VLEEM

Human Development & Sustainability of Energy Systems

Resources

Mark Whiteley

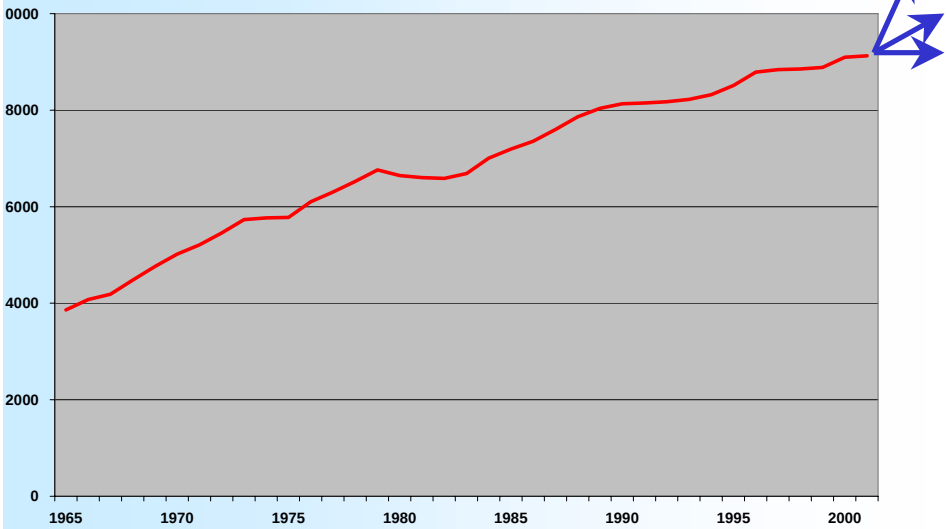
Energy for Sustainable Development Ltd

UK

Issues for Future Generations to 2100

- Heating & cooling
  - By sector
- Electricity
  - Centralised
  - Decentralised
  - Off-grid
- Transport
  - Road/rail
  - Sea
  - Air
  - Space
- What technology developments will there be?
- Consumption levels?

World Primary Energy Consumption (Mtoe)

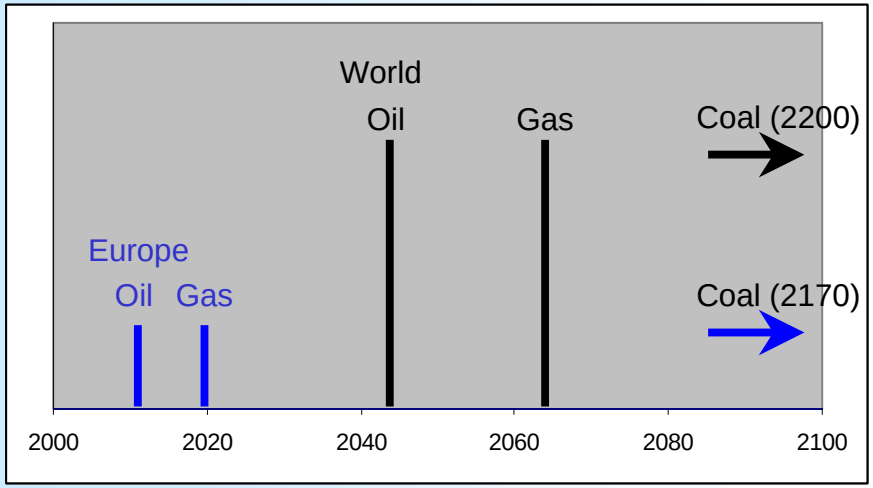


Source: BP Review of World Energy 2002

Resources - Options to 2100

- Fossil fuels?
- Renewable energy?
- Nuclear: Fission? Fusion?
- Hydrogen fuel?
- (A mix of the above?)
- (Other?)

Depletion of Fossil Fuel Reserves



Source: BP Review of World Energy 2002

Coal

- Resource
  - 200 years
- Advantages
  - Established technologies
- Disadvantages
  - Dirty (additional technologies required for mitigation)
  - Transport sector?
  - Avoids the sustainability question

Renewable Energy

- 2 levels of resource
  - Unlimited – wind, solar, wave, geothermal (heat pumps), OTEC
  - Limited – hydro, biomass, tidal
- Advantages
  - Global applicability
  - Decentralised
  - Lower infrastructure requirements
- Potential problems
  - Storage link need to be sorted
  - Intermittency problems need to be overcome

Nuclear Energy

- Uranium limited (500 years?)
- Fusion?
- Advantages
  - Fission is established technology
  - Can be established and run centrally
- Issues
  - Public perception
  - Proliferation
  - Infrastructure
  - Waste

Hydrogen Fuel

- Resource
  - Fuel is unlimited (water)
  - Energy supplies are limited (electrolysis, bacteria, etc)
- Solves the energy storage problem
- Whole hydrogen cycle must be considered
- Ideal to use with renewables or nuclear energy

"Large scale renewable energy production…. is an essential precondition for the hydrogen economy. Without renewables, hydrogen is dirty…."

EWEA (24th April 2003)

Hydrogen Fuel

- Advantages
  - Covers all 3 demand sectors (with fuel cells)
  - Transportability (future)
- Disadvantages/Issues
  - New infrastructure required
  - Global inequality
  - Transportability
  - Storage & distribution

Conclusions

- Resource options for 2100 point at:
  - Coal, *renewables*, nuclear energy, hydrogen, or a mix
  - Must look at the whole fuel cycle
- Each option has its advantages and disadvantages!
  - Equality
  - Networks & infrastructure
  - Meeting all types of demand
  - Safety
- Ultimate drivers for new energy networks likely to be non-resource issues
- Revolution & cultural shift - political confidence/arrogance

Questions for 2100

- What is the driver - the technology or the resource?

Therefore, in 2100….

- What will and can replace oil and gas AND meet the energy demand of the future (by type)?
- The issue is not what is sustainable, but how sustainable will we be?
- Dynamics of change: Top-down or bottom-up?