Imperial College London

東京大学 THE UNIVERSITY OF TOKYO

Energy and Green House Gas Mitigation Technologies

Japan Society for the Promotion of Science-Imperial College London-University of Tokyo Symposium on Climate Change

Thursday 28th and Friday 29th September 2006

energy futures lab

Imperial College London, South Kensington Campus, London SW7 2AZ

JAPAN SOCIETY FOR THE PROMOTION OF SCIENCE · FOUNDED 1932 ·

Trends in Energy R&D

John Loughhead

Executive Director

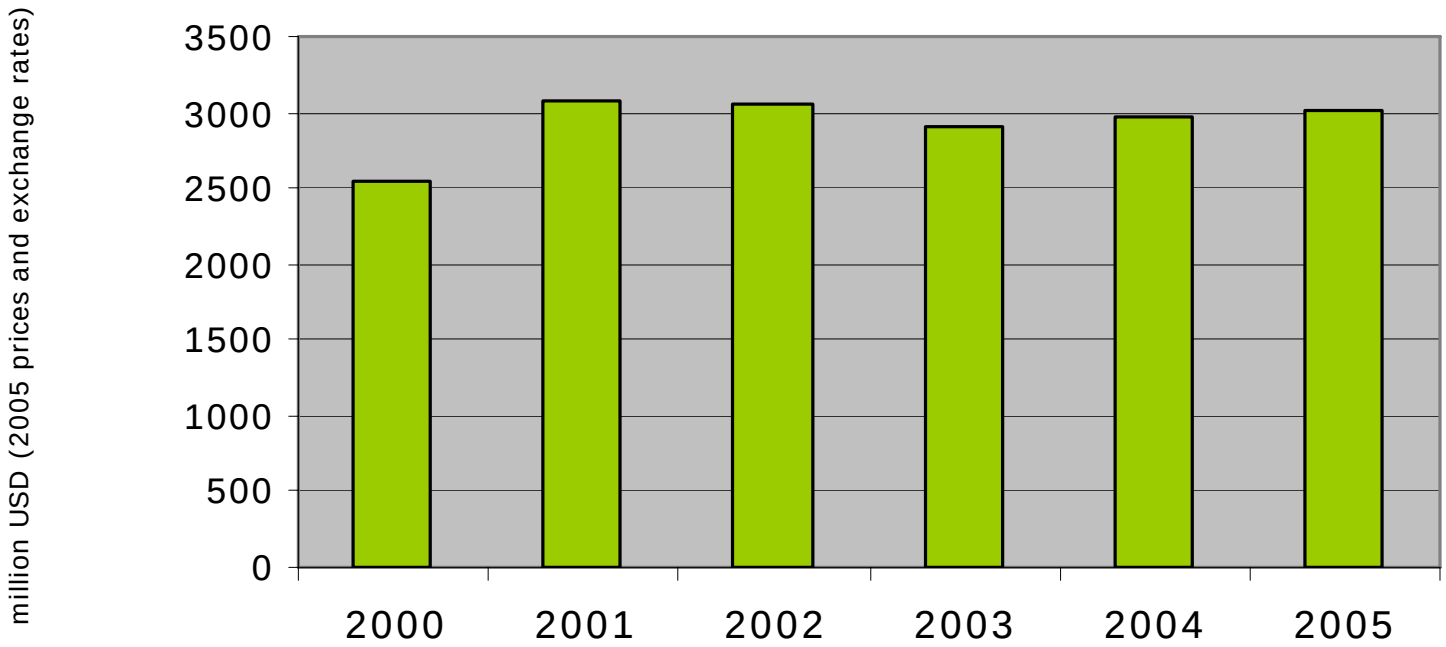
UK Energy Research Centre

Energy and Greenhouse Gas Mitigation Technologies

Imperial College

28th September 2006

US Energy R&D Spend



Source: IEA

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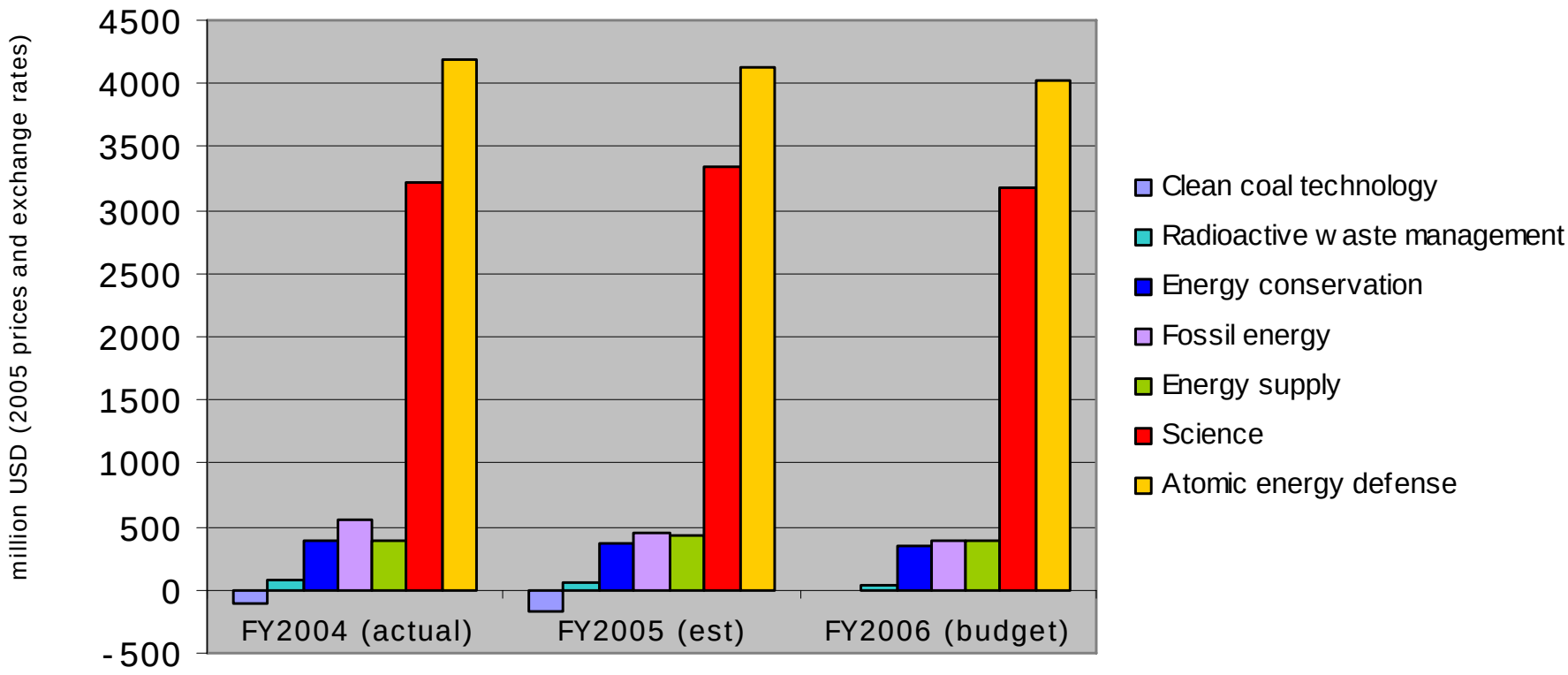
US Energy R&D Spend



