Achievable Energy Efficiency
Some Reflections for the 30th Anniversity ACEEE Conference

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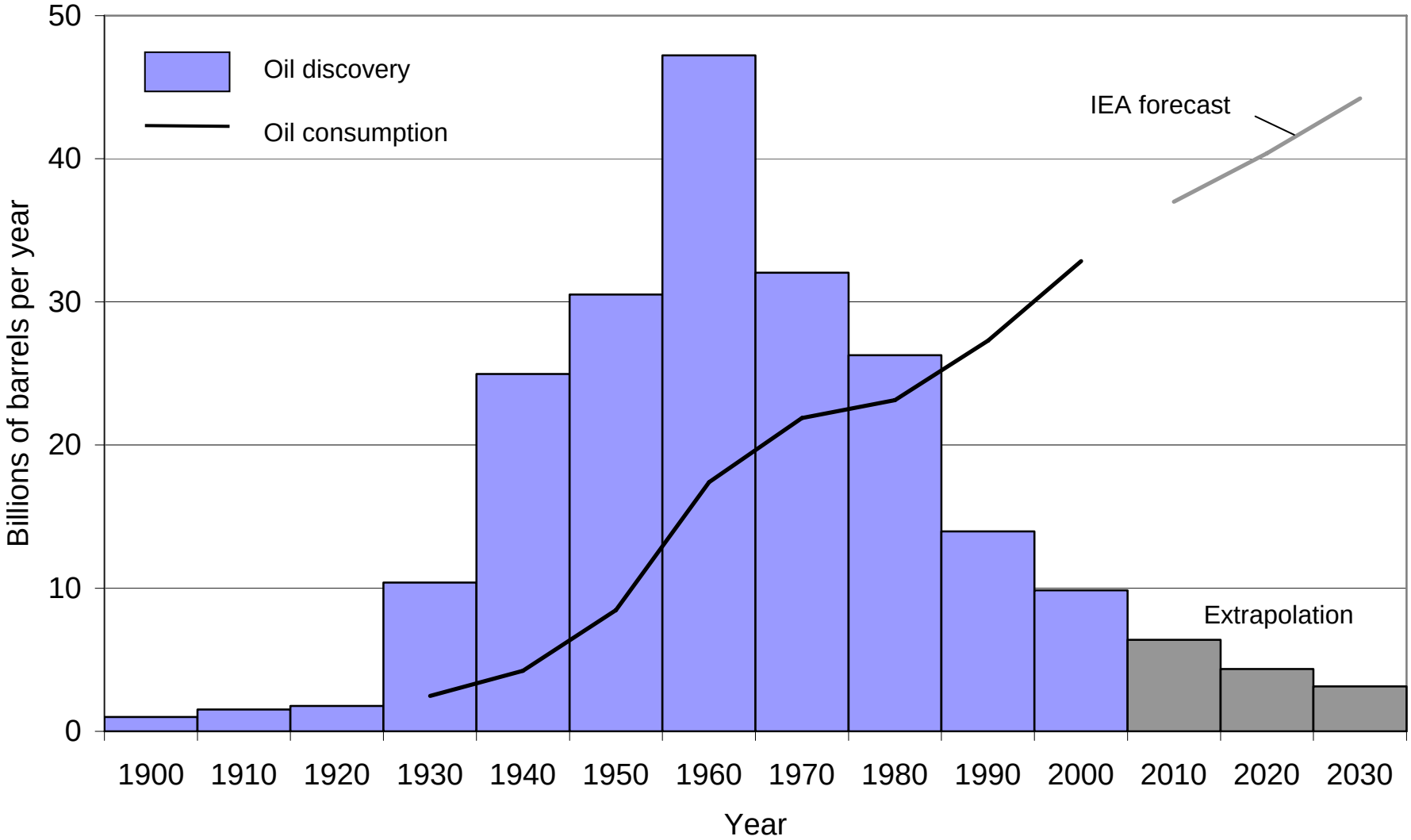
The achievable energy efficiency largely depends on how hard we try and how much we are prepared to spend. That in turn depends on are awareness of two major issues (among others):

- Limitations in fossil fuel supplies
- Global warming – eventually catastrophic climate change

Peak Oil

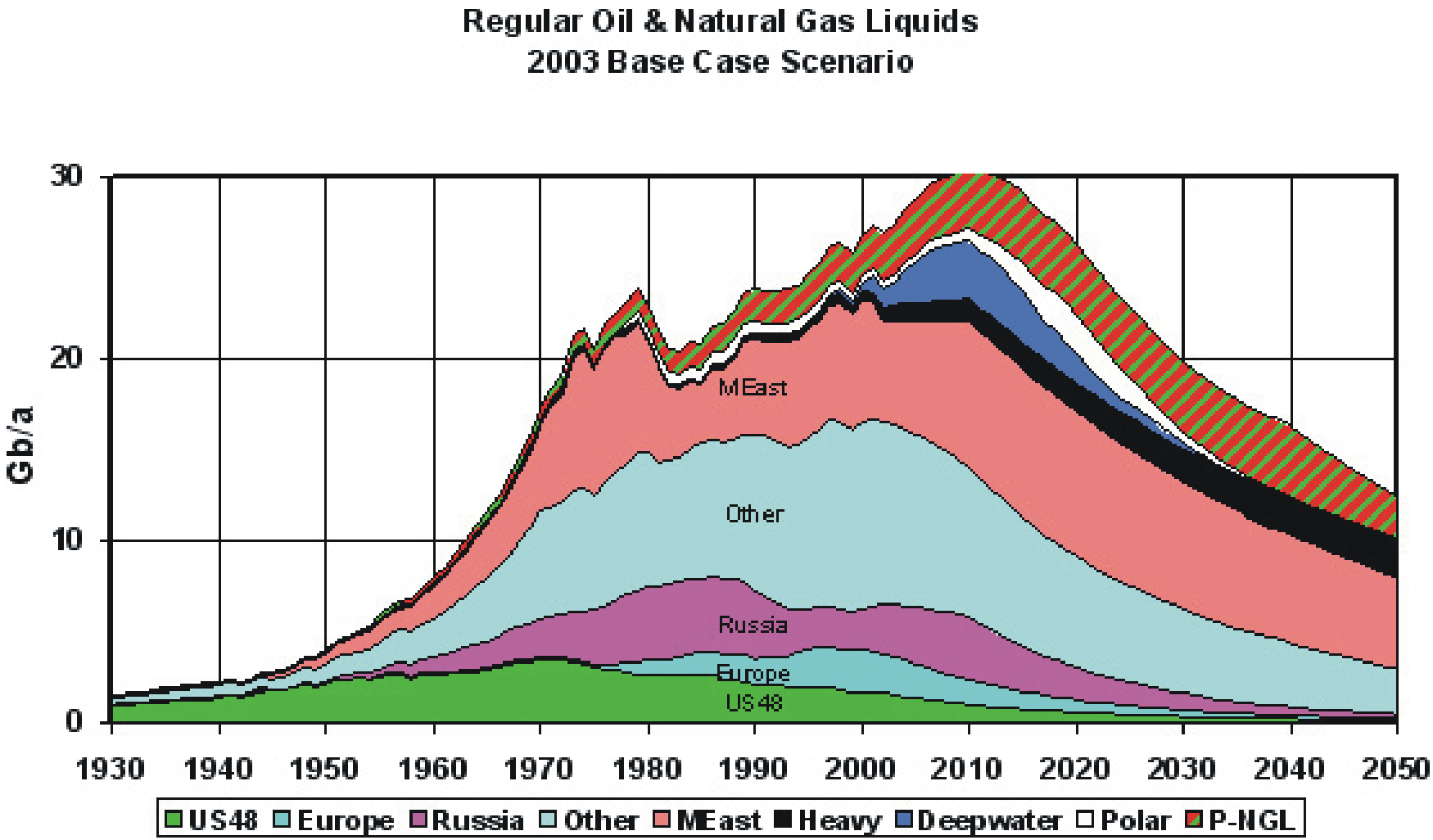
- Analyses from1972 to the present have *consistently* predicted a peaking of world oil supply between 2000 and 2020
- This is related to the estimates of ultimate cumulative oil extraction of 2-3 trillion barrels
- Cumulative consumption so far is about 1 trillion barrels

