Chemistry, Energy

and

Climate Change

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Royal Society of Chemistry

Thursday 26 February, 2009
Physics and Chemistry of Climate Change
Entrepreneurship Meeting
Sao Paulo

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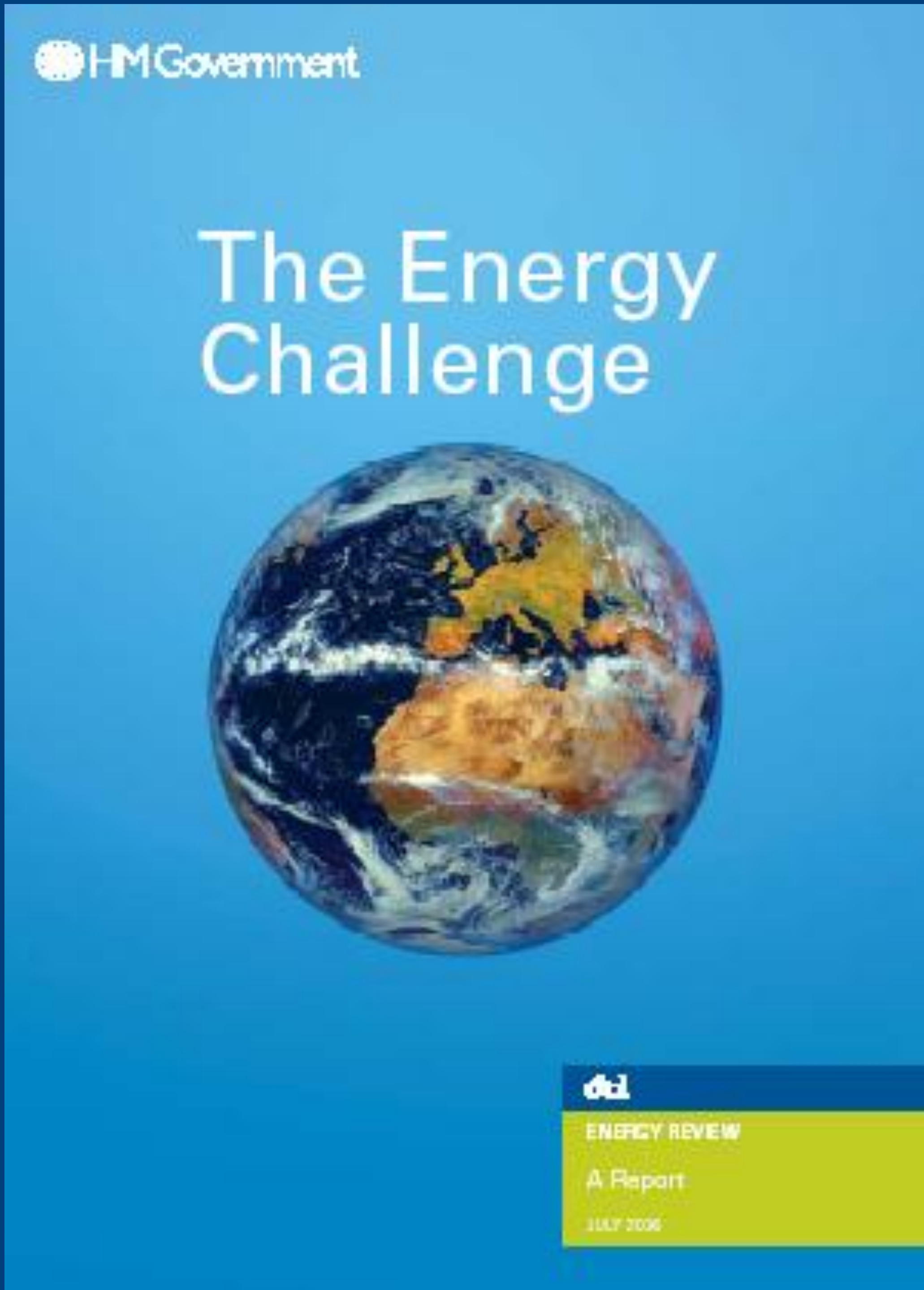
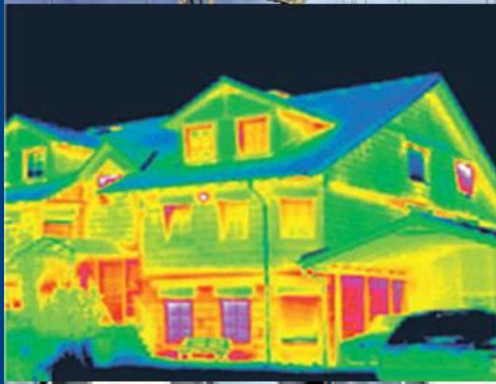


Some key energy facts

- UK energy consumption statistics show that 30% of the energy generated is lost before it reaches end-user
- 42% of non-transport energy consumption is used to heat buildings, and in turn, a third of this energy is lost through windows
- Transportation represents 74% of UK oil usage and 25% of UK carbon emissions
- To achieve the 2010 EU 5.75% bio-fuels target would require 19% of arable land to be converted from food to bio-fuel crops

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Chemical science can provide energy that is………..

- Secure
- Affordable
- Sustainable

→ Addressing climate change

Key messages are:

- Saving energy is critical
- Nurture and harness research skills
- Provide vision, mechanisms and funding to deliver solutions

Energy usage depends on the type of fuel – world picture

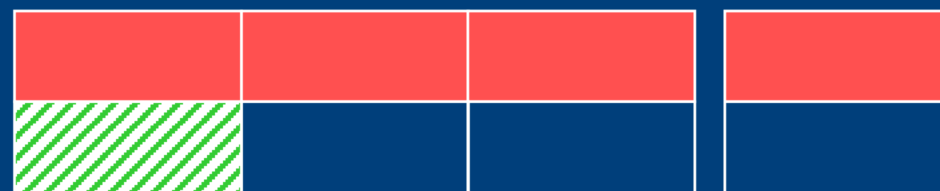
11.1 Gt/annum oil equivalent

FOSSIL AND FISSILE

Power Heating Transport Chemicals

Oil, gas, coal [80%]

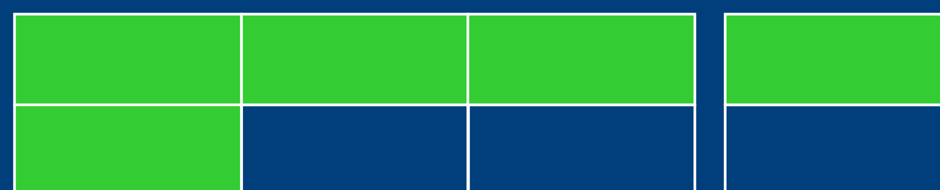
Uranium [7%]



RENEWABLES

Biomass [~10%]

Photo-voltaics, wind, tidal, hydro [~3%]



Carbon positive · Carbon neutral · Carbon neutral with radioactive waste

~40% of 8.8 GtC/annum (3.5GtC) into atmosphere of 5,300,000 Gt where already around 750 GtC

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Global and national strategies must be integrated

