100% Energy from Wind

Gordon Taylor

G T Systems

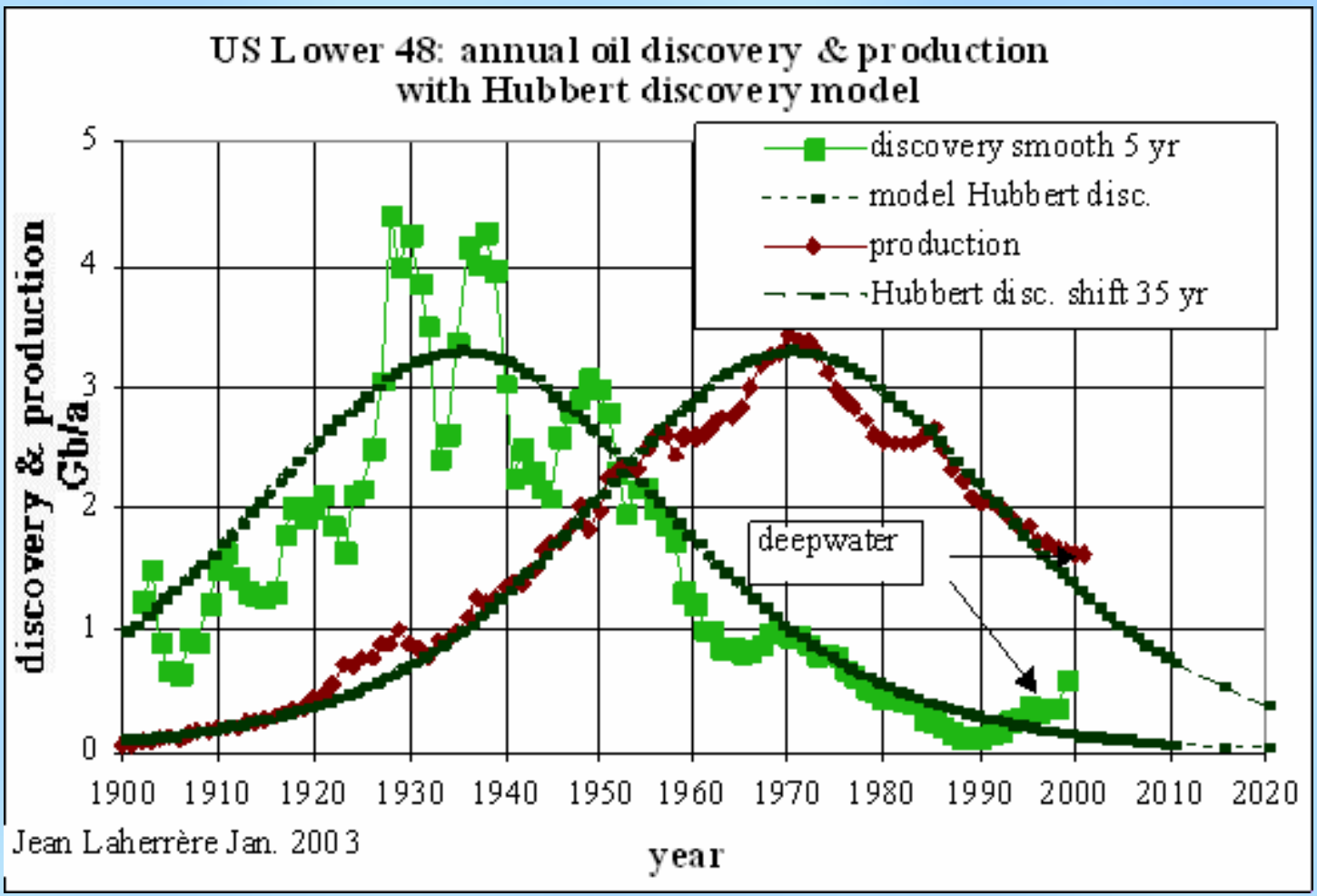
www.energypolicy.co.uk

March 2011

Depletable Resources

- The 'abundance' of a resource is not sufficient
- The extraction must be economic of money and - for energy resources – of energy
- Hence the resources should be concentrated and easy of access
- Yet most 'new' depletable energy resources are small, lean or deep below the land or sea

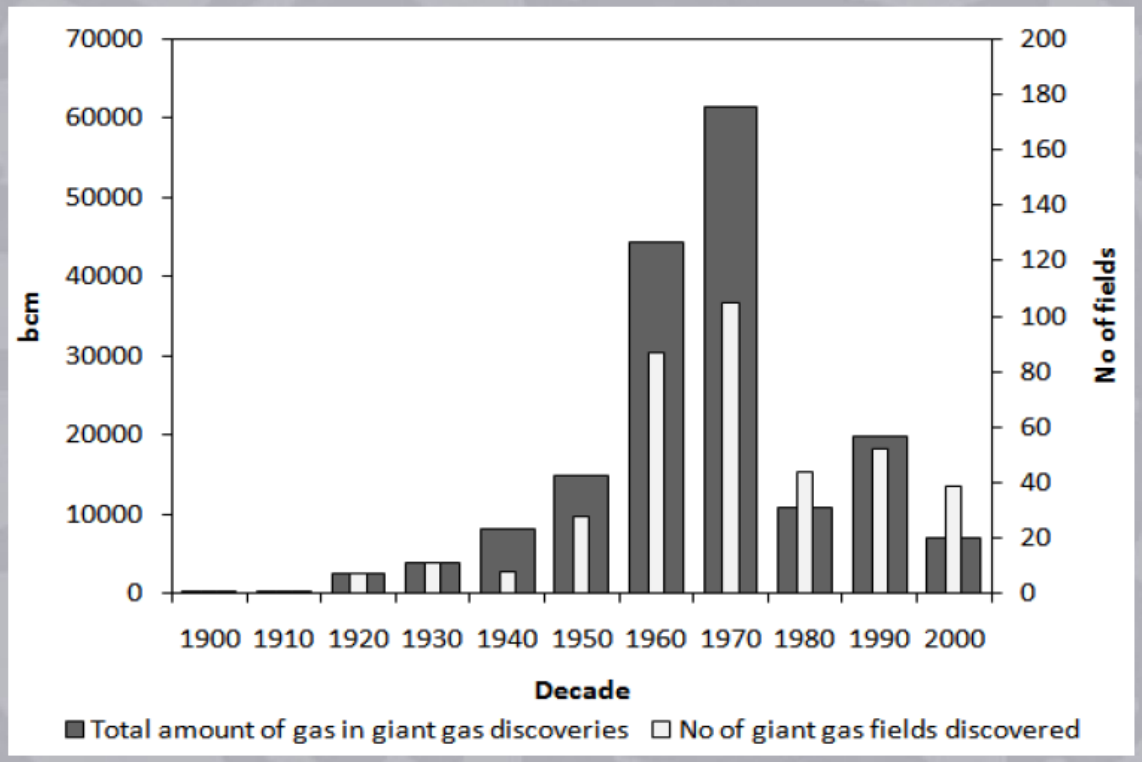
All depletable energy and material sources are finite
Hence the yields must 'peak' as in 'Peak Oil/Gas/Coal'



Peak Oil Etc

- Resources are only those Found and Proven
- Discovery is of a resource – e.g. barrels - but Production is defined by a rate – e.g. barrels/day
- From Peak Discovery to Peak Production for oil was about 35 years, so there was ample notice
- 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!

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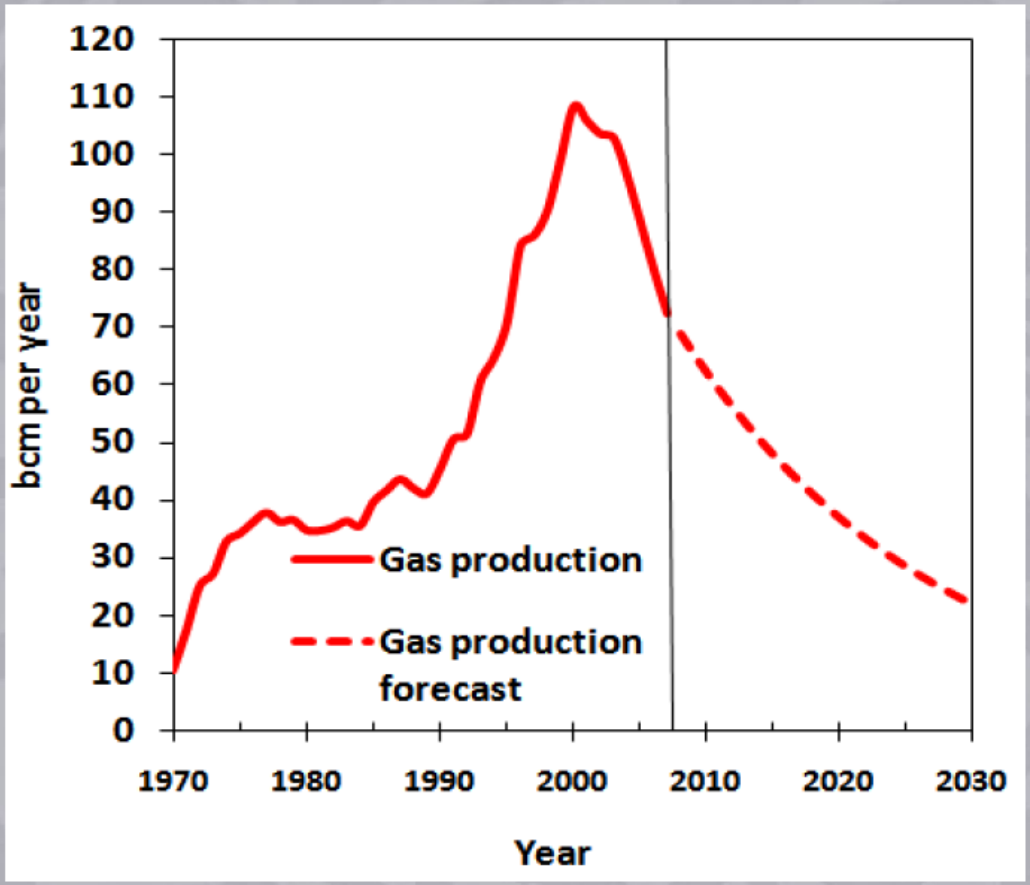
UK Gas Production Peaked in 2000



