Energy Resource Depletion and Carbon Emissions – Global Projections to 2050

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Melbourne, October 2009

Outline

- **Summary of questions and findings**
- **Model description**
- **Results to 2050**
  - **Coal**
  - **Oil**
  - **Natural gas**
- **Carbon dioxide emissions**
- **Policy issues**

Key questions

- **When will energy resource depletion, of coal, oil and gas, significantly affect supply?**
- **How will trade flows be affected by resource depletion?**
- **How is projected fossil fuel resource consumption related to future carbon dioxide emissions?**
- **Will resource depletion play any near term role in the mitigation of emissions?**
- **Are there policy issues that relate to both resource depletion and CO_2 emissions mitigation?**

Key findings

- **Energy resource depletion will affect fuel supply in several major economies in the near term**
- **Global fuel consumption will be will be dependent on reallocation of trade flows and supply lines to adequately maintain domestic supplies**
- **If consumption is maintained, global CO_2 emissions are likely to proceed to levels that are inconsistent with avoiding climatic catastrophe**
- **However the magnitude of the required trade reallocation, will likely make sustaining global fuel consumption problematic**

Model Framework

- **Projections are based on a new 79 country macro growth model, with three major components**
  - **Macro aggregates in real terms are determined by growth rate equations and macro elasticities**
  - **Exports in current prices are determined from import demands via a commodity trade flow matrix**
  - **Resource supply and demand is determined by a stock adjustment model**
- **The model arose from the idea of using short term Project Link forecasts as a basis for long term projections**

Model attributes

- **Advantages**
  - **Model is highly amenable to user adjustable parameters and coefficients**
  - **Supply shortages flow through to export response**
  - **Allows comprehensive calculation of trade implications of resource depletion**
- **Current limitations**
  - **Little account taken of how supply logistics may constrain imports and consumption**
  - **Insuficient price driven subsitution**

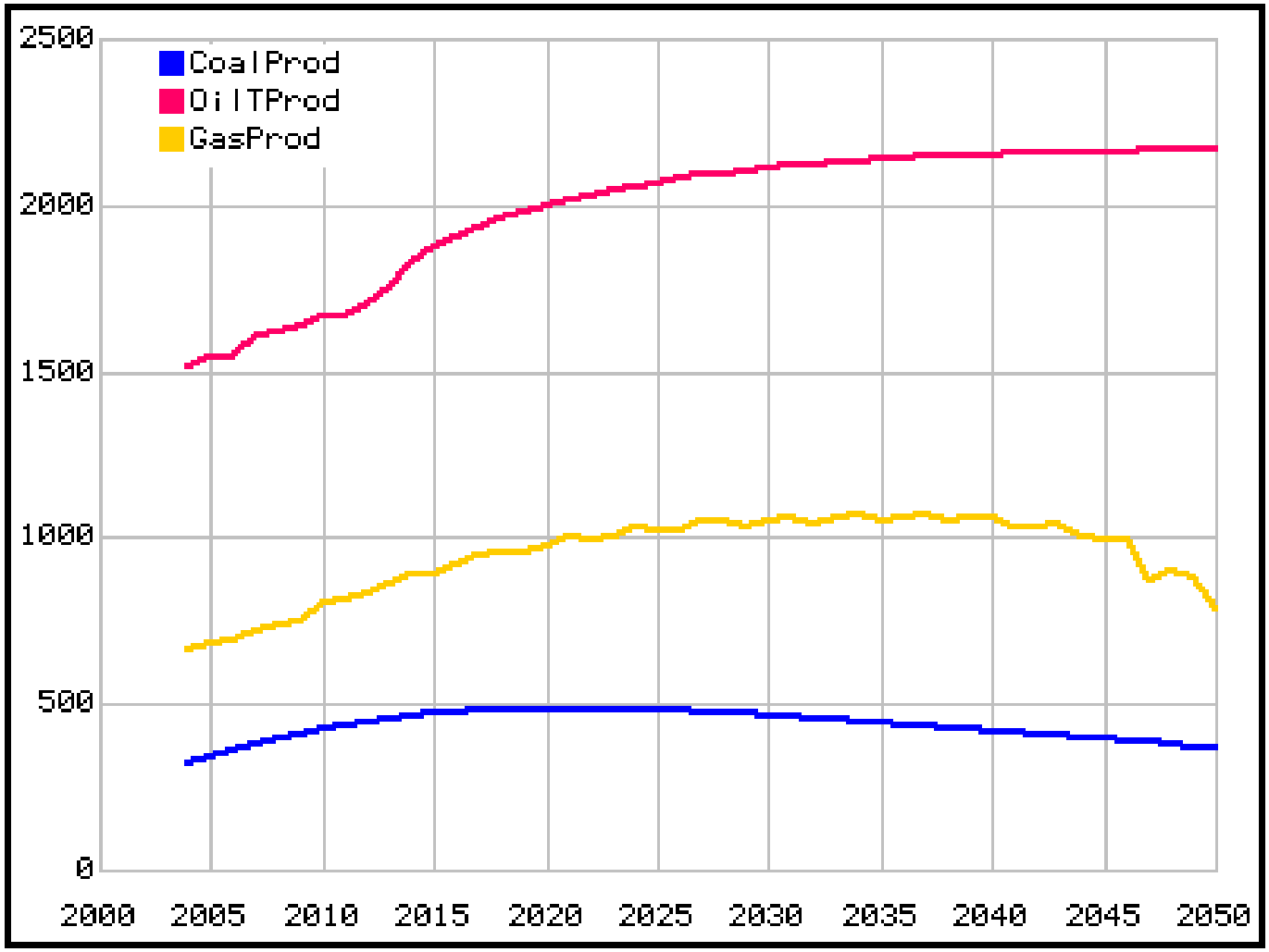
Key Assumptions

- **Real growth rates converge to 1% in 2050**
- **Relative price increases:**
  - **Coal 4%**
  - **Oil 3%**
  - **Gas 2%**
  - **Agricultural and raw materials 1%**
- **GDP intensity (*constant rate*)**
  - **Coal -2%**
  - **Oil -1%**
  - **Gas 0%**