Source: IEA

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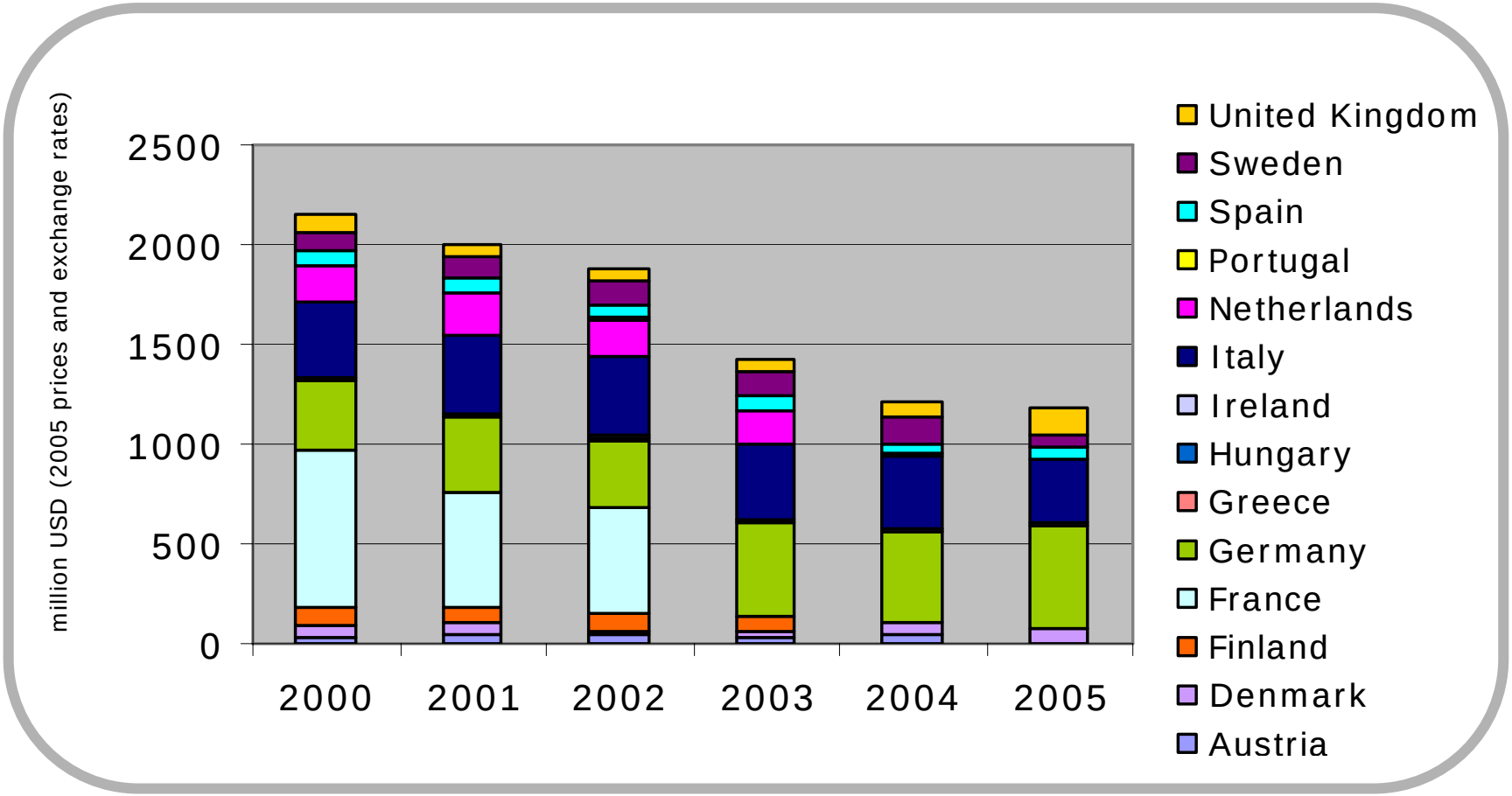
EU-15 Energy R&D Spend



Source: IEA

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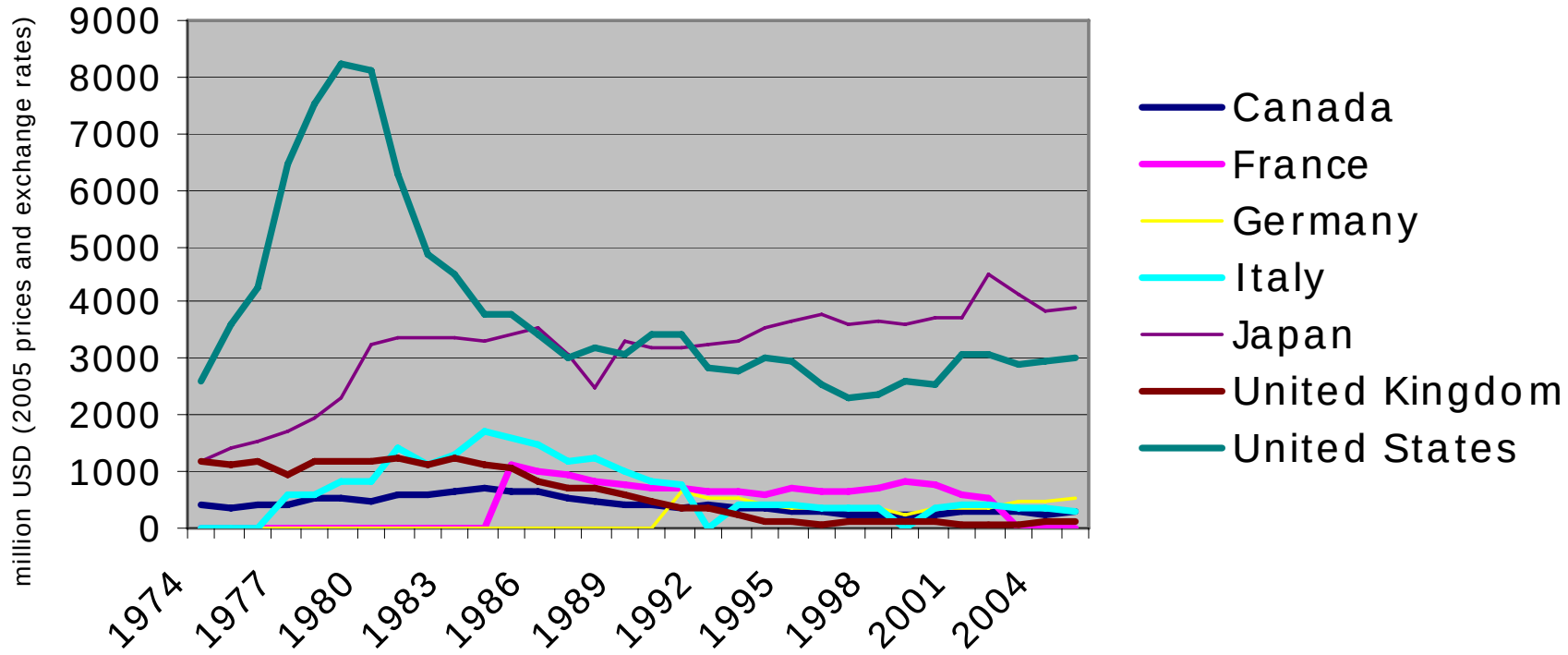
G7 Energy R&D Spend 1974-2005



