Hybrid Nuclear-Fossil Systems for Low-Emission Production of Synthetic Fuels

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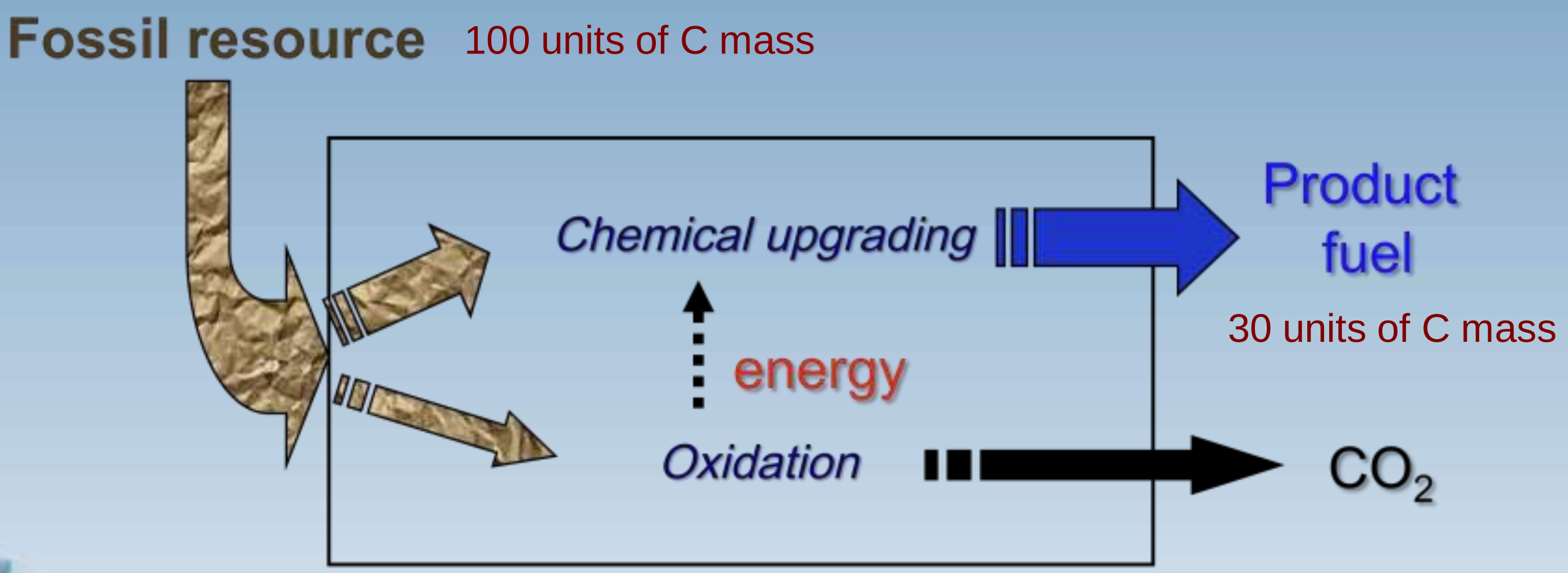
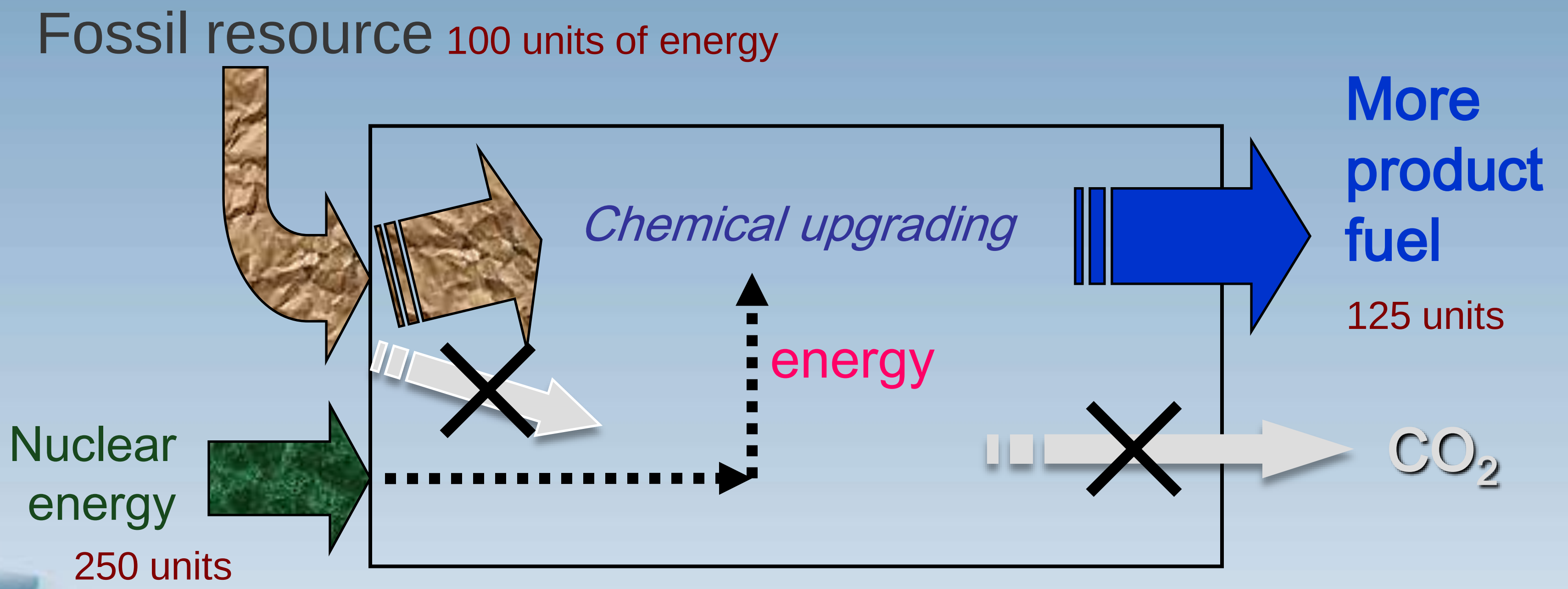
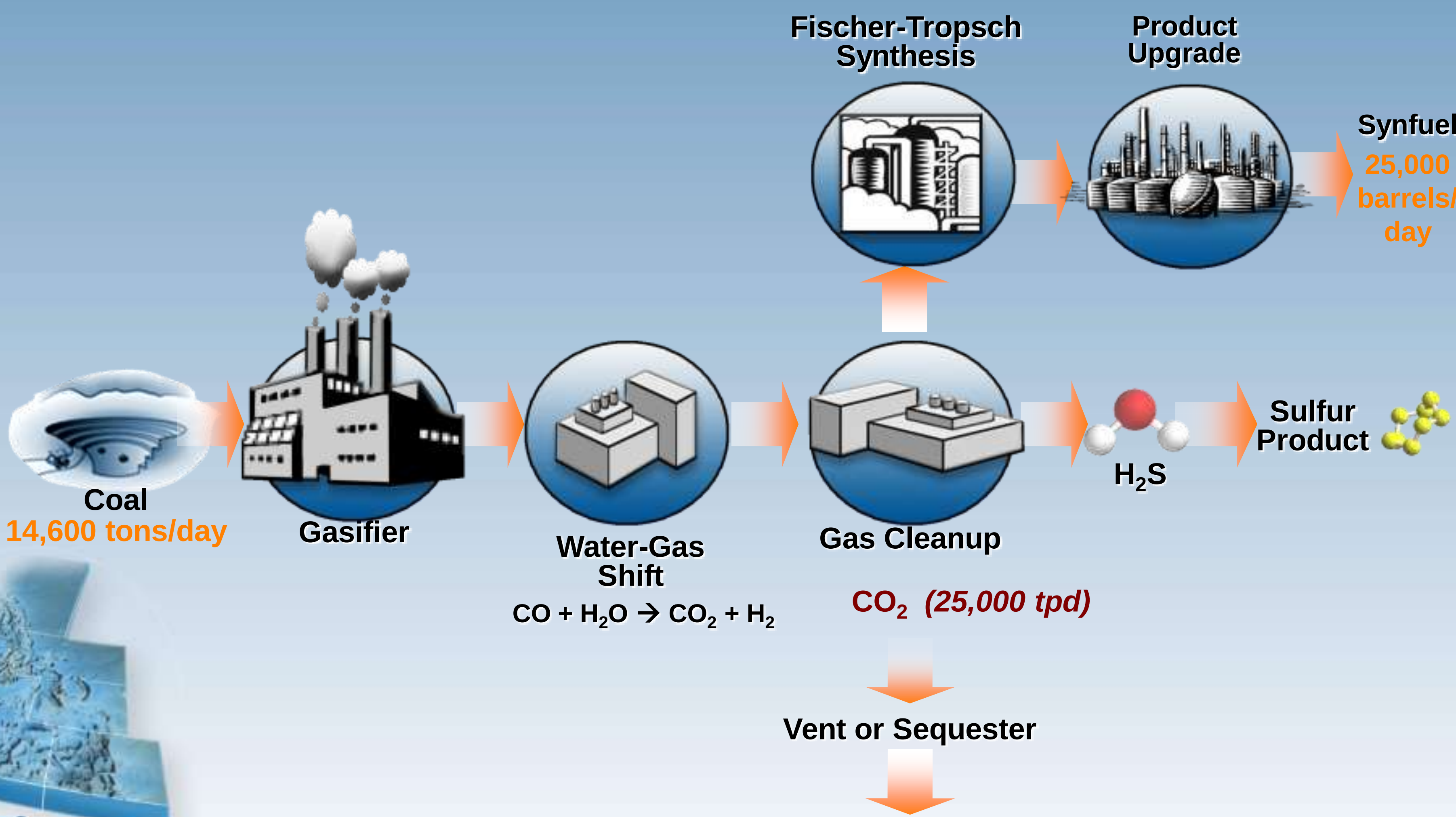
Traditional synthetic fuel processes



