

Powering the world: a very major project indeed.

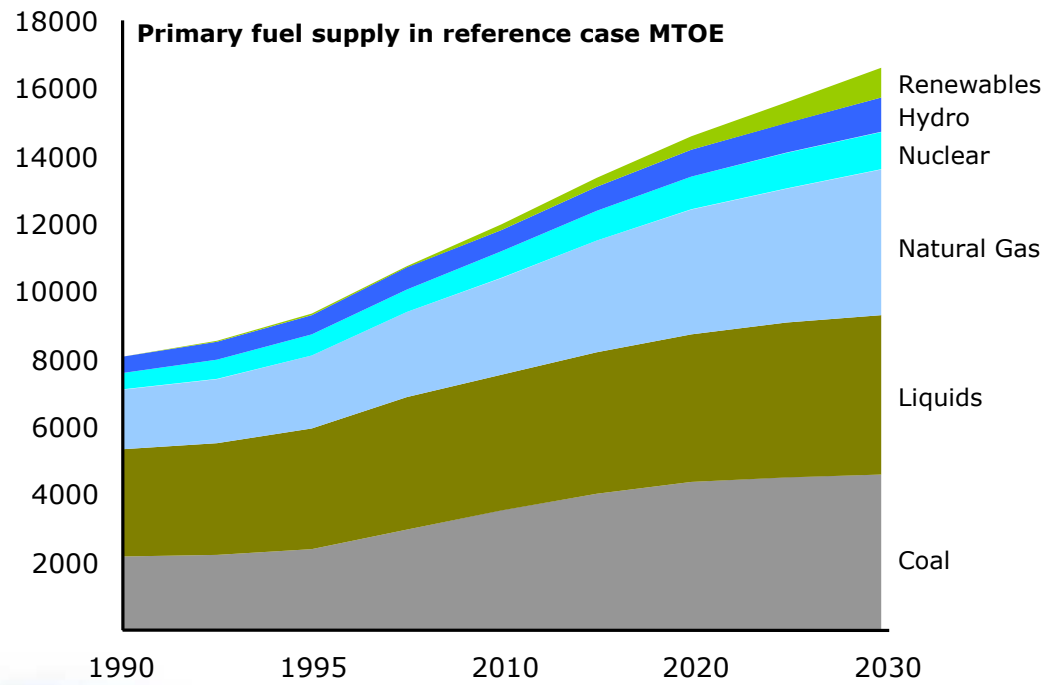
- Incessant world energy demand growth
- Energy supplies increasing concentrated
- Many pollution sink limitations
- Supply alternatives are not attractive
- Solutions have a characteristic form

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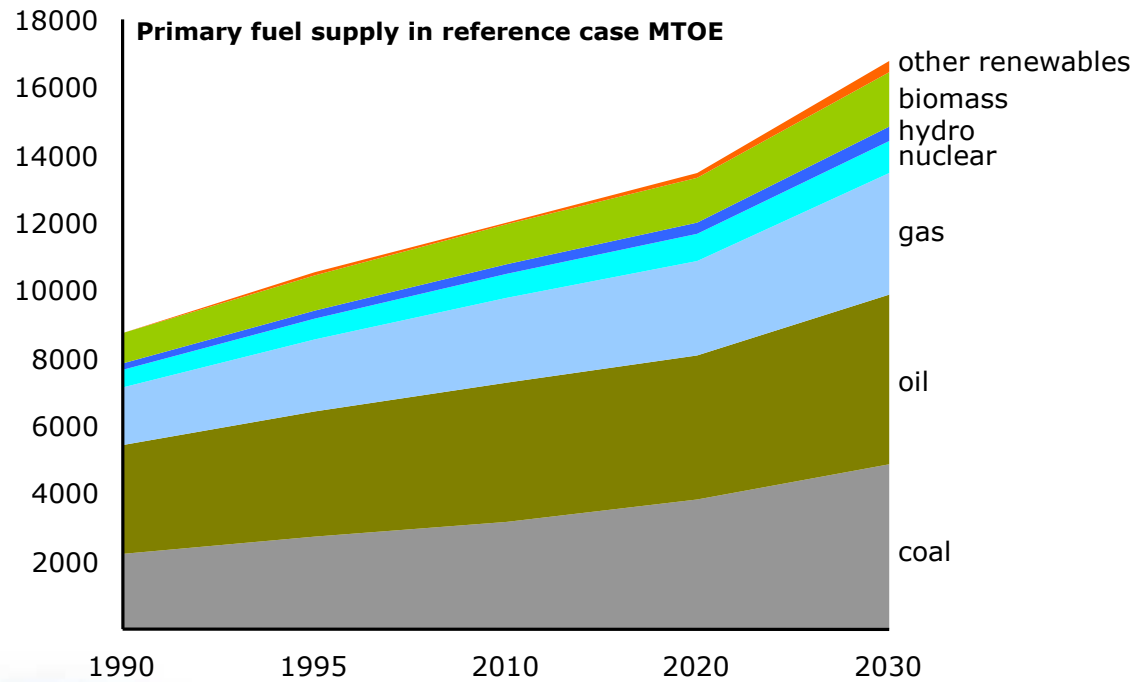


Here is BP's view



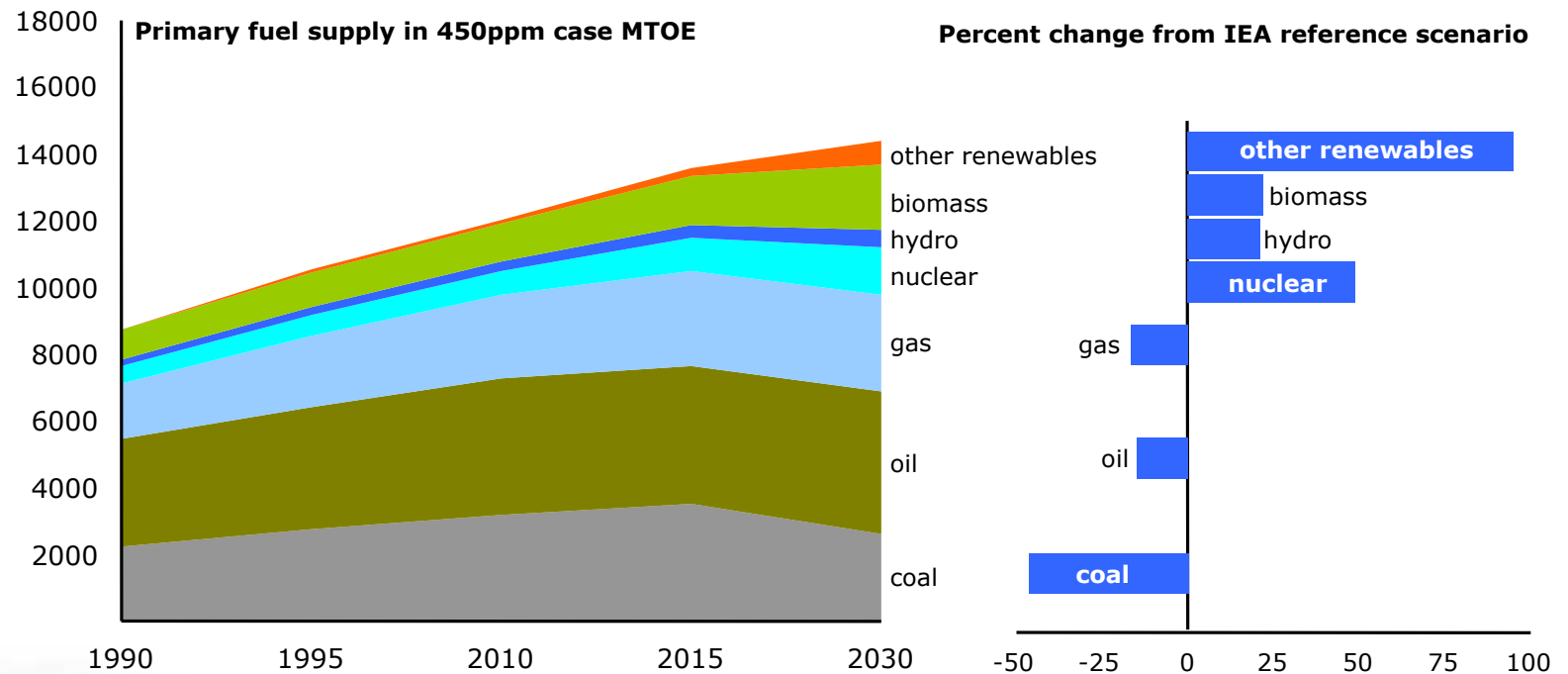
Here is BP's view
... and here is the IEA's view

The IEA have generated a scenario that keeps world CO2 concentration below 450 ppm, chiefly through cap-and-trade and other incentives



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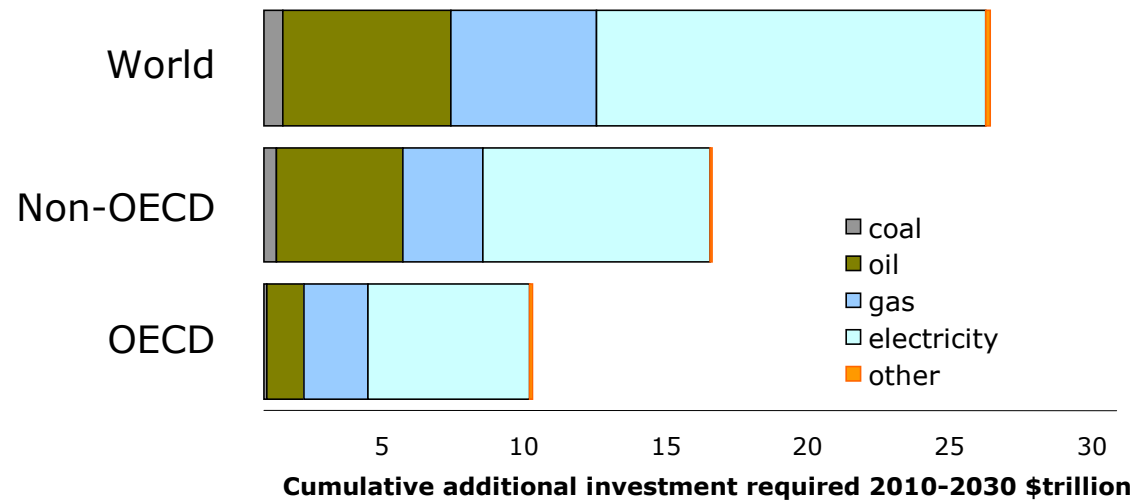
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As is evident, it is extremely difficult to change long run demand patterns.