Source: IEA

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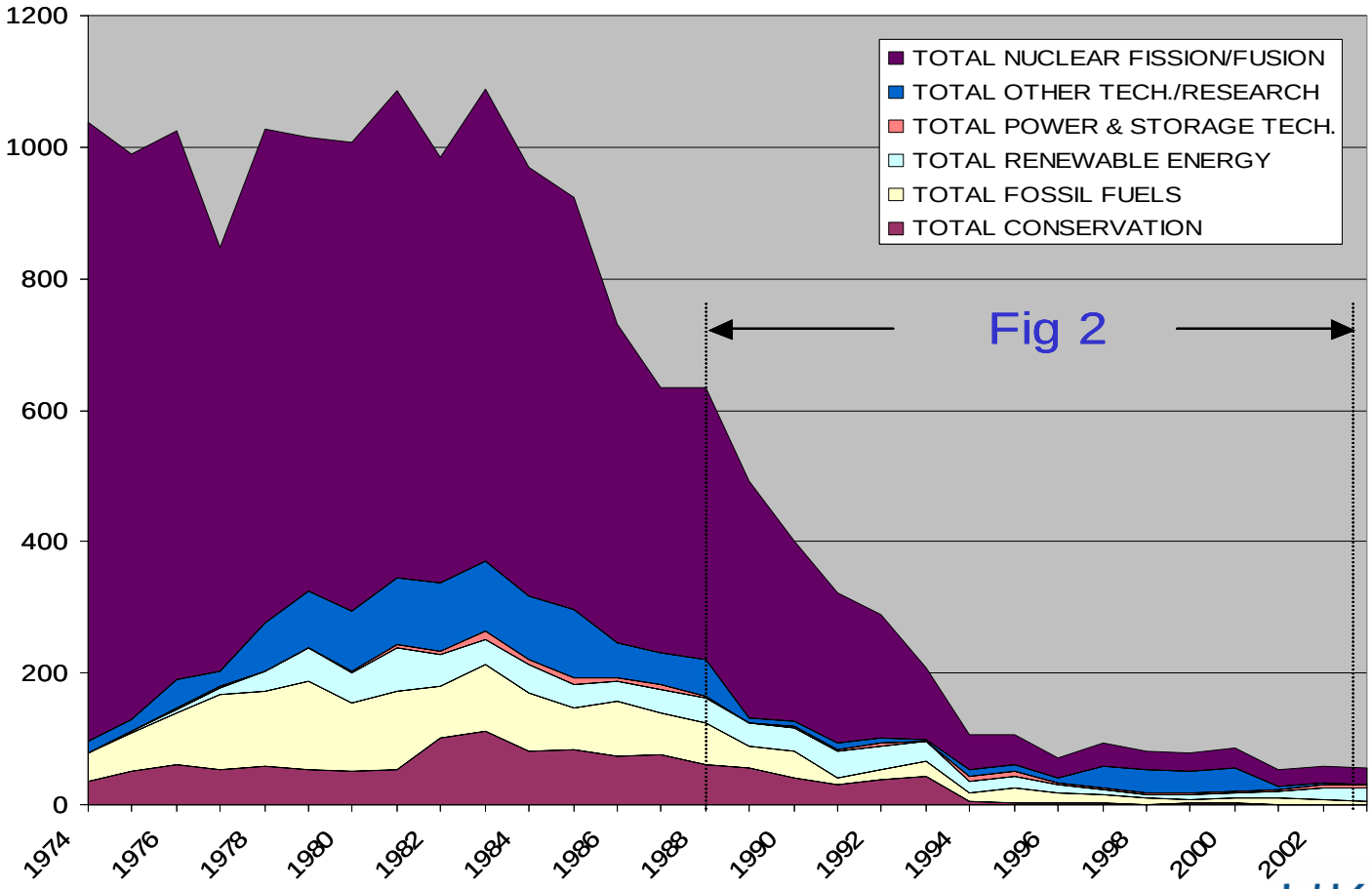
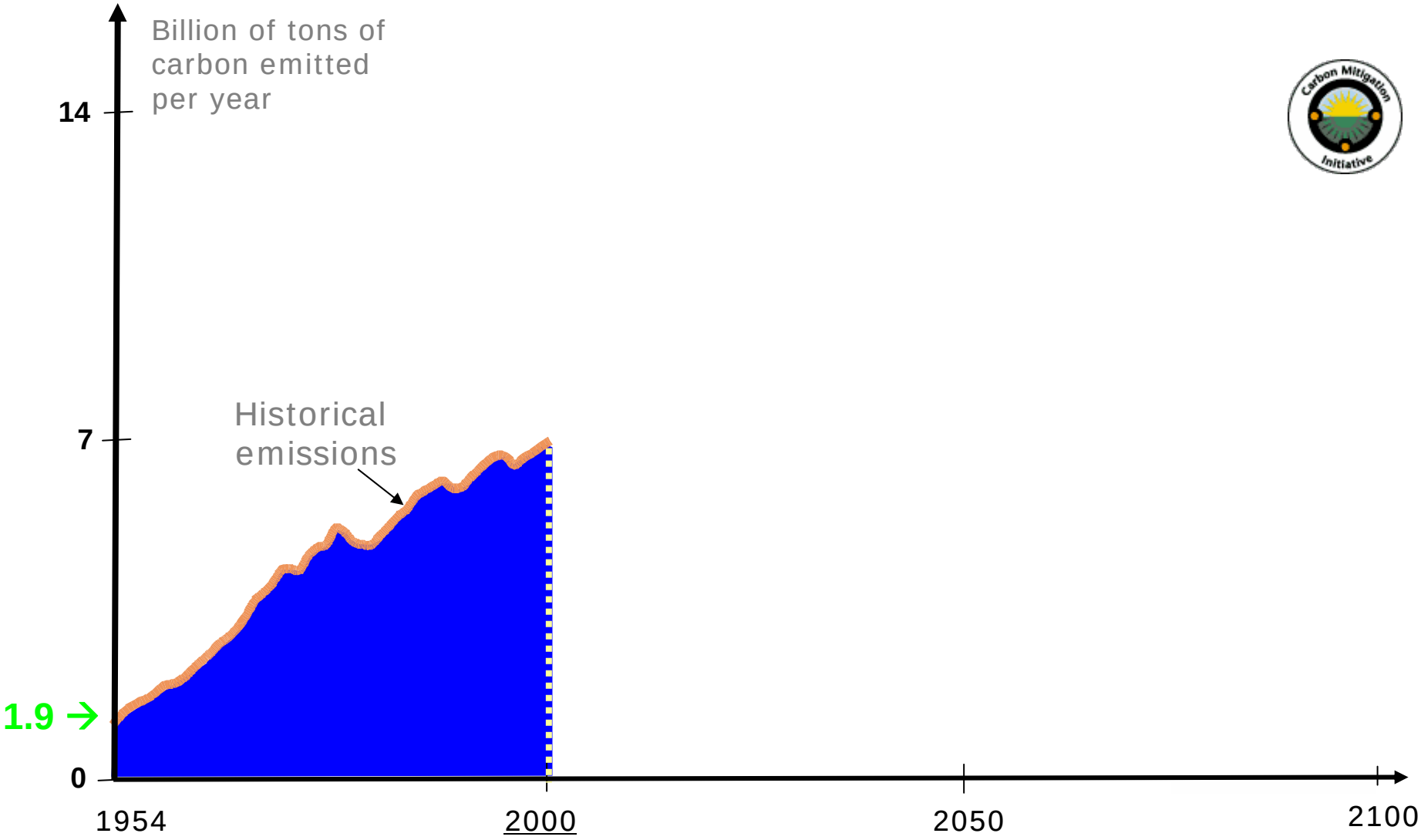
UK Energy R&D Spend