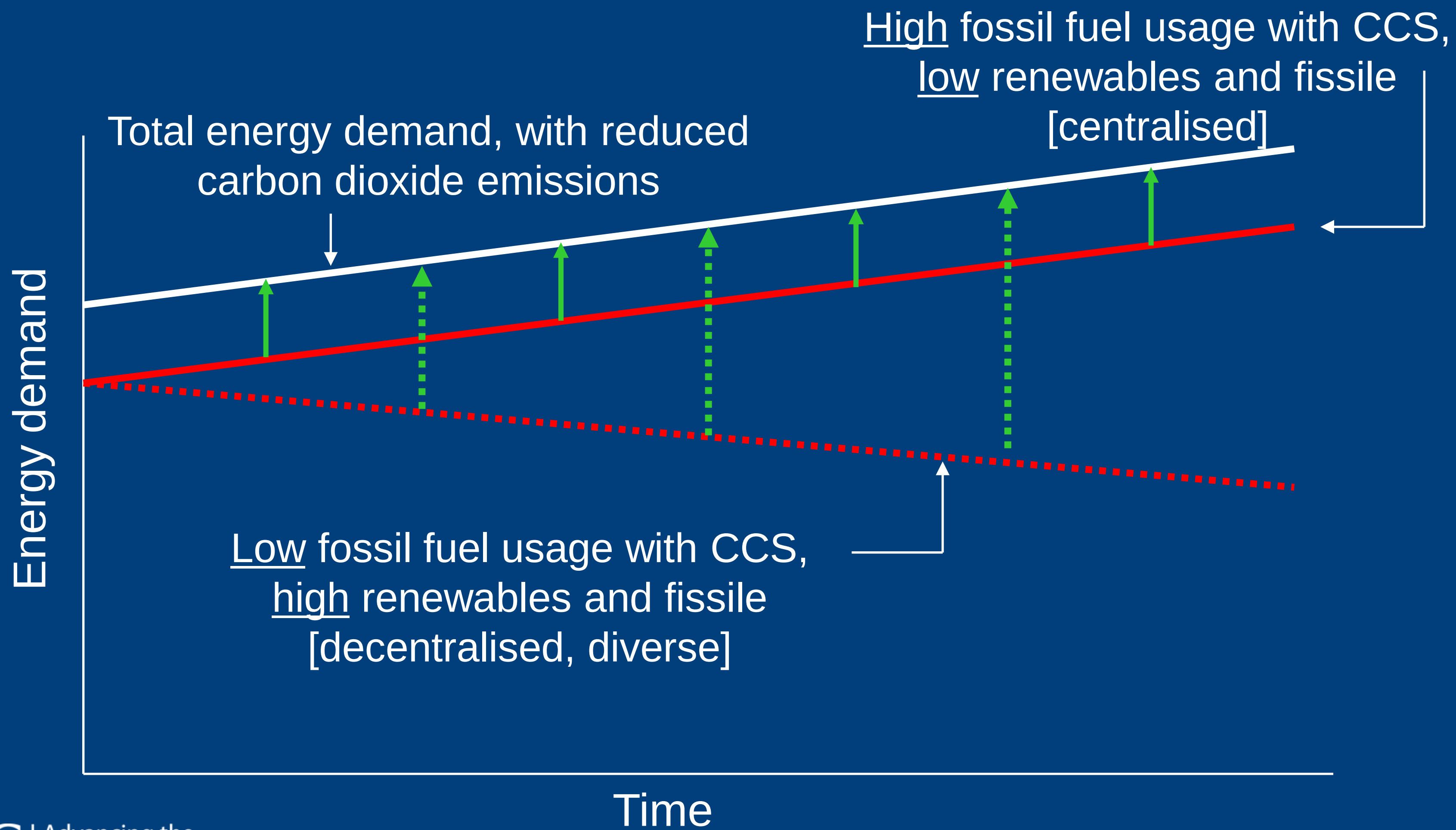
- Global strategy must be based not on 'fossil fuels are running out', but 'we must address climate change'

- Major consumer country strategies (eg UK) must
  - -respond to declining local oil and gas supply
  - -conserve for high-value applications
  - -improve utilisation and efficiencies throughout the supply chain
  - -innovate with these and other non-fossil energy sources

Some early observations are alarming

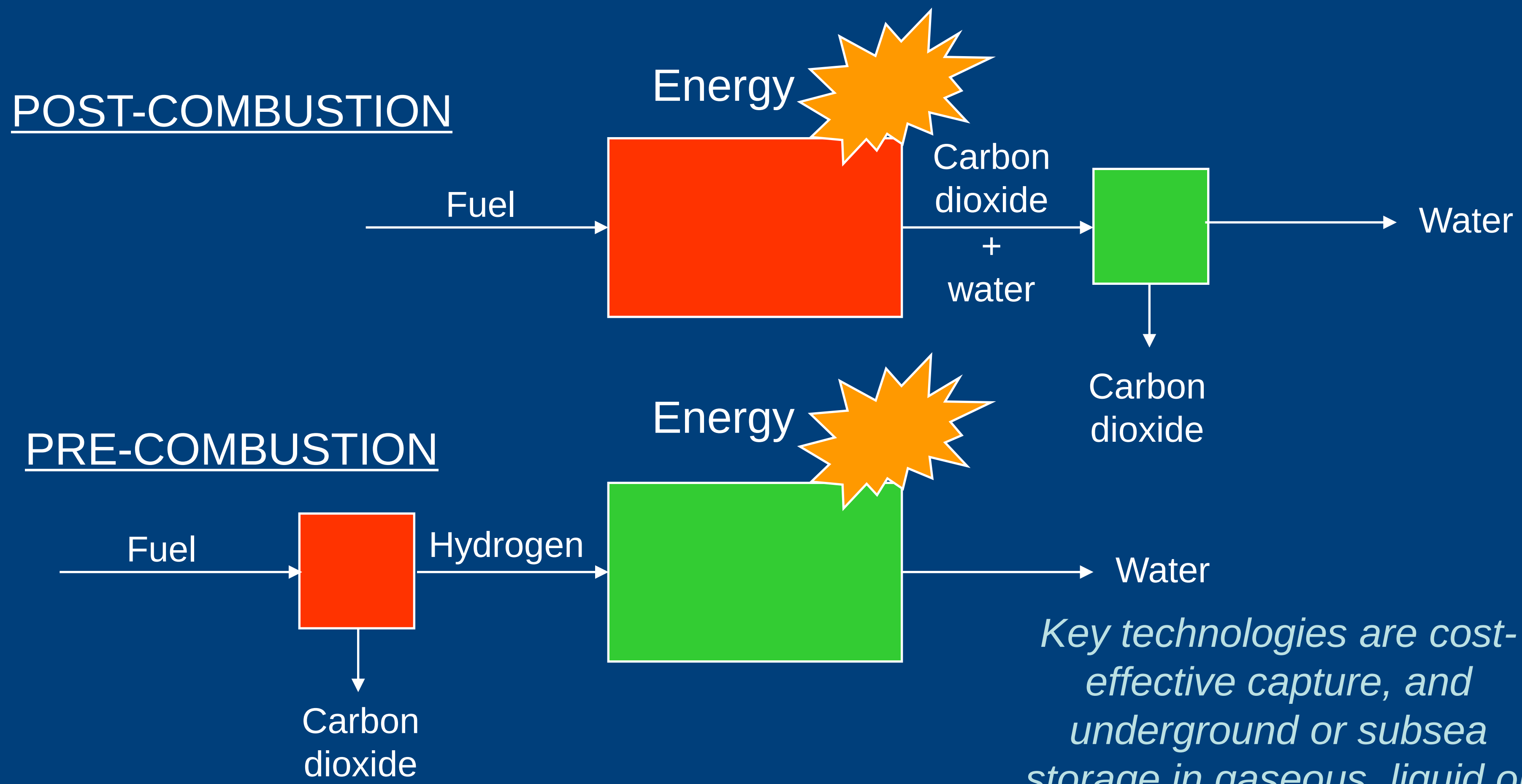
- Focus on some, trivial energy-saving schemes is detracting from the 'big picture'
- Lack of global, decisive strategy is leading to extraordinary contradictions [melting of permafrost → more opportunities to drill for oil]
- Lack of appreciation of numbers, mechanisms and processes is inhibiting good decision-making [yields, life cycle analysis, pros and cons, economics……eg balance of wind vs tidal, solar vs biofuel]

Future energy portfolios must address usage and waste management



CCS could be the most massive industrial chemical process in history

-*globally tens of millions of tons/day*



Key technologies are cost-effective capture, and underground or subsea storage in gaseous, liquid or solid states without contamination

