Technology for a Secure & Clean Energy Future

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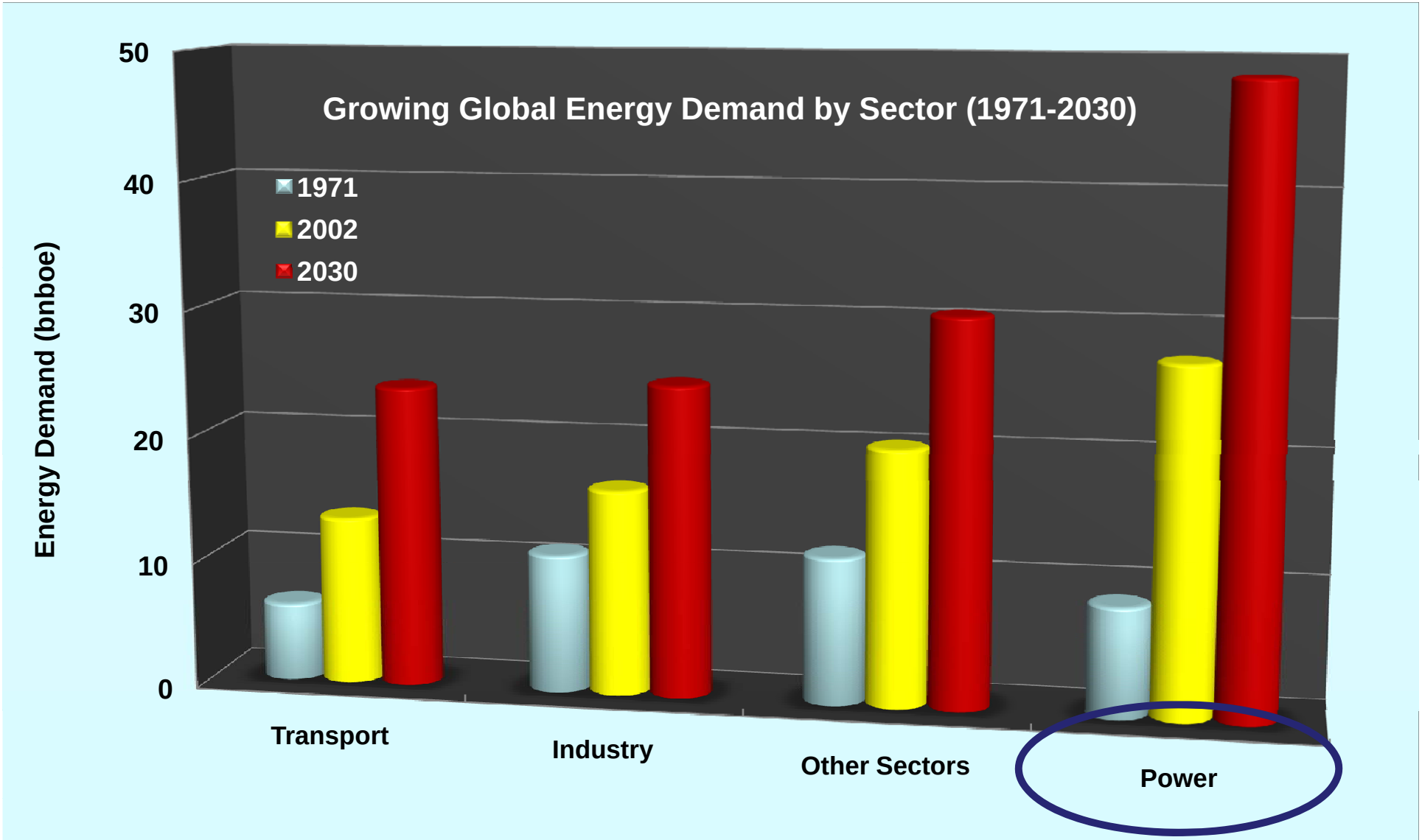
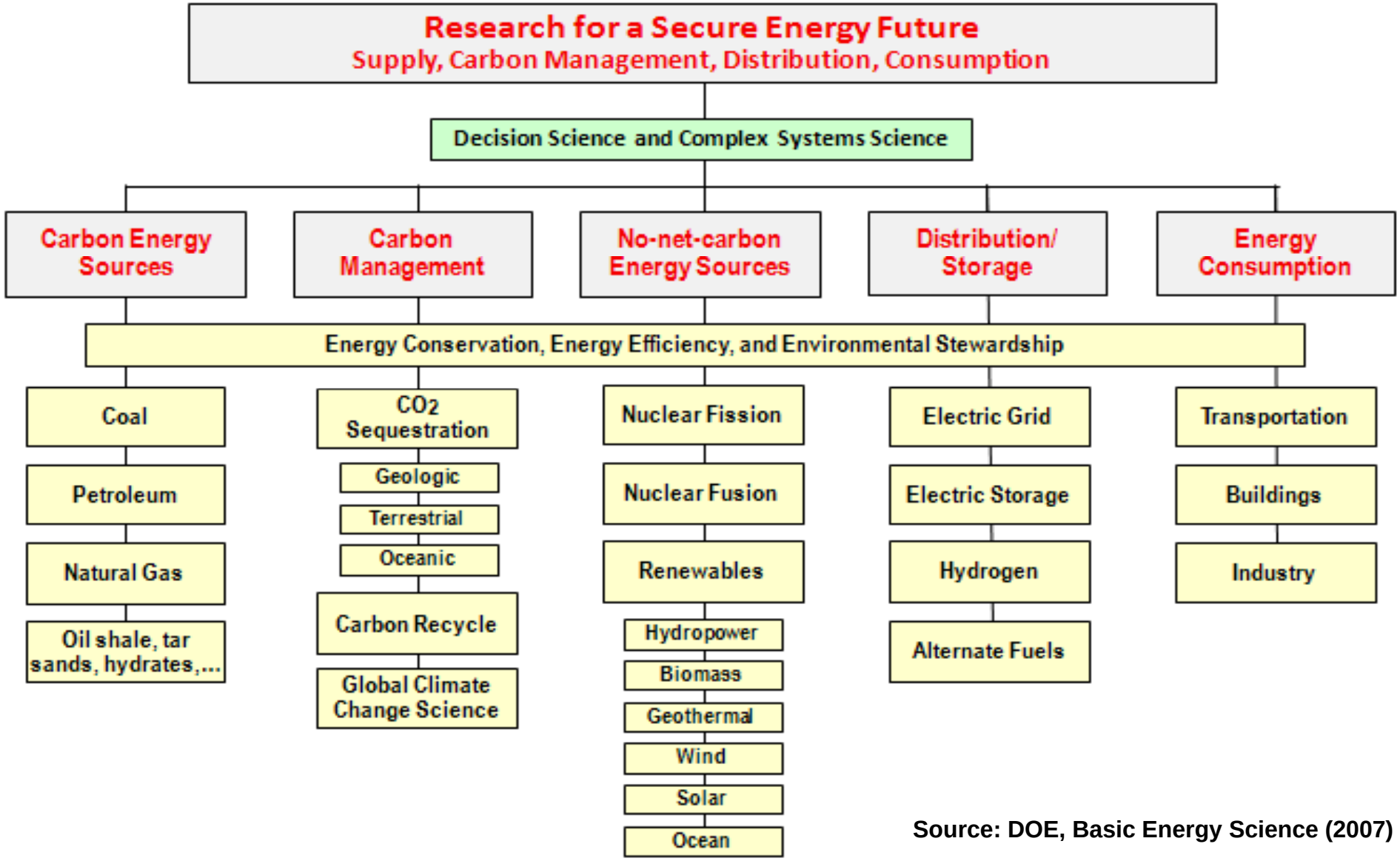
reducing carbon emissions & fuel poverty