- 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)

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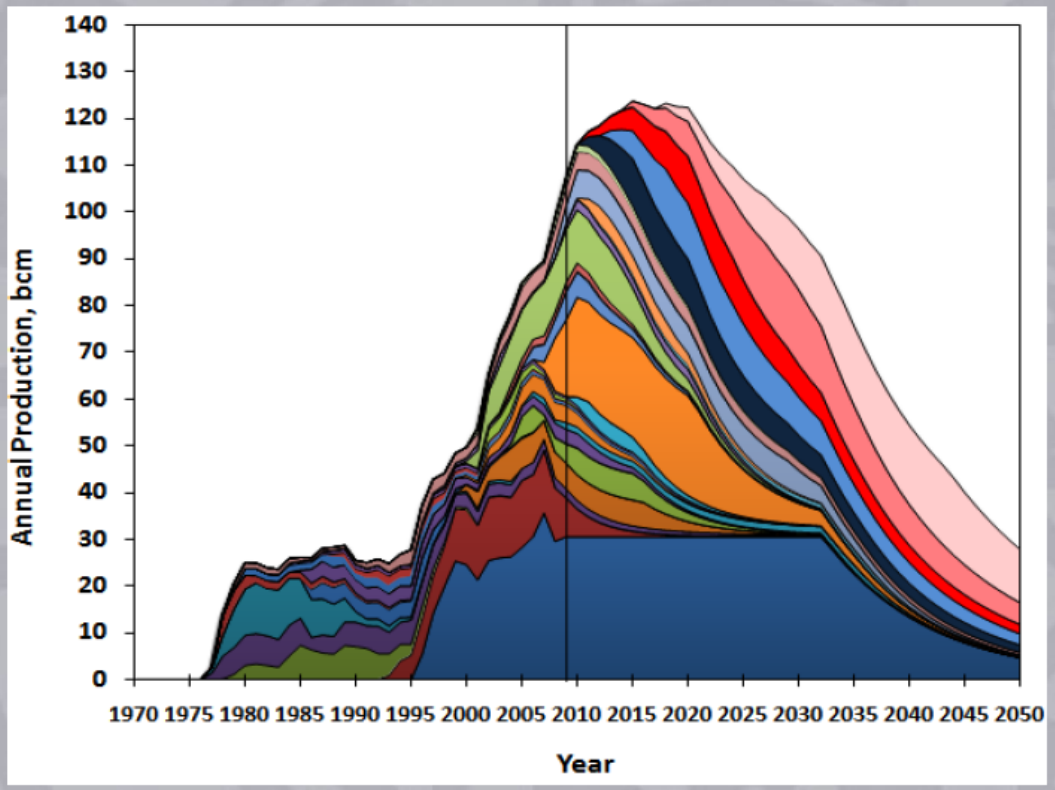
Norway - A Bottom-up Analysis

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)

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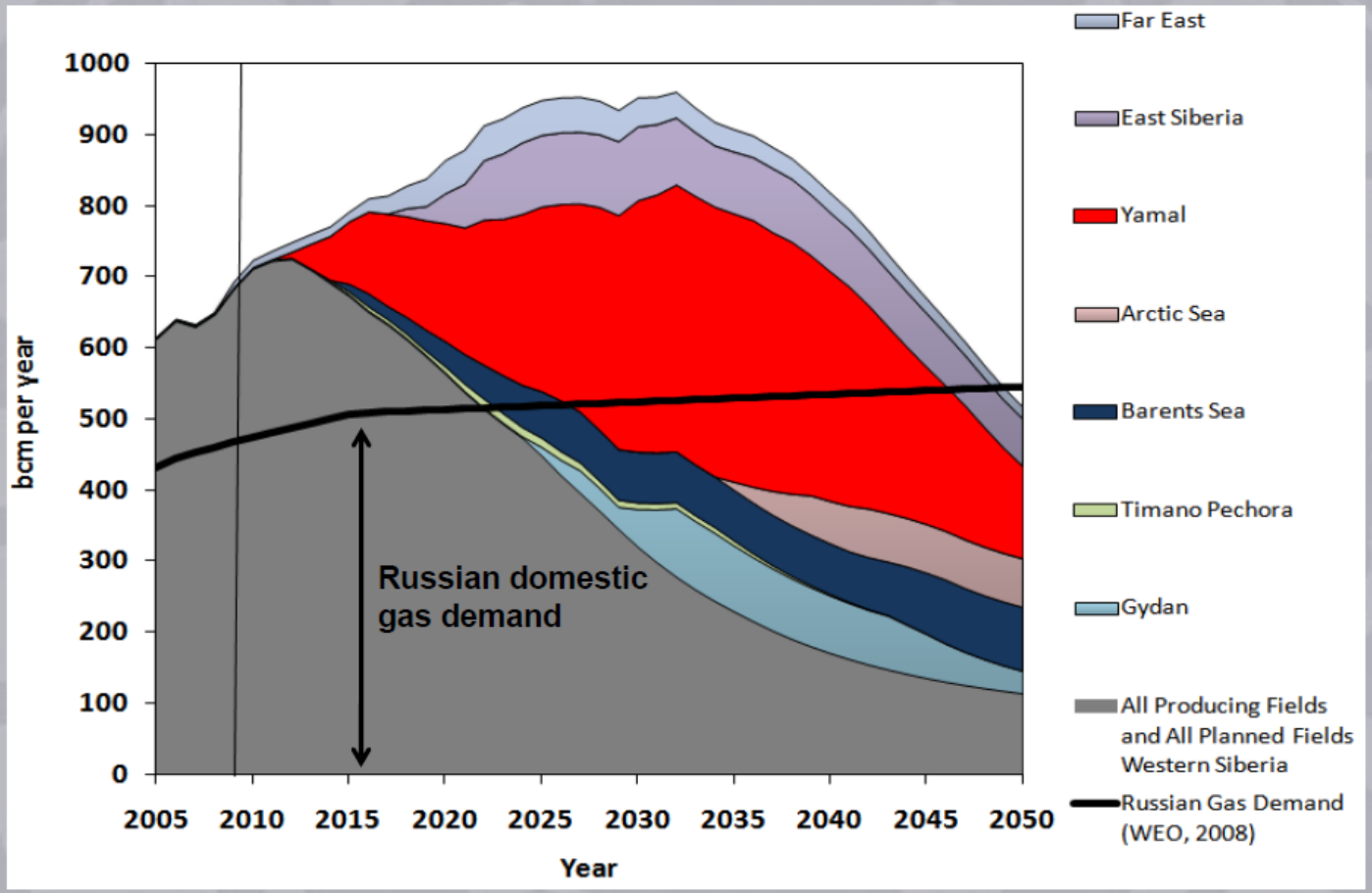
Future Russian Gas Production and Demand



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

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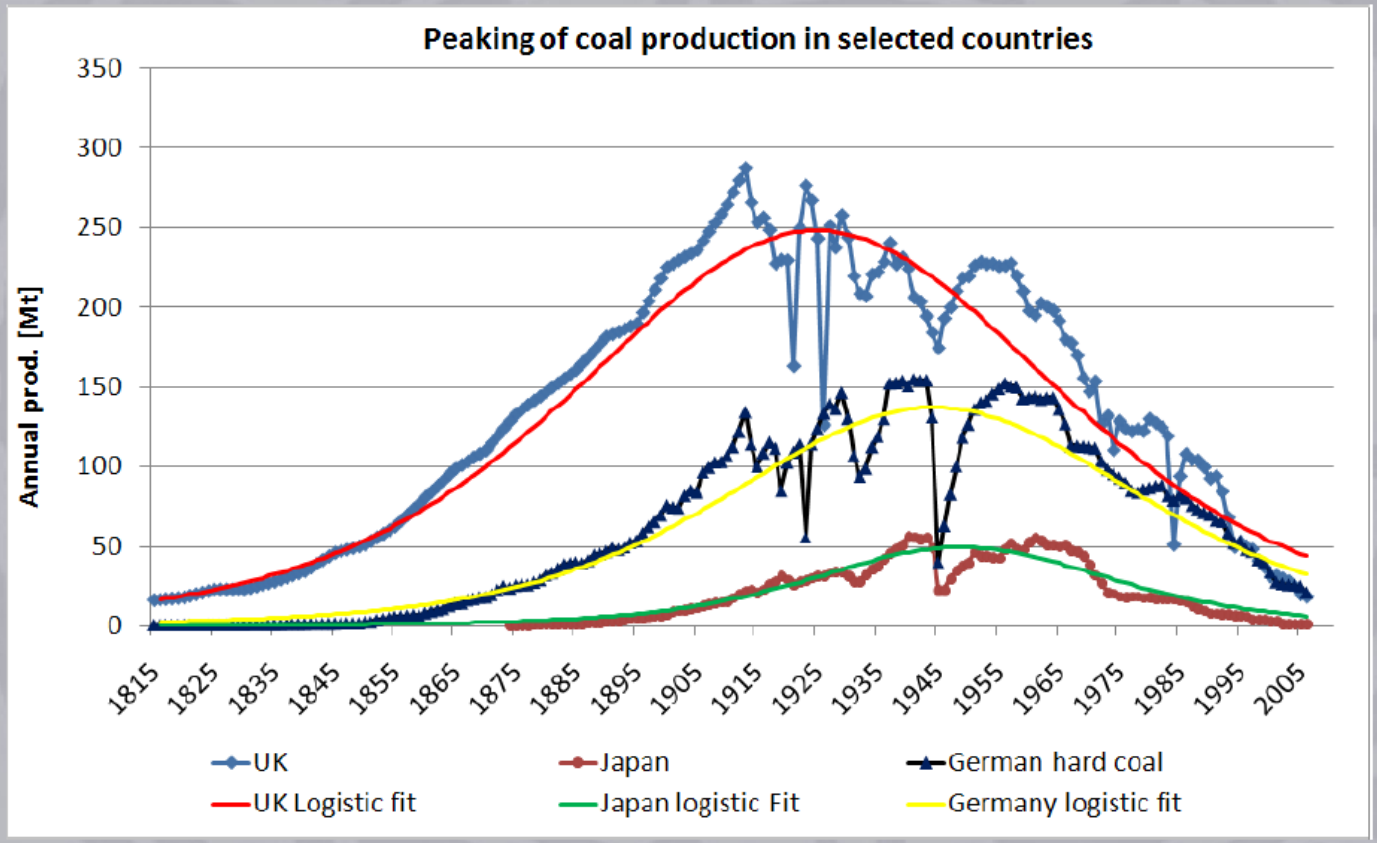
Peak Gas