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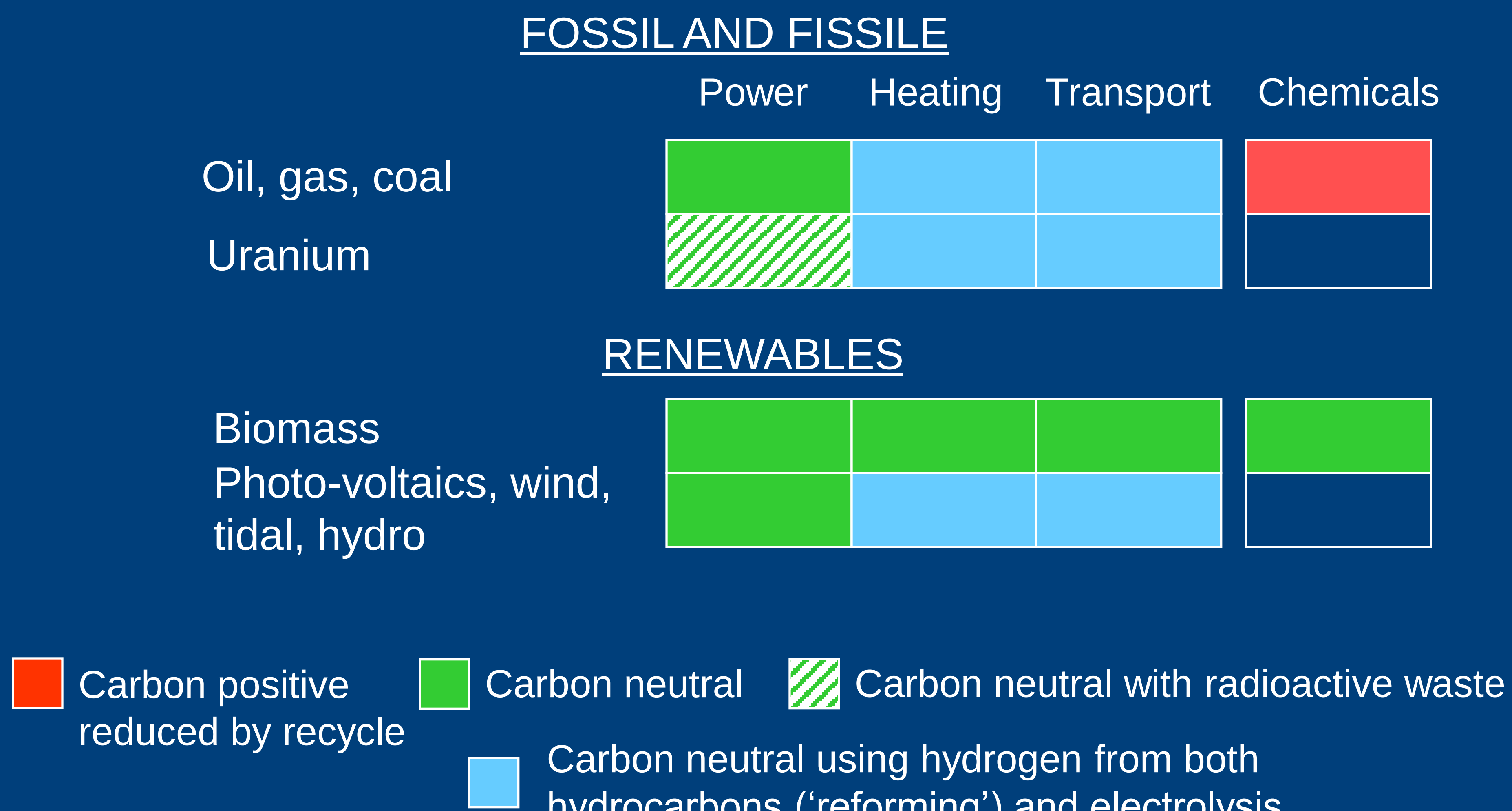
A longer-term scenario has extensive fossil-fuel CCS, biomass and hydrogen



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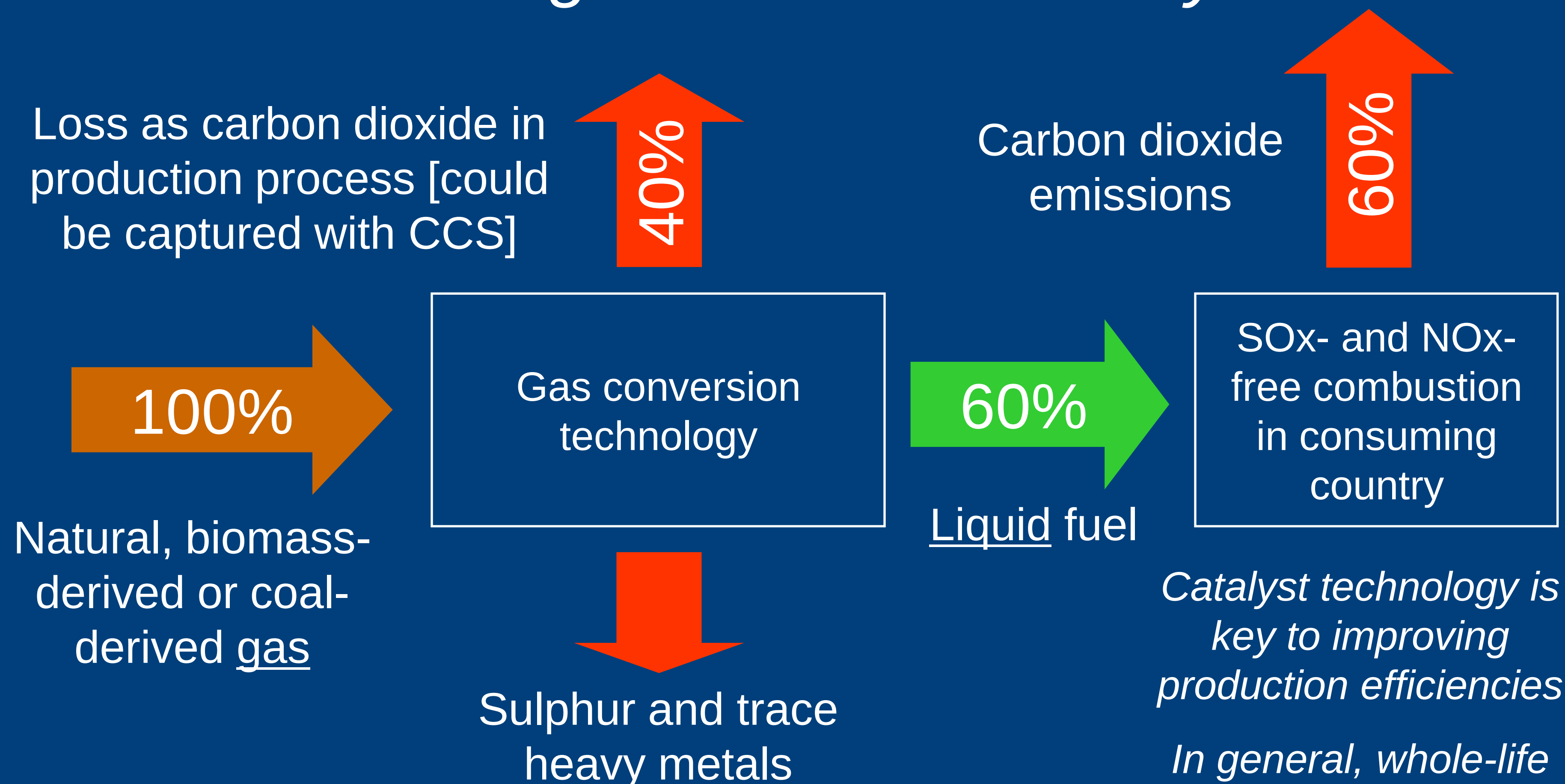
ELECTRICITY AND HYDROGEN STORAGE KEY

