# Energy Resources and Rates for Depletables and Renewables

Gordon Taylor

G T Systems

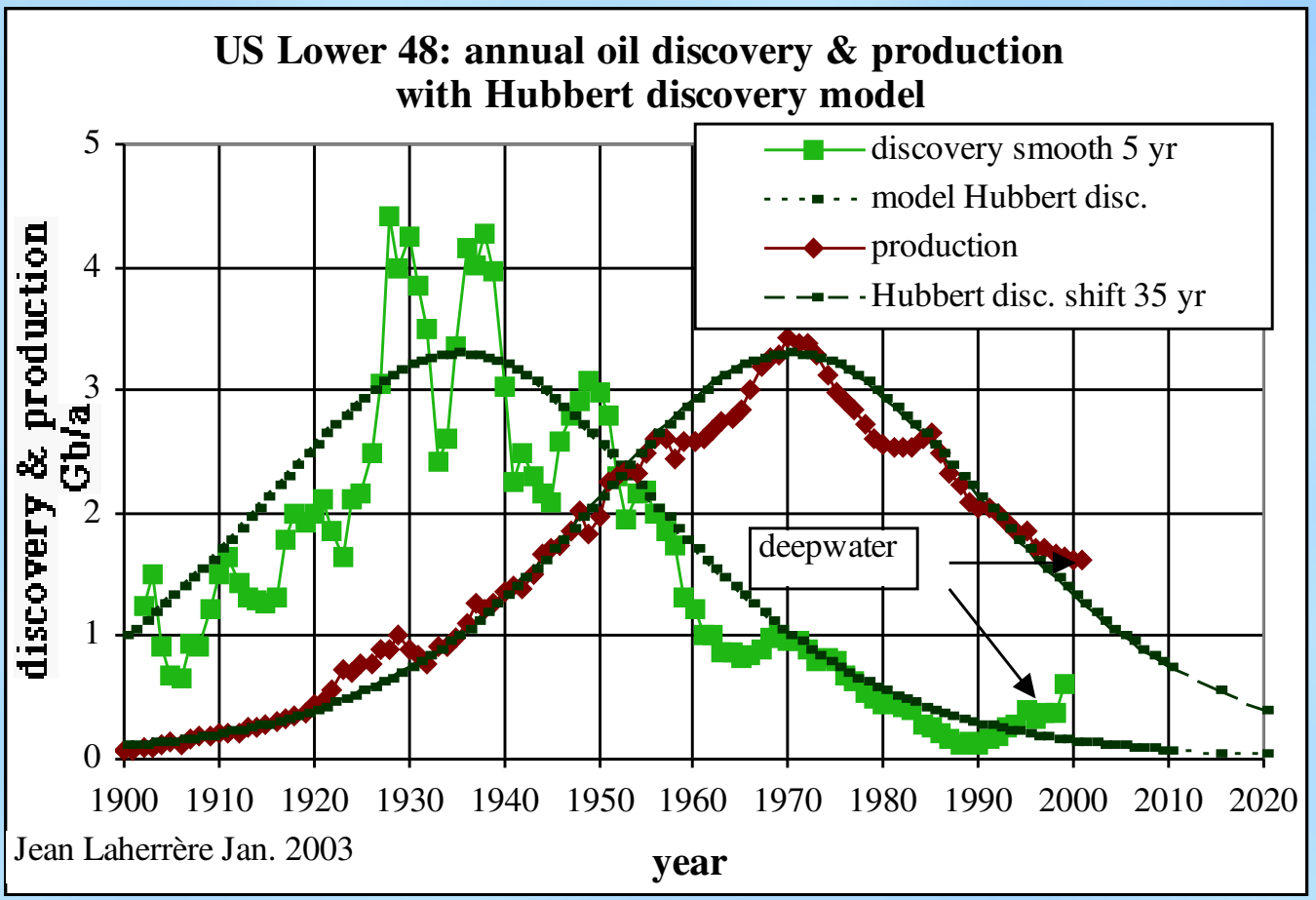
www.energypolicy.co.uk

Created September 2010

# Extracting Depletable Resources

- The overall 'abundance' of the element, compound or mixture is not enough
- The extraction must be economic of money and - for energy resources – of energy
- Hence the resources should be concentrated rather than lean
- And easy of access rather than difficult
- This means on land rather than under the sea and near the surface rather than deep

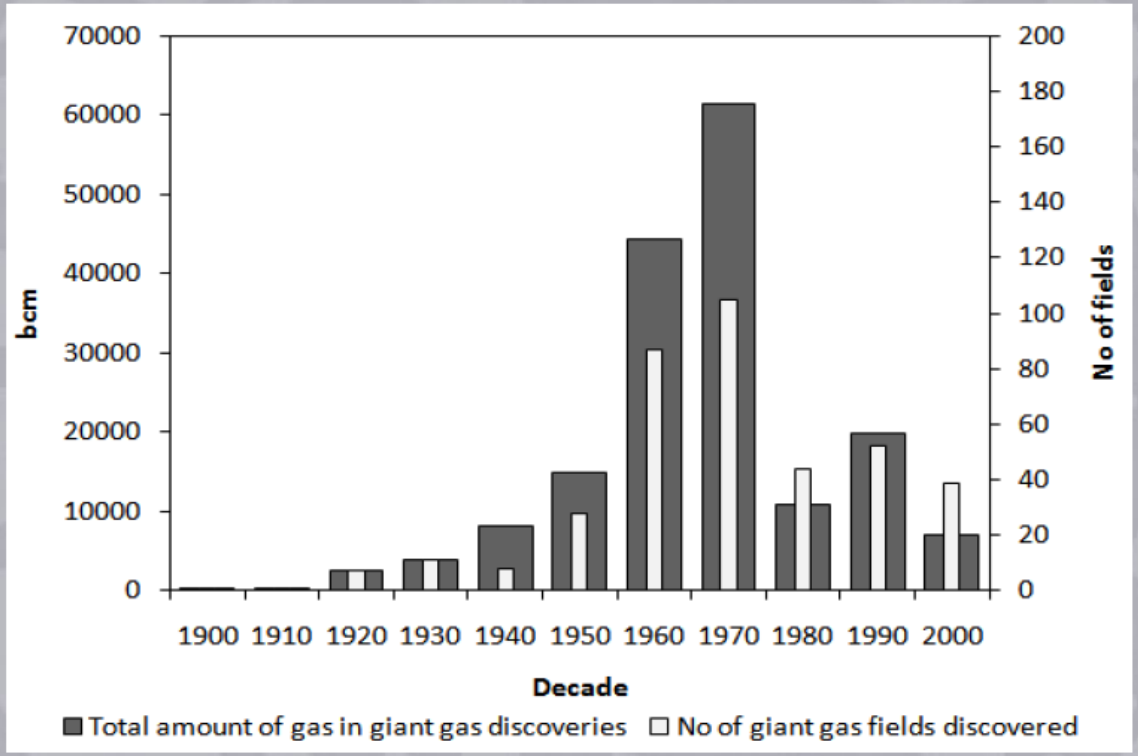
# All depletable energy and material sources are finite
# Hence the yields must 'peak' as in 'Peak Oil/Gas/Coal'