Strategy for nuclear integration

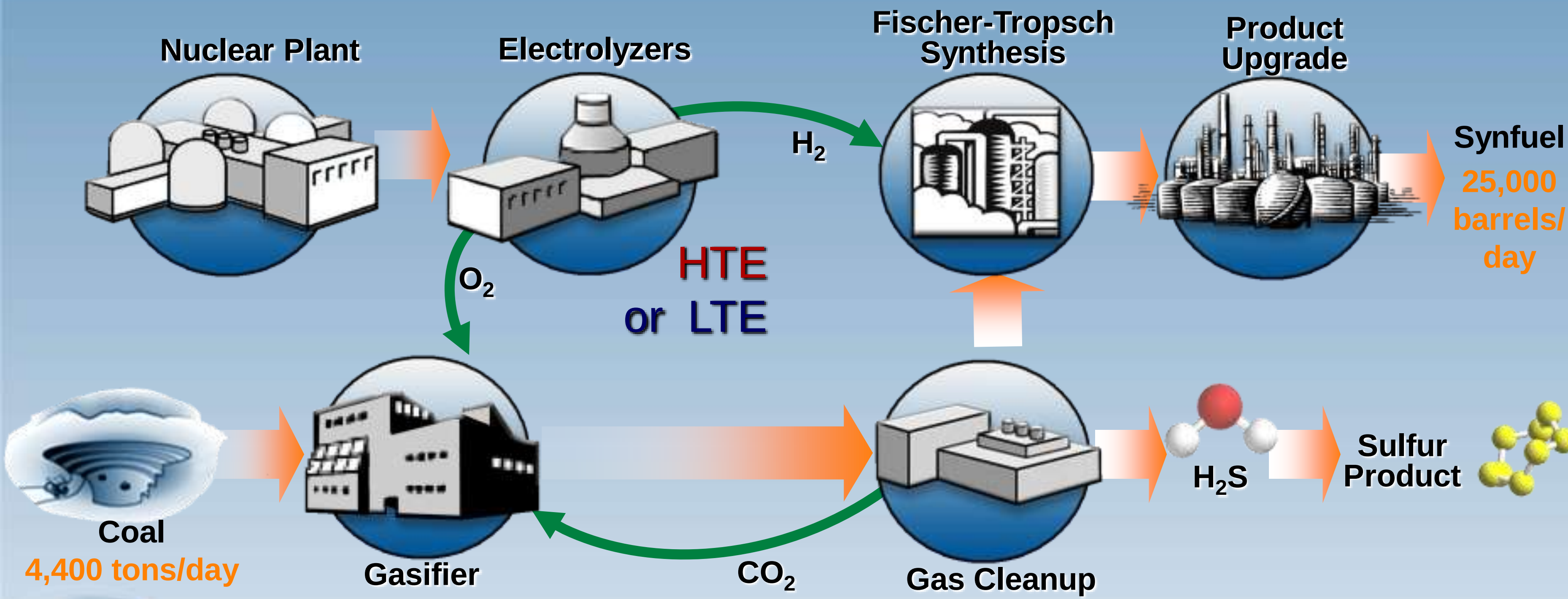


Example: Traditional Coal to Liquid



Over 65% of carbon in feed is lost

Nuclear Hybrid Coal to Liquid



- Uses 70% less coal
- Virtually no CO_2 emissions
- Over 95% of carbon in feed is converted to product

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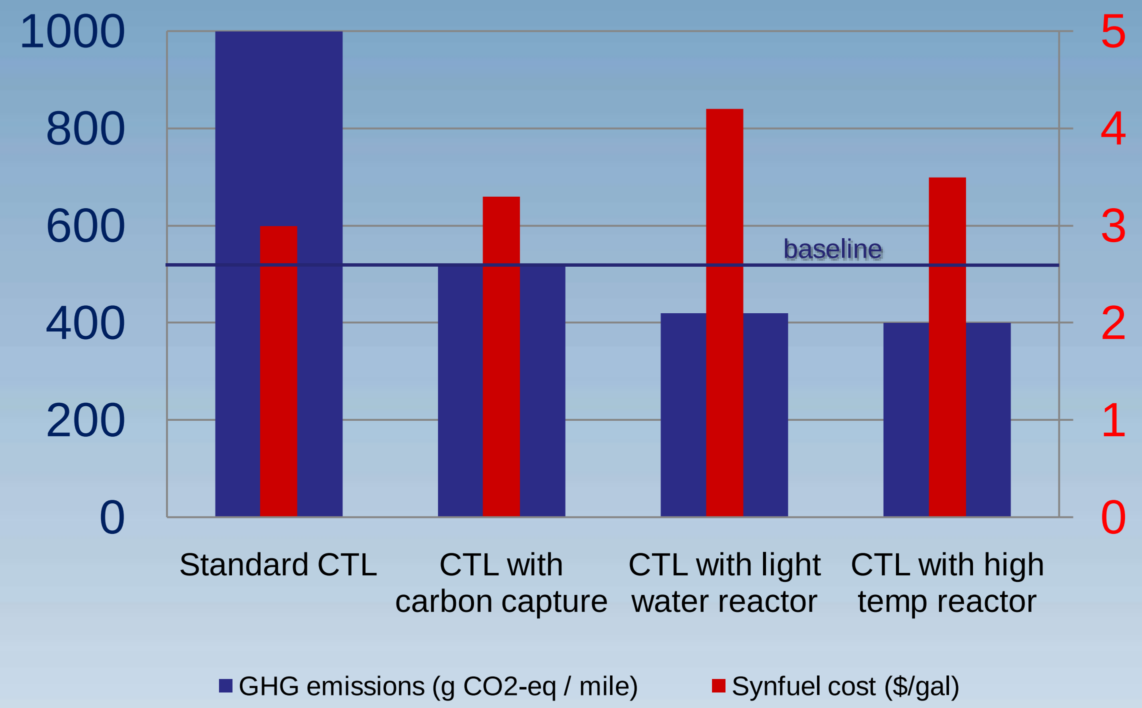
What do low emissions cost?