Decade-by-decade discovery and global consumption of oil



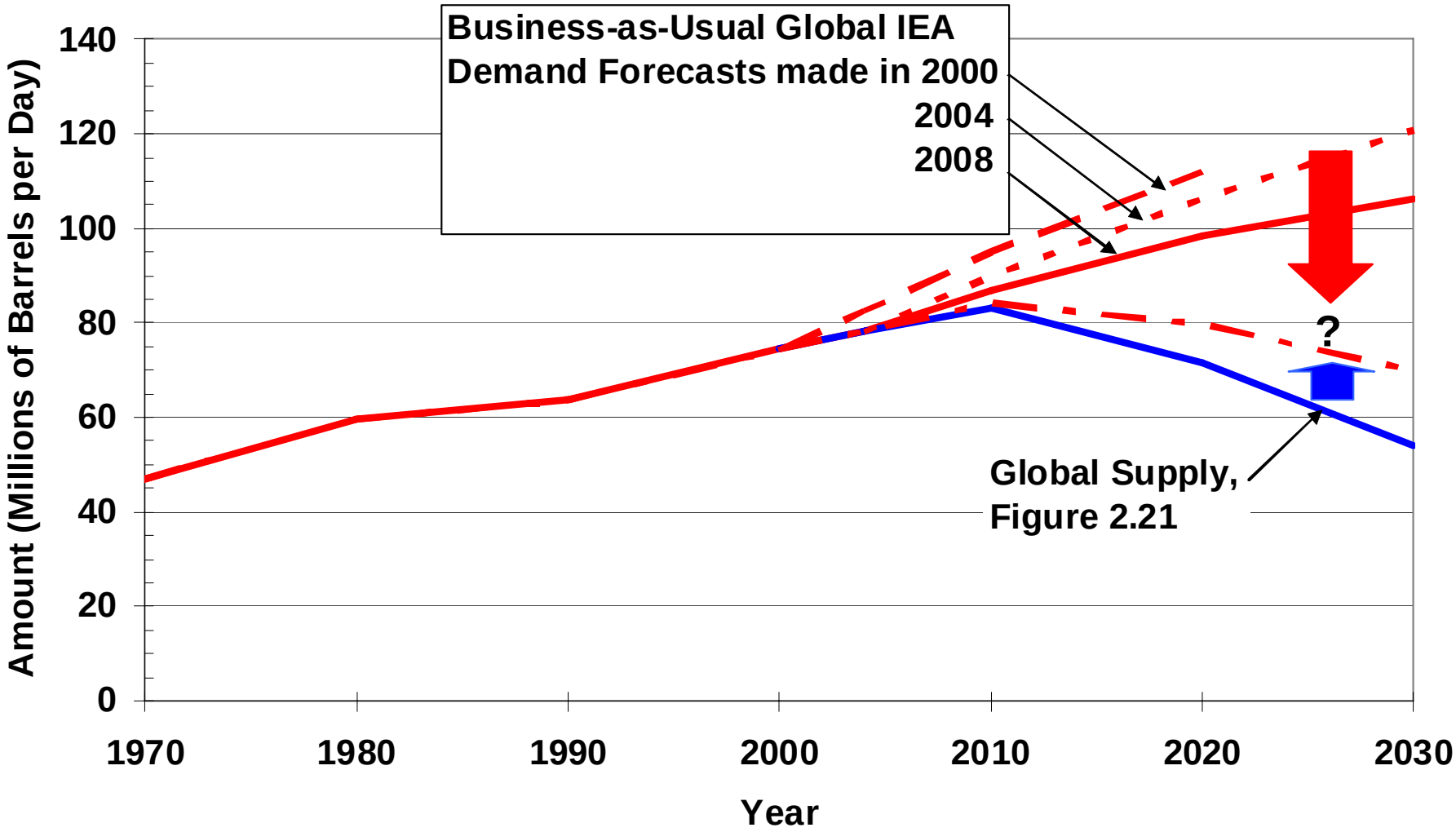
Source: Campbell and Siobhan (2009, *An Atlas of Oil and Gas Depletion*, Jeremy Mills Publishing, UK)

Figure 2.21 Geologically-based assessment of world oil supply (Campbell and Siobhan, 2009)



