

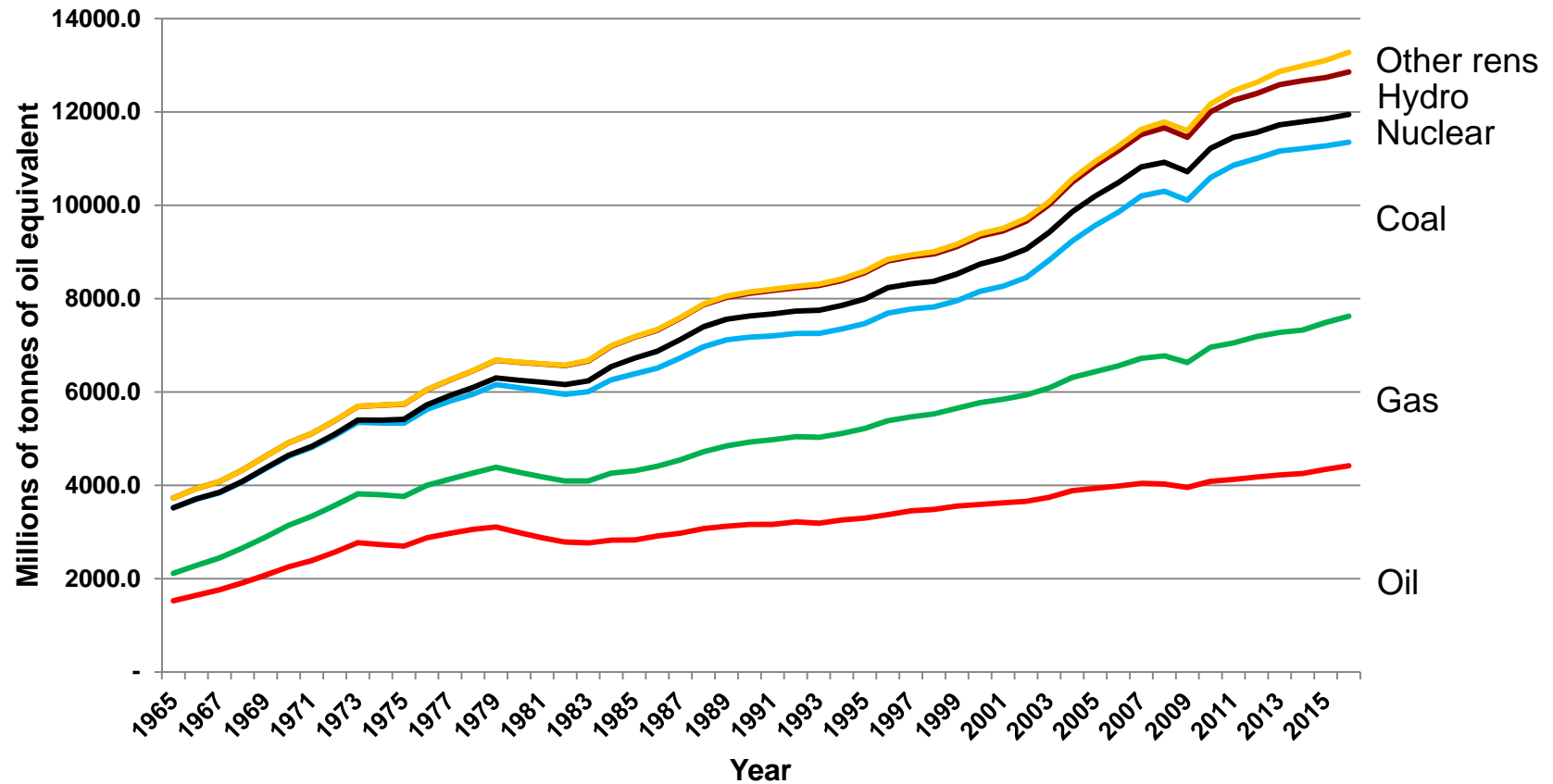
The Potential Contribution of Renewables to Decarbonising Energy