- Comparable to conventional CTL with CO_2 cost of $50/ton
- Major nuclear cost is capital cost of reactors (2002 costs)
- Only nuclear has a clearly lower carbon emission than the baseline of conventional light crude oil

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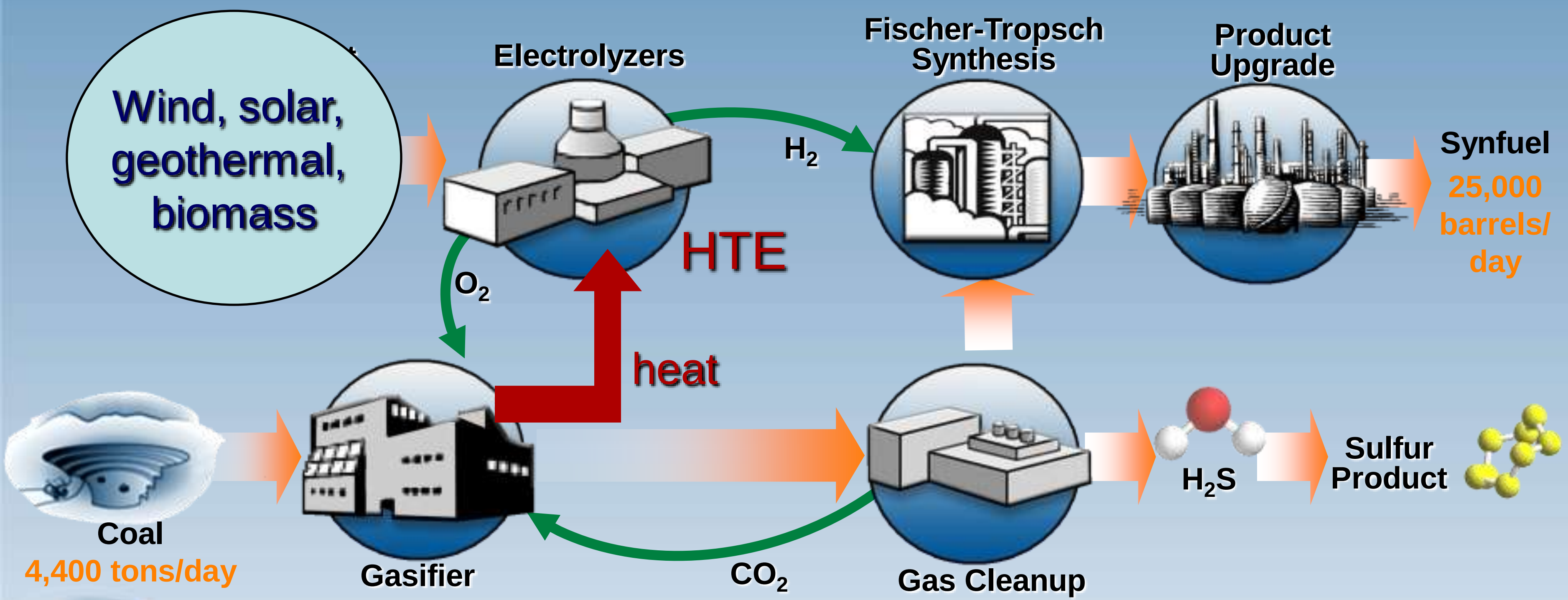
Can Also Use Other Energy Sources



- Uses renewables, but intermittency requires operating flexibility or storage of hydrogen and oxygen
- Can be smaller scale than with a dedicated nuclear plant

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Hybrid systems can use multiple feeds

Energy Sources

- Nuclear (Gen 3 and 4)
- Geothermal
- Biomass/MSW
- Supplemental wind/solar

Energy Forms

- Heat at various levels
- Electricity
- Shaft work
- Steam
- Water splitting (H_2)
- Air separation (N_2 / O_2)
- Desalination
- Waste heat recovery, nonevaporative cooling

Carbon Sources

- Biomass
- Coal / petcoke
- Oil shale / oil sands
- Heavy petroleum
- Carbon dioxide

Hydrogen Sources

- Methane
- Water

Processes

- Synthetic diesel / gasoline
- Methanol / dimethyl ether
- Synthetic natural gas
- Ethylene / propylene
- Ammonia / fertilizers