- 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



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

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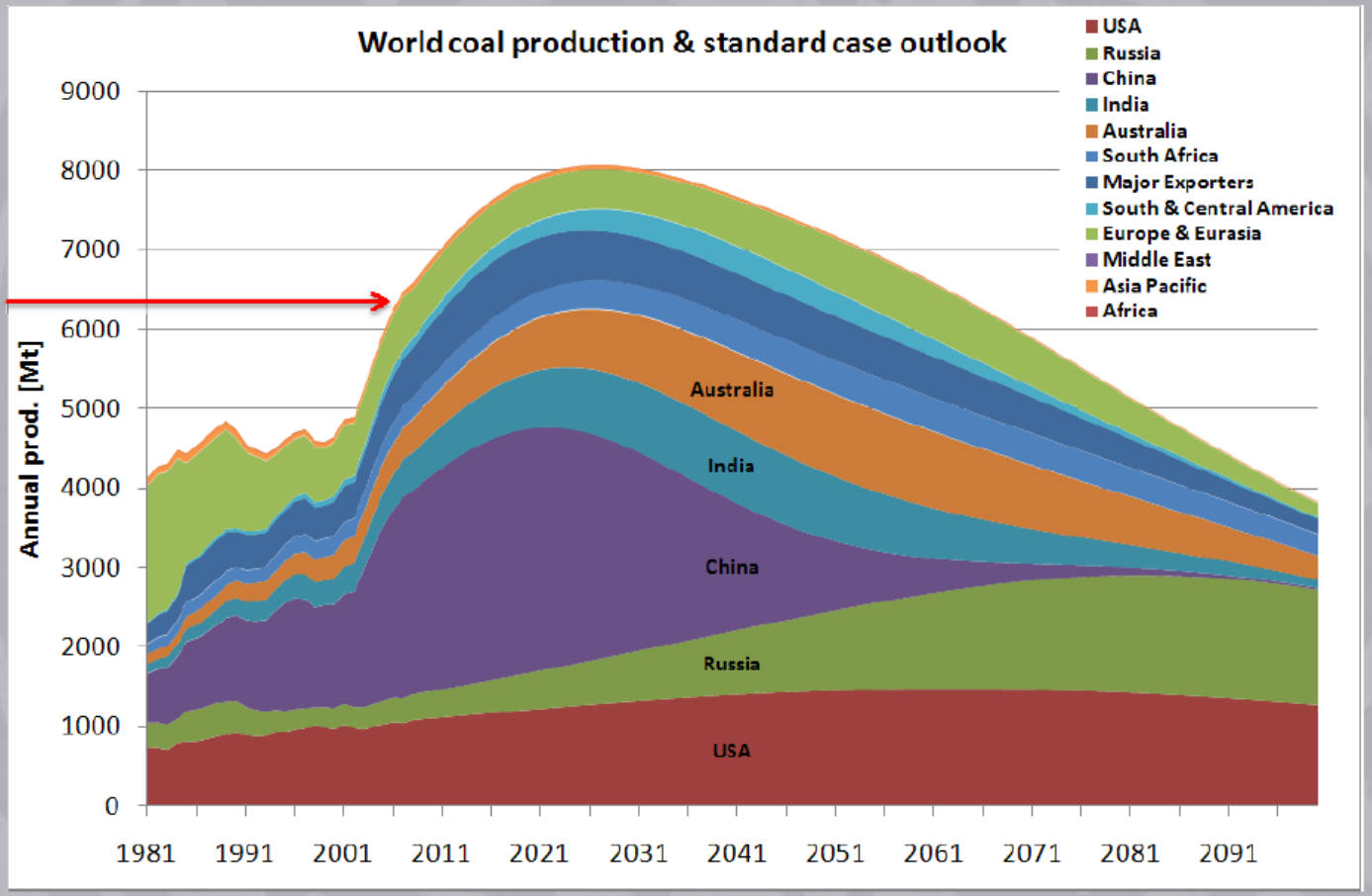
Coal production forecast

2006



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

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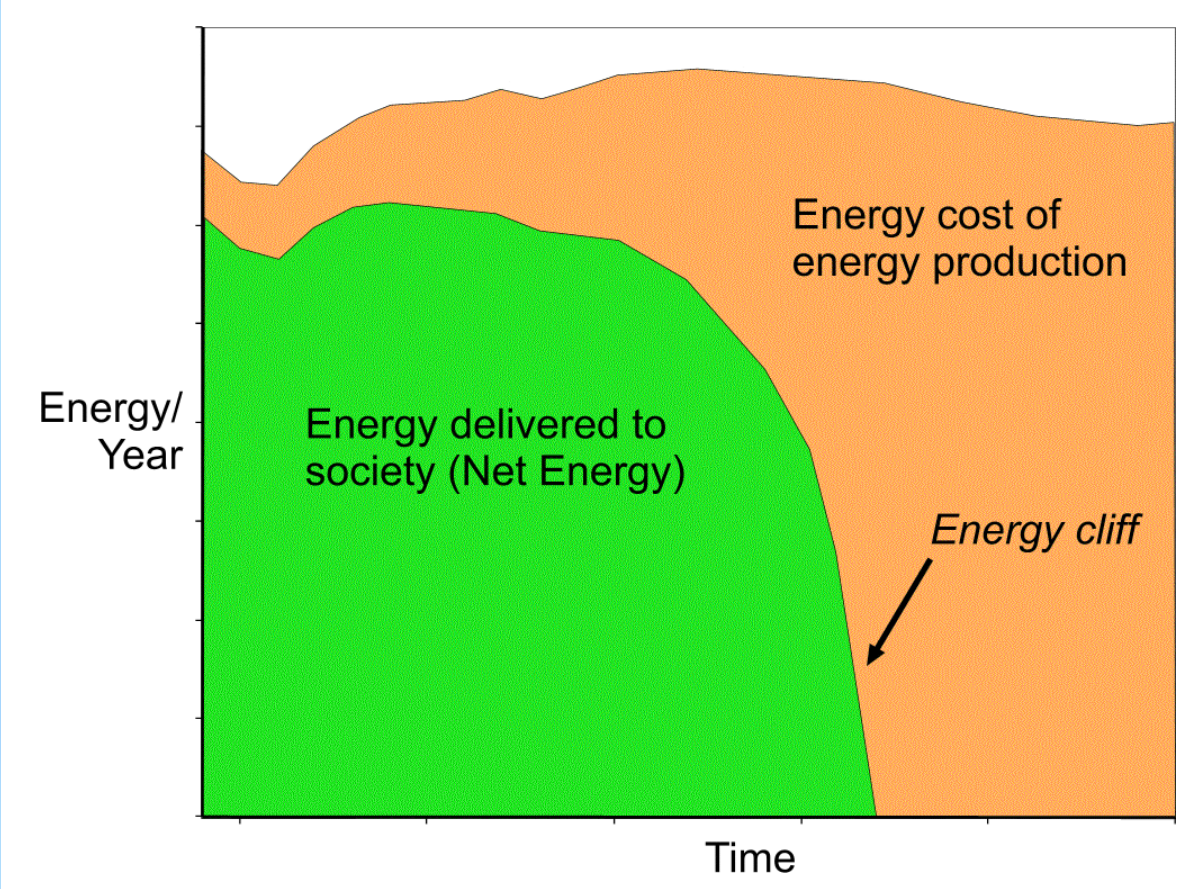
Peak Coal

- 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’