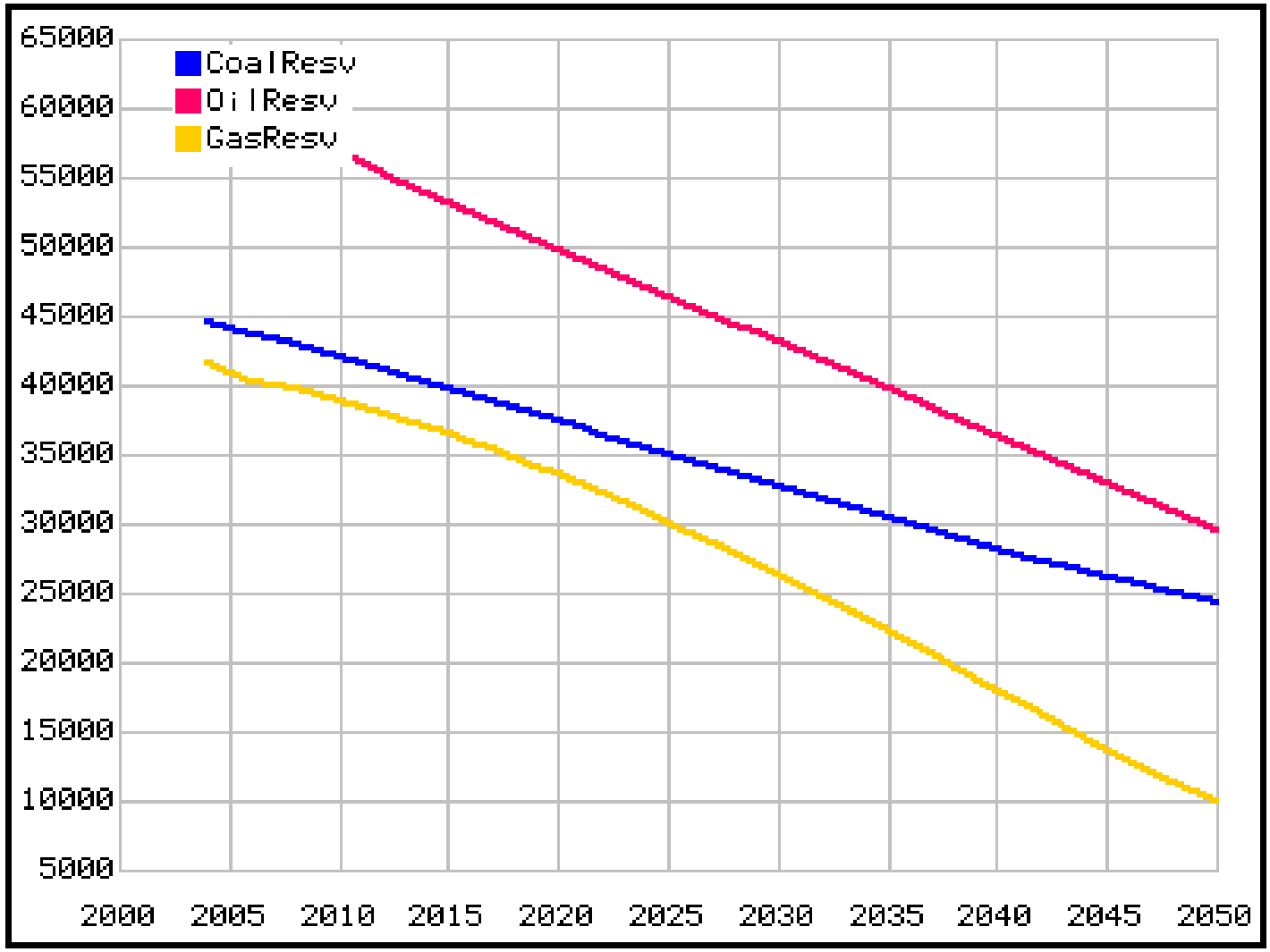
Model results

- **Trade increases as a share of national income**
- **Fuel consumption stabilises as GDP growth is counteracted by the GDP mitigation factor**
- **Reserves decline substantially, by at least half for oil, more for gas, less for coal**
- **The global results mask dramatic results at the national level**

Fossil fuel production (2005 $bn)



Fossil fuel reserves (2005 $bn)

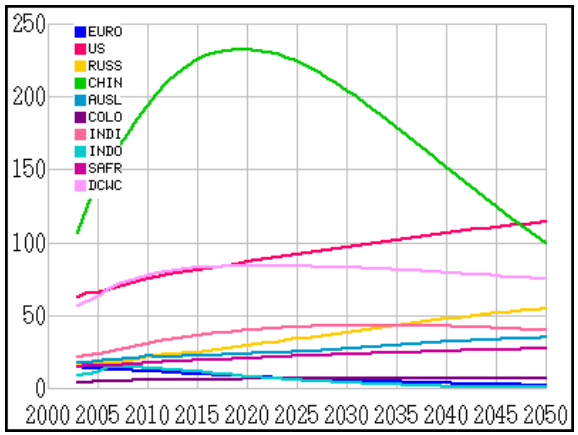


Coal reserves in 2005 (bill tonnes)

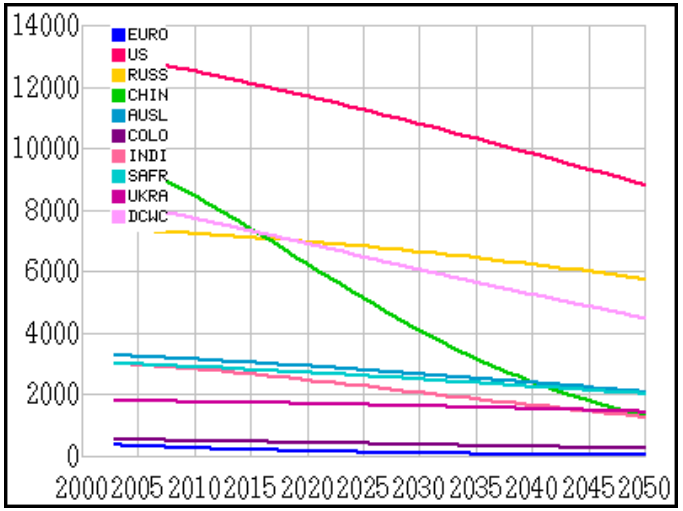
	Reserves	Cum %	Years of supply
United States	**200.7**	**29.3**	**195**
Russia	**124.6**	**47.5**	**428**
China	**98.8**	**61.2**	**65**
Australia	**64.7**	**71.3**	**172**
India	**55.2**	**79.4**	**129**
South Africa	**48.0**	**86.4**	**195**
Ukraine	**28.3**	**90.5**	**469**
Total	**685.6**	**100.0**	**107**