Secure, low CO_2, domestic supplies

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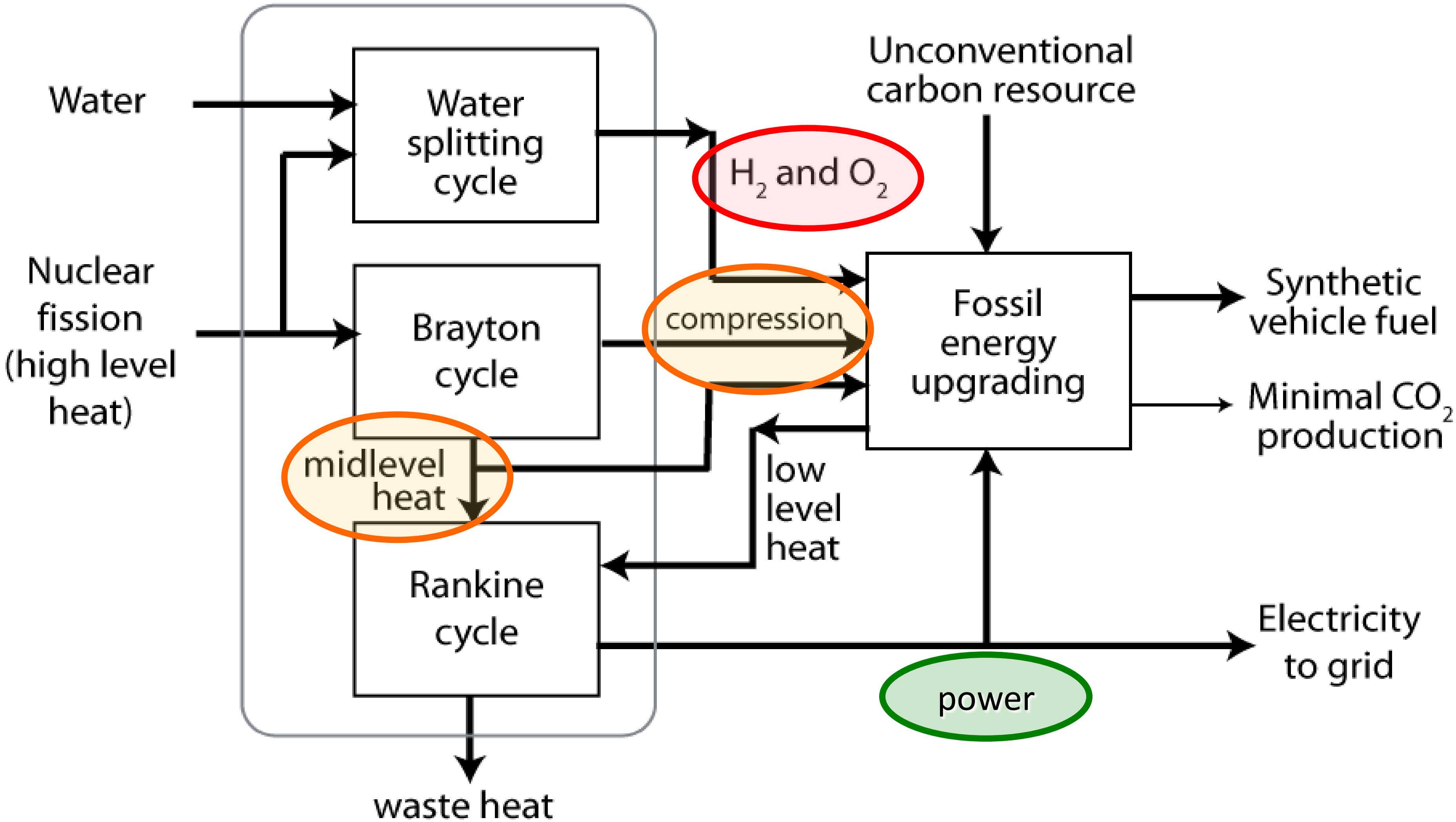
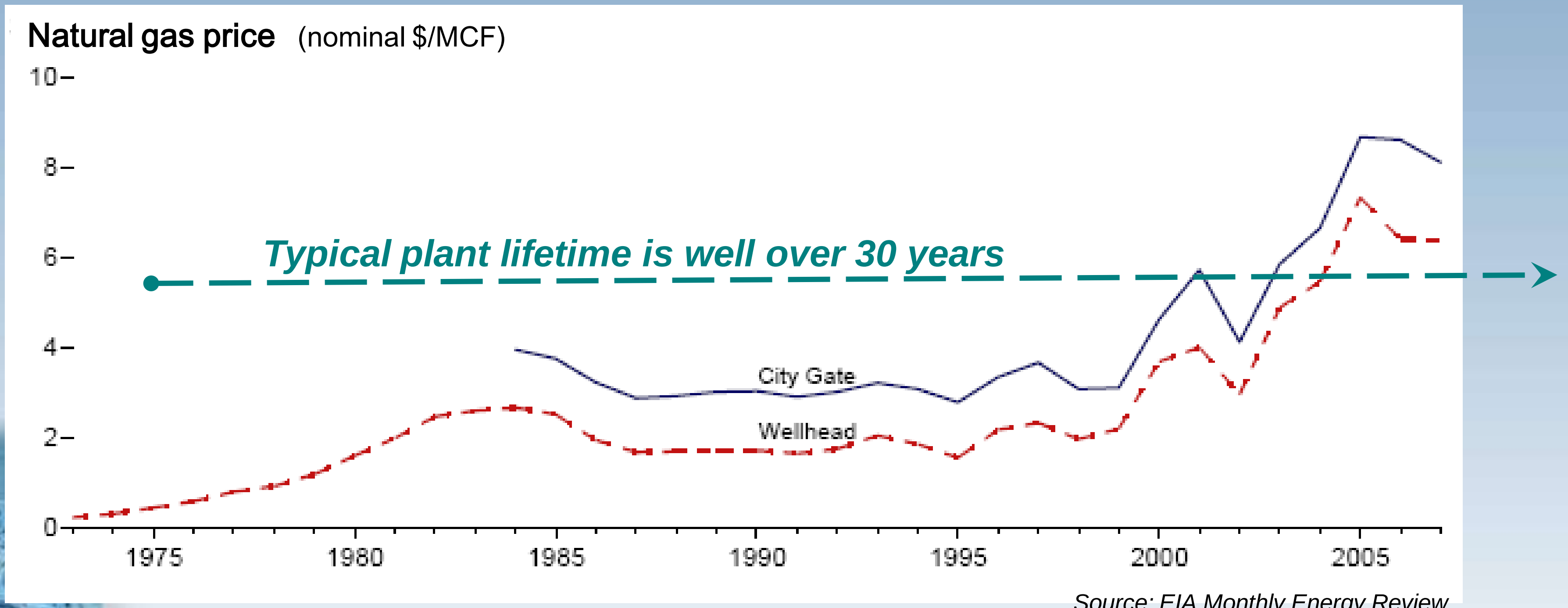
Nuclear Energy for Upgrading



Why conversion flexibility?