# Depletable Realities

- Discovery must occur before Production. This means not 'Yet-to-Find' but Found and Proven
- These stages take decades, with e.g. 35 years between Peak Discovery and Peak Production
- Discovery is of a resource – e.g. barrels - but Production is defined by a rate – e.g. barrels/day
- Production projects for oil, gas, coal and U take decades, so they define the near-term supply

# Peak Gas

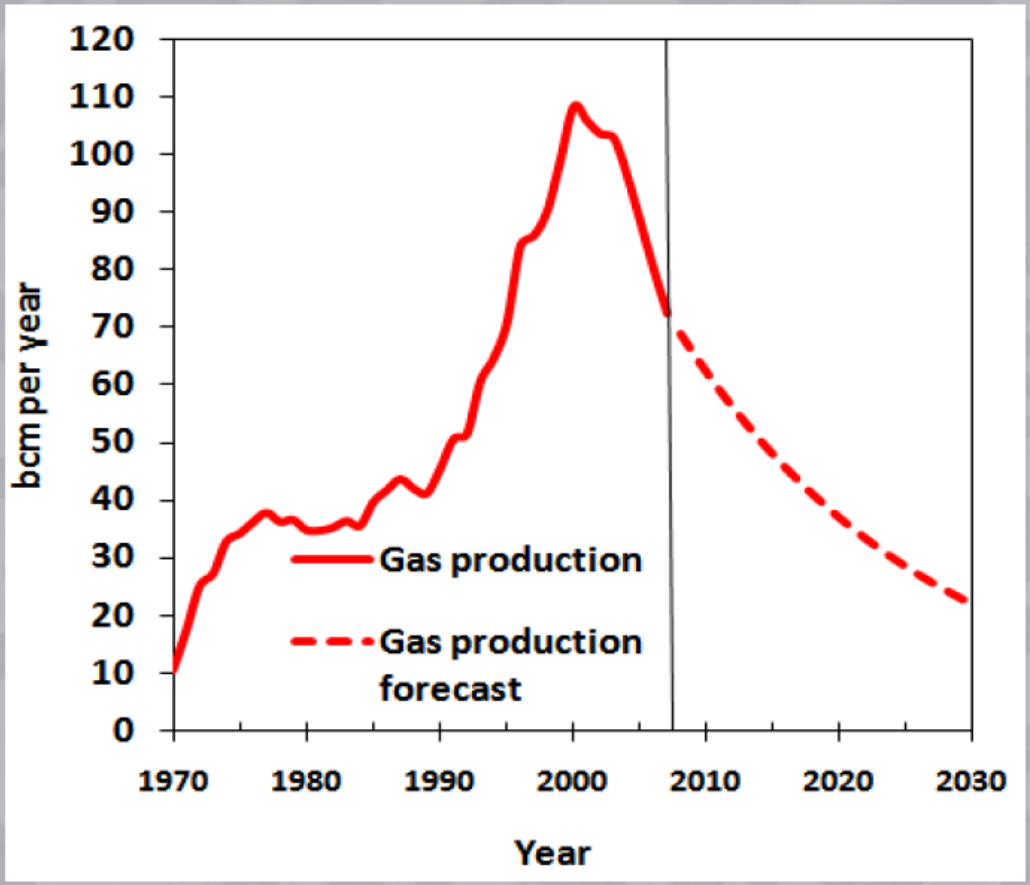



**A peak in discoveries must give a peak in production!**

UPPSALA UNIVERSITET

Kjell Aleklett

# UK Gas Production Peaked in 2000




- The biggest gas producer of the EU.
- Became net importer of gas In 2004.
- The UK and the Netherlands produce 70% of EU gas output

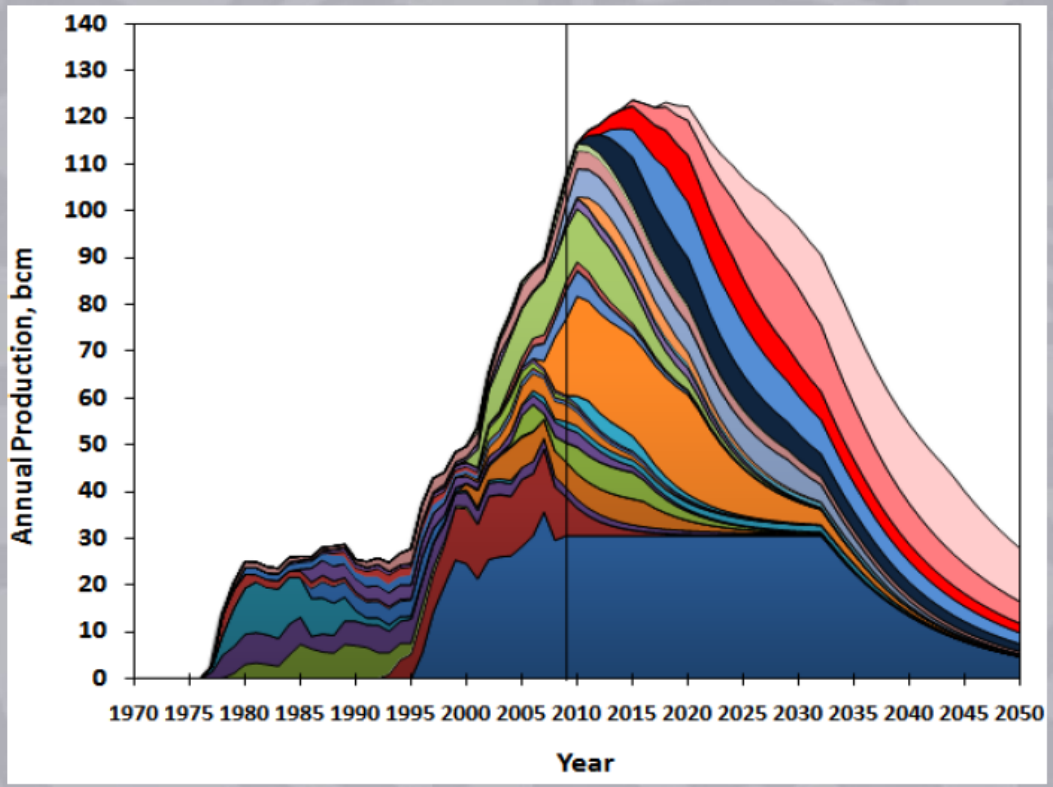
Sources: BP Statistical Review 2009, Söderbergh (2010)