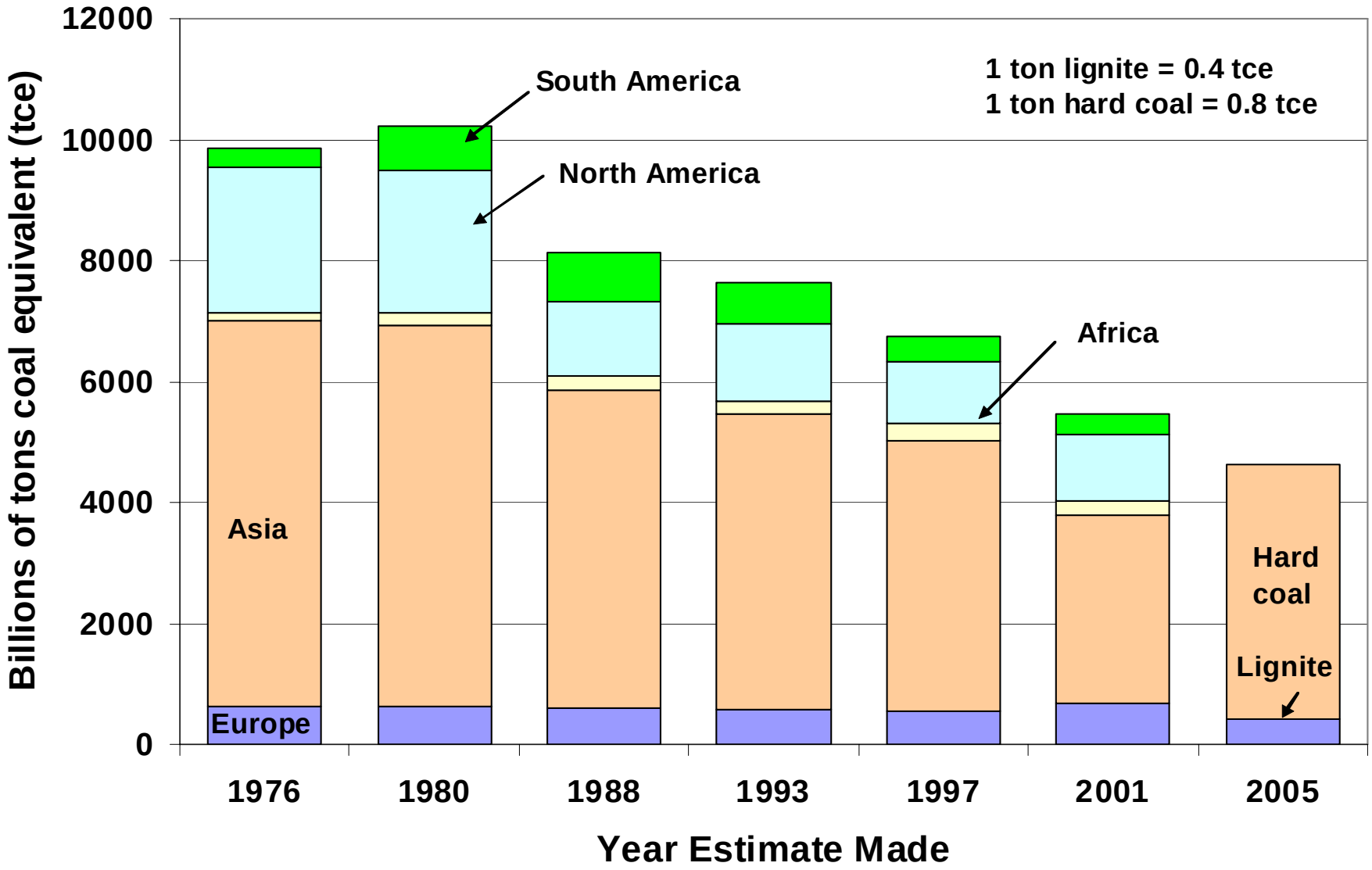
Source: Campbell and Siobhan (2009, *An Atlas of Oil and Gas Depletion*, Jeremy Mills Publishing, UK)

Figure 2.22 Balancing supply and demand. This will be accomplished through an increase in the price of oil, which increases supply and reduces demand



Peak Coal

Figure 2.25 Changing estimates of the size of the global total recoverable coal resource



Source: EWG (2007, *Coal: Resources and Future Production*)

US National Academy of Sciences, 2007 report on coal:

"Present estimates of coal reserves are based upon methods that have not been reviewed or revised since their inception in 1974, and much of the input data were compiled in the early 1970s. Recent programs to assess reserves in limited areas using updated methods indicate that only a small fraction of previously estimated reserves are in fact minable reserves"

Global Warming

- The science is strong
- The evidence that the climate is warming is all around us and it is overwhelming
- Public perceptions and statements by many elected official often have no connection with reality
- We face a high risk of catastrophic consequences if we continue along the current path

