Recent Developments in Coal Liquefaction

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IEA CCC

- The current CCC study has focused primarily on the possible production of transport fuels
- With the price of oil topping $100/bbl and serious discussion about ‘peak oil’, alternative sources of transport fuels are being sought
- These include coal-based liquids, various biofuels, and the use of tar sands and/or oil shales
- Alternative strategies would include reducing transport fuel use by improving engine efficiency

IEA CCC

- interest is centred on three key countries with large coal reserves but limited reserves of oil and gas ie China, India and the USA.
- there has been extensive development work in Japan
- there is current active interest in Australia, Botswana, Germany, Indonesia, Mongolia, the Philippines, as well as South Africa

Map showing the principal sites for CTL

What the report contains

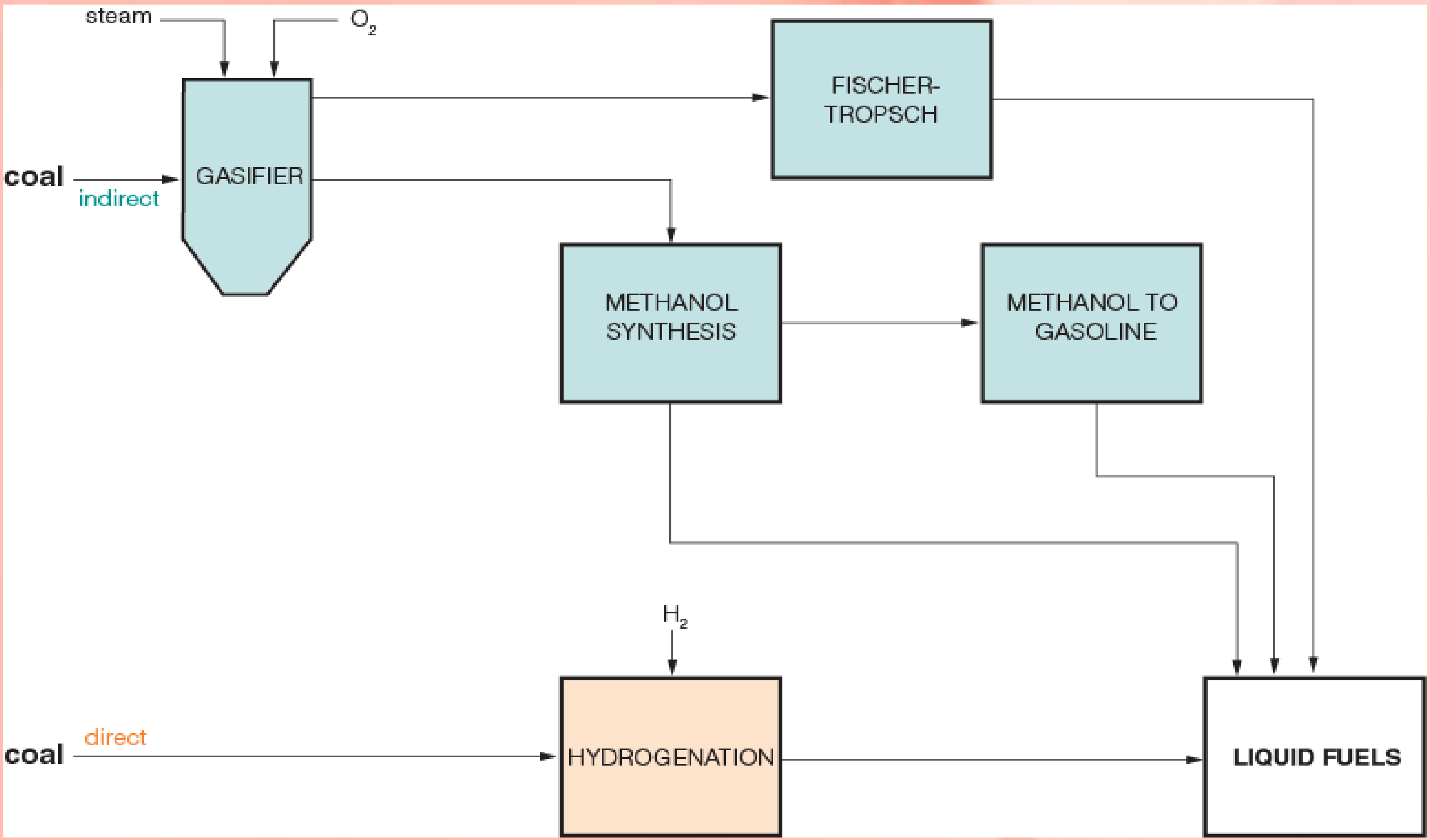
- process routes
- the effects of coal rank and composition
- the need for catalysts
- country by country reviews
- the environmental footprint of CTL activities
- economic overview

The need for hydrogenation

coal isn't the ideal starting point

- it is a solid with a H_2 content of 4-6%, compared with oil with twice as much
- it contains organically bound impurities and mineral matter
- the H_2 content of transport fuels varies from ~12.5% in some gasolines to ~14.5% in jet fuels