UPPSALA UNIVERSITET

Bengt Söderbergh
Kjell Aleklett

# Norway - A Bottom-up Analysis

Norwegian Natural Gas Production Forecast – Reference Scenario



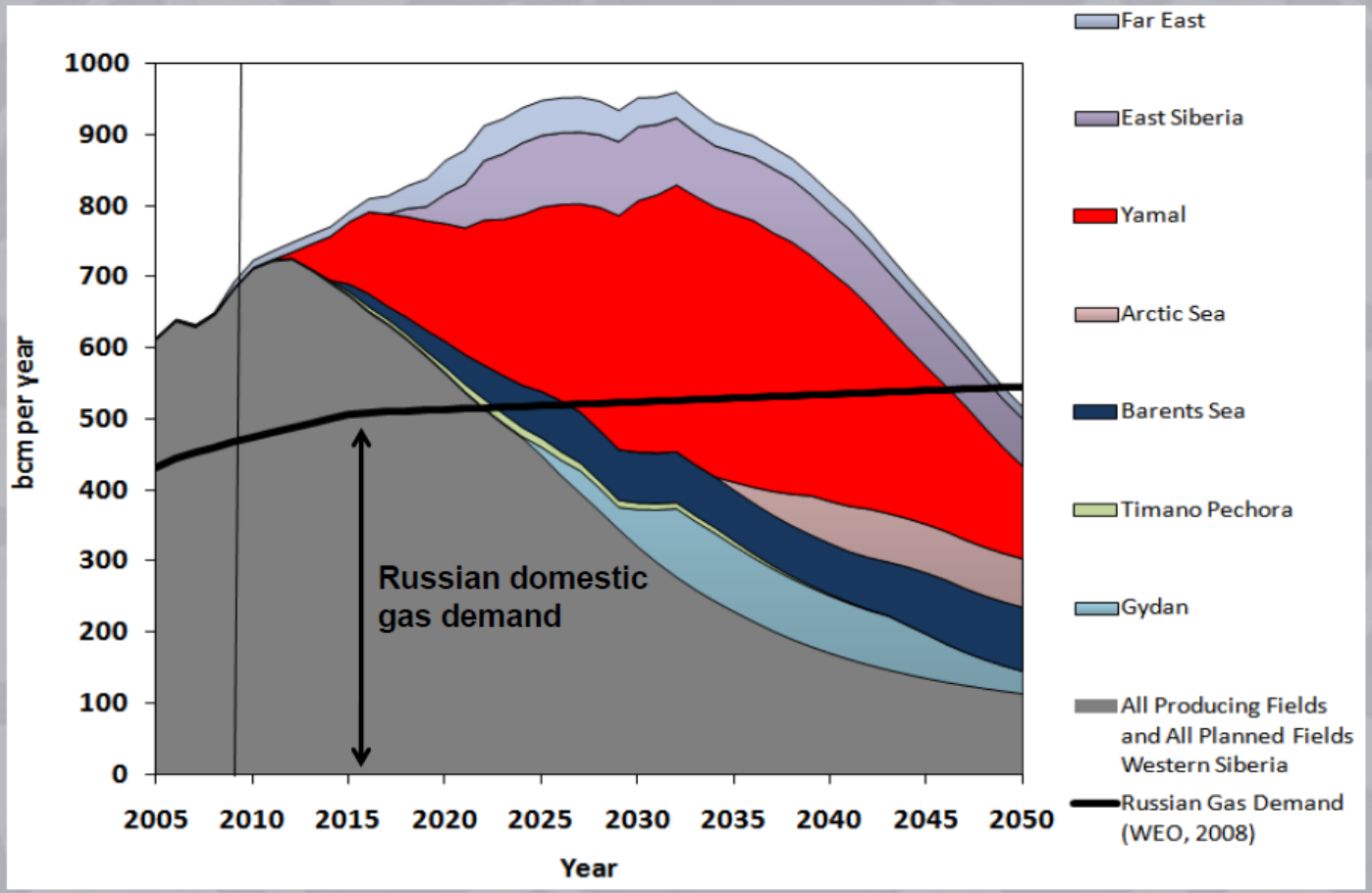

- Field-by-field study of Norwegian gas production.
- Contingent and undiscovered resources included.

Source: Söderbergh, B., et al., European energy security: The future of Norwegian natural gas production, Energy Policy (2009)

UPPSALA UNIVERSITET

Bengt Söderbergh
Kjell Aleklett

# Future Russian Gas Production and Demand




**Limited increase of export potential due to increasing Russian domestic demand.**

Source: Söderbergh, B., (2010). Production from Giant Gas Fields in Norway and Russia and Subsequent Implications for European Energy Security

