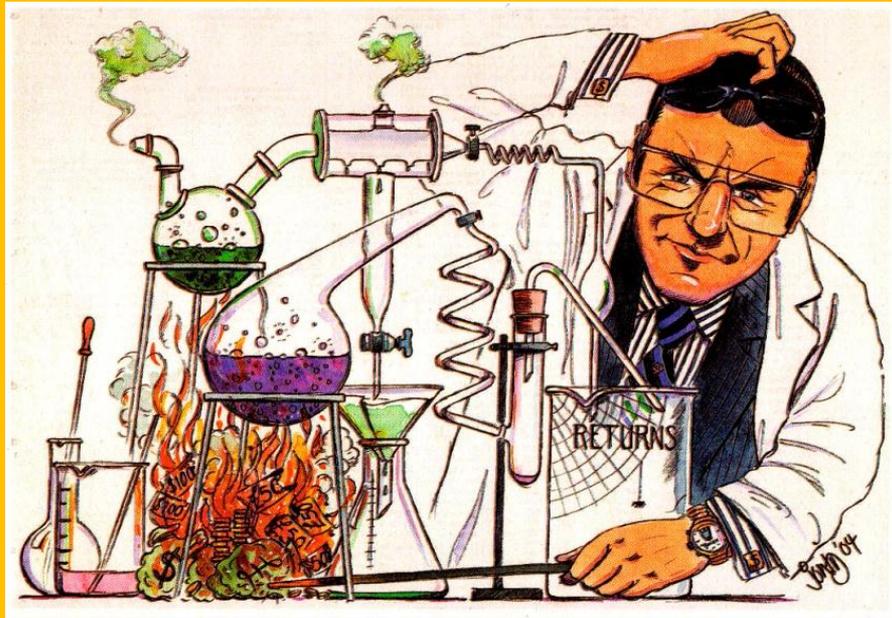


The Chemical Industry



Fertiliser, Sulphuric Acid,
Petrochemical, Pharmaceutical and
Chemical Industries

The question is how to make a profit from science

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Industrial Chemistry



Fertiliser Industry and Haber process



Sulphuric Acid Industry



Petrochemical Industry and Natural Gas



Plastics Industry



Pharmaceutical Industry



Industrial Chemistry

The UK chemical industry is the nation's 4th largest manufacturing industry and the 5th largest in the world.

The 3 largest sections are

- (a) food, drink and tobacco,
- (b) mechanical engineering and
- (c) paper, printing and publishing

All chemical plants require a source of **raw materials**, which can either be non-living eg minerals, or living, eg plants and micro-organisms. (collectively known as biomass).

A chemical plant produces the desired products.

The process used to manufacture the product may be operated in **batch** or **continuous** sequences.



Batch versus Continuous manufacturing in the Chemical Industry

	Batch	Continuous
For	<p>OK for up to 100 tonnes per annum.</p> <p>More versatile.</p> <p>Good for multi-step reactions.</p>	<p>OK for over 1000 tonnes per annum.</p> <p>Good for fast single step processes.</p> <p>Easy to automate.</p>
Against	<p>Contamination of product is more likely.</p> <p>At times, no product is made.</p> <p>Safety more of an issue.</p>	<p>Capital cost is high.</p> <p>Less flexible.</p> <p>Need to run at full capacity to make a profit.</p>