(US$ equivalent ($m)

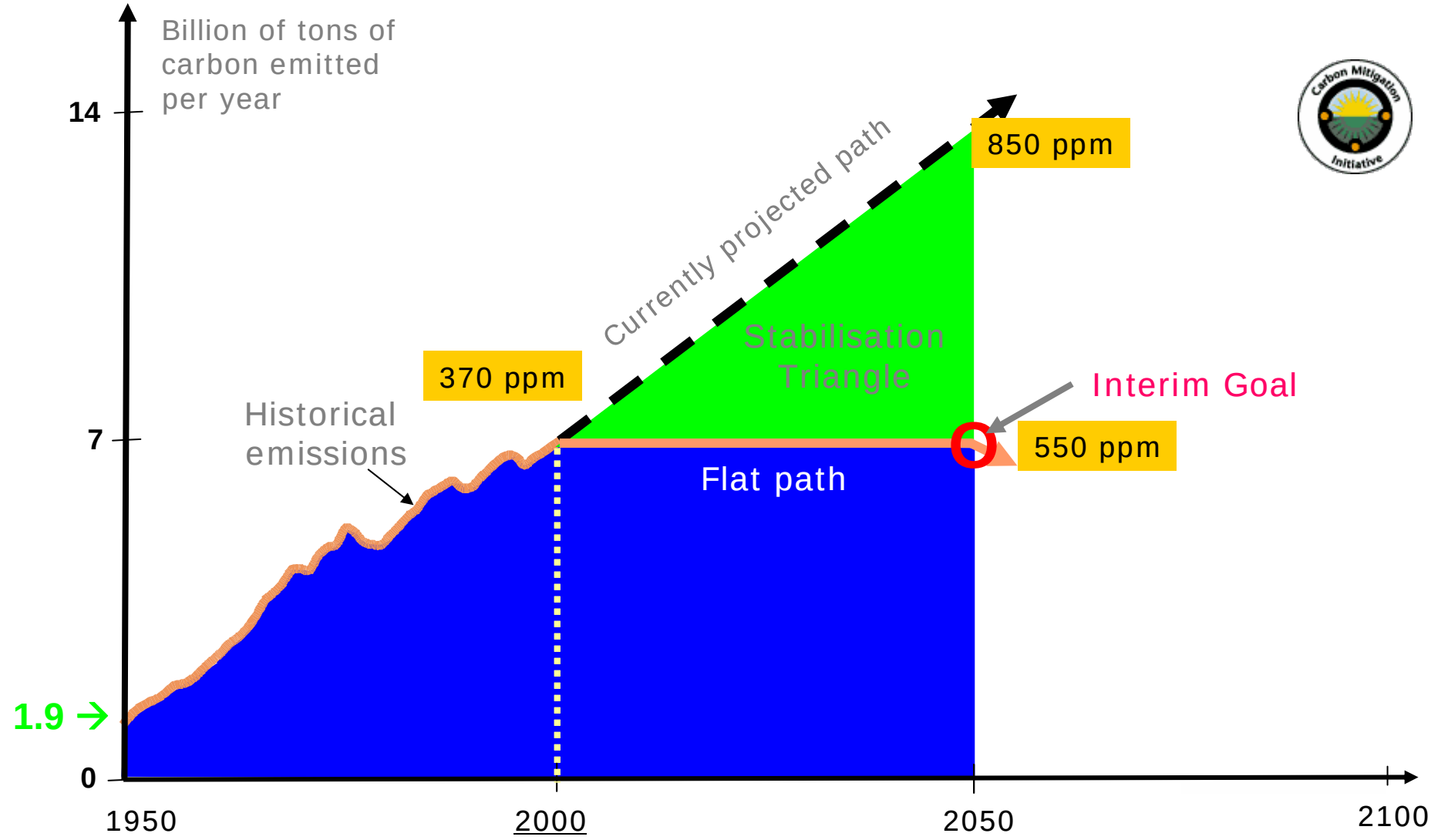


Source: Council for Science and Technology, 2005

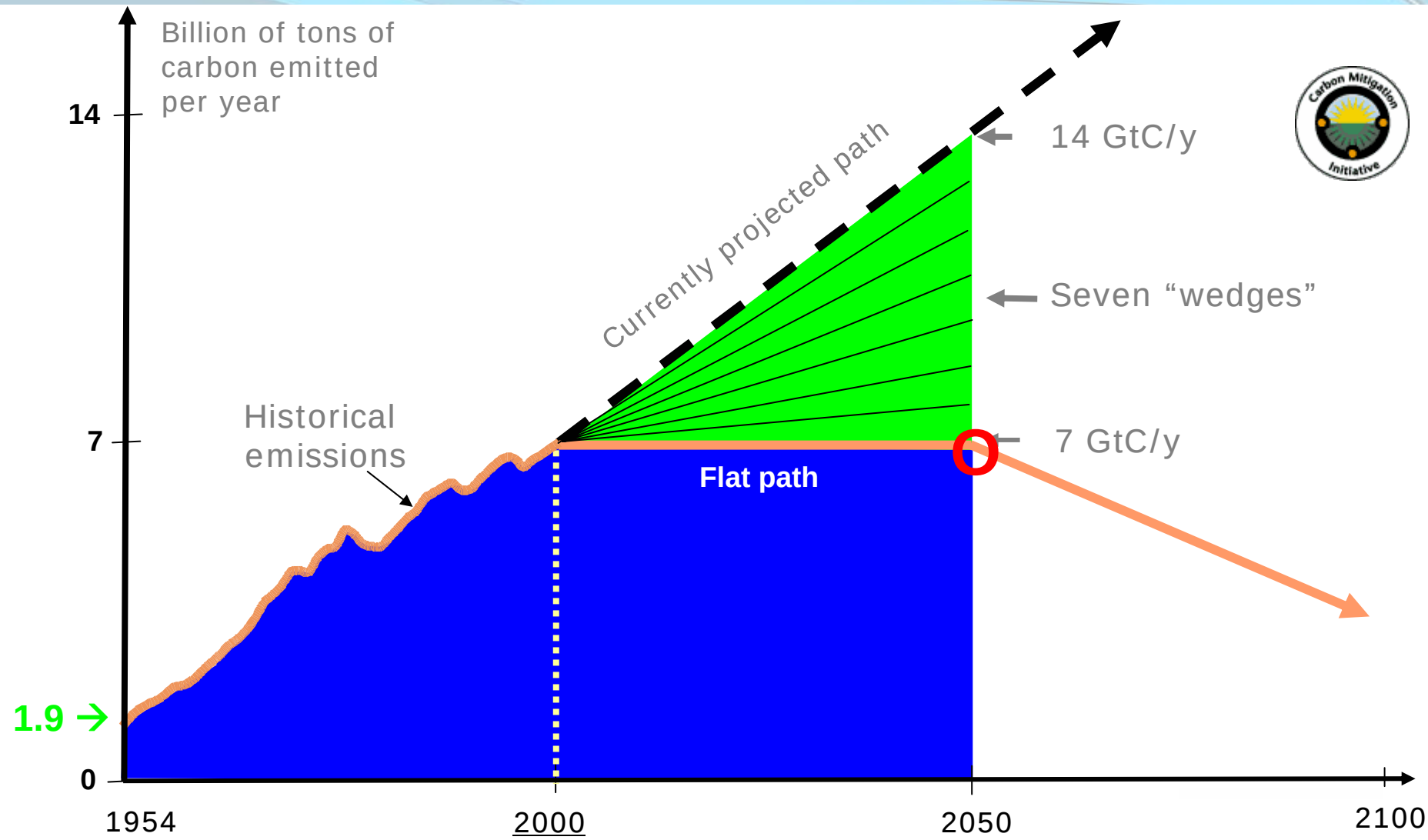
Past Emissions



The Stabilisation Triangle

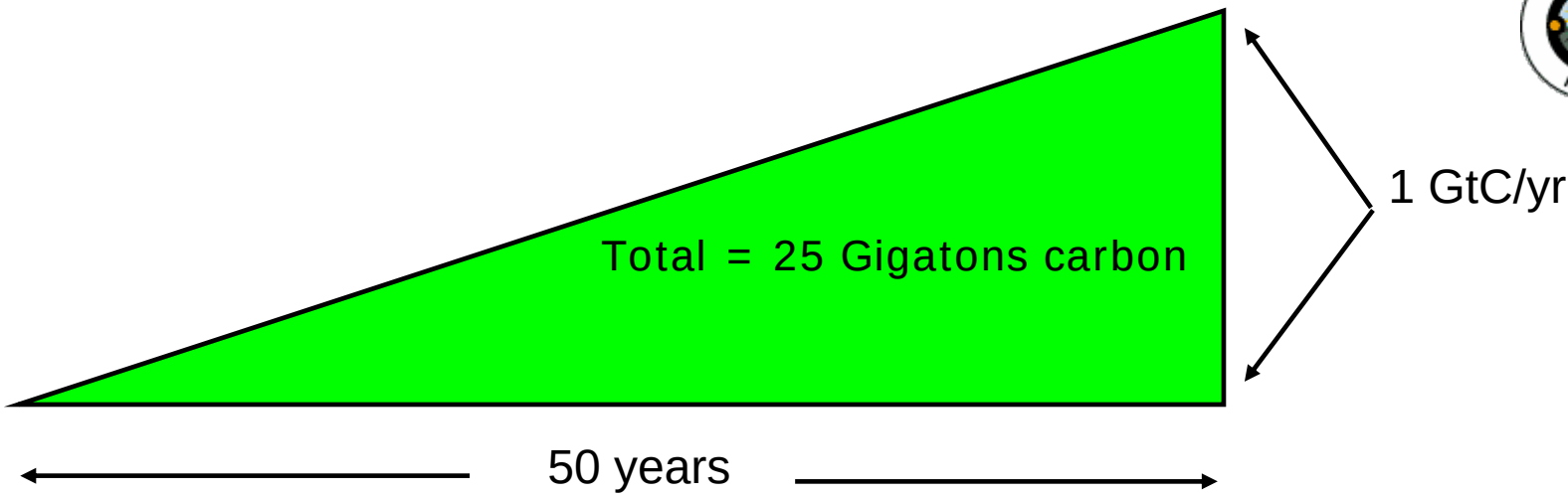


Wedges


Billion of tons of carbon emitted per year
14
7
1.9 →
0
1954
2000
2050
2100
Historical emissions
Currently projected path
14 GtC/y
Seven “wedges”
7 GtC/y
Flat path
Carbon Mitigation Initiative

What is a “Wedge”?

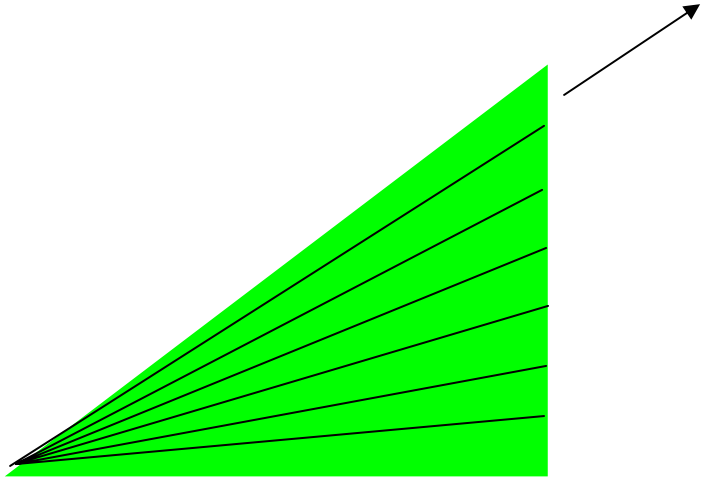
A wedge is a strategy to reduce carbon emissions that grows in 50 years from zero to 1.0 GtC/yr