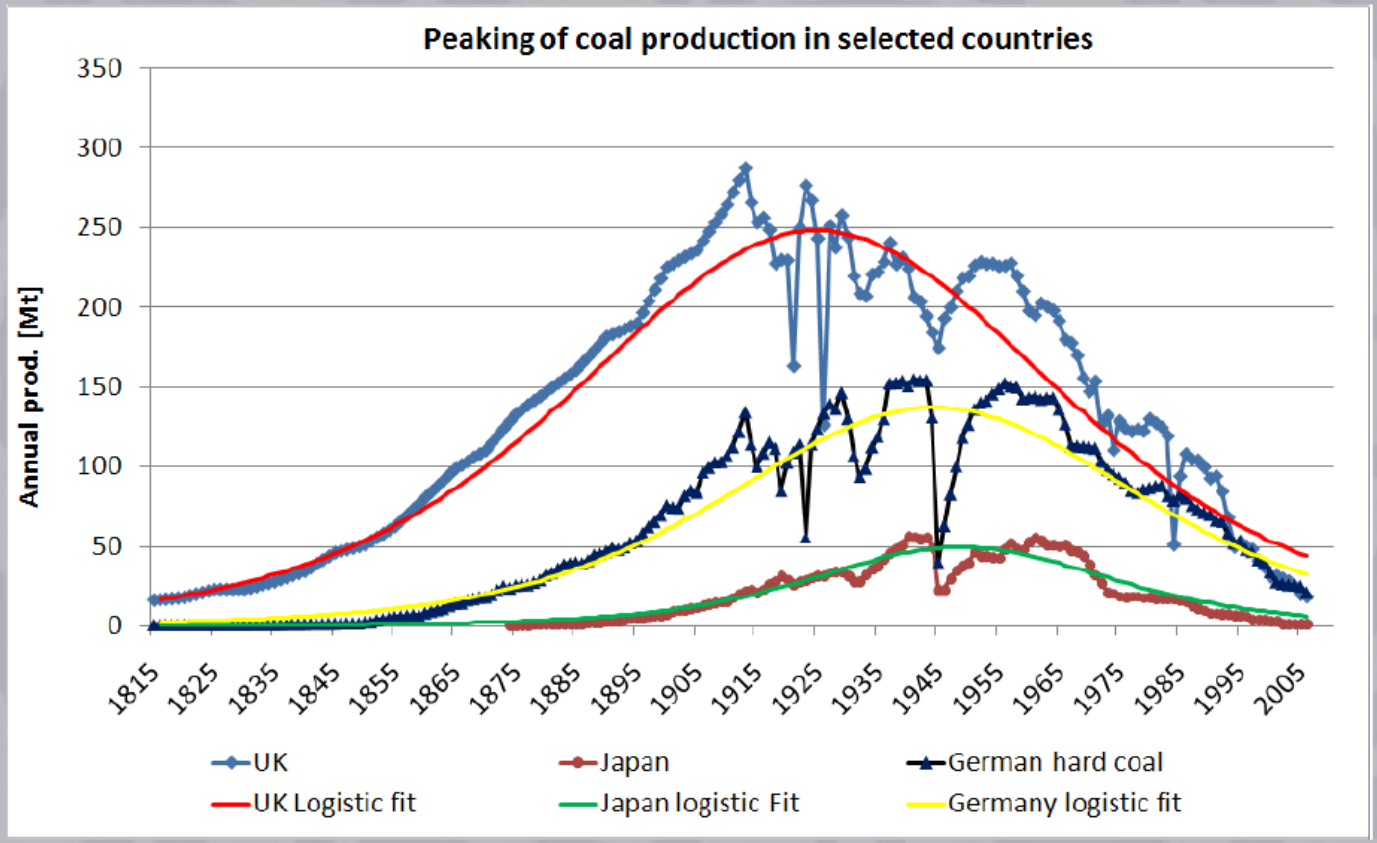

Bengt Söderbergh
Kjell Aleklett


UPPSALA UNIVERSITET

# Peak Gas

- UK Peak Gas occurred in 2000, accompanied by a steep decline in the Petroleum Revenue Tax
- Norwegian Peak Gas will occur in 2015, even with 'contingent and undiscovered resources'
- Russian Peak Gas will occur in 2025, brought forward by high and rising domestic demand
- Much of the exportable Russian gas will go to China and India, as will most of the LNG
- It would be naïve to assume that UK demand could be met even at world prices, if at all