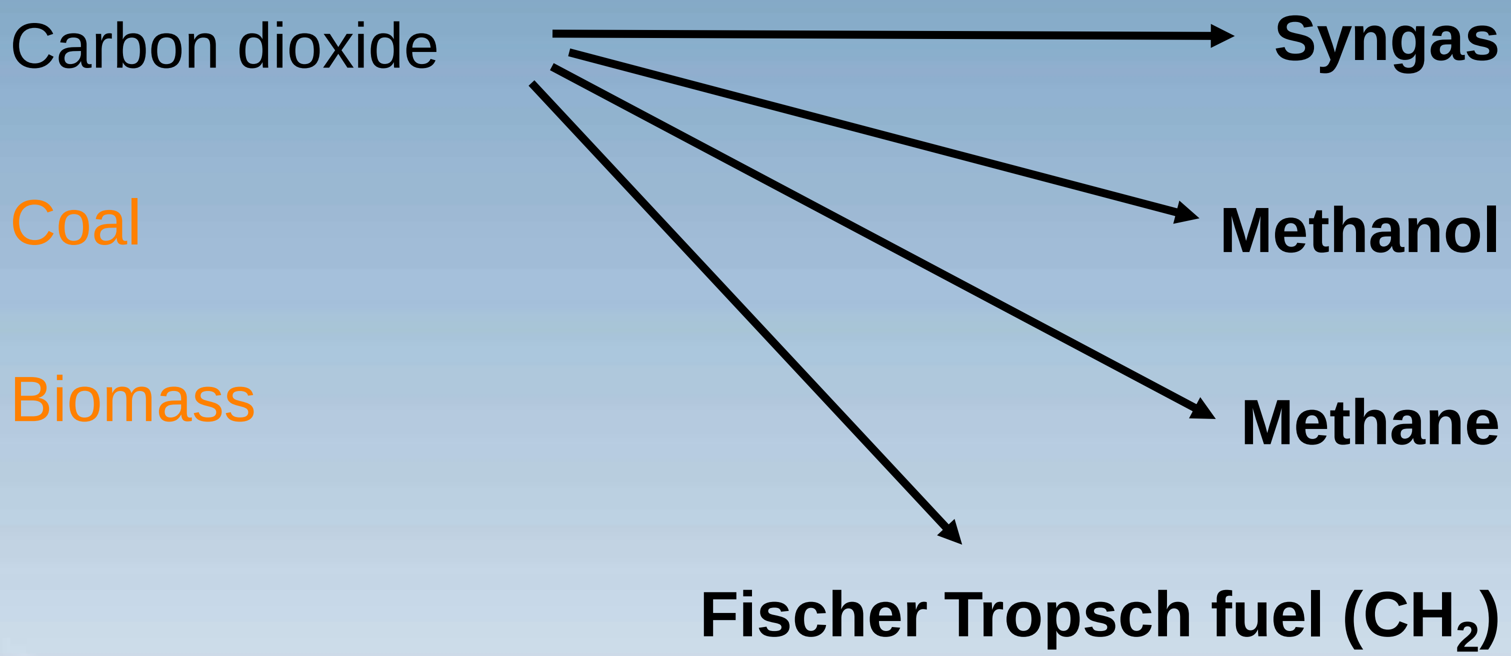
Demand, alternatives, and relative costs change faster than facilities do



Source: EIA Monthly Energy Review

Synfuel + O_2

CO_2 + H_2O
+ energy


Carbon dioxide
Coal
Biomass
Syngas
Methanol
Methane
Fischer Tropsch fuel (CH_2)

Assumptions

- Reactions at standard conditions of 25 C and 1 atm
- Thermal input/recovery efficiency is 70%
- Electrolysis efficiency is 75% based on electricity. Power generation is 33%, for 25% overall thermal efficiency

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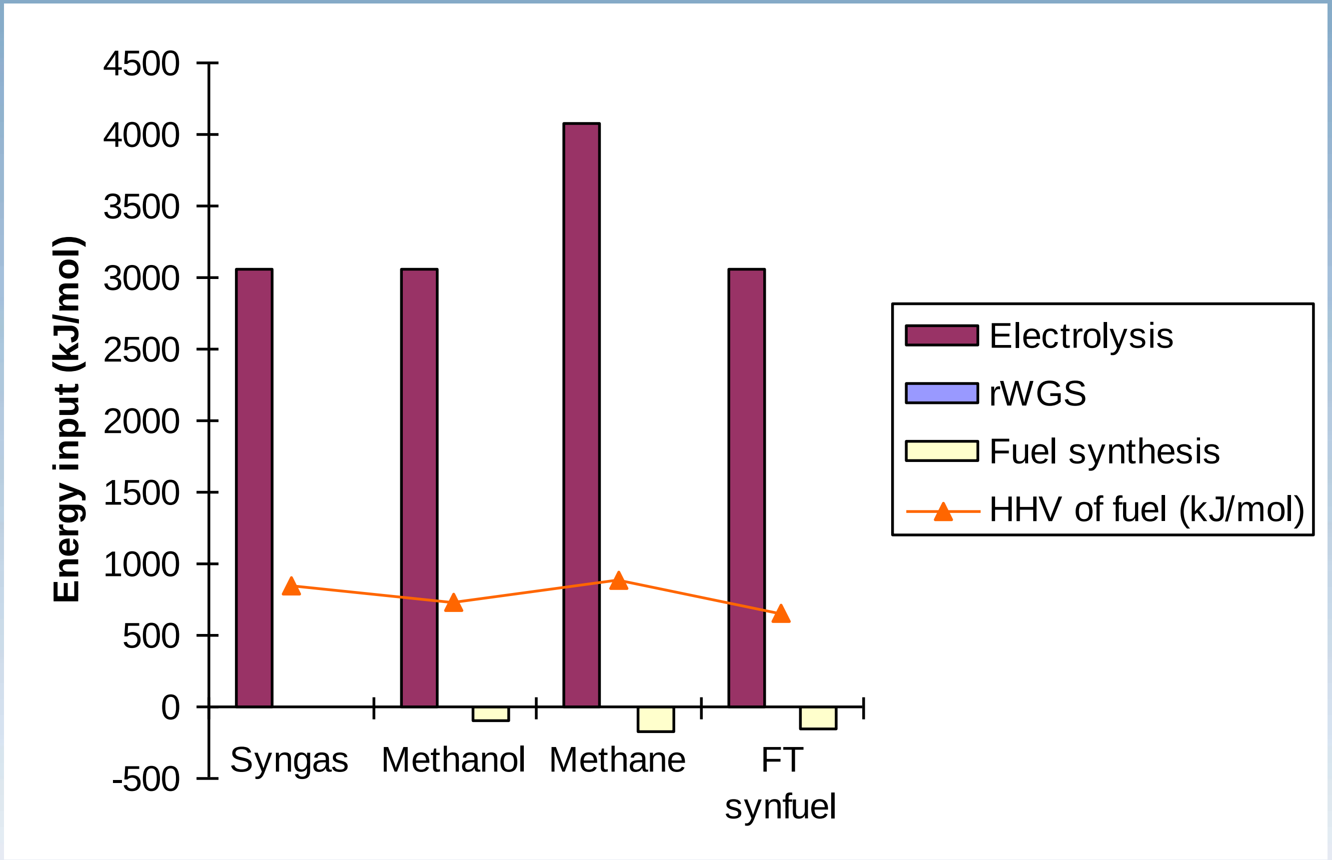
All synfuels require similar energy input when starting from CO_2