Growing Global Energy Demand by Sector (1971-2030)
Energy Demand (bnboe)
50
40
30
20
10
0
1971
2002
2030
Transport
Industry
Other Sectors
Power



Source: DOE, Basic Energy Science (2007)

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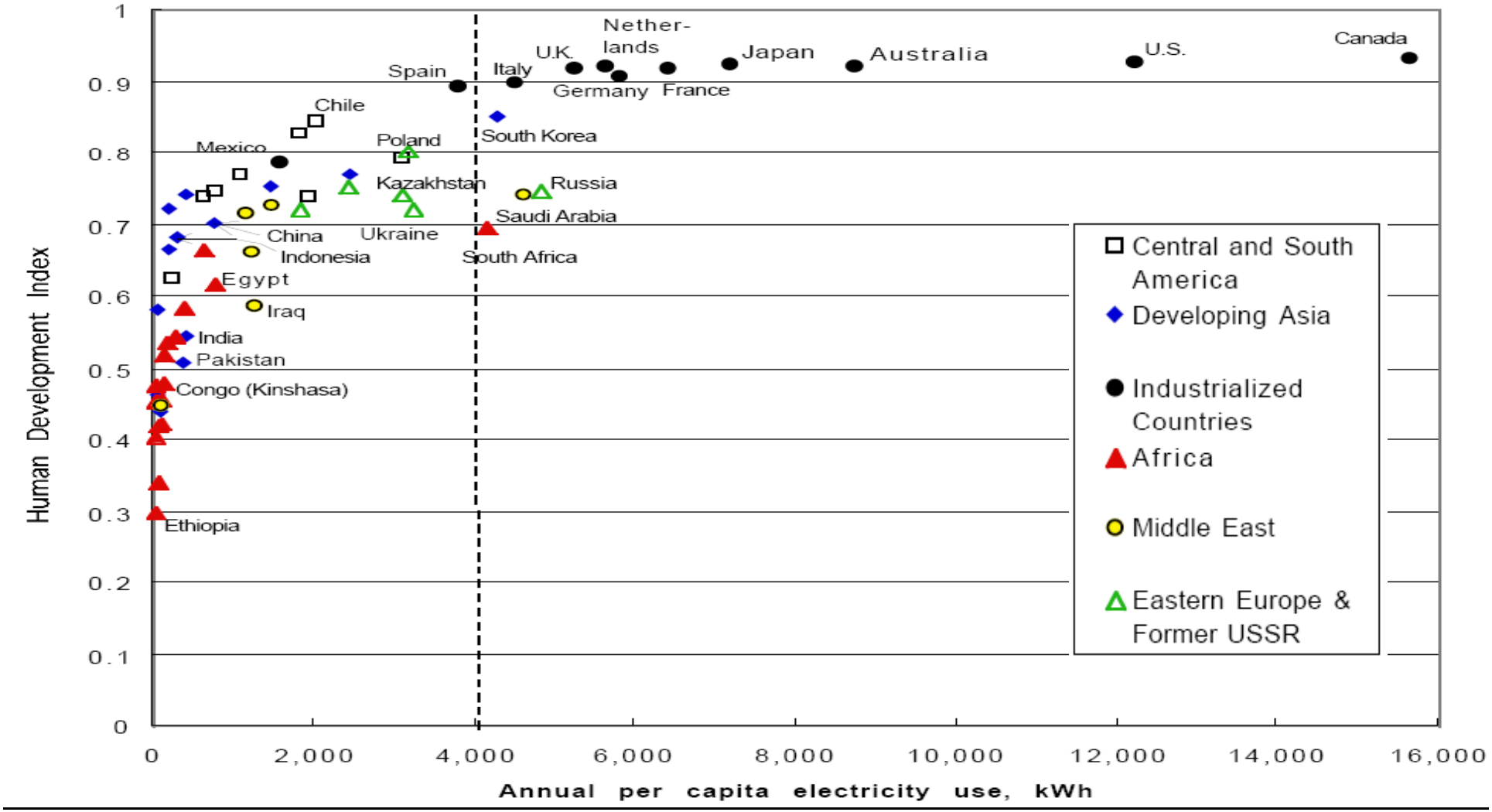