Figure 1.1 Variation in CO_2 and CH_4 Concentration

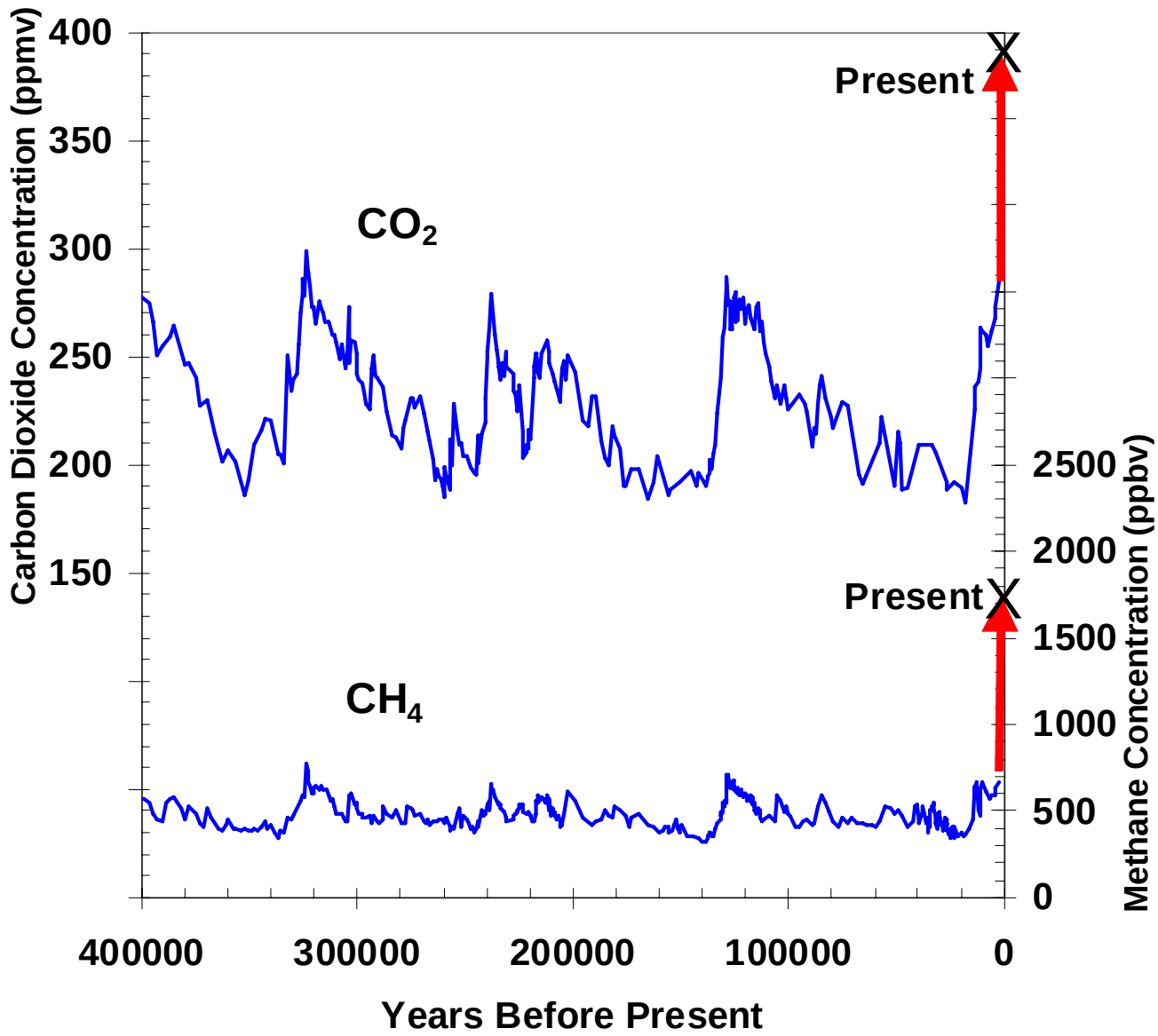


Figure 1.2 Variation in global average surface temperature, 1856-2009

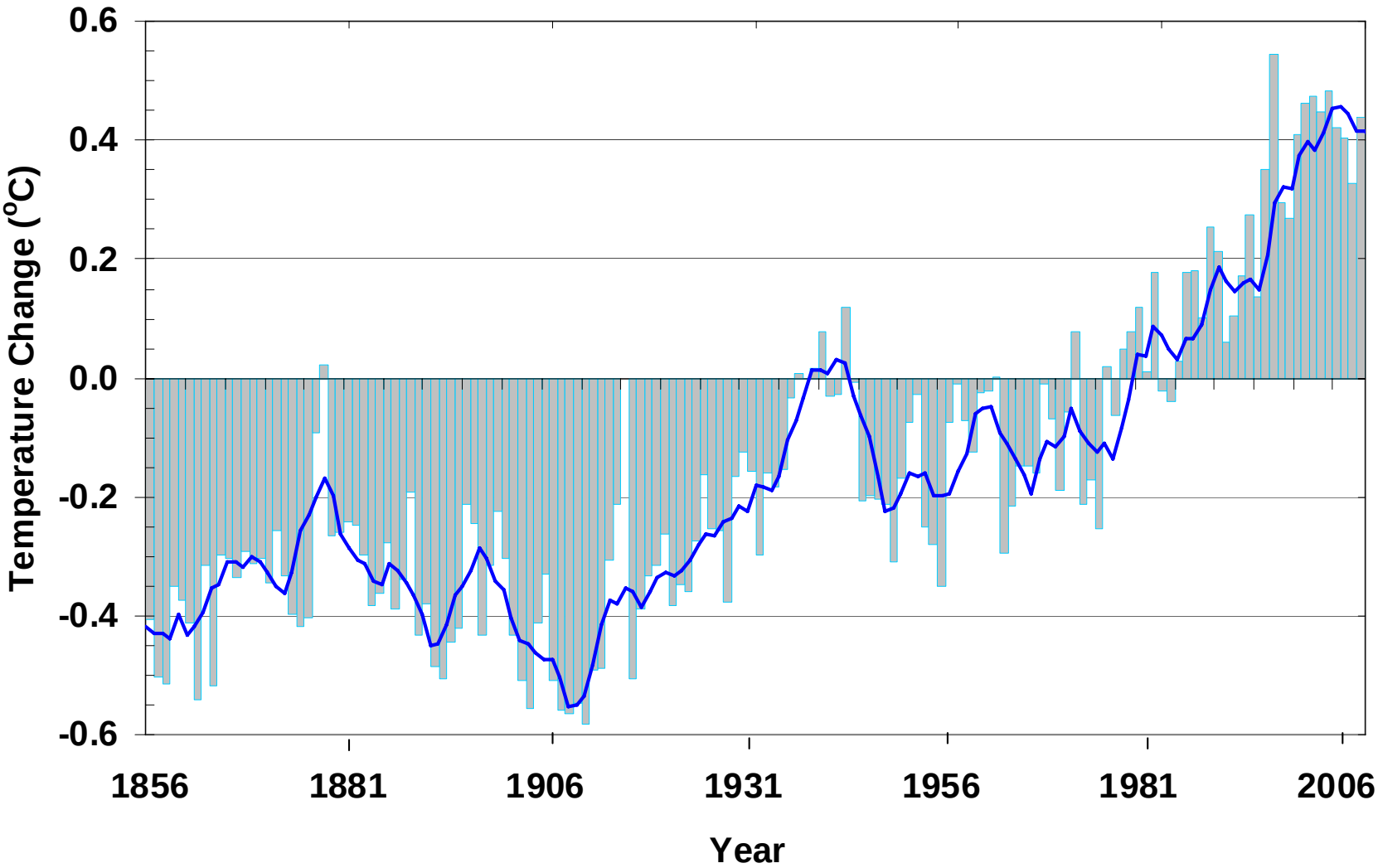
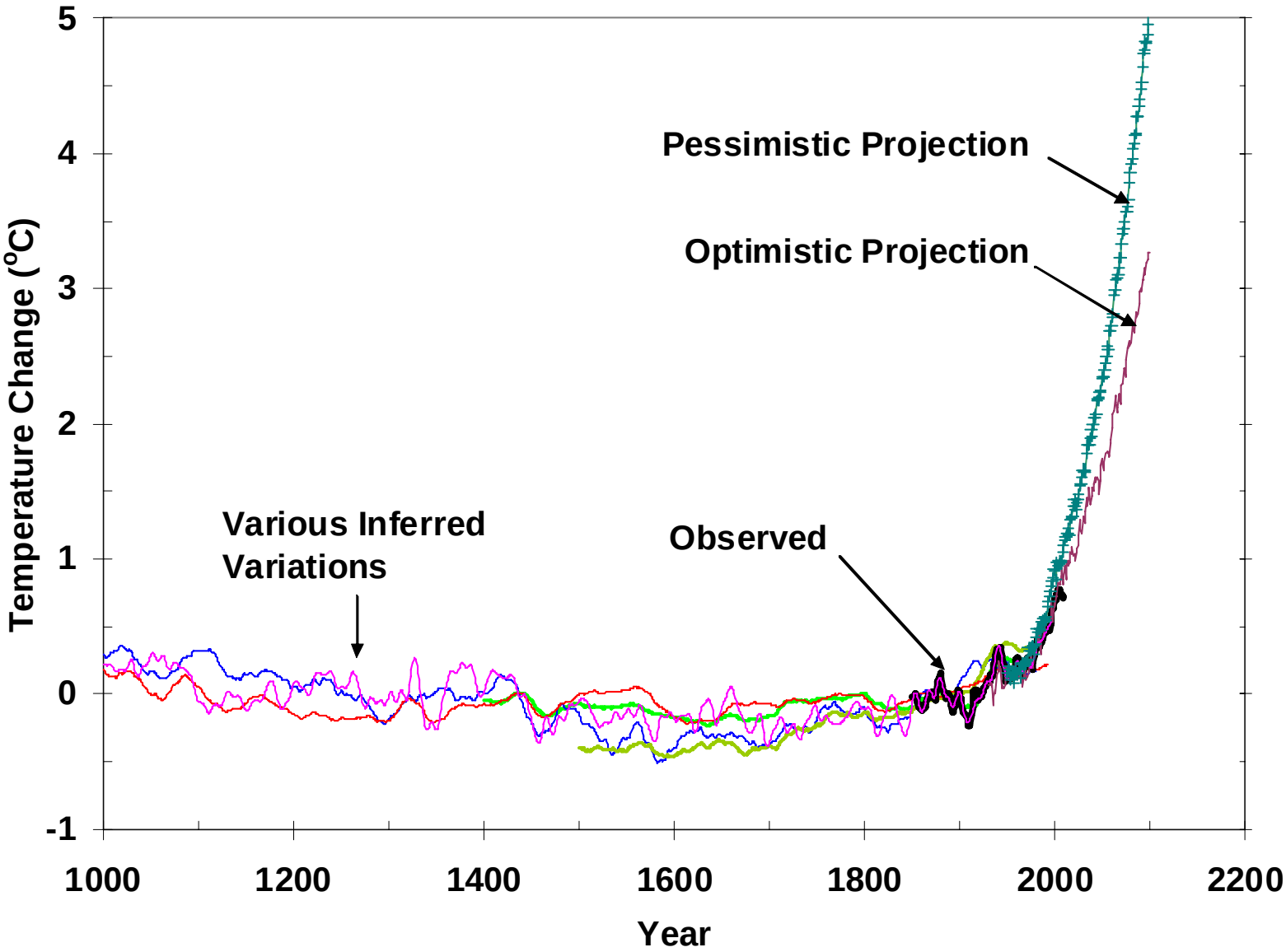


Figure 1.5 Business as usual change in global mean temperature in the context of observed or inferred past variations



What follows is drawn from the 1st of this 2-part series:

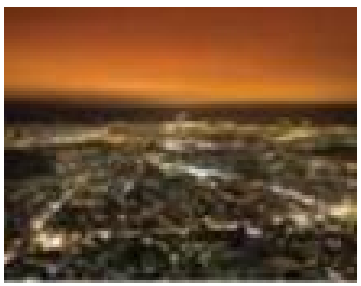
Energy and the New Reality, Volume 1:

Energy Efficiency and the Demand for Energy Services

and

Energy and the New Reality, Volume 2:

C-Free Energy Supply



published by Earthscan (book homepage: www.earthscan.co.uk/?tabid=101807 and

www.earthscan.co.uk/?tabid=10108)

Energy Efficiency Potential

For new buildings, energy use can typically be reduced by 75% compared to current practice, through a combination of

- high-performance envelopes,
- utilization of passive heating and ventilation, and passive/low-energy cooling techniques,
- advanced systems (especially displacement ventilation and chilled-ceiling cooling in commercial buildings),
- advanced lighting systems involving daylighting,
- use of the most efficient equipment, properly sized and commissioned
- enlightened and co-operative occupant behaviour (especially acceptance of adaptive thermal comfort systems, daylighting and passive ventilation)

Working with rather than against nature: Solar chimneys on the Building Research Establishment (BRE) building in Garston, UK

Source: Copyright by Dennis Gilbert, View Pictures (London)

Comprehensive renovations can often achieve 50-75% energy savings in existing buildings through

- External or internal insulation in residential buildings
- Curtain-wall replacement in commercial buildings
- Revamping of antiquated HVAC systems
- Lighting upgrades
- Fixing defective control algorithms
- Solar renovations – glazed balconies, transpired wall solar collectors