Source: US EIA. Black coal equivalent. China reserves increased by 50%

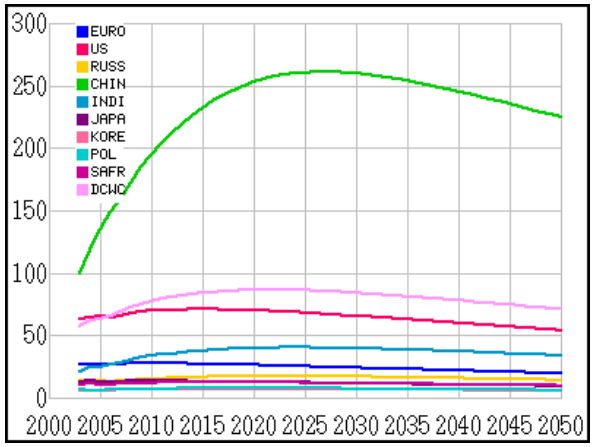
Coal disposition – 2005 US $billion



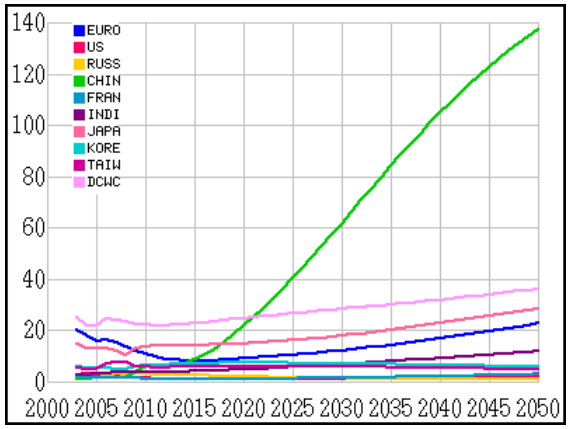
Production



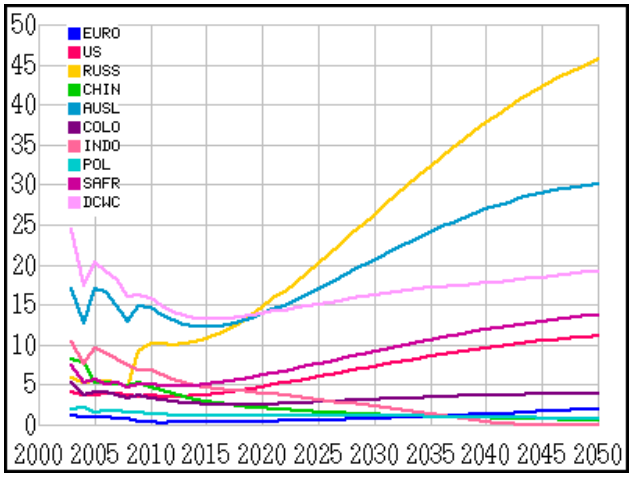
Reserves



Consumption



Imports



Exports

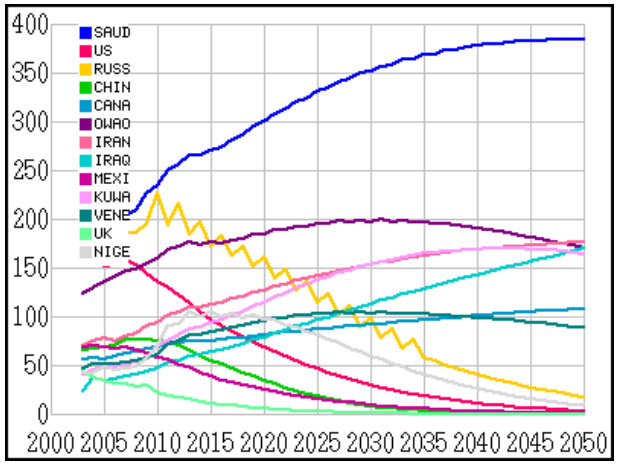
Oil reserves in 2005 (bill barrels)

	Reserves	Cum %	Years of supply
Saudi Arabia	**262.3**	**21.8**	**76**
Iran	**134.6**	**33.0**	**90**
Other West Asian Exporters *	**131.2**	**43.9**	**54**
Iraq	**120.0**	**53.8**	**176**
Canada	**102.4**	**62.3**	**119**
Kuwait	**100.8**	**70.7**	**110**
Russia	**67.2**	**76.3**	**21**
Venezuela	**66.4**	**81.8**	**72**
Total	**1204.1**	**100.0**	**39**

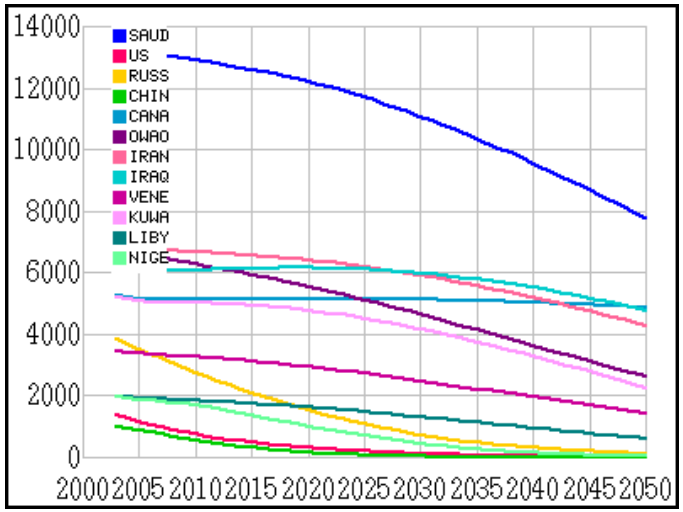
*** Principally United Arab Emirates, Kazakhstan and Qatar**

Source: US EIA. Average of World Oil and Oil & Gas Journal estimates.

