

Technologies for Stabilizing Climate Change

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Which world
do we want?

The future is always present, as a promise and a lure.

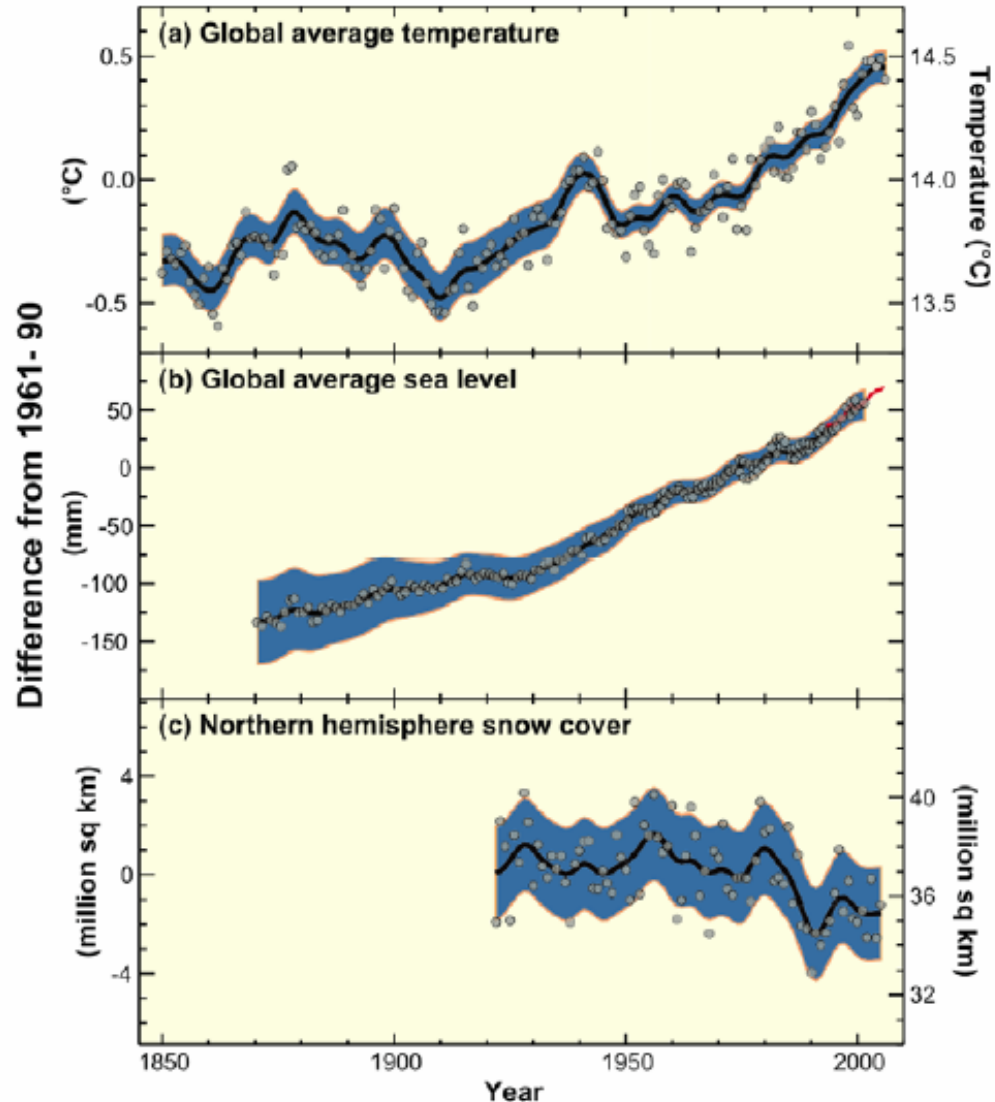
Karl Popper

Global Energy Challenges

- Access to modern forms of energy (a prerequisite for reaching MDGs)
- Growing demand for *energy services*
- Security and reliability of systems
- Deep CO₂ and GHG reductions
- Investment in RD&D and diffusion

Observed Climate Changes

Surface temperature, sea level and snow cover



INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)



WMO

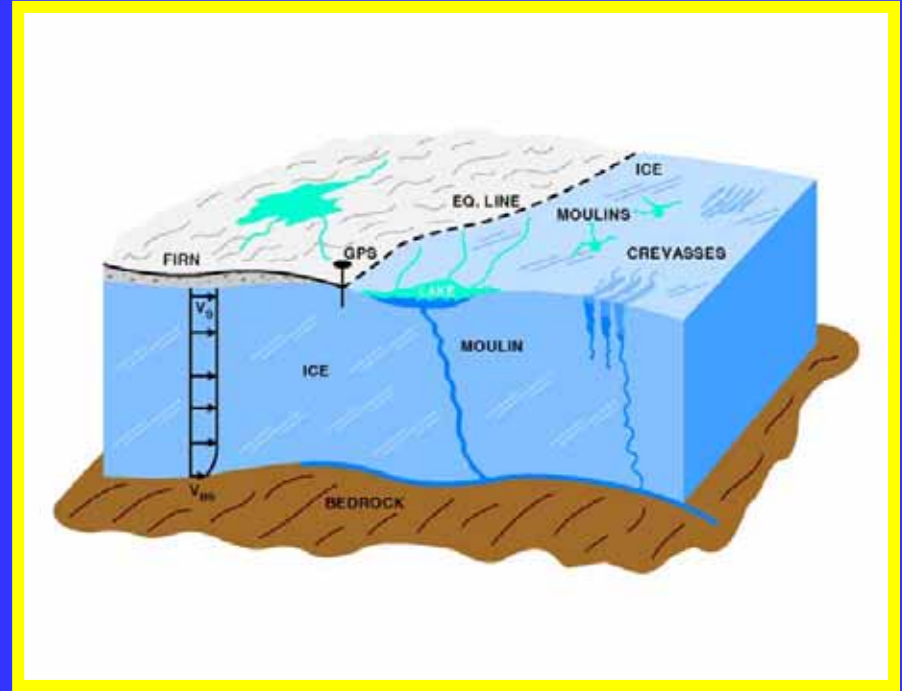


UNEP

Meltwater Flowing into a Moulin



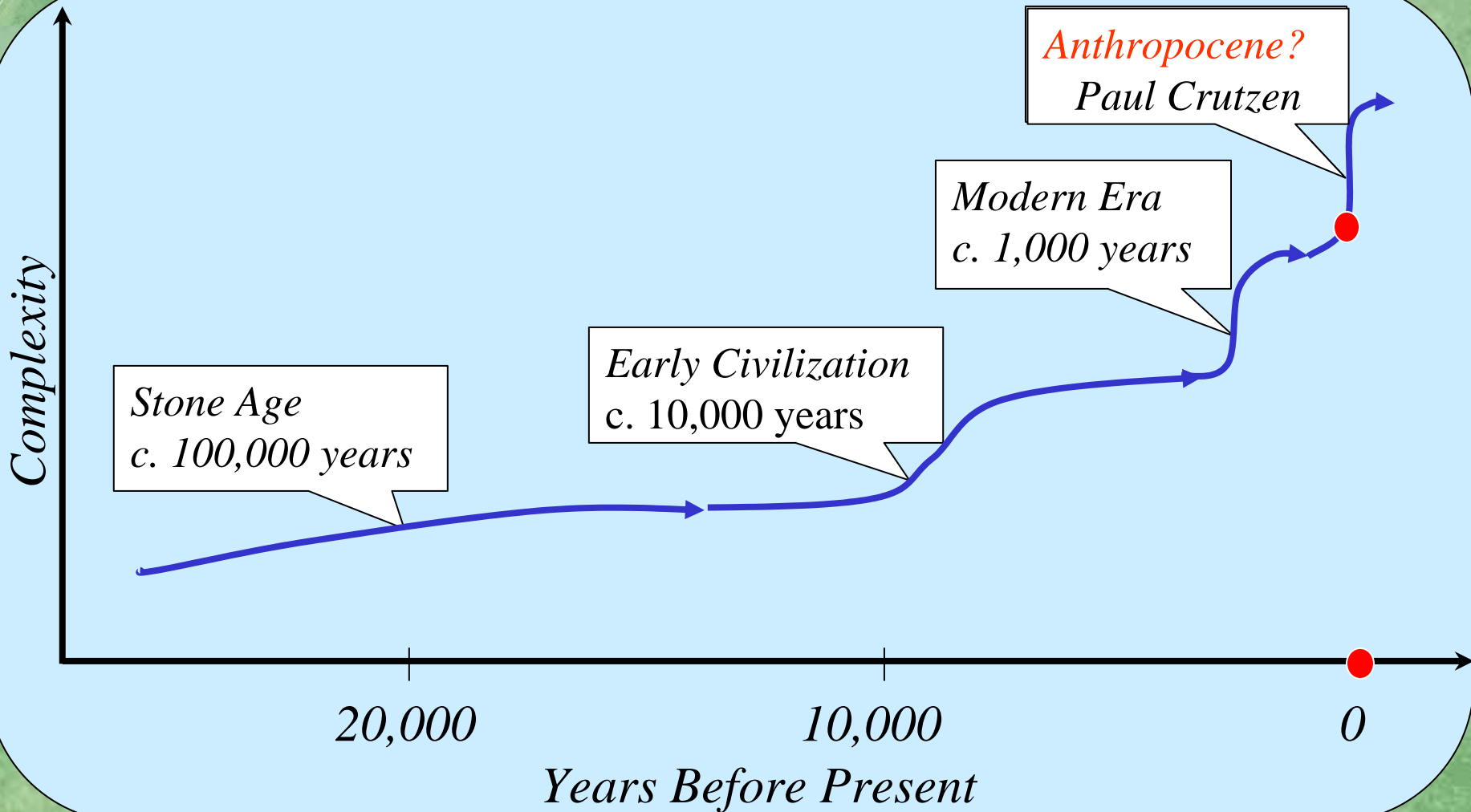
Nakicenovic



Meltwater stream flowing into a large moulin in the ablation zone (area below the equilibrium line) of the Greenland ice sheet.