Dr. Stas Burek

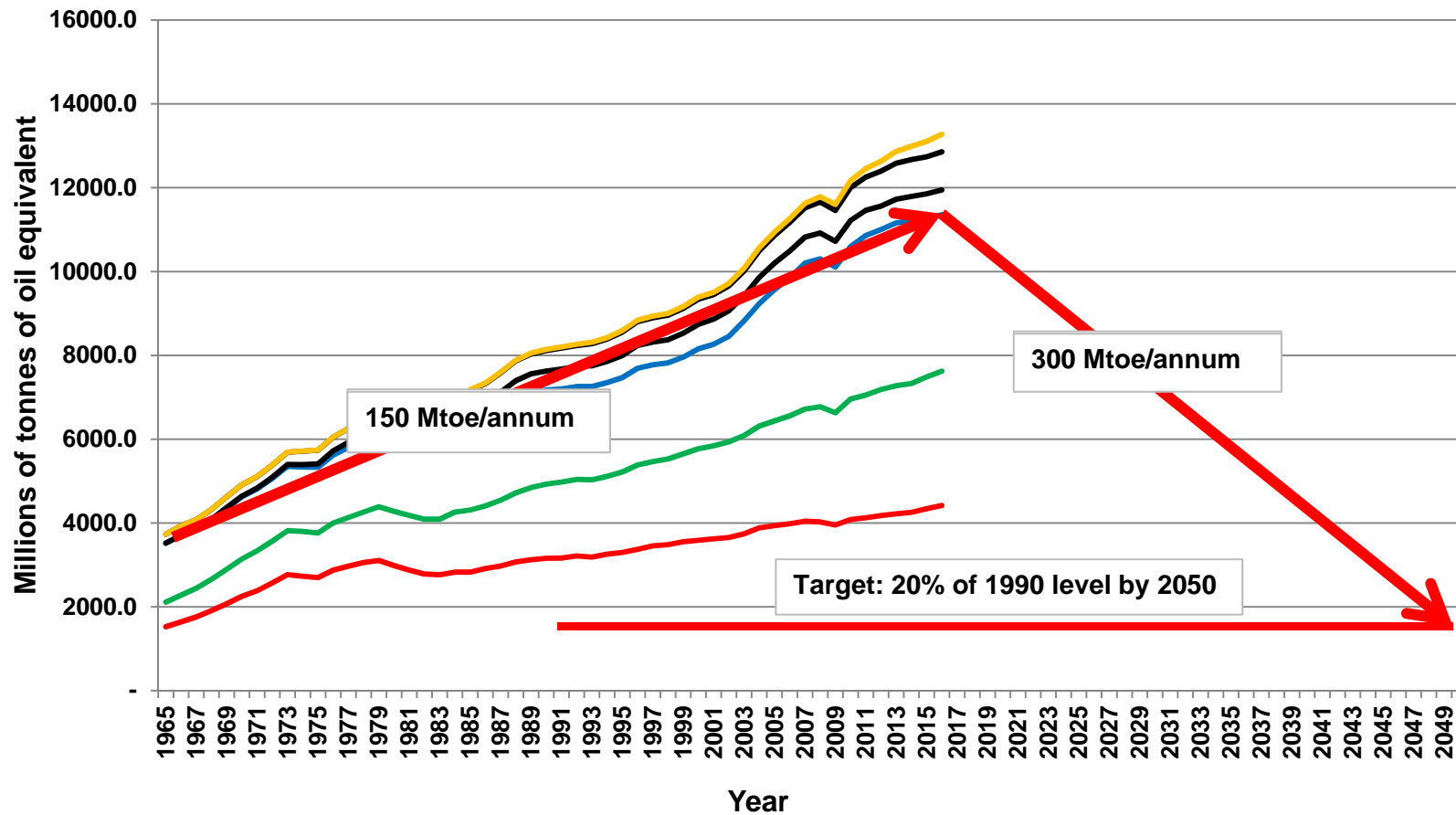
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