Climate Change: a Critical Driver for Policy and Practice in the Built Environment

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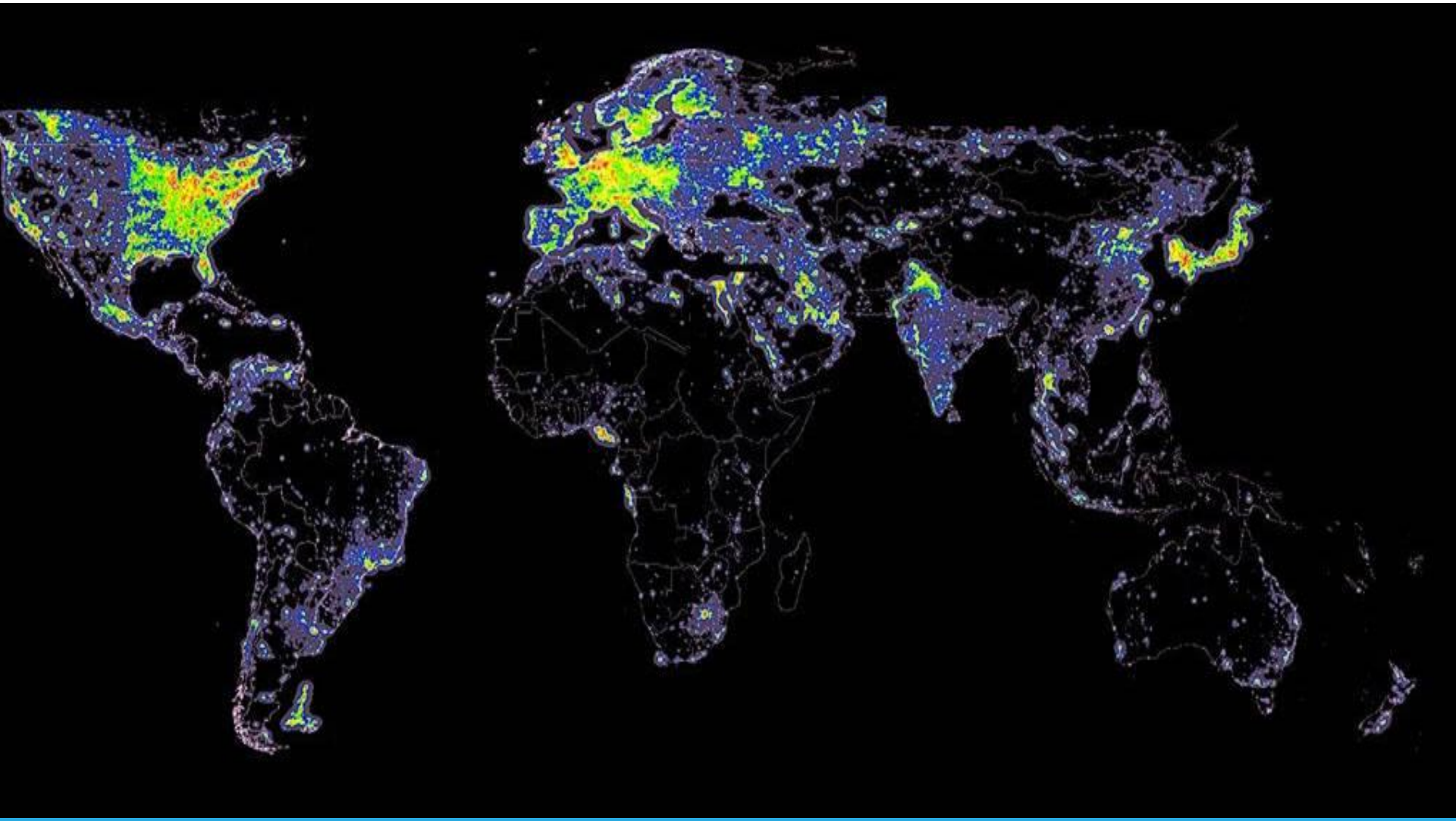
ARUP