Source: Roger J. Braithwaite, The University of Manchester, UK

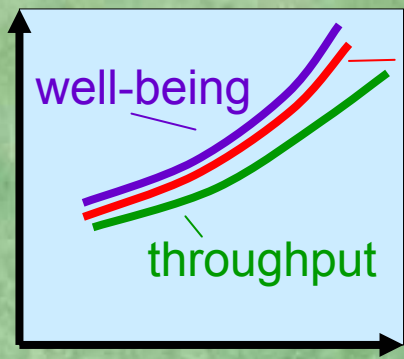
Historical Transitions



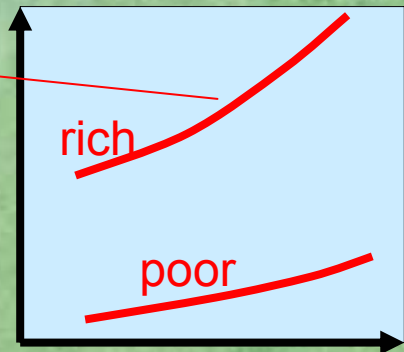


Tools for Transitions

Market Forces



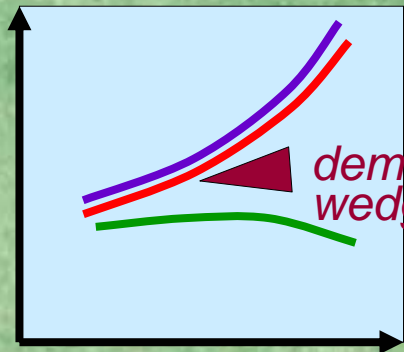
consumption



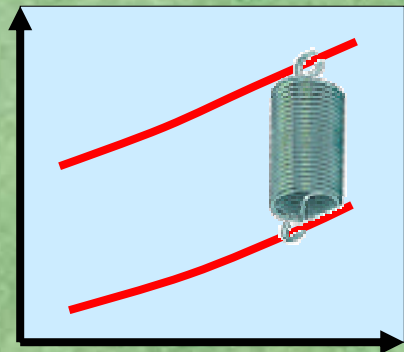
rich

poor

Policy Reform

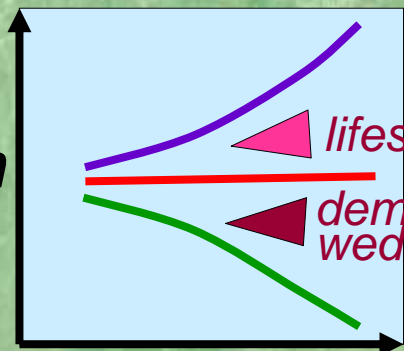


dematerialization wedge



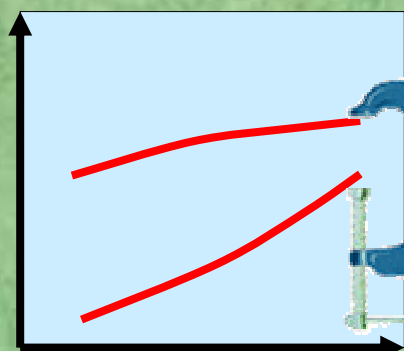
poverty spring

Great Transition



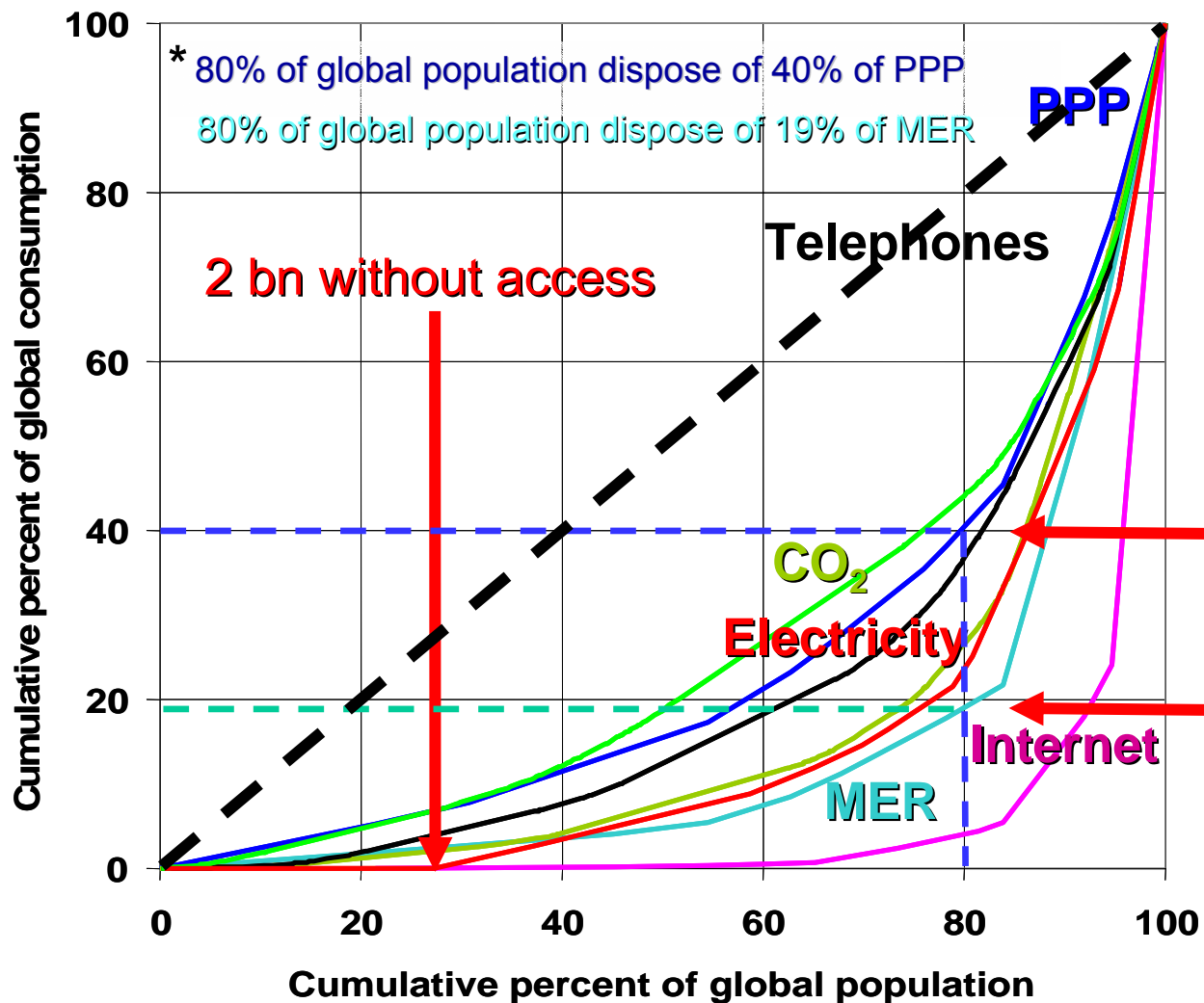
lifestyle wedge

dematerialization wedge

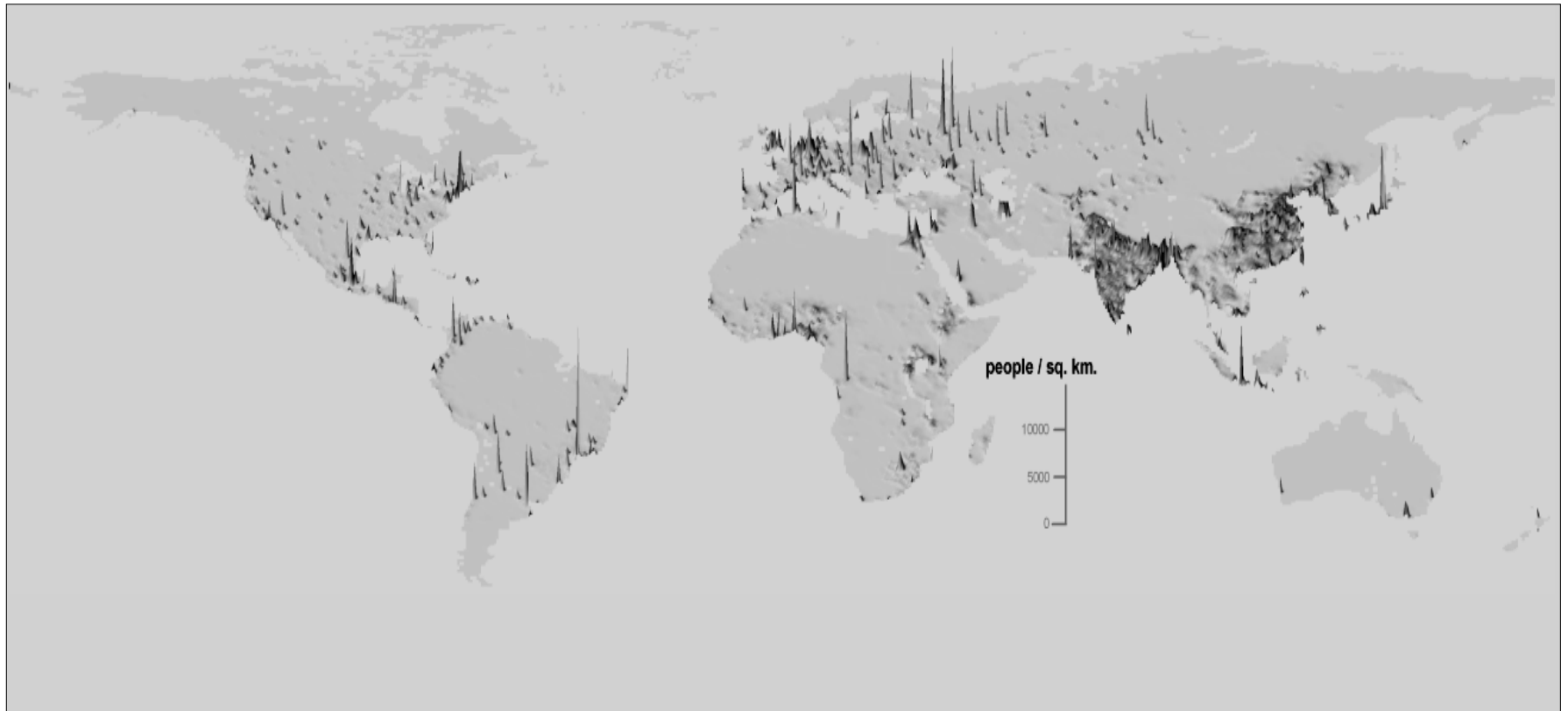


equity clamp

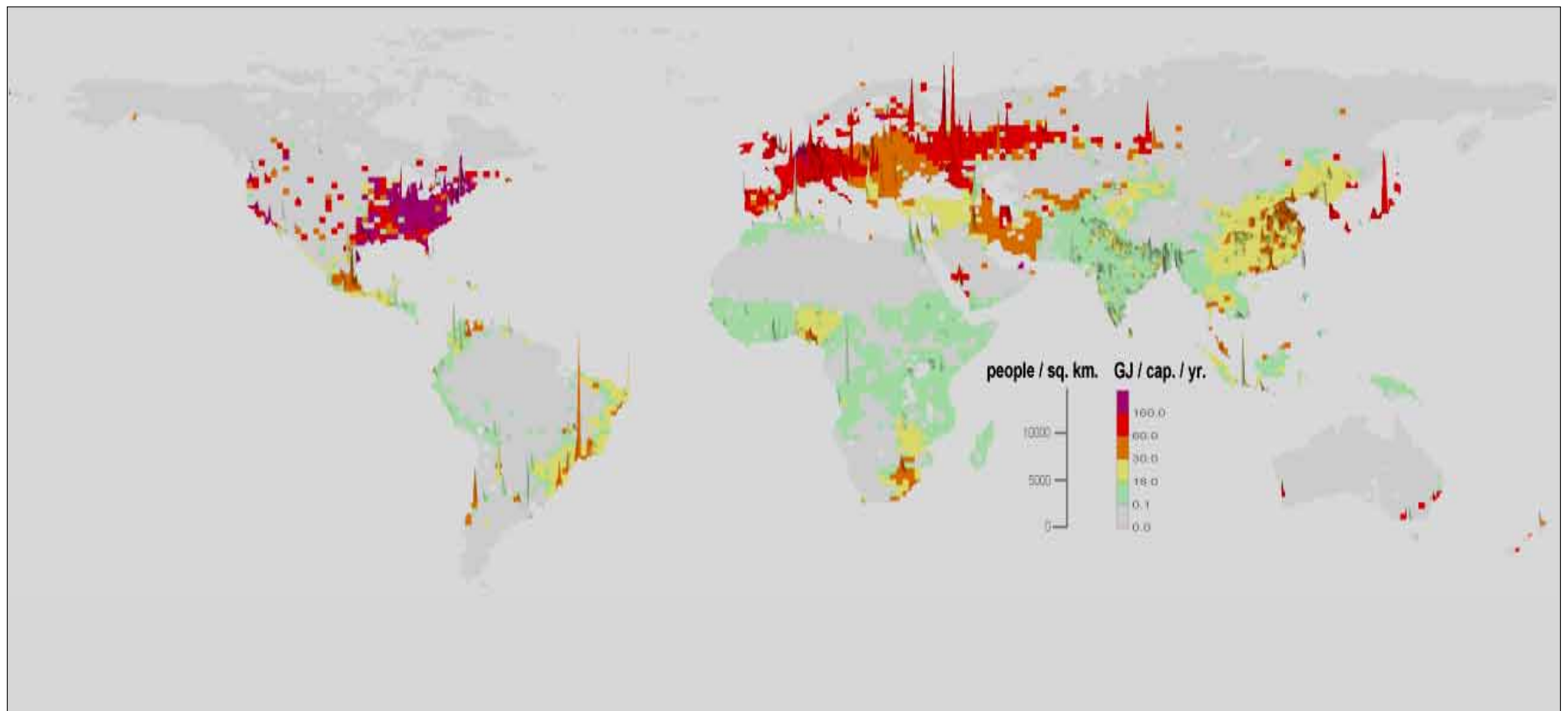