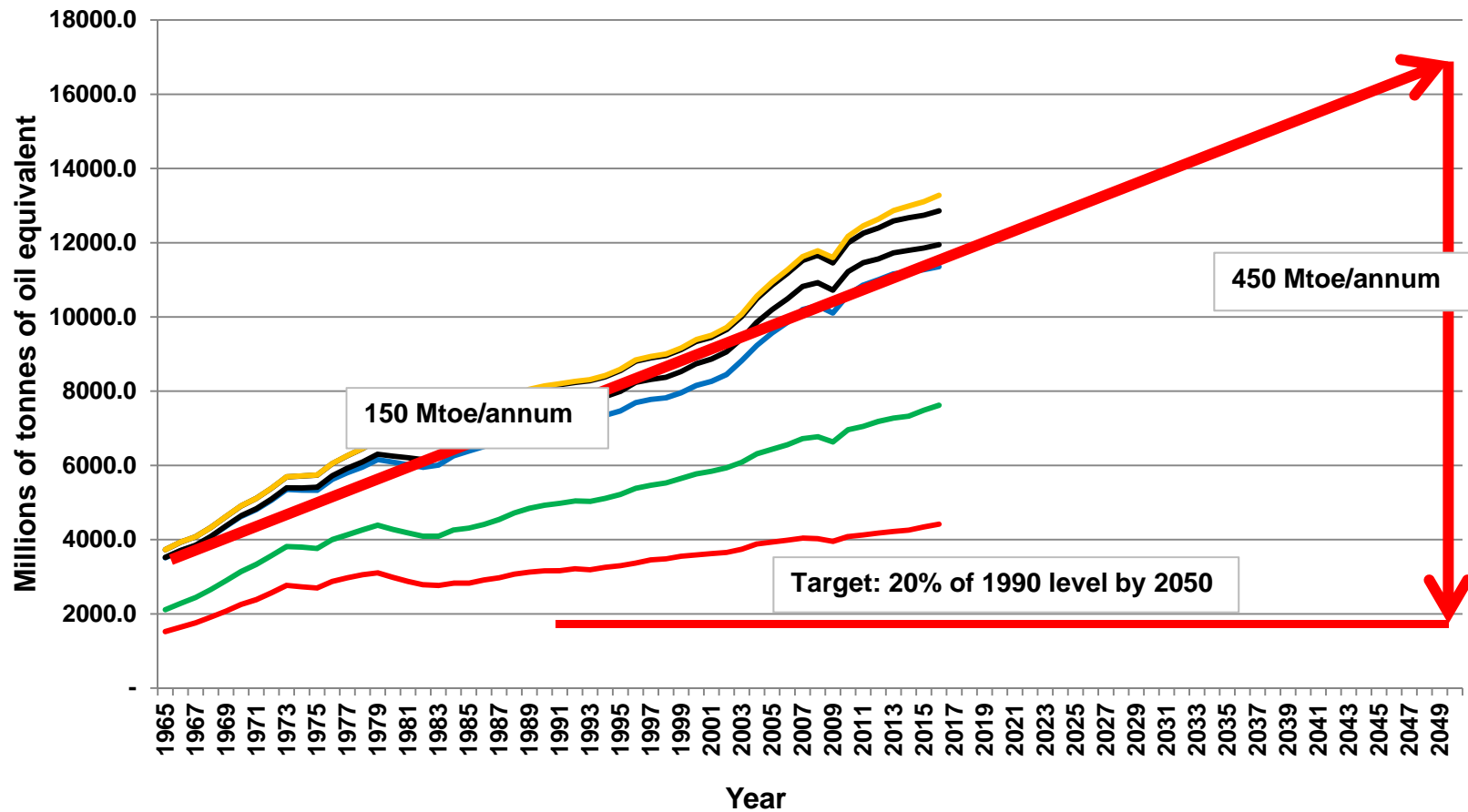
Global energy consumption