Costs

Cost considerations

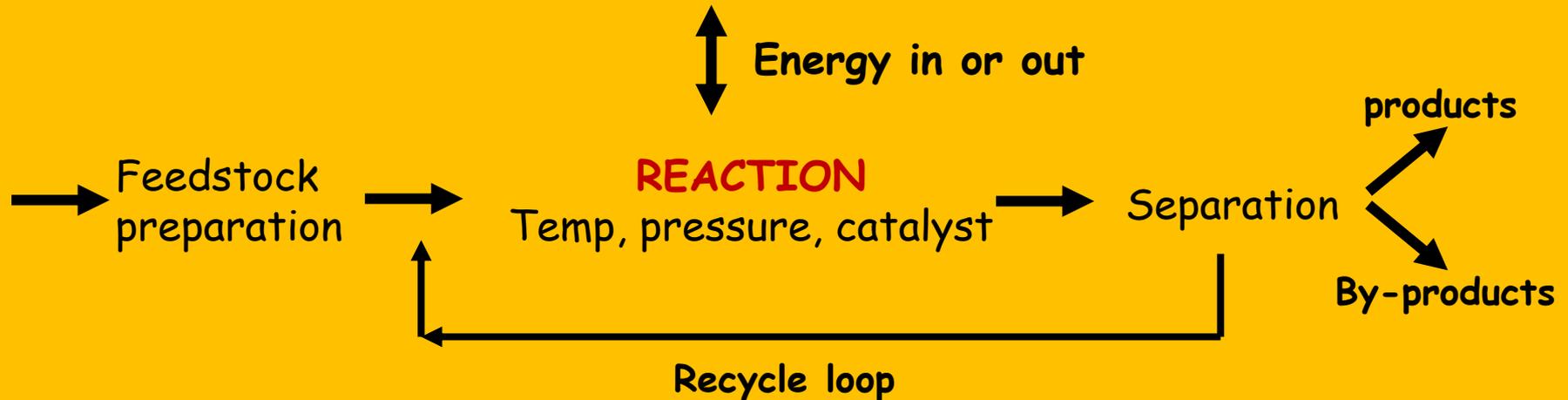
Capital costs: The one-off cost of constructing the plant and all the associated costs of all buildings.

Variable costs: The cost that changes throughout the year and is dependant on how much product is sold. e.g. Buying raw materials, treating waste and despatching the product.

Fixed costs: The annual cost of the staff, local rates, advertising and utility bills.



Economic considerations



Consideration has to be given to:

Operating conditions

Costs, capital, fixed and variable

Use of energy

Location of the Chemical industry

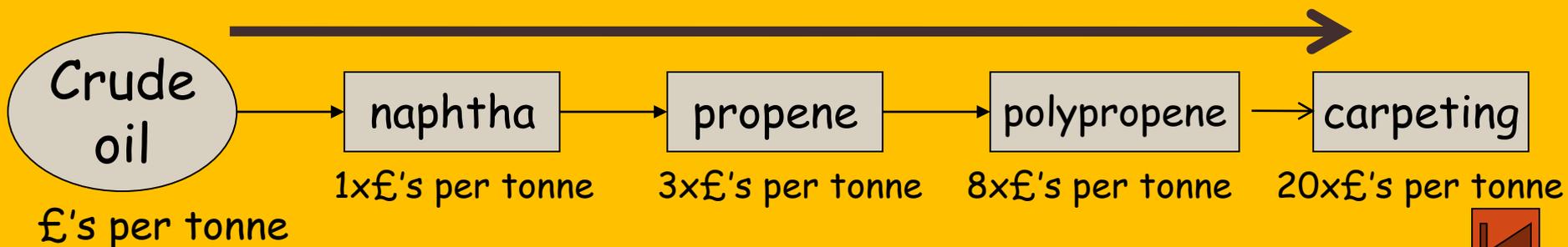
Safety and the environment



Choices to be made

1. Cost, availability of feedstocks
2. Yield of the reaction
3. Can un-reacted materials be recycled?
4. Can by-products be sold?
5. Cost of waste disposal
6. Energy consumption, generating your own, conservation, use of catalysts, recycling of heat, (heat exchangers),
7. Environmental issues