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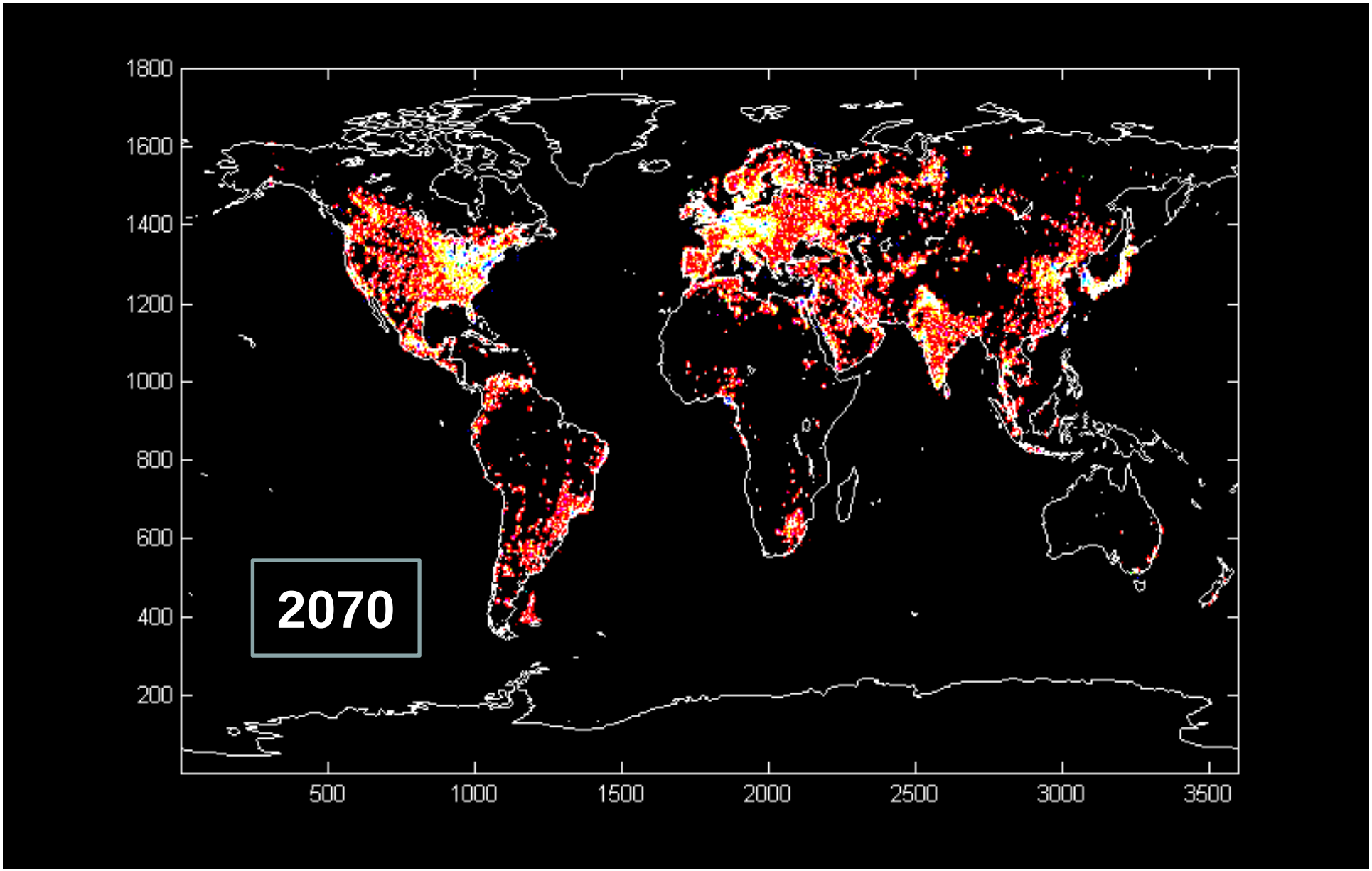