Cumulatively, a wedge redirects the flow of 25 Gt(C) in its first 50 years. This is 2.5 trillion dollars at $100/t(C)

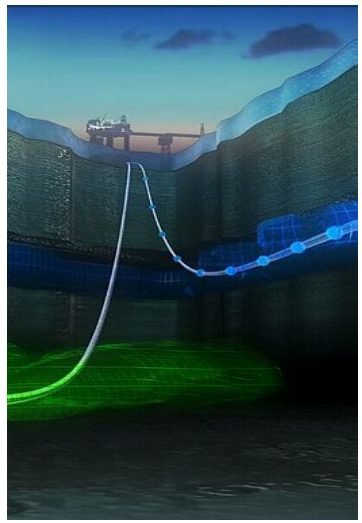
A “solution” to the Greenhouse problem should have the potential to provide at least one wedge

Effort Needed by 2054 for 1 Wedge



CCS

- 3500 Sleipners @1 MtCO2/yr
- 100 x U.S. CO2 injection rate for EOR
- A flow of CO2 into the Earth equal to the flow of oil out of the Earth today



Source: Bernie Bulkin, Sustainable Development Commission

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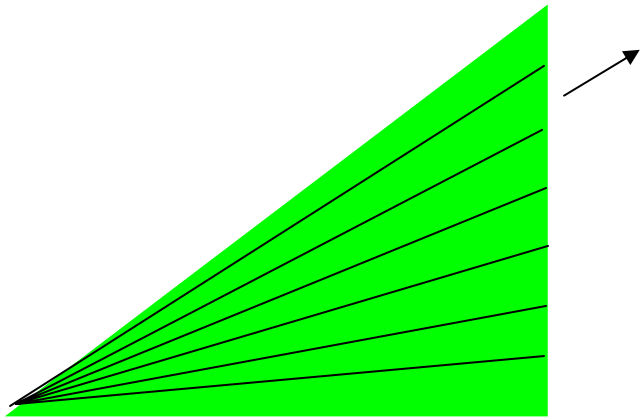
Effort Needed by 2054 for 1 Wedge