# Peak Coal



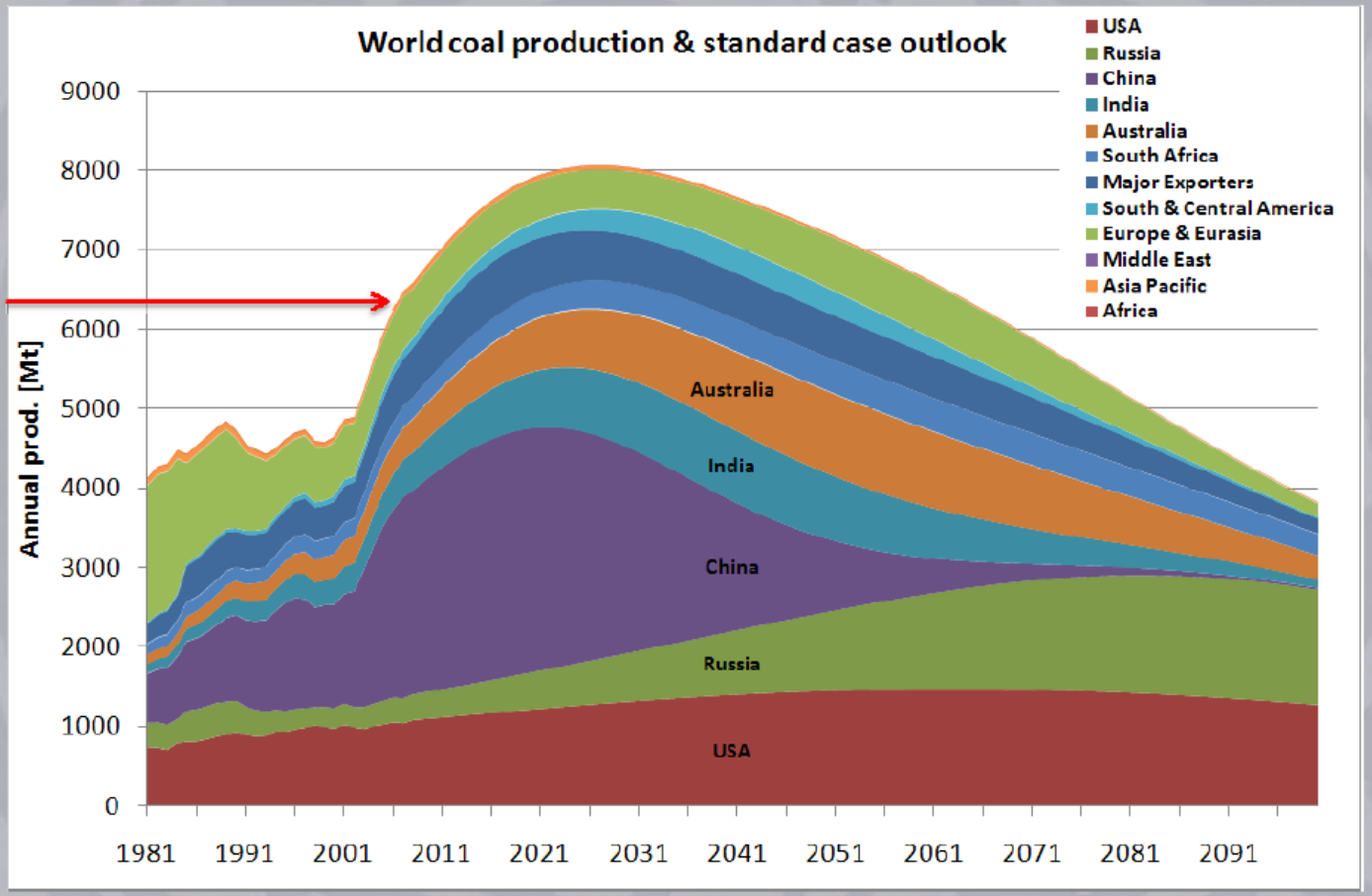

UPPSALA UNIVERSITET

Source: M. Höök, W. Zittel, J. Schindler, and K. Aleklett: Global coal production outlooks based on a logistic model, Accepted by Fuel.

Kjell Aleklett

# Coal production forecast

2006




UPPSALA UNIVERSITET

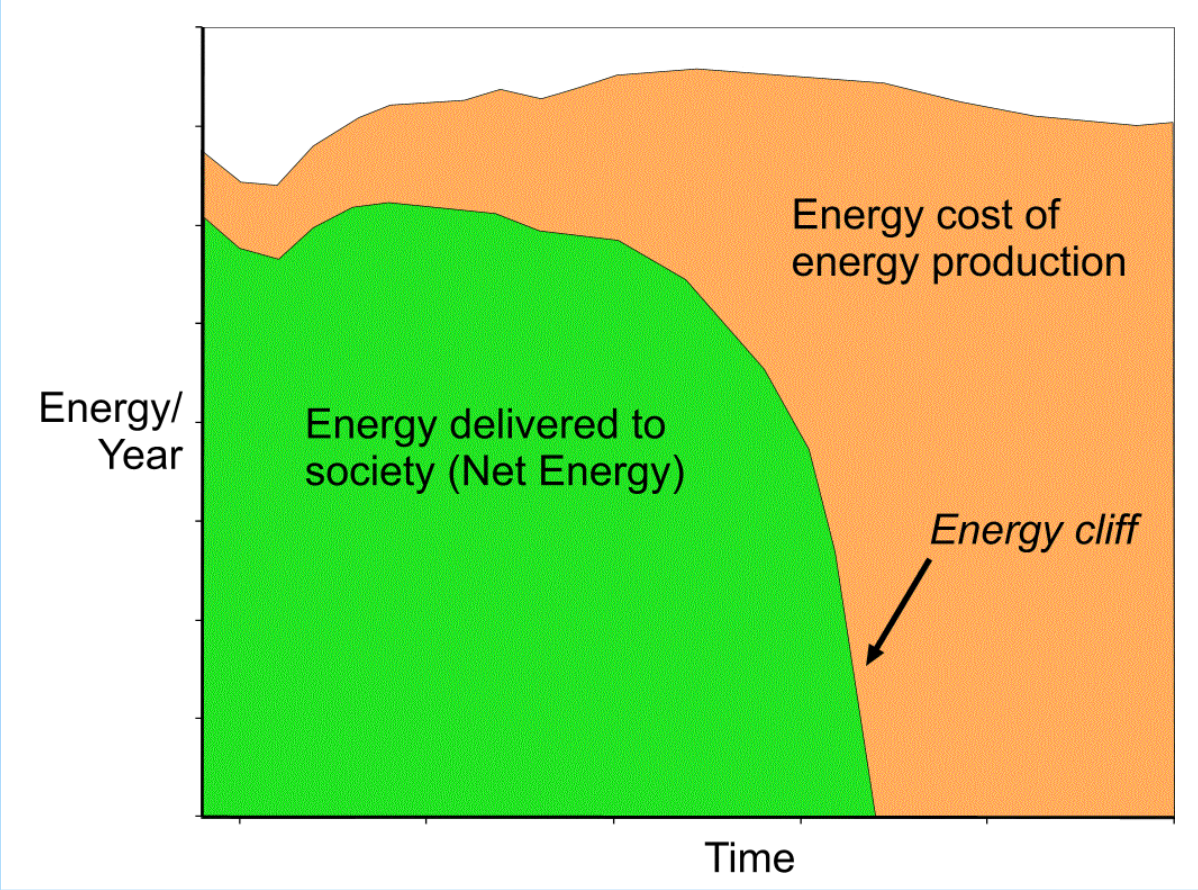
Source: M. Höök, W. Zittel, J. Schindler, and K. Aleklett: Global coal production outlooks based on a logistic model, Accepted by Fuel.

Kjell Aleklett

# Peak Coal

- UK Peak Coal occurred in about 1917 (actual) or about 1925 (smoothed)
- Höök et al, 2010 put global Peak Coal at about 2027 but Patzek and Croft, 2010 put it at 2011
- Most recent reappraisals of coal reserves have resulted in downgrades
- In 2004 German hard coal reserves were downgraded by 99% from 23 to 0.2 billion tonnes
- Even coal producers should not assume future supplies, much less an importer like the UK

# Depletable energy sources suffer declining ‘net energy’ and finally an ‘energy cliff’



# Quantifying the Problem

- The decline of Net Energy may be described qualitatively and quantitatively
- Thus once the 'low-hanging fruit' have gone, what remains must be harder to extract
- One quantitative term is the 'Energy Return On Invested' – EROI
- This may be estimated with Life Cycle Analysis, but needs care in choosing the system boundaries
- Moreover, for depletables, the future energy investments to maintain supply are hard to quantify