Global Disparities



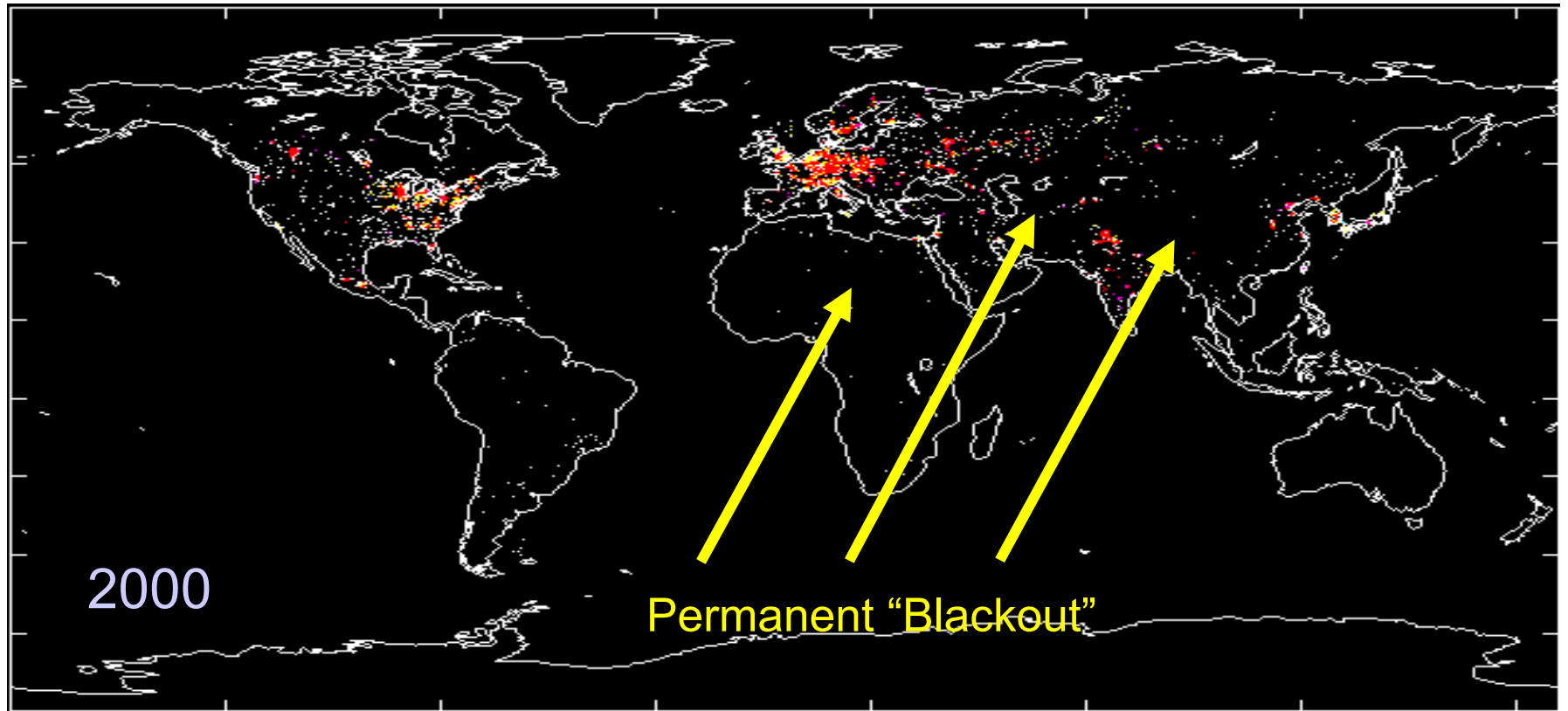
Global Population



Global Final Energy

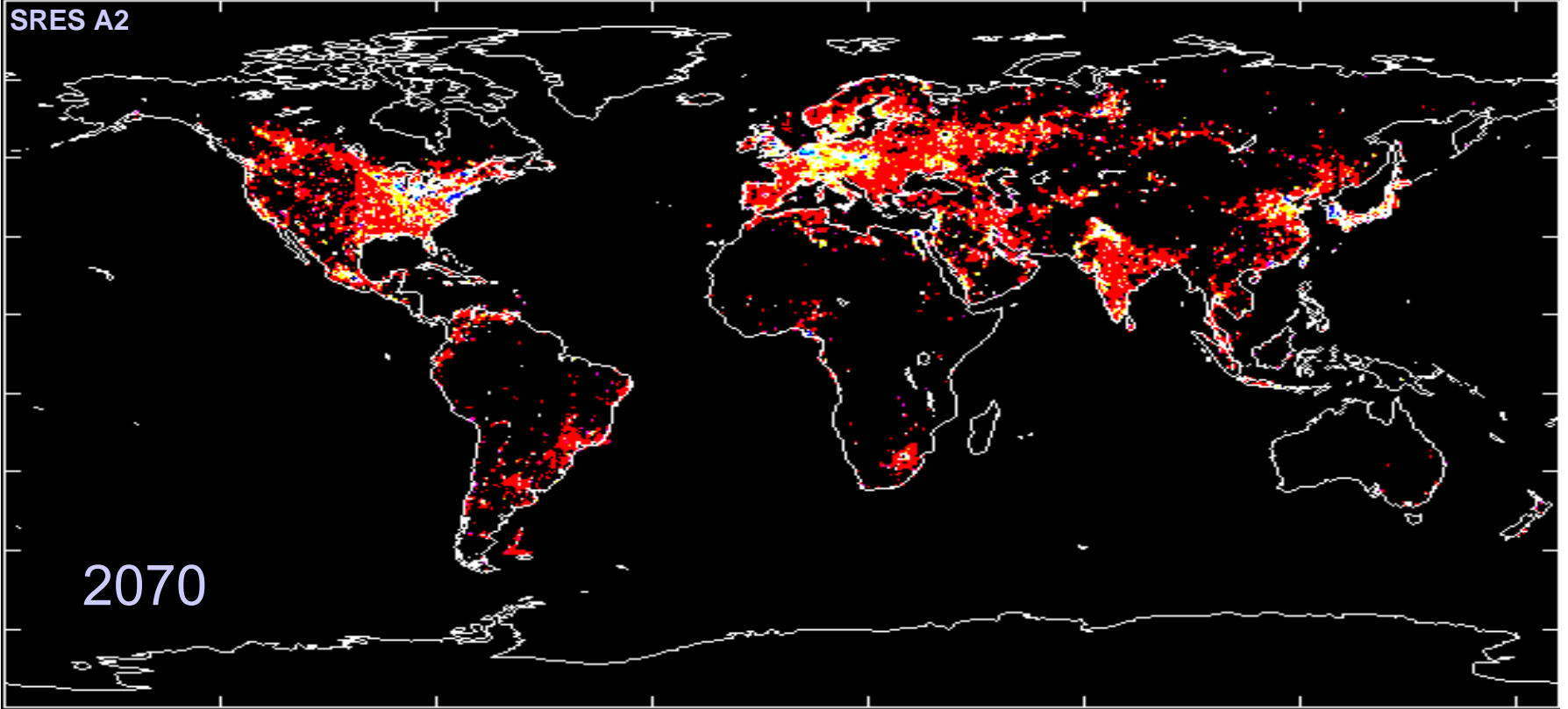


Night Lights



Night Lights

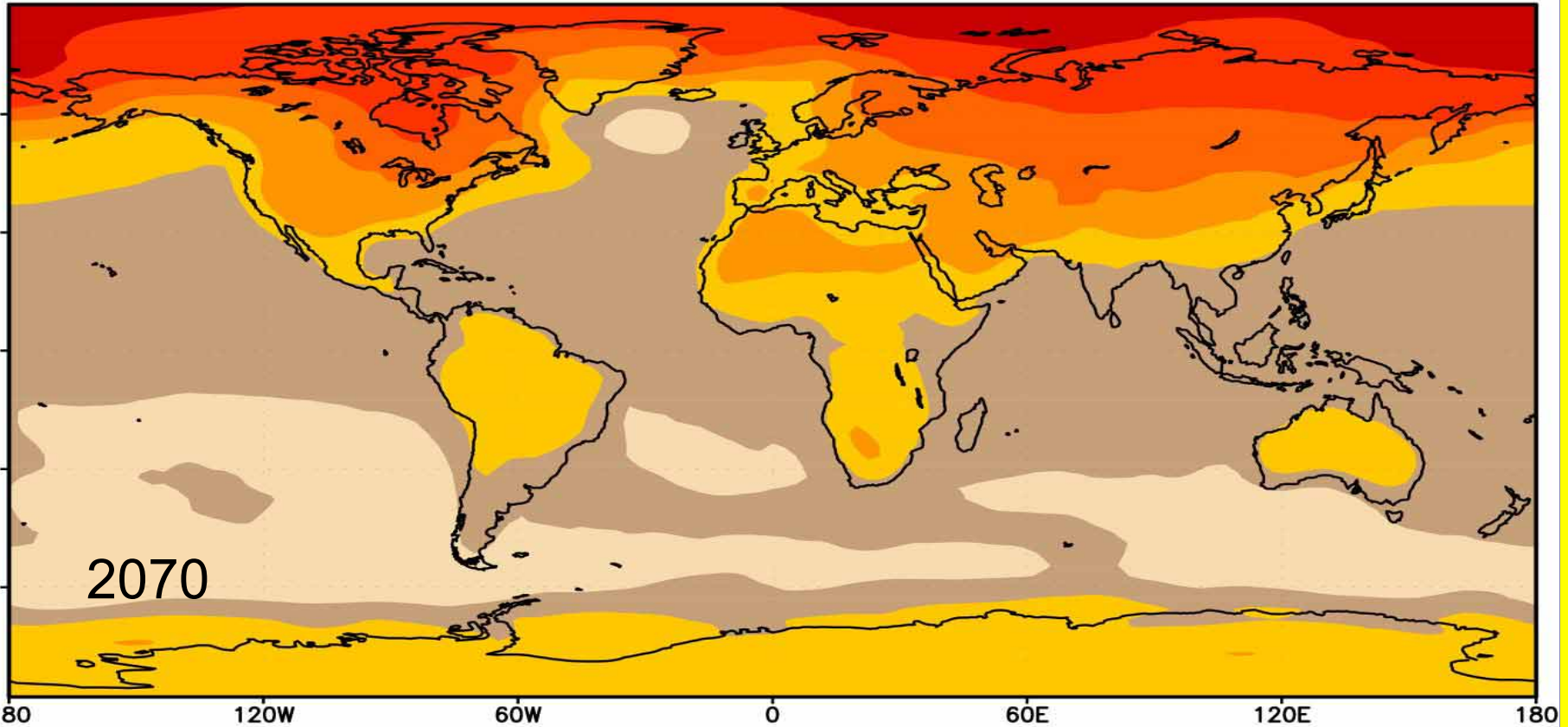
SRES A2



2070

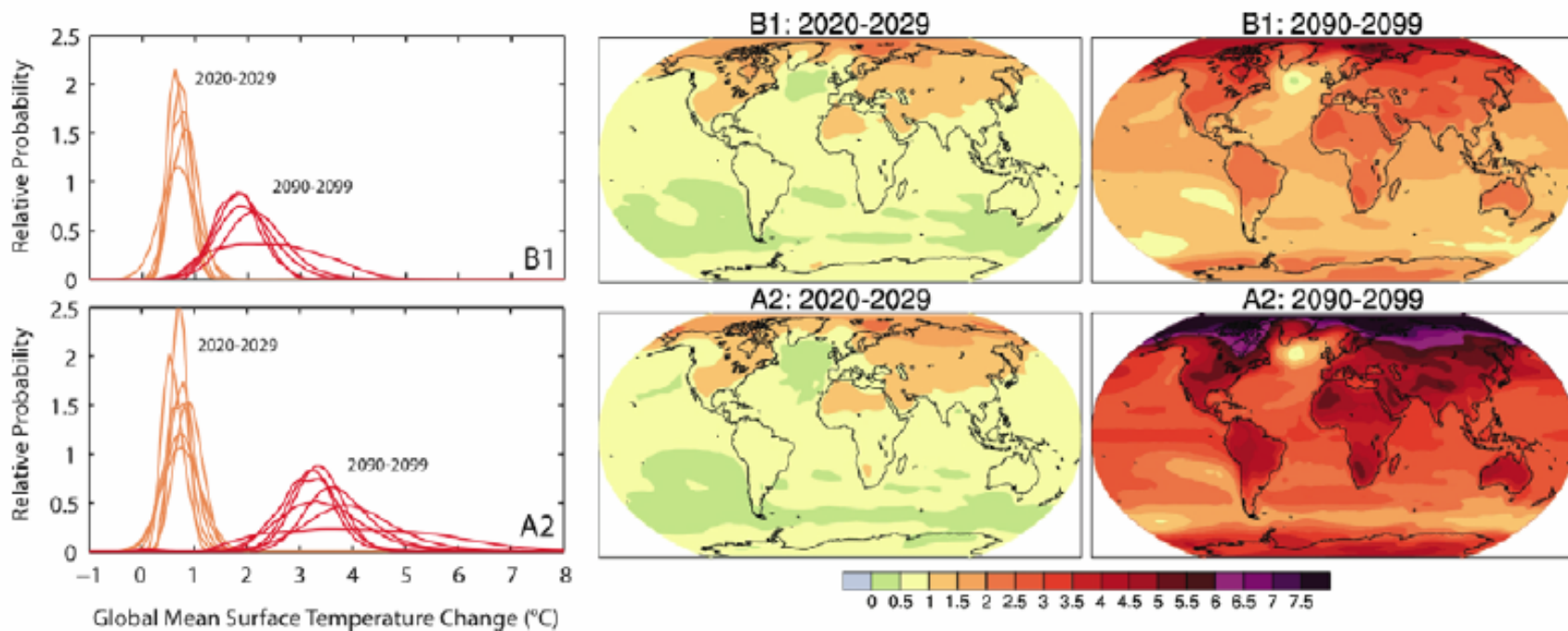
Δ Temperature

SRES A2

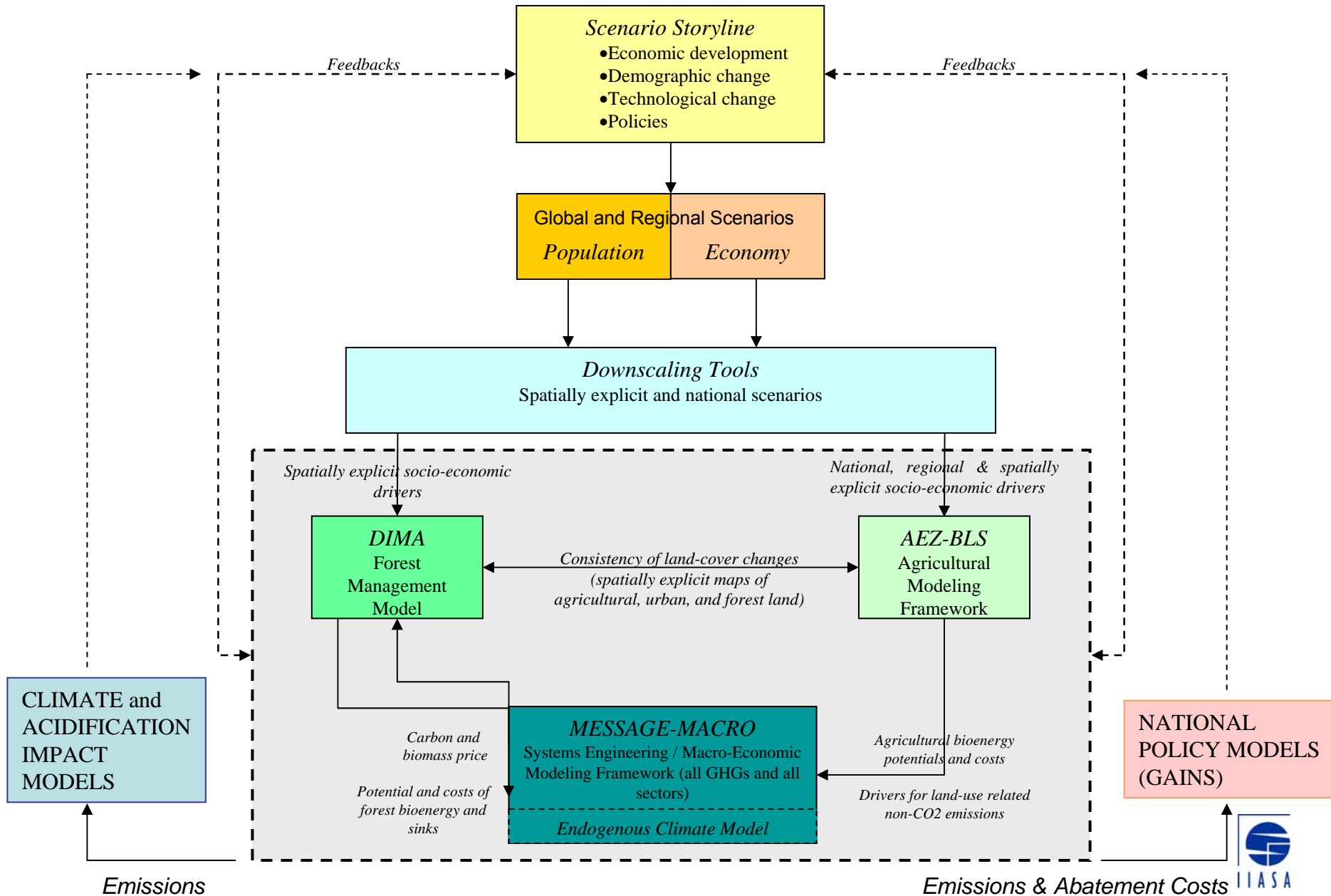


Surface Temperature Change

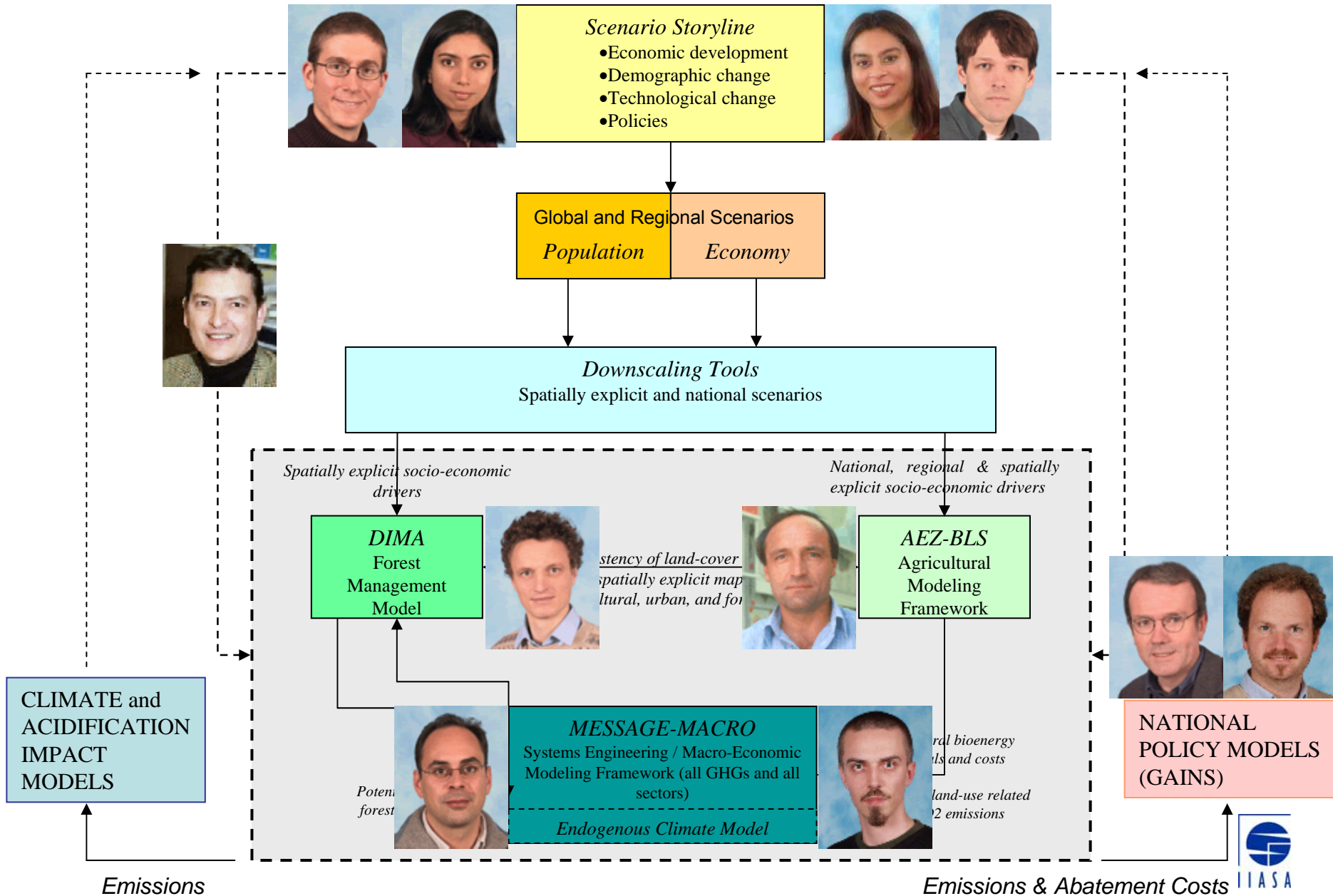
AOGCM projections for illustrative SRES scenarios



Integrated Assessment Framework



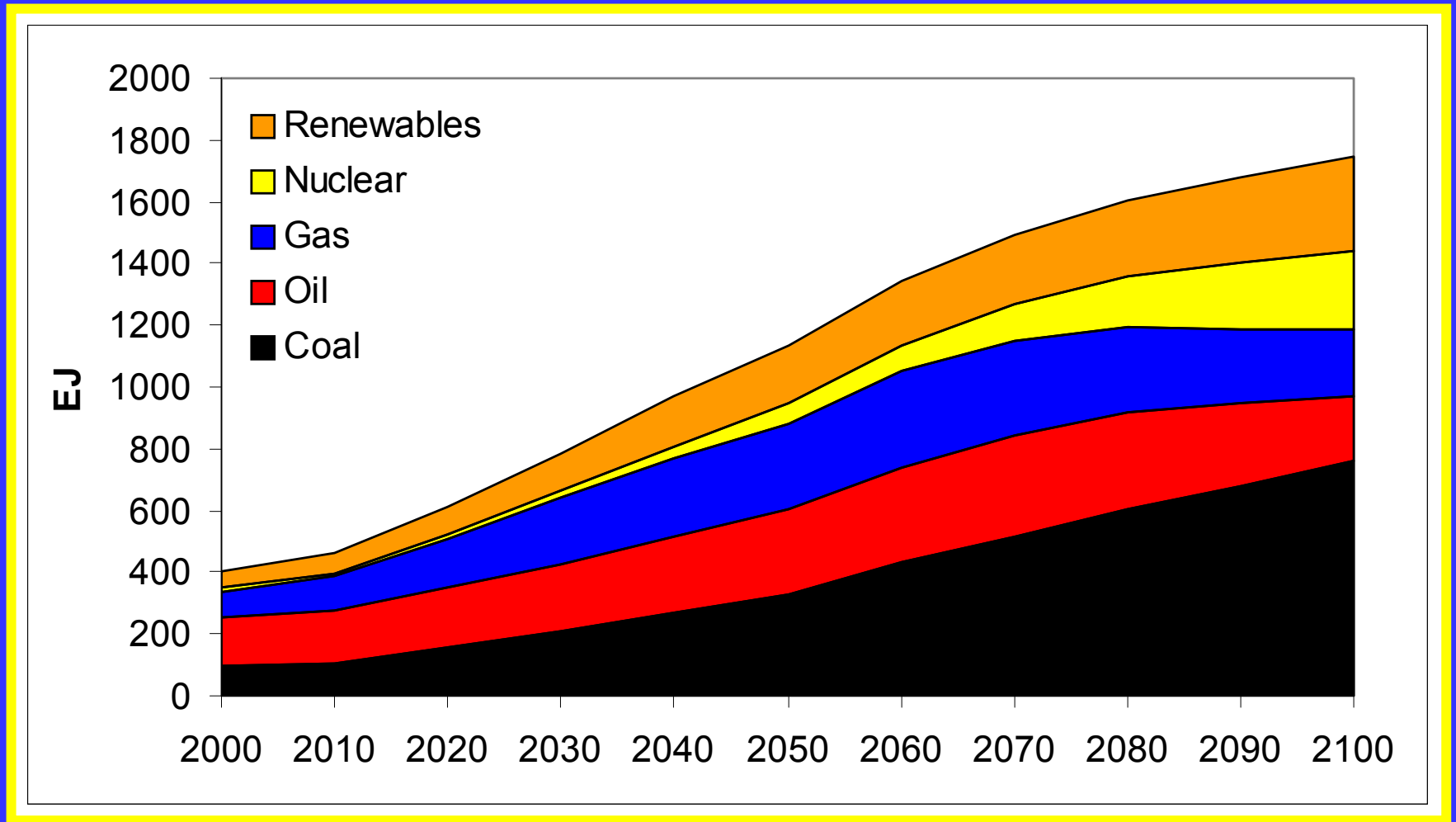
Integrated Assessment Framework



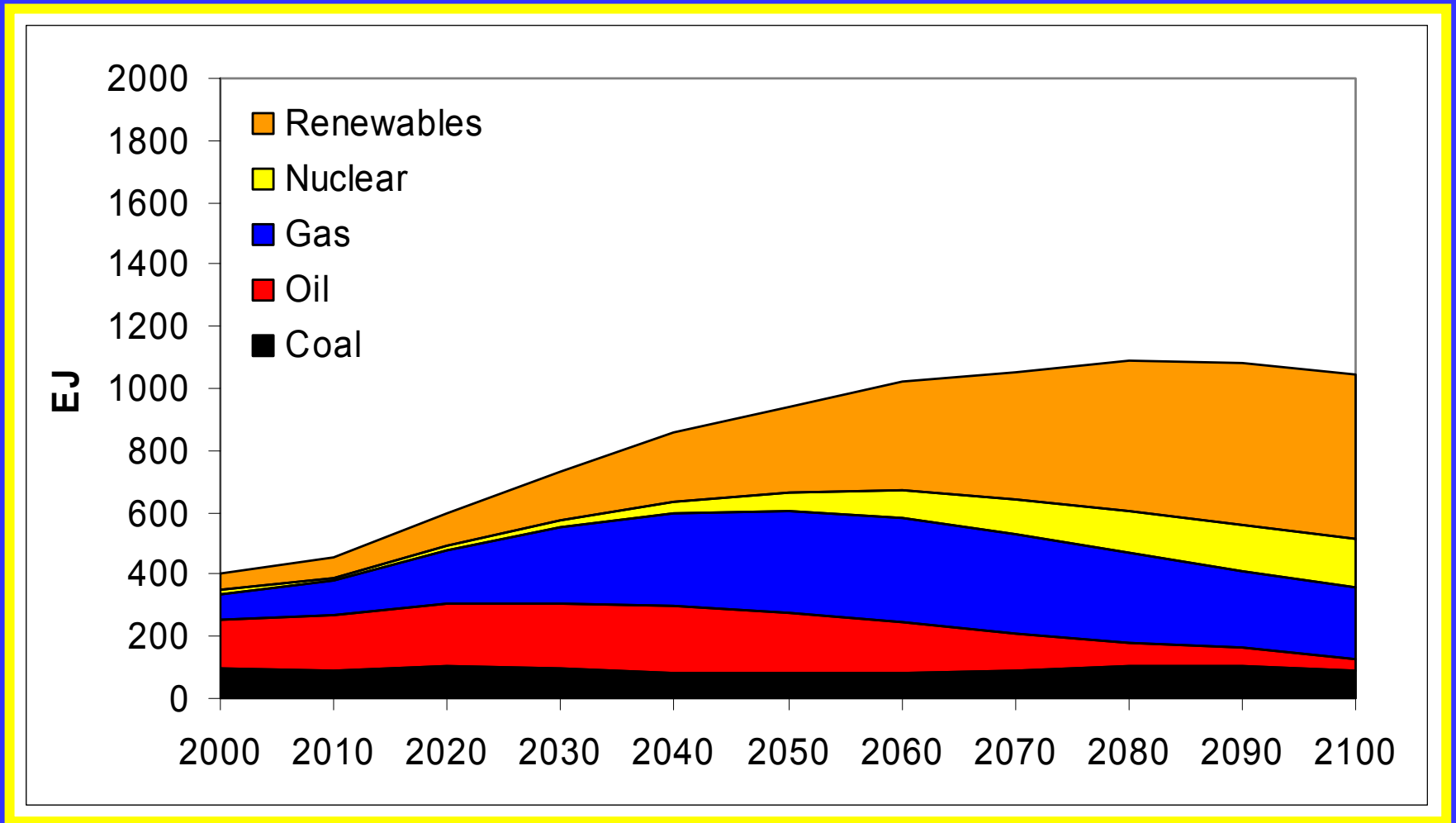
What's New?