20% target



20% target



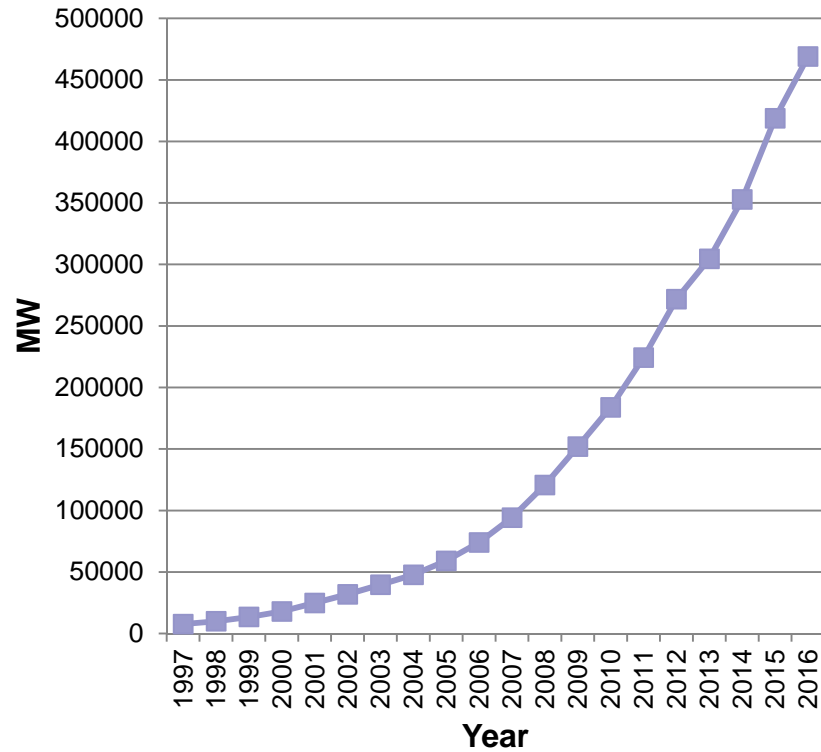


Earth's energy flows

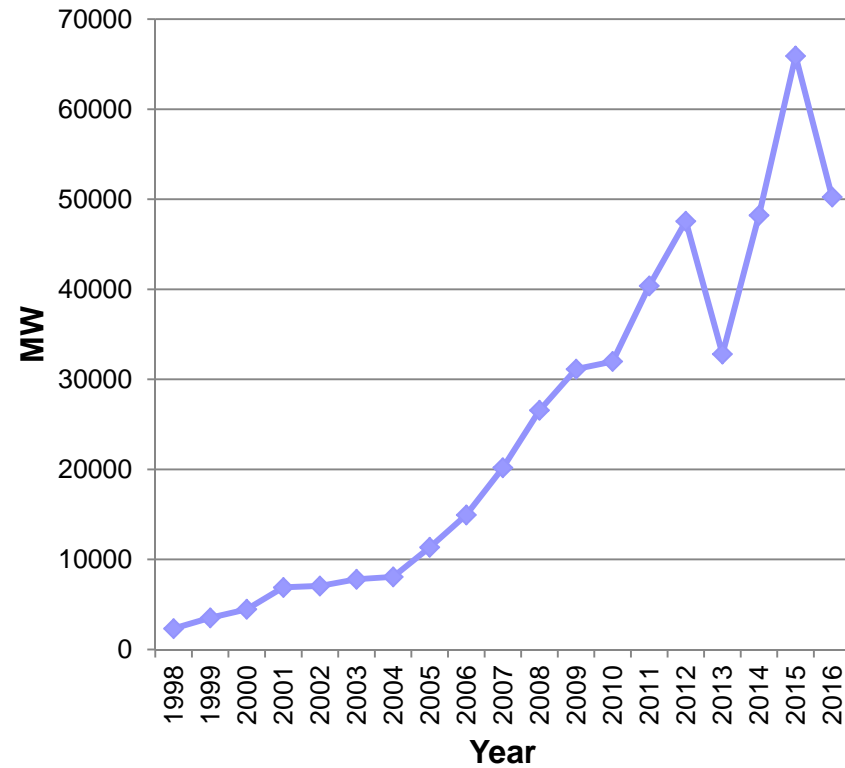
Resource	Mtoe per year	Ratio to fossil fuel use (2016)
Consumption of fossil fuels (2016)	1.135×10^4	
Incident solar energy	1.31×10^8	11542
Direct reflection	3.94×10^7	3471
Entering the atmosphere	9.20×10^7	8106
Conversion to heat	6.13×10^7	5401
Evaporation etc.	3.03×10^7	2670
Wind and waves	2.76×10^5	15.5
Photosynthesis	7.04×10^4	6.20
Tidal energy	2.25×10^3	0.20
Terrestrial energy	2.43×10^4	2.14
Formation of fossil fuels	9.52×10^{-3}	8.39×10^{-7}