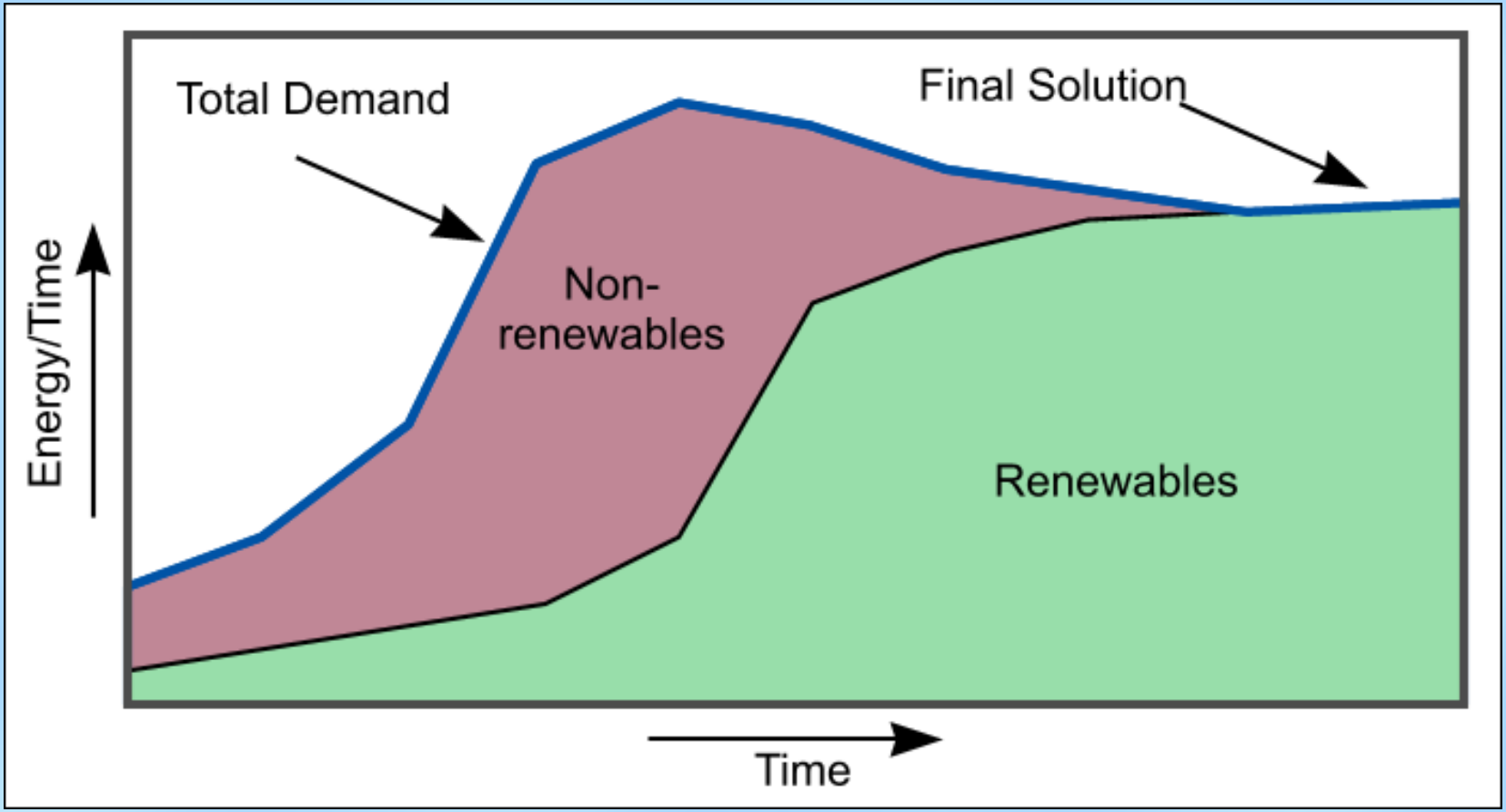


Depletables and Prices

- Net Energy can decline very rapidly, along with the 'Energy Return On (Energy) Invested' – EROI
- Hence for depletables, the energy investments even to maintain the present supplies must increase
- But rising global demand for depletable energy leads to continually rising prices
- Hence the money costs to maintain depletable energy supplies would increase even faster
- So future supplies cannot be priced or even assured, yet depletables still quote 'levelised' prices

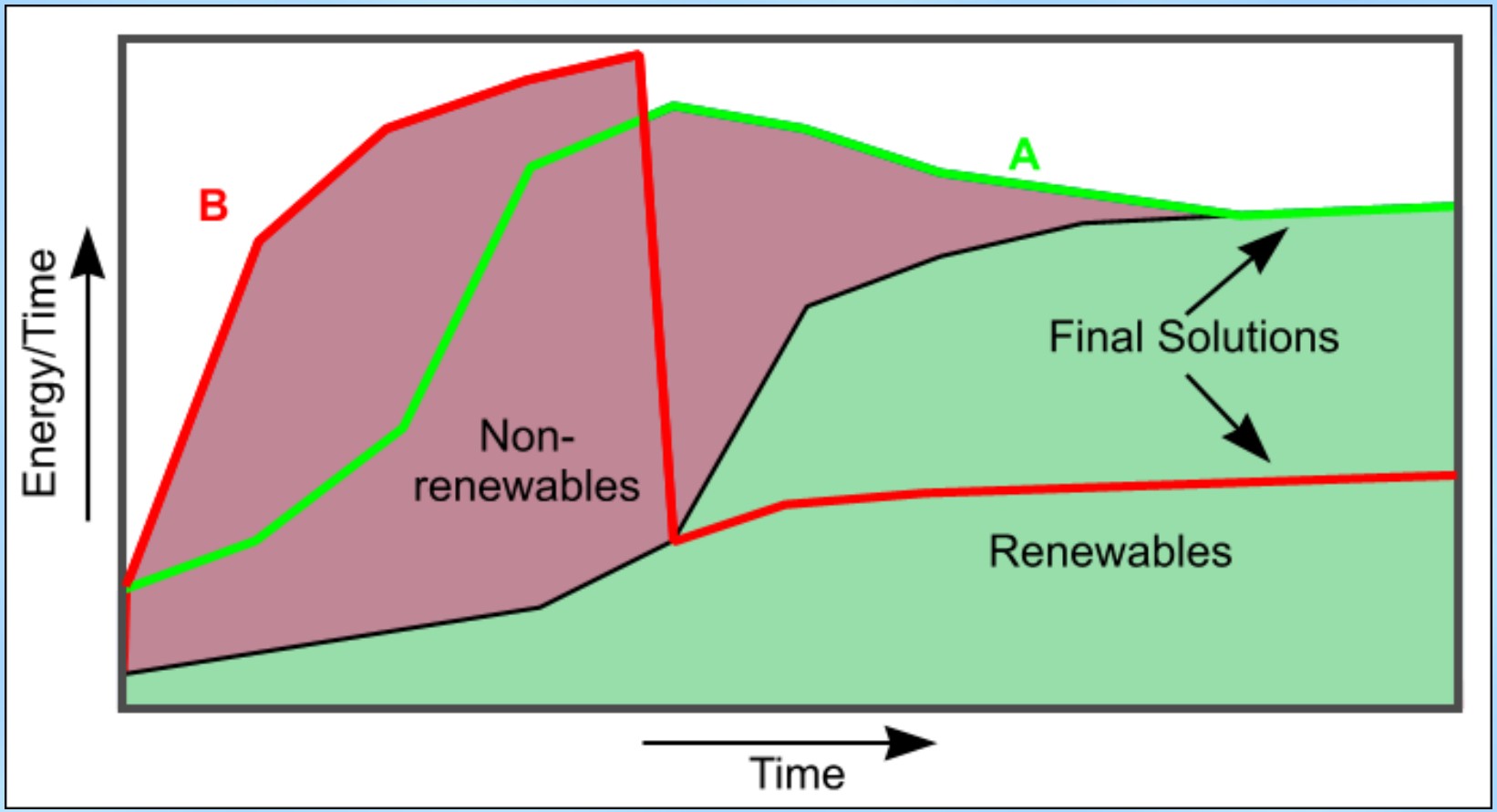
Transitions: Smooth

Investing enough of the limited fossil fuels can lead to a smooth transition and ample sustainable energy/time



Transitions: Collapse

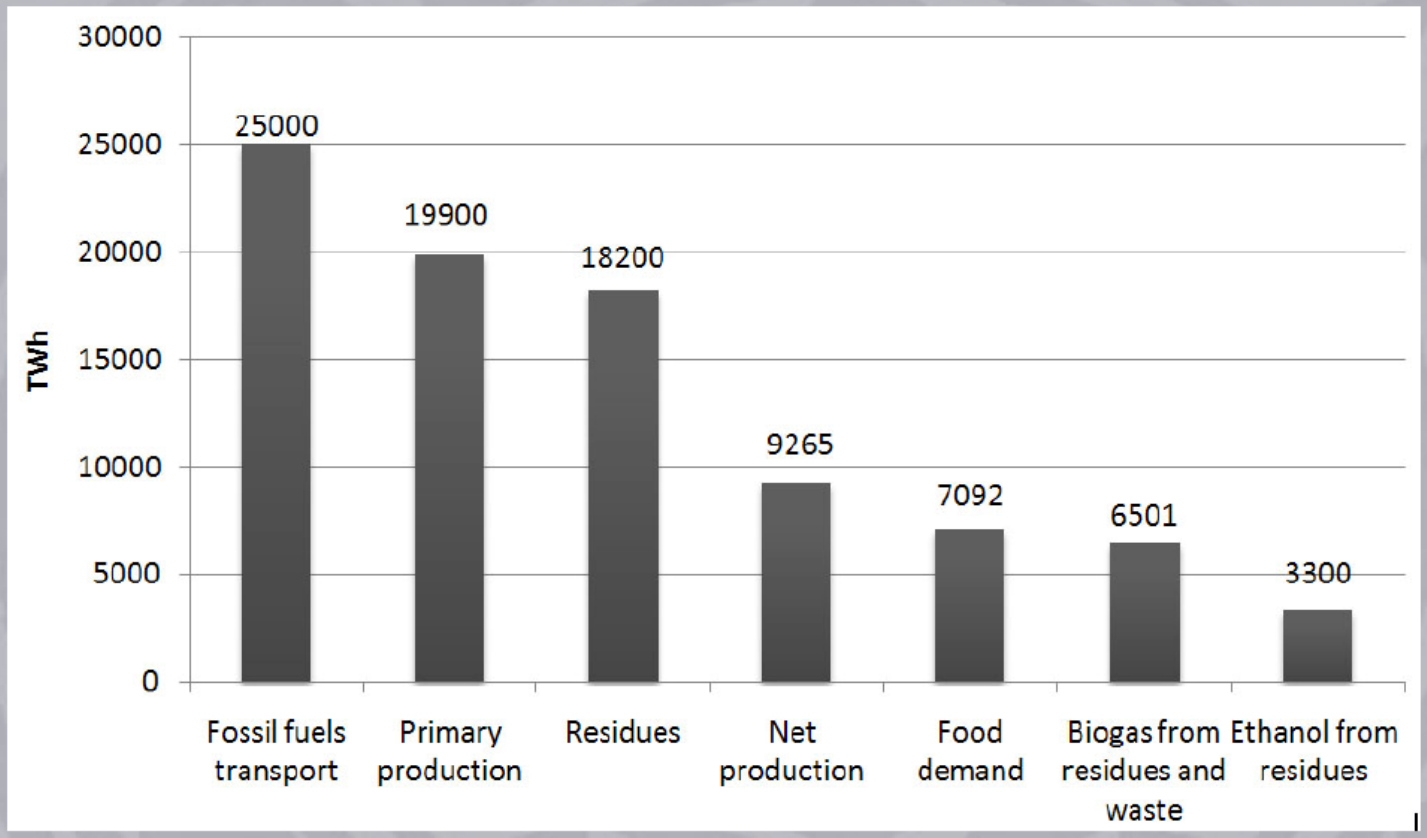
Thoughtless use of the limited fossil fuels would lead to collapse and much less sustainable energy/time (curve B)