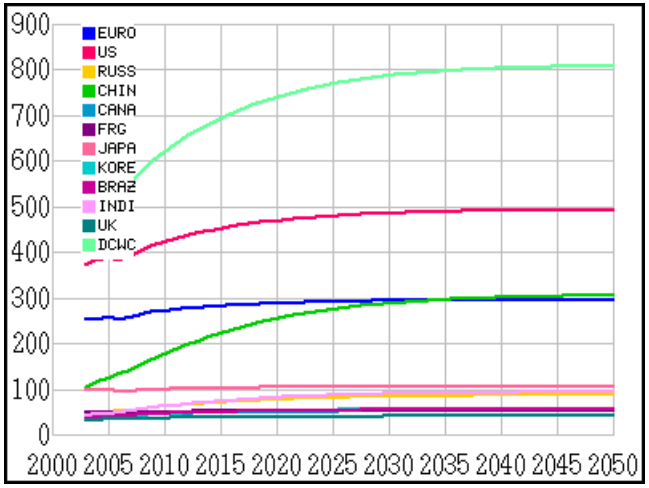
Oil disposition – 2005 US $billion



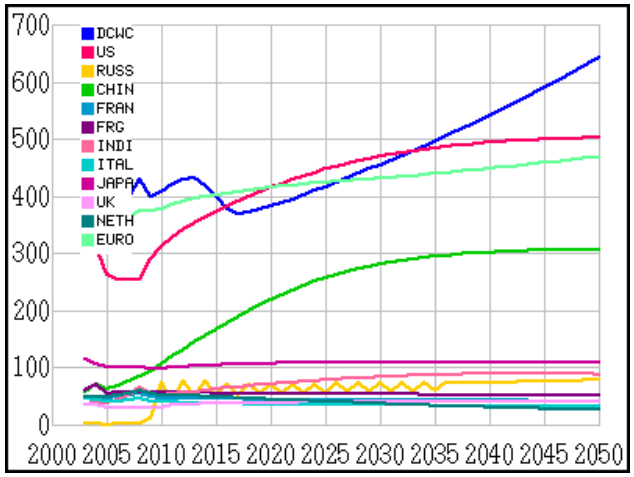
Production



Reserves



Consumption



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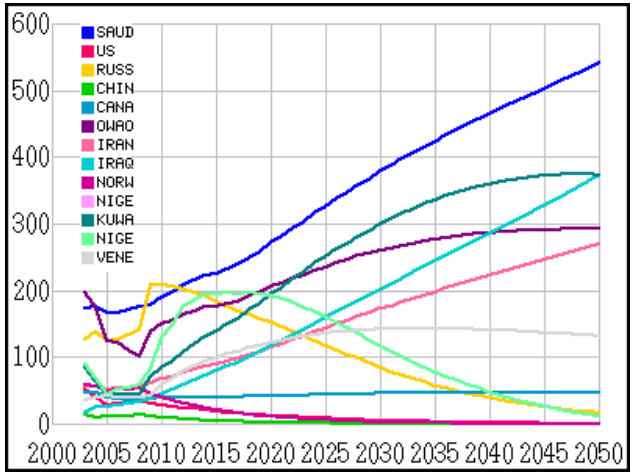


Exports

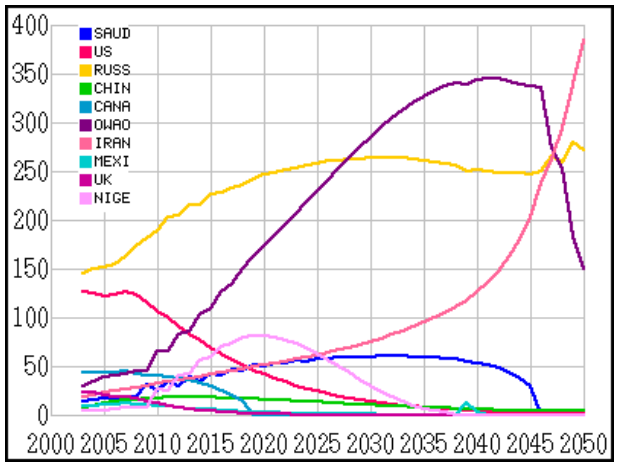
Natural gas reserves, 2005 (trill cubic feet)

	Reserves	Cum %	Years of supply
Russia	**1684.4**	**27.6**	**75**
Other West Asian Exporters *	**1241.2**	**48.4**	**218**
Iran	**974.0**	**64.5**	**274**
Saudi Arabia	**246.3**	**68.6**	**99**
United States	**211.1**	**72.0**	**13**
Nigeria	**183.2**	**75.1**	**53**
Algeria	**161.5**	**77.7**	**125**
Venezuela	**151.7**	**80.2**	**151**
Total	**6048.9**	**100.0**	**58**

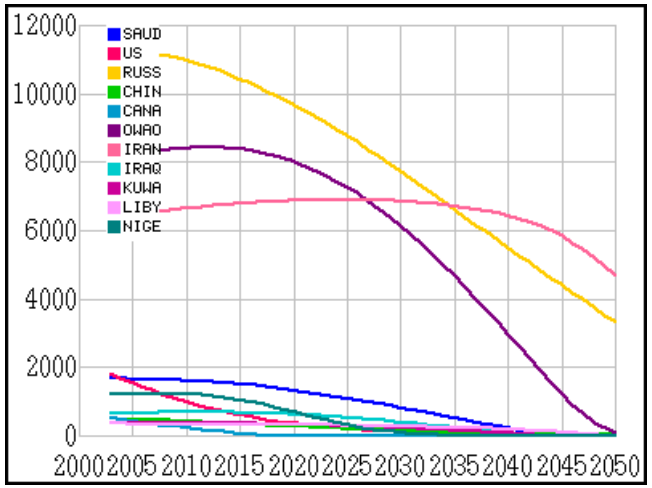
*** Principally Qatar, UAE and Kazakstan**

Source: US EIA. Average of World Oil and Oil & Gas Journal estimates

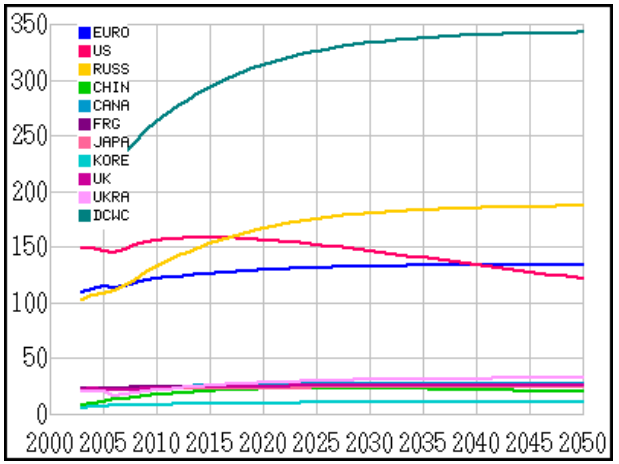
Natural gas disposition – 2005 US $billion



Production



Reserves



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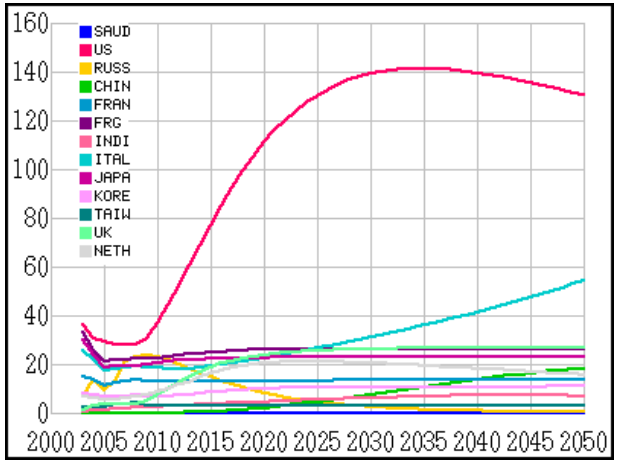