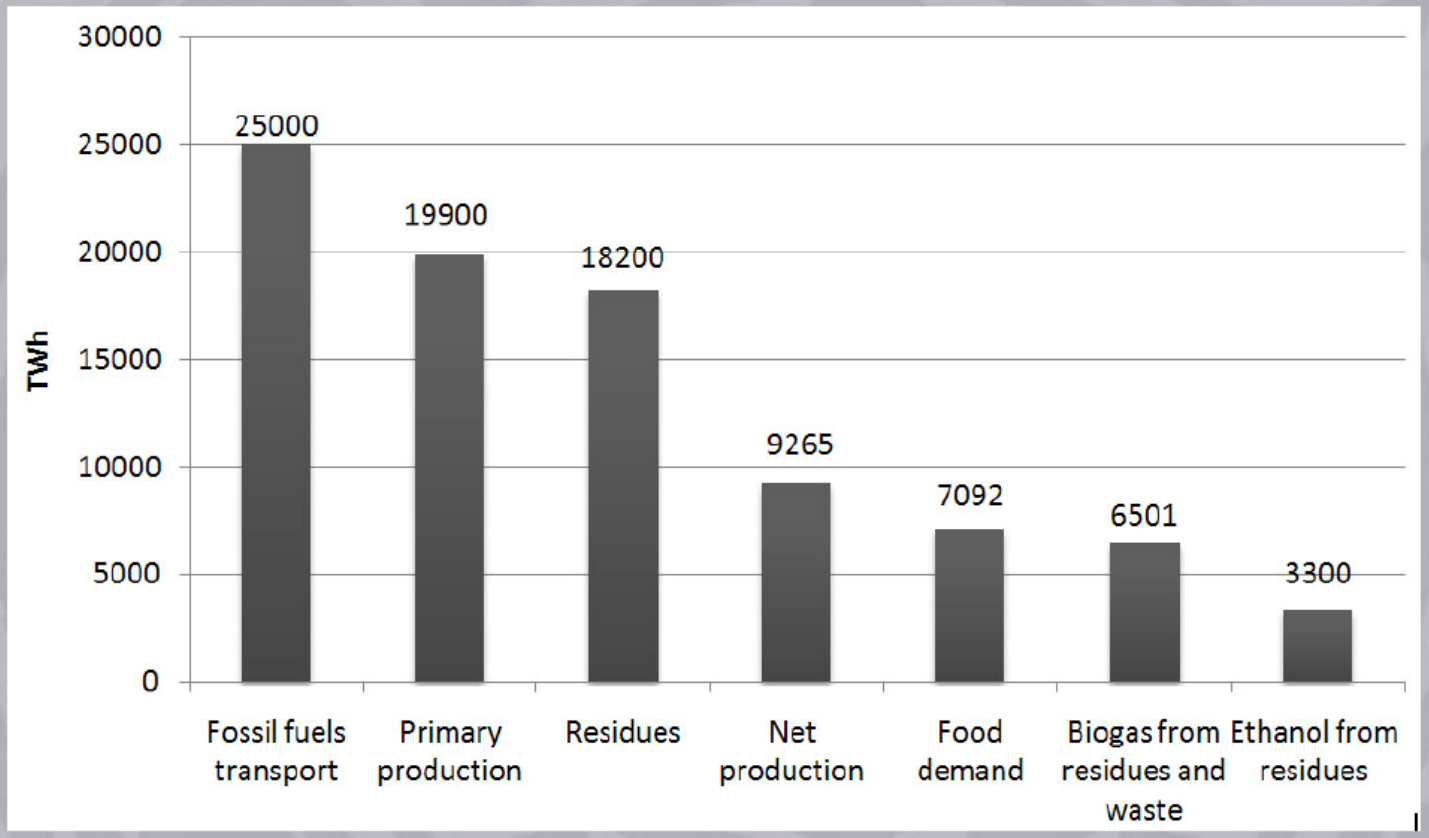
# Asymmetry and Prices

- The gross Production curve for a single oil field is asymmetric, but for a country is roughly symmetric
- Yet the Net Energy for a country is asymmetric
- So the decline from the peak may be very rapid, as is happening with North Sea oil and gas
- As it is accompanied by fast-rising global demand, this leads to continuously rising prices
- But higher prices may do little to increase supplies as depletables do not obey 'market economics'
- This is due to ever-declining Net Energy and EROIs

# Renewables

- Depletables quote 'levelised' prices, but future fuel supplies cannot be priced or even assured
- The same applies to depletables EROIs
- So only carbon-free renewables are sustainable
- Hydro-power and geothermal energy are site-specific and relatively small overall
- Marine current turbines are also site-specific, while wave power has yet to be proven
- Only solar, wind and biomass could ever make major contributions to all countries and the world