Wind turbine capacity

Global capacity



Annual installations



20% annual growth since 2006



Wind energy: 2016

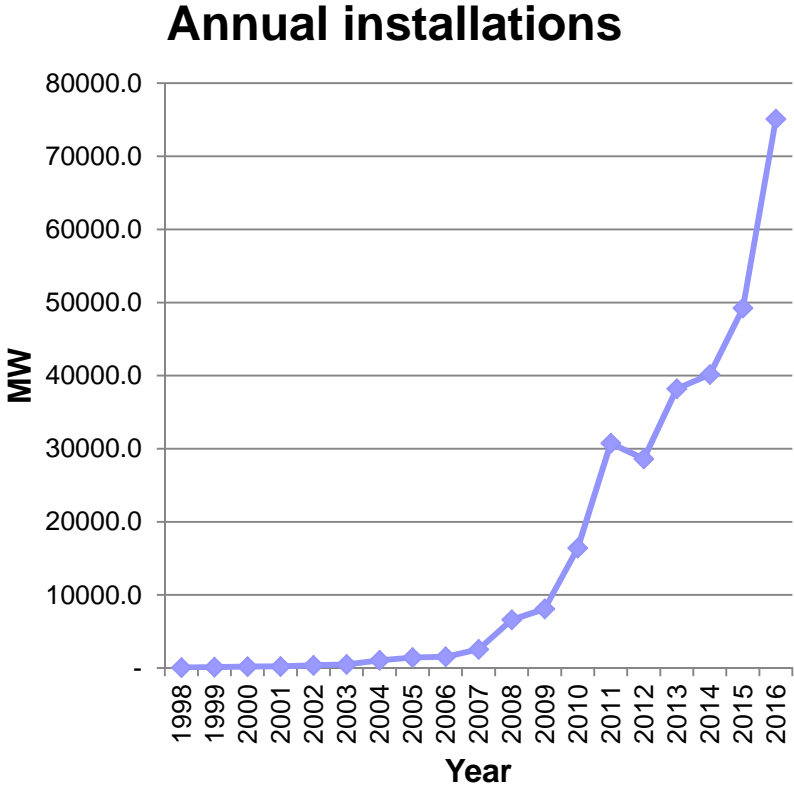
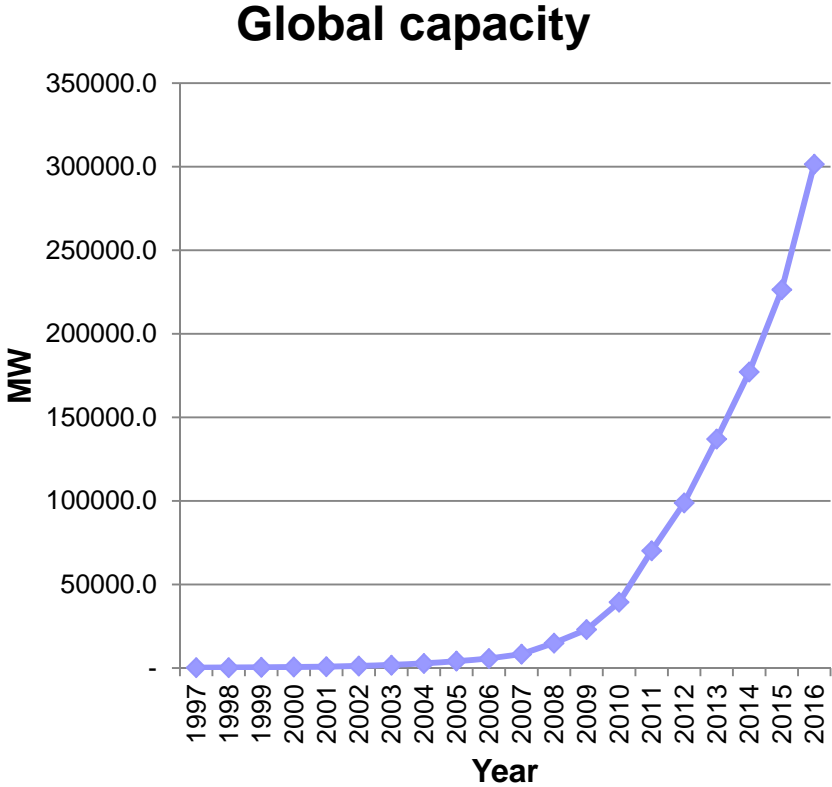
- Wind and waves: 15.5 times fossil fuel use
- Total generation worldwide 959.5 TWh
- 1.9% of global fossil fuel consumption
- Compare with electricity consumption:
 - 3.9% of world total
 - 22% of US total (4351 TWh)
 - 2.83 times UK total (357 TWh)
 - Japan 999.6 TWh