Currently even ‘clean fuels’ from fossil sources are very energy intensive

-solving this is all chemistry



Catalyst technology is key to improving production efficiencies

In general, whole-life assessments must be undertaken for all energy processes

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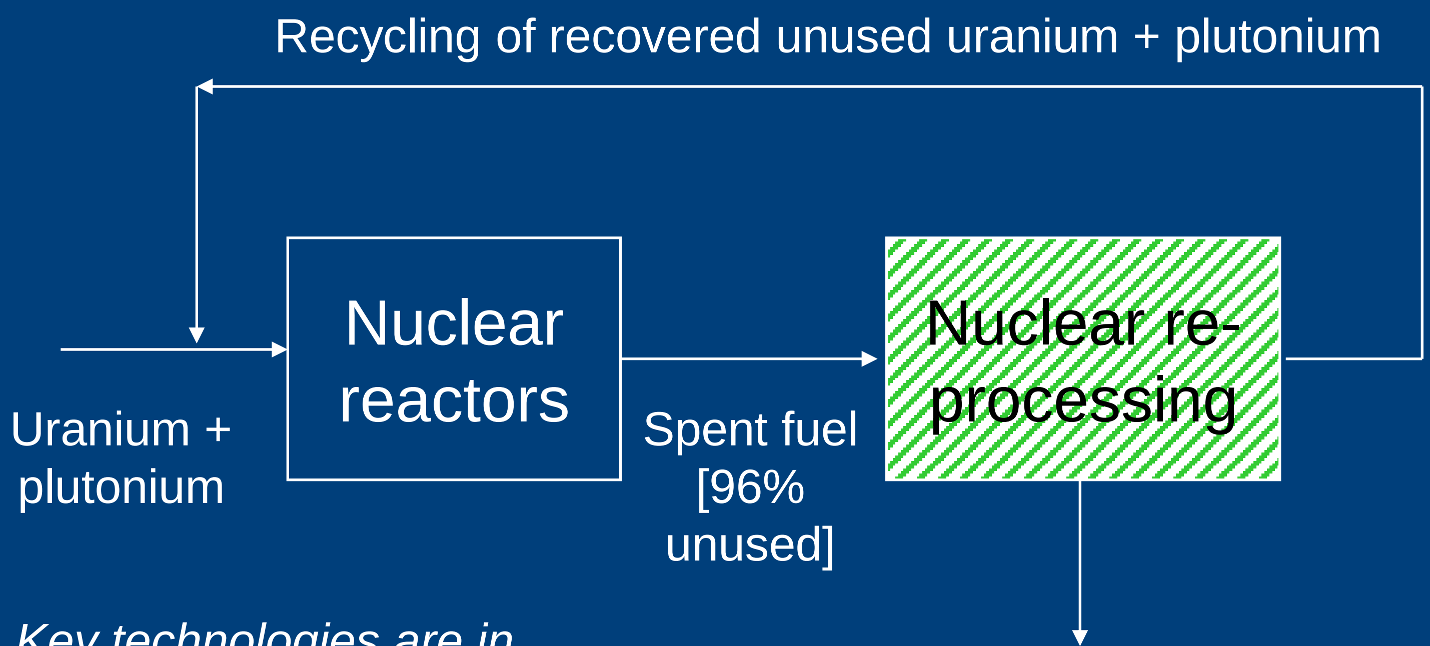
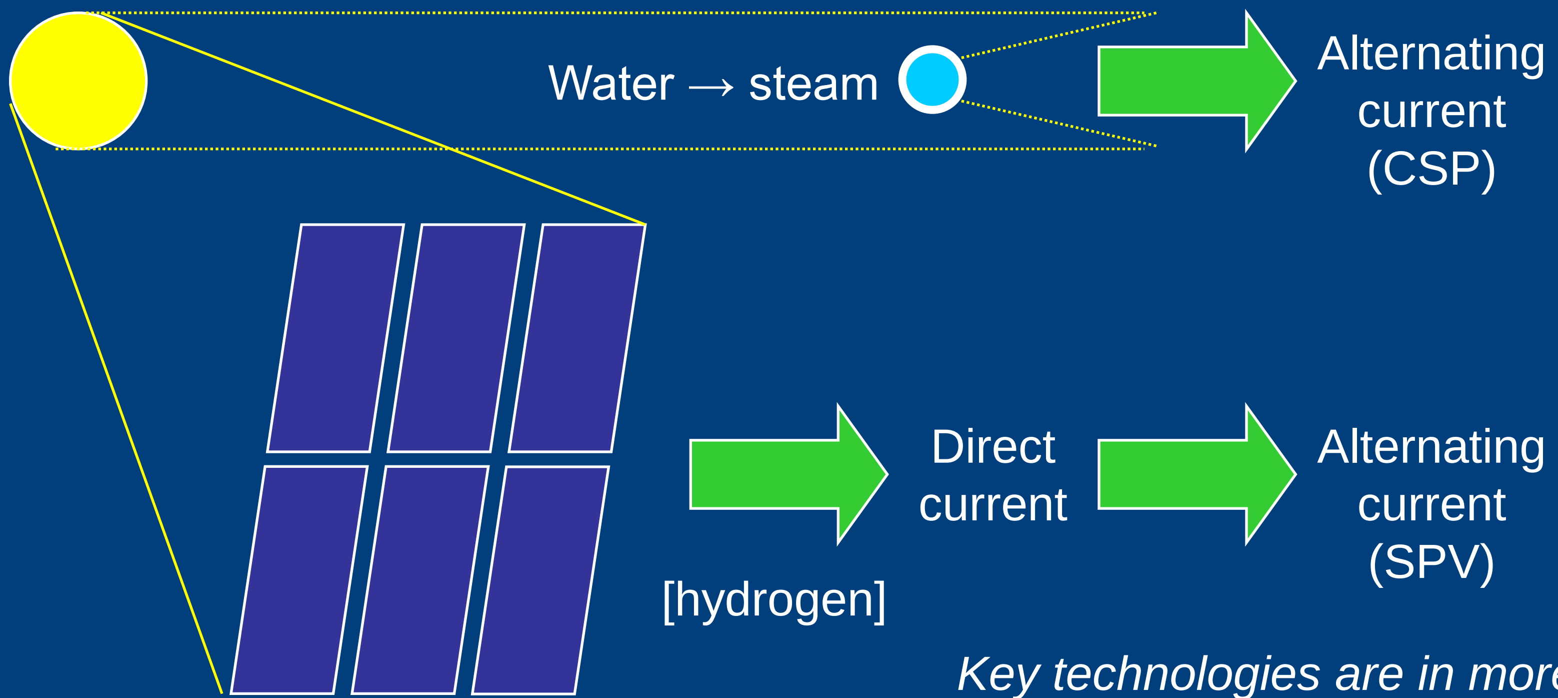
Nuclear cycle requires significant chemical science support



Radioactive solids and gases as waste material [some with half-lives of more than a million years]

Key technologies are in processing efficiencies, waste encapsulation, environmental and biological monitoring, and risk management

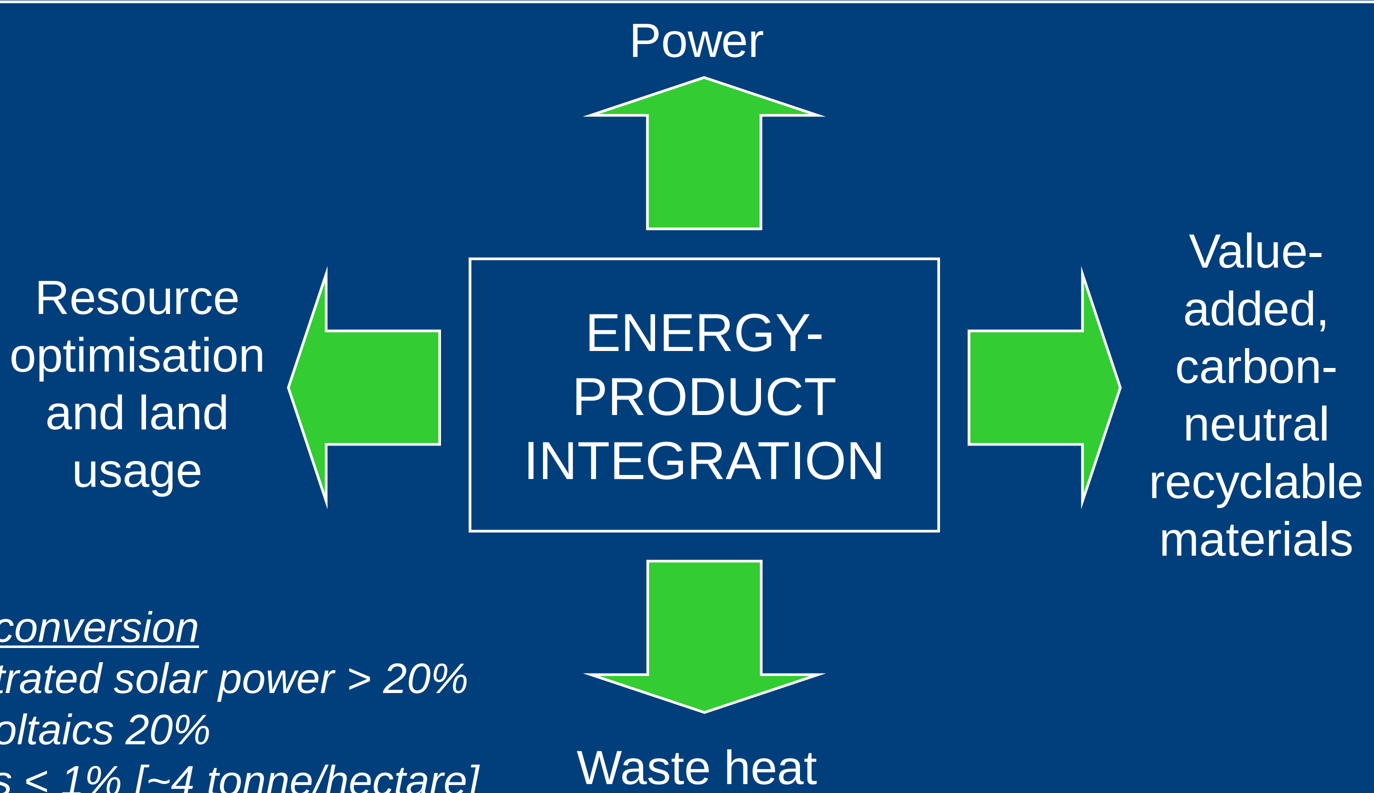
Long-term sustainable energy is likely to be from solar photo-voltaics (SPV) and concentrated solar power (CPS)