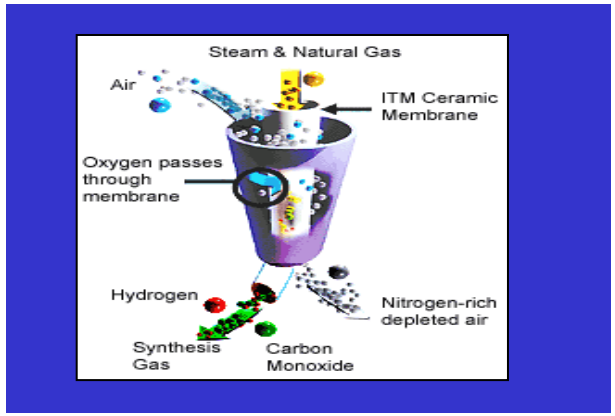


Fossil-fuel-based H2 with CCS

Use: H_2 instead of gasoline or diesel in 2 billion vehicles

Production: Capture and store, instead of venting, the CO_2 byproduct of 250 MtH_2/year produced from coal

Today: 40 MtH_2/year is produced from all sources



Source: Bernie Bulkin, Sustainable Development Commission

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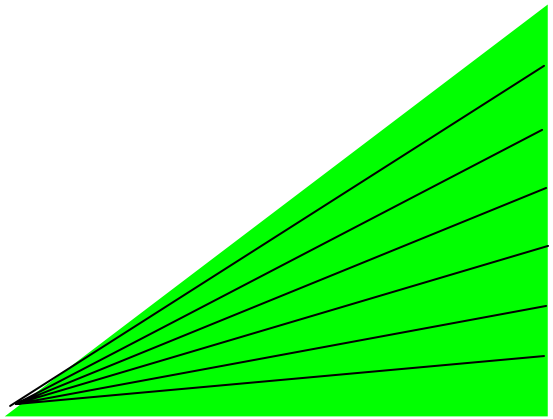
Effort Needed by 2054 for 1 Wedge



Offshore Wind

Effort needed by 2050 for 1 wedge:

2 000 000 MW

Source: Bernie Bulkin, Sustainable Development Commission

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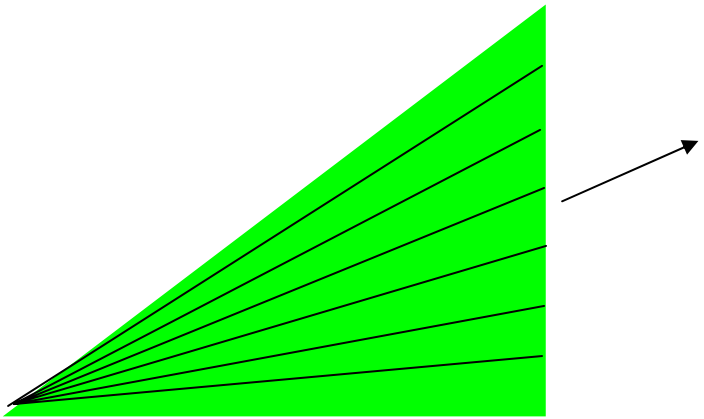
Effort Needed by 2054 for 1 Wedge



Nuclear

700 GW (twice current world capacity) displacing coal power

Phase out of nuclear power creates the need for another half wedge

Source: Bernie Bulkin, Sustainable Development Commission

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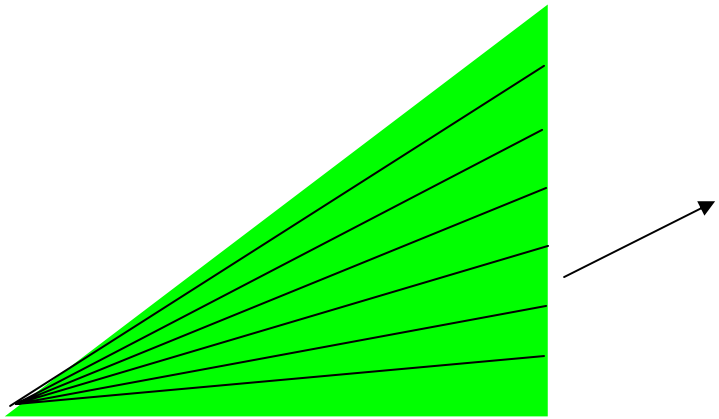
Effort Needed by 2054 for 1 Wedge



Biomass

Two billion 60 mpg cars running on biofuels
250 million hectares of high-yield crops (one sixth of world cropland)

Source: Bernie Bulkin, Sustainable Development Commission

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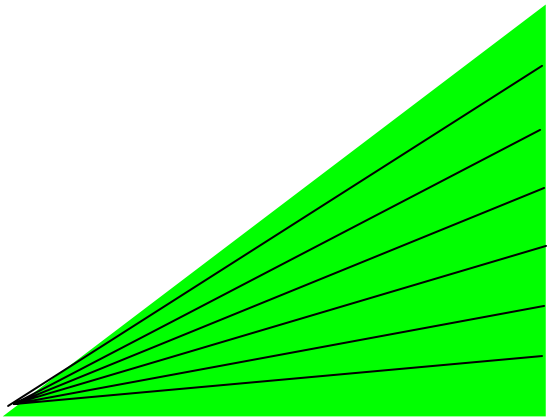
Effort Needed by 2054 for 1 Wedge



Wind hydrogen

- H_2 instead of gasoline or diesel in 2bn vehicles
- 4m 1 MW windmills
- Twice as many windmills as for a wedge of wind electricity
- Today: 40,000 MW (1%)
- Assumes the H_2 fuels 100-mpg cars

Source: Bernie Bulkin, Sustainable Development Commission

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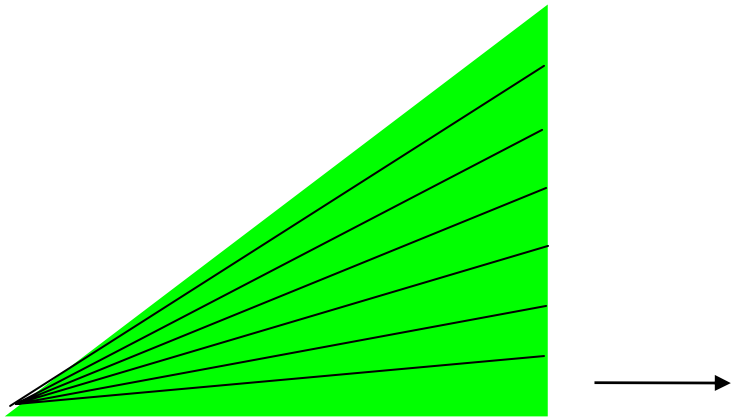
Effort Needed by 2054 for 1 Wedge



Source: Bernie Bulkin, Sustainable Development Commission

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Solar Collection Contribution

- 1 wedge = 1 400 000 MW
  or 12 000 000 000 MWh/yr

- Solar irradiance = 3-6kWh/m^2/day or 1-2MWh/m^2/yr
- So 1 wedge = 6-12 000 000 000 m^2 of collector

- Over 50 years we need to install

  120-240 000 000 m^2 each year

Total today of 1000MW is approximately 10 000 000 m^2

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- Meeting future needs through renewables will be challenging
- Fossil fuels will remain a major player