Renewables

- Only renewables are non-depletable with near-zero net carbon emissions and thus 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



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

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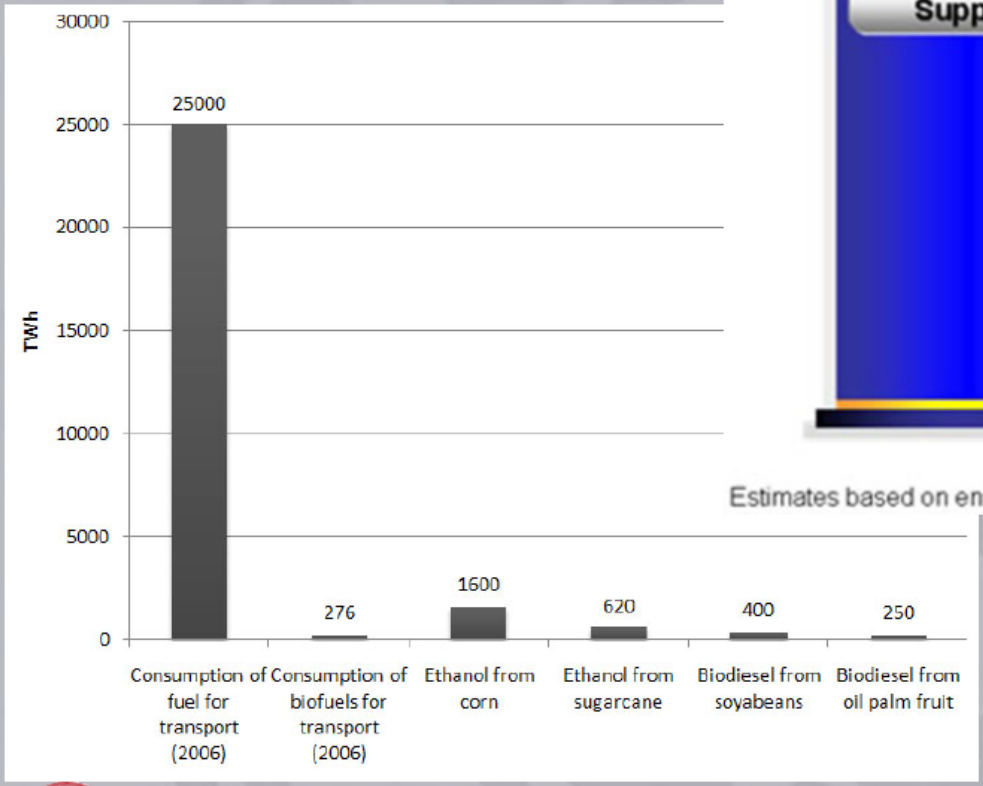
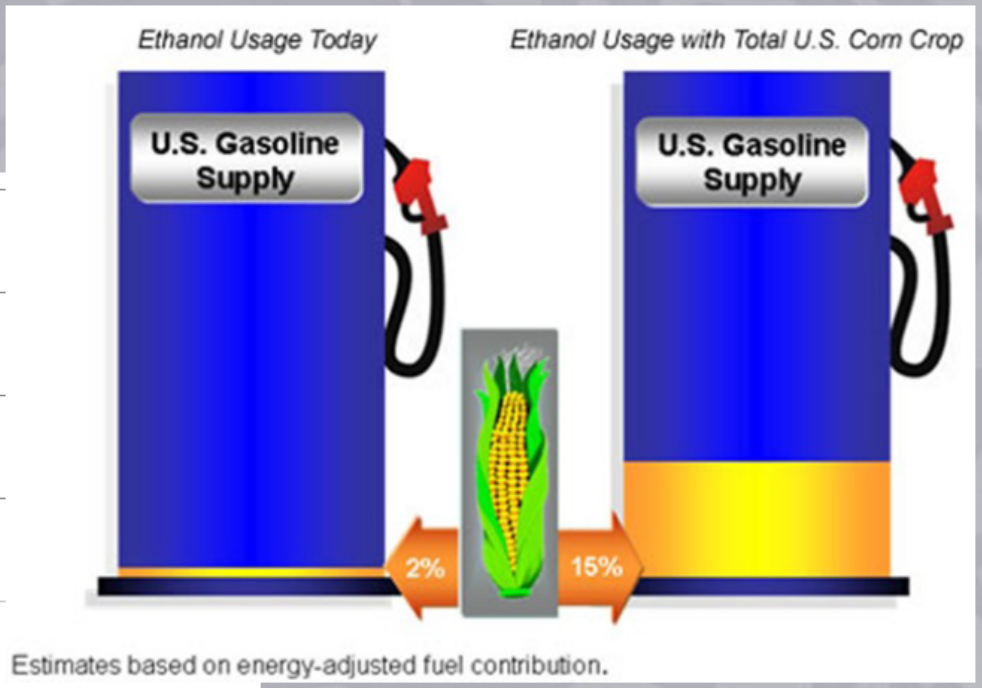
Food or Fuel





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

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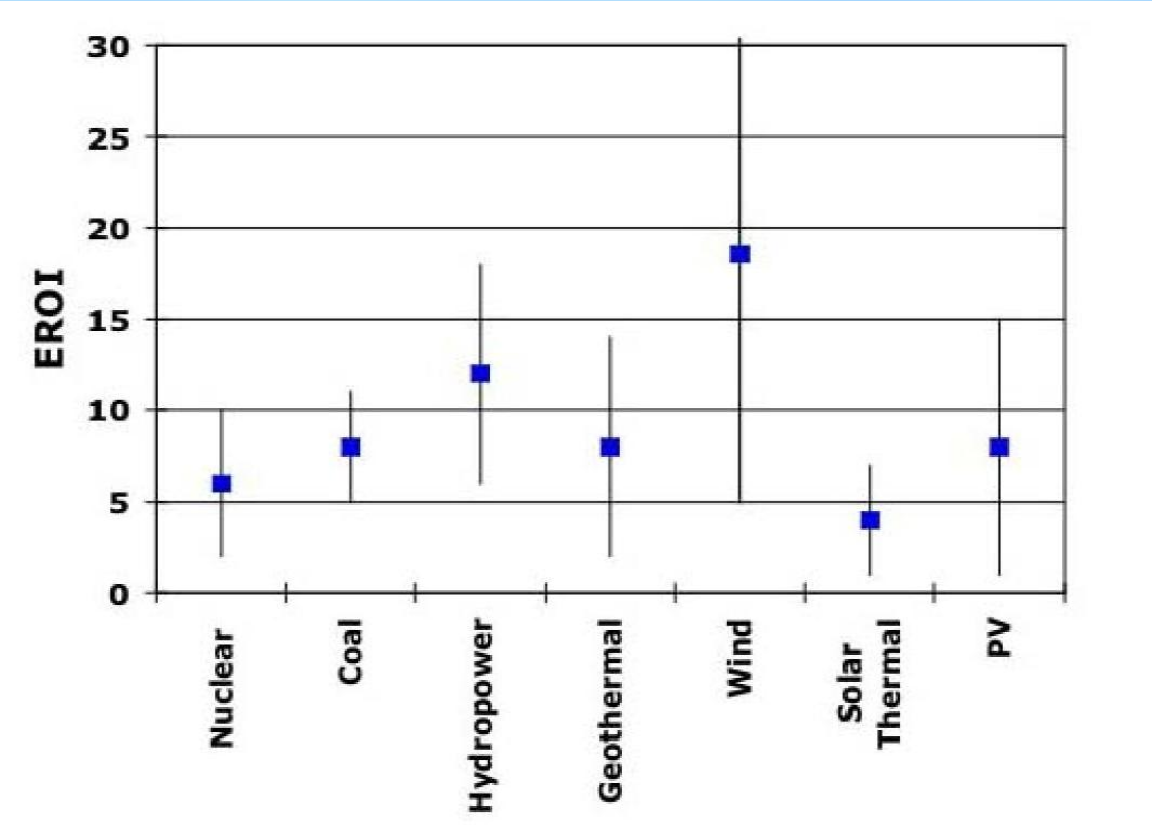
EROIs of Electricity Sources