- New demographic perspectives (lowering of “high” population projections)
- Low (EU) targets included (20% by 2020)
- Consistent multi-gas multi-sector analysis (land-use conflicts, impacts,..)
- New technological options included (e.g. biomass, CCS, hydrates, hydrogen)
- Assessment of impacts (climate AND mitigation)
- “Downscaling”: spatially explicit scenario indicators available (POP, GDP, FE)
- Linkage to national policy frameworks (GAINS)

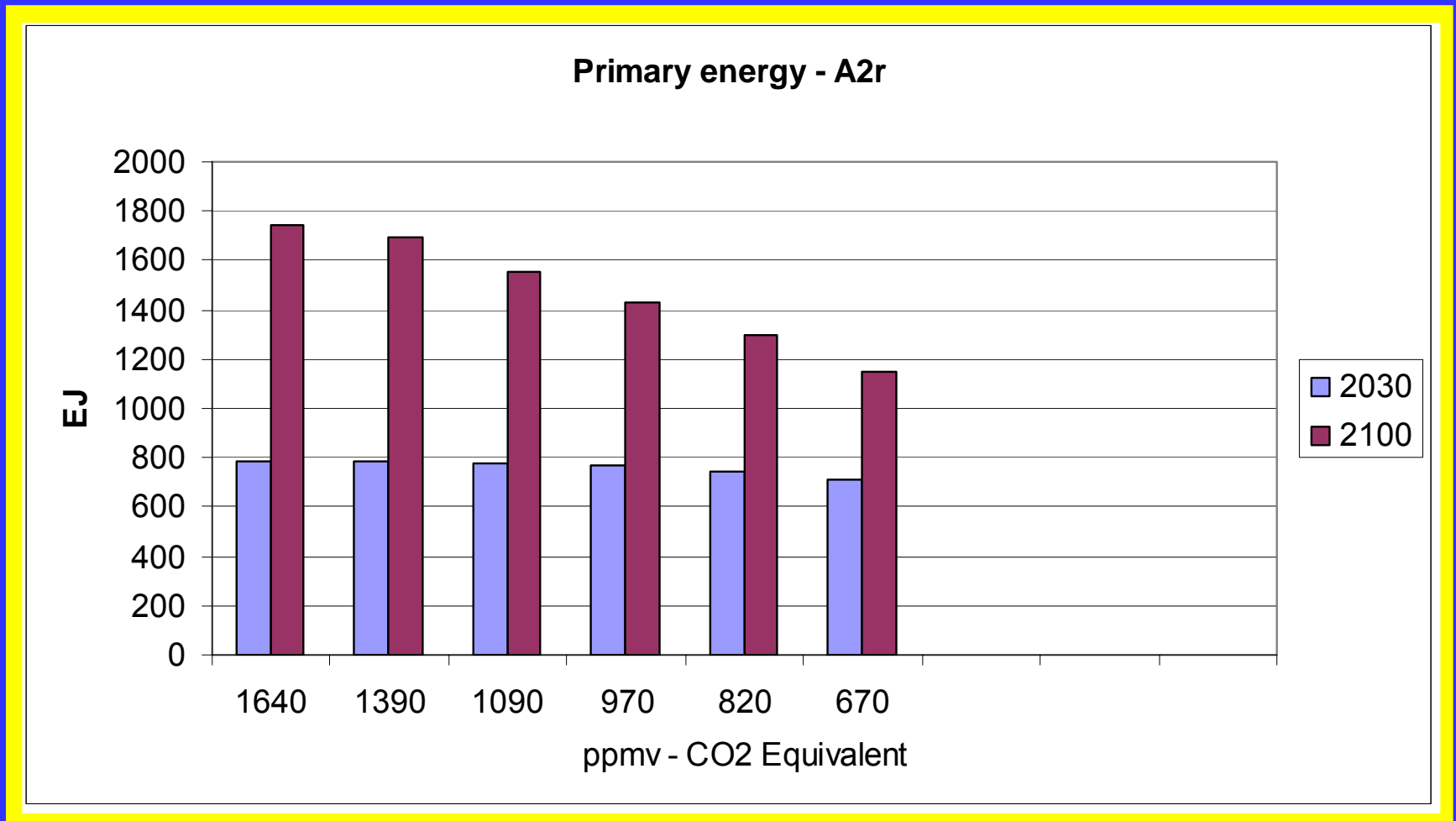
Global Primary Energy – A2r



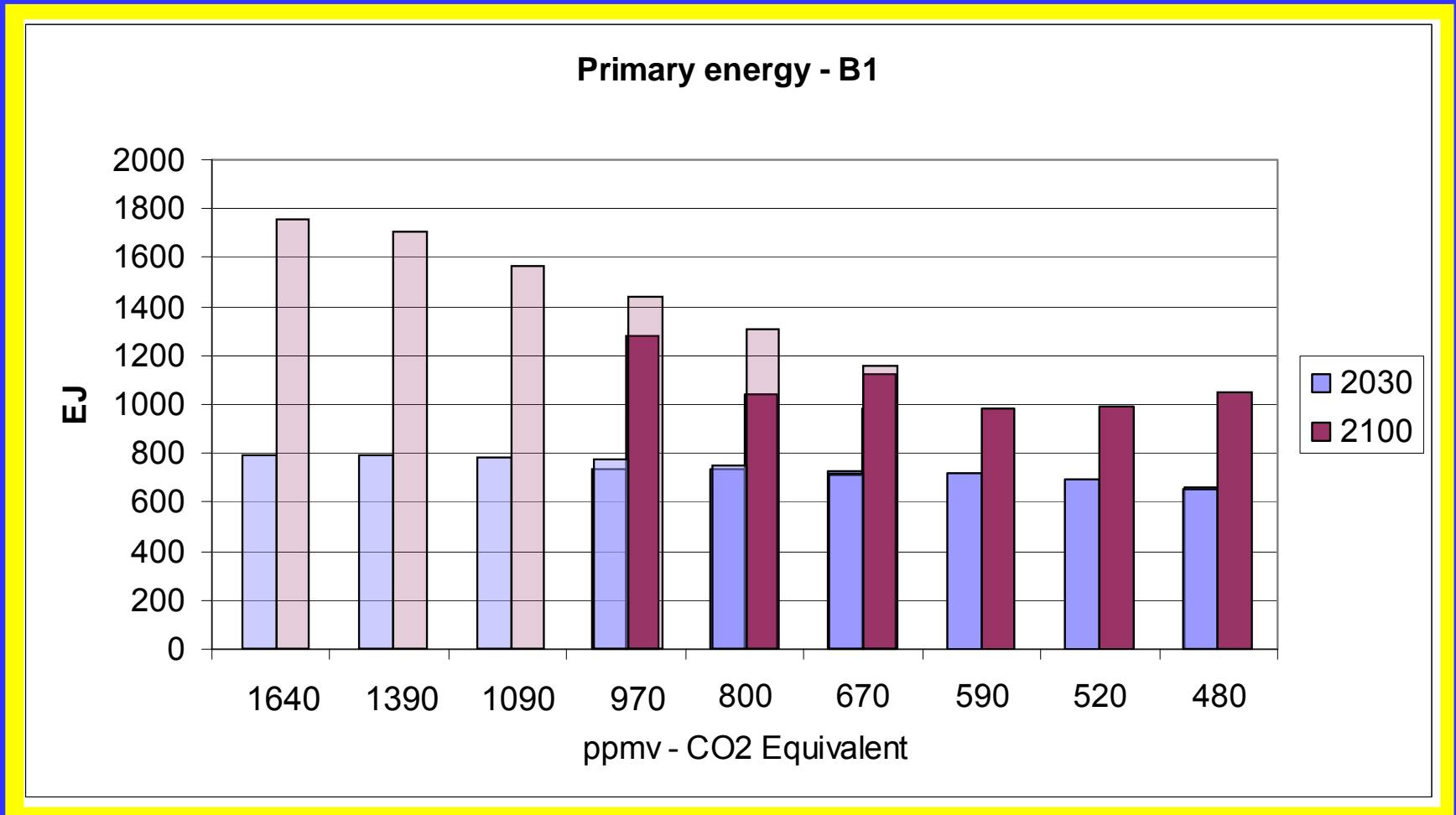
Global Primary Energy – B1



Primary Energy in A2r

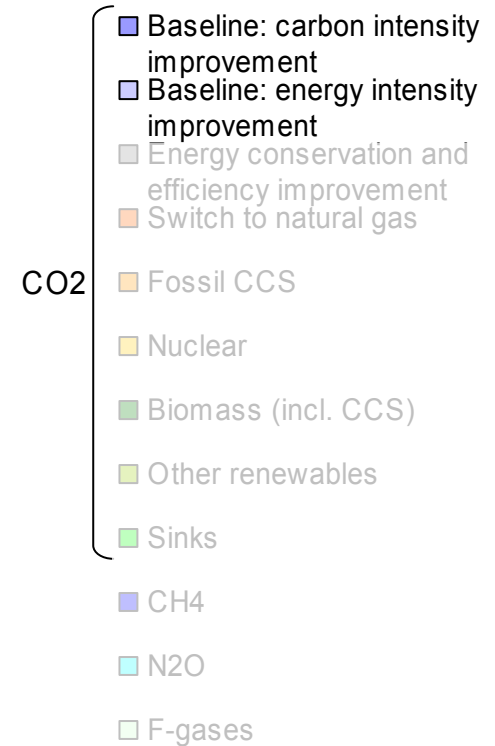
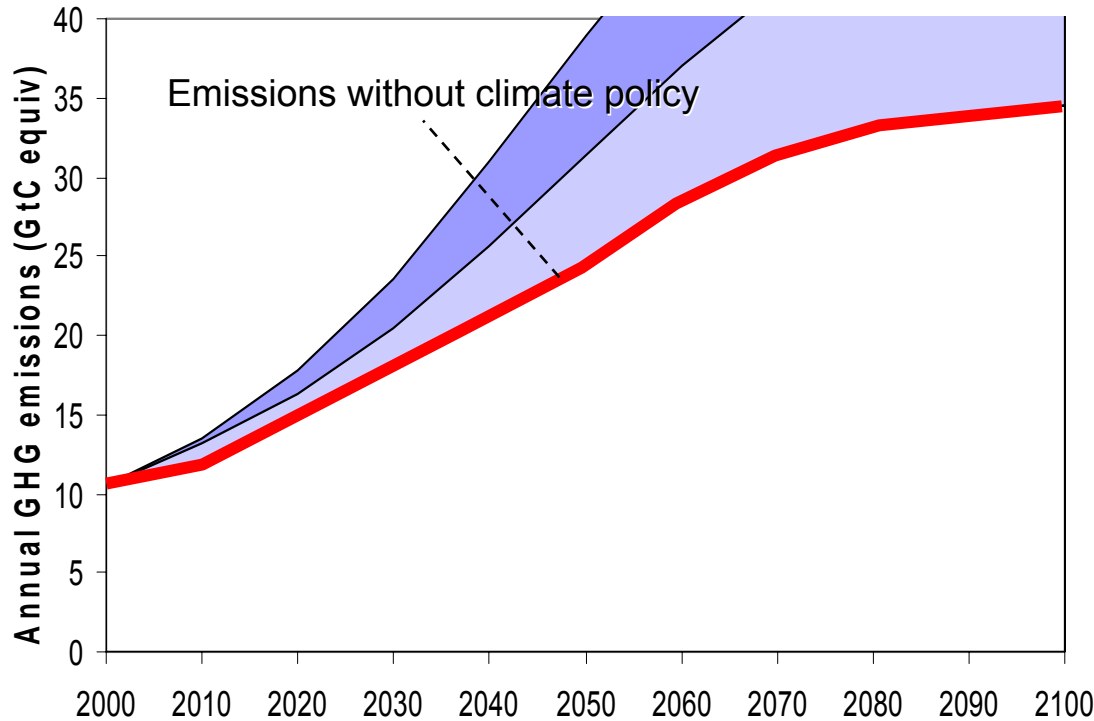


Primary Energy in B1r



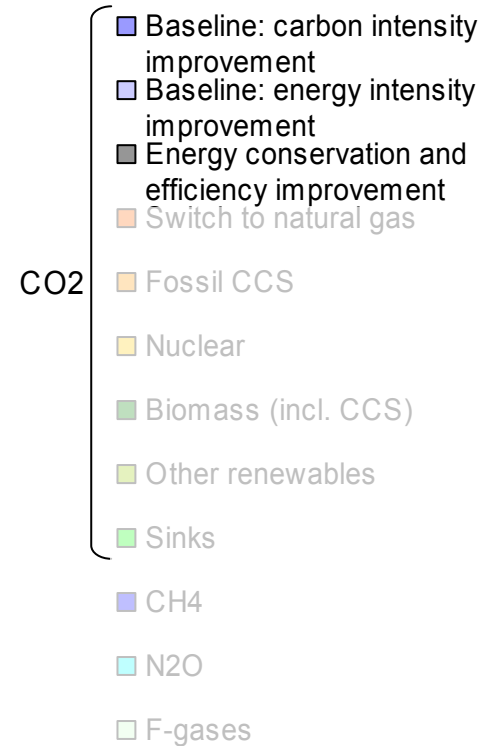
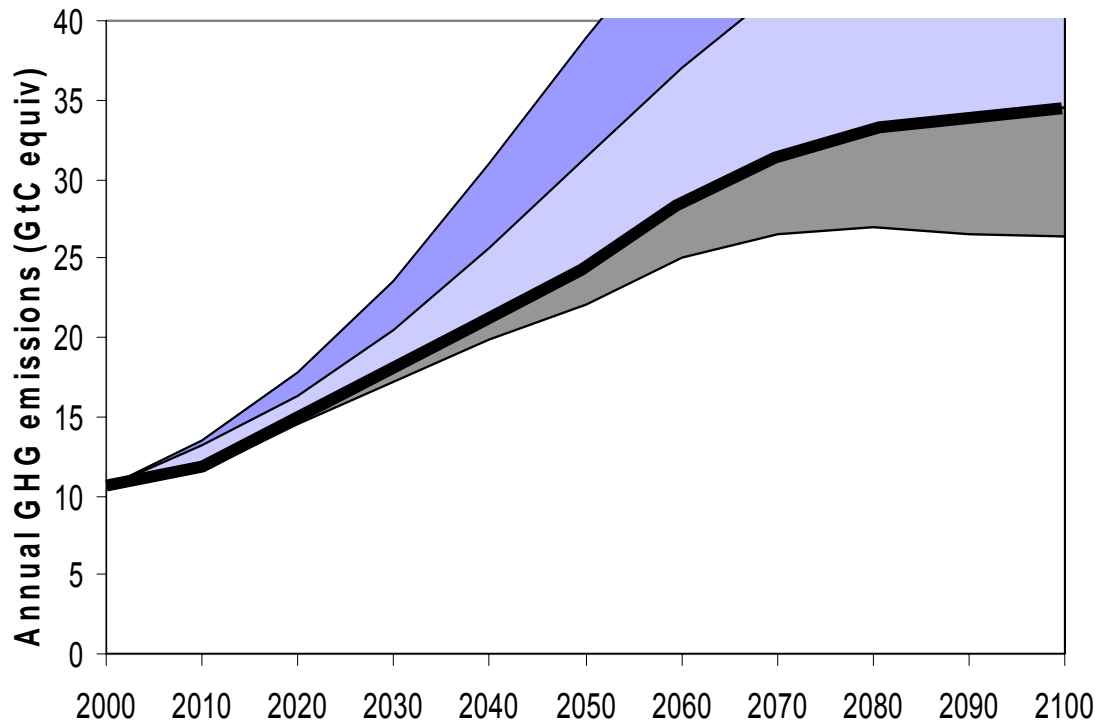
World GHG Emissions

IIASA A2r Scenario



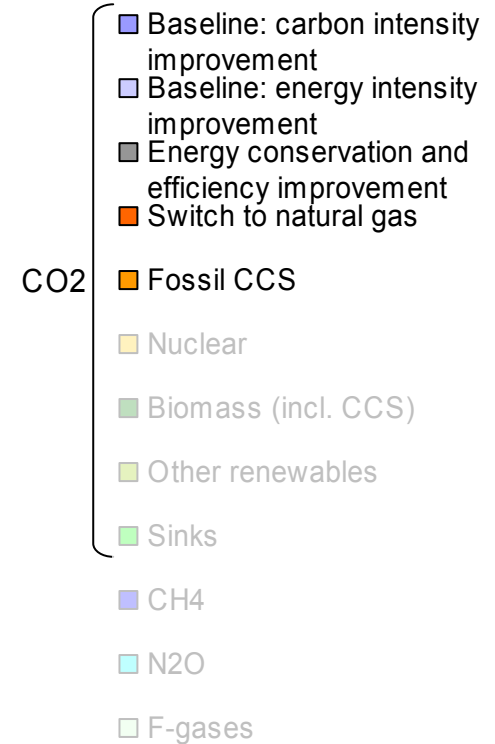
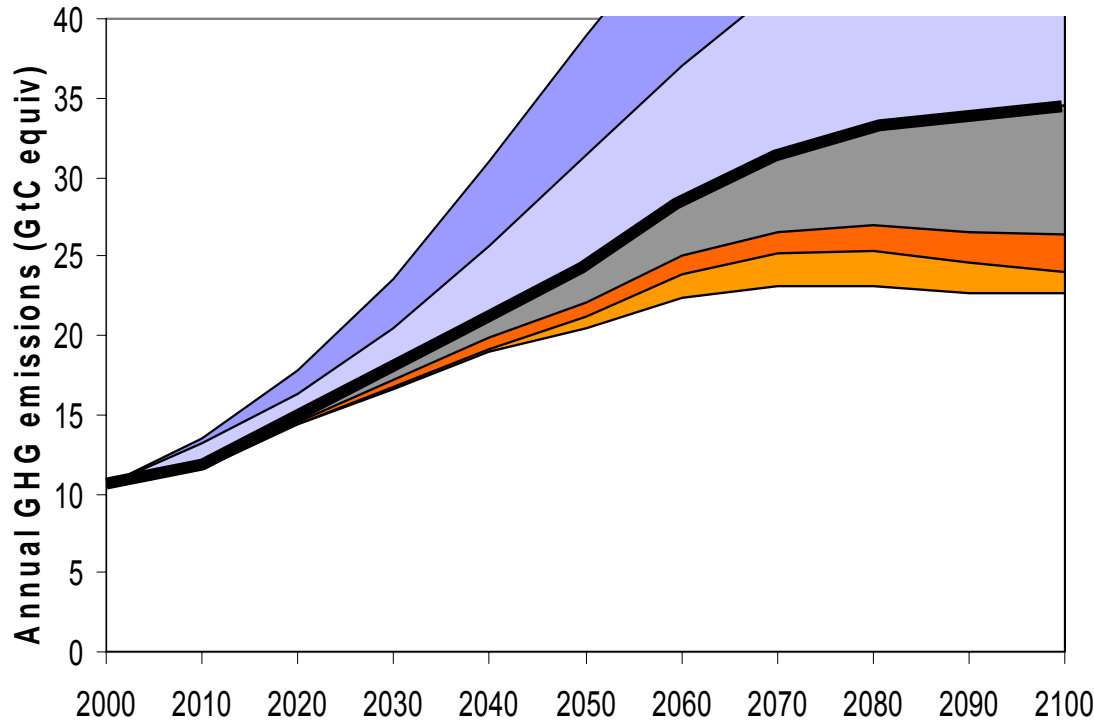
World GHG Emissions