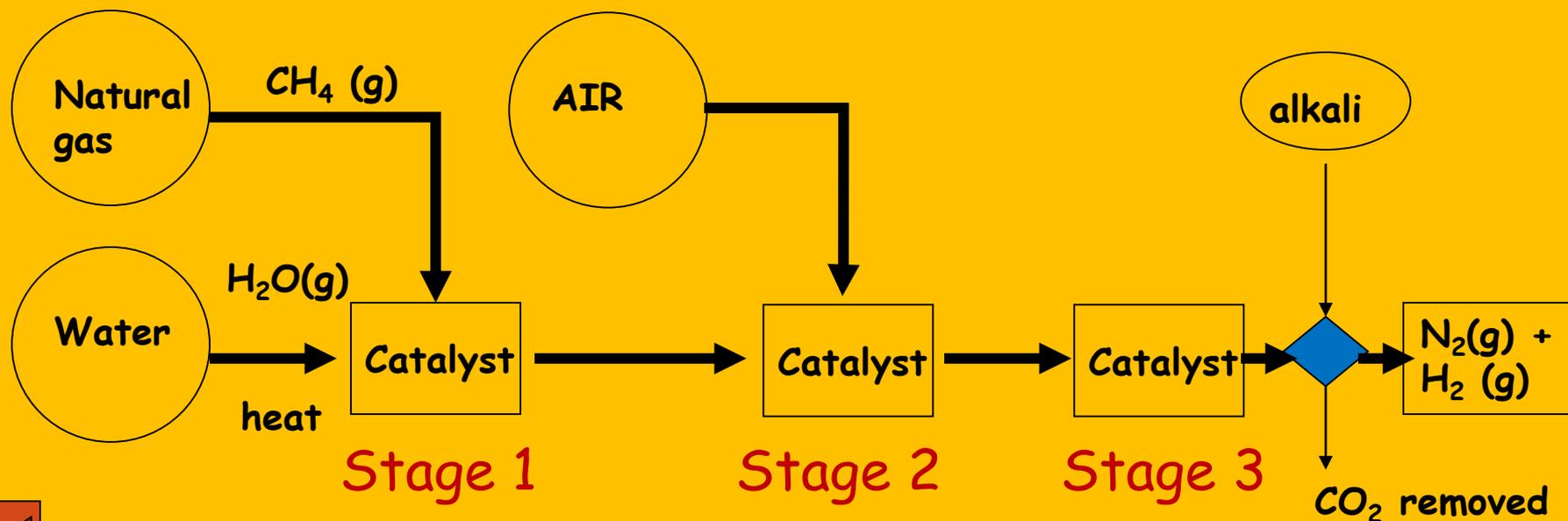
Value added, eg increasing the value of the products from crude oil



Fertiliser Industry

Haber Process

Ammonia is manufactured from N_2 and H_2 . The nitrogen is available from the **raw material**, air. (something which is available naturally). The other **feedstock** for the manufacture of NH_3 is hydrogen which is usually produced from methane.



Haber process

Reaction
Conditions



Low **temperature** shifts the equilibrium to the right, but means a slow reaction rate. Fe catalyst improves this. A high **pressure** favours also shifts the equilibrium to the right because this is the side with fewer gas molecules.

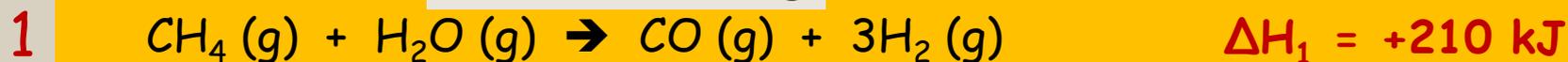
Temperatures around **500°C** and pressures of over **150 atmospheres** give a **yield** of ammonia of about **15%**.

Product removal: In practice, equilibrium is not reached as unreacted gases are recycled and the ammonia gas is removed as a liquid.



Haber Process, overall, an exothermic process

Steam reforming



Synthesis gas

In order to achieve a ratio of 3x hydrogen to nitrogen, stage 1 and 3 need to be 3.5x greater than stage 2.