Liquefaction routes



Liquefaction routes

- Direct liquefaction (DCL) where the products are dependent on the chemical structure of the coal being used
- Indirect liquefaction (ICL) where the molecules are broken into very small components (principally H_2 and CO) and then rebuilt

- Both produce molecules with the appropriate range of boiling points
- Both involve (expensive) high temperature/pressure reactors, and subsequent treatment
- They are at different stages of development, making realistic comparisons difficult

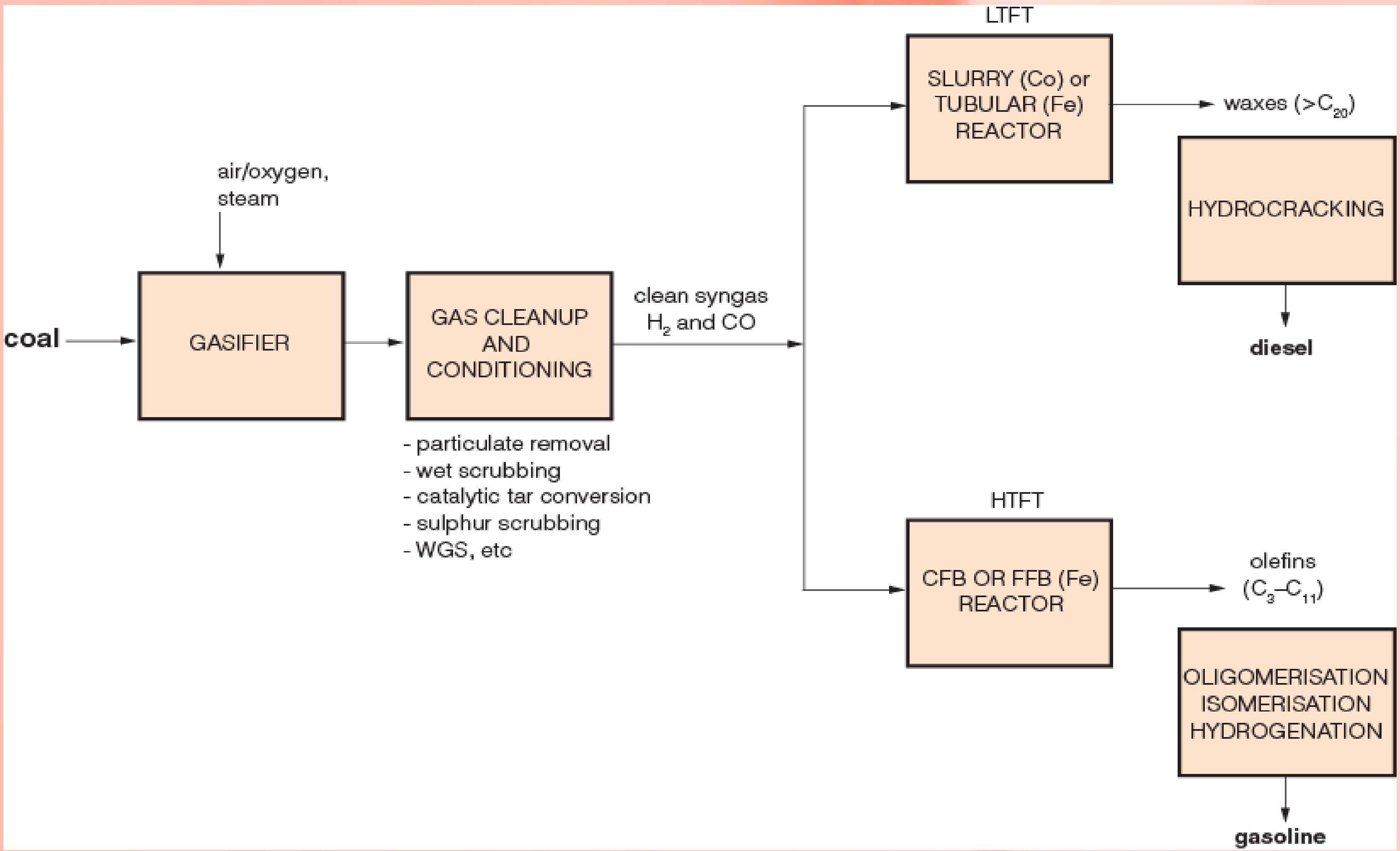
Direct liquefaction

- DCL was used in the 1940s
- There was a lot of experience in the US and Japan in the 1980s and 90s up to PDU scale (50-200 t/d of coal), and in the UK there was the Point of Ayr pilot plant
- A 1 Mt/y (~20,000 bbl/d) commercial-scale demonstration plant in Inner Mongolia is currently being commissioned

Indirect liquefaction

- FT synthesis has been widely used for transport fuel production, notably by:
- Sasol (with 150,000 bbl/d capacity in SA)
- PetroSA (with 36,000 bbl/d capacity for GTL)
- Shell at Bintulu, Malaysia (with 15,000 bbl/d capacity for GTL)
- Qatar Petroleum/Sasol (with 34,000 bbl/d capacity for GTL) at Oryx, Qatar