IIASA A2r Scenario



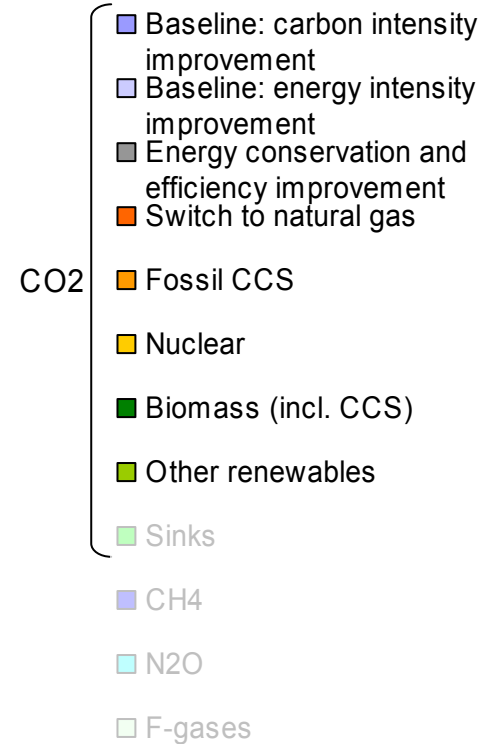
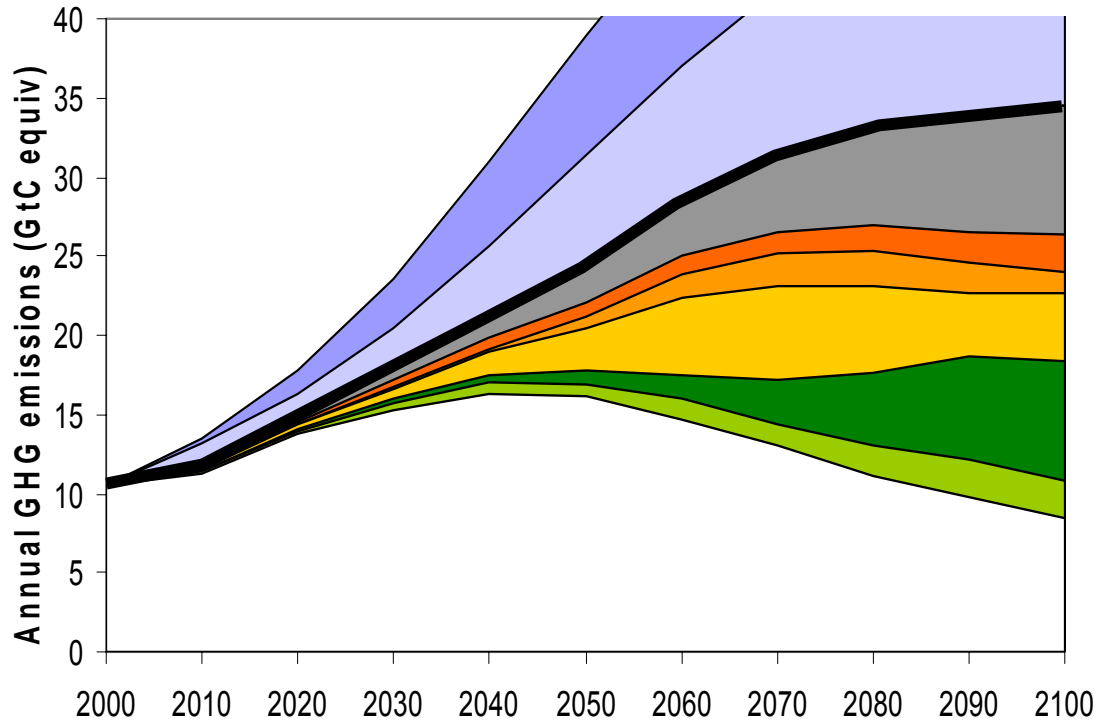
World GHG Emissions

IIASA A2r Scenario



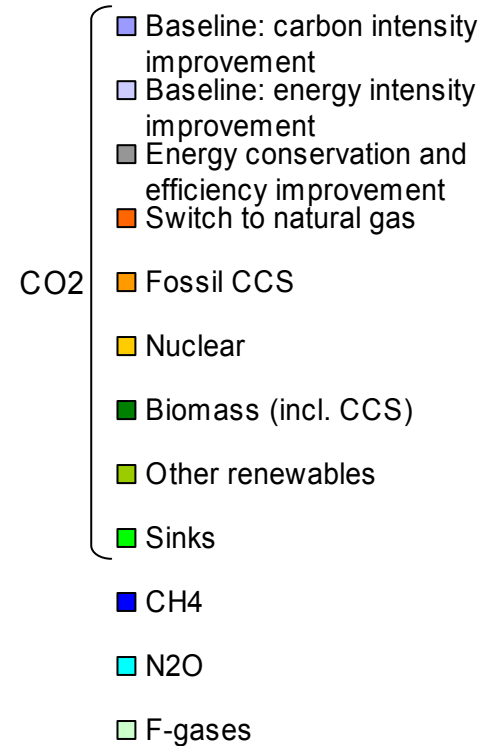
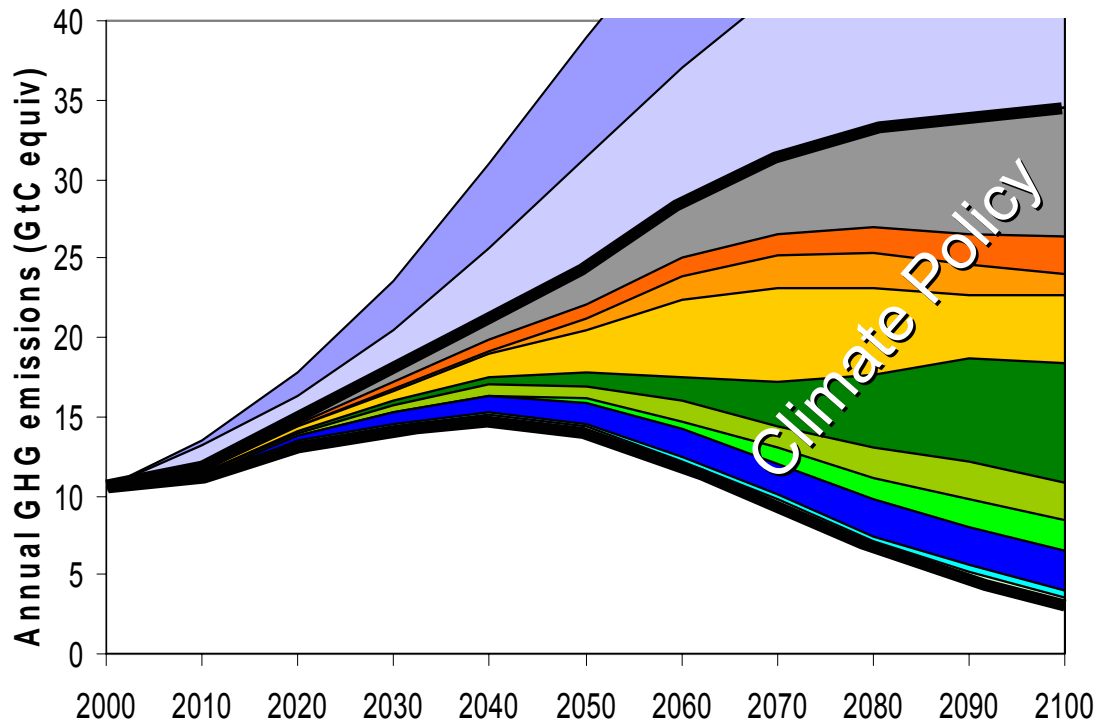
World GHG Emissions

IIASA A2r Scenario



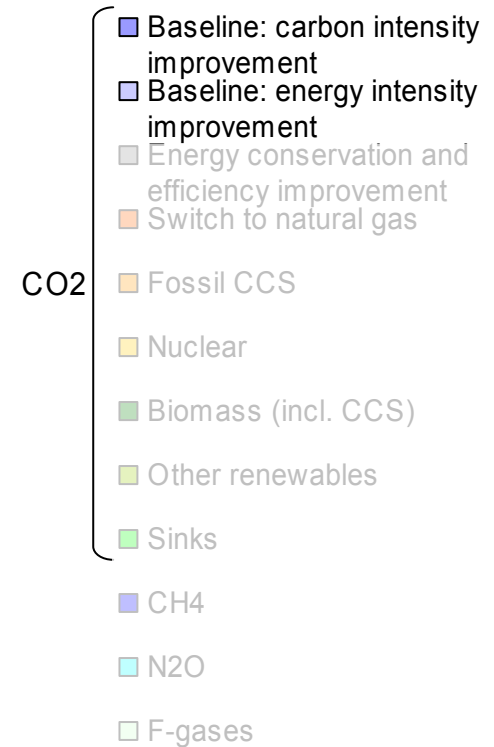
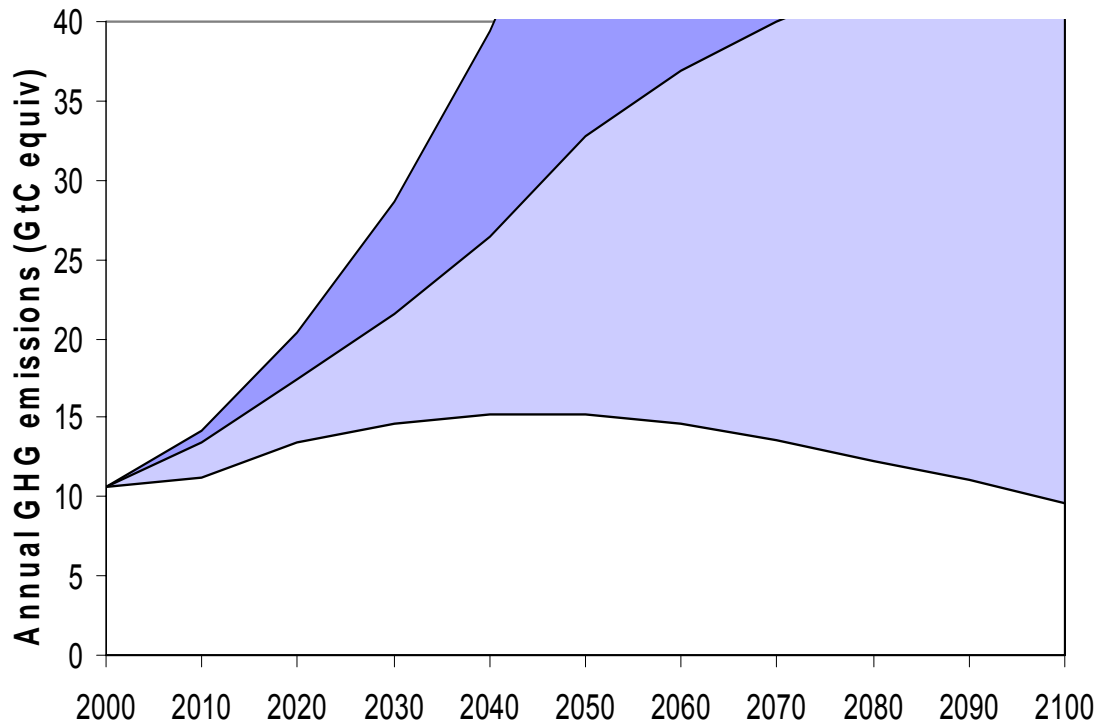
World GHG Emissions

IIASA A2r Scenario



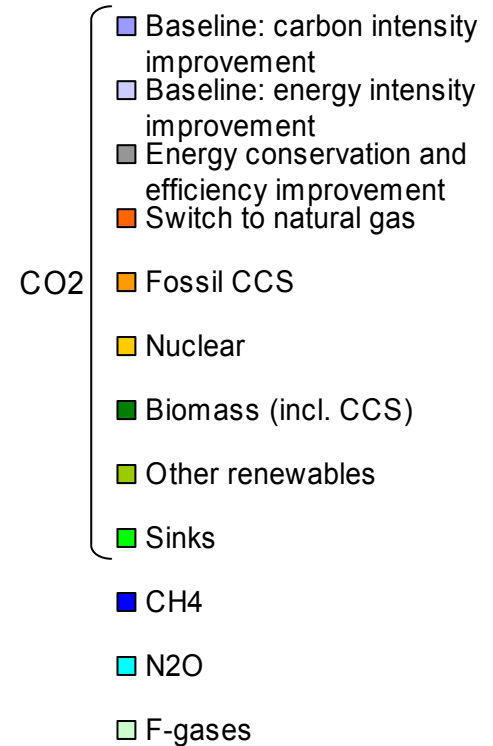
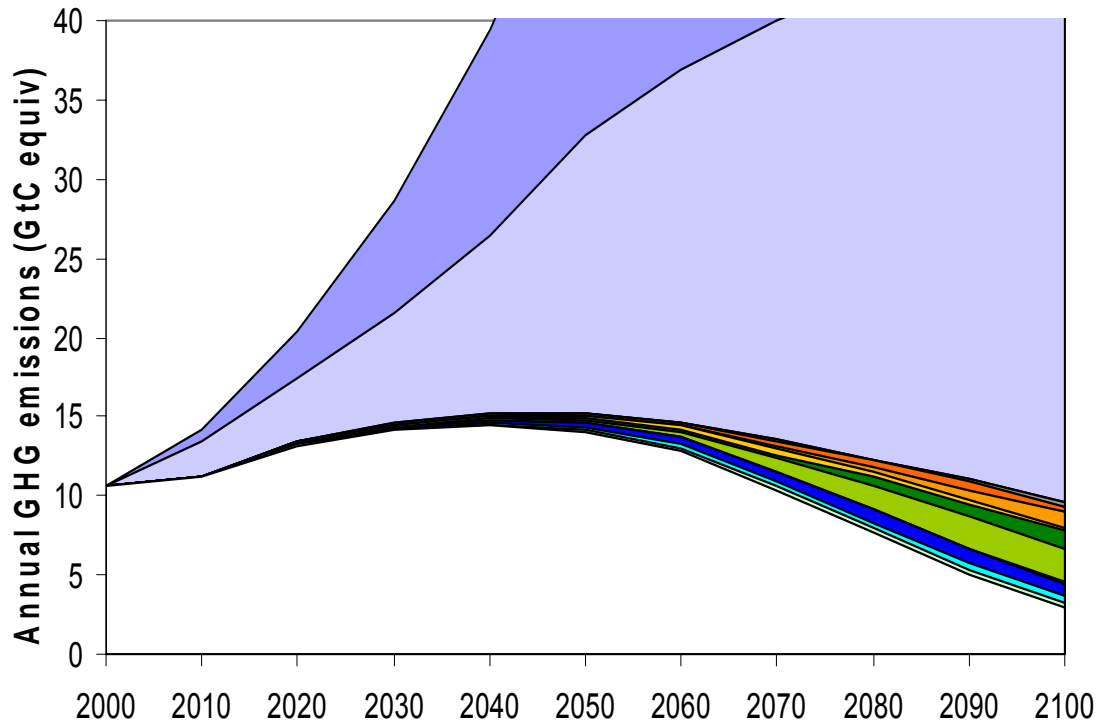
World GHG Emissions