# Food and Fuel

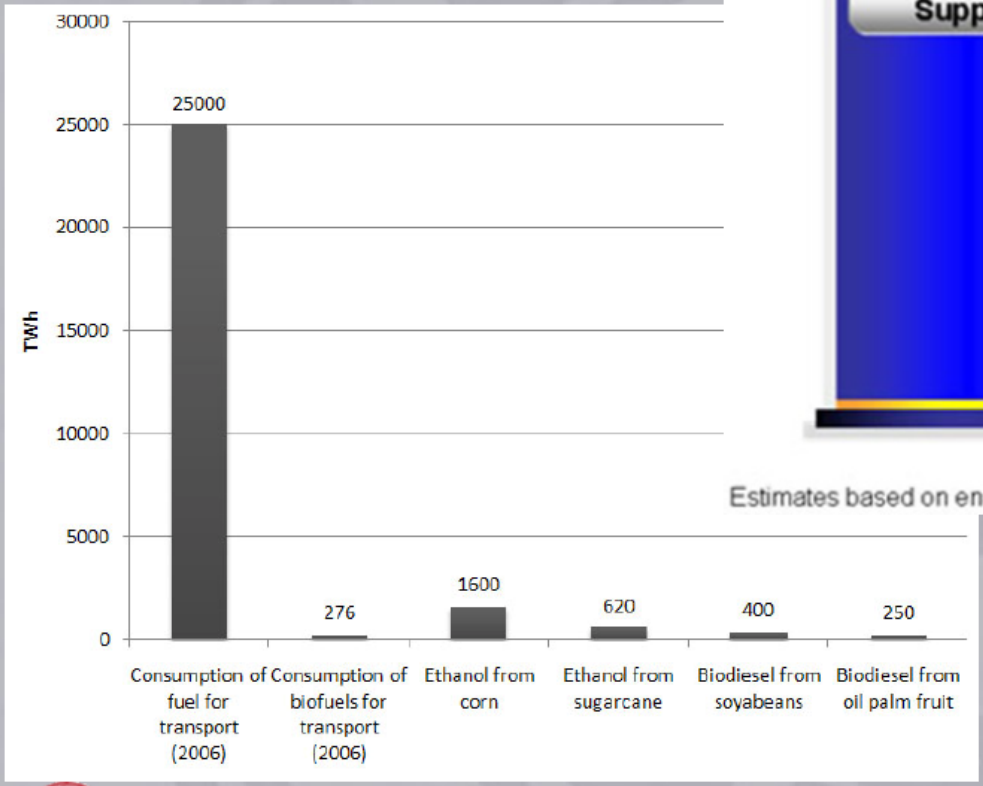


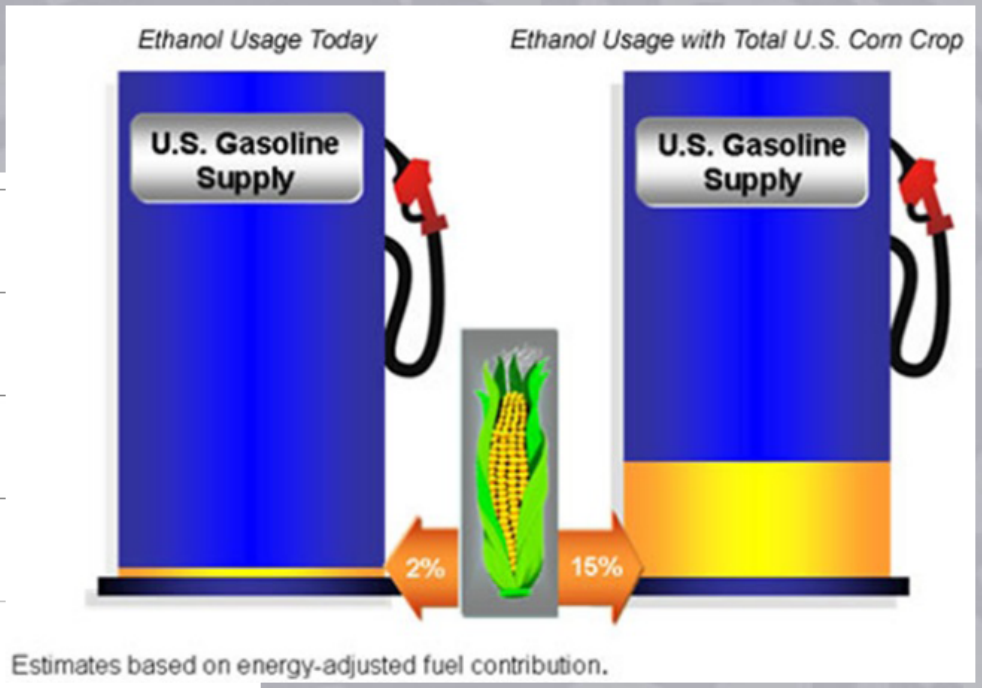

**Global agricultural production and some scenarios for possible biogas and ethanol production compared to present consumption of fossil motor fuels and global food demand.**

UPPSALA UNIVERSITET

Kjell Aleklett

# Food or Fuel




**Today's agricultural cannot provide us with food and fuel.**

UPPSALA UNIVERSITET

Kjell Aleklett

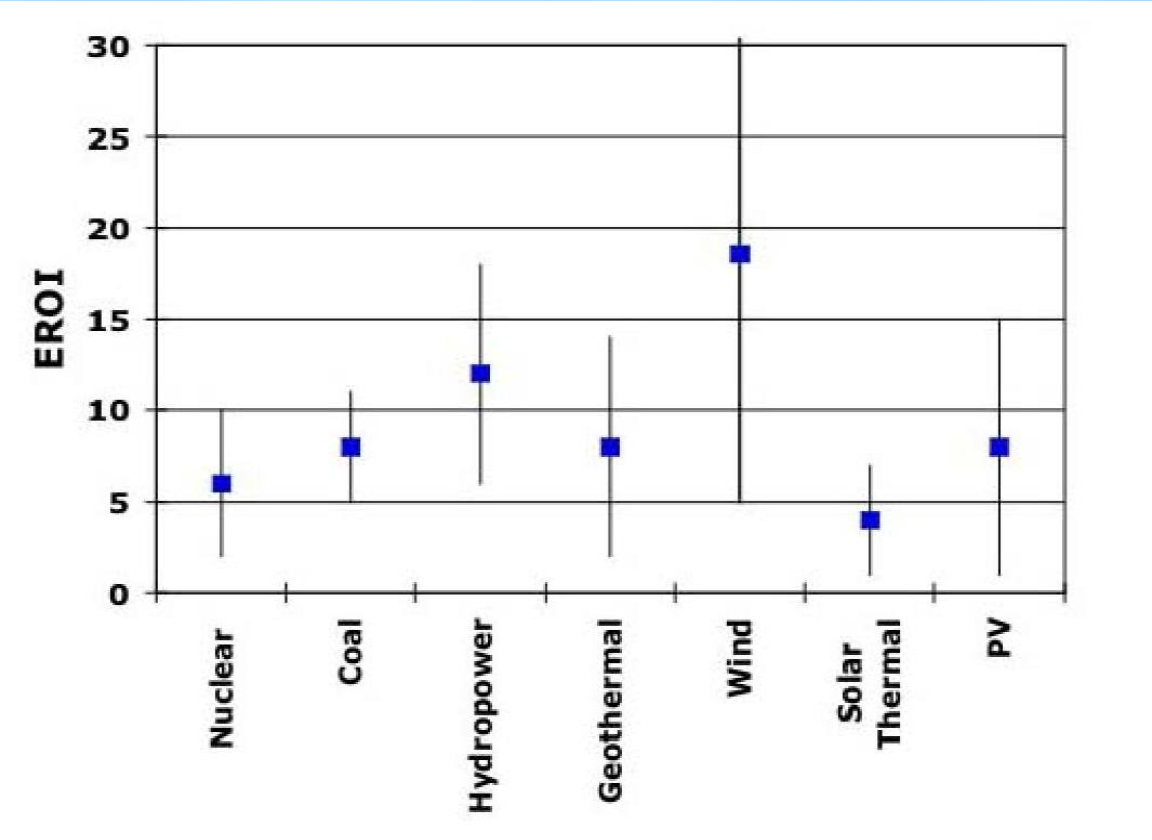
# Wind Energy

- Biomass is multi-constrained, while solar CSP and PV have poor EROIs in temperate climates
- However, wind energy can produce electricity – the highest form of energy - with very high EROIs
- Also large wind turbines can be located offshore, either bottom-sitting or floating
- This is particularly welcome in an increasingly crowded world
- The global wind resource has been put at 96 TW and the UK wind resource at up to 2 TW