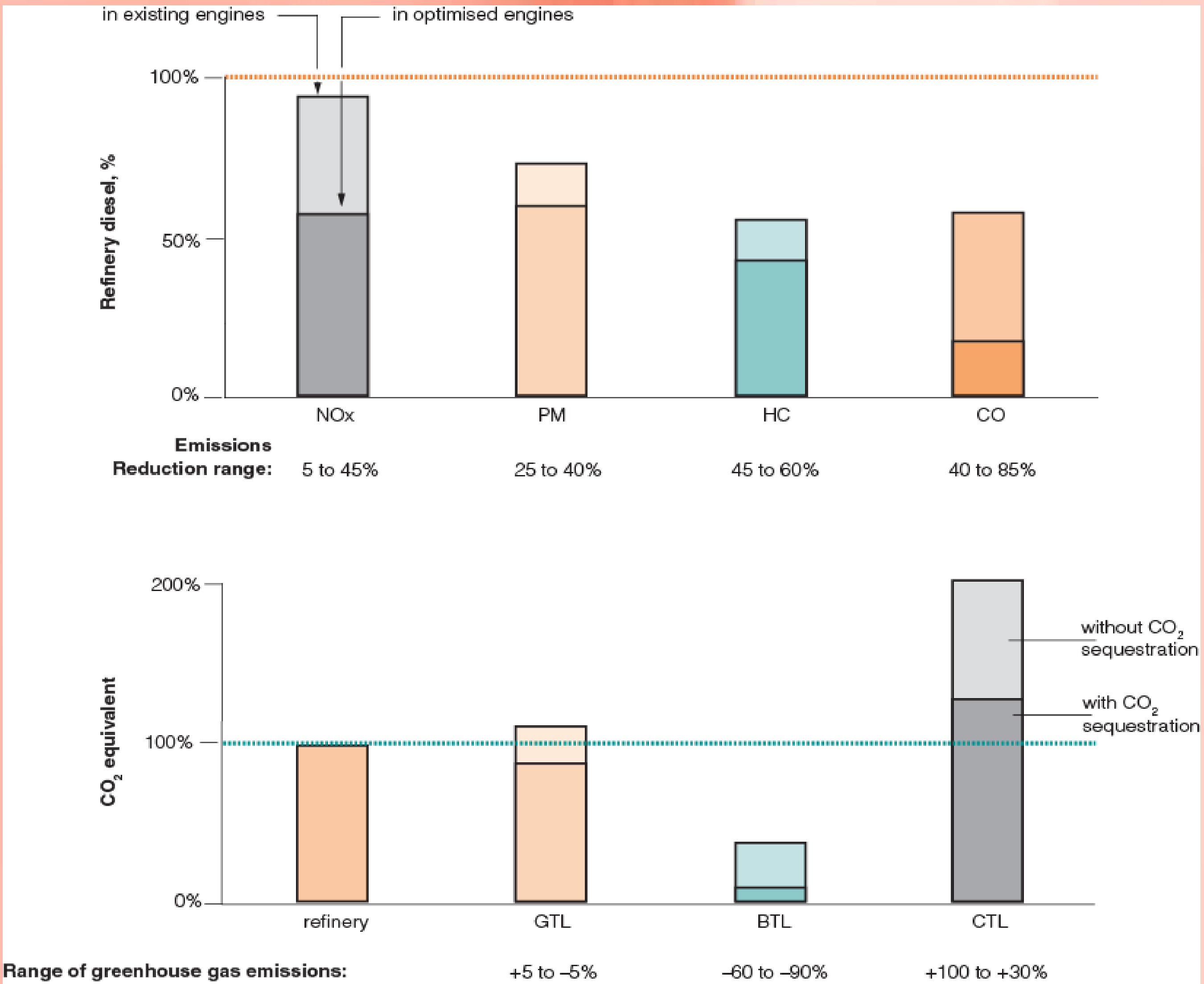
The Fischer-Tropsch routes



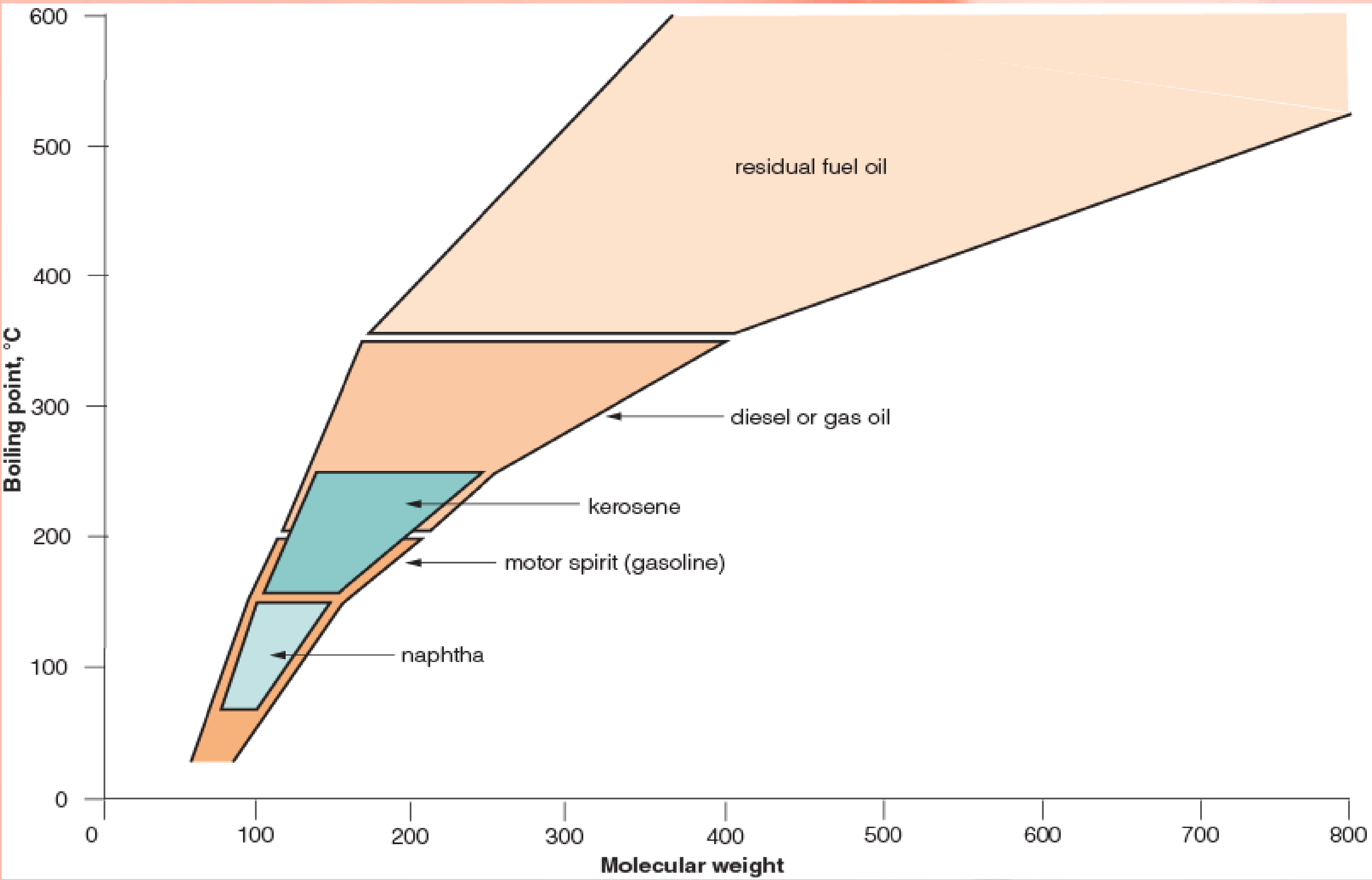
Fischer-Tropsch synthesis

- LTFT operates in the range 200-250ºC and produces a liquid product with a high proportion of high molecular weight linear waxes, which maximises the production of diesel
- HTFT operates between 300-350ºC to produce a light product stream with some low molecular weight olefines, maximising the gasoline fraction
- a key advantage of FT fuels is that they are potentially less polluting

Environmental benefits and challenges



Transport fuel properties



Transport fuel properties

- The potential advantages of matching the properties of petrol, diesel and jet fuel are enormous, as the additional cost of developing new distribution systems and engines is substantial
- However, the formulations used to optimise both performance and safety are quite complex
- The Chinese are testing a number of buses in Shanghai using DME as the fuel, needing engines with a higher compression ratio than diesel