Carbon emission: a top-level driver

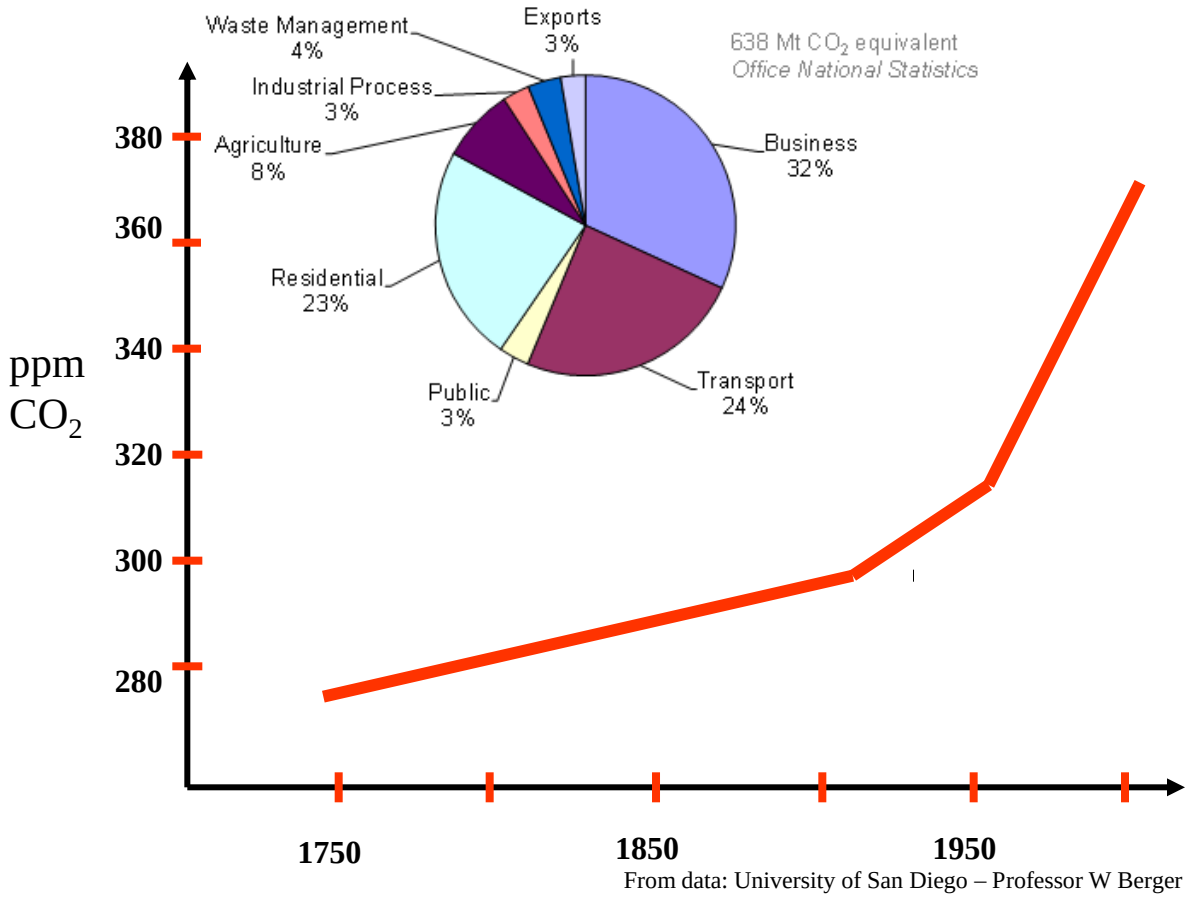


Drivers and Trends: CO_2

Keeling curve

CO2 rise derived from Antarctic ice core measurements and readings from Mauna Loa, Hawaii.

James Watt's steam engine developments took place in the 1750s.



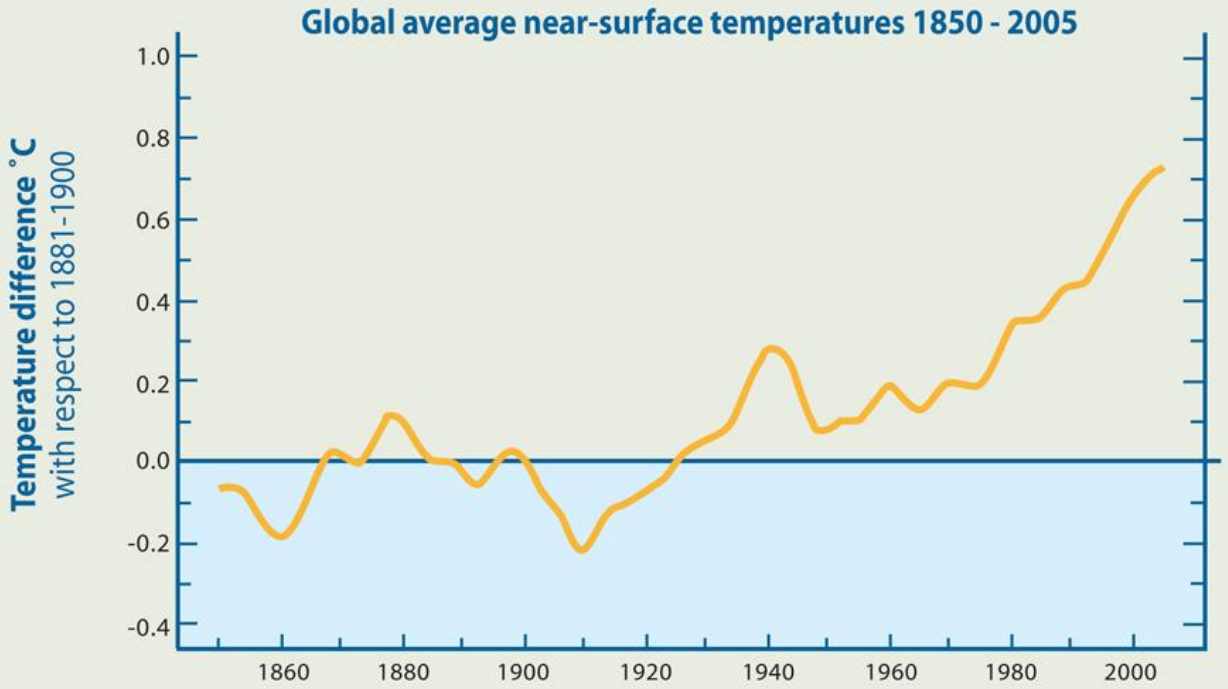
From data: University of San Diego – Professor W Berger