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A Projection to 2050

- Renewables provide an increasing amount of energy but do not meet our ambitions
- Fossil fuels remain dominant, and available, but at a price
- Coal becomes increasingly important
- Improved technologies for fossil use and carbon management are critical
- Developing world is key both as user and as developer of energy technology
- Nuclear renaissance
- Demand reduction becomes key theme

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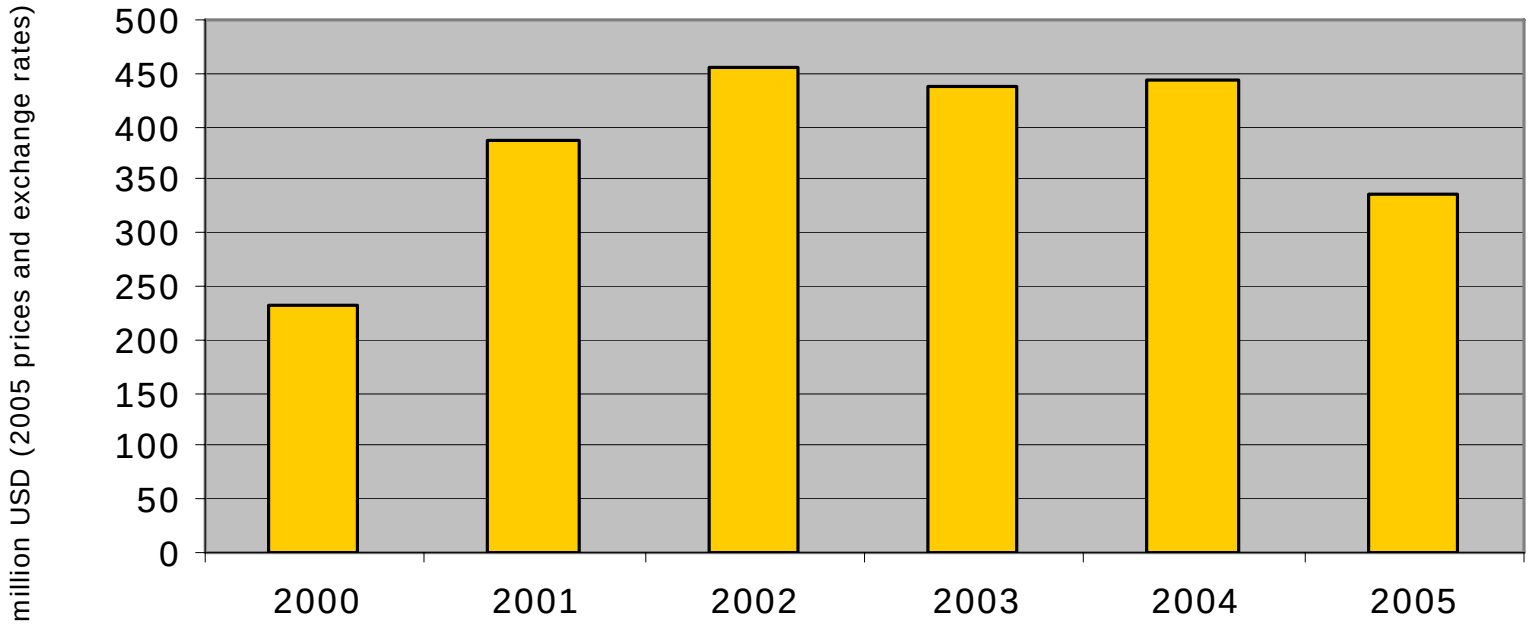
US R&D Spend: Fossil Fuels



Source: IEA

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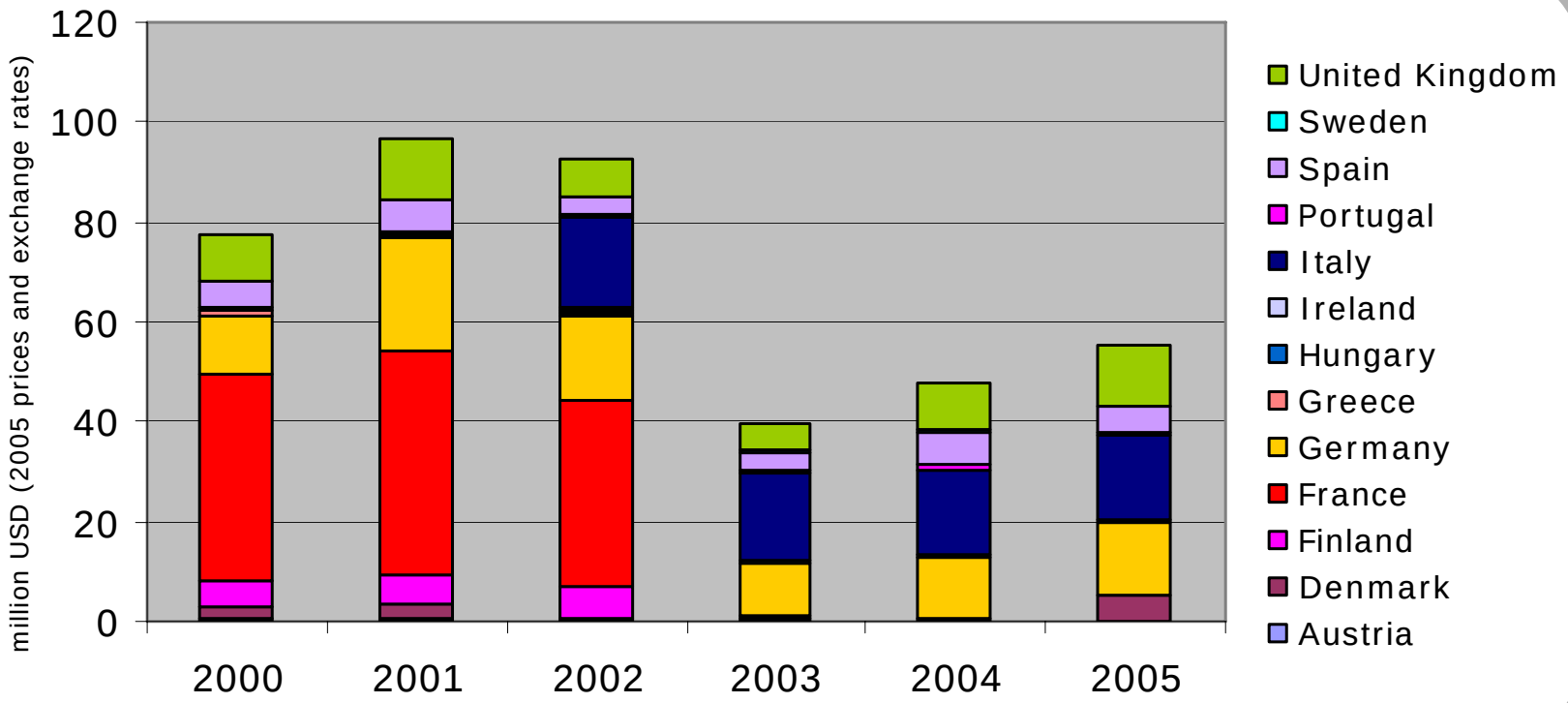
EU R&D Spend: Fossil Fuels



Source: IEA

(from available data)