Even wind and tidal will require anti-corrosion coatings, based on nano-technology developments

Key technologies are in more cost-effective manufacture, energy conversion (from global annual average of 174 W/m^2 at Earth's surface), transmission efficiency, electricity storage, hydrogen storage and new materials for sustainability

Key issue will be making the best use of all resources – all chemistry driven



<u>Energy conversion</u>
Concentrated solar power > 20%
Photo-voltaics 20%
Bio-fuels < 1% [~4 tonne/hectare]

OPTIMAL AREA UTILISATION FOR FOOD, BIOMASS, PHOTO-VOLTAICS, POPULATION AND INFRASTRUCTURE?

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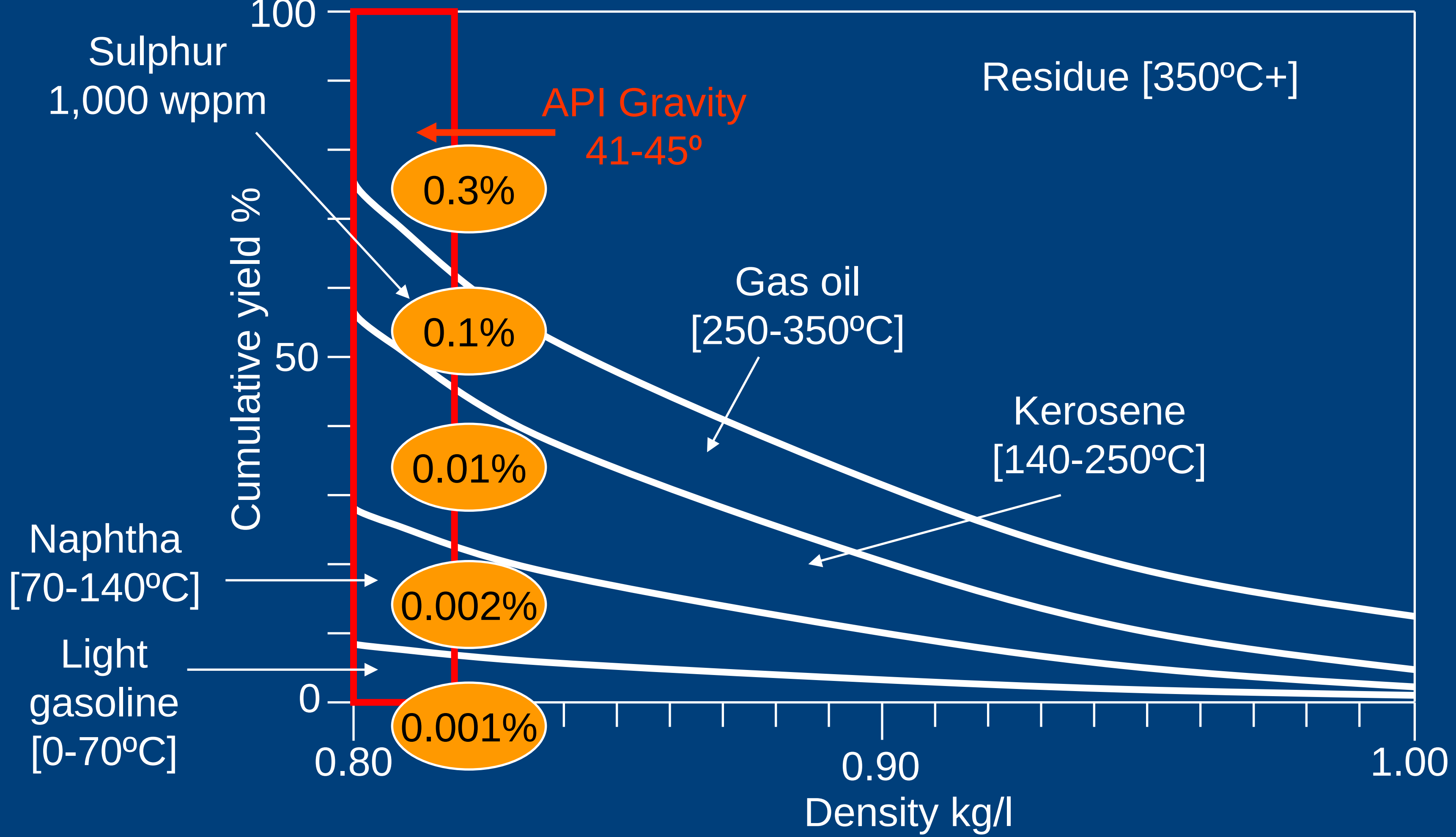
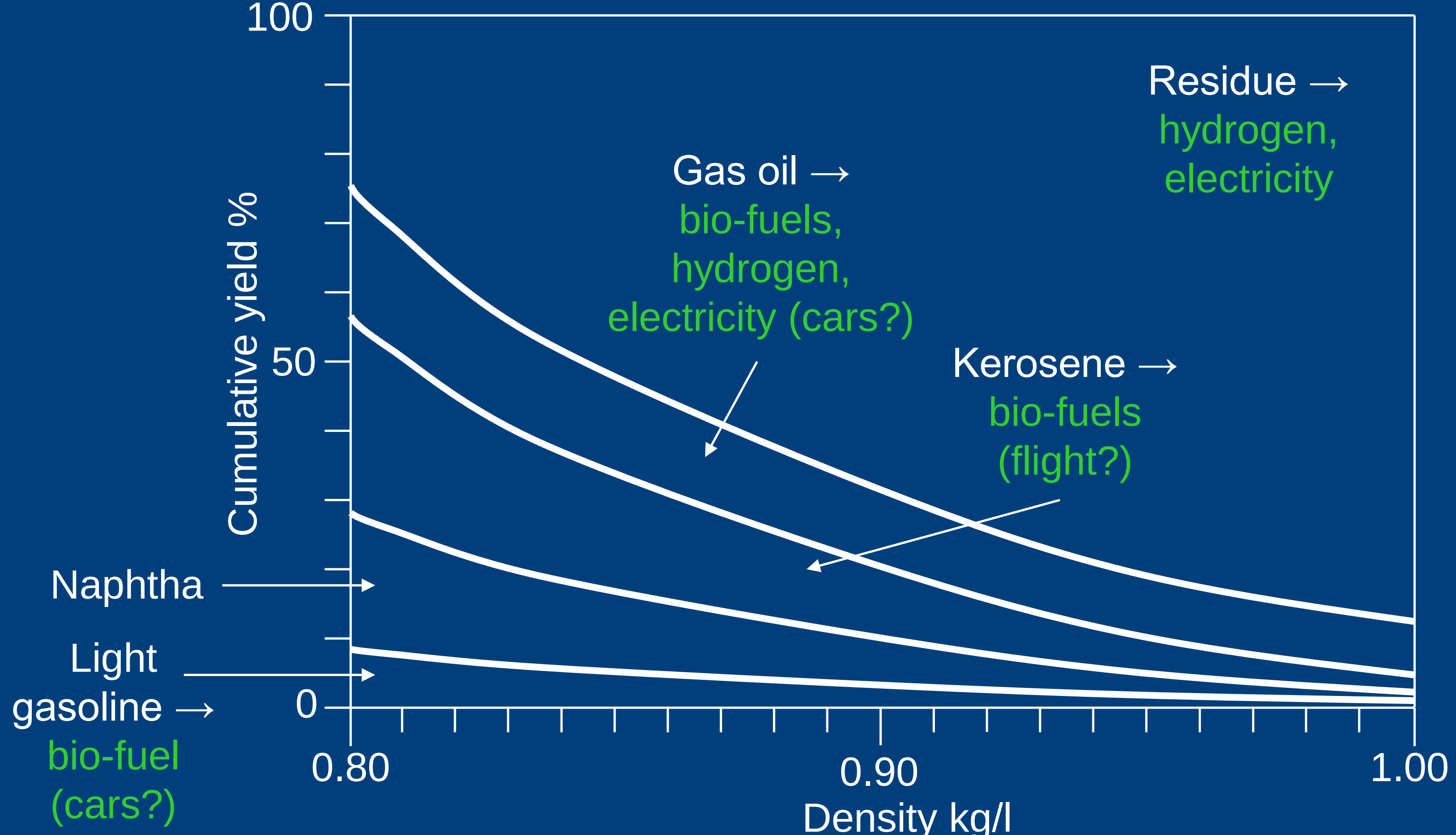
Eg bio-refinery with combined heat and power supporting the community with district heating