Energy is complex, dangerous and expensive

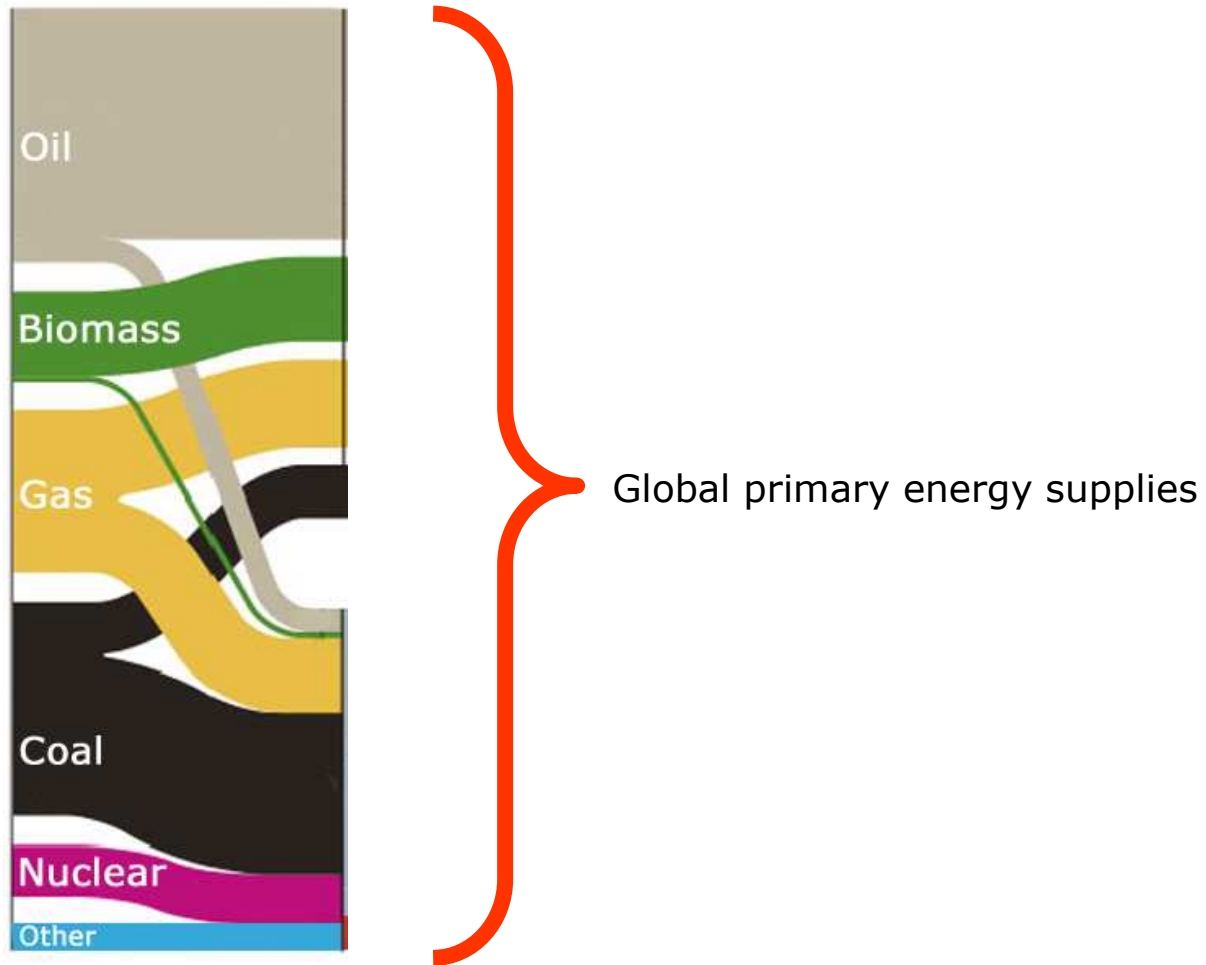
Consider what is being changed

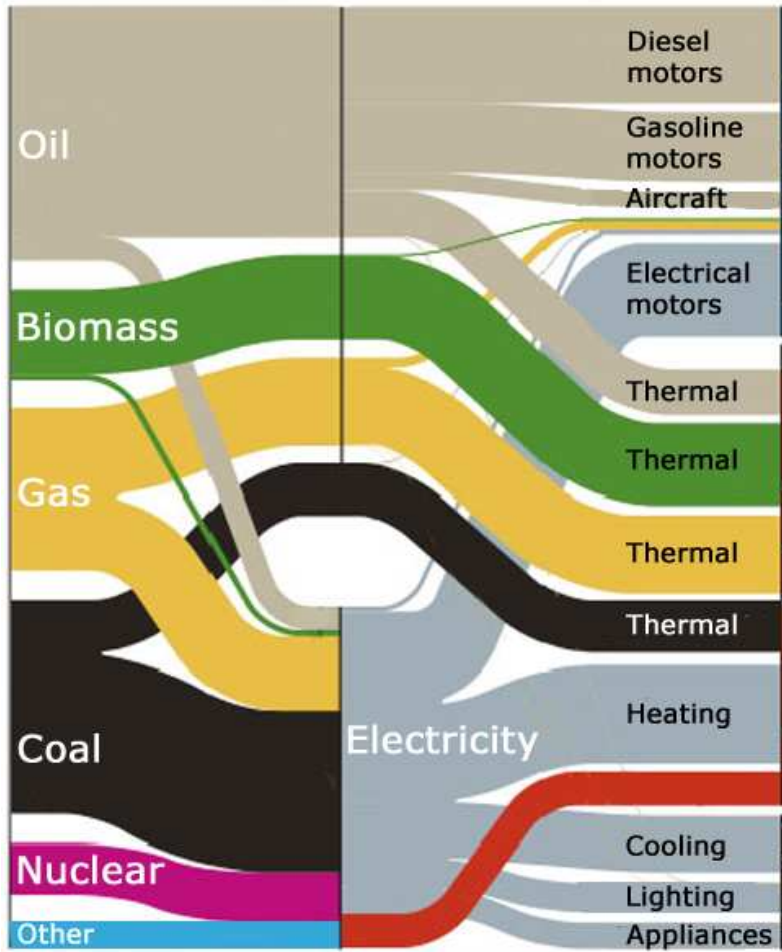


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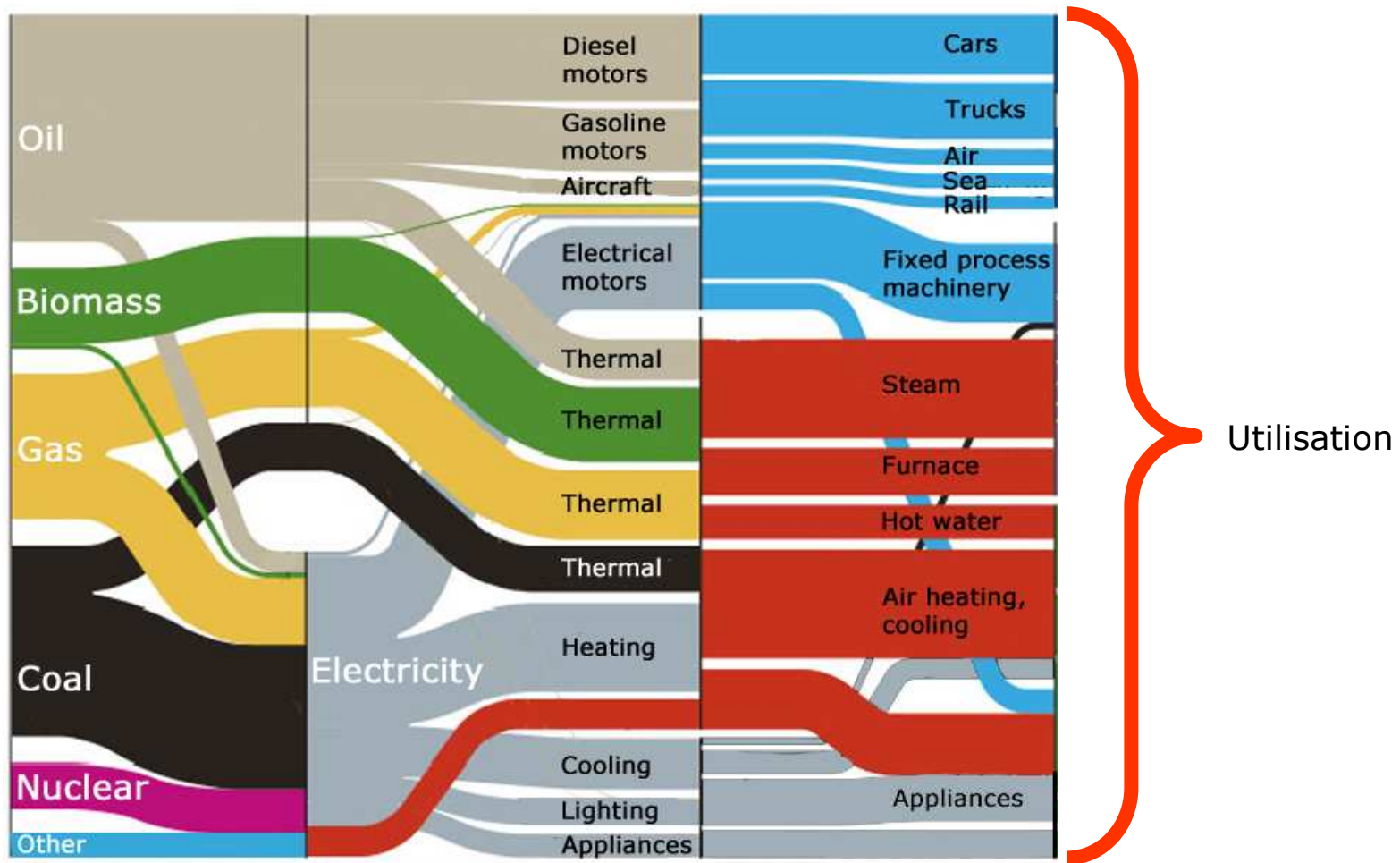
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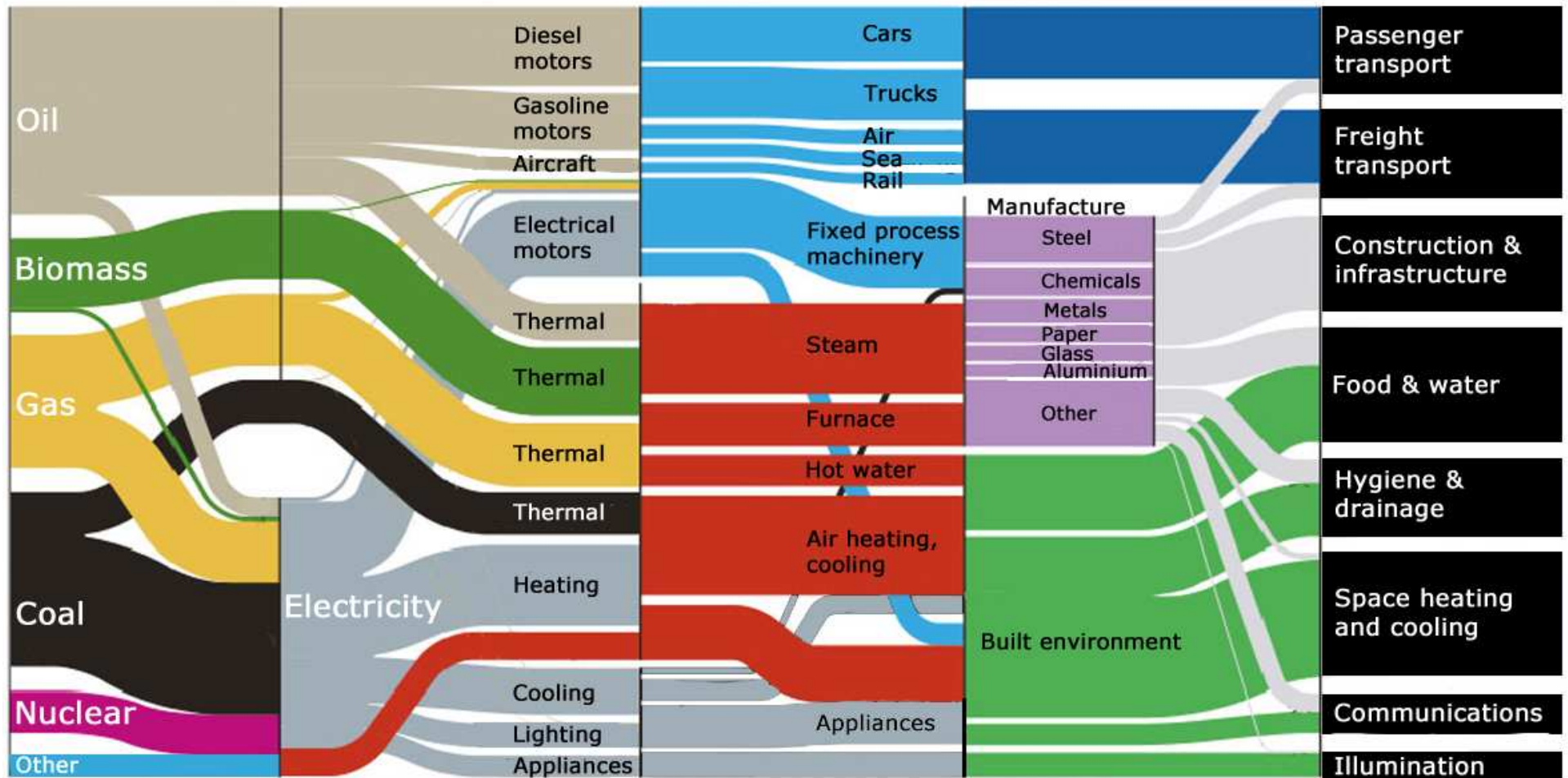


Energy conversion



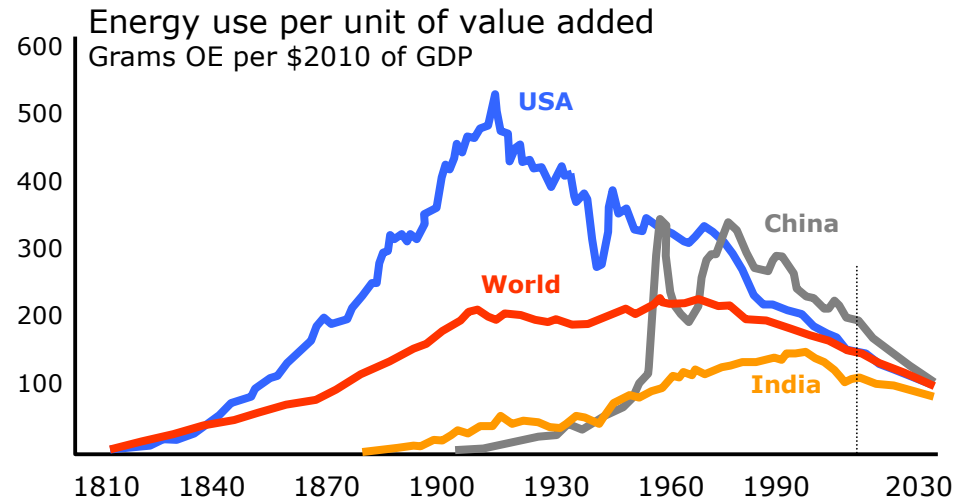
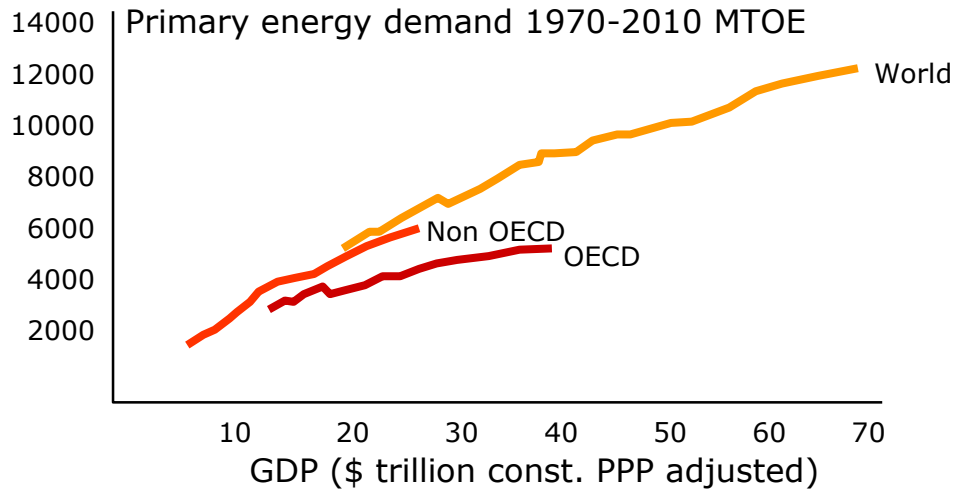
What allows analysts to be so confident of future demand?

Sectors and end use

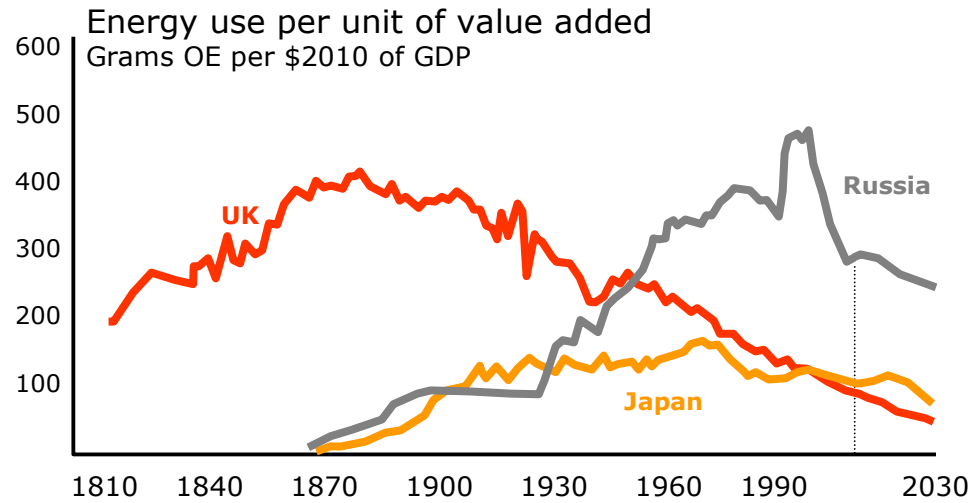


Energy is not only closely entwined in economics, but also follows economics

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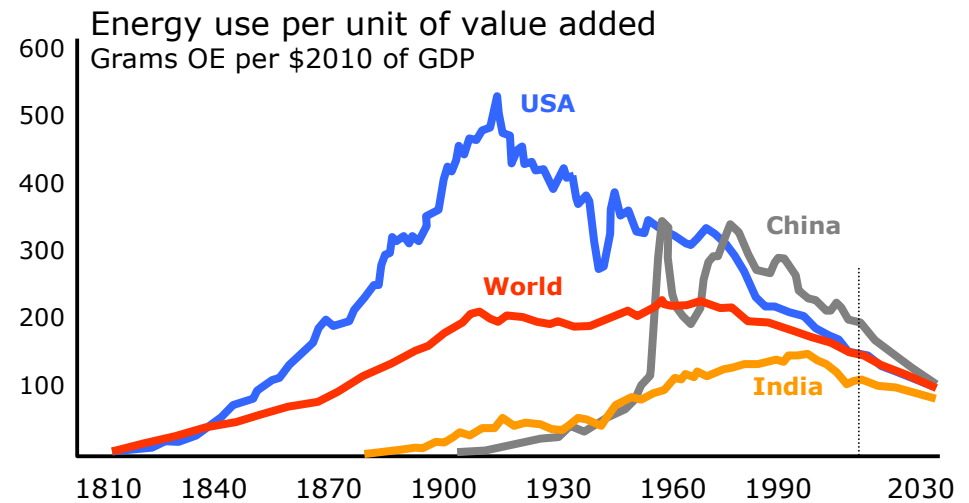


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Energy use decouples from economic activity for a number of reasons:

- Changing industrial mix
- Technological efficiency gains
- Price driven efficiency gains
- Regulation