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nuclear
14Mboe/d

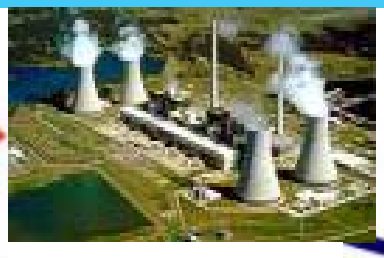
renewables
5Mboe/d

biomass
23Mboe/d

coal
43Mboe/d

gas
38Mboe/d

oil
63Mboe/d



Power Generation
76 Mboe/d

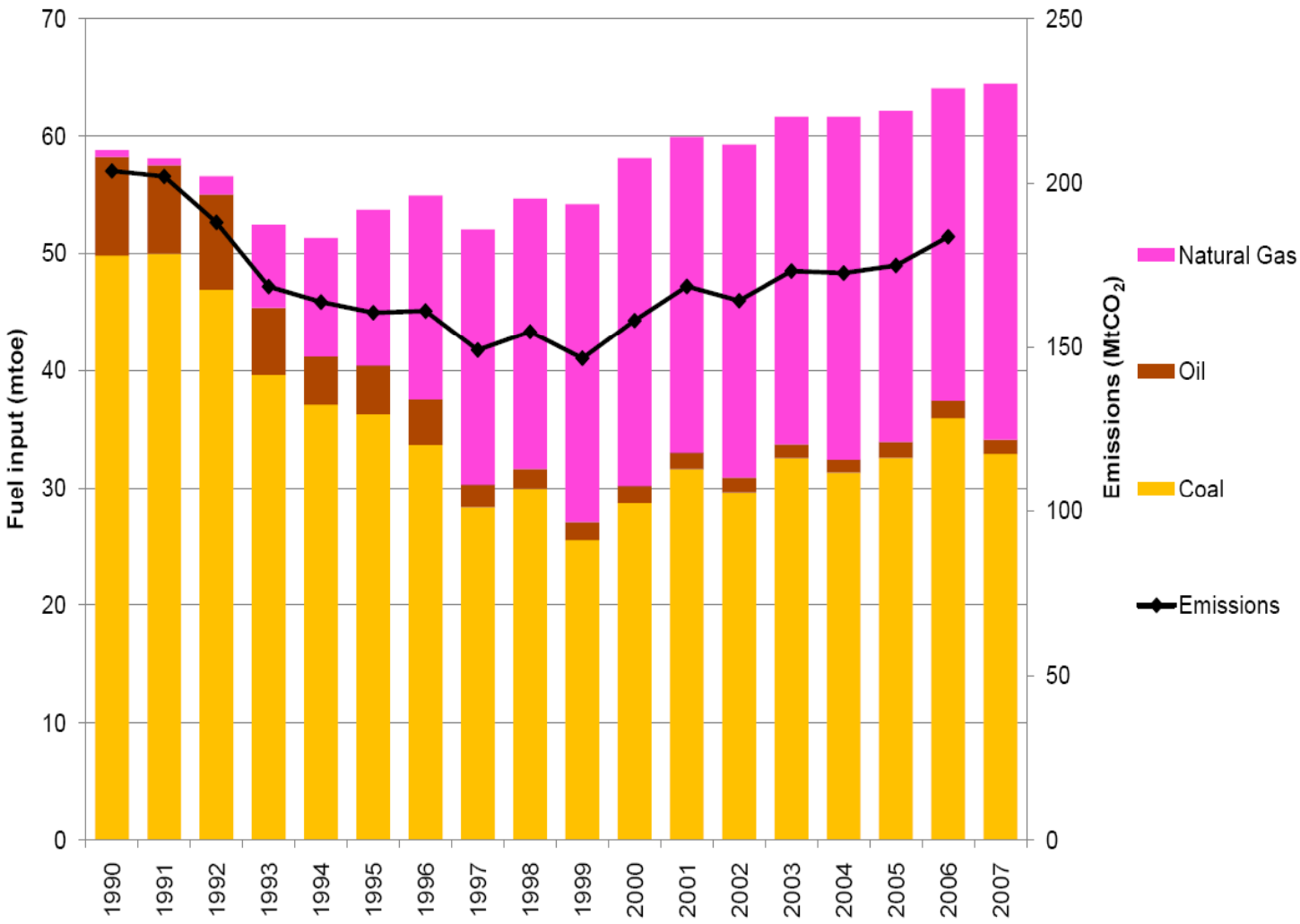
Industrial CO_2 sources
45 Mboe/d

Buildings (56 Mboe/d)

Transport 38 (Mboe/d)