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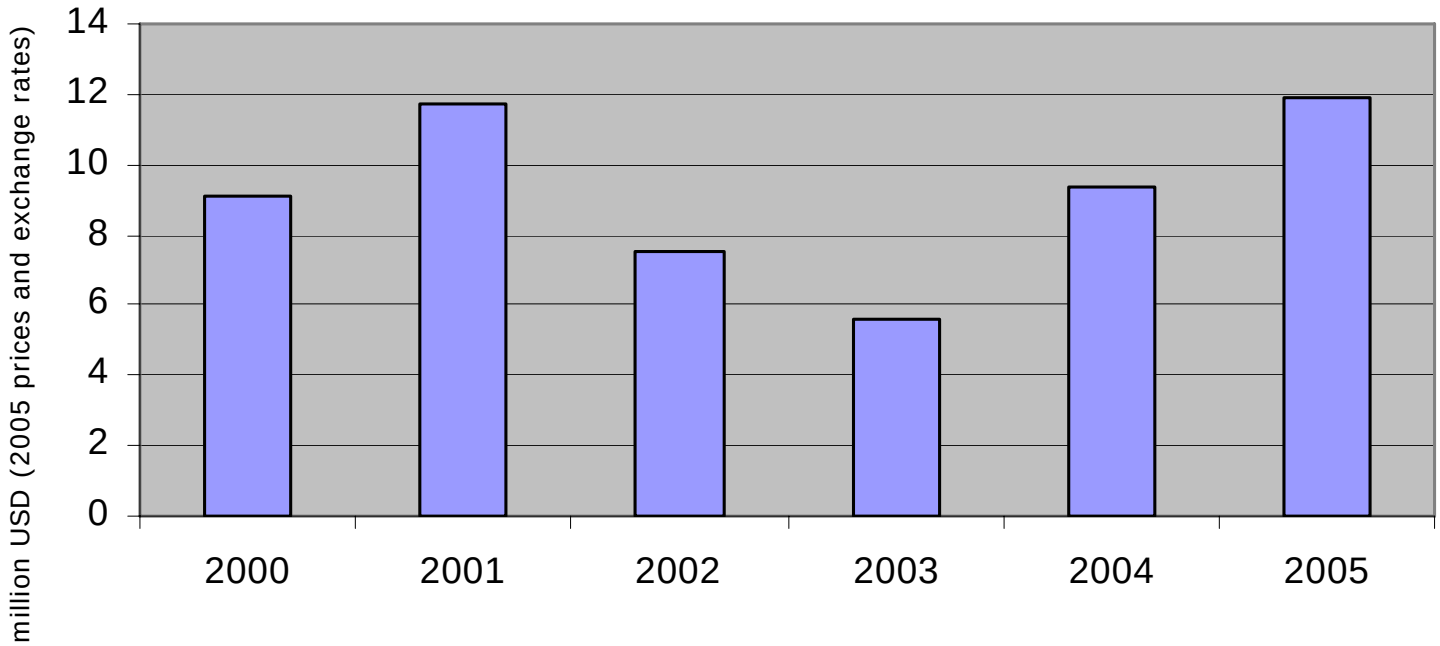
UK R&D Spend: Fossil Fuels



Source: IEA

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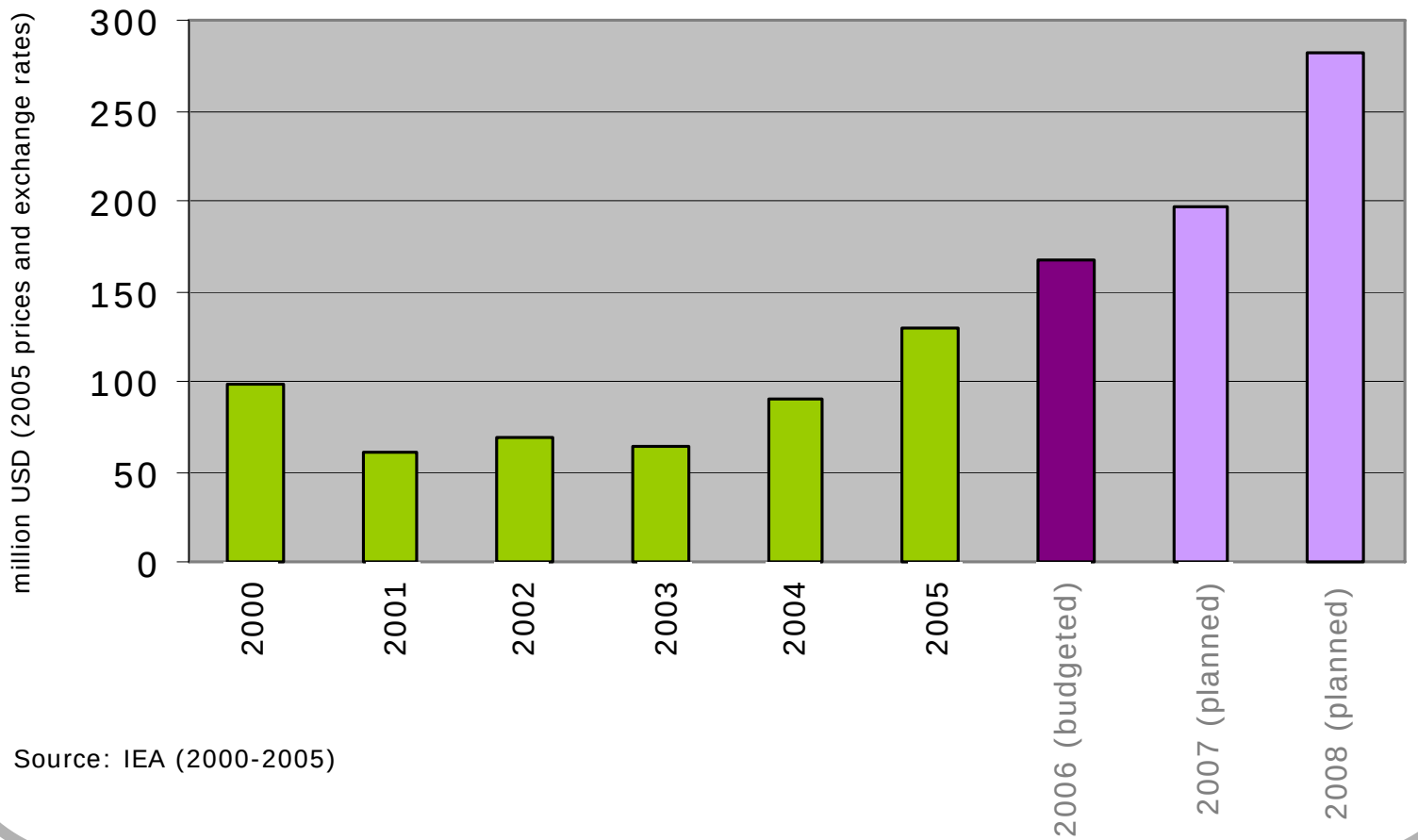
UK Energy R&D Spend



Source: IEA (2000-2005)

R&D Topics

- Advanced HC recovery systems
- Renewables, notably solar and marine
- Bio-processes for capture and conversion
- Energy vectors – hydrogen, HC – product, energy storage
- Clean coal, CCS
- Sociological aspects of demand reduction
- Energy efficiency
- Socio-economic means of demand modification

- Presently unrecognised technology

- Skills, skills, skills

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