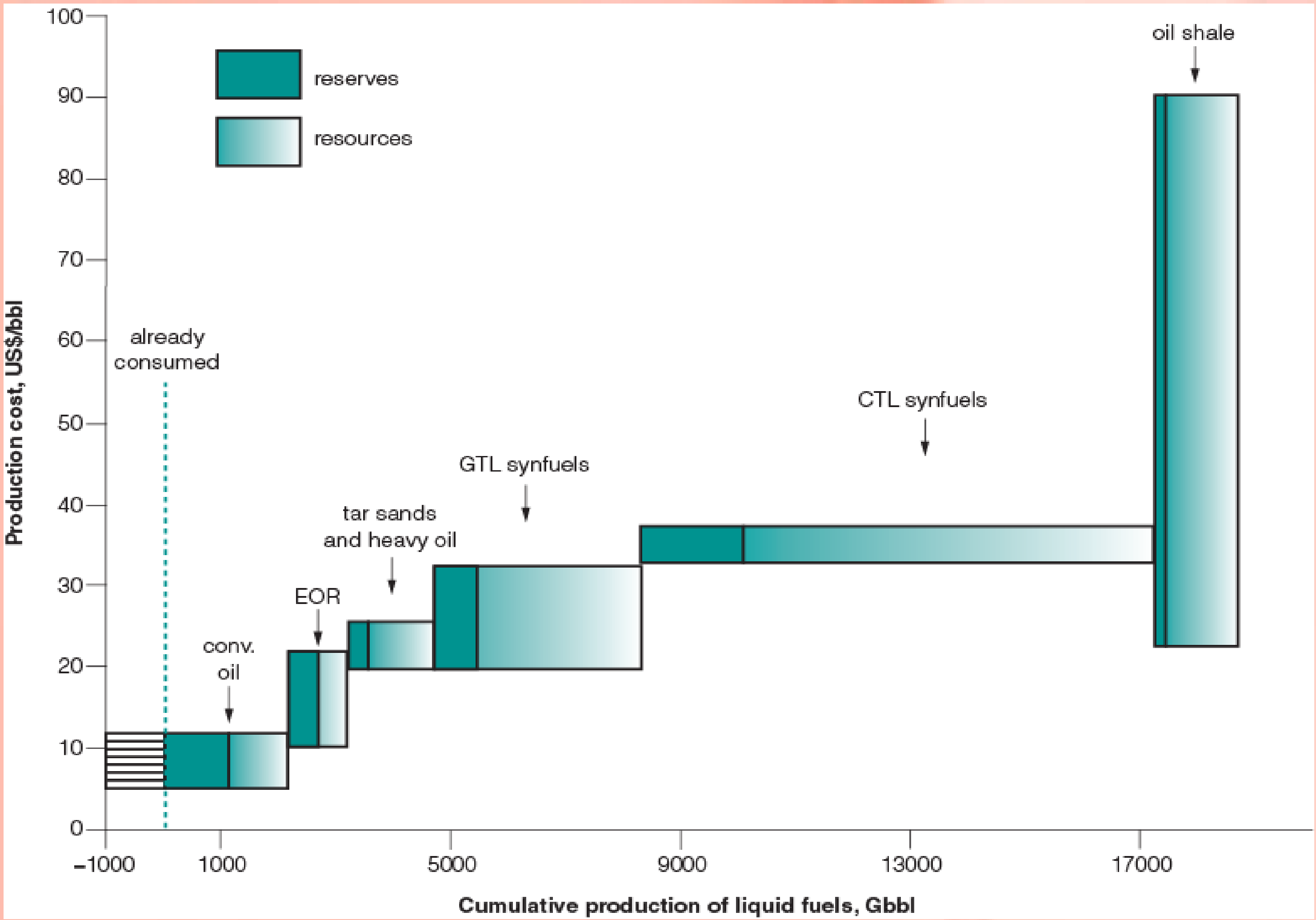
Comparisons between different raw materials

The next two slides are taken from:

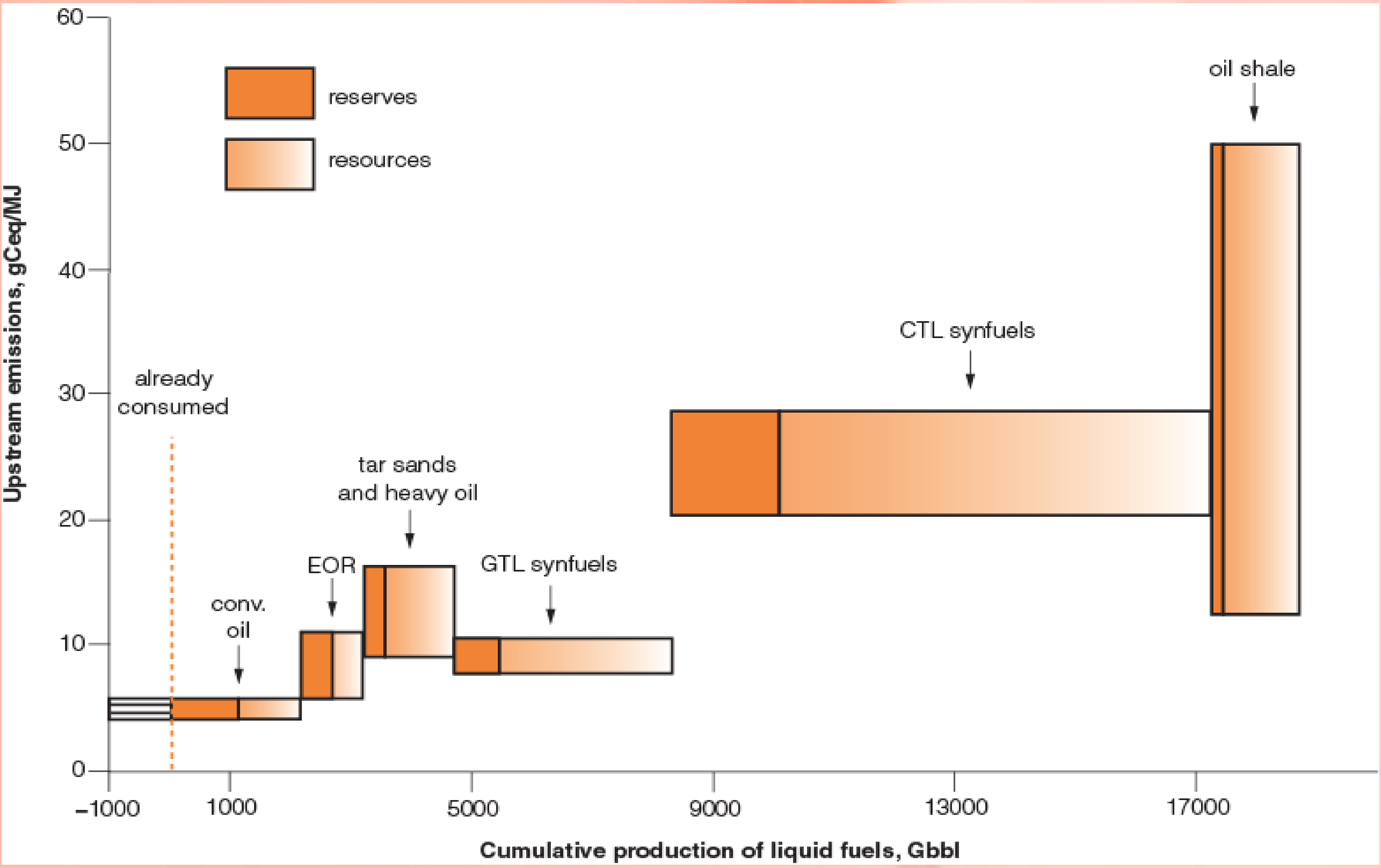
Brandt A R, Farrell A E (2007) Scraping the bottom of the barrel: greenhouse gas emission consequences of a transition to low-quality and synthetic petroleum resources. *Climatic change*. **84**, (3-4); 241-263 (Oct 2007)