Source: BP

Fuel input for electricity generation and CO2 emissions

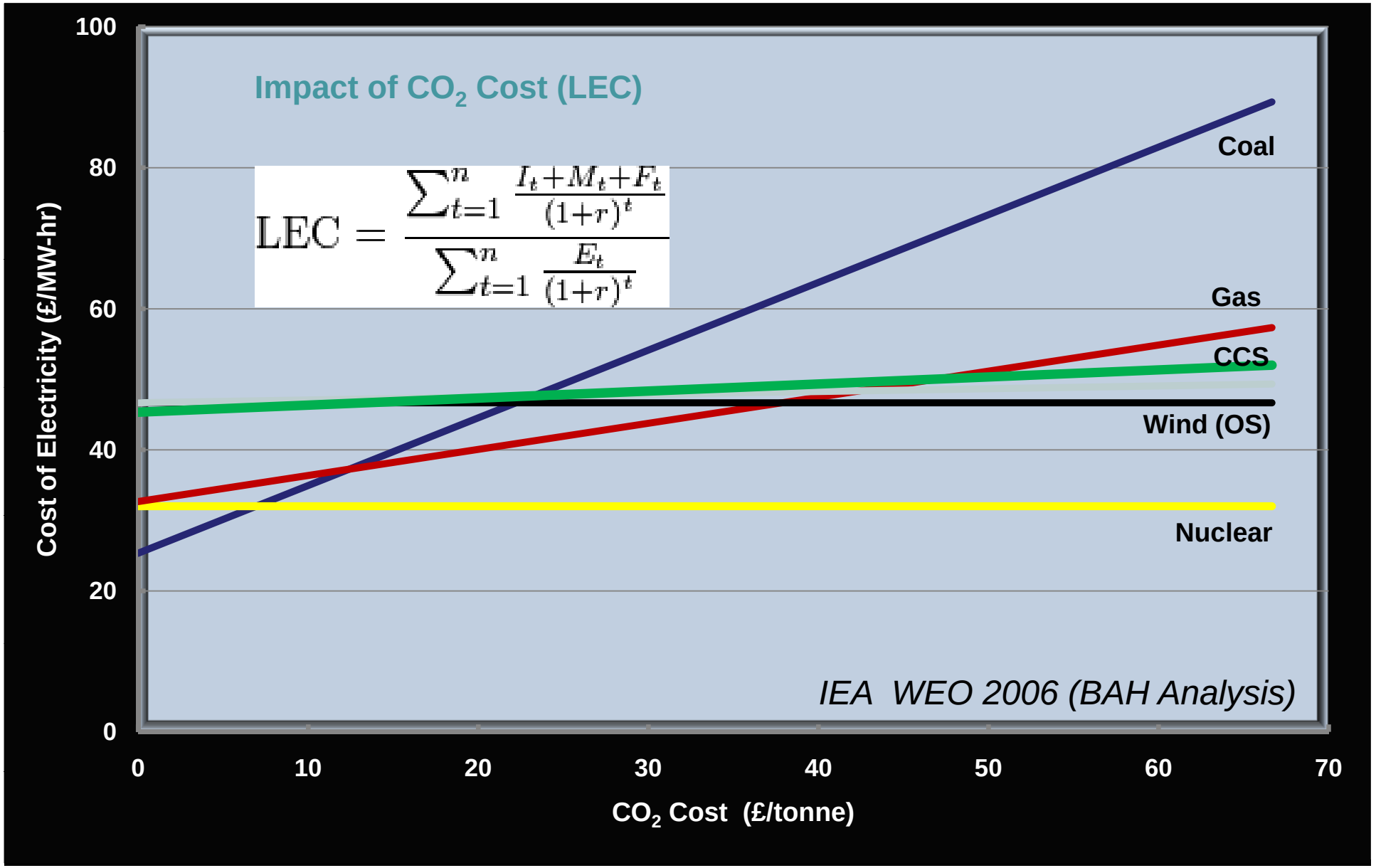


- An existing coal plant emits around 930gCO2/kWh.
- A gas plant around 410gCO2/kWh.
- Nuclear and renewables emit no carbon

Source: DUKES (2008) *Long Term Trends, NAEI (2008).*

Carbon-Free Electric Power

- Nuclear power
  - large C-free source today
- Coal fired power generation with carbon dioxide capture and sequestration
  - large C-source today!
- Renewables: Alternative fuels (eg Biomass, bio-fuels, H_2), wind, waves & tides, hydro, geothermal, solar (PV, thermal,H_2)
  - solar (long-term potential)



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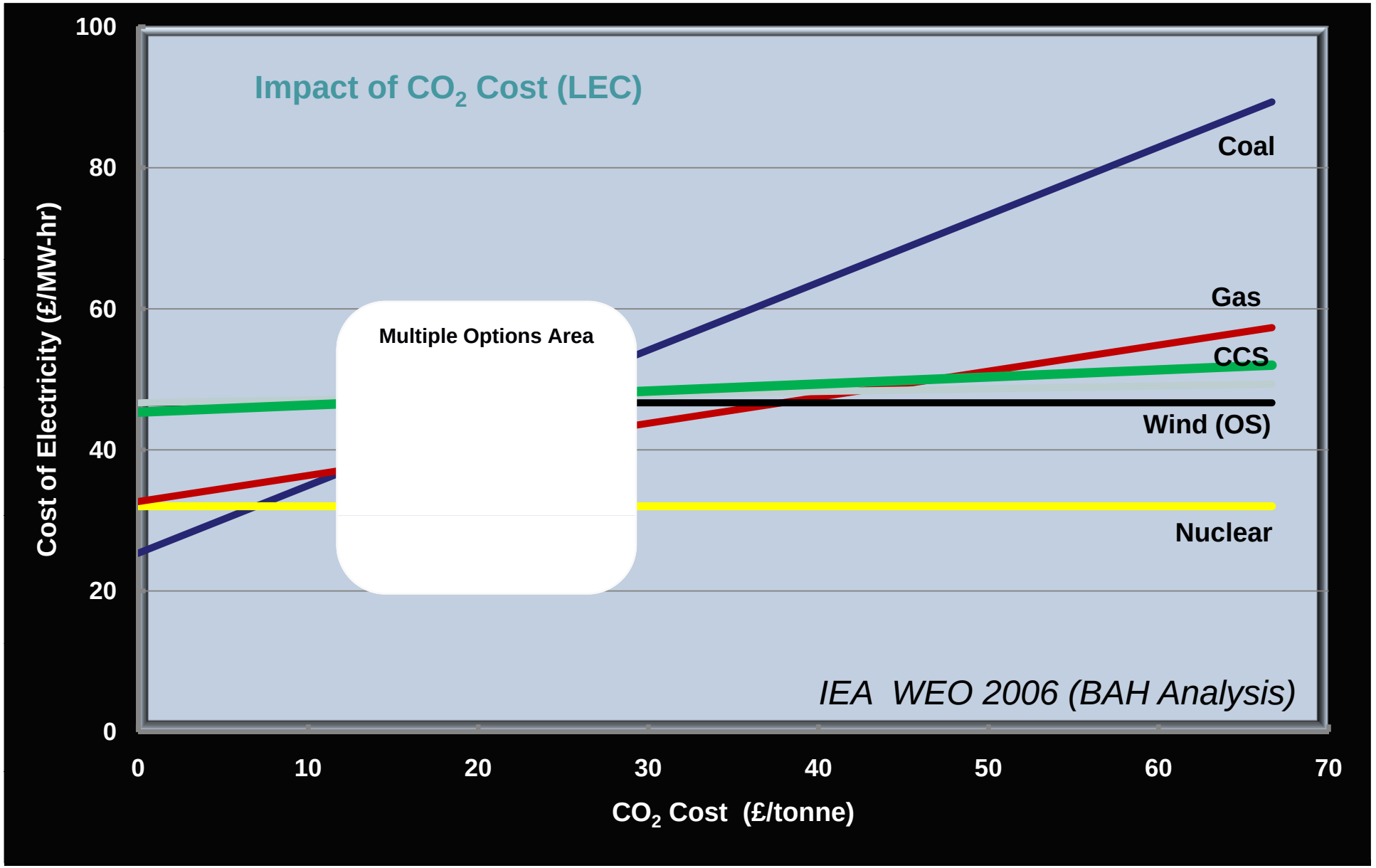
Impact of CO_2 Cost (LEC)
Cost of Electricity (£/MW-hr)
100
80
60
40
20
0
0
10
20
30
40
50
60
70
CO_2 Cost (£/tonne)
Coal
Gas
CCS
Wind (OS)
Nuclear
Multiple Options Area
IEA WEO 2006 (BAH Analysis)