- Tipping point – 500ppm?

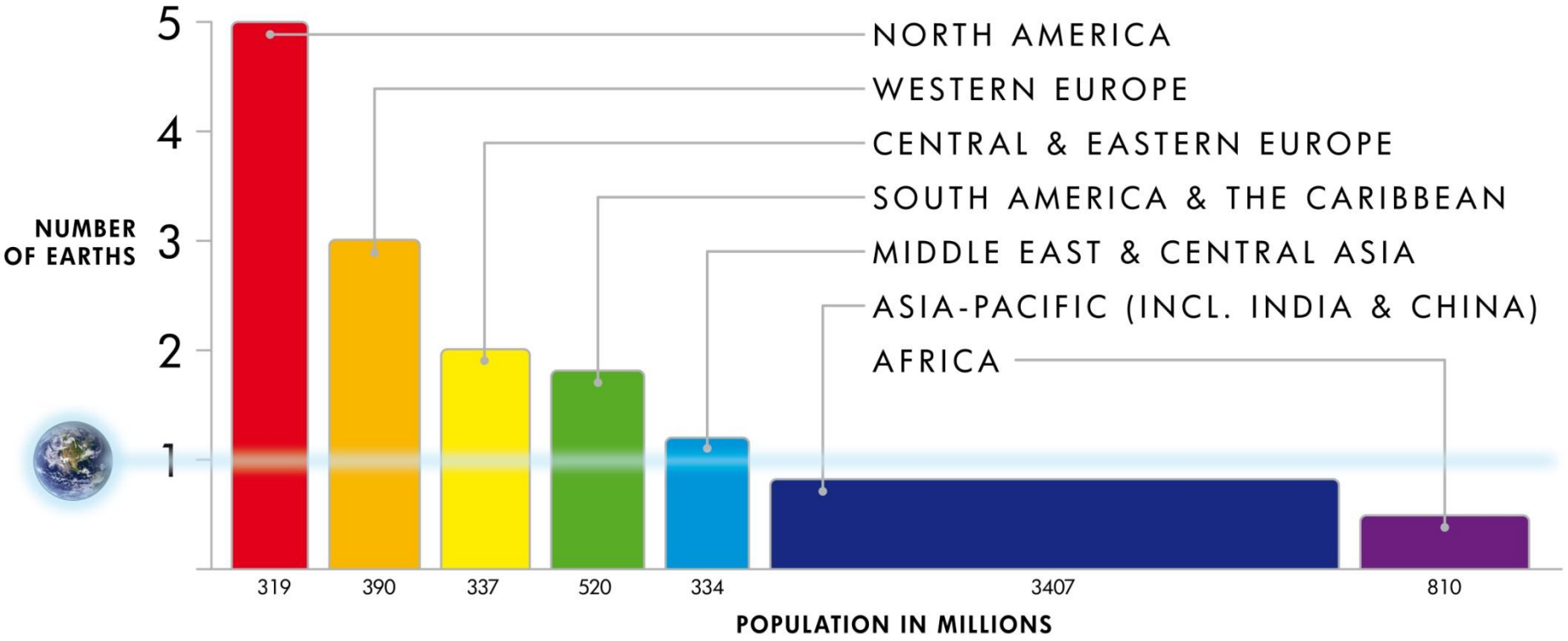
  Ice caps melt, more sunlight absorbed, trapped CH4 & CO2 released

Drivers and Trends: Temperature

- **Direct correlation between CO_2 levels and temperature rise**
- **City 'heat island' effects magnify impact**
- **Adaptation a key issue as well as mitigation**



Resource use of regions



In 2007, the world's population used a third more resources than the planet can renew.