# EROIs of Electricity Sources

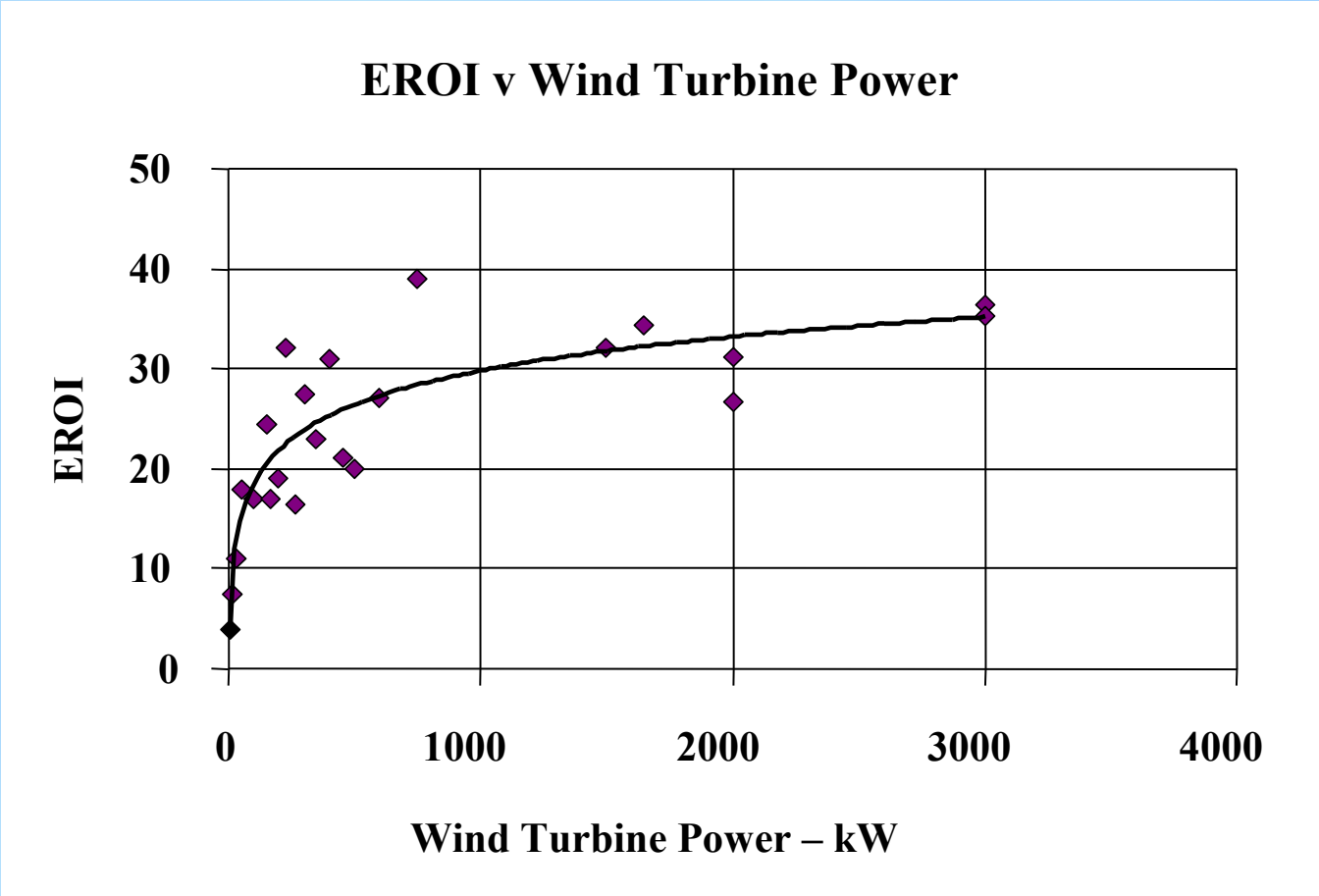
Of the renewable electricity sources:

- Hydropower and Geothermal are good but site-limited.
- Wind Turbines are much better than PV or Solar Thermal



# EROIs of Electricity Sources: Scale Effect

The EROIs of Wind Turbines show a marked scale effect
Hence we should invest only in large machines - MW class



## Transition to Sustainability - Phase 1

| Sector | |
|---|---|
| Electricity | Increasingly from Wind<br>Balance from existing Coal and Gas |
| Fuels | Scale-up of Wind-powered Renewable Power Methane and Renewable Synthetic Fuels Plants |
| Heat | Urban: Start of District Heating from Gas-fired Combined Heat and Power Plants - existing and new<br>Balance from Gas<br>Rural: Some LPG, some Biomass |

Time

## Transition to Sustainability - Phase 2

| Sector | Time |
| --- | --- |
| Electricity | Still more from Wind<br>Balance from Gas, with some RPM |
| Fuels | Increasing Wind-powered<br>Renewable Power Methane<br>and Renewable Synthetic Fuels |
| Heat | Urban: More District Heating from<br>Combined Heat and Power<br>and Renewable Synthetic Fuel Plants<br>Balance Gas, some RPM<br>Rural: Some LPG, some Biomass |

## Transition to Sustainability - Phase 3

| Sector | |
|---|---|
| Electricity | Maximum from Wind<br>Balance from Gas with RPM |
| Fuels | 100% Wind-powered<br>Renewable Power Methane<br>and Renewable Synthetic Fuels |
| Heat | Urban: 100% District Heating from<br>Combined Heat and Power and<br>Renewable Synthetic Fuel Plants<br>Rural: Synthetic LPG, some Biomass |

Time

# Transition - Phase 4: CO2 Rollback

- Increasing capture of CO2 from air, initially for 100% RPM and Renewable Synthetic Fuels
- More capture of CO2 from air, for sequestration and ‘rollback’ of the atmospheric concentration
- Hence the North Sea stores should not be used for CCS, but reserved for ‘rollback’ CO2
- Government should fund demonstrations of CO2 capture from air and of the sequestration of this

# Thank you for your attention

Gordon Taylor

G T Systems

Several of the energy presentations are at:
www.energypolicy.co.uk