Carbon-Free Electric Power

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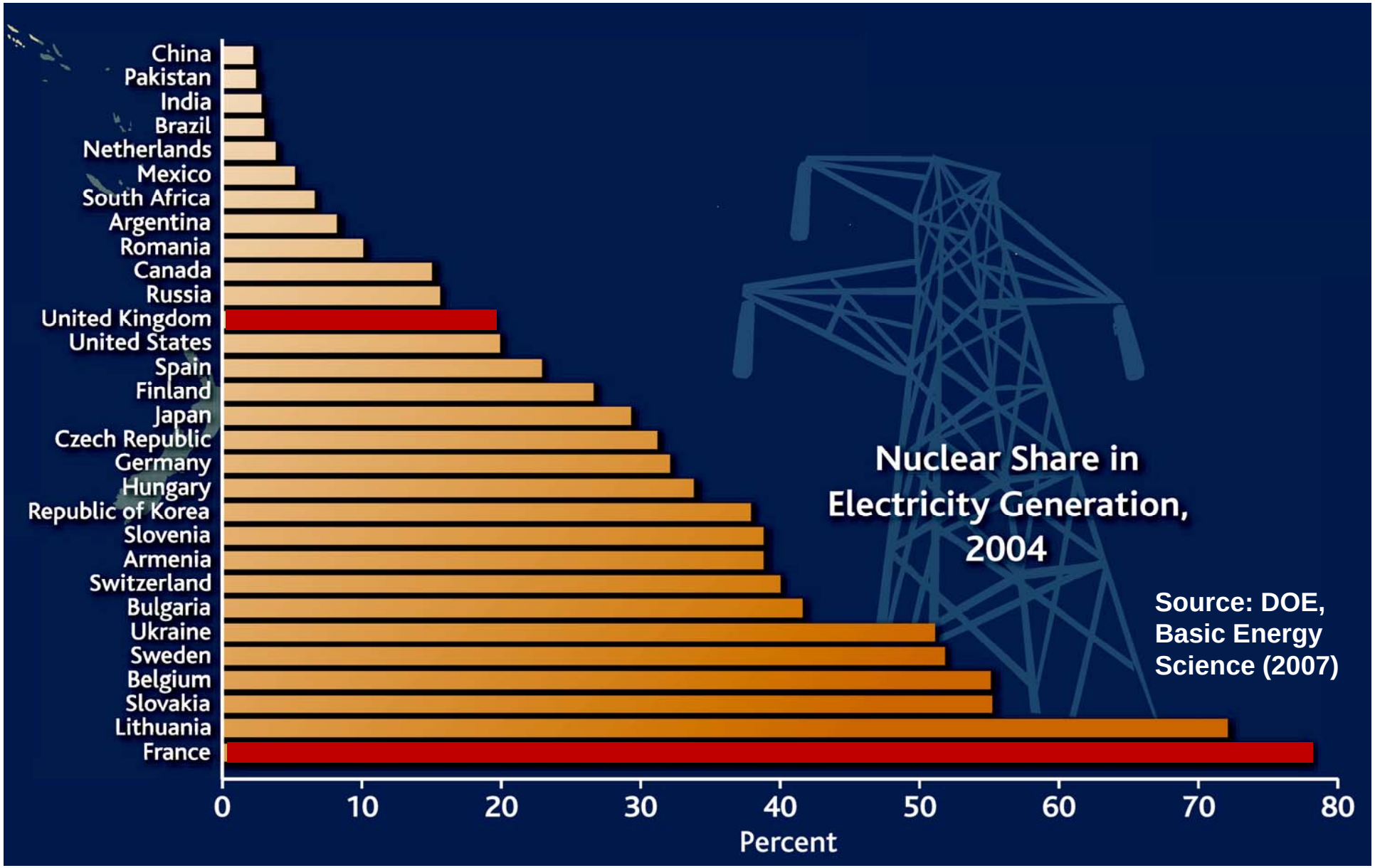