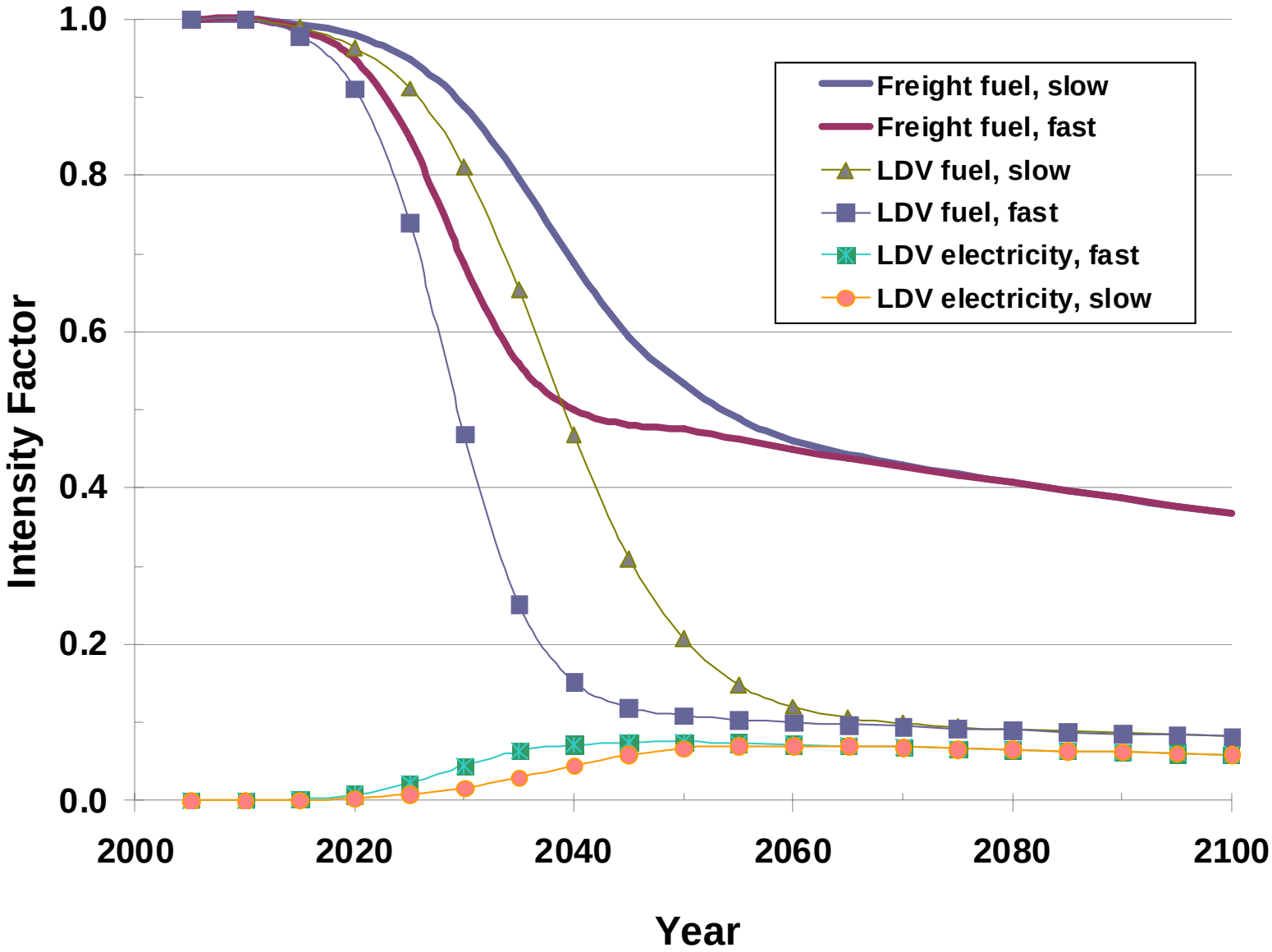
German example: 90% reduction in heating energy use by retrofitting, before and after photos