Combining the three stages



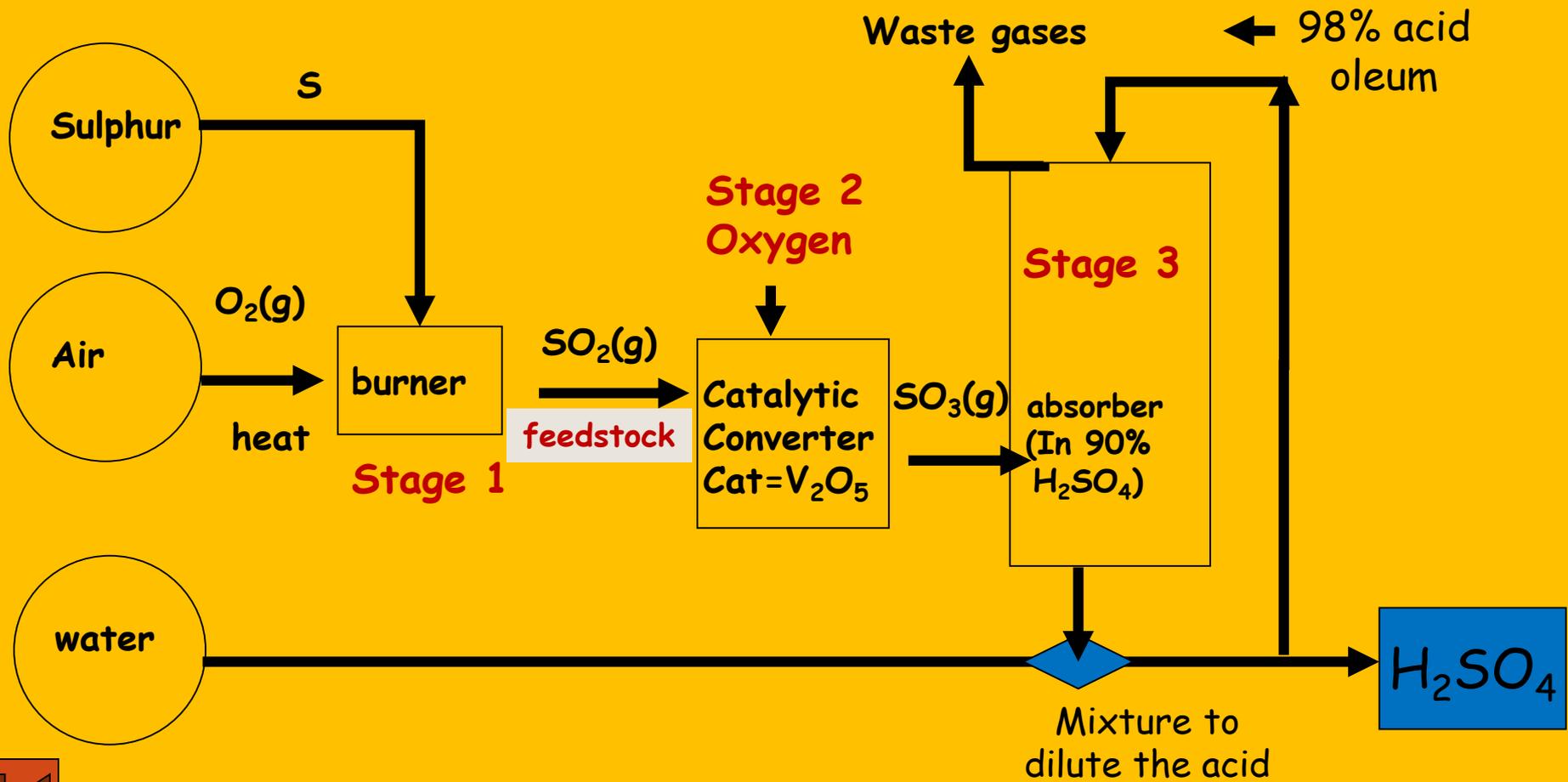
$$\Delta H_1 = (+210 \times 3.5) \text{ kJ} \quad \Delta H_2 = -(484) \text{ kJ} \quad \Delta H_3 = -(41 \times 3.5) \text{ kJ}$$

$$(\Delta H_1 + \Delta H_2 + \Delta H_3) \Delta H_{\text{total}} = -41 \text{ kJ}$$



Sulphuric Acid Industry

Sulphuric acid is manufactured by the Contact Process.



Sulphuric Acid

The **raw materials** for the manufacture of H_2SO_4 are H_2O , O_2 from air and S or a compound containing sulphur.

Possible sources of the raw material, **sulphur**

- SO_2 from smelting of ores, eg ZnS . The SO_2 is converted into sulphuric acid rather than released into the atmosphere.
- CaSO_4 , the mineral anhydrite, is roasted with coke (C) and SiO_2 (sand)
- S deposits in the ground.
- S can be extracted from oil and natural gas.



The catalyst (V_2O_5) does not function below 400°C , a 99% yield is obtained.



The acid produced is absorbed in 98% H_2SO_4 . If dissolved in water too much heat is created and gases are lost to the atmosphere.



Petrochemical Industry

Grangemouth is one of the UK's major oil refineries and petrochemical plants. The crude oil is processed to increase its market value.

Oil refining is a **continuous process**. The fractions produced have many uses and heavier fractions are further processed by **cracking** which produces **key feedstock** for the plastic industry.