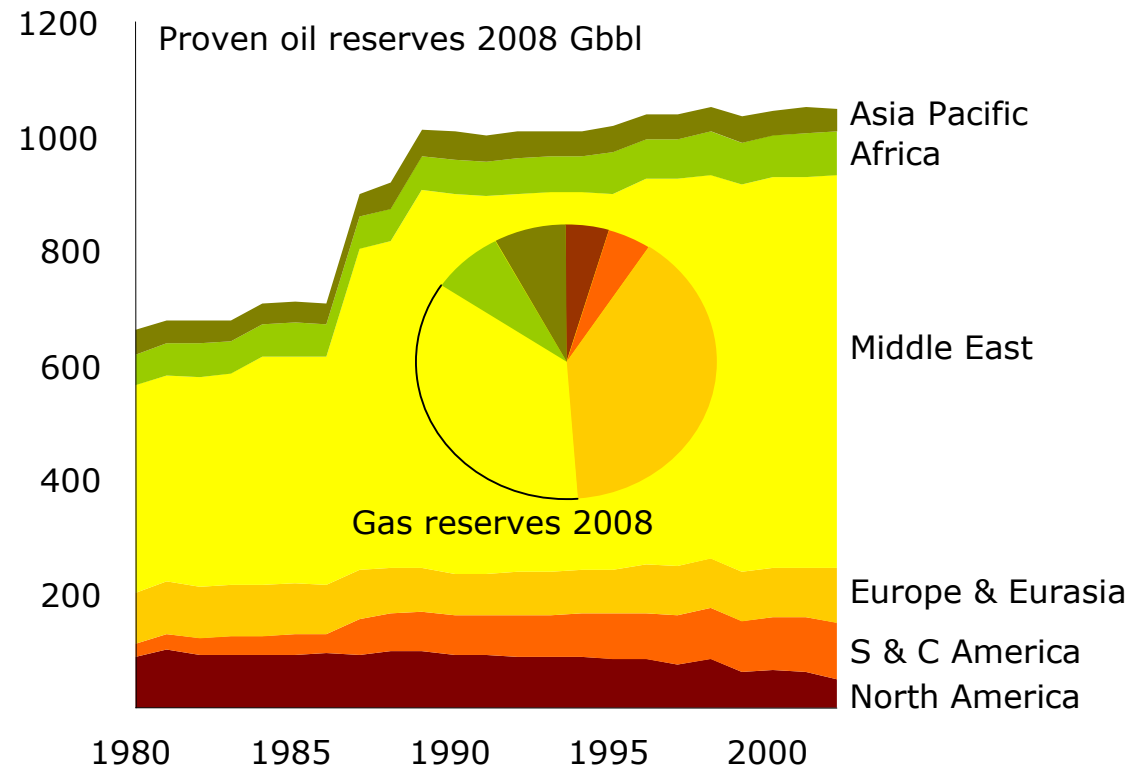


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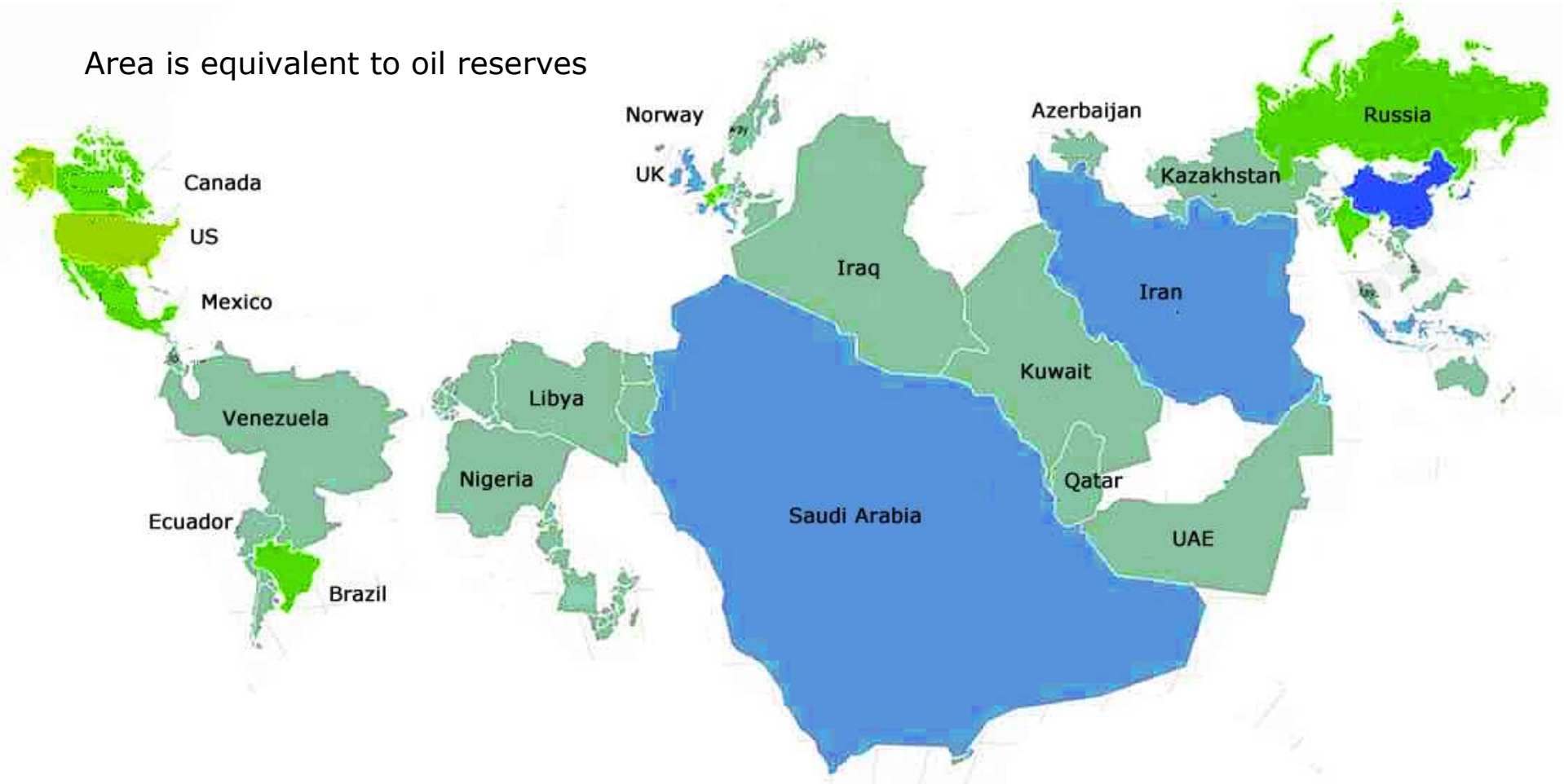




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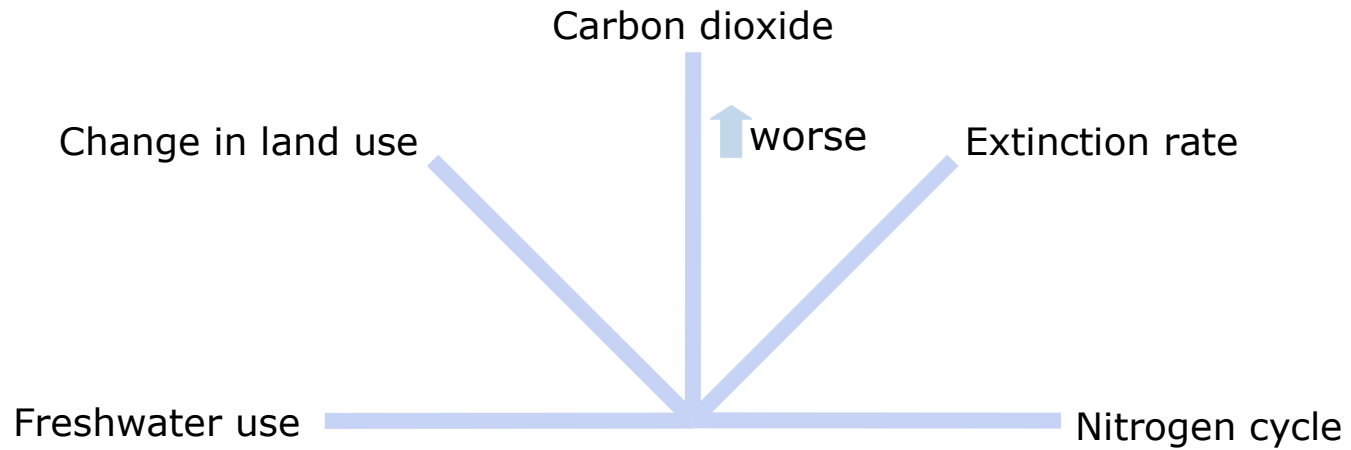


Area is equivalent to oil reserves



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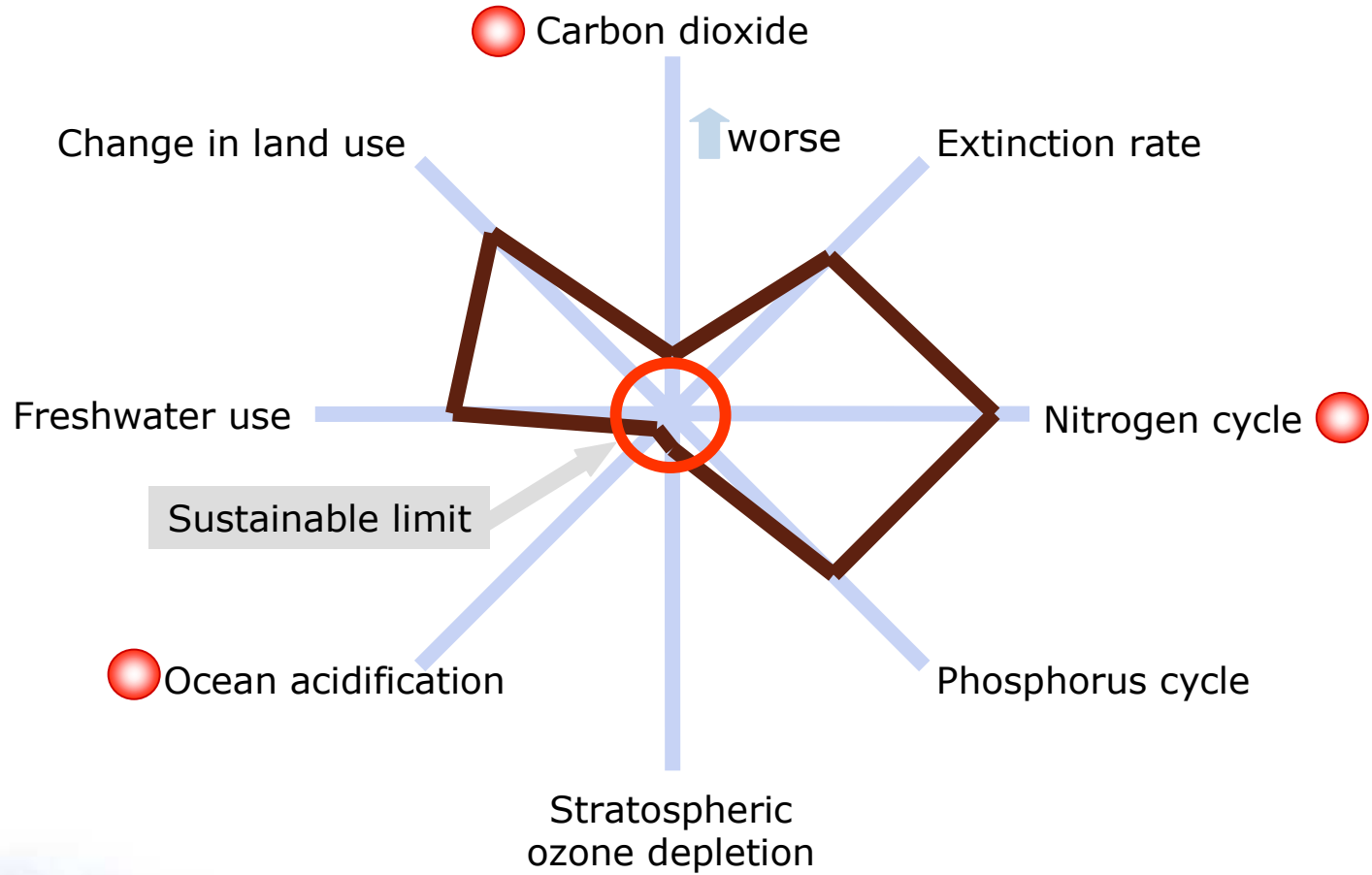




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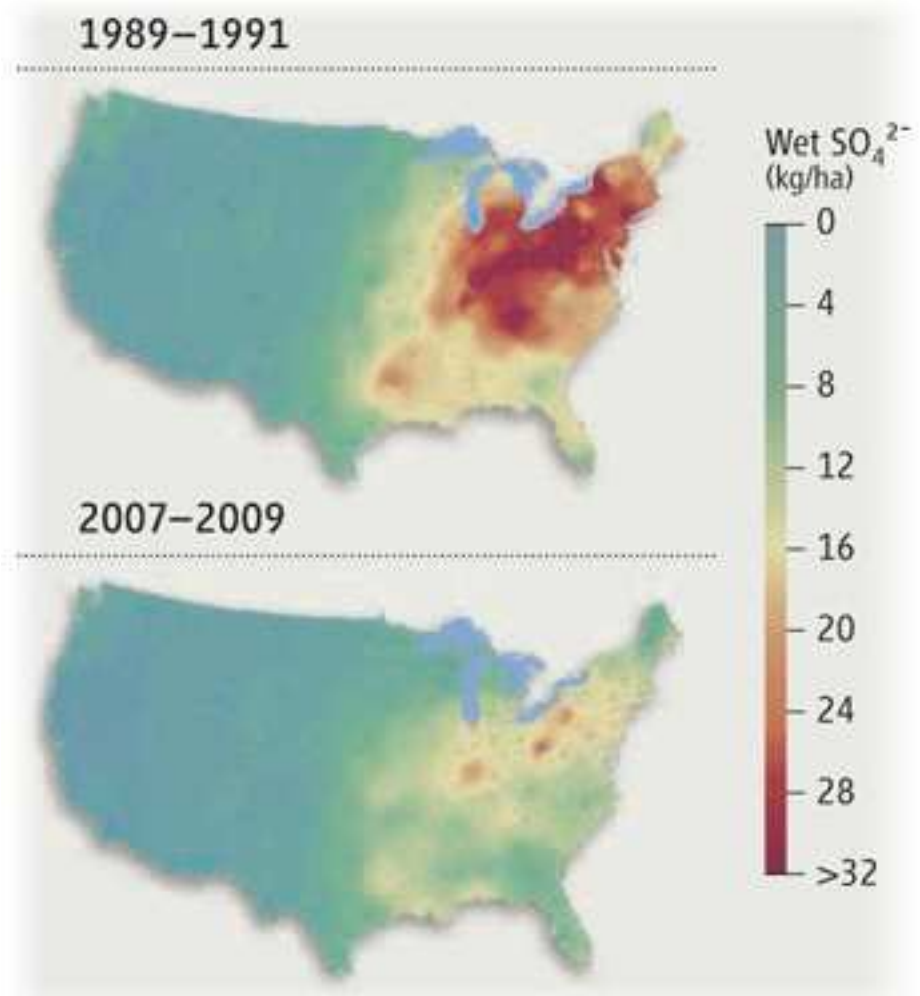
Logarithm of the ratio between the current situation to the probable long term sustainable limit



Direct effects of energy use

Some pollutants are relatively easy to abate

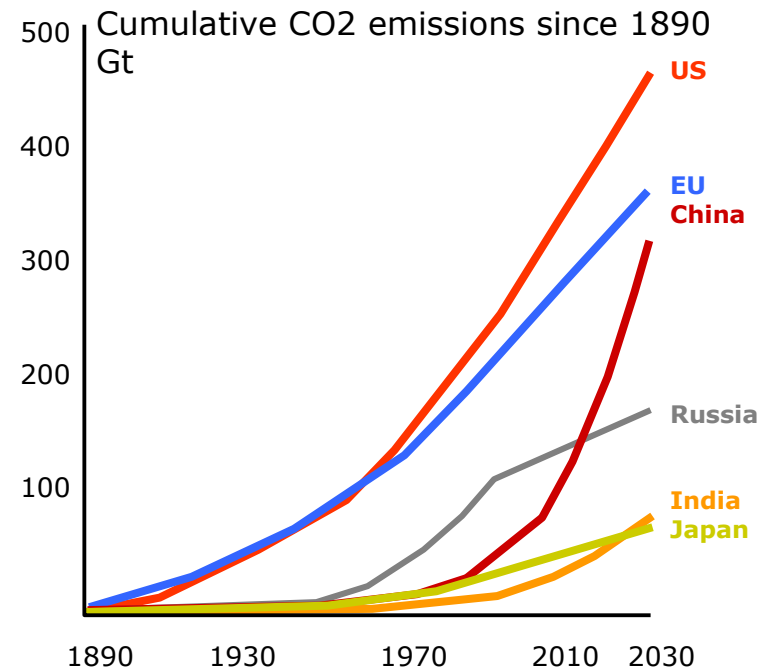
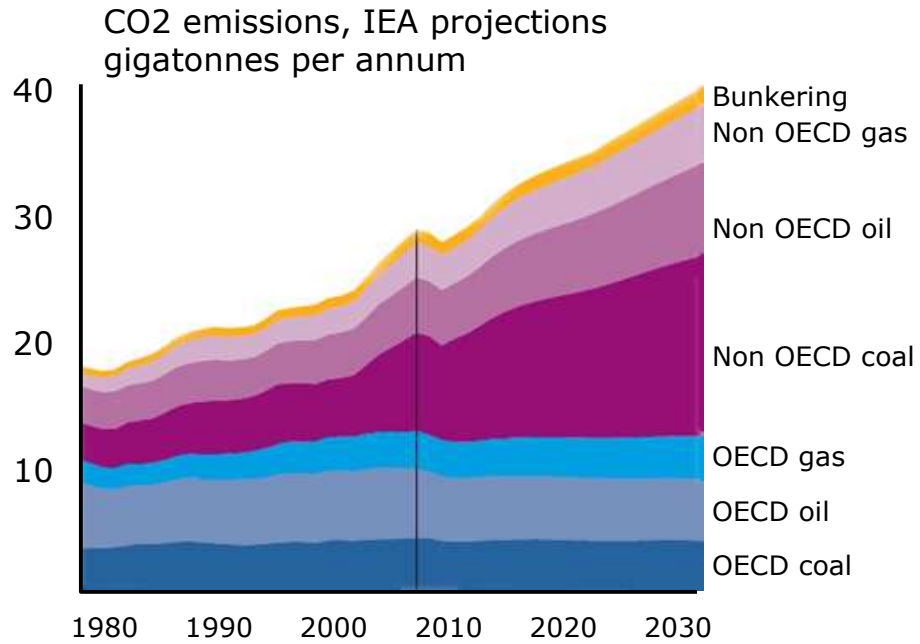
Others, such as CO₂, are much less tractable