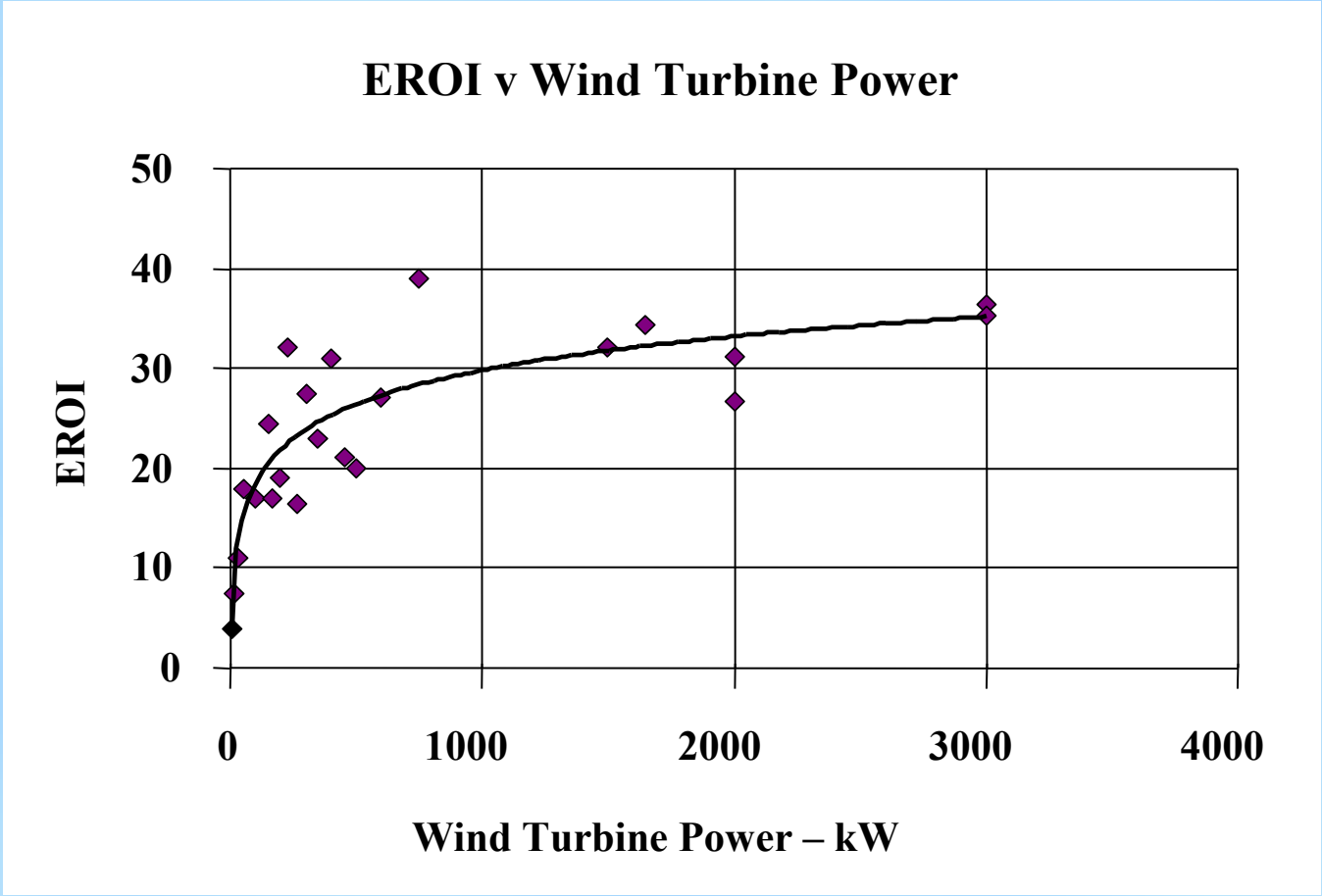
Of the renewable electricity sources:

- 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



Wind Energy

- Biomass is multi-constrained, while Solar Thermal and PV have poor EROIs in temperate climates
- However, wind energy can produce electricity – the highest form of energy - with very high EROIs
- Large wind turbines can be sited onshore or offshore, with the latter fixed or floating
- Offshore siting 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

100% Energy from Wind

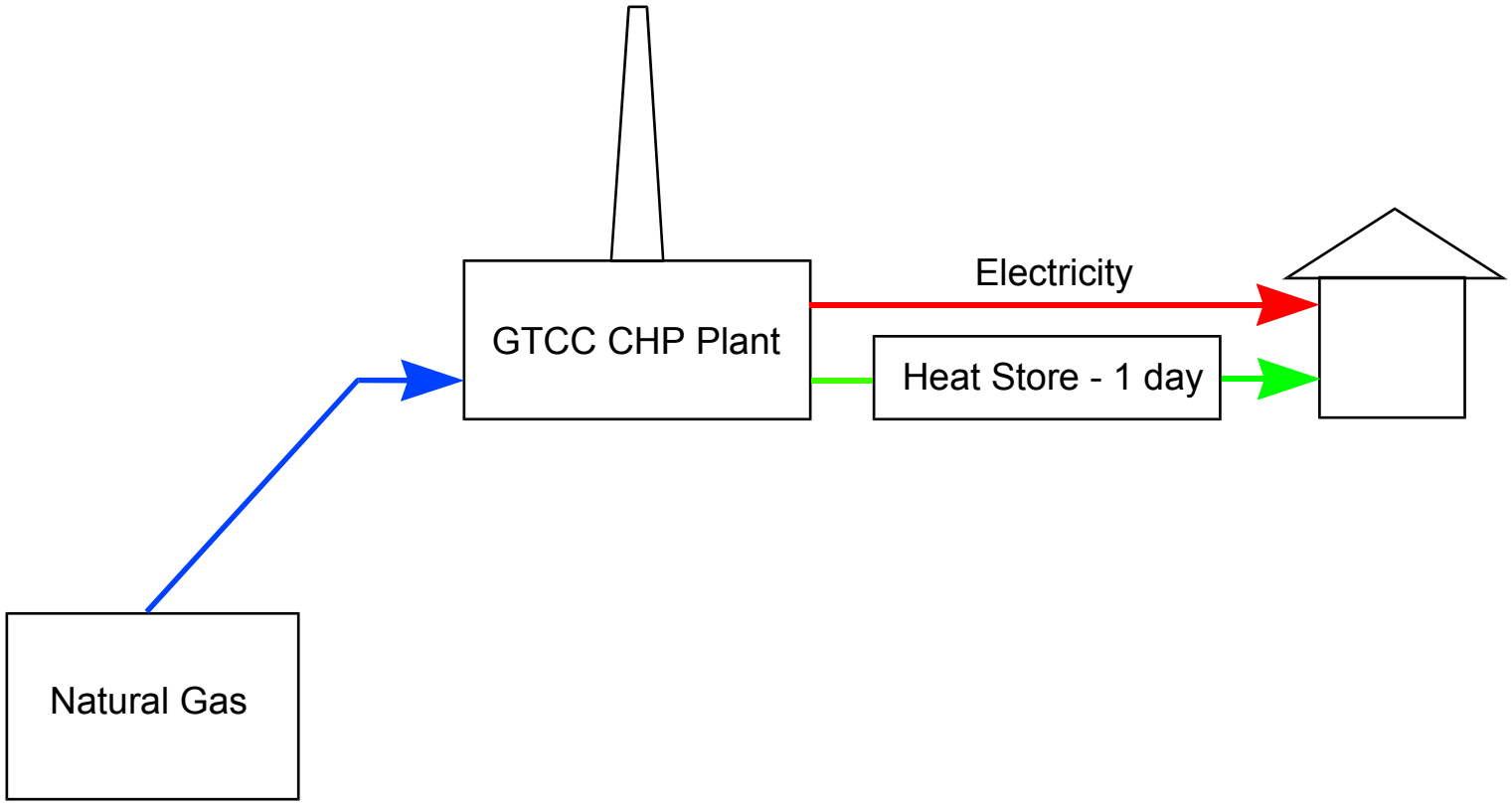
- to carbon-free sustainability in four steps

- 0% Electricity from Wind
- 50% Electricity from Wind
- 100% Electricity from Wind
- 100% Electricity, Transport and Heat from Wind

0% Electricity from Wind

- This was true of the UK a few years ago
- Depletable power is represented by gas-fired GTCC power plants, the youngest in the fleet
- Even without wind power, GHG emissions can be reduced by co-generating heat at up to 100 C
- This could be supplied via district heating networks and displace electric and gas heating
- The resulting carbon saving would be about 80%

0% Electricity from Wind

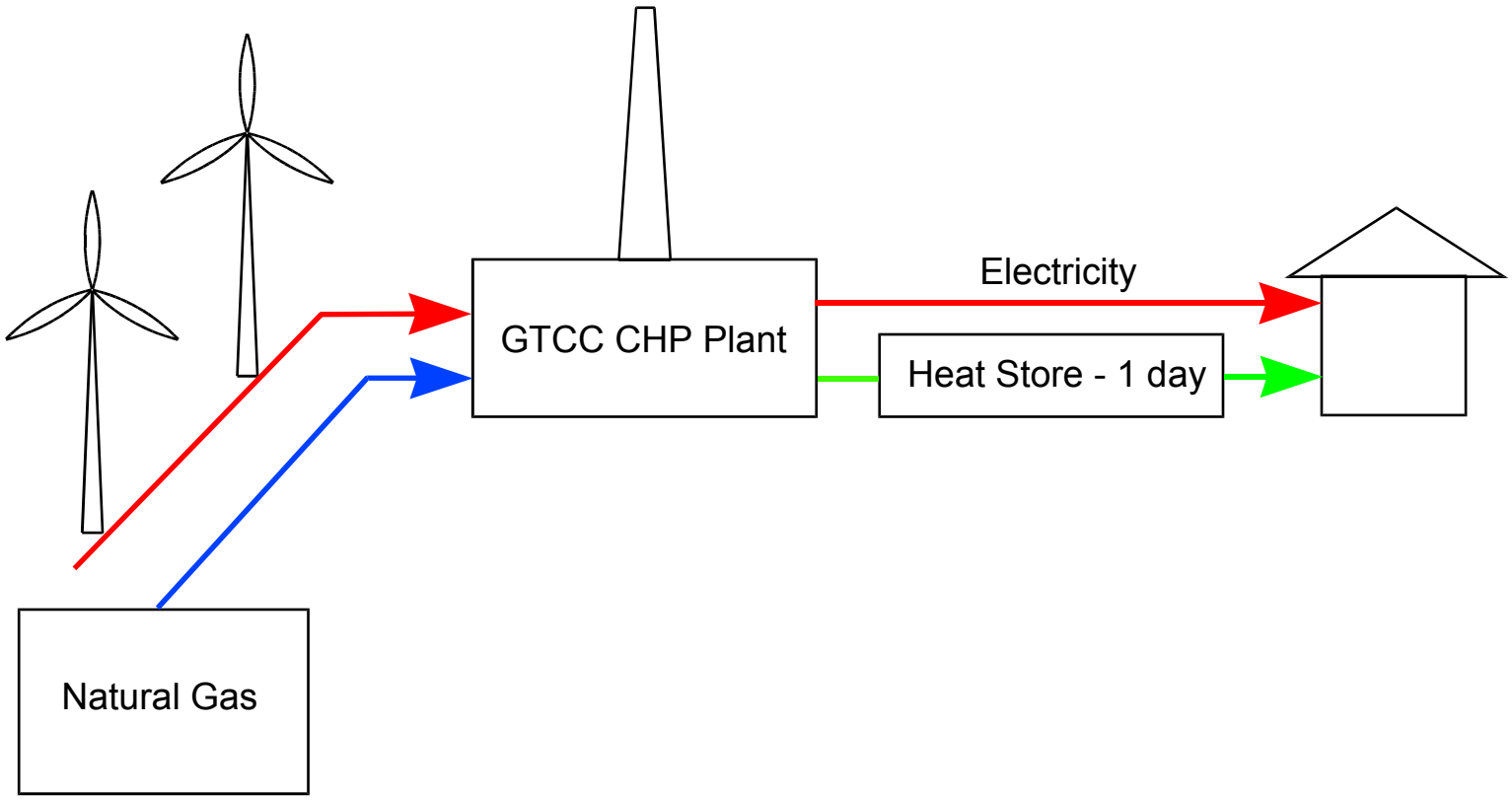


Integrated Energy Hub

50% Electricity from Wind

- Wind power is predictable days ahead and has annual average Capacity Factors of 0.20 – 0.45
- When wind power is less than the electric load, balancing power is required
- This can come from existing GTCC plants fuelled initially with natural gas
- But the wind power would reduce gas use and GHG emissions