IIASA B1 Scenario

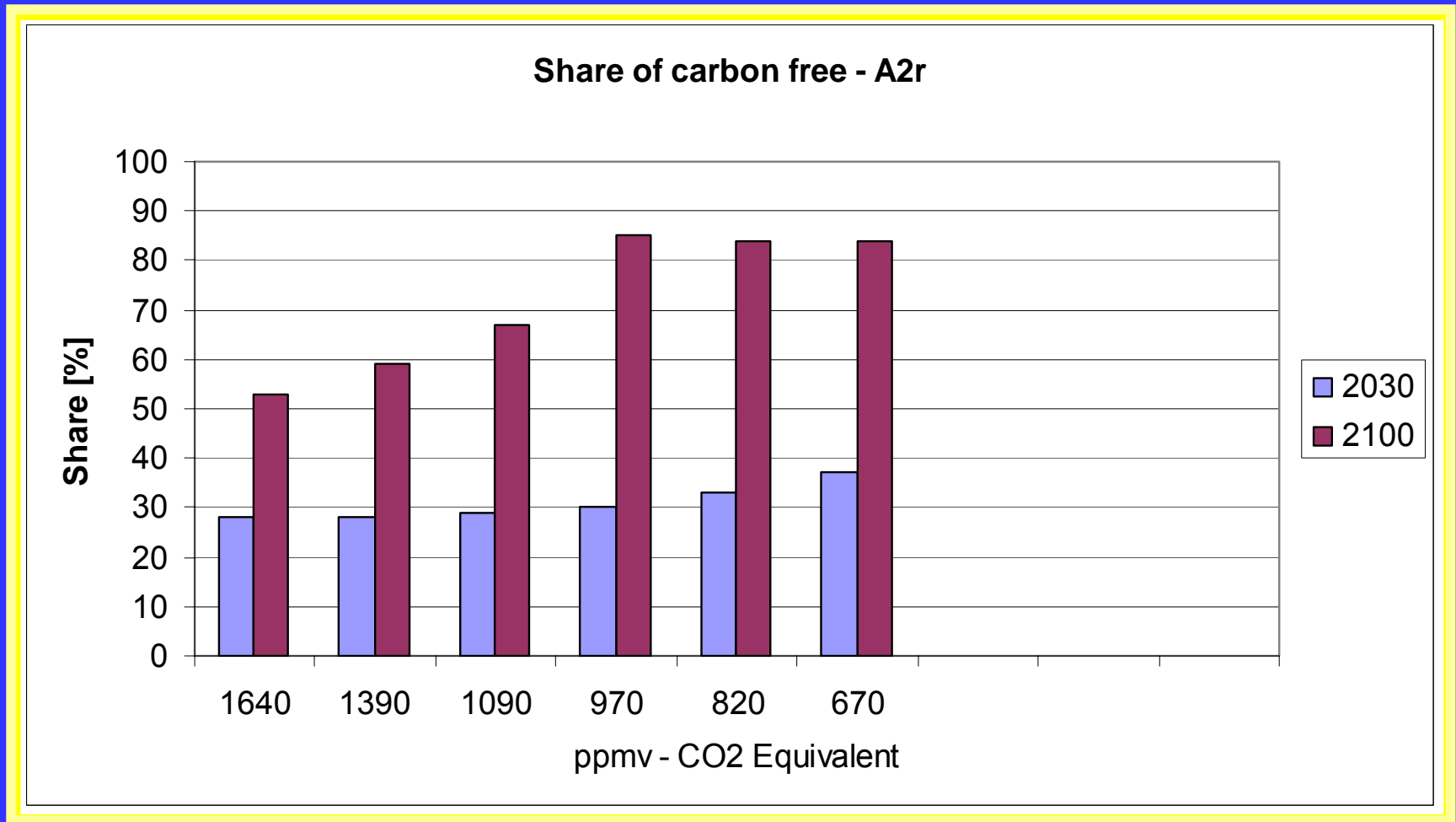


World GHG Emissions

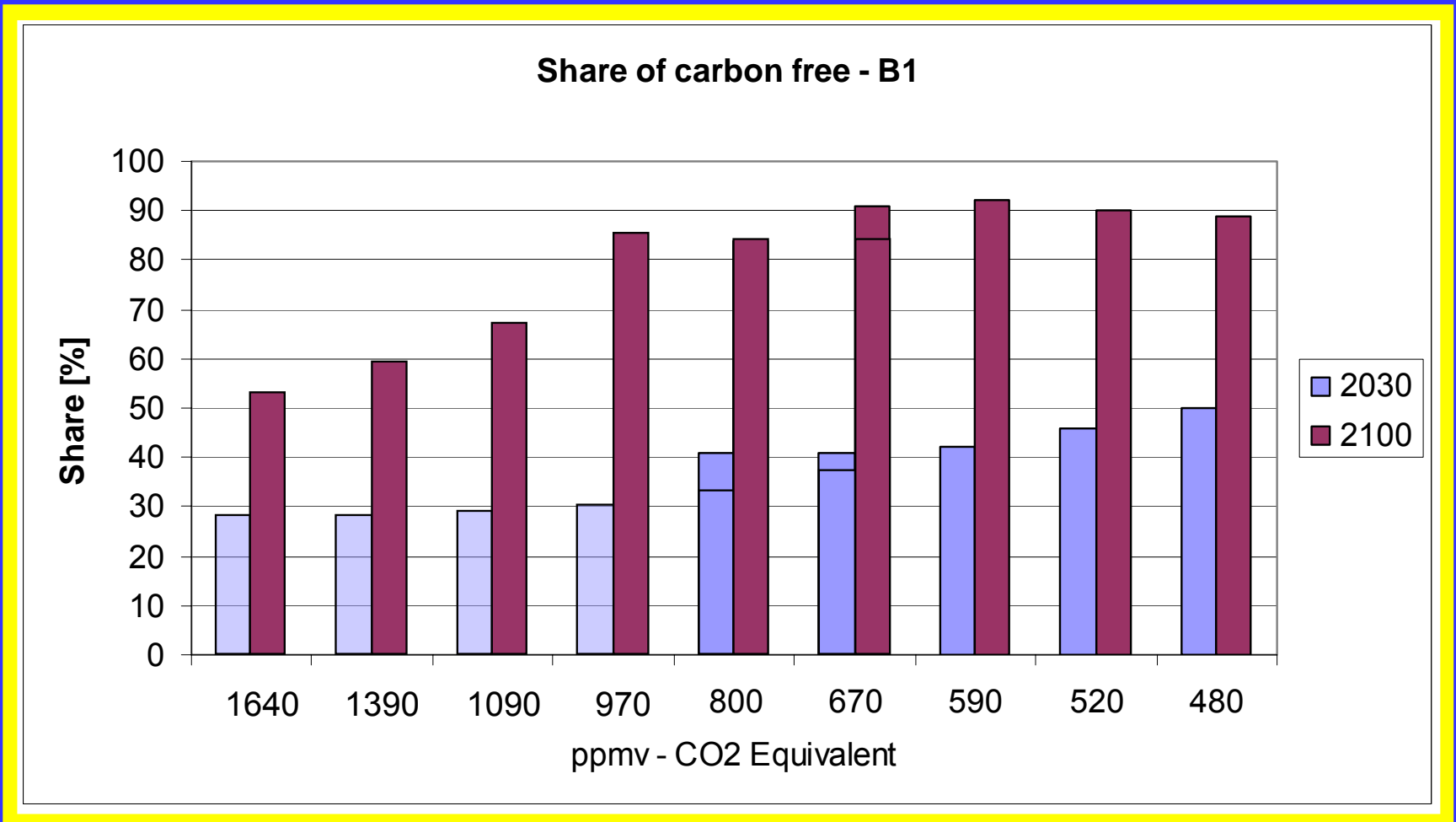
IIASA B1 Scenario



Share of Carbon-Free in A2r



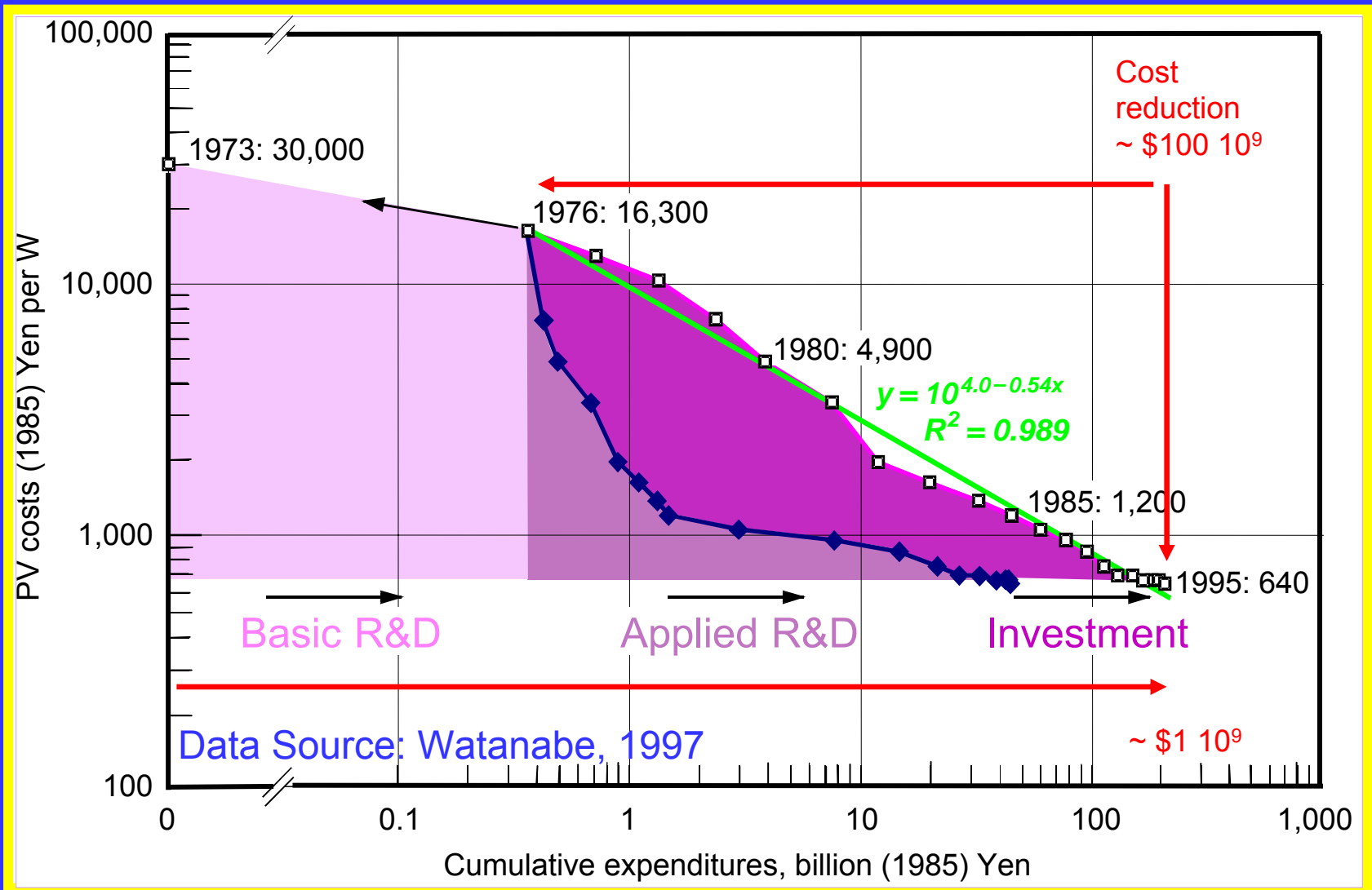
Share of Carbon-Free in B1_r





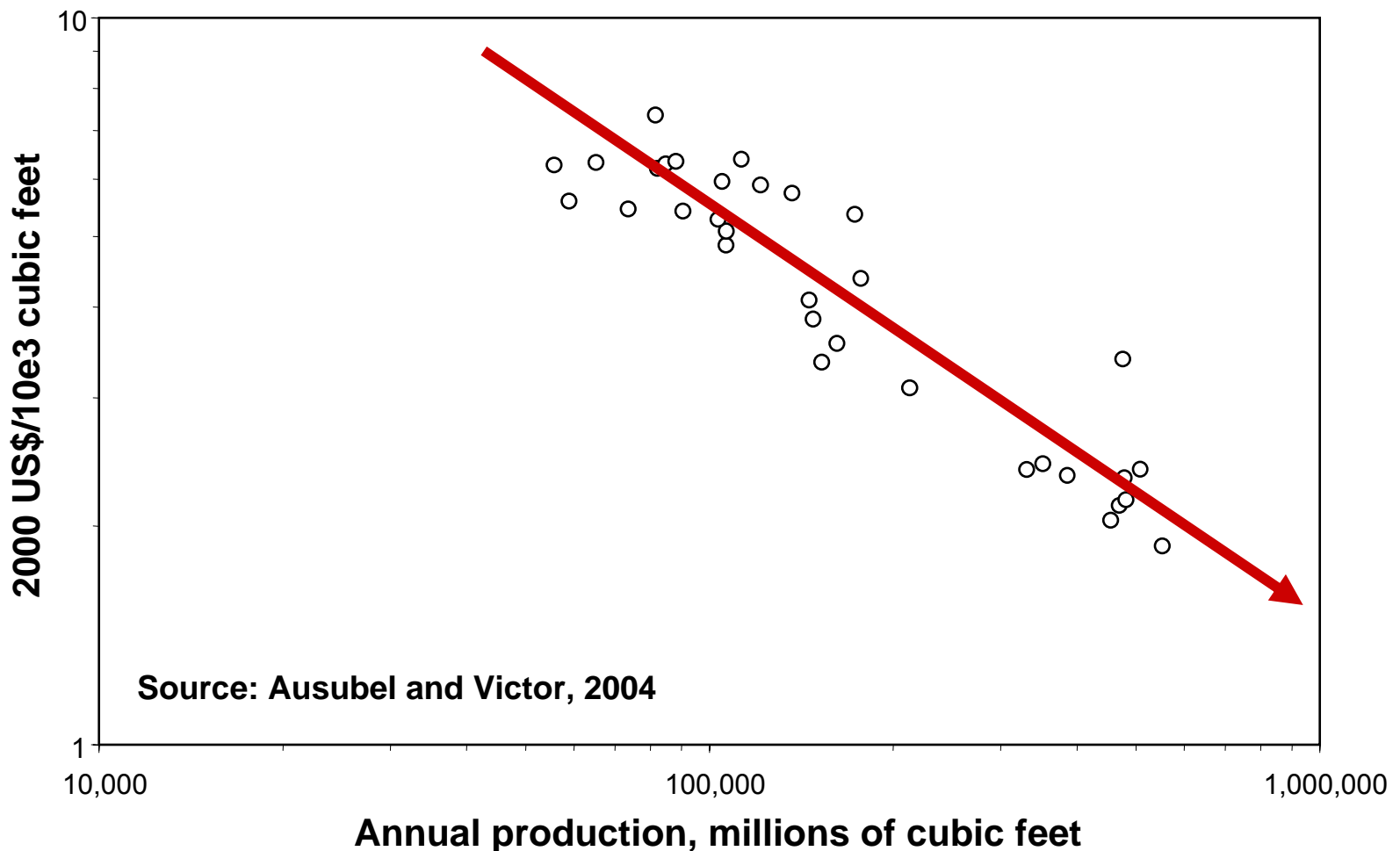
- **Research and Development Programs**
- **Demonstration and Niche Markets**
- **Early Deployment (Cost Buy-Downs)**
- **Widespread and Pervasive Diffusion**

Japan - PV Costs vs. Expenditures



Hydrogen Buy-Down as a Learning Curve

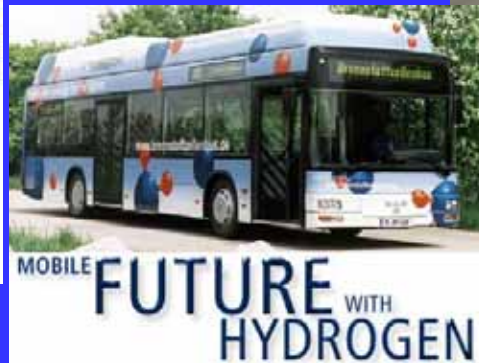
Falling hydrogen price versus hydrogen production, USA, 1971-2003



Toyota Prius CNG



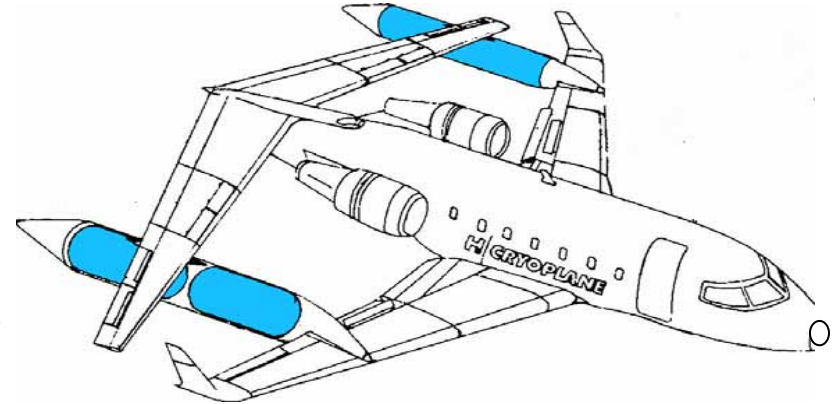
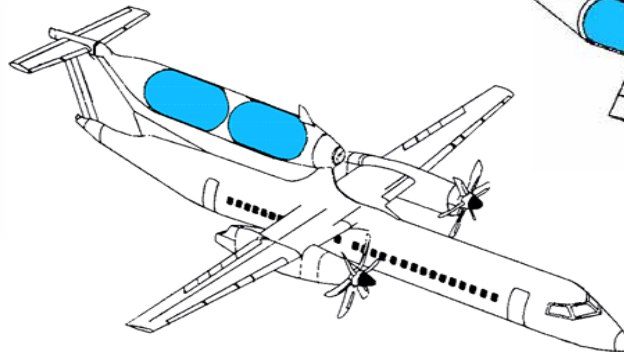
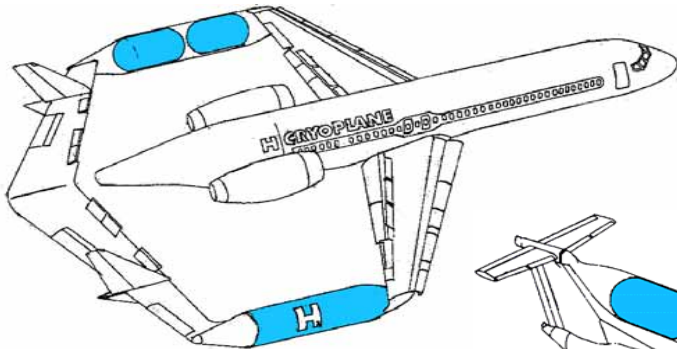
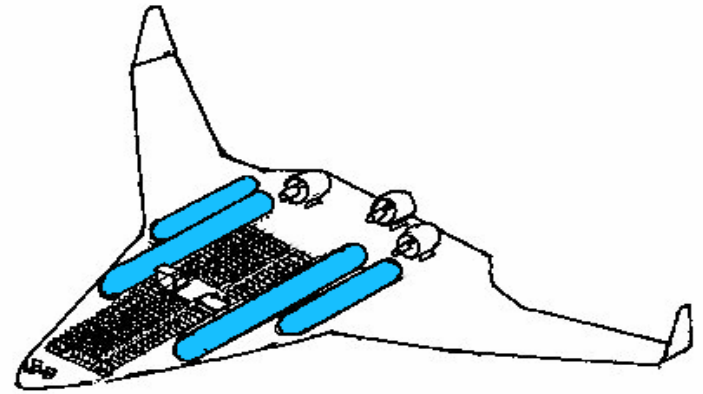
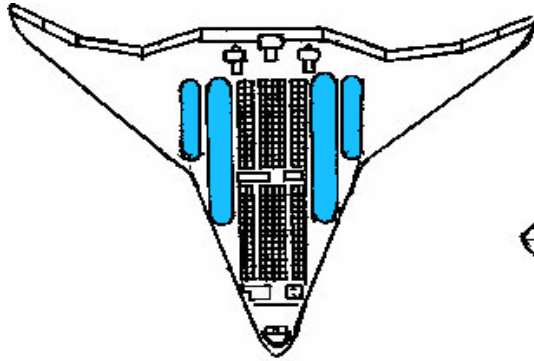
Hydrogen Vehicles