This is the principal oil 'slate' for 'green' substitution [34% of energy]



Illustrative substitutions by end-user application



Ethanol production steps by feedstock and conversion techniques

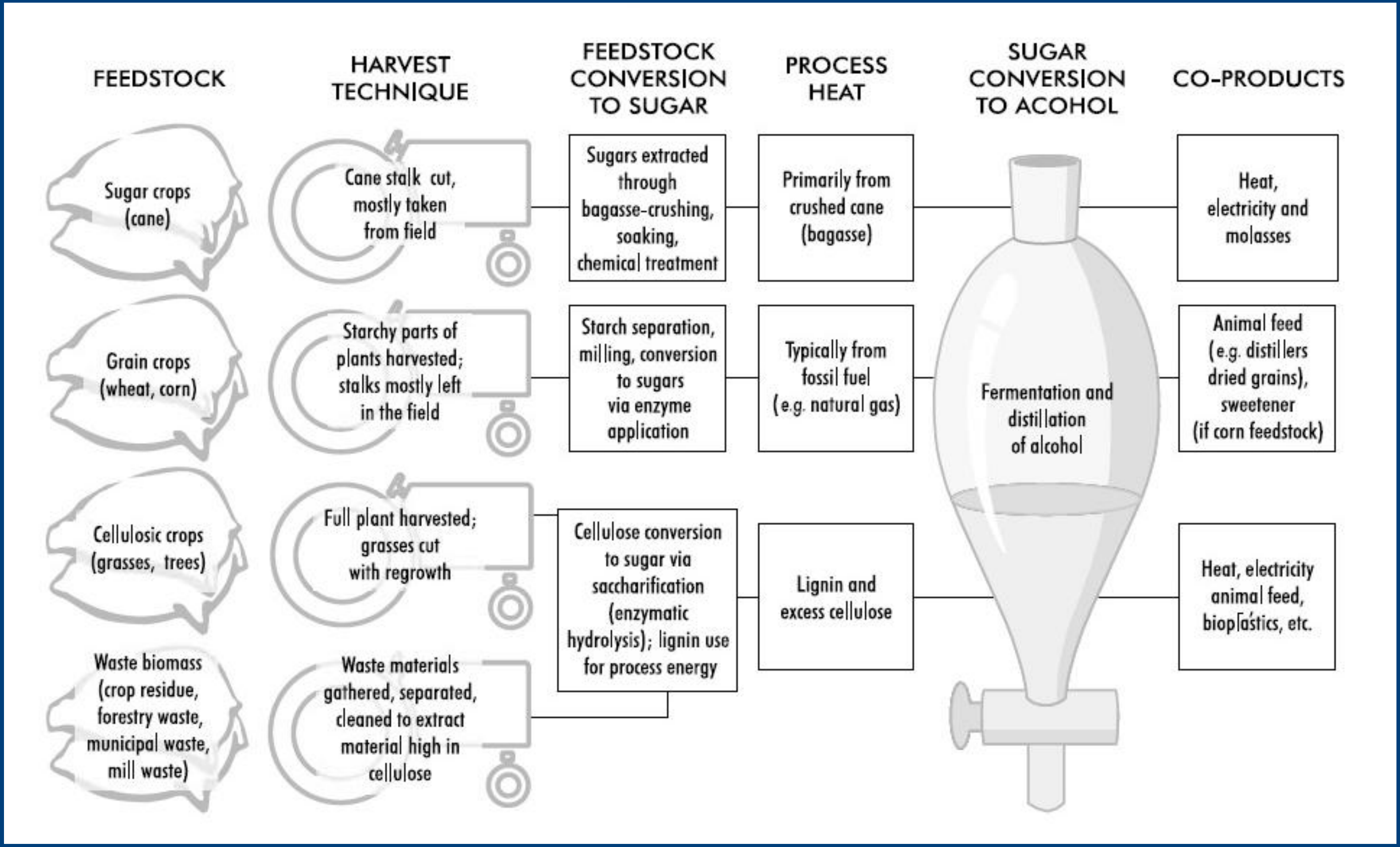


Figure taken from “Biofuels for transport – an international perspective”, IEA, 2004