50% Electricity from Wind

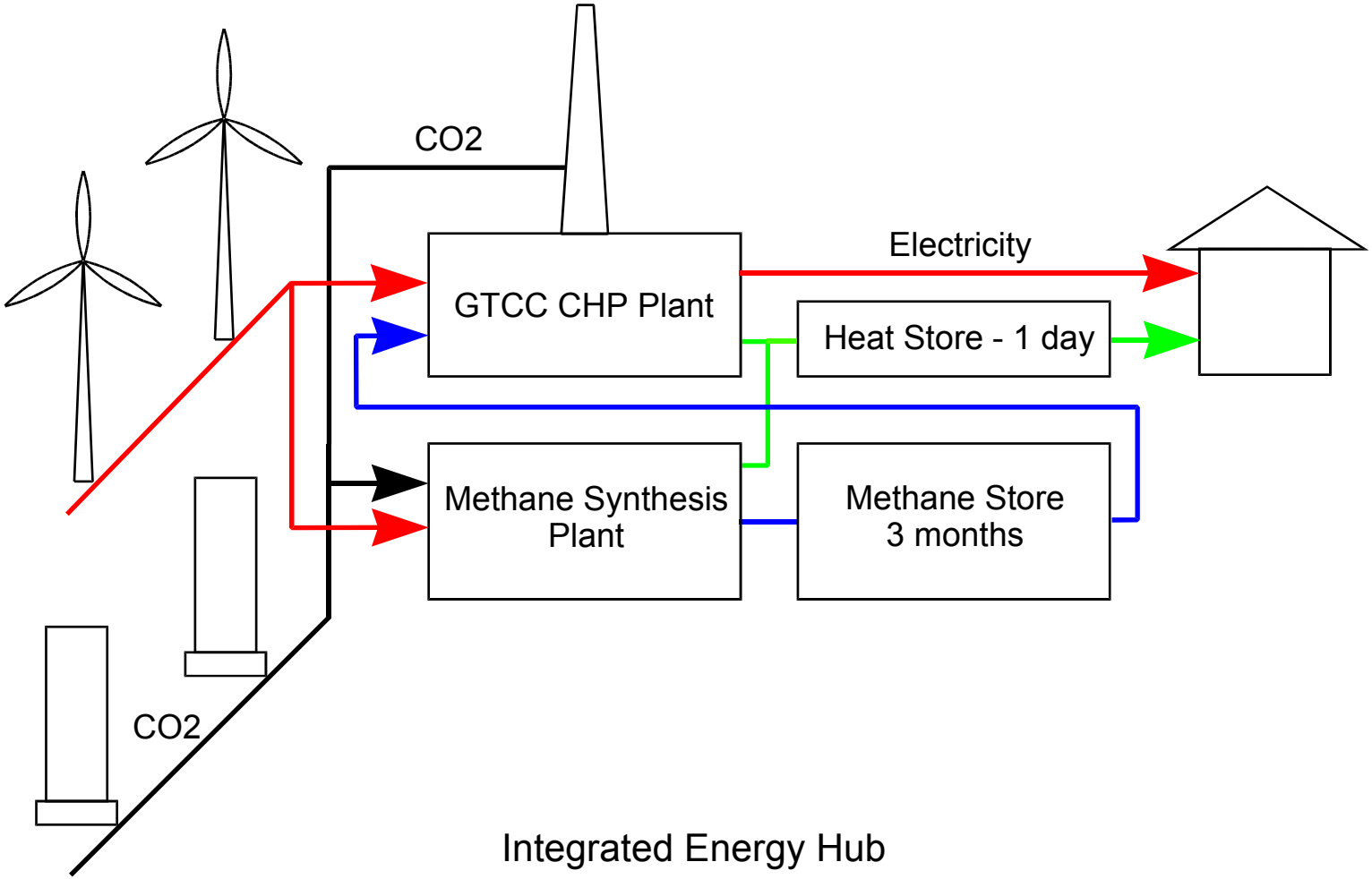


Integrated Energy Hub

100% Electricity from Wind

- At high wind percentages, wind power surplus to load could produce Renewable Power Methane
- This could be stored in the existing gas network and stores, enough for several months of electricity
- The existing GTCC plants could then be fuelled with Renewable Power Methane
- With such plants providing all the balancing power, 100% of electricity would be from wind

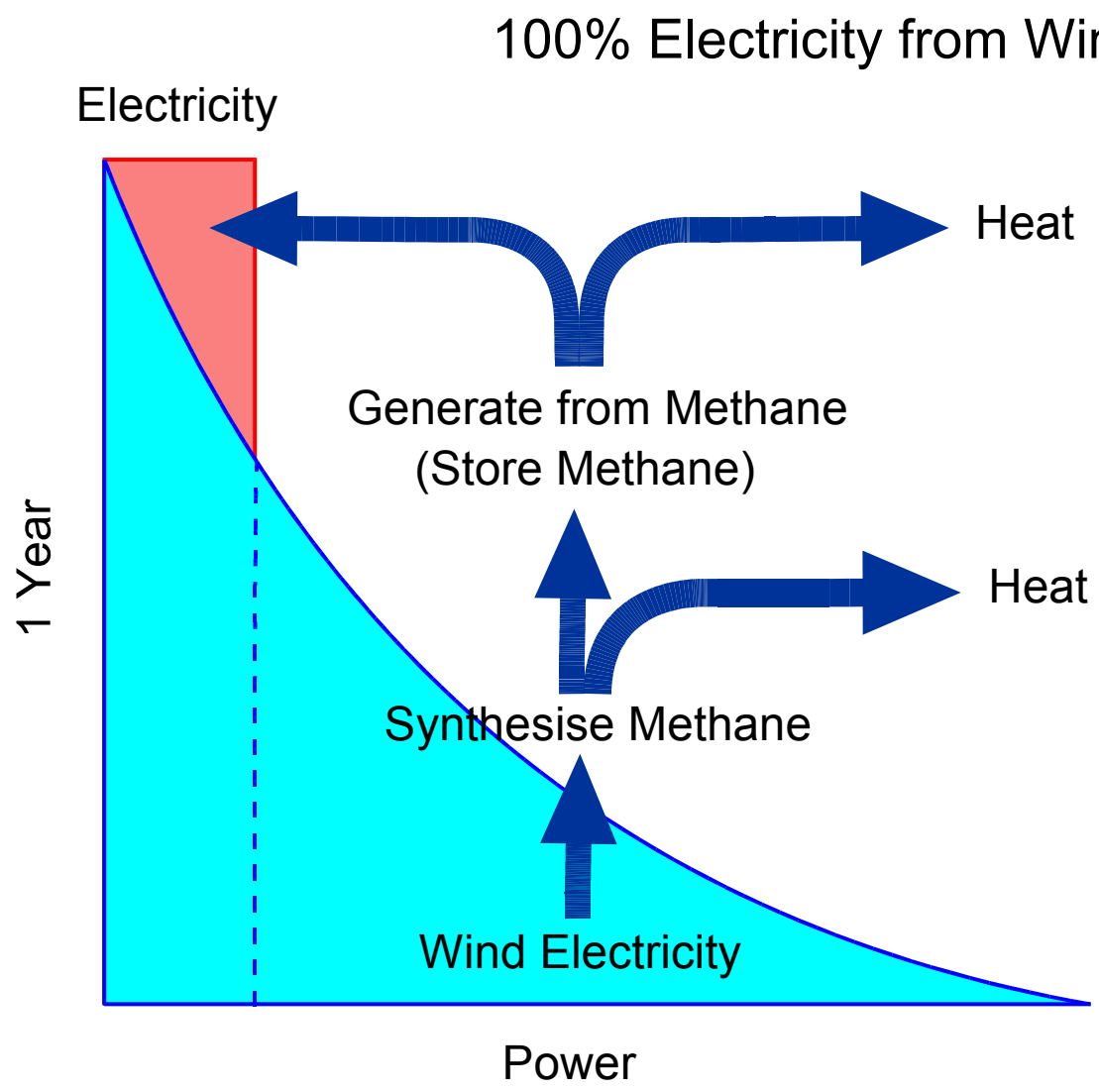
100% Electricity from Wind



Integrated Energy Hub

100% Electricity from Wind

- The average world electrical load is about 2 TW
- So the annual world electrical energy is about 2 TWy
- The Renewable Power Methane efficiency is ~ 0.5
- The Gas Turbine Combined Cycle efficiency is ~ 0.5


100% Electricity from Wind
Electricity
Heat
Generate from Methane
(Store Methane)
Heat
Synthesise Methane
Wind Electricity
1 Year
Power