Source: Wolfgang Greifenhagen, BASF

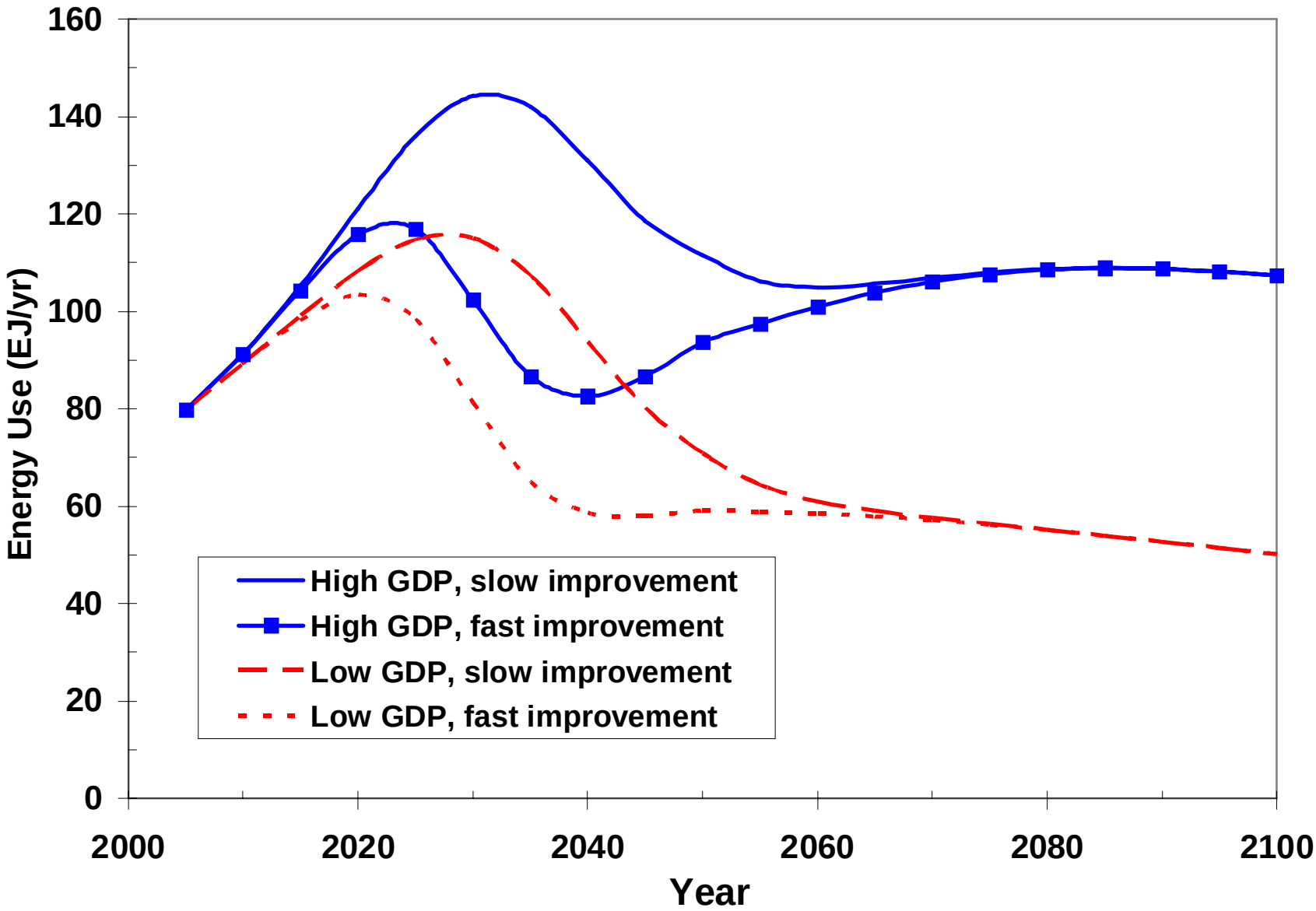
Transportation: cars & light trucks

- Advanced but non-hybrid gasoline vehicle: 36% reduction in fuel use
- 10% savings due to downsizing (20% in US, 0% elsewhere)
- Plug-in hybrid with 25% of driving from fuels, 75% from electricity
- On-site energy/km using electricity is 1/3 that using gasoline in an advanced vehicle
- On-site energy using hydrogen is 40% that of the advanced (but non-hybrid) gasoline vehicle

Transport intensity (MJ-passenger-km, compared to present) with slow or fast implementation of strict fuel economy standards

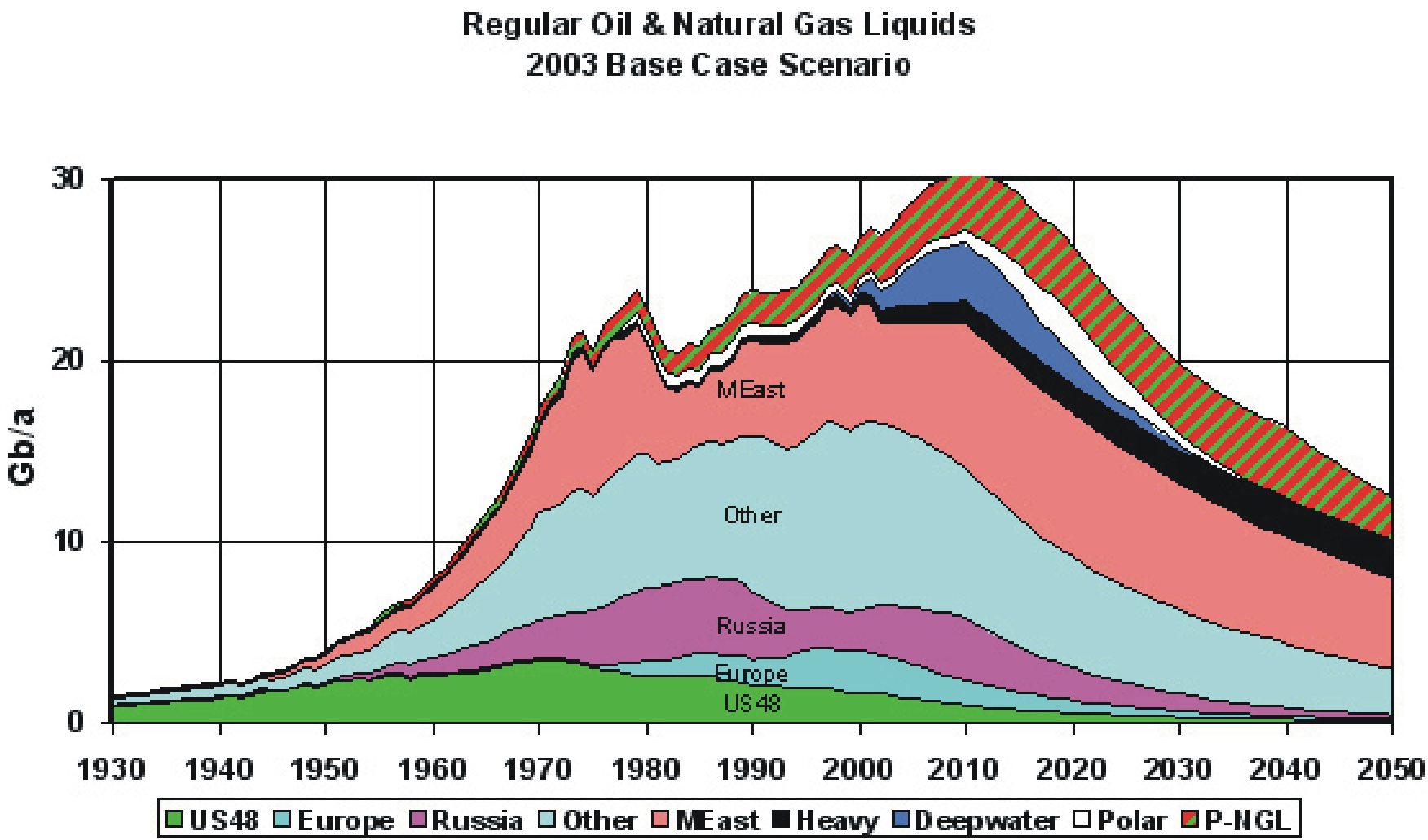


Global transportation fuel energy use



The fuel demand in both the low and high GDP scenarios is not realistic, in that it grows substantially (in spite of very rapid and stringent efficiency improvements), whereas global oil supply is likely to peak during the coming decade (and biofuels cannot be ramped up quickly enough to meet the demand projections in the proceeding figures). Thus, an even more aggressive scenario, ‘Fast+Green’, needs to be considered.