Acknowledgements: Jacometti Associates

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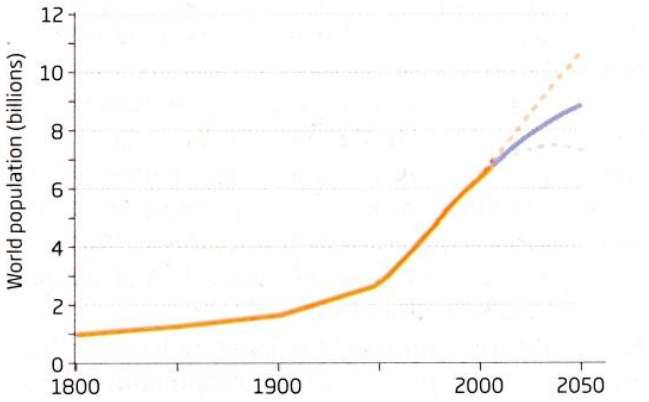
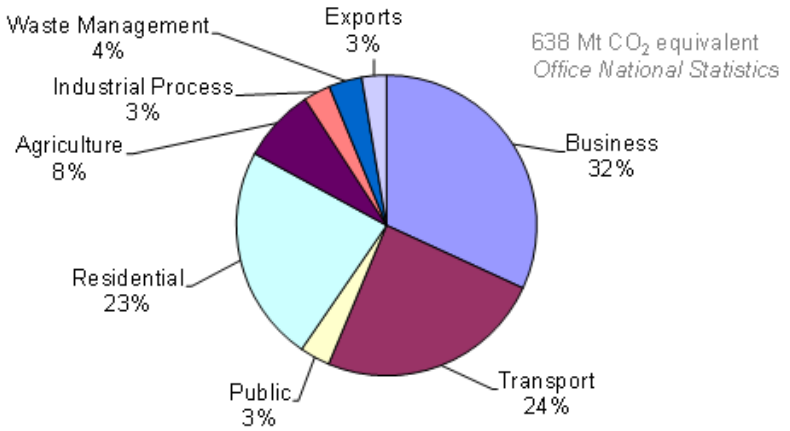
So what's the problem?

- **Expanding population ~7bn**
  - Ubiquitous expectation of economic development and increased standard of living



- **Ranked contributors to CO2**
  - Built environment (40%)
  - Road transport (24%)
  - Air transport (3% - IT same level)
  - Shipping
  - Manufacturing



- **Raw material shortages**
  - Indium
  - Platinum
  - Tantalum, etc.

Impacts

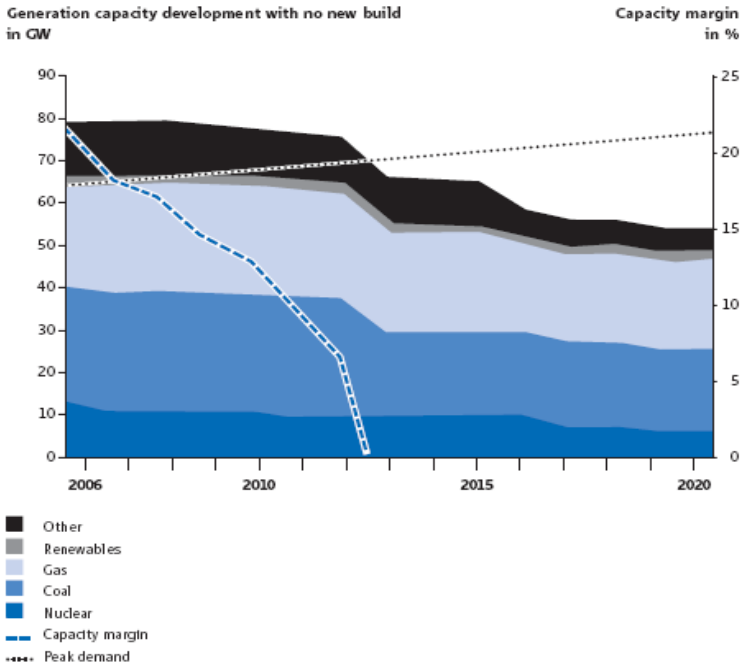
Flat screen displays

Catalysers, fuel cells

Electronic equipment

Drivers and Trends: Energy Sufficiency

- **Fuel security**
  - Indigenous gas and oil exhausted
  - Supply from unpredictable nations
- **Fossil fuel price increases**
- **Inadequacy of electricity supply**
  - Nuclear capacity build inadequate
  - ‘Crunch’ in 2012 / 2013?