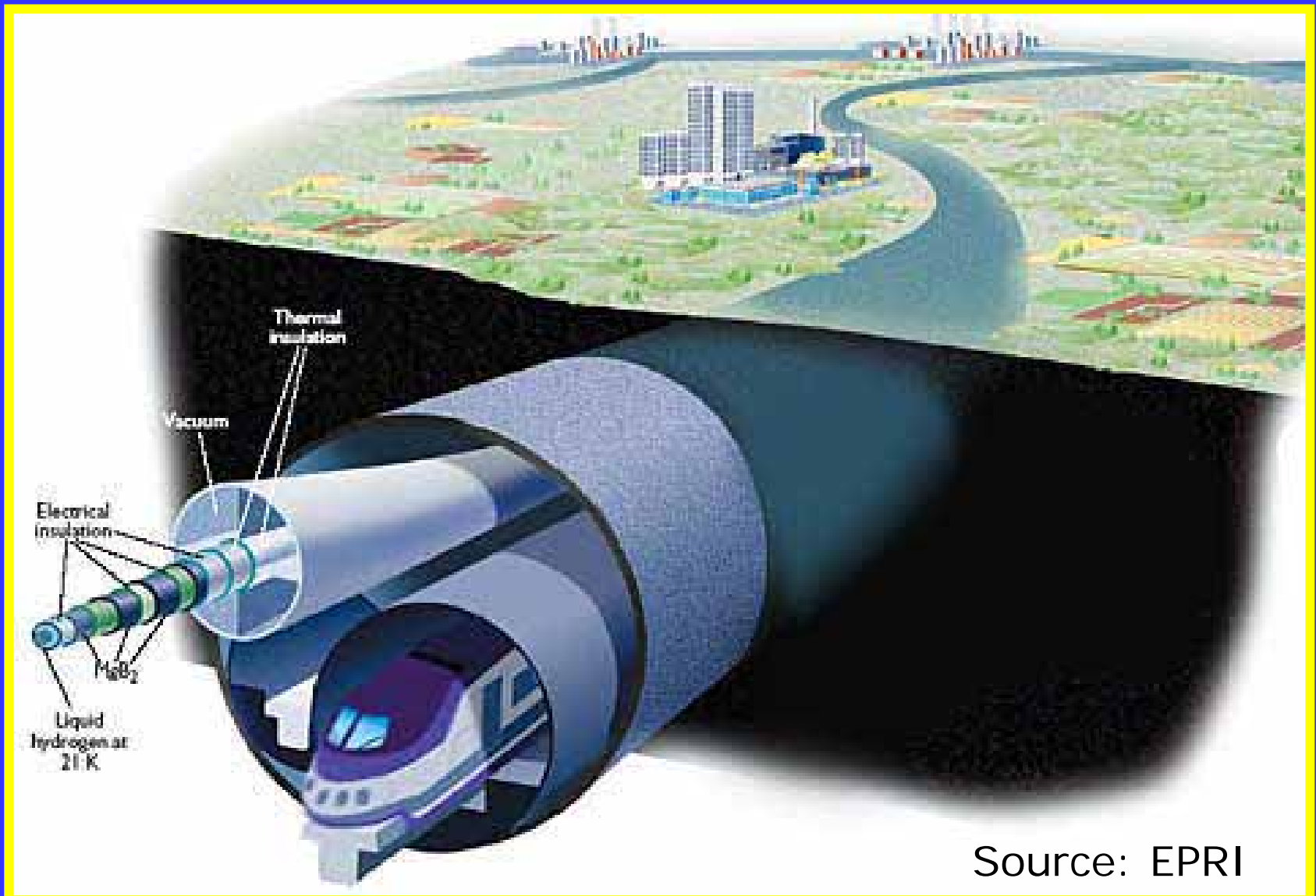
Hydrogen Airplane Design



Source: Airbus



Energy SuperGrid and MagLev Trains



Source: EPRI

Methane Hydrate





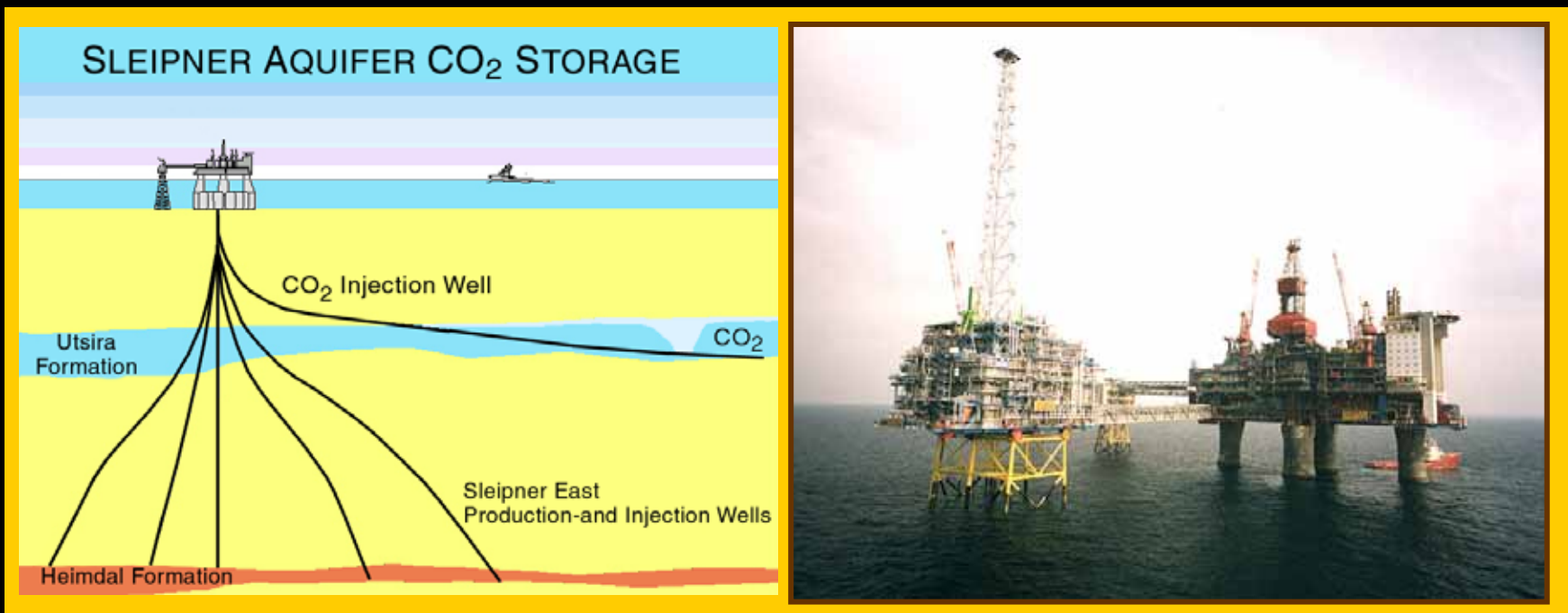
A seafloor hydrate mound in the northern Gulf of Mexico (© Ian MacDonald)

Minerals Management Service



Existing and Planned Projects

- **Sleipner Project, saline formation, North Sea**
- **Weyburn, EOR, Saskatchewan, Canada**
- **In Salah, gas reservoir, Algeria (development)**
- **Snohvit, off-shore saline formation, North Sea**
- **Gorgon, saline formation, Australia (planning)**