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Renewable Energy For Carbon-Free Electric Power

Solar
- Photovoltaics
- Concentrated Solar Power

Hydroelectric
- Limited Resources

Biomass

Wave/Tidal
Mechanical
- Technical source potential =

Wind
- **Onshore**
- **Offshore**

Geothermal
- Limited Resources

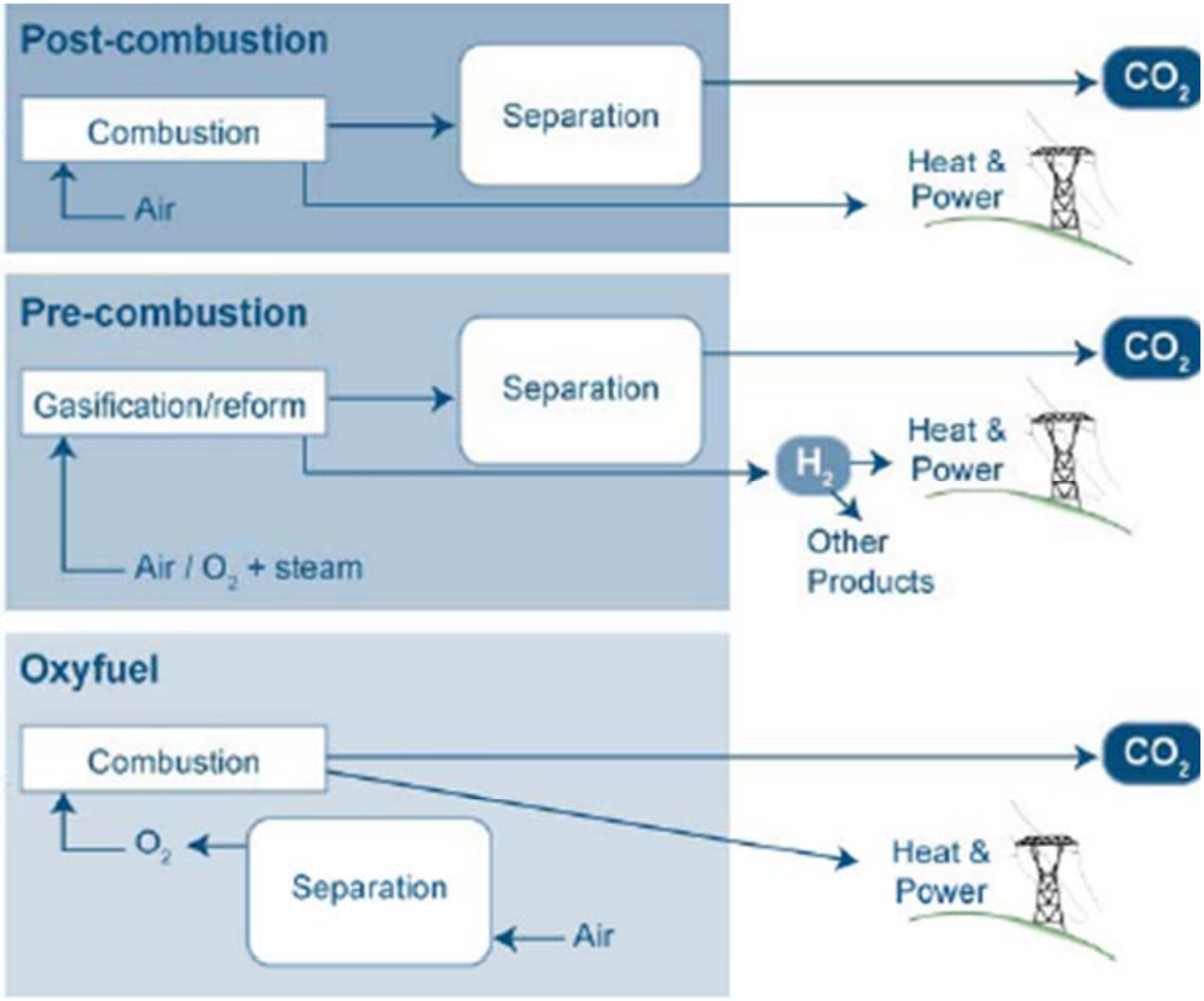
Source: DOE, Basic Energy Science (2007)

(Still) Under Construction

- O_2/CO_2 recycle combustion is interesting an option for power generation with CCS:

Fossil fuels, biomass

- use advanced steam technology
- reduce the boiler size and cost and
- to design a zero-emission power plant



THREE WAYS TO CAPTURE CARBON DIOXIDE

Post combustion

- No change to main plant
- Separate CO2 from N2, H2O and O2 in combustion products
- Big plant, separation itself takes energy

Pre-combustion

- Don't naturally have CO2 before combustion
- Convert fuel to H2 + CO2 instead of burning to H2O + CO2
- Separate CO2 from H2 at high pressure
- Separation more efficient but lose energy to produce H2
- and when burning H2 in power plant

Oxyfuel

- Separate oxygen in air from nitrogen
- Burn fuel in oxygen to give CO2 and H2O
- Clean and compress to give concentrated CO2
- Requires new equipment to be developed

Concluding Remark

- Substantial contributions from coal fired power stations with CCS is required in order to meet the increasing power demand.
  - This is in addition to improved efficiency and renewables.
- There is a sense of urgency in order to control the carbon dioxide emission when one considers a "ticking climate clock" and a highly inertial energy supply system
- CO2 pricing will have a major impact on coal with CCS to be viable options for the C-free power production.