Wind energy: 2016

- 468,989 MW installed capacity worldwide
- 20% annual growth since 2006
- 20 years to replace fossil fuels?
 - One tenth of the Earth's surface
 - 150m diameter turbine every 2.5 km²

Photovoltaic capacity



49% annual growth since 2006



Photovoltaics: 2016

- Entering the atmosphere: 8106 times fossil fuel use
- Total generation worldwide 333.1 TWh
- 0.66% of global fossil fuel consumption
- Compare with electricity consumption:
 - 1.3% of world total
 - 7.7% of US total (4351 TWh)
 - 98% of UK total (339 TWh)



Photovoltaics: 2016

- 301,473 MW installed capacity worldwide
- 49% annual growth since 2006
- 20 years to replace fossil fuels?
 - 300-fold increase
 - 3% of the Sahara desert (25% of Egypt)
 - Intercontinental transmission
 - Manufacturing bottlenecks
 - Shortage of raw materials?



Hydropower: 2016

- Water cycle: 2800 times fossil fuel use
- Current contribution 910.3 Mtoe
 - 8.0% of fossil fuel consumption
- Mature technology
 - Low growth rate (only 3.5%)
 - 80 years to replace fossil fuels
- Three Gorges Dam
 - 22,500 MW
 - 84.7 TWh per year (19.3 Mtoe)
 - 0.17% of fossil fuel consumption
 - Need another 600 similar schemes to replace fossil fuels



Biofuels: 2016

- Solar energy to photosynthesis 6.5 times annual fossil fuel usage
- Current production 82.3 Mtoe
 - 0.7% of fossil fuel consumption
- To replace fossil fuels:
 - 15% of the Earth's surface
 - 46% of global land area
- Conversion efficiency of plants ~1-2%



Geothermal

- 2.3 times annual fossil fuel usage
- Very localised resource
- Difficult to harness
 - Volcanoes, etc
- Mature technology
 - Low growth rate



Other renewables

■ Tidal

- Early stages of commercialisation for tidal stream devices
- Tidal barrages very expensive

■ Wave

- Currently at prototype stage


■ Solar thermal

- Local generation and usage



Conclusions

- Some renewable technologies could replace fossil fuels...
- ... but would need massive and rapid expansion...
- ...but could reach saturation first.
- Nuclear fission will continue to play a part
- Immature technologies need rapid development
 - Including shale gas, CCS and nuclear fusion
- Small-scale developments
- Mix of technologies
- Environmental impacts
- NO 'SILVER BULLET'!



‘If this business of Global Warming is to get sorted out, and the Earth to continue as a habitable planet, we people on it are going to have to be clear-sighted, imaginative and yet sceptical; absurdly ambitious, and at the same time hard-working and humble.’

Ronald Turnbull, ‘Granite
and Grit’



Thank you

Any Questions?

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