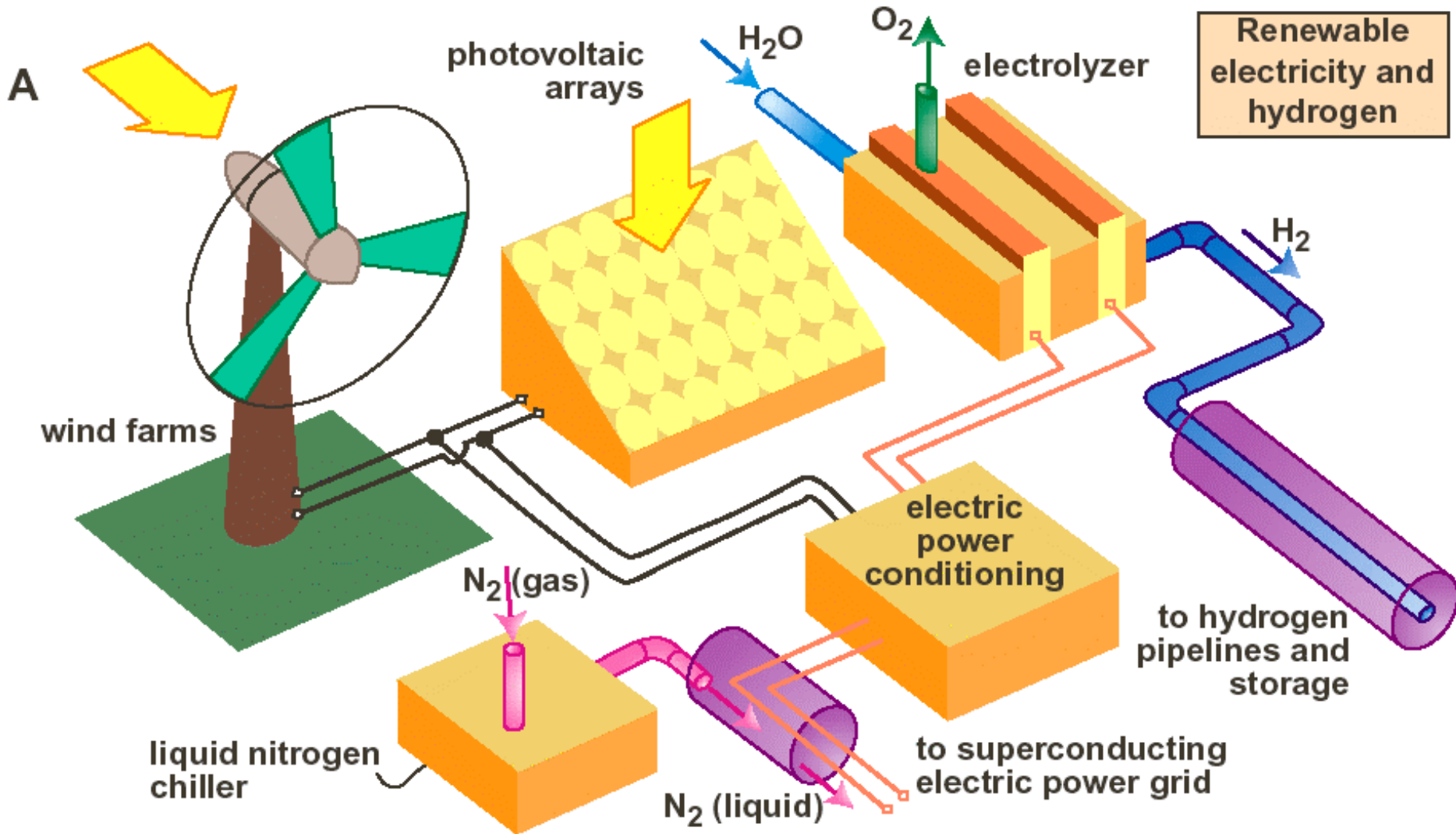


Nakicenovic #41

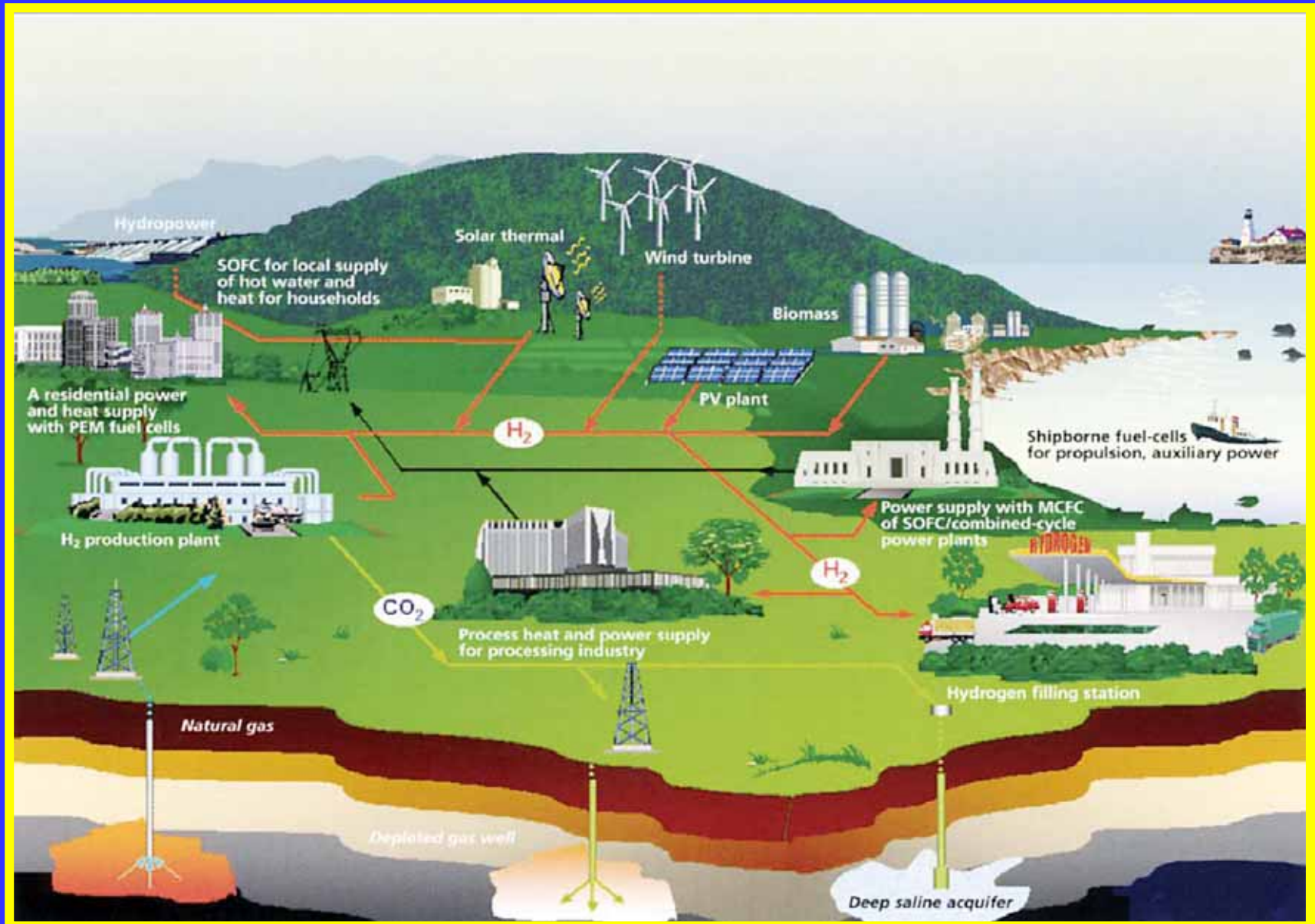
Source: Sally Benson, 2003

RENEWABLES

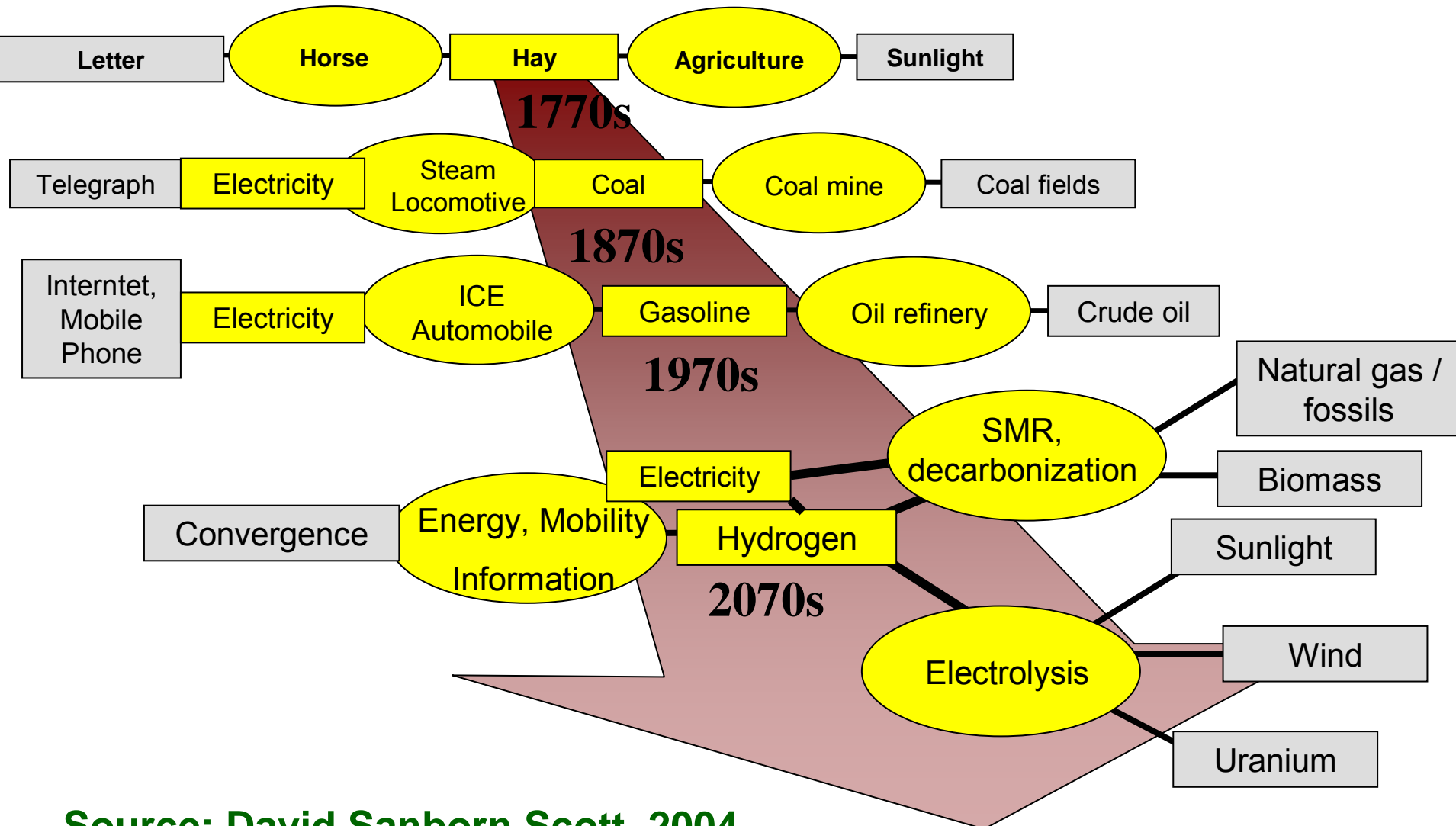
Hoffert et al., Science, 2002



A Future Energy System

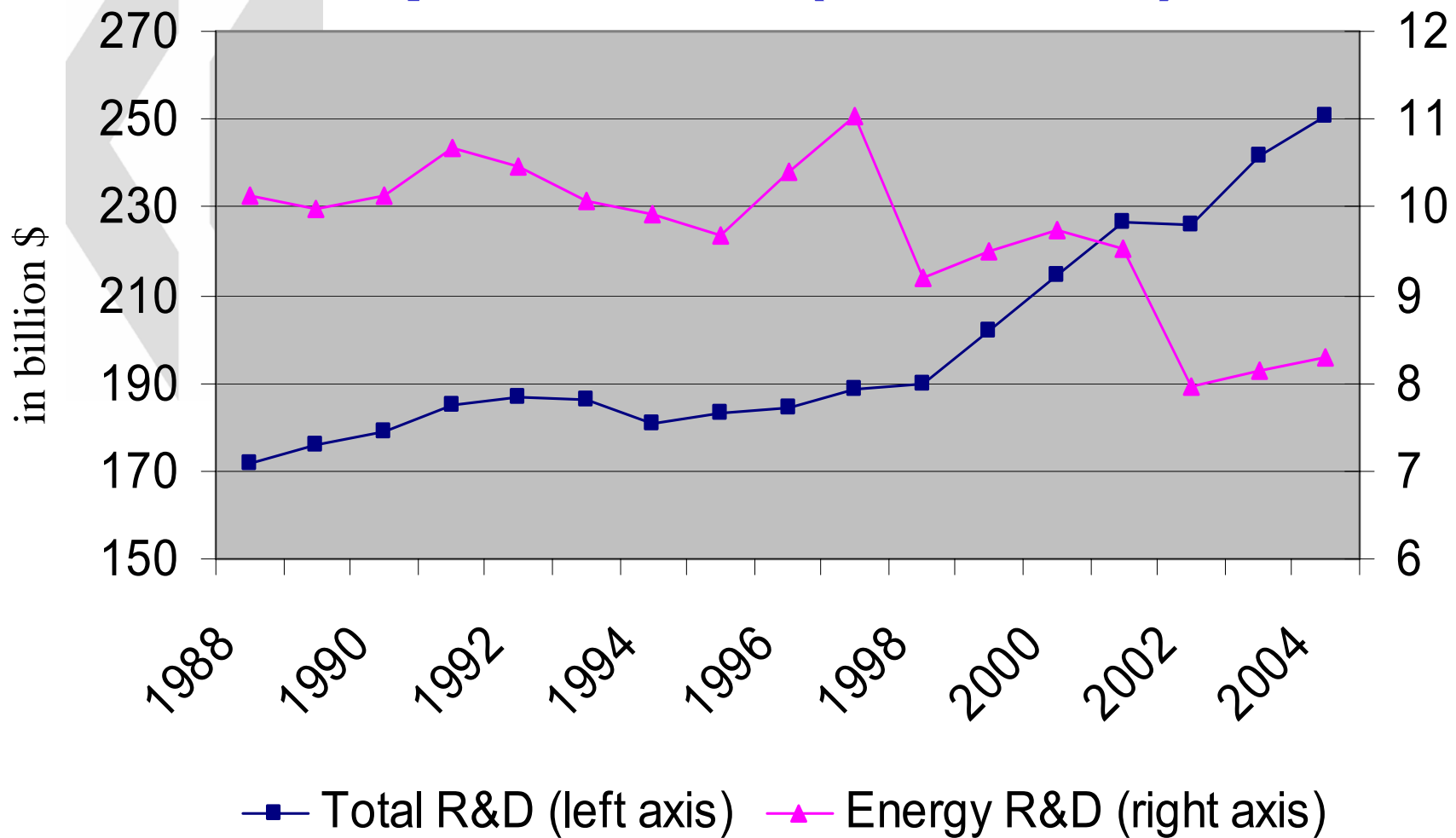


Energy Services and Sources Through Time



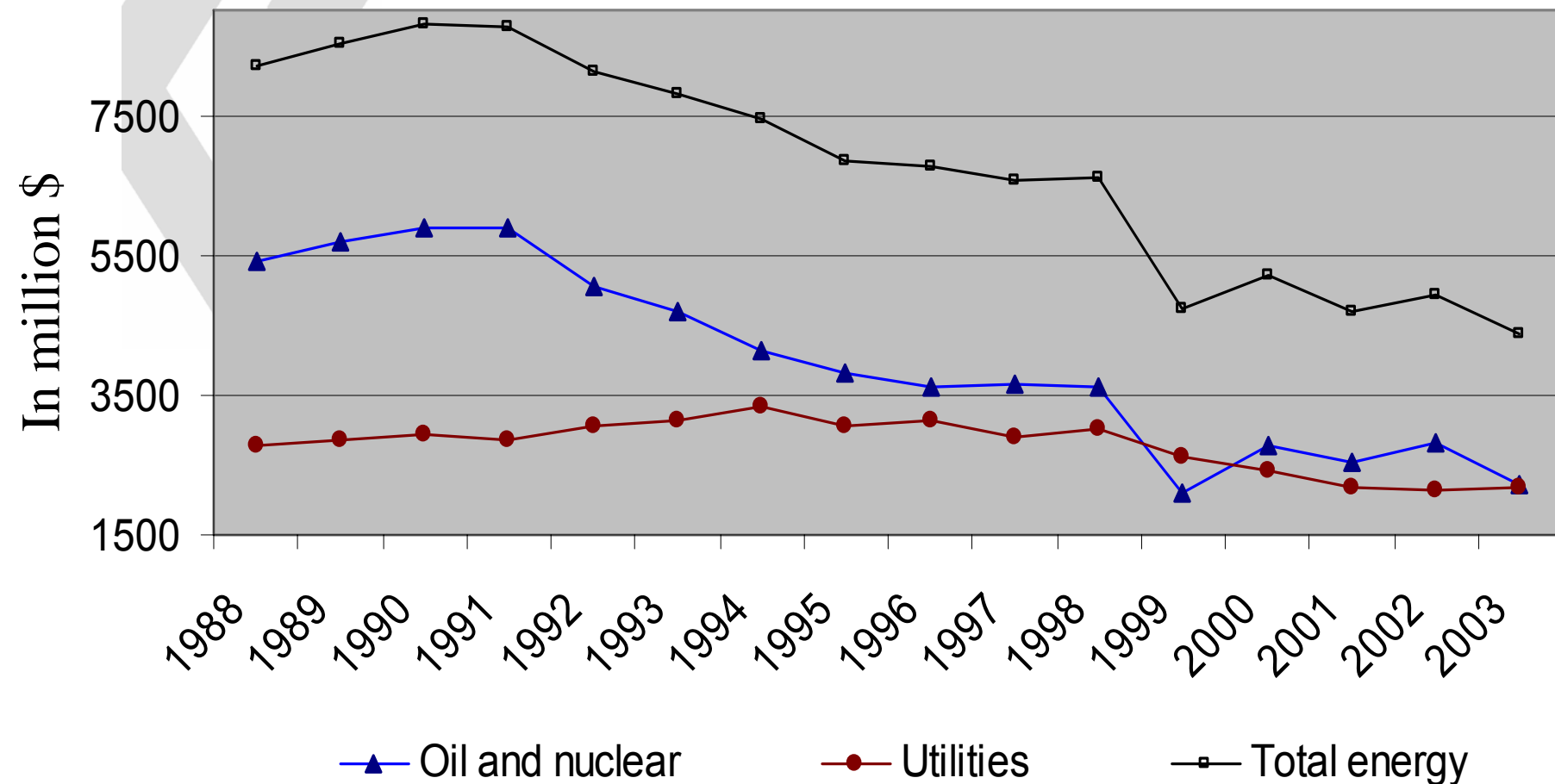
Source: David Sanborn Scott, 2004

Development public R&D expenditure (in OECD)



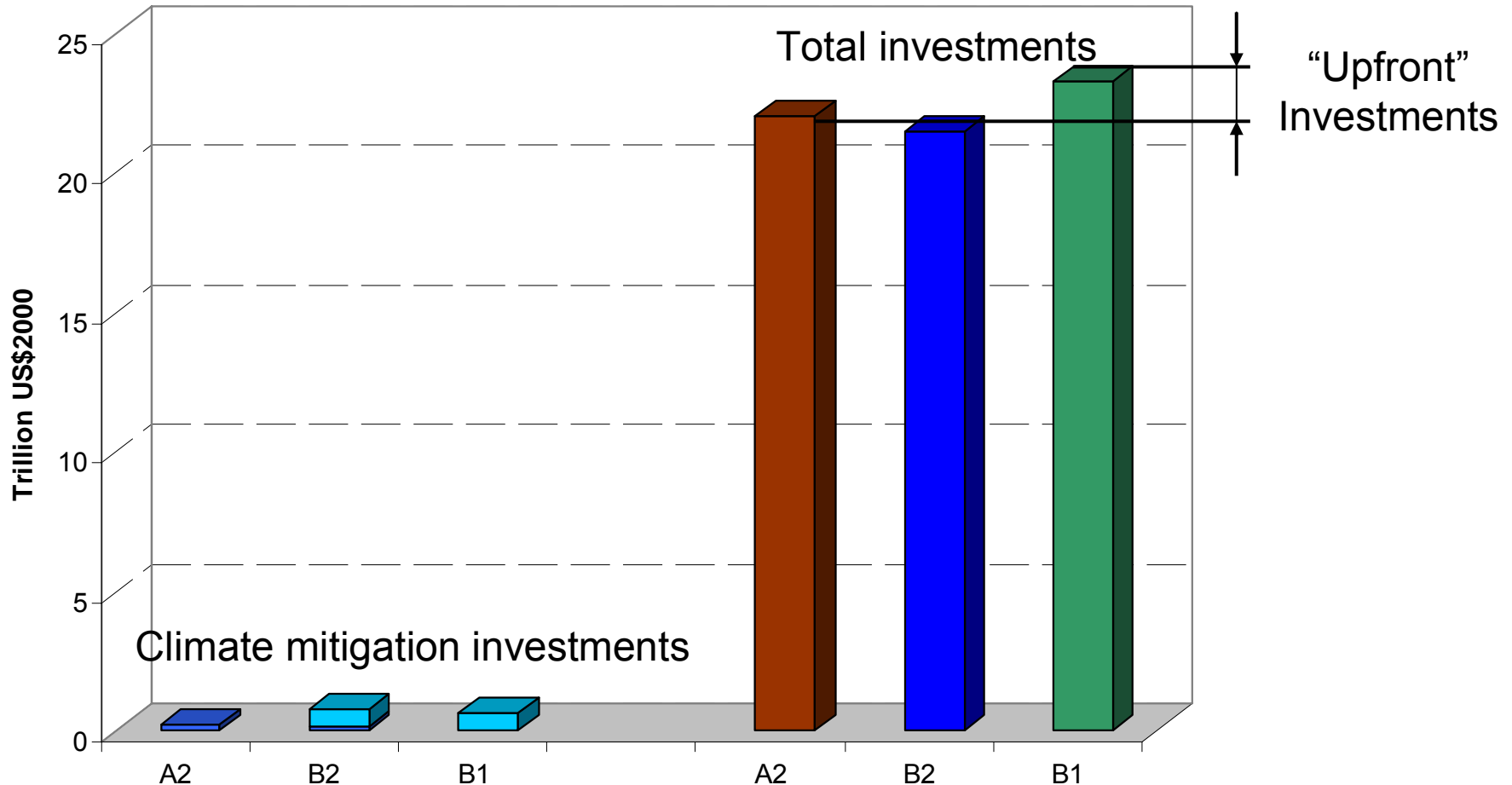
Source: Doornbosch, 2006

Development private R&D expenditure (in OECD)



Source: Doornbosch, 2006

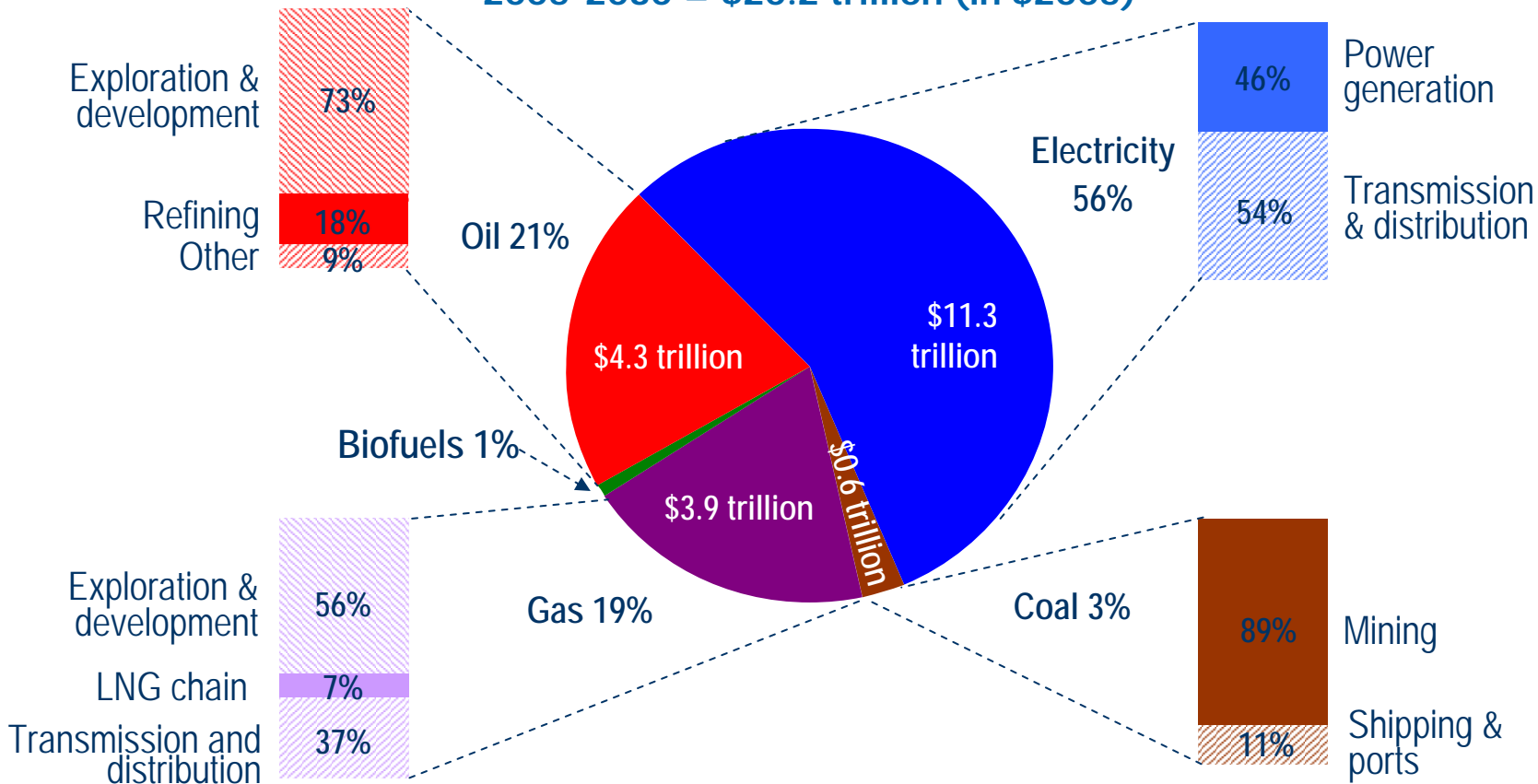
Climate Mitigation vs Total Energy Investments (World, 2000-2030)



The Reference Scenario: Investment



**Cumulative Investment in Energy-Supply Infrastructure,
2005-2030 = \$20.2 trillion (in \$2005)**



Just over half of all investment needs to 2030 are in developing countries, 18% in China alone

Global Energy Assessment

Towards a more Sustainable Future

- The *magnitude* of the change required is *huge*
- The challenge is to find a way forward that addresses all the issues *simultaneously*
- A paradigm shift is needed: energy end-use efficiency, new renewables, advanced nuclear and carbon capture and storage.

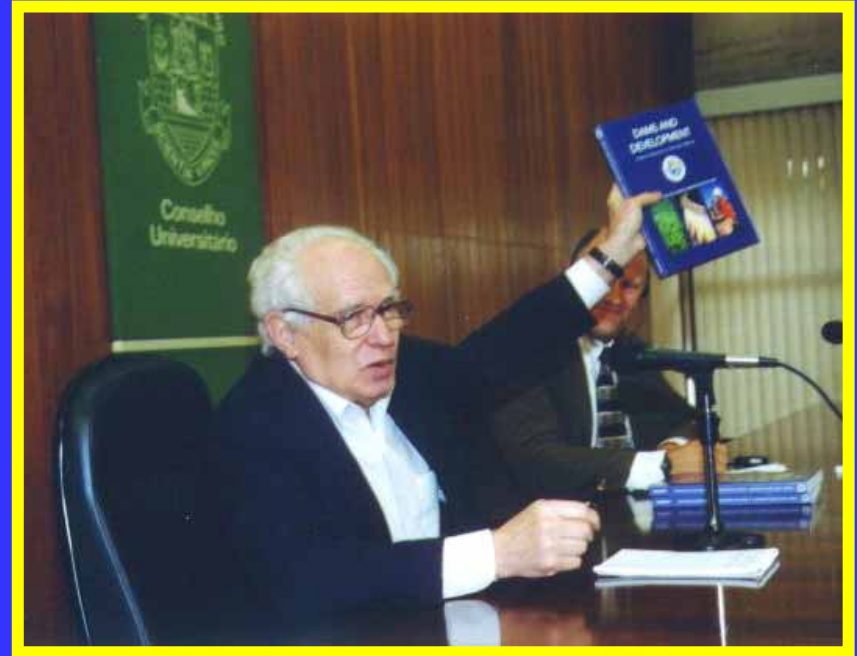
How will GEA be different?

- **comprehensive and integrated** assessment of energy issues
- combine a **technical** assessment with **strategic** policy and investment **recommendations** for global and place-specific actions
- provide timely advice for addressing **recent and emerging global challenges**; and synthesize recent studies on energy

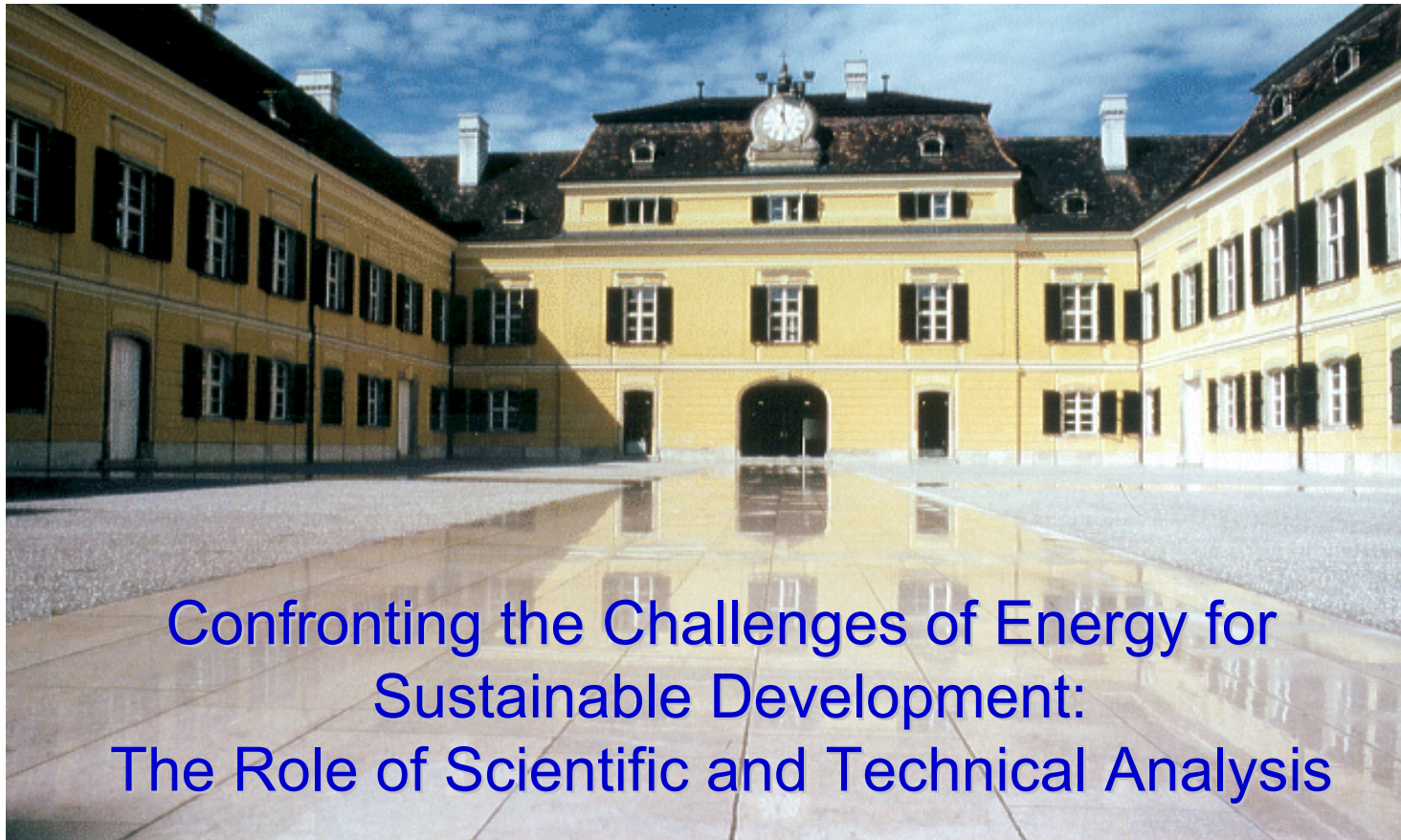
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