- **Regulation generates new markets and models in low carbon technologies**
  - Built environment: city systems to building components
  - Consumer products → Consumer services

Opportunities: Business, Economic & Sustainability

- **‘Ecological age’ – transition/’skip over’ industrialisation (Peter Head)**
  - New business opportunities in low energy components, systems and services
  - But – western world has reduced local carbon footprint of manufacture by ‘exporting carbon’ to China
- **New economic models less predicated on material consumption growth**
- **Innovative sustainable solutions – systems thinking**
  - Energy – minimise loss and usage behaviours
  - Materials – reduced resource consumption
  - Social – shared responsibility

Priorities for the Built Environment

- **Adaptation (time-frame 0 to 50+ years)**
  - Global temperature increase has already led to seasonal extremes in Europe
  - 23,000 died in 2003, ~900 in UK
  - Need to design buildings with passive cooling (and ensure that compliance with high code levels does not make things worse)
- **Energy shortages (time frame 5 to indefinite years)**
  - Global depletion of fossil fuels and exhaustion of indigenous fossil fuels
  - Drive to de-carbonise central energy resources – need to 'go nuclear'
  - Need to minimise energy consumption in buildings (2016 – zero-carbon new build)
- **Mitigation (time frame 0 – 200+ years)**
  - We have to live with effects of already-emitted carbon for 200+ years
  - Ultimately must bring carbon emissions to an equilibrium point
  - Possible active sequestration – CCS plus atmospheric abatement
  - Buildings viewed at district-level should be carbon neutral or negative

Buildings, Energy and Carbon - summary

- **Buildings account for 40% of total EU energy consumption**
- **UK – 45% (28% residential; 17% non-domestic)**
- **Energy supply and security issues – high and rising demand and peaks, over-dependency on fossil fuel-based generation, intermittency of renewables, very limited storage**
- **Link between atmospheric CO_2 level, climate warming and man-made emissions**
- **Need to think about Adaptation and Energy Security as well as Mitigation**

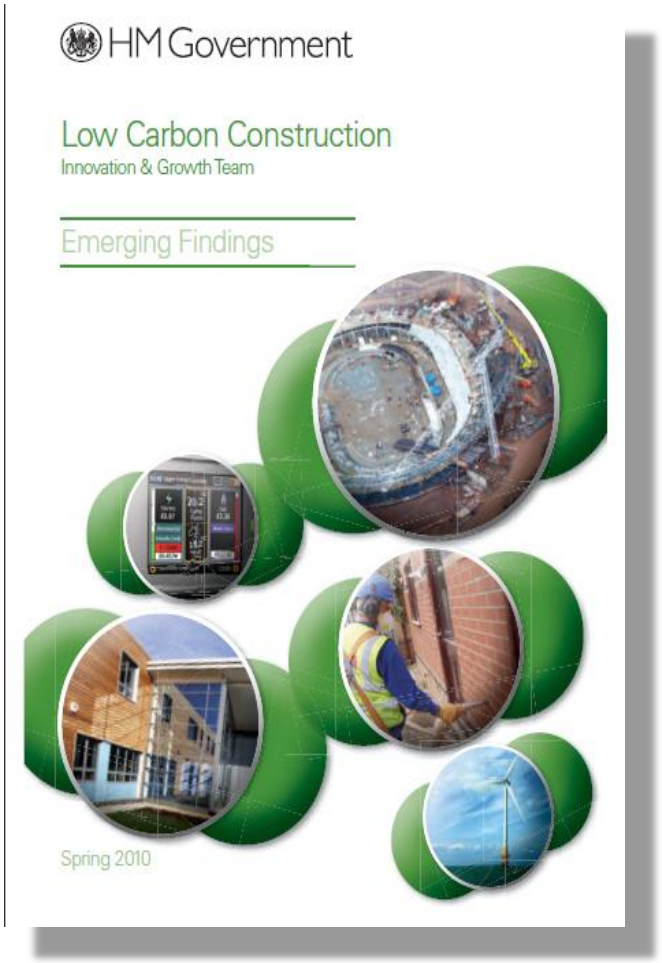
UK Government responses

- Energy White Papers, 2003, 2009
- Nuclear WP, 2008
- Low Carbon Transition Plan; Renewable Energy Strategy; Low Carbon Industrial Strategy; Carbon Valuation, 2009
- Building a Greener Future, 2007 (2016 Zero Carbon target)
- Code for Sustainable Homes, 2007
- Household Energy Management Strategy, 2010
- Building Regulations
  - Energy performance standards from 1960's
  - Part L, *Conservation of fuel and power*; Part F, *Ventilation*, 2006, 2010
- Full system of FITs and banded ROCs
- 'Green Deal' energy efficiency improvements in home (*via* PAYS), business and public sector buildings – successor to HEM
- Green investment Bank
- Construction Innovation & Growth Team (CIGT)