Refinery gas, eg propane and butane bottled gases

Gasoline, which is further purified and blended to make petrol

Naphtha, a feedstock for the plastic industry

Kerosine, which can be used as an aviation fuel

Diesel,

Fuel oil, e.g. ships, power stations, industrial heating

Residue, which produce lubricating oil, waxes, bitumen

Refining tower



Plastics industry

- The UK Plastics industry sales account for about £17.5 billion i.e. 2.1 percent of UK G.D.P.
- The processing sector accounts for £12.4 billion.
- The Industry employs 230,000 in polymer and additive manufacture, polymer processing and machinery manufacture.
- There are over 5000 firms processing plastics with material usage increasing year on year.
- Nearly 25 percent of all plastics products manufactured in the UK are exported.
- All helps to reduce the UK Trade Deficit of £65 billion.

Plastics use only 4% of world crude oil, petrochemicals a further 4%

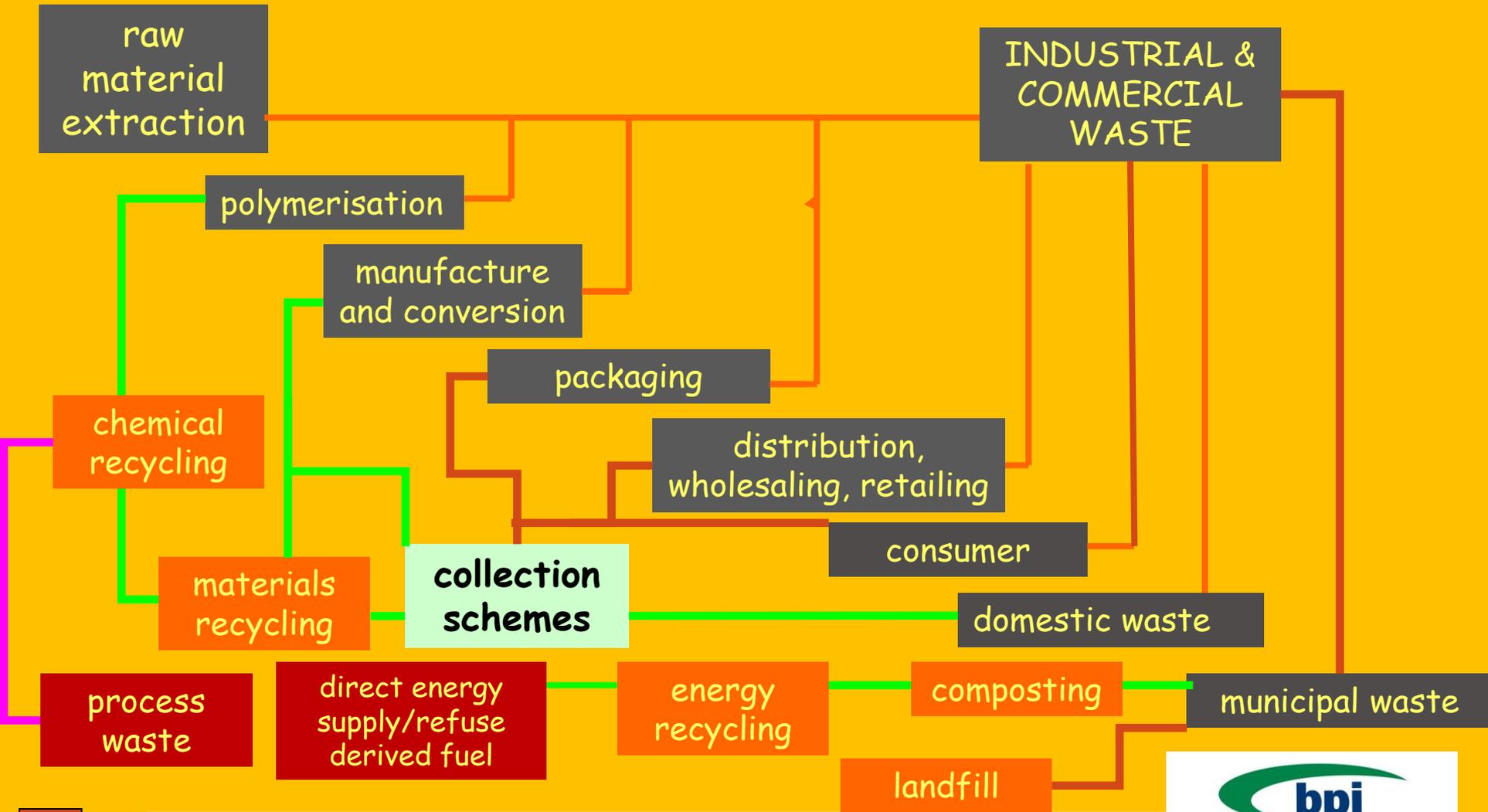


Plastics industry

- Most plastics are “organic” i.e. based on Carbon
- So the **feedstock** can be coal, oil, gas, biomass or waste plastic
- The **cheapest** feedstock is natural gas
- The **cheapest location** is the Middle East where there is no other good use for it.
- P.V.C. is a special case as it is half inorganic and is best made where the chlorine is available.

