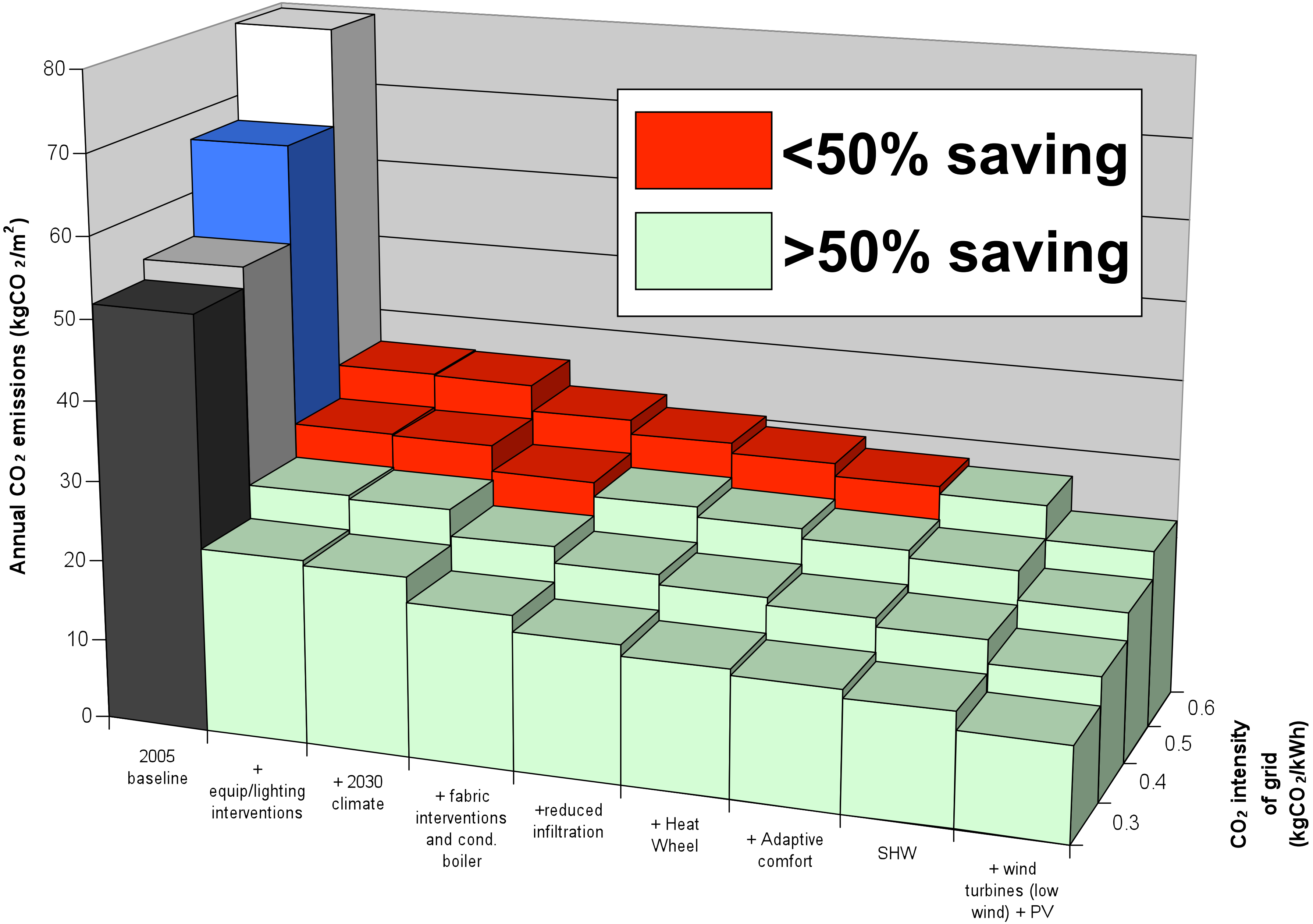


Grid CO_2 intensity



Some conclusions

- Similar results from schools/retail sectors
  - Overheating problems in schools…
- Internal activity is key
  - Can this be standardised?
- "Unregulated" and "regulated" energy use
  - Not independent quantities
- CO_2 savings are (almost) all about demand-side measures
- Grid CO_2 intensity should not be oversimplified
- Whole life costing of interventions
  - What if interventions don't pay back?

Thank you

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