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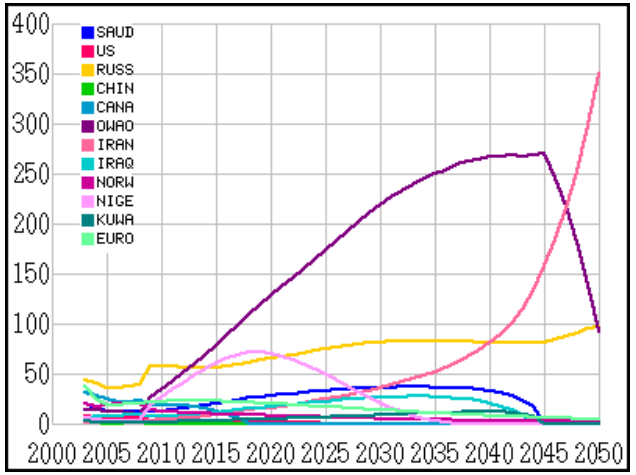
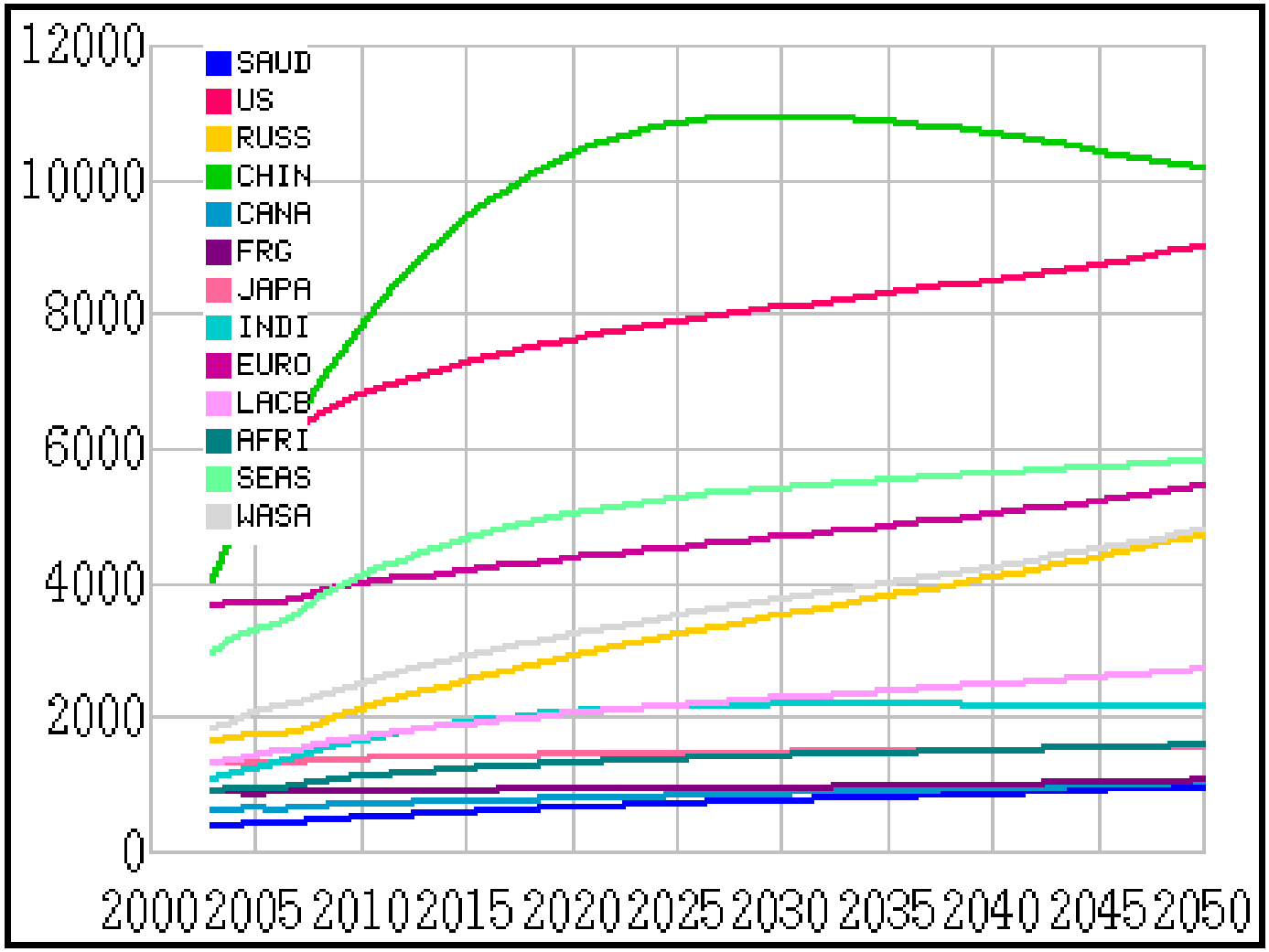