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Carbon dioxide → Methanol

Coal (CH) → Methanol

Biomass (CHOH) → Methanol

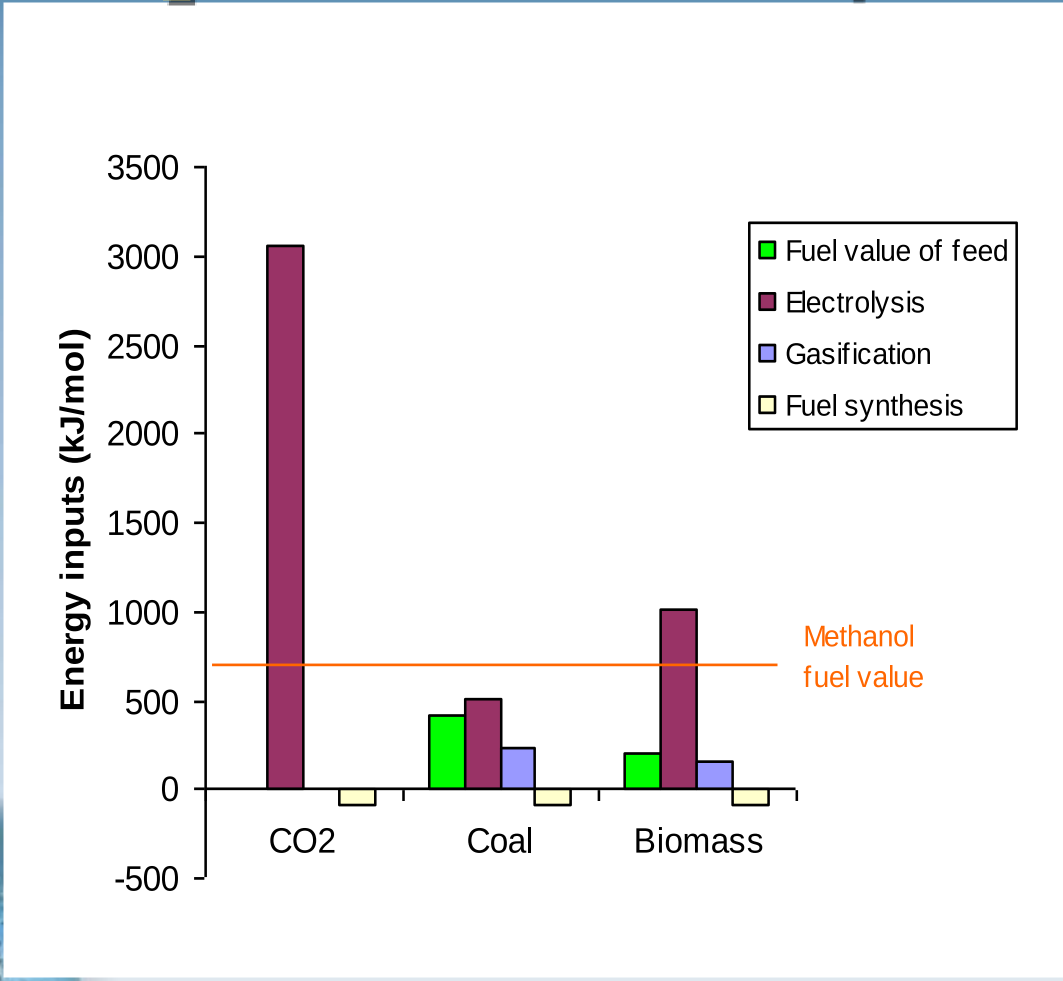
Syngas

Methanol

Methane

Fischer Tropsch fuel (CH_2)