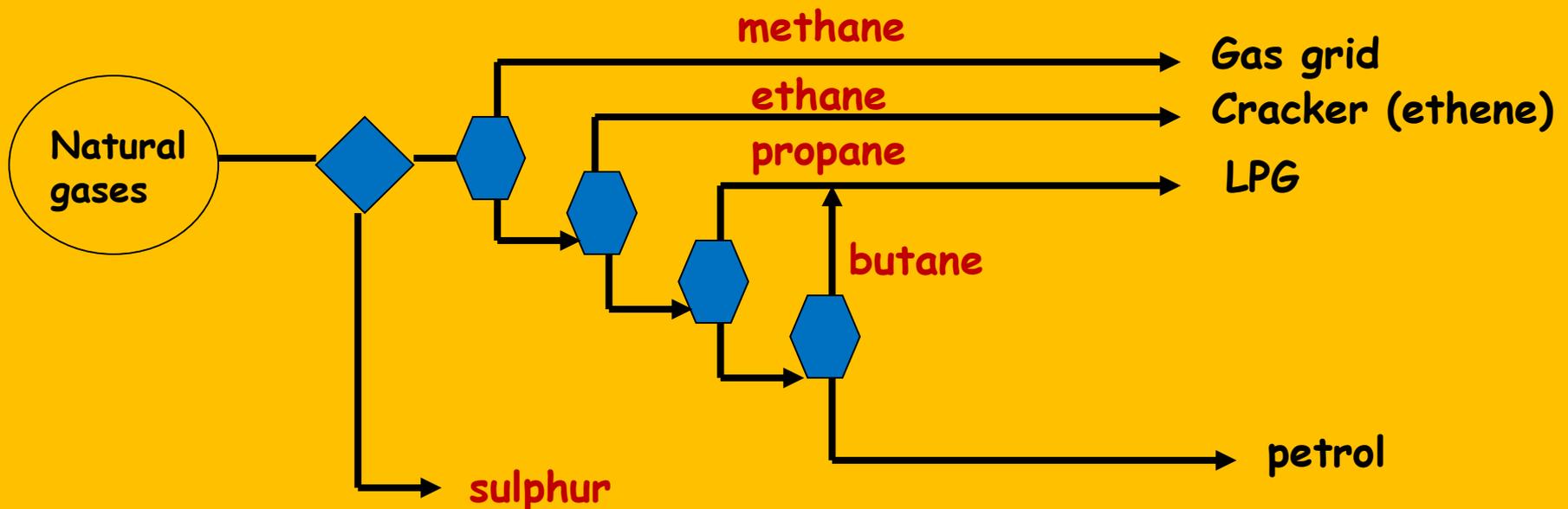


Plastics Sustainability



Natural gas

The **market value** of Natural Gas is **increased** by desulphurisation and separating it into its constituent parts. Natural gas becomes a liquid at temperatures below -161°C . Fractional distillation is then used to separate out the constituents of natural gases in a **continuous process**.



Pharmaceutical Industry

Drugs alter the biochemical processes in our bodies, for example, changing the way we feel and behave. Drugs which lead to an improvement in health are called **medicines**.

Once a new drug is discovered, it will be **patented**, the licence lasting **20 years**. Many years of trials may be needed before the drug even becomes commercially available. The Government is also involved in this process, providing the necessary licensing for the new drug. The Chemical Industry earns £1000 million pounds a year in '**invisible earning**' for **licensing fees** for patented chemicals and processes.

Once the necessary licensing has been granted **a pilot plant** will be built for small scale production to allow for product evaluation. **Full scale** production is then implemented, where safety, environmental and energy saving factors have to be considered.