US Sulphur contamination



Direct effects of energy use



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The overall energy *problematique* is more complex than pollution management

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- Minimising cost of supply
- Minimising price volatility
- Pollution management

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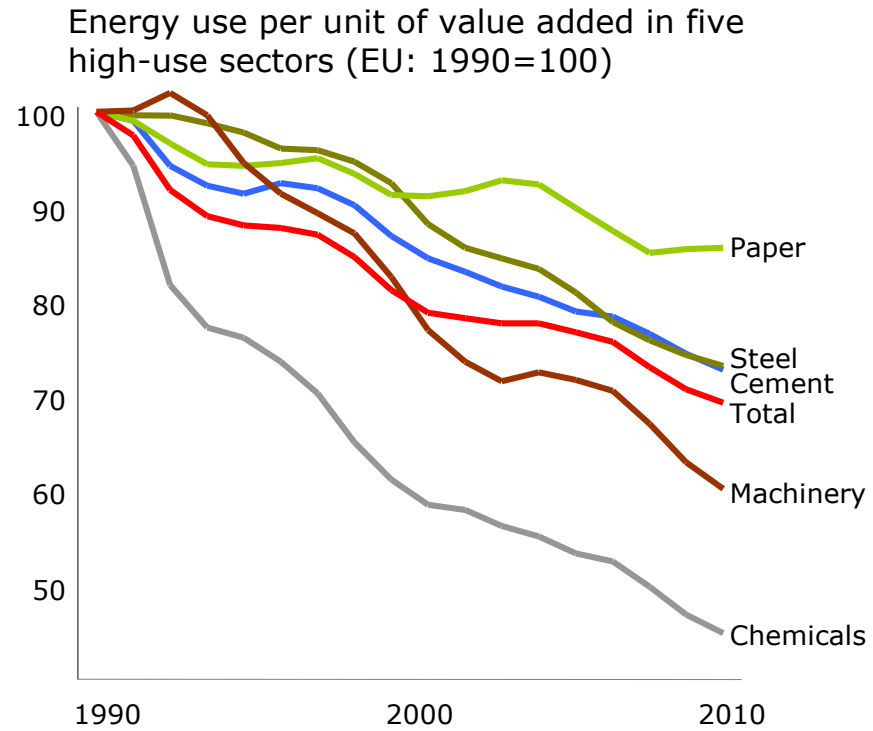
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Change economic mix	Repatriate supply	Diversify fuels used	Push for efficiency
✓	✓	✓	✓
		✓	✓
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		✓	✓

tools



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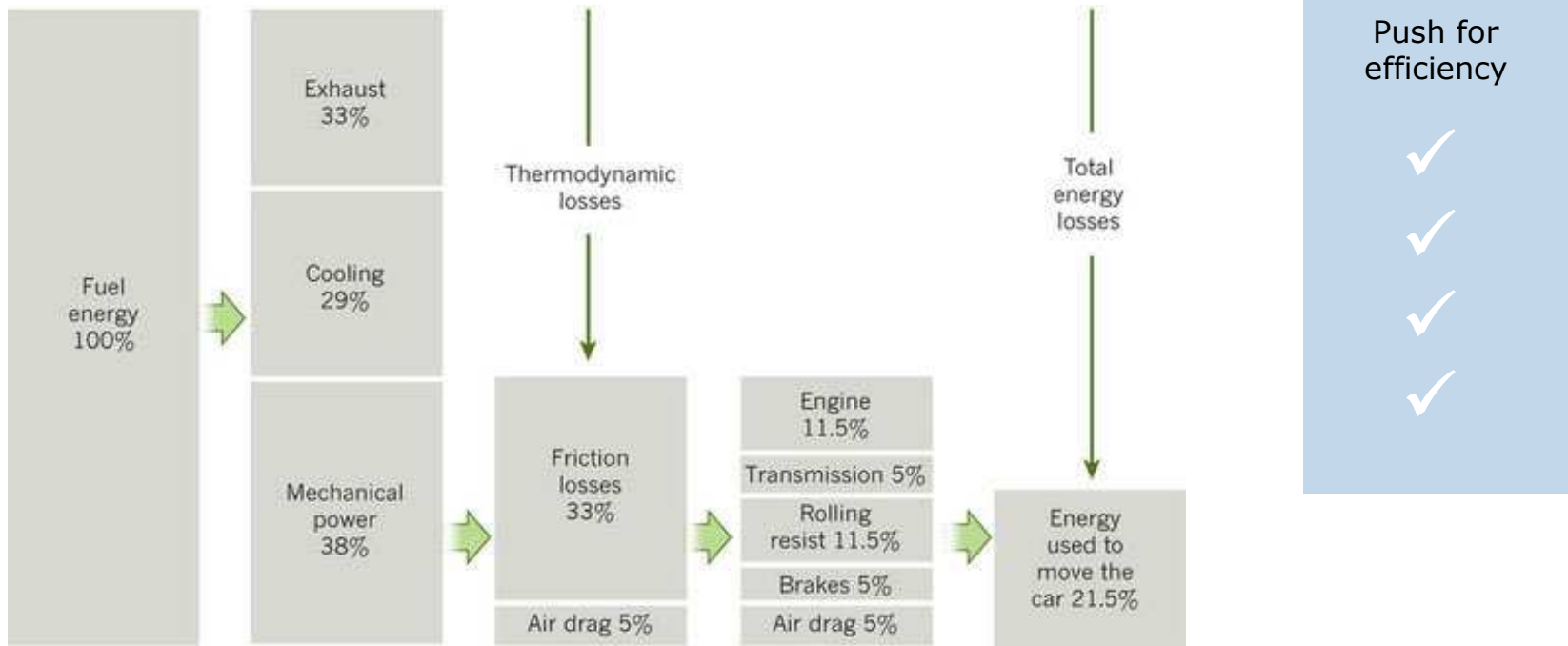


Push for efficiency

- ✓
- ✓
- ✓
- ✓



The overall energy *problematique* is more complex than pollution management



Current vehicle engines have an enormous potential for improvement



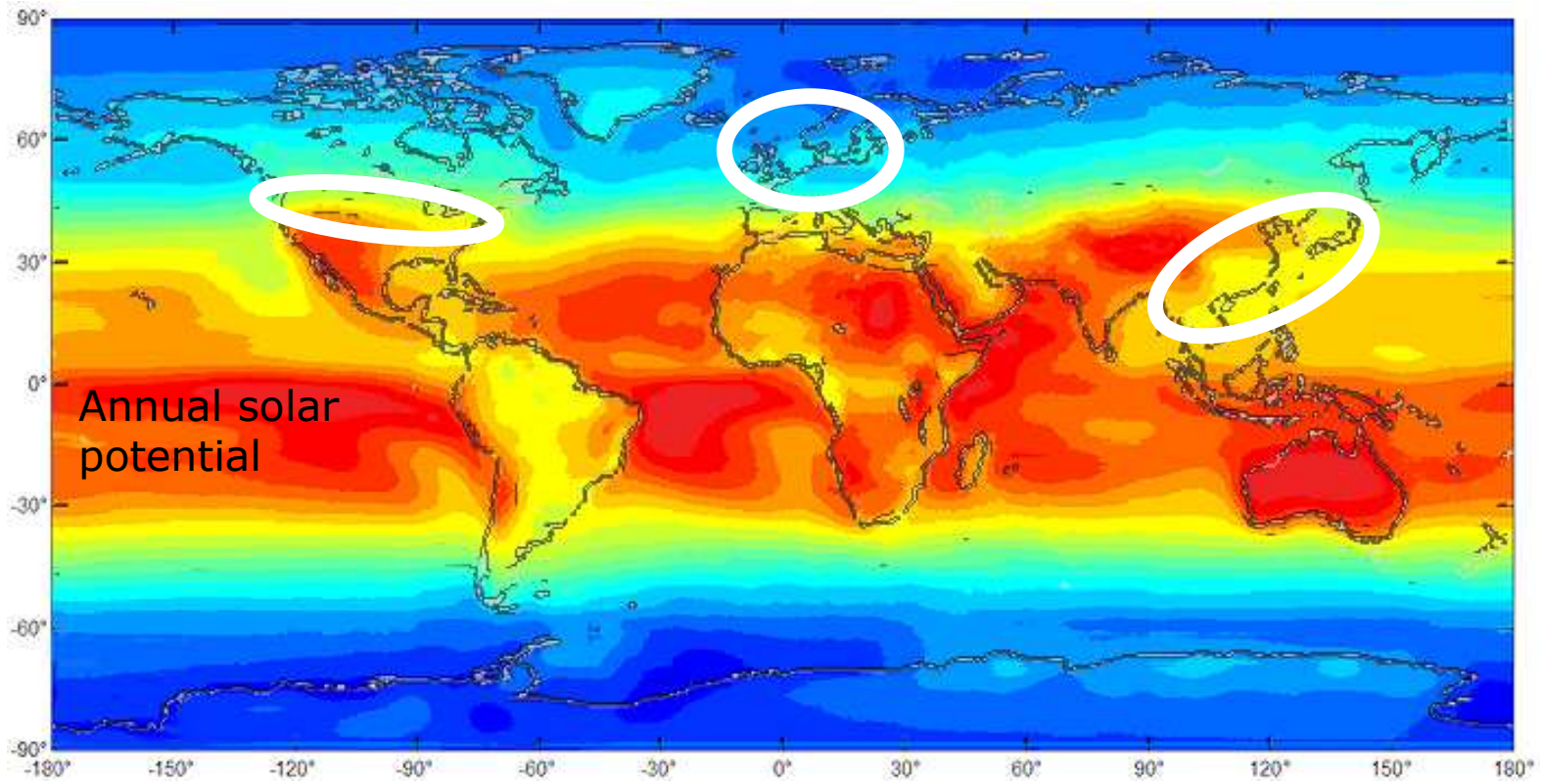
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Renewables





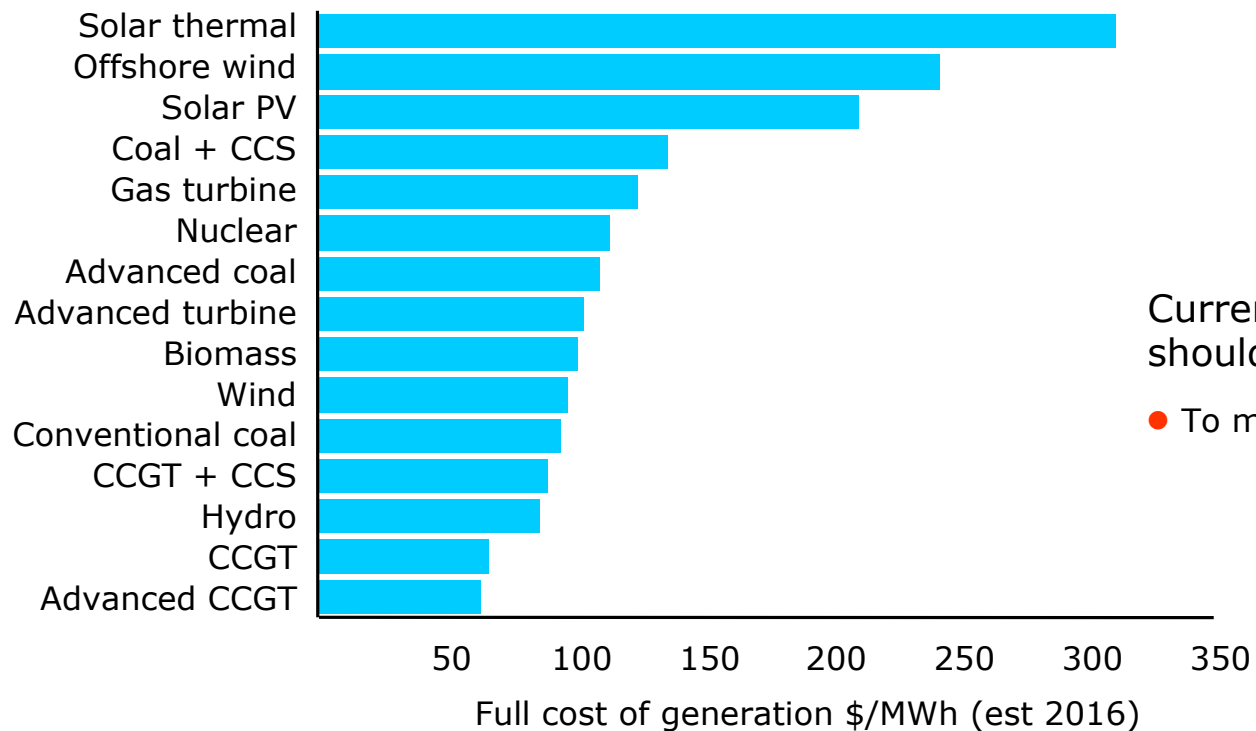
Annual solar potential

Renewables



- Often not in the right place
- Frequently economically unattractive





Current argument is that the state should subsidise renewables:

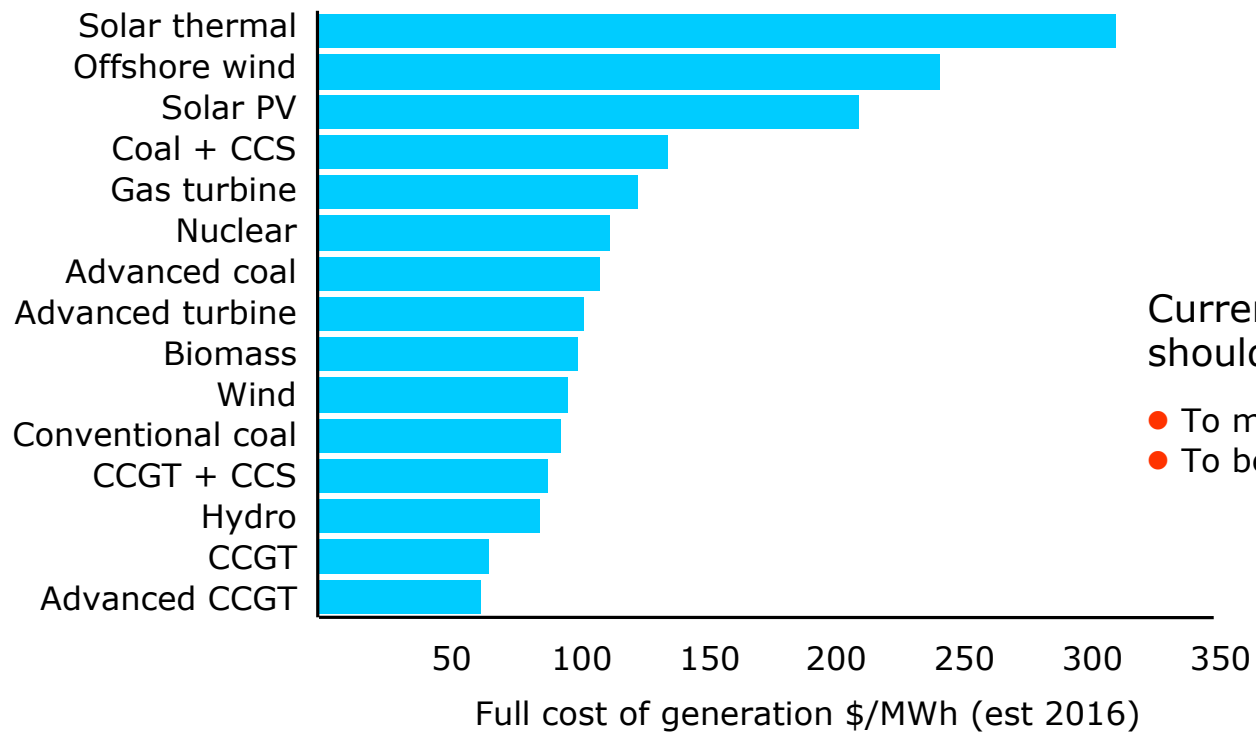
- To move down the cost curve

- Often not in the right place
- Frequently economically unattractive
- Dependent on volatile subsidy regimes

UK offshore wind:

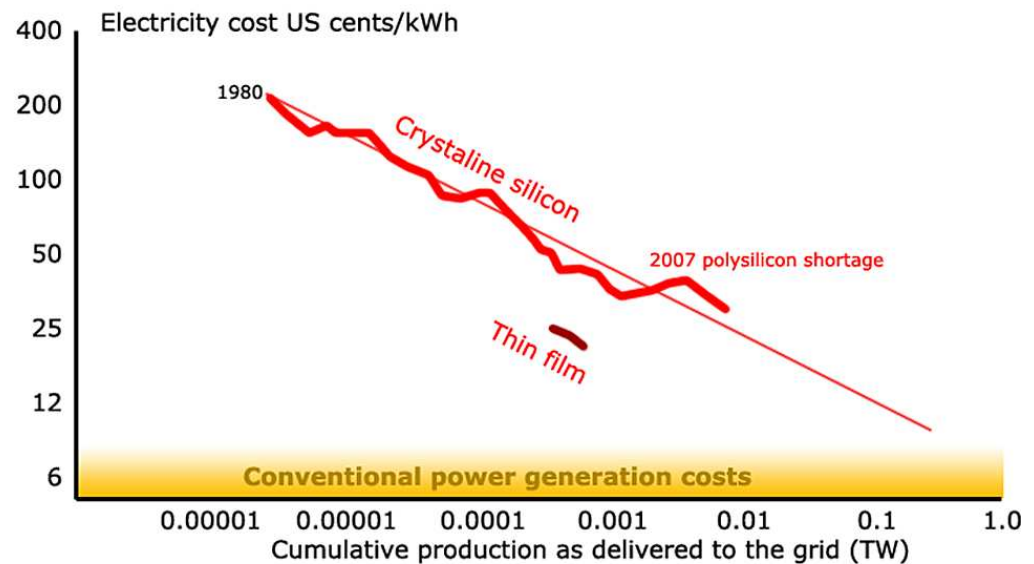
A turbine that creates £150,000 worth of power receives around £250,000 in annual subsidy

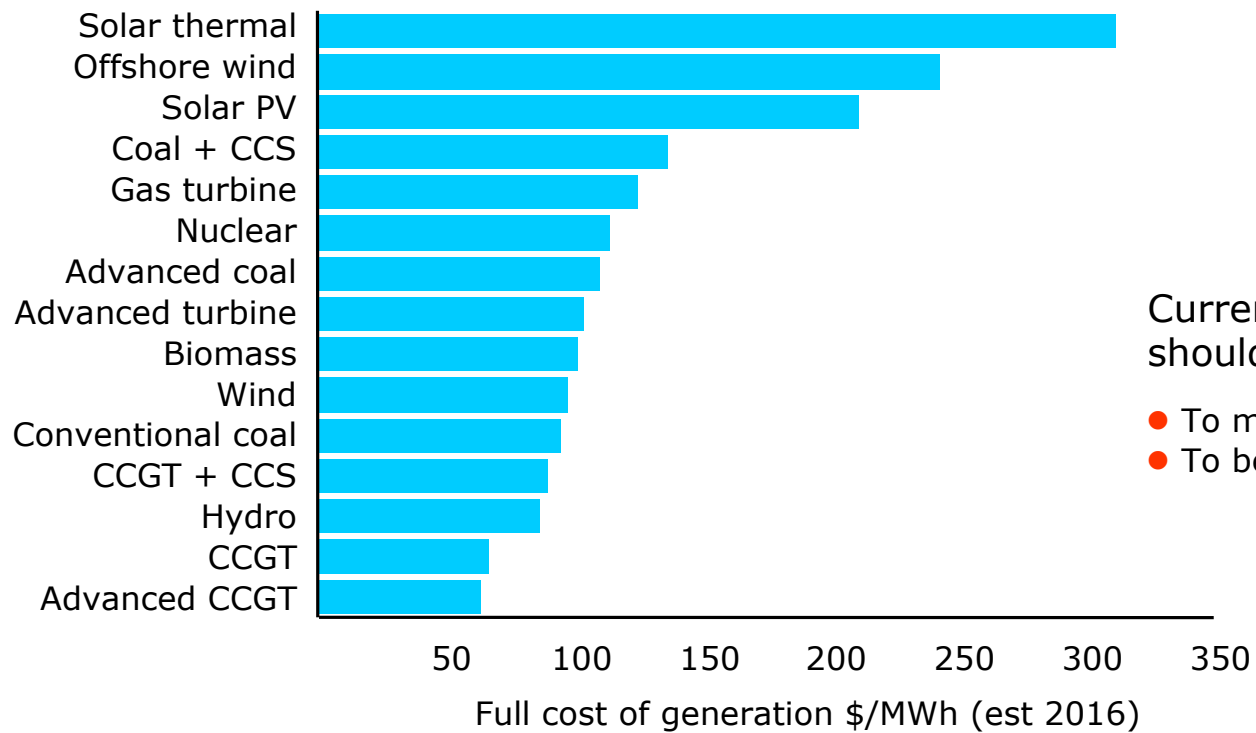




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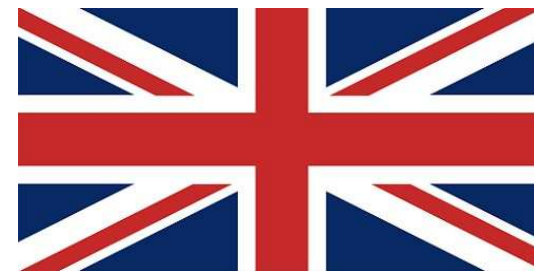


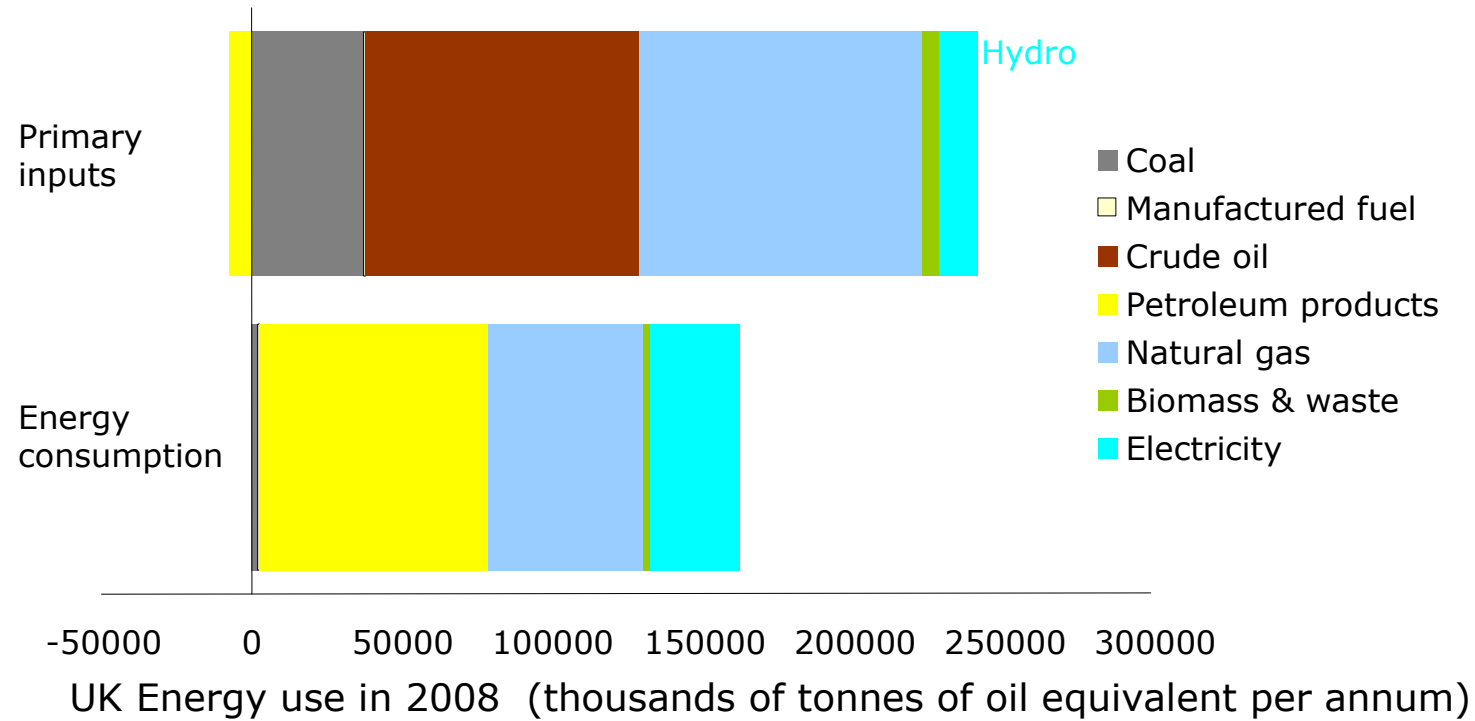


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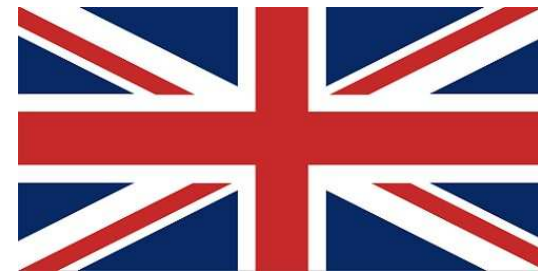
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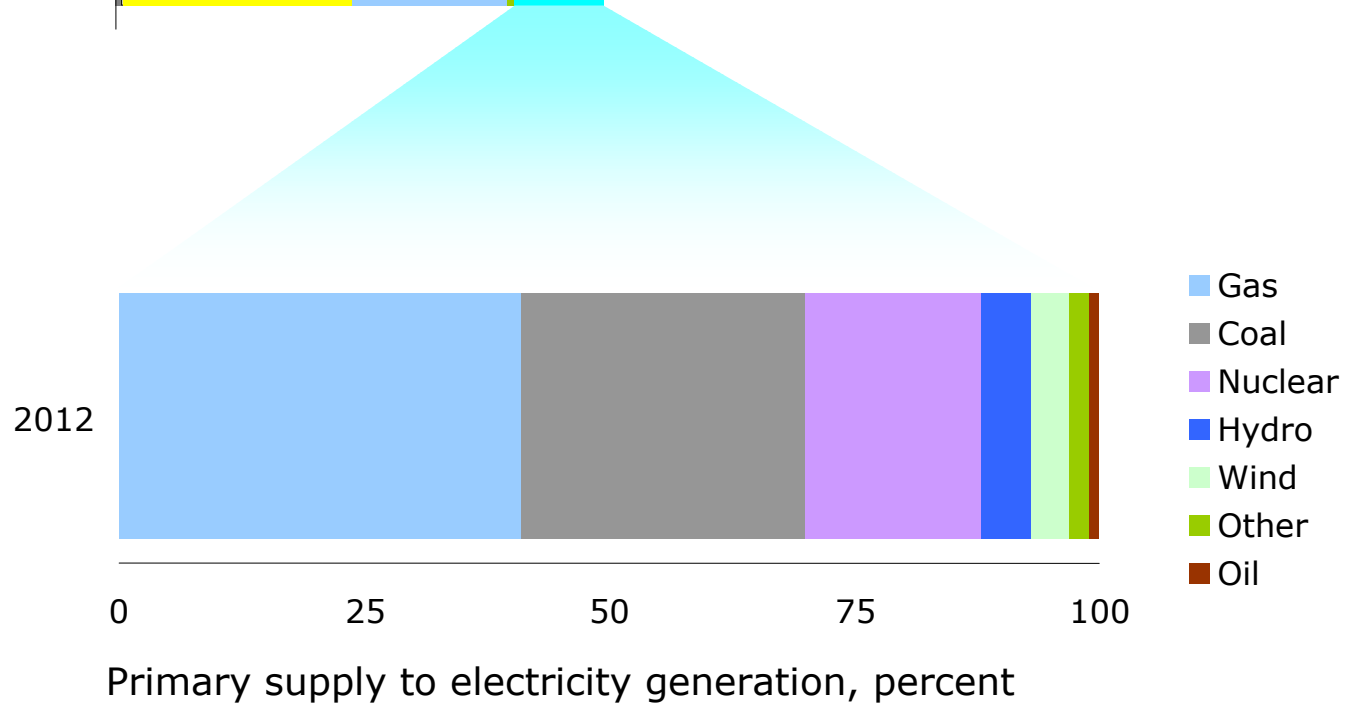
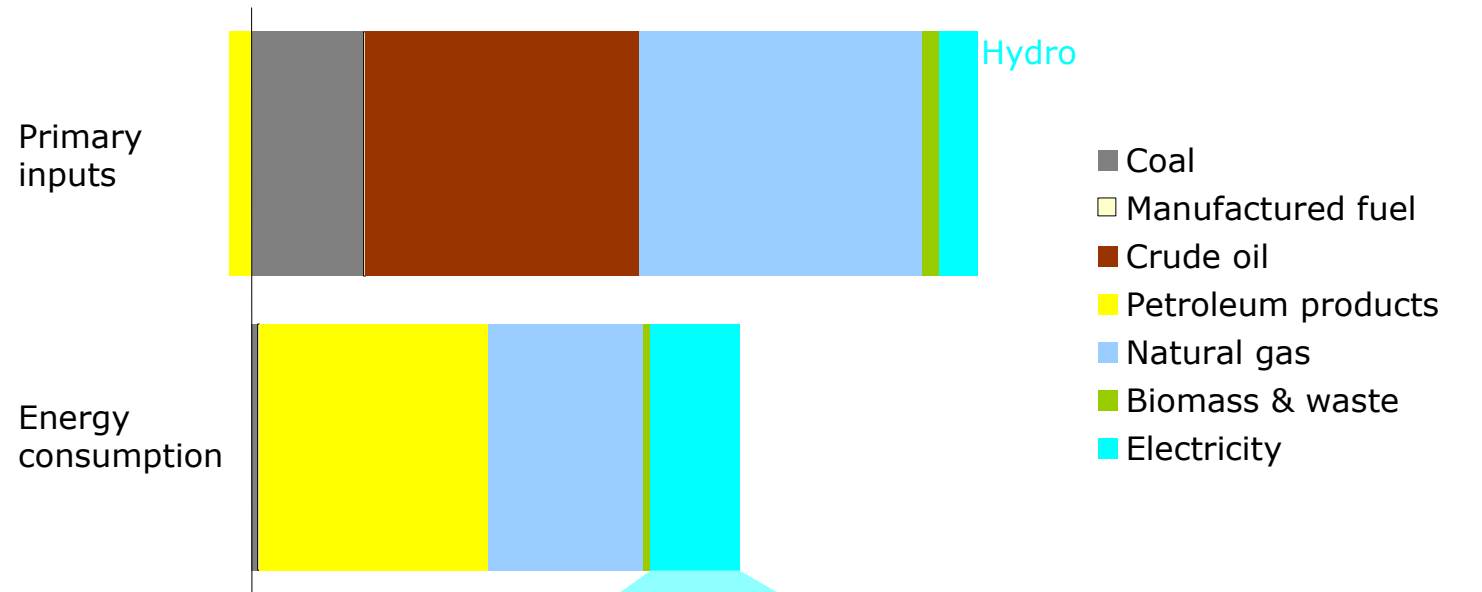
This is not without its costs:
consider UK plans for electricity