Exports

Carbon dioxide emissions and fossil fuel consumption

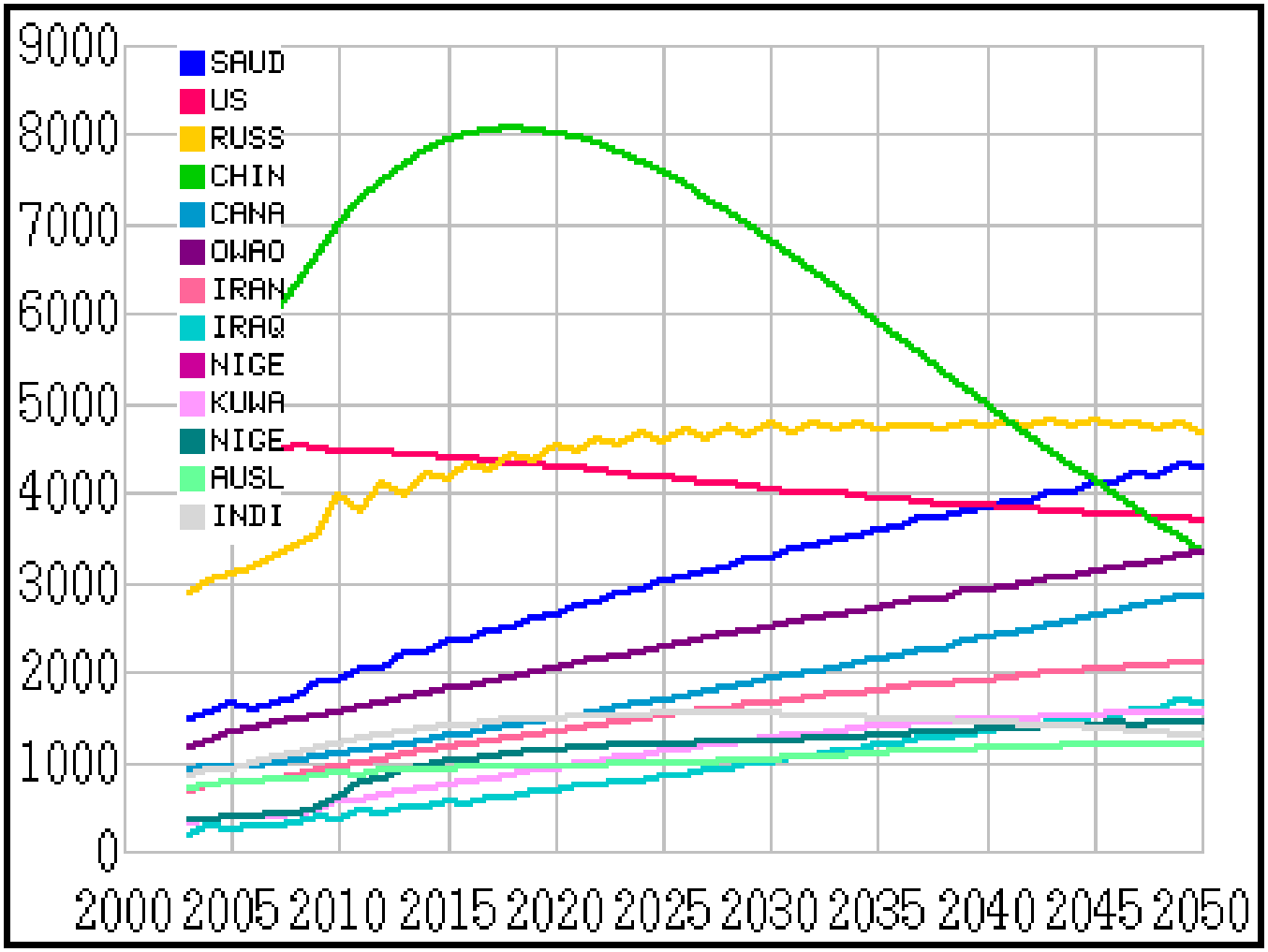
- **The carbon content of each fuel type can be readily used to compute CO_2 generation, and thereby emissions**
- **Emissions, and thereby mitigation policies, are typically associated with the country of final fuel use**
- **In a global trading environment it may also be relevant to associate emissions with the country of fuel origin**
- **The idea of “taxation at source” may have future relevance in terms of carbon pollution reduction, and in terms of global equity, where resource prices may deviate widely from production costs**

CO_2 emissions from fuel use – mill tonnes



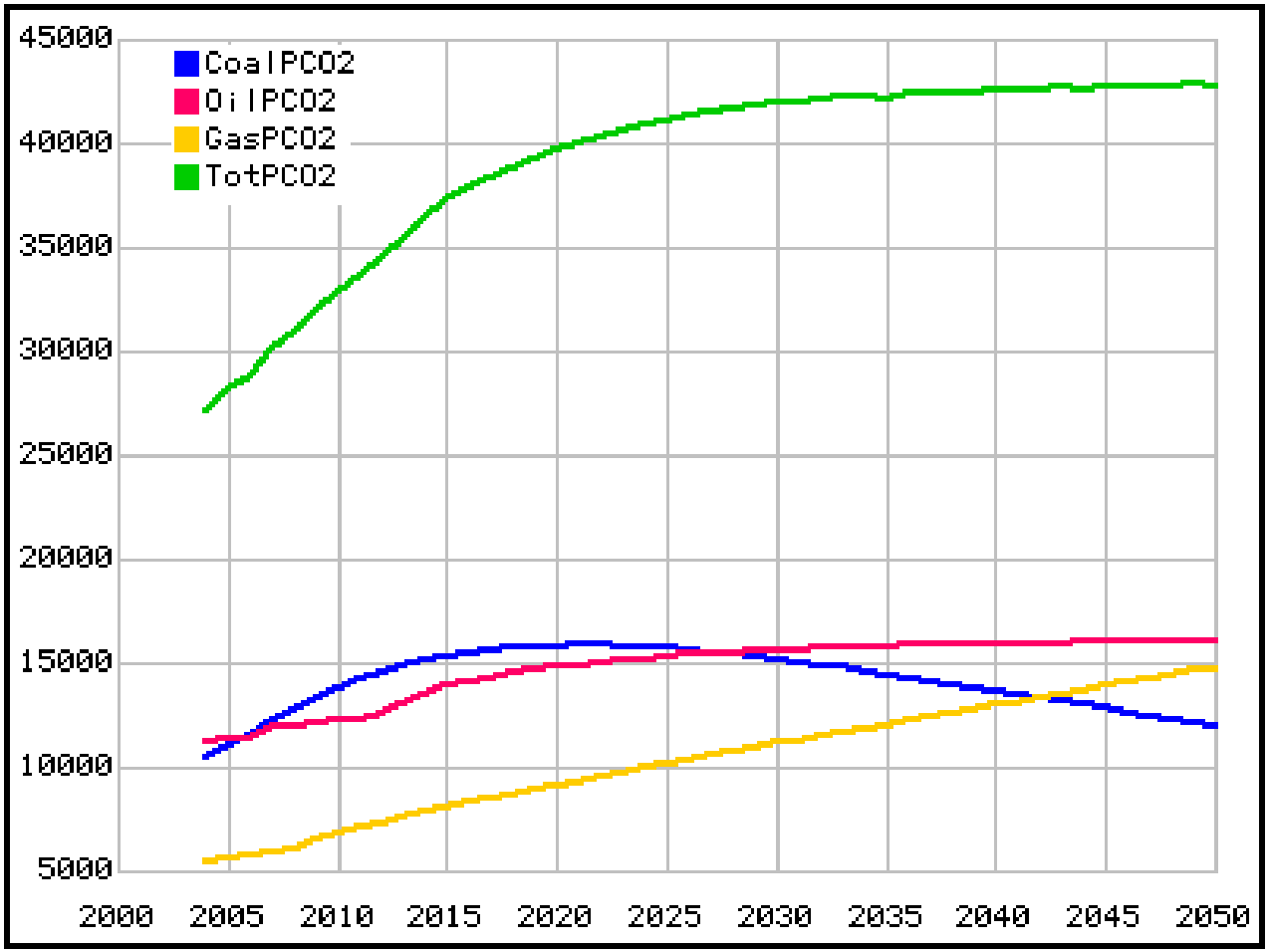
By country of coal, oil and gas consumption