Low Carbon Construction Innovation & Growth Team

Paul Morrell
Chief Construction Adviser

- Housing
- Buildings
- Infrastructure
- Major Projects



Regulatory obligations

- **HMG is committed to an 80% reduction in carbon emissions by 2050 and 45% of all present carbon emissions come from existing buildings, with 27% from homes**
- **85% of existing buildings will still be here in 2050**
- **Standards – e.g. worst choices should be made less attractive or removed**
  - Code for Sustainable Homes, LEED, etc.
- **Obligations – e.g. mandatory emissions reduction targets**
  - **2016** – Residential new build zero carbon
  - **2019** – Commercial new build zero carbon
  - **2050** – 80% carbon impact reduction: legacy and new build

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Retrofit is the challenge

Retrofit case study: Drum Housing

6 semi-detached homes

- **Measures:**
  - Energy efficiency:
    - Cavity wall insulation
    - Loft insulation 300mm
    - Double glazed windows
    - Low-energy light bulbs
    - Draught proofing & ventilation
    - Waste water heat recovery
  - Renewables:
    - Ground source heat pumps
    - Solar Photovoltaics
- **Savings:**
  - 50% on bills (~£600pa)
  - 75% C-saving

Part of 'Generation Homes' initiative
www.generationhomes.org.uk

Cost per home £22,750 ► £10,000
(⇒ 38 ► 17 year payback)

Retrofit challenges in short 1

Issues

- ~22m homes to be retrofitted by 2050 ⇒ 1500 per day from now ‘till 2050
- £10,000 - £20,000 cost per home
- Impact of £220bn - £440bn
- Michael Kelly estimated up to £700bn
- Inhomogeneity of stock implies challenge in achieving ‘standard solutions’
- Lack of standard solutions implies difficulty in obtaining cost-down through scale

Needs

- Cooperation across the supply chain – industry association as collaborative and single-minded as SEMI
- Deployment at scale of relevant materials, components and systems
- Skills to install

Retrofit challenges in short 2

Some new technologies needed

- High performance insulation
- Advanced intelligent controls
- Thermal energy storage systems (with solar-thermal)

But:

Opportunities in:

- Development of manufacturing capability and fitting know-how
- Up-skilling and jobs
- Export as well as indigenous markets

Local and national challenges

Economic and business models

- 2050 sets an unprecedented challenge. Who will bear retrofit cost? Payback may be of the order of 15+ years
- New financing structures need to be designed and implemented

Skills development

- 85% of building contractors 4 staff or less
- Specialist capability needed to achieve building performance
- Familiarisation and training challenge – role for KTPs?

Assuring predicted energy performance is being achieved

- Large-scale, statistically valid demonstrators are required
- Comprehensive, ubiquitous energy loss monitoring
- Precision energy auditing to assure payback for the finance providers

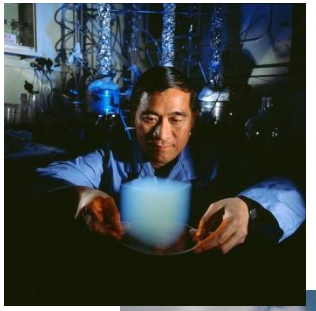
New service business models centred on optimising building energy

- Retrofit finance – Pay As You Save (PAYS)
- Real-time optimised building control based on server farms

Key Technologies

Materials

- Insulative (e.g. vacuum-aerogels)
- Thermal mass and phase-change heat storage (PCM)
- Advanced functional – PV coatings, thermo-electric, etc.



Energy conversion

- Solar thermal for heating and cooling (absorption cycle)
- Photovoltaic: Si, CdTe → Polymer → Biotechnology
- Wind turbines: microgeneration (district, rural)
- Heat pumps: refrigeration cycle and advanced Peltier
- Biomass combustion from renewable sources

ICT, including Control & Instrumentation

- Energy scheduling from multiple local and network sources
- Active zone control in buildings – condition only where needed
- ‘Network control’ of individual appliances
- Intelligent, self-learning controls operating holistically