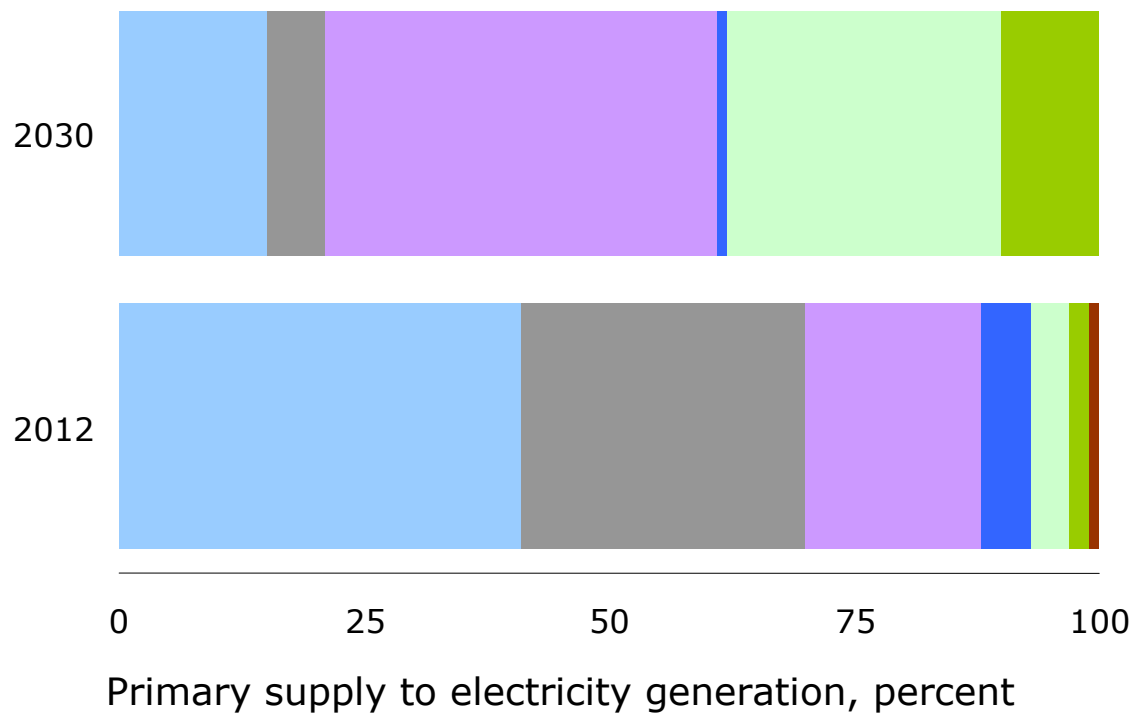
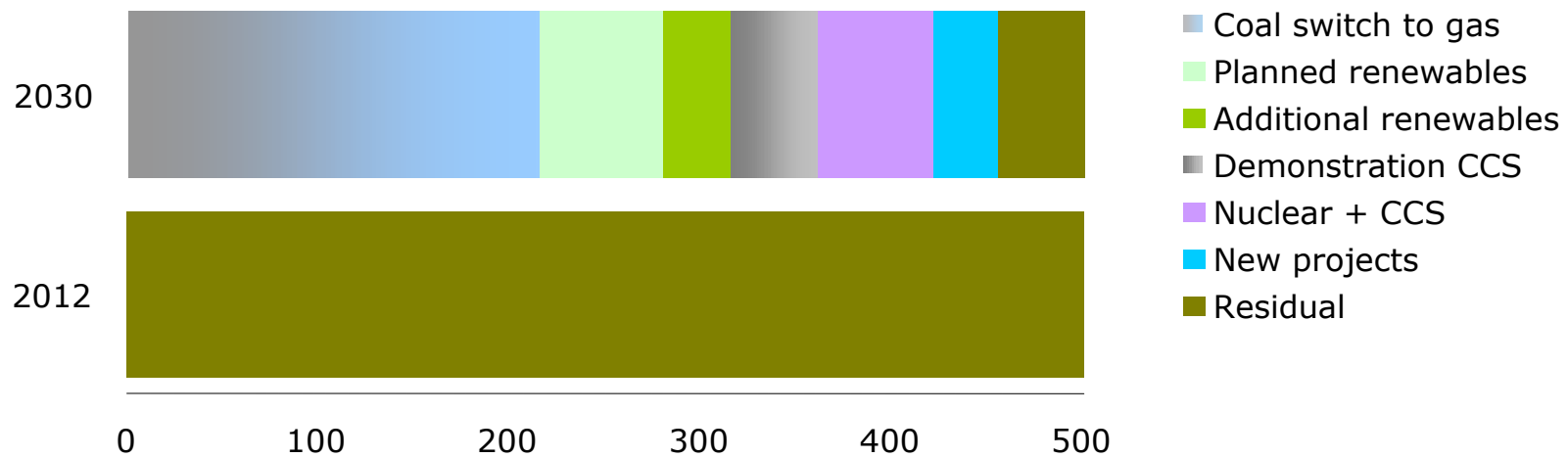


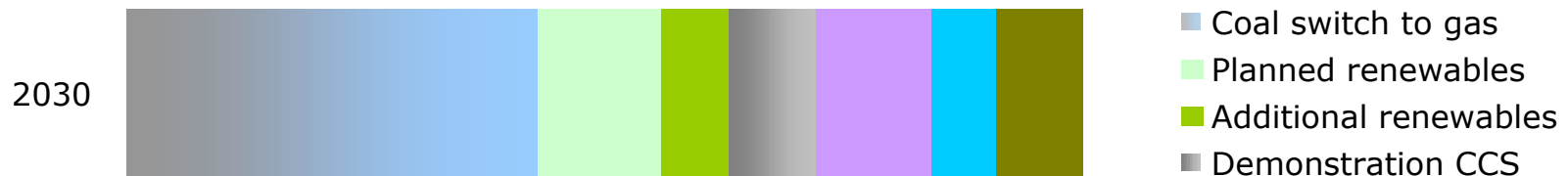


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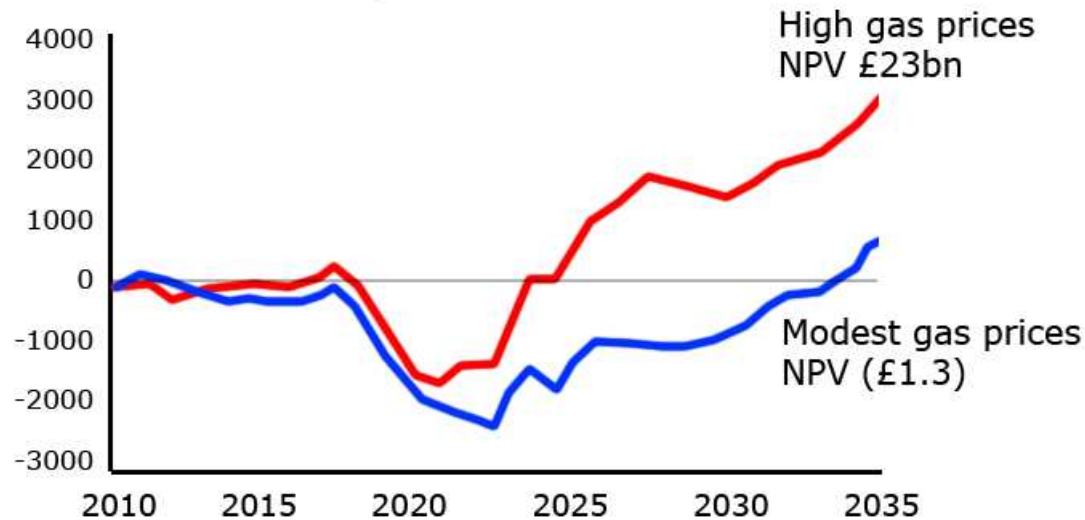








Net annual cash flow \$bn 2010



- Wind power is intermittent, requiring supporting capacity from, for example, gas.
- Planned 33 GW of wind power would therefore need at least 13 GW of gas.
- Overall cost of both is around £120 bn, given shorter turbine life.
- Supplying the same capacity just on gas would cost about £13 bn.
- Using DECC gas prices, gas-only would cost £2.9 bn more annually than gas+wind.
- That requires $(120-13)/2.9 = 37$ years to break even, when both plant will be obsolete.
- The issue then comes down to (a) gas prices and (b) carbon mitigation.



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There are major problems with “feel good”, woolly policy

What is the purpose of an electrical car?

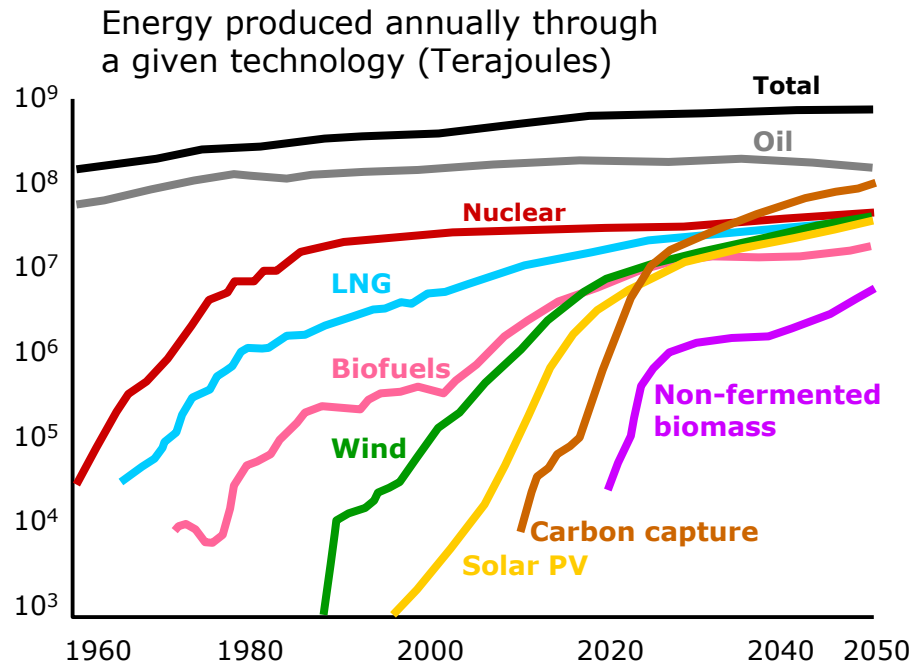
Does not use oil. In theory, renewables delivered as electricity. Shifts pollution. Iconic.

U.S. taxpayers will give \$3 billion in federal and state loans, rebates, grants and tax credits towards Volt production. GM sold 8000 of them by 2012. (Forbes)



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There is a titanic problem associated with investment in conventional fuels
 The current focus on renewables can be a distraction from solving this
 A candidate to replace “conventionals” will always penetrate slowly
 However, near-conventional solutions can propagate rapidly



Exponential growth – typically 26% per annum
 - continues to a 1% share in world energy and then slows to linear growth.

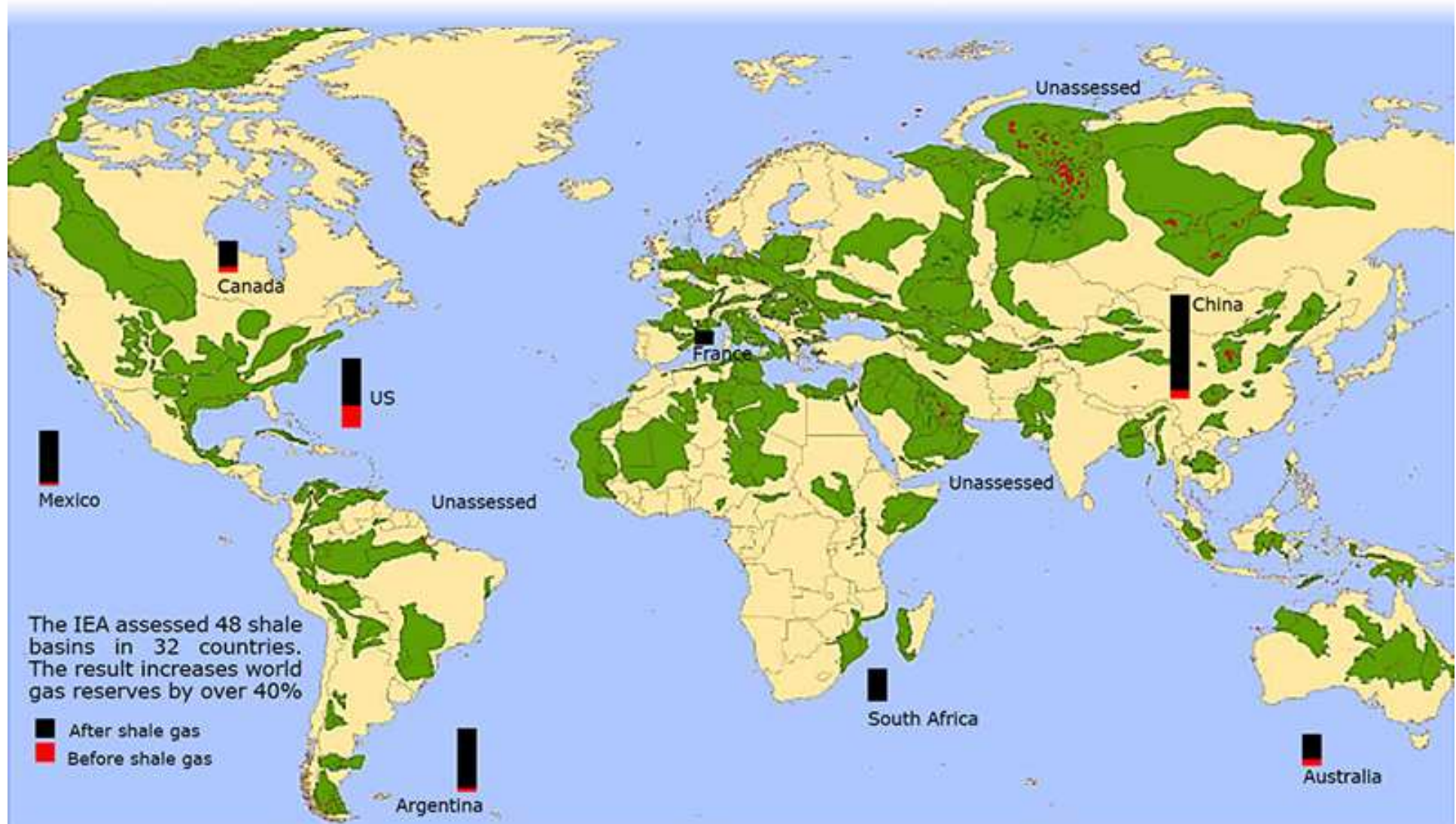
It costs around \$200 million to prove an energy concept to the 10¹ Tj stage, \$200 billion to bring it to the 1% stage.

The linear stage capacity lasts for 15-20 years, implying 2-4% annual replacement. Owners are always reluctant to retire capacity.



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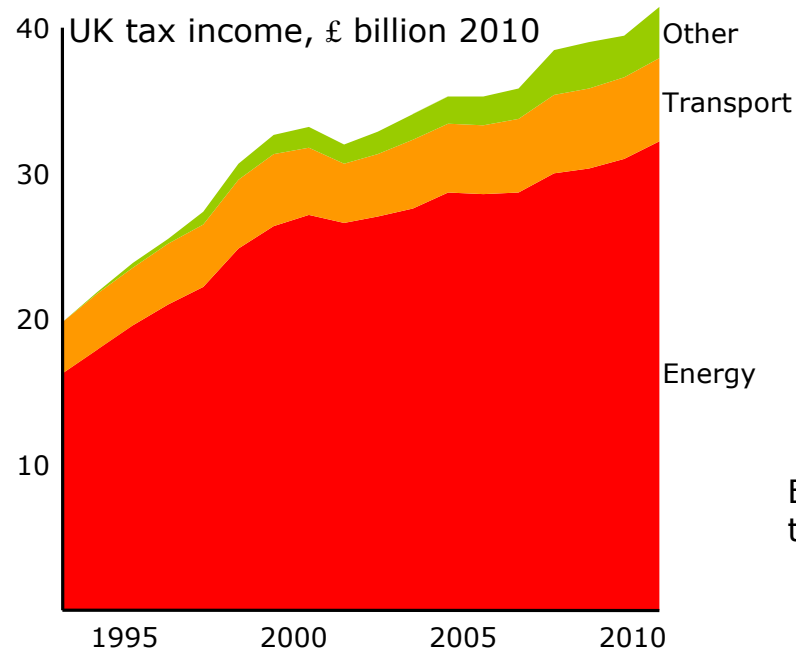


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What would a new energy supply look like?