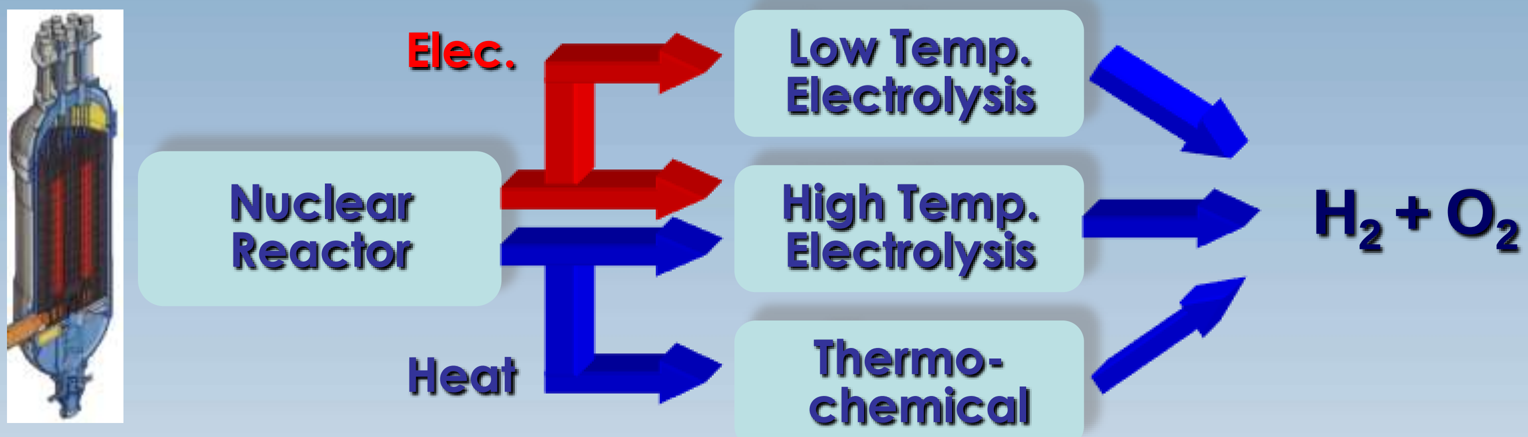
CO_2-to-methanol requires much energy



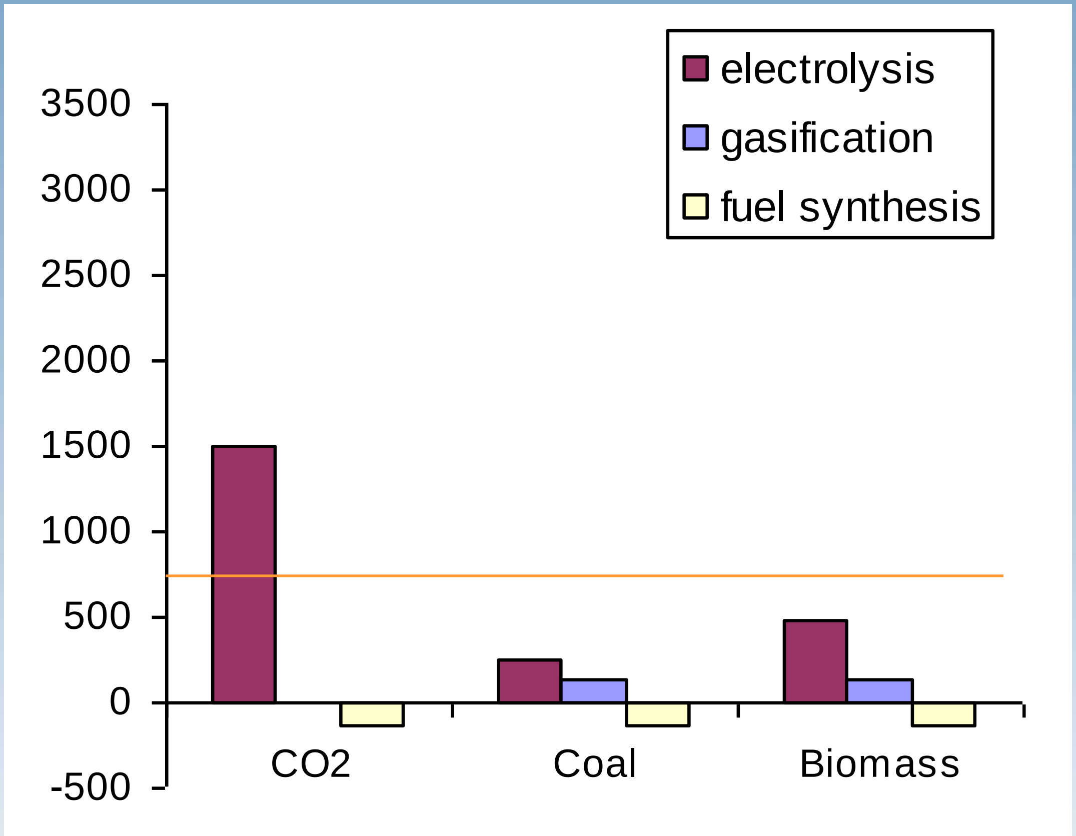
Why is CO_2 so different?

- Largest need for H_2
- Low production efficiency
  - Electrolysis 75%
  - Power generation 33%

Alternative water-splitting routes to make H_2



High Temp Electrolysis looks better



Data from J. O'Brien/INL

Overall View of the HTE Test System

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Nuclear energy's potential roles

Hydrogen

Near term

- natural gas
- coal
- **biomass**
- **electrolysis**

Long term

- **high temperature electrolysis**
- **thermo-chemical water splitting**
- gas hydrates

•Courtesy Dr. R. Carrington

Carbon

Near term

- natural gas
- coal / petcoke
- **unconventional fossil**
- biomass

Long term

- coal
- biomass
- **unconventional fossil**
- gas hydrates
- **CO_2 recycling**

Energy

Near term

- coal
- natural gas
- **nuclear**

Long term

- **nuclear**
- renewables
- gas hydrates
- coal with CO_2 capture

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Conclusions

- When making synfuels, consider the sources of carbon, hydrogen, and energy individually

- Nuclear systems provide a low CO_2 source of energy, but the conversion efficiency between energy forms (heat, electricity, hydrogen, others) is important