Design in Architecture

Situational design

- Orientation for optimum solar energy utilisation

Facades

- Green facades
- Controlled shades
- Functional design, e.g. photovoltaic

Natural ventilation and air conditioning

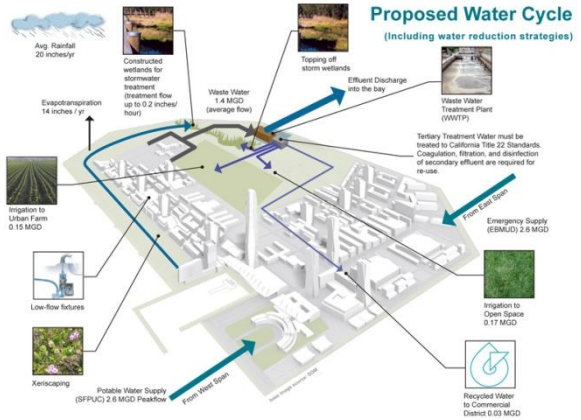
- Roof cowls

Natural & high-efficiency lighting

- ‘Ducted’ light
- Electro/Thermo-chromic glass
- Electronic ballast compact fluorescent and LED technologies

City-level integrated design

- Air flow and light optimisation
- Carbon footprint minimisation – systems view of heating and cooling requirements



Thames Gateway Institute for Sustainability

"Our vision is to significantly advance the UK's capability to deliver solutions for a sustainable future, by forging practical research collaborations and sharing the outcomes regionally, nationally and internationally"

A charitable company, majority private sector controlled, set up to promote practical research supporting delivery of sustainability to communities and businesses

Collaboration of world class commercial and academic partners

Strong links with a sister Institute in Shanghai

Board of 13 made up of 7 private sector and 6 public sector / academic individuals

Interventions: EU

Framework 7 and the European Construction Technology Platform (ECTP)

- FP7 is technology-aligned
- Challenges are orthogonal to technologies, crossing many
- ECTP maps built environment challenges to FP7 themes

Energy Efficient Buildings PPP

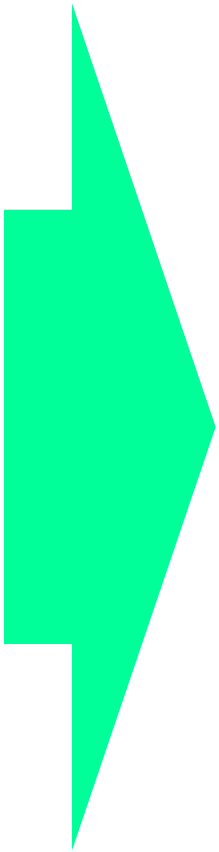
- €2bn over 10 years; €500m earmarked now, €65m first call
- 50% government funding
- Focus on social housing and public buildings
- Ring-fenced FP7 funding
- Arup holds only UK board position on governing body on behalf of DBIS

Summary points for the built environment

- Retrofit is the big challenge
- Need systems thinking, international collaboration
- Cross-disciplinary research: Behaviour, design, regulation, technology
- Value Mapping and strategic procurement to create capability and business direction
- Need skills development at scale – role of HEIs, Third Sector and KTPs

Where could we be heading?

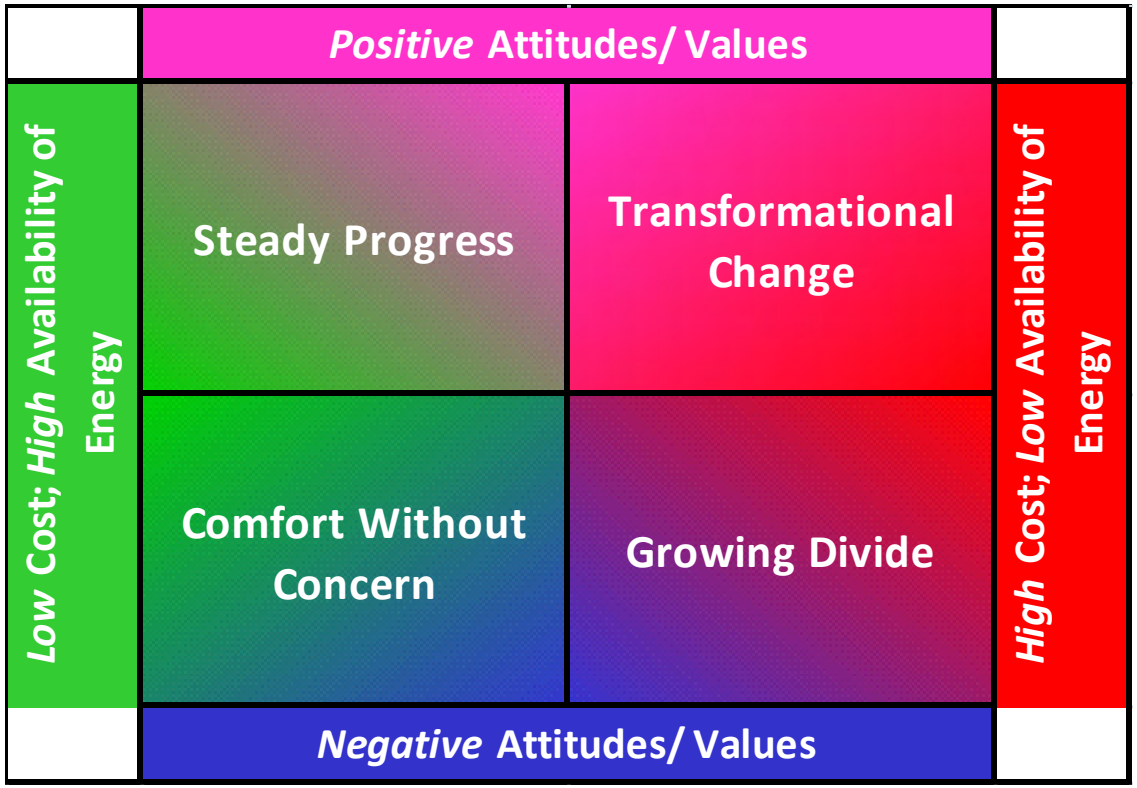
- **Overpopulation**
- **Environmental perturbation**
  - CO_2 ramping up – extreme weather
  - Sea level rise
- **Resource shortages**
  - Strategic materials
  - Food
  - Water
- **Energy shortages**
  - Need balanced generation portfolio – nuclear & renewables
  - Advanced energy-saving measures
- **Loss of coastal and estuarine land**