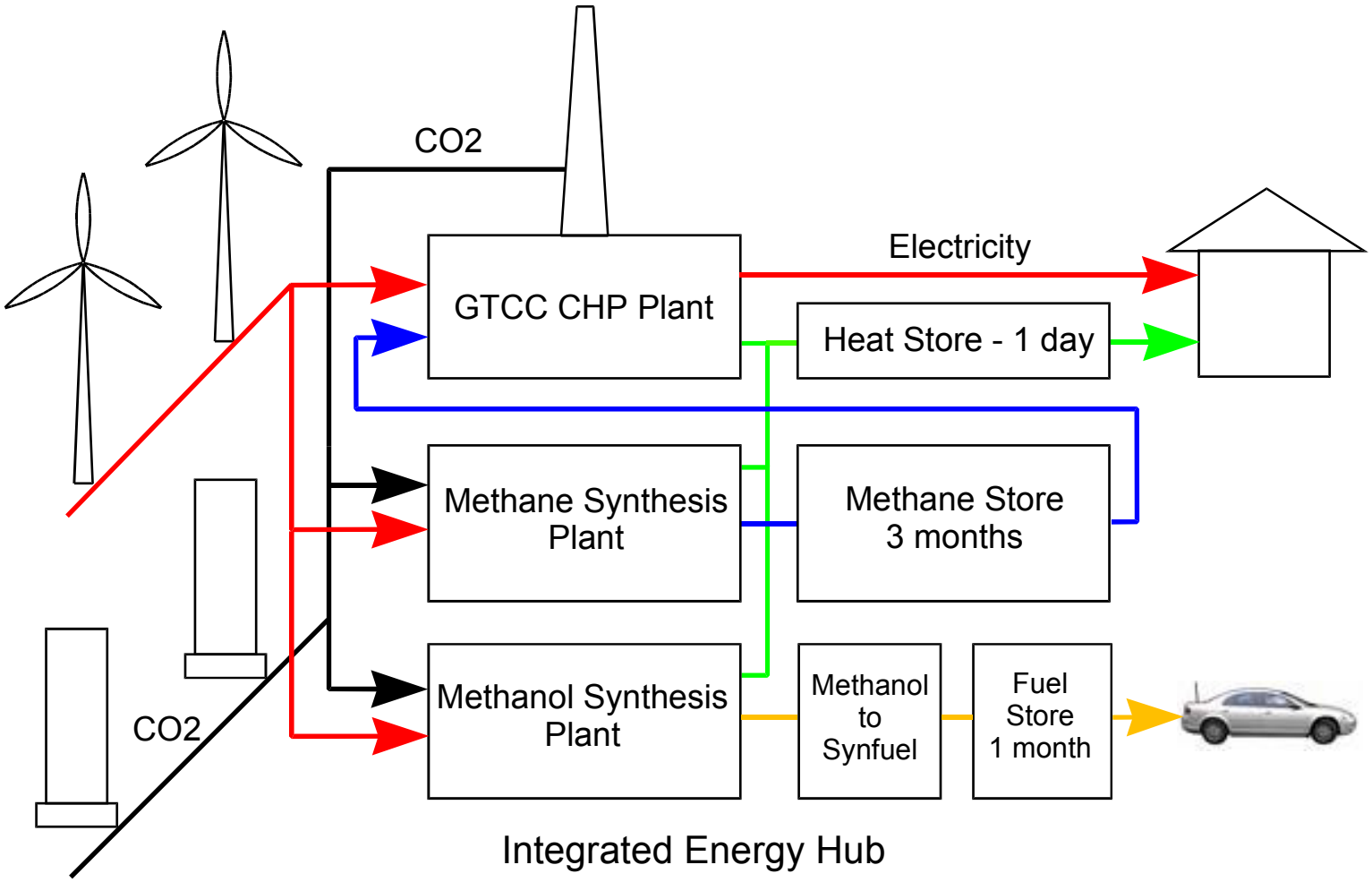
100% Electricity from Wind

- For an average conversion efficiency of 0.5, the average electricity input would be about 4 TW
- Compared with a world average wind resource of 96 TW, this would be only about 4 per cent
- For a Capacity Factor of 0.35, the required wind capacity is ~ 3 x the average input - i.e. ~ 12 TW
- More co-generated heat would be available for district heating of buildings and industry
- Such a 100% electricity solution would be indigenous, secure, renewable and carbon-free - hence sustainable

100% Energy from Wind

- Wind could also meet 100% of electricity, 100% of transport fuels and 100% of the heat demand
- Wind power in excess of the electric demand could produce RPM and Renewable Synthetic Fuels
- Producing balancing electricity with GTCC plants and RPM and Renewable Synthetic Fuels for transport could co-generate heat for buildings and industry
- In practice, the rural heat demand may be met from sustainable biomass and biogas

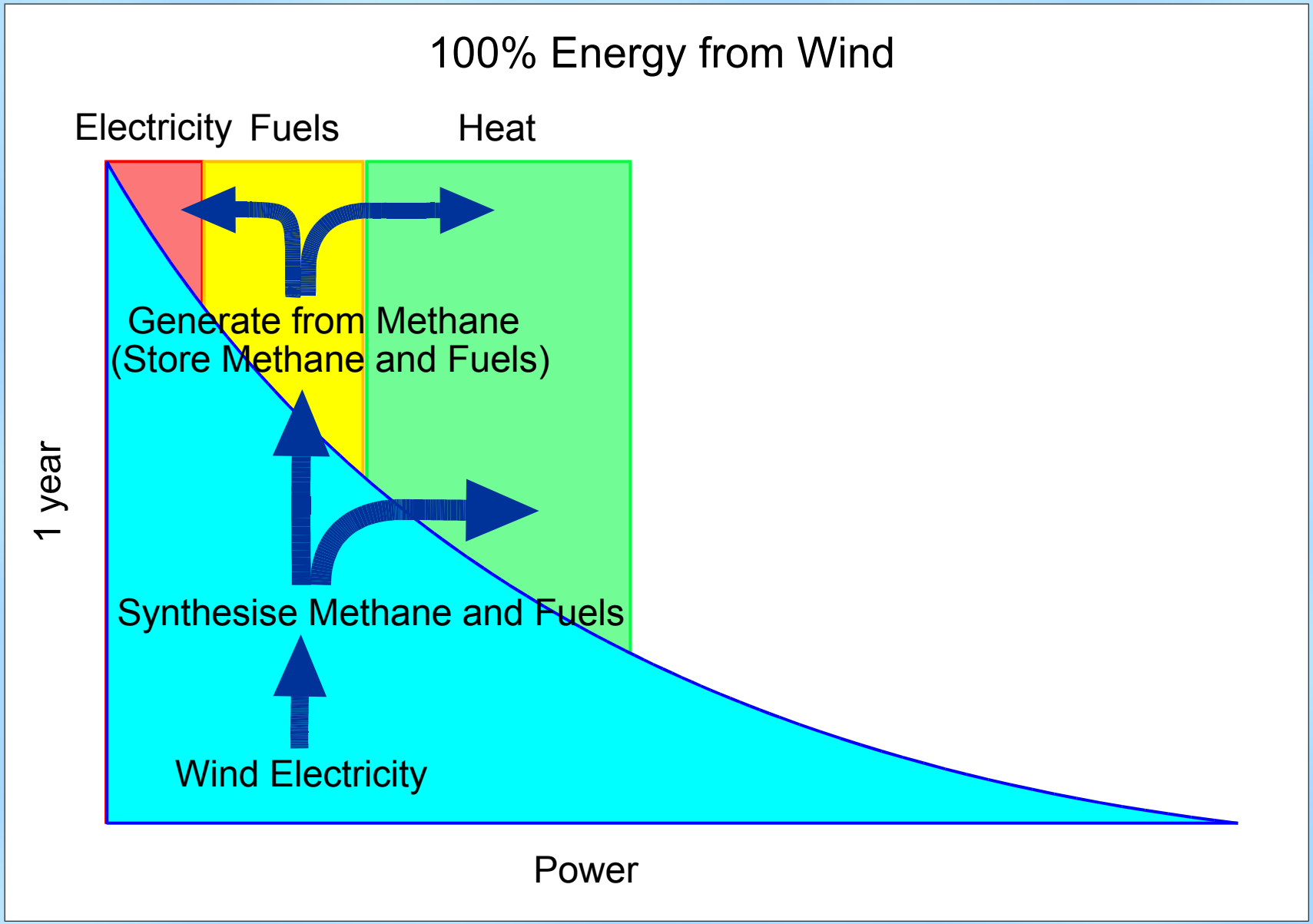
100% Energy from Wind



Integrated Energy Hub

100% Energy from Wind

- The annual world electric energy is ~ 2 TWy
- The annual world transport fuel is ~ 3 TWy
- The annual world heat energy is ~ 5 TWy
- The Renewable Synthetic Fuel effy is ~ 0.5


100% Energy from Wind
Electricity
Fuels
Heat
Generate from Methane
(Store Methane and Fuels)
Synthesise Methane and Fuels
Wind Electricity
1 year
Power

100% Energy from Wind

- 100% final energy is ~ 10 TW, but by using the co-generated heat, the electricity input could be ~ 10 TW
- Compared with the world average wind resource of 96 TW, this is only about one-tenth
- For a Capacity Factor of 0.35, the required wind capacity is ~ 3 x the average electricity input - i.e. ~ 30 TW
- Such a 100% energy solution would be indigenous, secure, renewable and carbon-free - hence sustainable
- Investing in such a solution would increase indigenous employment and reduce overseas expenditure

Delivery – via ESCOs

- Grant access to UK energy markets only via franchises subject to agreed GHG outcomes
- Franchise holders would be Energy Service Companies, selling energy savings and services
- Unlike individuals or other companies, they could access both expertise and low-cost capital
- Combining savings and renewable energy supply would deliver the carbon-free sustainable outcome

CO2 Rollback

- CO2 from air would be needed to make methane and Renewable Synthetic Fuels for 100% energy
- More CO2 could be captured for sequestration and ‘rollback’ of the atmospheric concentration
- Hence stores under the North Sea should not be used for CCS, but reserved for ‘rollback’ CO2
- Governments should fund demonstrations of capturing CO2 from air and of sequestering it

Key Players in 100% Wind Solutions

- The European Wind Energy Association (ewea.org), who expect 10,000 visitors at their Annual Event in Brussels on March 14-17
- Solar-Fuel.com, who have built a pilot plant capturing CO2 from air and making methane
- CarbonRecycling.is, who are completing an Industrial Scale Plant using renewable energy to make methanol

Videos on 100% Wind Solutions

- Statoil and Siemens 'HyWind' project on floating wind turbine of 2.3 MW – 1 minute & 7 minutes
- Solar-Fuel.com pilot plant capturing CO2 from air and making methane – 5 minutes

Thank you for your attention

Gordon Taylor

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