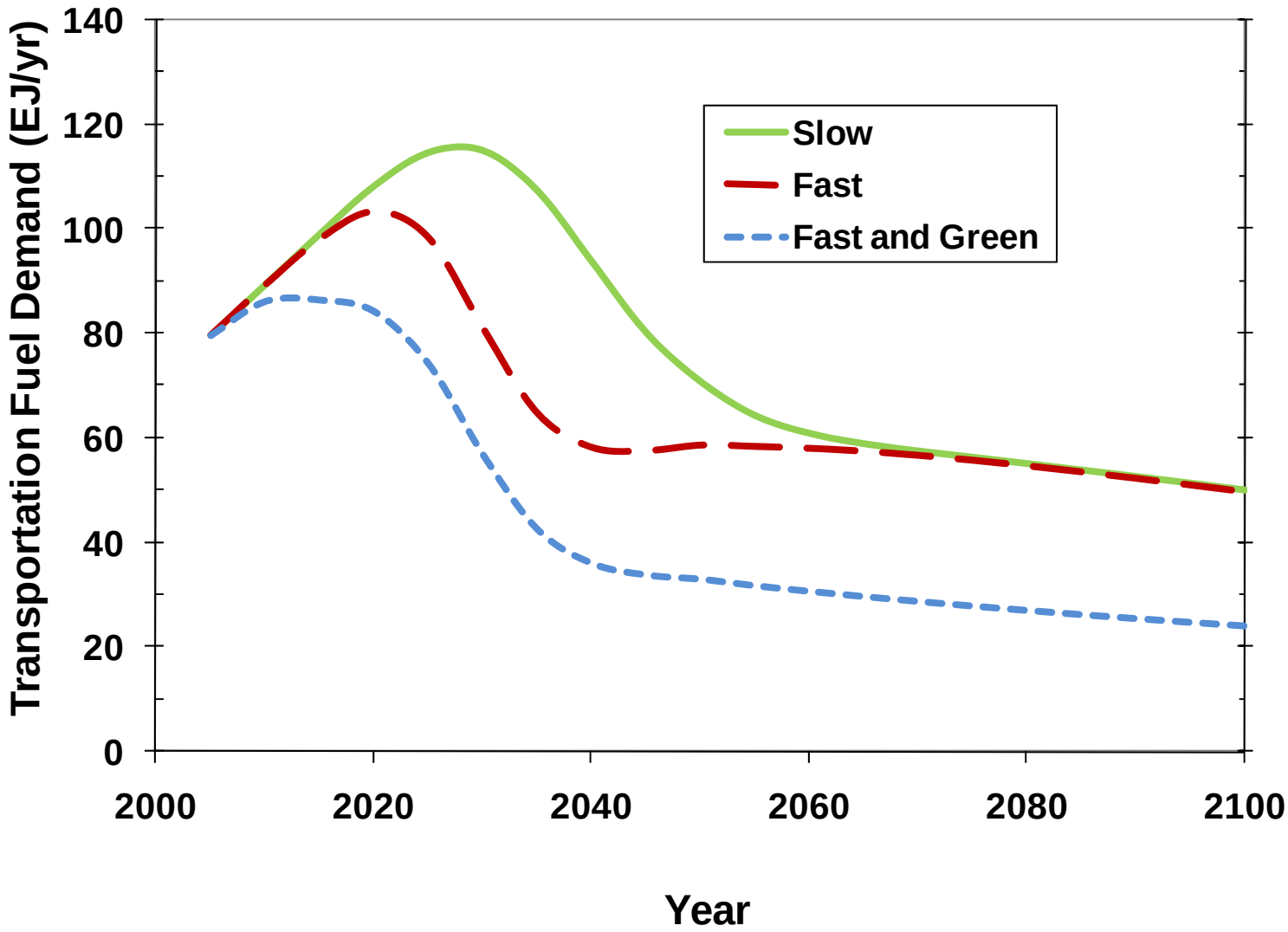
Geologically-constrained assessment of future oil supply



Fast+Green scenario

- Fast implementation of all the energy intensity reductions considered here
- Annual distance travelled on average per person drops by about 25% in PAO, NAM and WEU and is capped at 6000-8000 km elsewhere
- The share of total travel by LDVs drops from 0.8 to 0.7 in NAM, drops to 0.5 in WEU and EEU, drops to 0.4 in PAO, FSU and LAM, and is capped at 0.25 elsewhere
- The share of total travel by air drops to or is capped at 0.1 everywhere
- The ratio of global tonne-km/yr of freight to world GDP drops by a factor of 2.0 as world GDP increases by a factor of 2.7

Transportation fuel demand for the low population & GDP/P scenario for cases of slow and fast transition to radically more fuel-efficient transportation equipment and for the 'Fast+Green' scenario



Energy Savings Potential in Industry

- Biggest savings are through recycling
- In combination with improvements in the efficiency of producing primary and secondary metals, 90% recycling reduces the average energy requirement to make steel by a factor of 4-6 and aluminium by a factor of 5-7
- Factor of two potential reduction in world average cement energy use
- Pulp and paper industry can become a net exporter of energy

Energy Savings Potential in the Food System

- 25% for direct energy use on farms
- 20-50% reduction in energy required to make a given quantity of fertilizer, 50% reduction in fertilizer requirements in most industrialized countries
- Not considered with regard to energy demand: Low-meat diets – give a direct savings in energy inputs and permit a shift to organic systems (with 10-20% reduction in energy use per unit of food produced) and free up large amounts of land that could be used for bioenergy crops

Even with full implementation of these very stringent measures:

- Global energy use for grows for 2-3 decades before plateauing and then declining
- GHG concentrations plateau at the equivalent of a CO2 doubling
- Unless we rapidly draw concentrations down within 100-200 years, we will almost certainly eventually provoke 10 m sea level rise and potentially as much as 35 m sea level rise

For further material

- Go to www.geog.utoronto.ca, then click on ‘People’, ‘Faculty’, ‘Harvey’,’ Publications’, ‘Books’ and you’ll find powerpoint files for every chapter of the aforementioned two books (1900 slides in total), all the Excel files needed to generate your own energy scenarios, and a coupled climate-carbon cycle model in Excel to explore the range of possible climate consequences for different sets of scenario assumptions and physical climate parameters