it is based on work by the Energy and Resources Group at the Univ of California at Berkeley - and the various assumptions made are detailed in the paper

Economic comparisons



Comparisons in carbon emissions



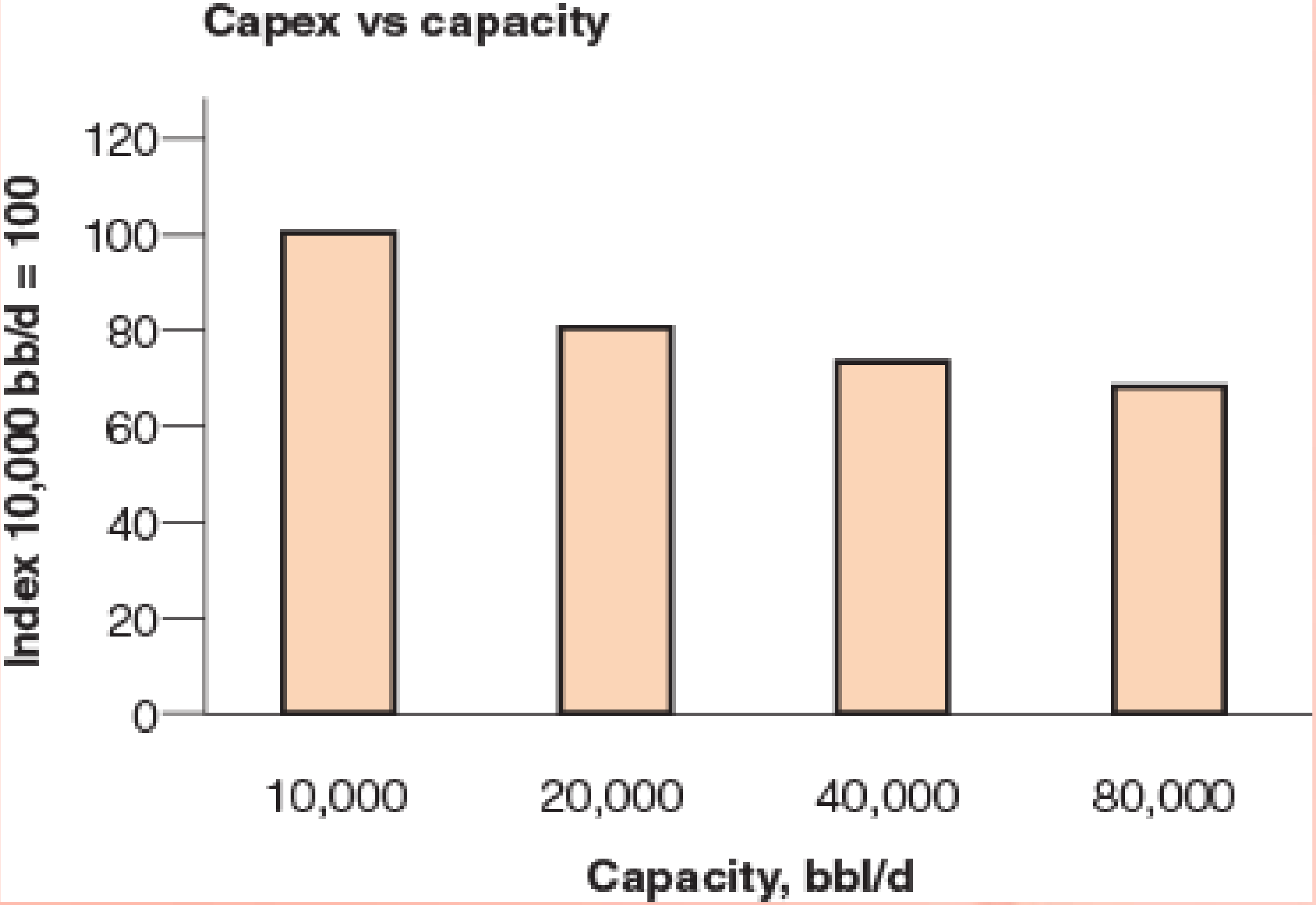
Environmental considerations

- In China and the US there would be more mining (to produce 10% of US demand would require about 250Mt/y of additional coal production)
- This represents a 25% increase
- CTL products can produce lower emissions from vehicles but can result in higher CO_2 emissions