OXY-CAP UK

Oxyfuel Combustion - Academic Programme for the UK

- (£1,789,493 from EPSRC-EON) 01/09/2009
- **Project Partner:**

UNIVERSITY OF CAMBRIDGE

UNIVERSITY OF LEEDS

The University of Nottingham

Cranfield UNIVERSITY

Imperial College London

University of Kent

ANSYS

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Collaborative Clean Fossil Fuel Research with China

In-depth Studies of OxyCoal Combustion Processes through Numerical Modelling and 3D Flame Imaging

(£1,049,016 from EPSRC, Collaborative Research with China) 01/07/2009

- **Project Partner:**

Imperial College London

UNIVERSITY OF LEEDS

University of Kent

国家电网 STATE GRID

中国电力科学研究院 CHINA ELECTRIC POWER RESEARCH INSTITUTE

华南理工大学 South China University of Technology

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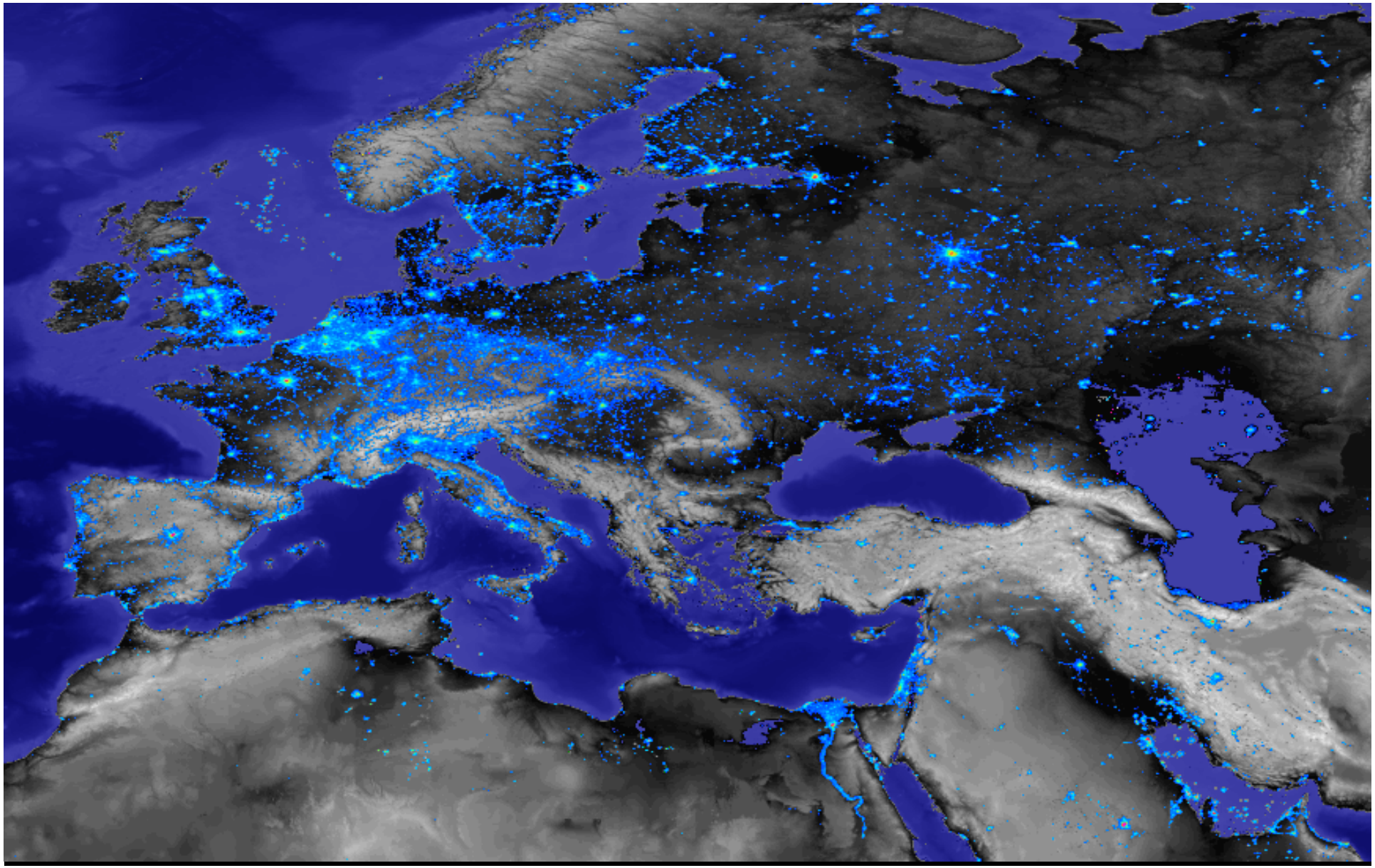

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