Biodiesel production steps

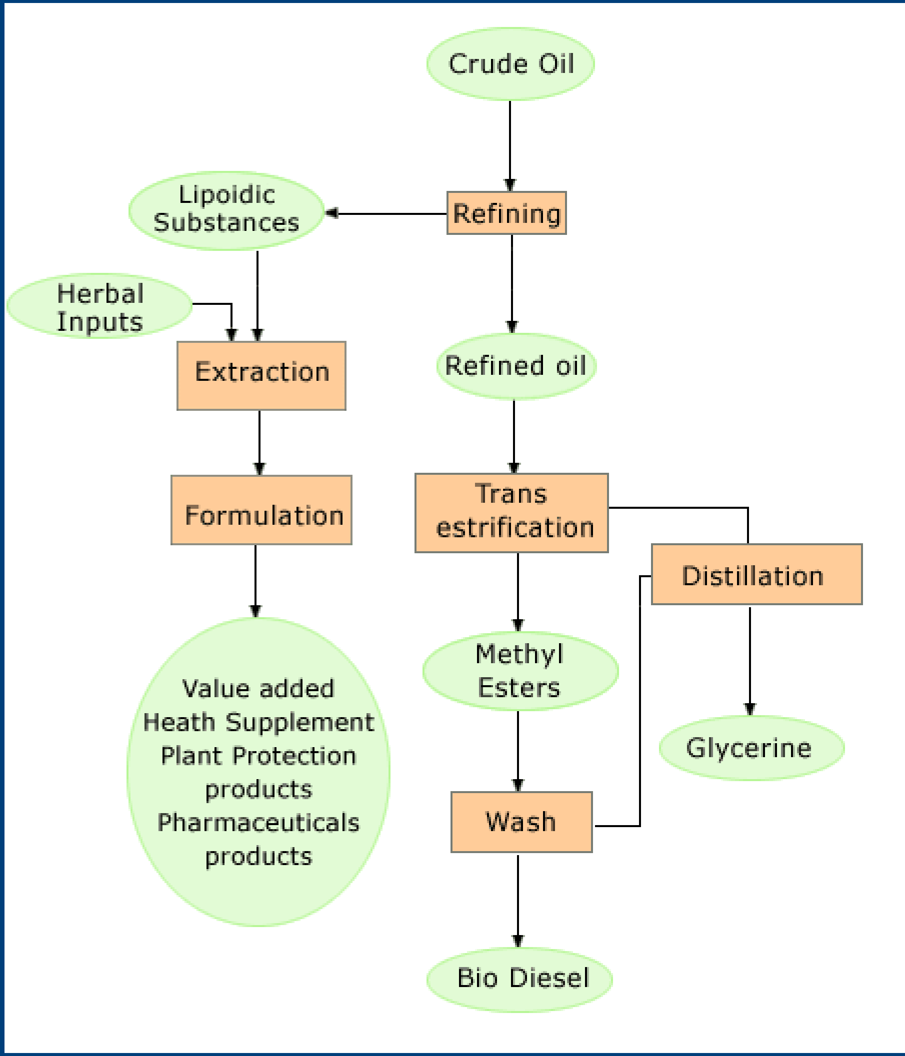


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Figure taken from www.aumconsultancy.com/gifs/flow-chart.gif

Biofuel yields per hectare for selected feedstock

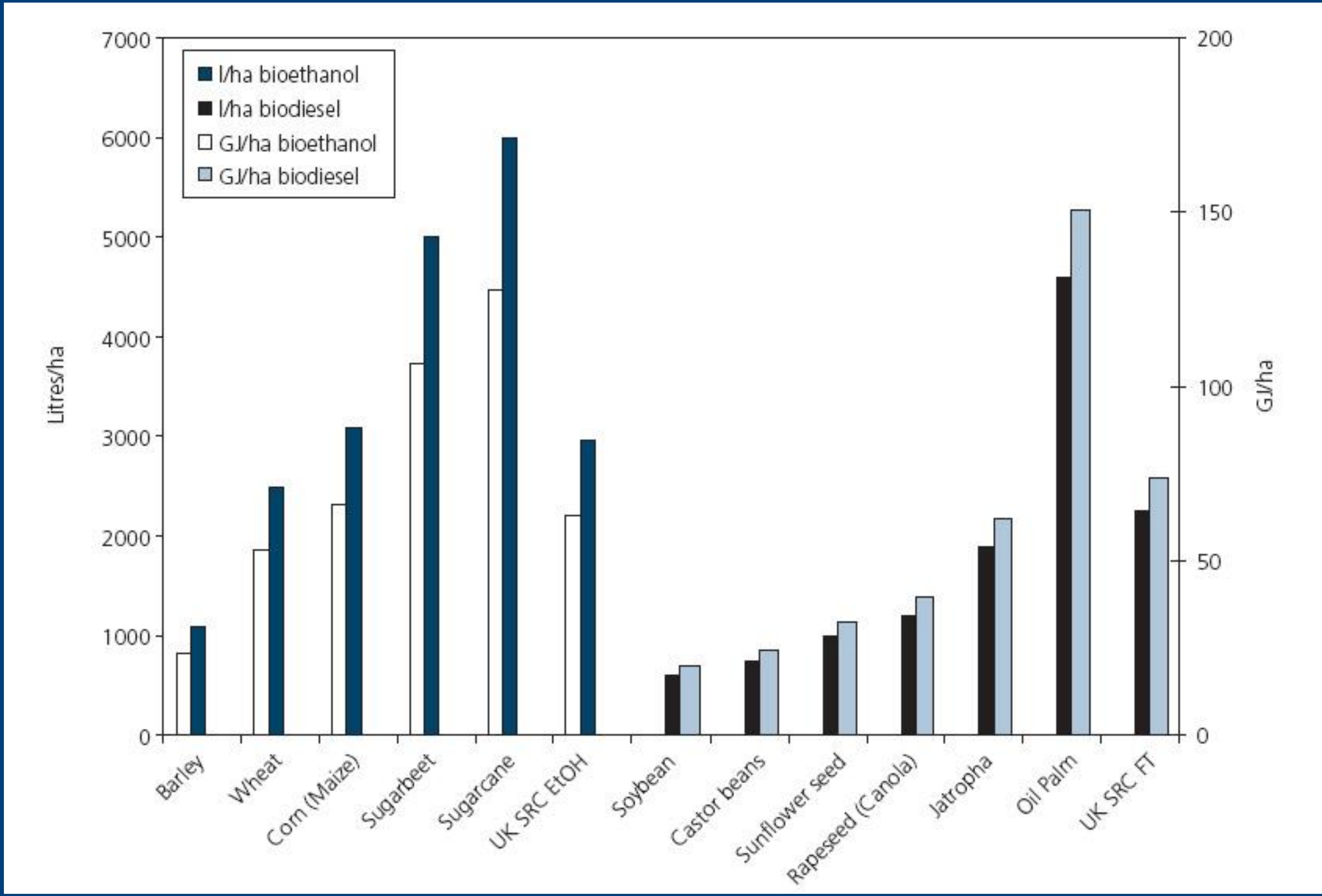

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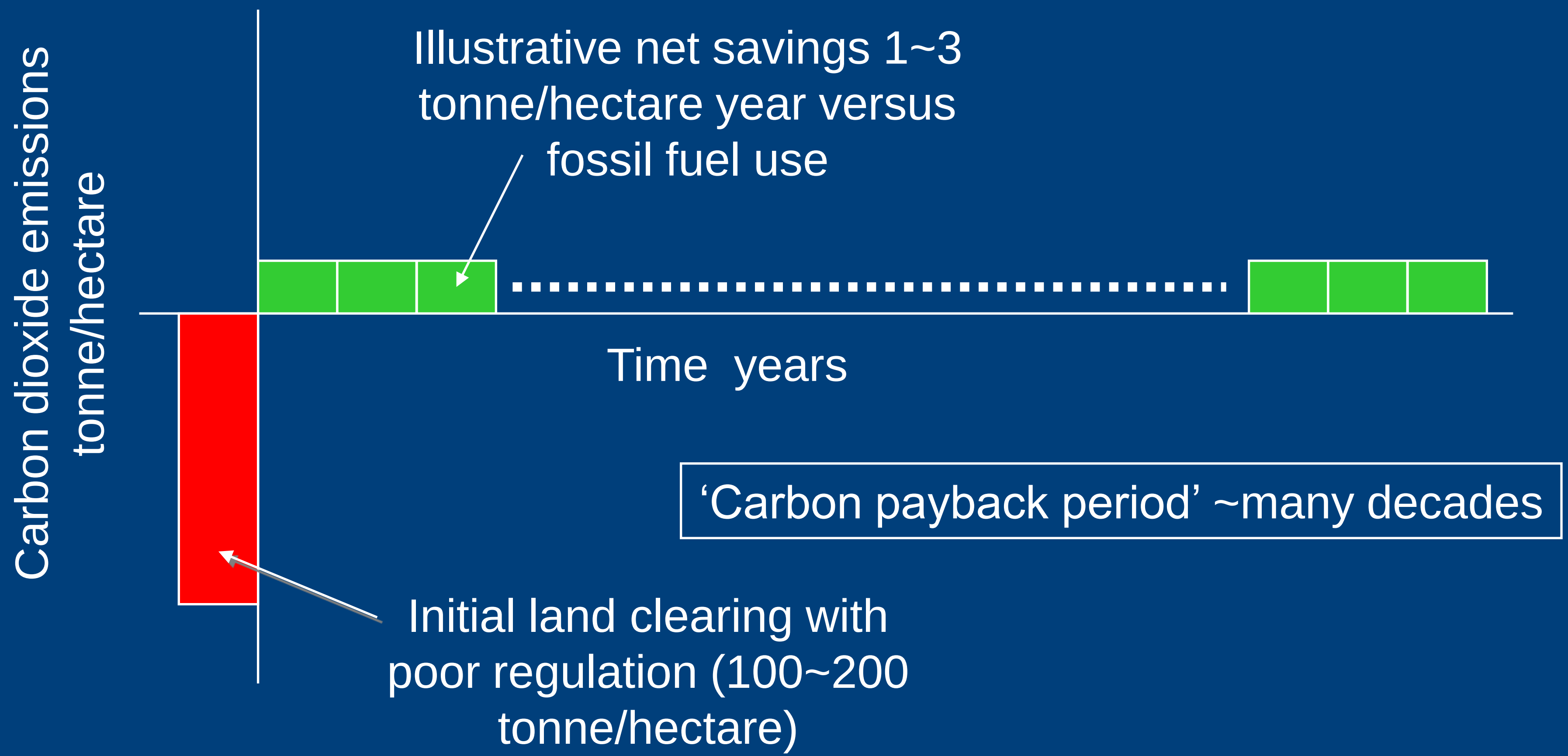
Figure taken from "Sustainable biofuels: prospects and challenges ", The Royal Society, policy document 01/08, January 2008