Economics: *Either* profitably self-funding at then-prevailing prices

Or subsidised in ways that transcend political vagaries



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Qualities: Capacity for global scale, scope for efficiency growth
Integration with existing energy economy: e.g. mobility
Constantly available, reliable, able to be stored
Geographically diverse supply, diverse fuel portfolio
Acceptable levels of pollution for entire chain
Acceptable levels of safety along supply chain
Based current or imminent technologies and skills



Intermittent or
remote primary
source



Immediate
energy
storage



Transport and conversion/
Conversion and transport
of stored energy

Solar

Batteries

Inverter, grid power

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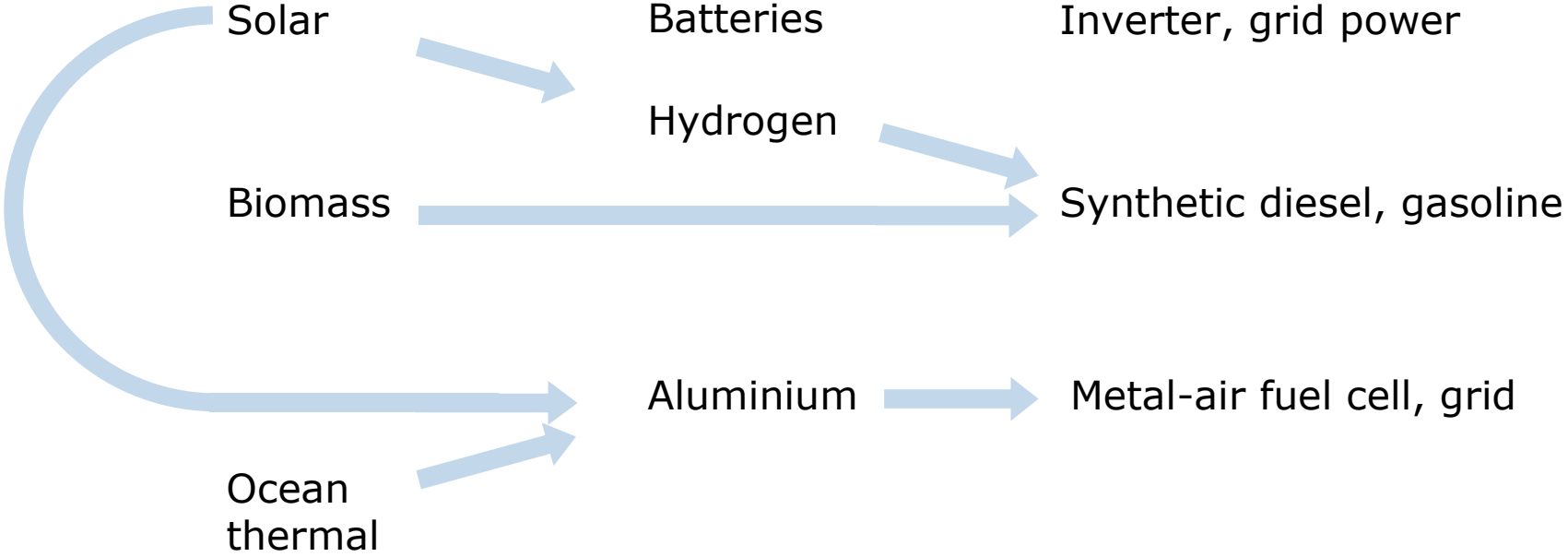
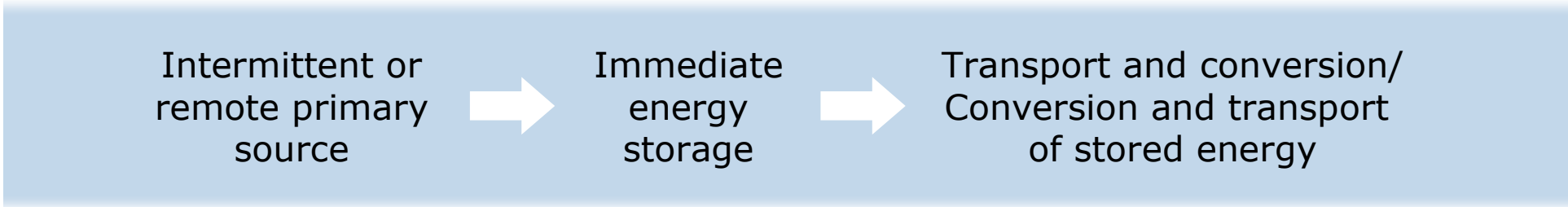
Geographically diverse supply, diverse portfolio

Acceptable levels of pollution for entire chain

Acceptable levels of safety along supply chain

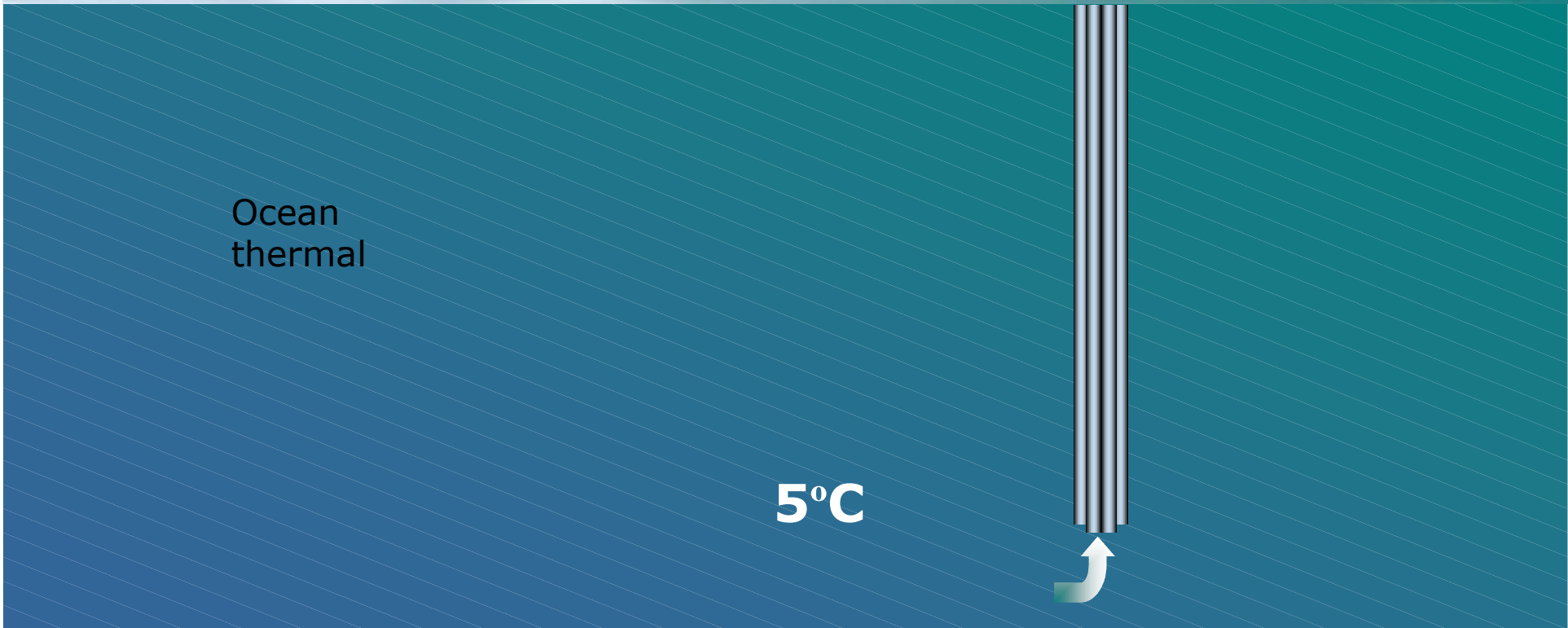
Based current or imminent technologies and skills





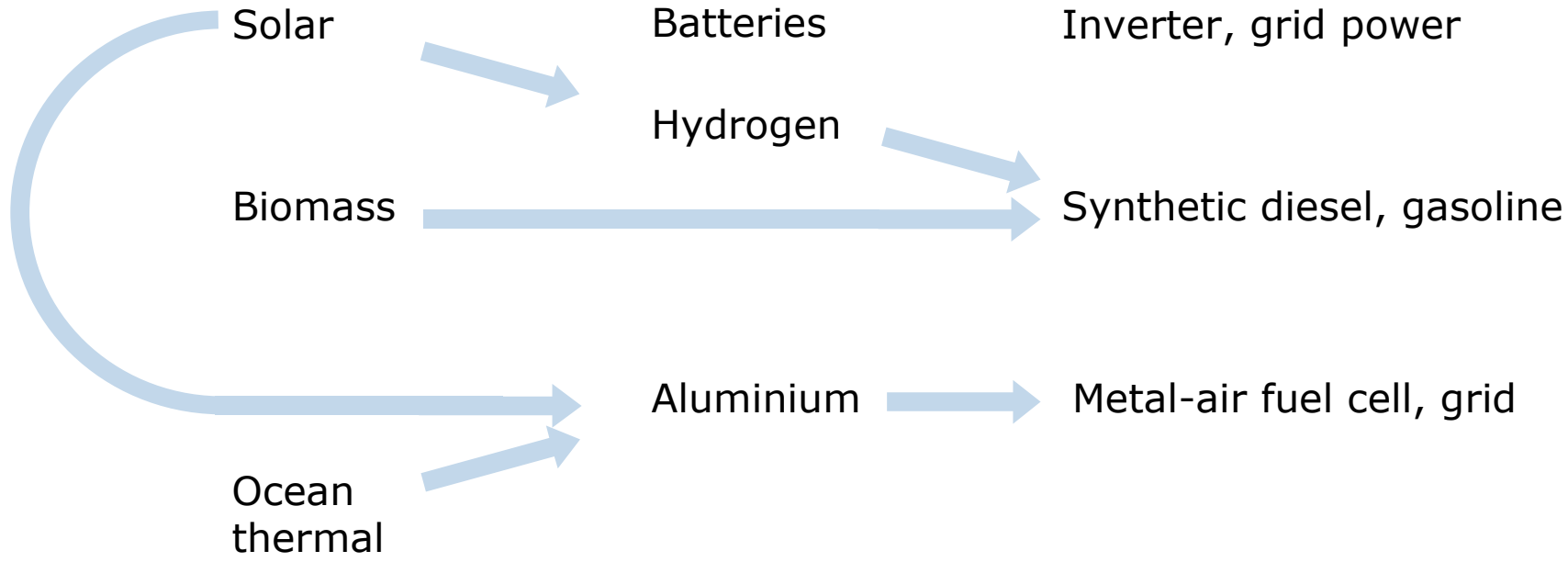
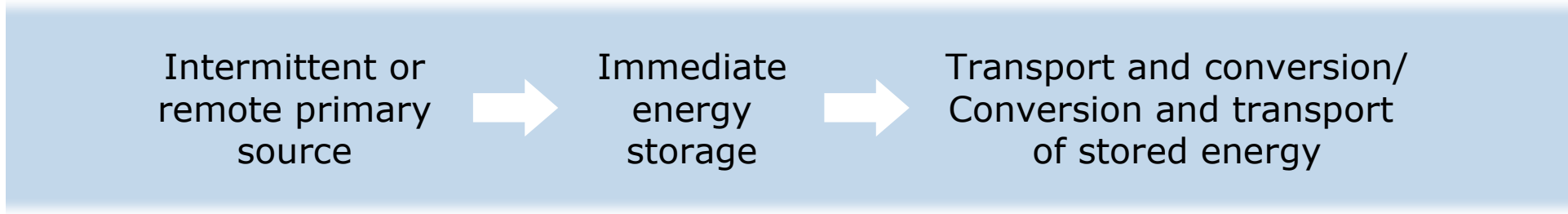


30°C



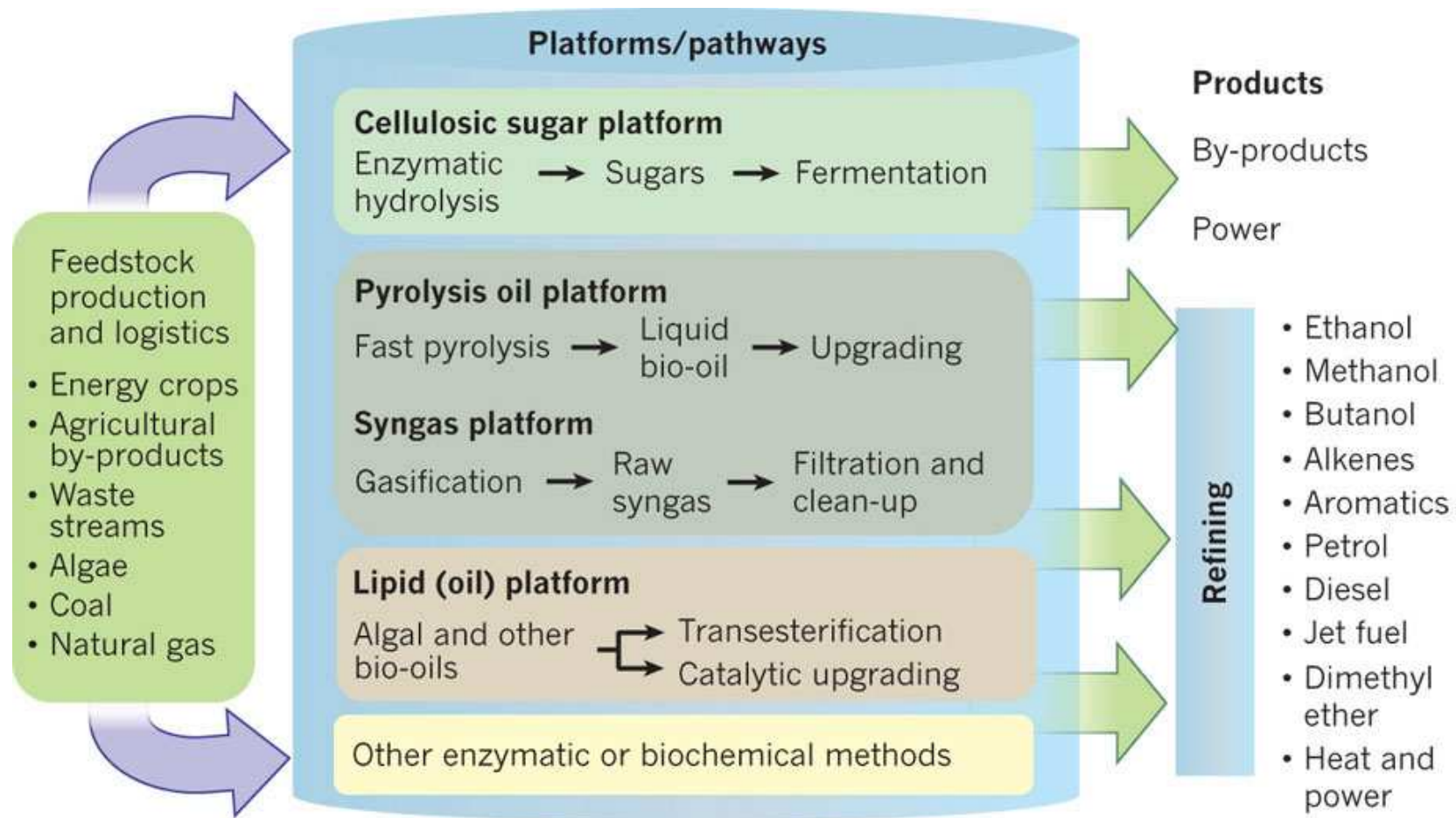
Ocean
thermal

5°C



Projects of this sort will need transnational political sponsorship and huge initial subsidy. This will have to occur while the conventional energy industry is fully stretched, through energy price turmoil and potential climate change.