CO_2 emissions from fuel supply – mill tonnes



By country of coal, oil and gas origin

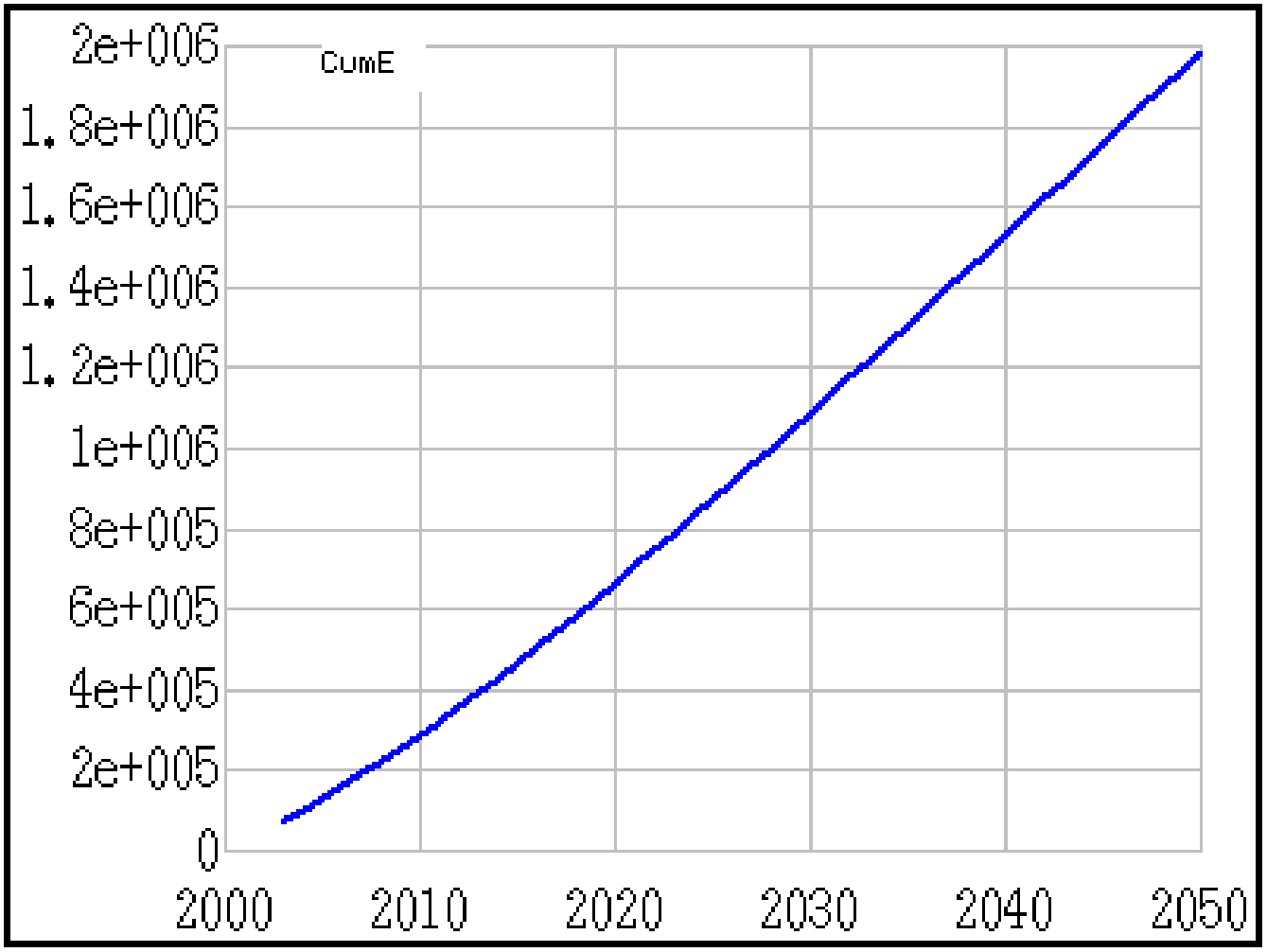
Global CO_2 emissions by fuel type – mill tonnes



Carbon dioxide emissions and the global environment

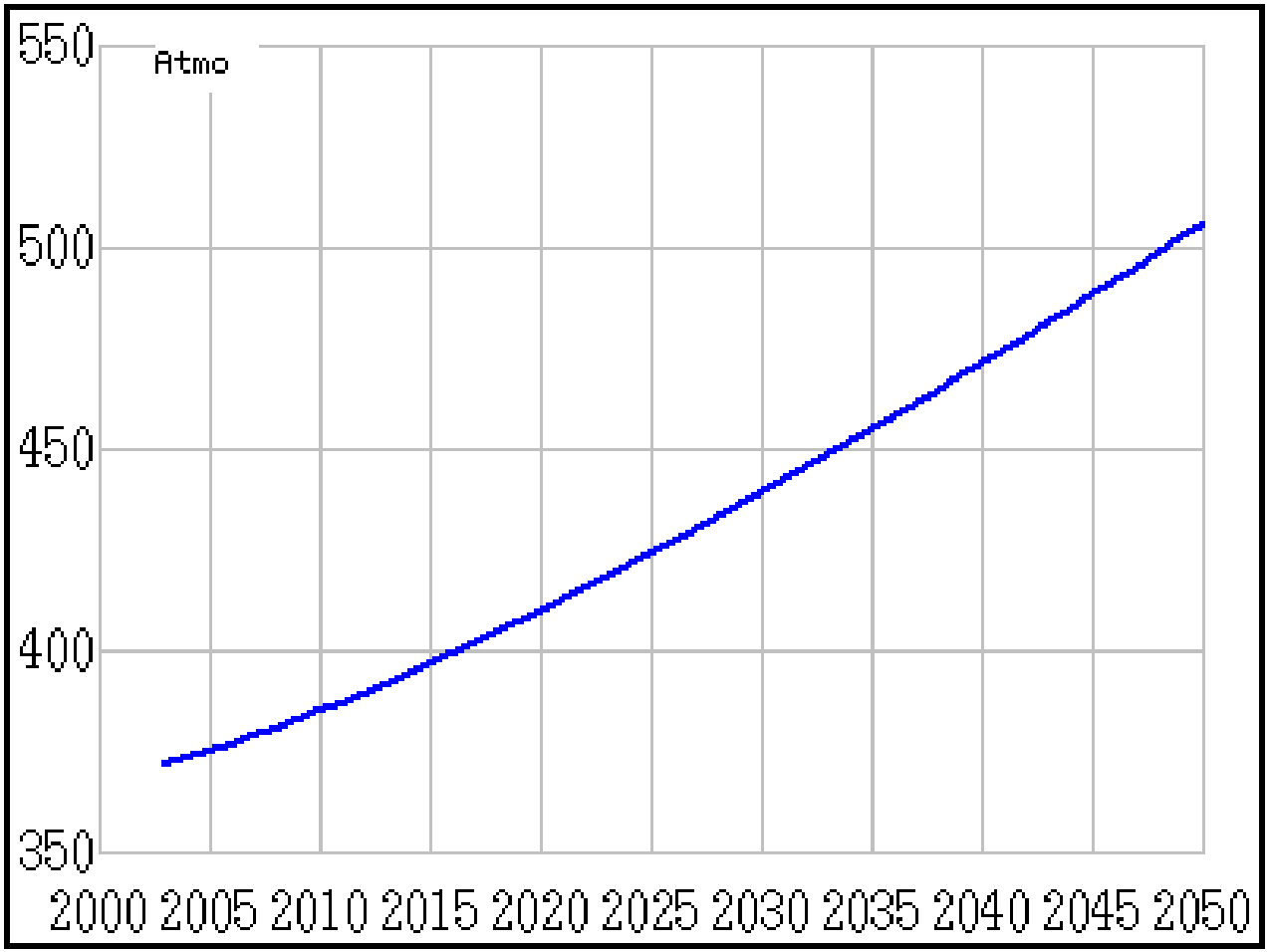
- **Global projections of fossil fuel use, given the assumptions made, lead to an emissions scenario inconsistent with environmental requirements**
- **Under the assumptions, data, and model used, total CO_2 emissions merely stabilise at a level 60% above 2000 levels**
- **Given that abatement requirements are equivalent to the total elimination of emissions from coal, far more drastic measures than those envisaged, need to be deployed**
- **In an ideal world, global supervision of resource prices, administered at the site of resource origin, may be part of a solution**