We need to consider LCA and carbon payback periods



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We must also encourage people to think ‘out of the box’

- Artificial photosynthesis to capture existing carbon dioxide in the atmosphere
- Combining this with photosynthetic electricity generation
- Massive reforestation, including genetically-modified plants (or even sea plankton) to capture carbon dioxide more rapidly, and recognition of fertiliser requirements
- Realisation that captured carbon dioxide must be ‘stored’ for thousands of years – biological devices will have to be prevented from decaying to avoid re-release of the gas
- Use of CCS even for biofuels, to provide net reduction in atmospheric carbon dioxide
- Reliable and safe CCS at the local level with micro-generation, and even for vehicles
- Photo-catalytic and biochemical decomposition of water to generate hydrogen

Chemical science can support the entire value chain and life-cycle analysis

RESOURCES
- -Geochemistry
- -Quantification
- -Extraction
- -Environmental monitoring
- -Fertilisers
- -Biomass development
- -Analytical chemistry

CONVERSION
- -Catalysis
- -Novel processes
- -Nuclear reactor science
- -Environmental monitoring
- -Materials chemistry
- -Hydrogen storage
- -Fuel cells
- -Photo-voltaic efficiencies
- -Energy-product integration
- -Battery technology
- -Light-weight materials
- -Analytical chemistry

WASTE MANAGEMENT
- -Carbon capture and storage
- -Nuclear fuel processing
- -Nuclear waste storage
- -Environmental monitoring
- -Recyclable materials
- -Biochemistry and genetics
- -Analytical chemistry

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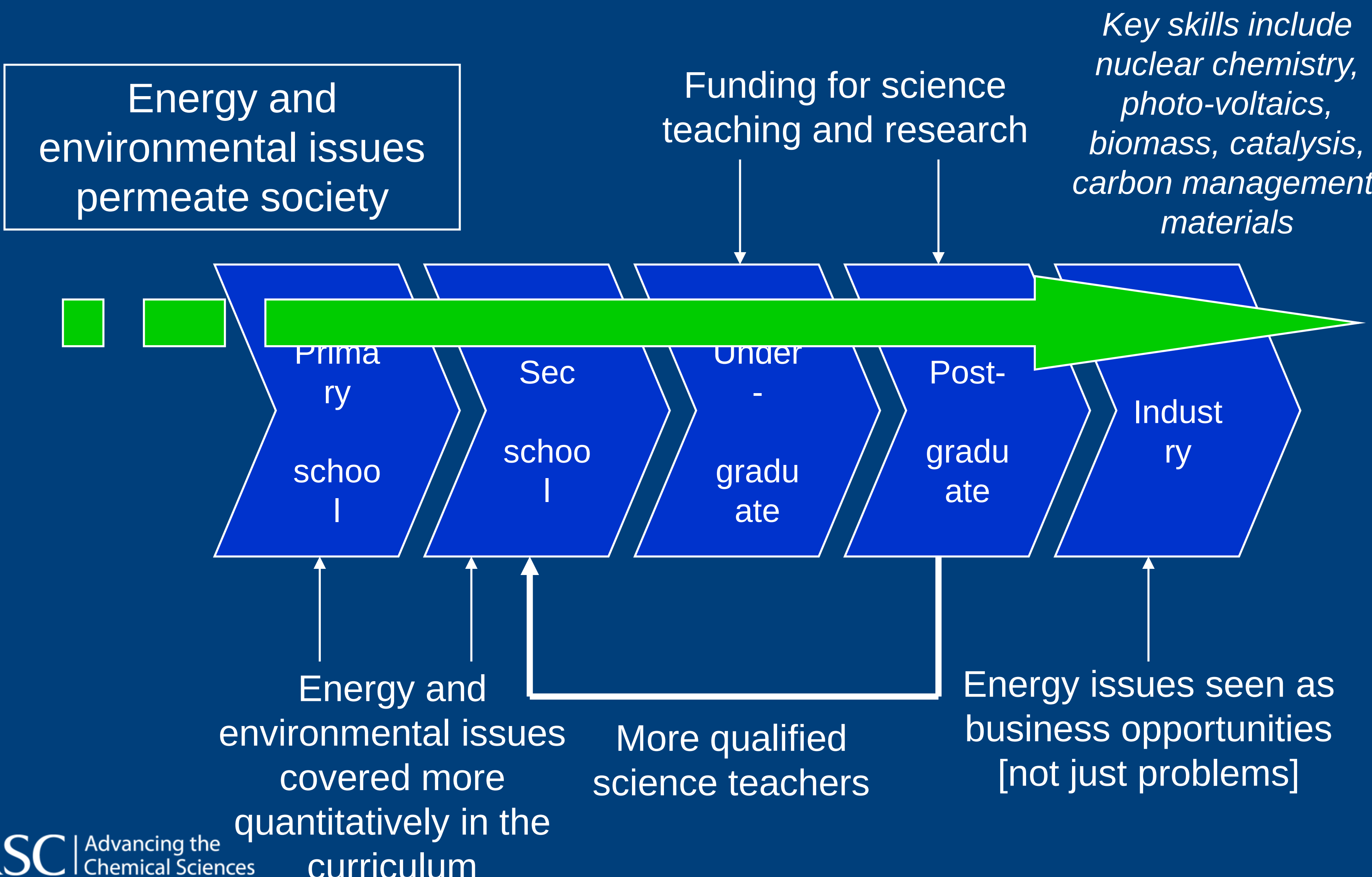
It will also be essential to have a supply chain of skills to support this



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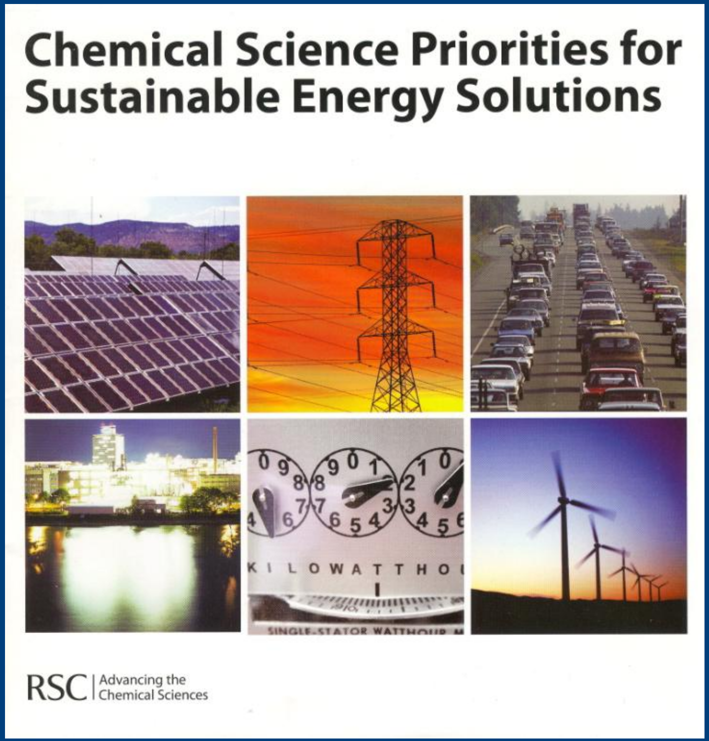
Key Royal Society of Chemistry document (2005)



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