- **Reduced/inequable standards of living, health and well-being**
- **Increasing costs of goods**
- **Loss of capability**
- **Economic and social unrest**
- **Population displacement**

Cambridge EEBE group scenarios

- 2 critical/ pivotal uncertainties identified
- Narrative descriptions of 4 scenarios



Cambridge EEBE group scenarios

Robust Strategies for Energy Generation and Consumption

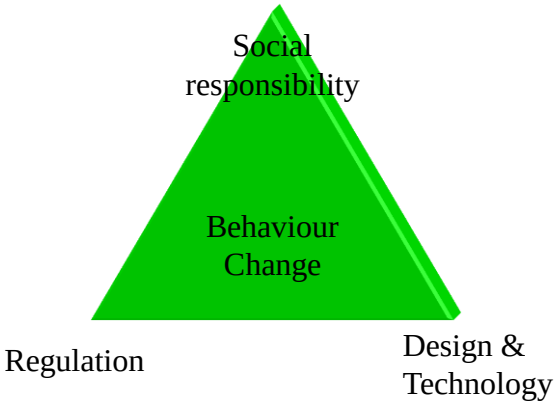
- Significant increase in renewable generation, meeting 25% - 50% of demand by 2050.
- Over 50% of energy consumption is met by importing energy generated abroad.
- Energy storage, such as improved batteries, and smart grids are important innovations.
- The carbon intensity of energy supplied to buildings is significantly reduced.
- Indoor environments to be more closely and strictly controlled.
- New strategies will be introduced through retrofit rather than new development.

Drivers and Trends: Social & Behavioural

- **Resistance to change**
  - "I won't reduce my water use until London Water repairs all the leaks"
  - "No-one will tell me how to behave in my own life/ home/ territory"

- **Green electricity tariffs - (FITS)**
  - Social norms are weak
  - Institutional support is at an early stage
  - Information is not widely available

- **Make it part of personal identity**
  - Social obligation: c.f. drinking and driving
  - Fashion: 'doing the cool thing'
  - Social comparisons & role models



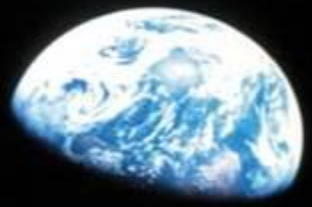
New ideas

- **Hyperautomation and manufacture close to point of consumption**
  - Move from human labour to automated production
  - Manufacturing in first-world economies cost-effective again
  - Minimise impact and cost of extended logistic chains
- **Pervasive ‘Systems View’ of design and engineering**
  - Particularly in large, complex systems like cities
  - Design process should look for synergies
- **Service models rather than consumption**
  - High quality, long-life goods provided under serviced contract
  - Analogies in the aero-engine business
- **New work/life models**

Built environment in the 22nd century

- High density, low rise, mixed use, ‘walkable’
- District-level thermal and electrical energy from waste and renewables
- De-carbonised electricity grid – nuclear and large-scale renewables, with distributed energy storage
- Water recycling and re-use; local high-intensity horticulture
- Local, hyper-automated manufacture of consumables, including food
- Service provision in place of capital consumer goods
- Adapted dietary habits and food requirements
- Reduced population, post demographic bulge, pervasive behaviour change
- New work styles enabled by ultra-high bandwidth ICT

Climate Change:
a Critical Driver for Policy and Practice in the Built Environment



Thank you for your attention

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