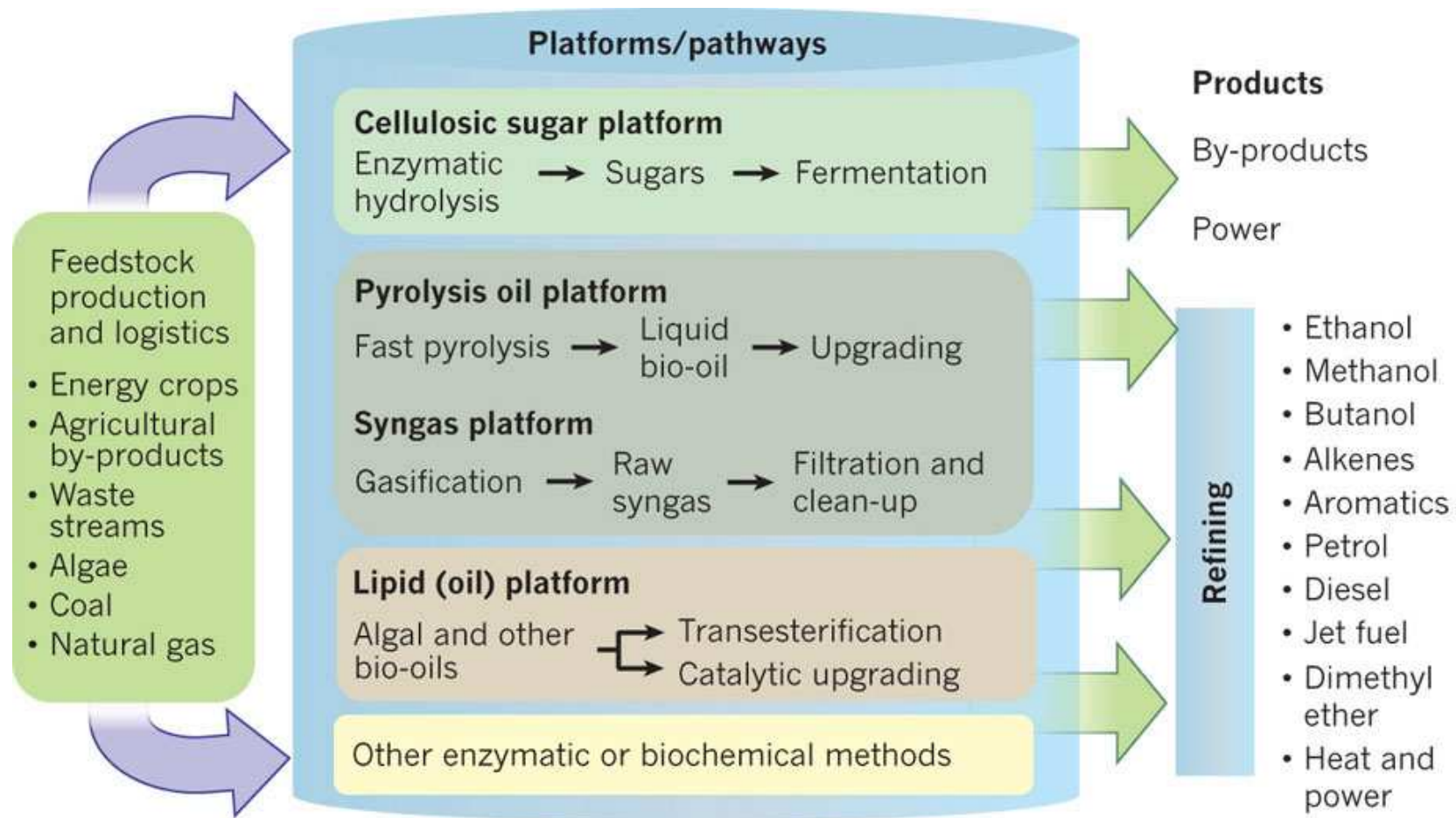
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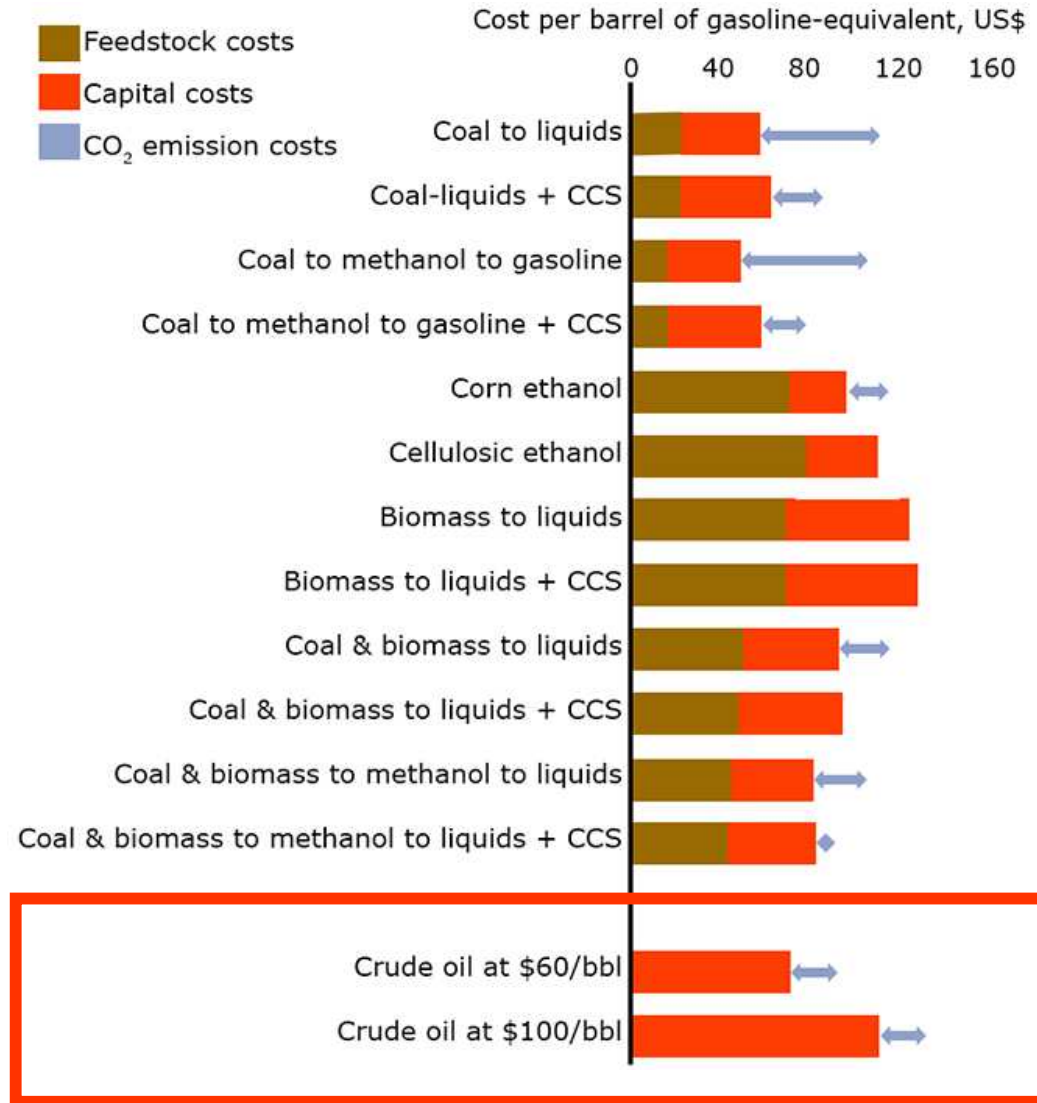




Around 40% of the US maize crop is used in biofuels, due to subsidy and regulation.

Some of these options are, however, near-economic

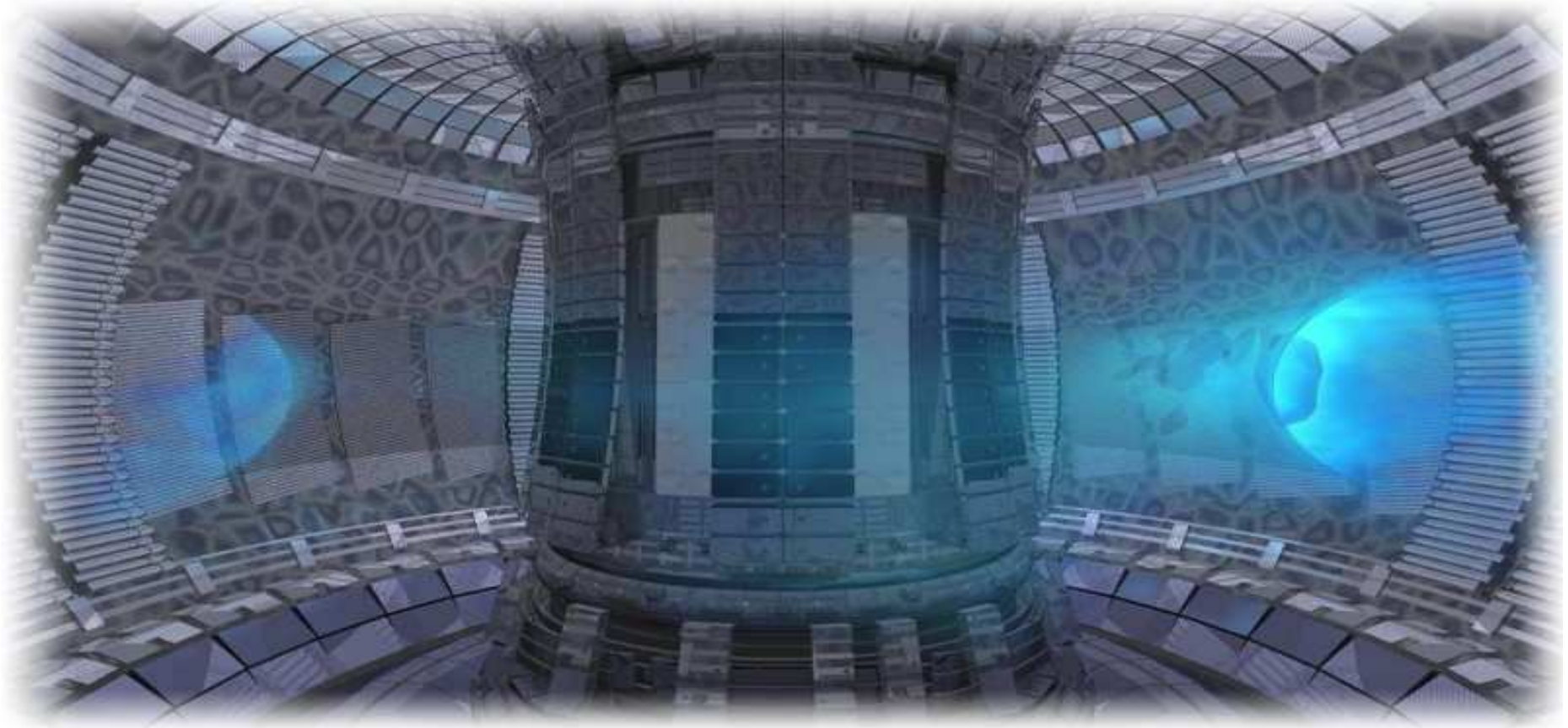




Some of these options are, however, near-economic
 But, the potential for mistakes is very considerable
 Plant construction time & capital requirements
 present formidable obstacles to fast change

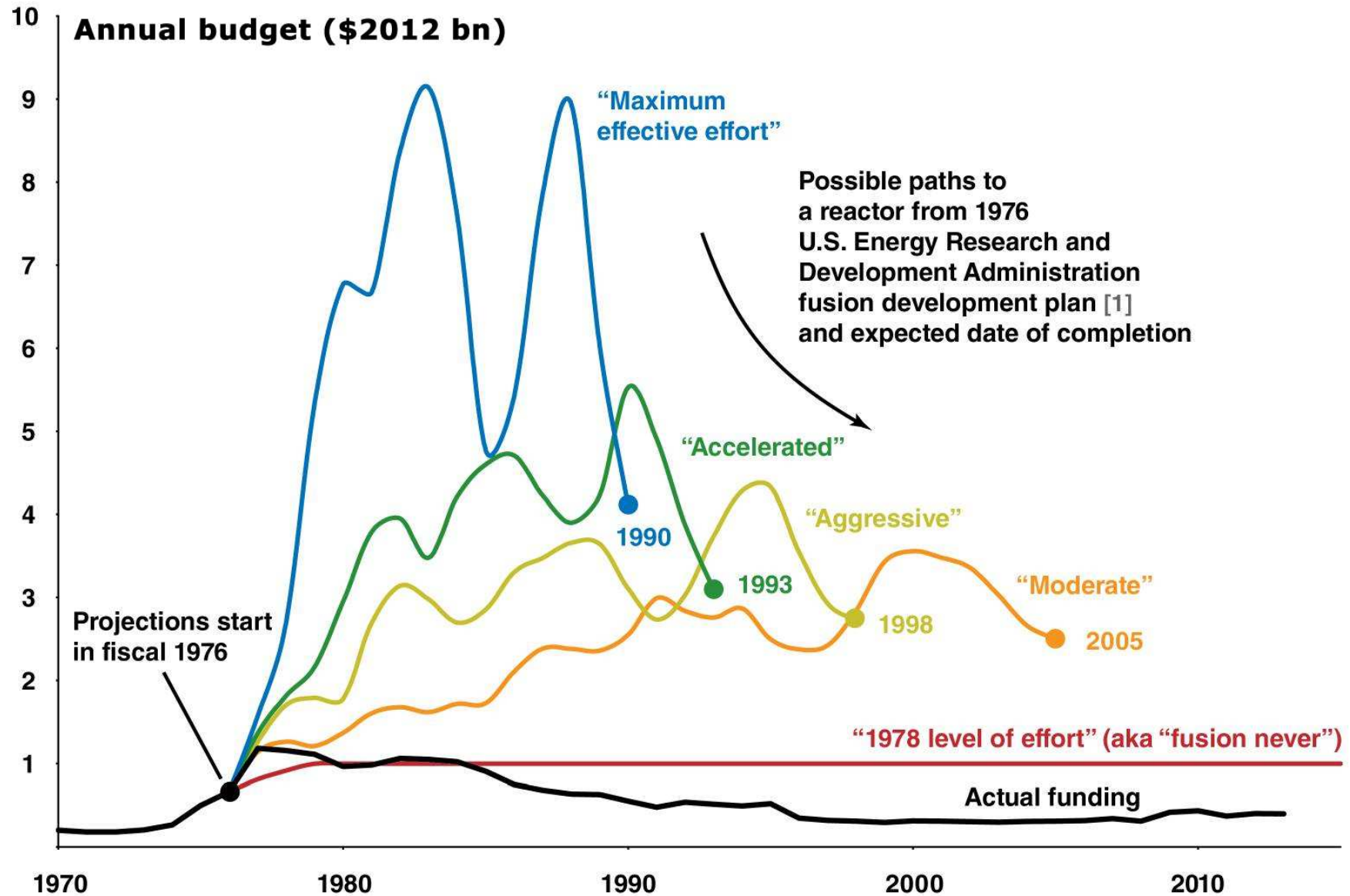


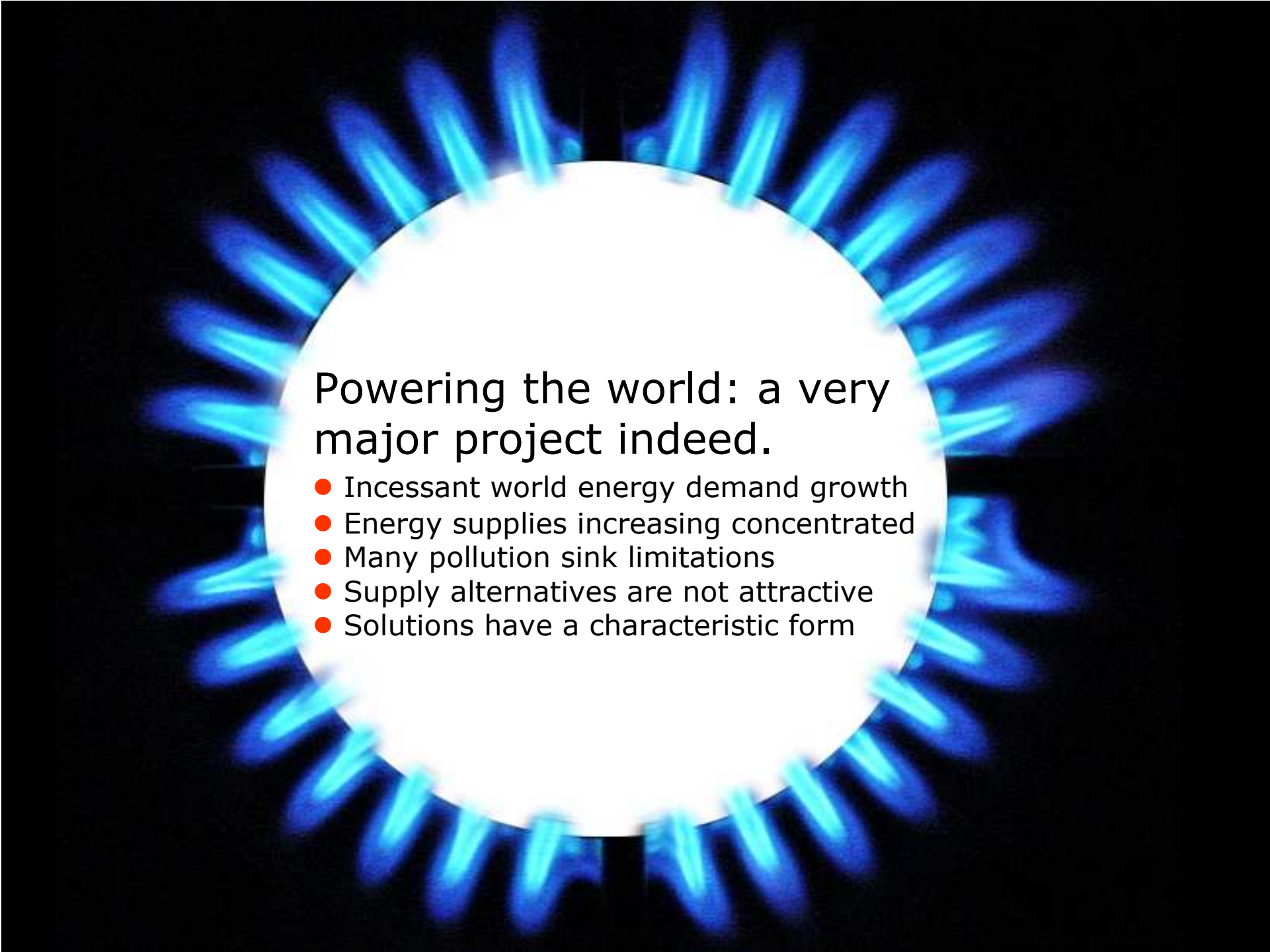
Or else we wait for nuclear fusion. To which the same issues apply



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