- Large amounts of water are needed (which is an issue in many places) ~5 to 7 litres of water per litre of liquid product

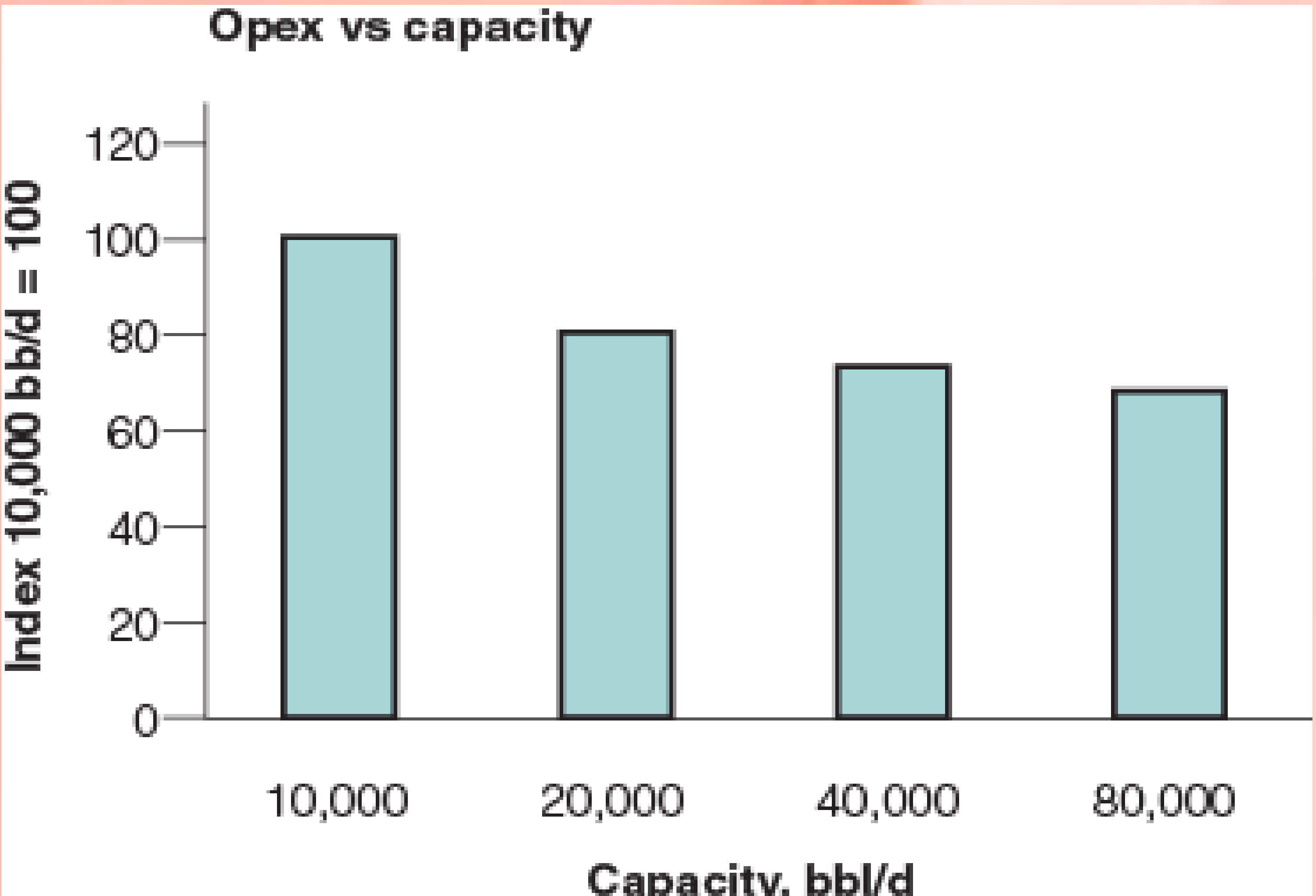
Economics

- The capital cost of a coal to liquids plant to produce 80,000 bbl/d is estimated to be around US$5-6 billion, compared with an equivalent gas to liquids plant which would cost something under $2 billion.
- but ALL assessments are site-specific
- to use low cost coal CTL plants need to be minemouth
- for cooling water a coastal site might be preferred
- plant size is a major consideration