Cumulative CO_2 emissions– mill tonnes



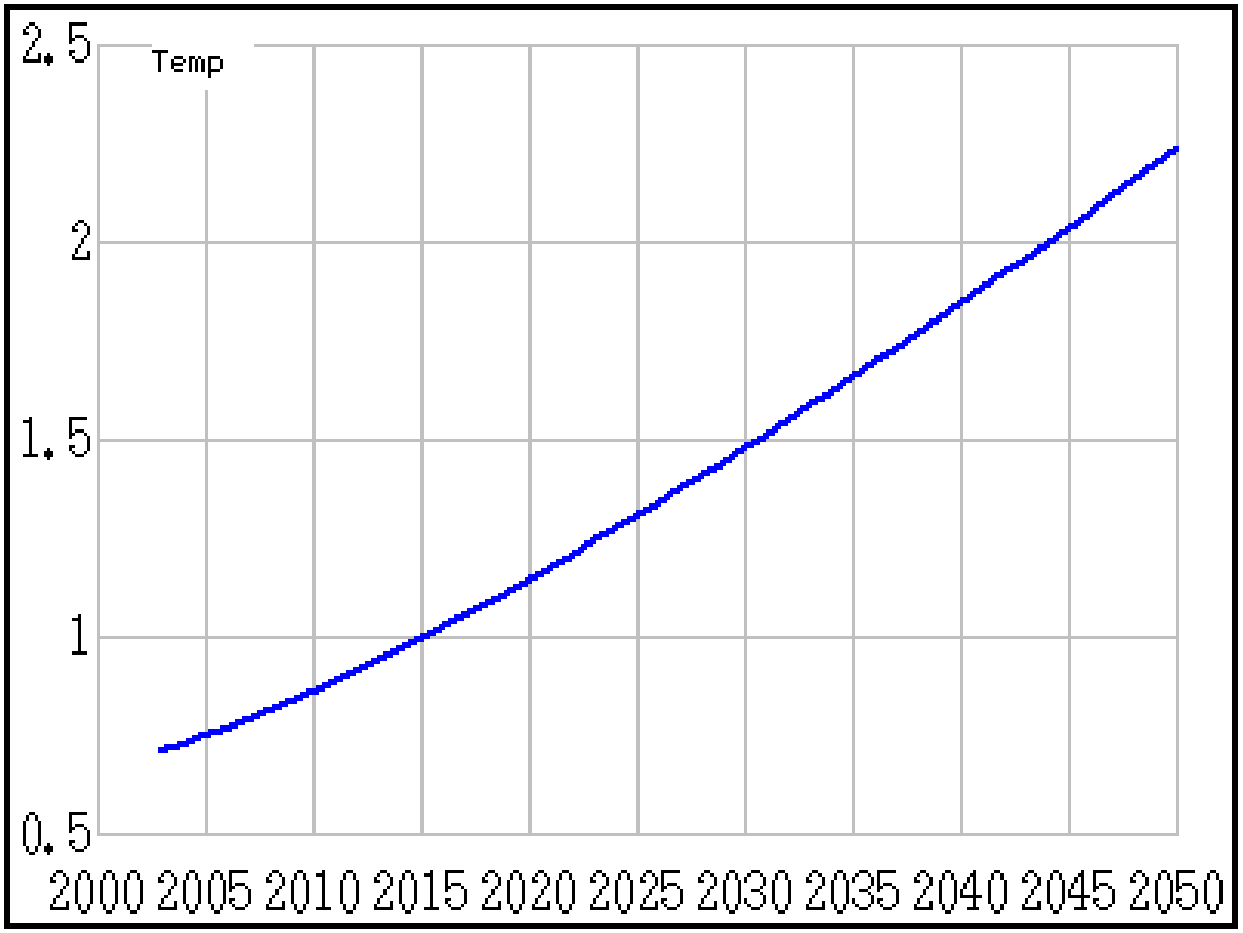
Emissions “budget” by 2050 is 1 trillion tonnes – exceeded in 2029

Atmospheric CO_2 concentration – ppm



Based on accumulated emissions discounted by retention factor

Global temperature change – Deg C



Difference from 1950-81 average. Based on a point estimate only of the impact of CO2 concentration on global temperature.

Policy issues

- **Constrains on resource supplies will put sustained upward pressure on resource prices**
- **These pressures will assist effective mitigation**
- **However divergence between resource prices and production costs from existing reserves may lead to global tensions over resource availability and inequitable financial imbalances**
- **Policy makers should consider assisting the deployment of resource wealth for the purpose of equitable alternative energy production**