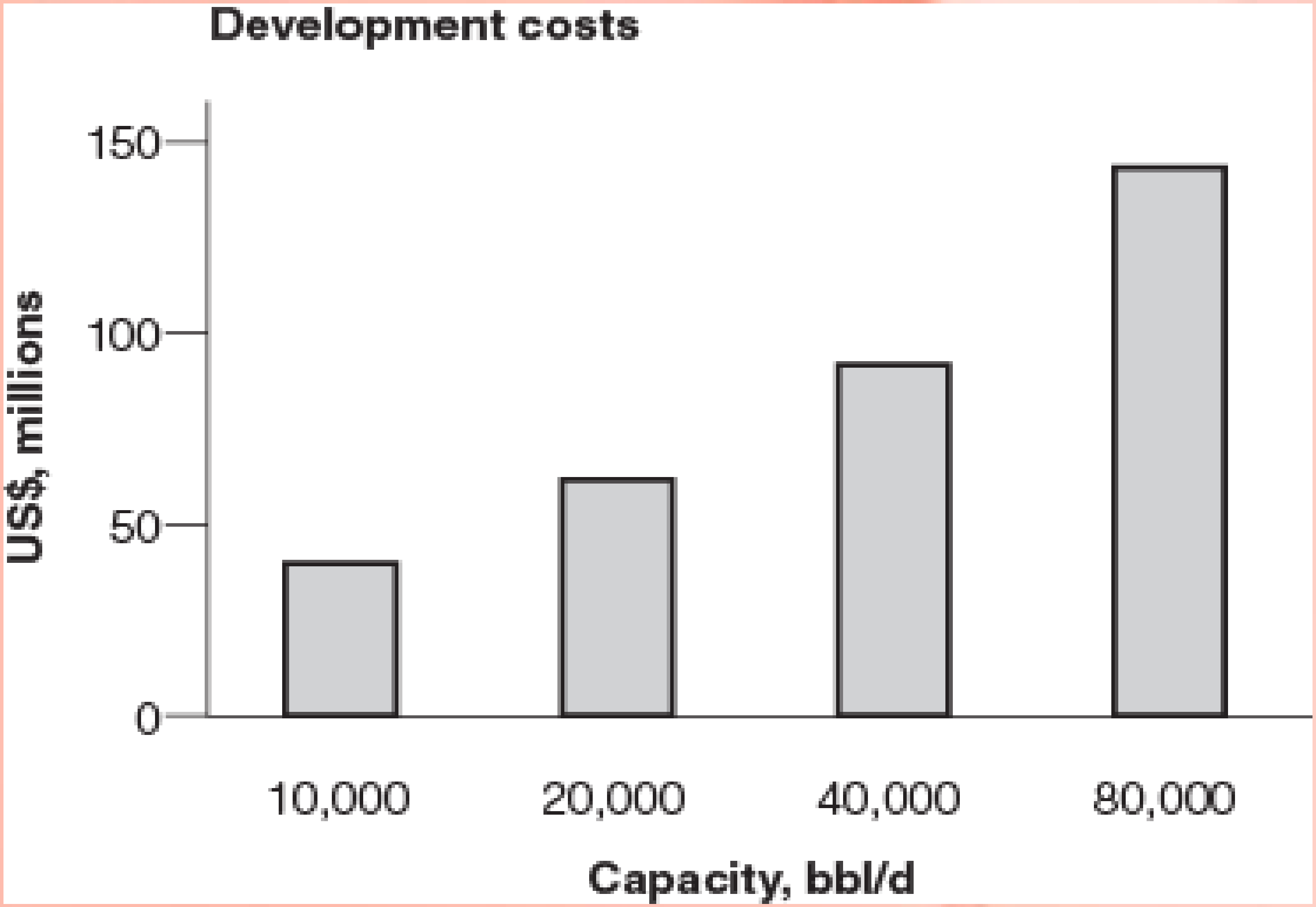
Capital costs vs plant capacity



Operating costs vs capacity



Development costs vs capacity



Planned developments

- Discussion in the US is mainly about smaller plants where capital cost can be contained in the US$1-2 billion area, thus limiting the risk
- In China the plans are for bigger plants with Shenhua building 1(DCL)+2+2 (ICL) Mt/y units (equivalent to 90,000 bbl/d)
- Yankuang has plans for 1+2+2 Mt/y ICL units
- Lu'an Group ICL is to produce 160,000 t/y and plans for capacity up to 5.2 Mt/y by 2016
- In view of cost and environmental issues, Chinese plans are being reassessed

Overview and conclusions

- the main drivers for the intense interest in CTL are the oil price and issues related to the security of supply
- the indications are that CTL processes are technically viable
- in a competitive market, overall production costs make it look an expensive option
- Thus overt or covert government support based on supply security considerations would be needed

Overview and conclusions

- Only when operational results have been obtained and lessons have been learned from the first group of demonstration plants will it be possible to assess the contribution which the technologies are likely to make in the longer term
- demonstration units need to run for two or three years to sort out teething problems
- because the projects involve high capital costs, and it is quite difficult to meet environmental requirements, the schedules for the various feasibility studies may be extended