
Elixir
CONSULTANTS

Climate Change

Climate Change

- Paris agreement target of limiting global warming below 2°C & pursuing efforts to limit to 1.5°C
- Current Practice of CO_2 release
- Transitioning away from the combustion of fossil fuels to cleaner energy sources and reducing process emissions will be central to tackle climate change.

Limiting the effects of climate change is absolutely vital, and as we accelerate towards the zero-carbon economy, investigating new energy technology is becoming more important.

We Engineers would like to be one of the true catalysts of systemic change to a greener society.

Energy Sources

Various energy sources

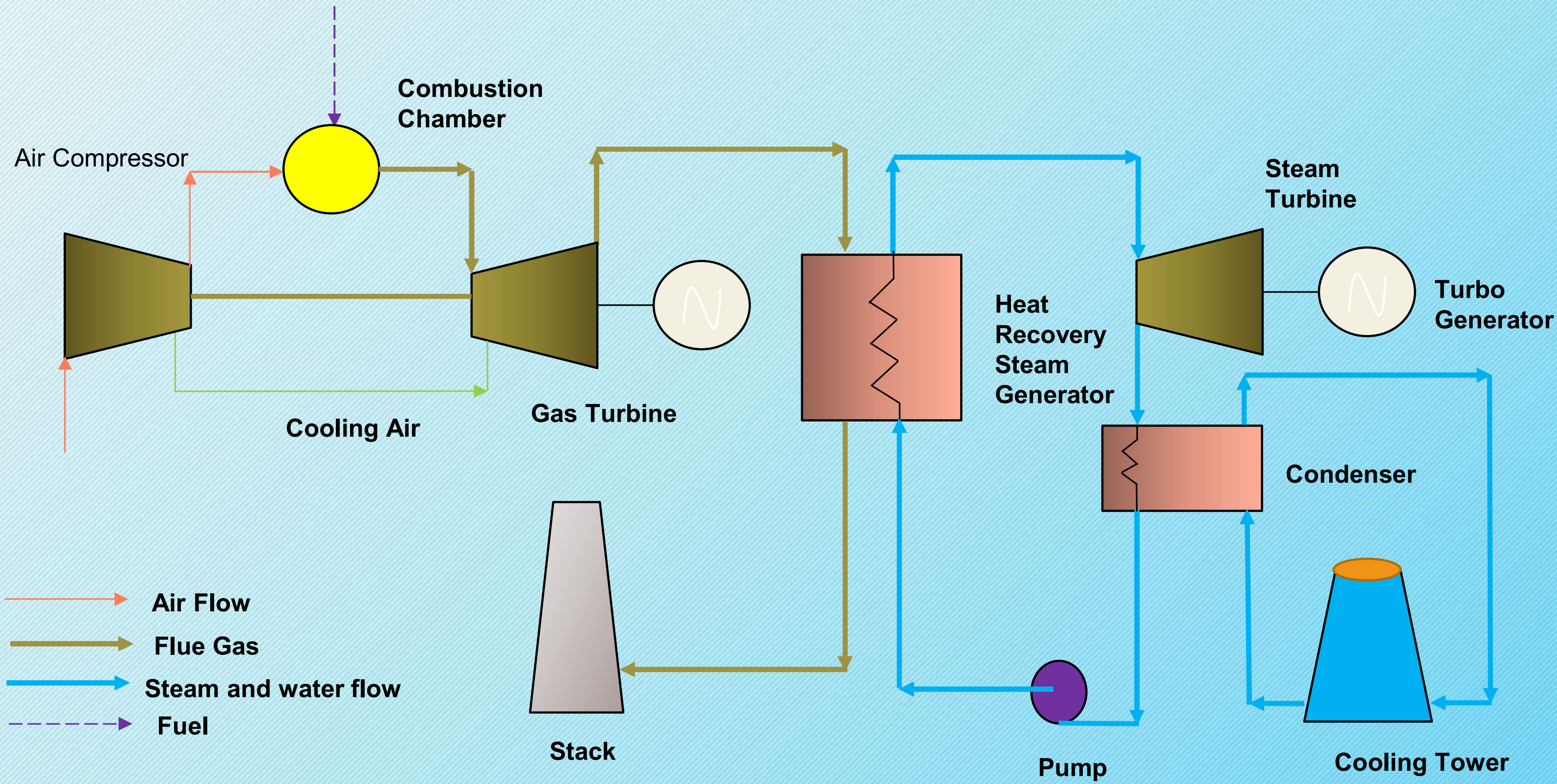
- Fossil Fuels (coal, oil, and natural gas)
- Biofuels
- Nuclear Energy
- Geothermal
- Hydraulic
- Renewable Energy (Solar, Wind, SW waves etc)

Power demand variation

- Nuclear is a bad match for renewables.
  - Nuclear power stations are highly inflexible (very difficult to turn up or down)
- Electric industry lacks large-scale storage.
  - power supply is adjusted to match the demand by varying the fossil fuel gas supply to power generators.
- Power stations account for approximately 18% of the total UK CO2 emissions.
  - Our Aim: To reduce the Net Carbon Footprint of the energy products by CCS, BECCS (Bioenergy CCS), DAC (Direct Air Capture).

Combined Cycle Power Plant

Natural gas as fuel for power generation



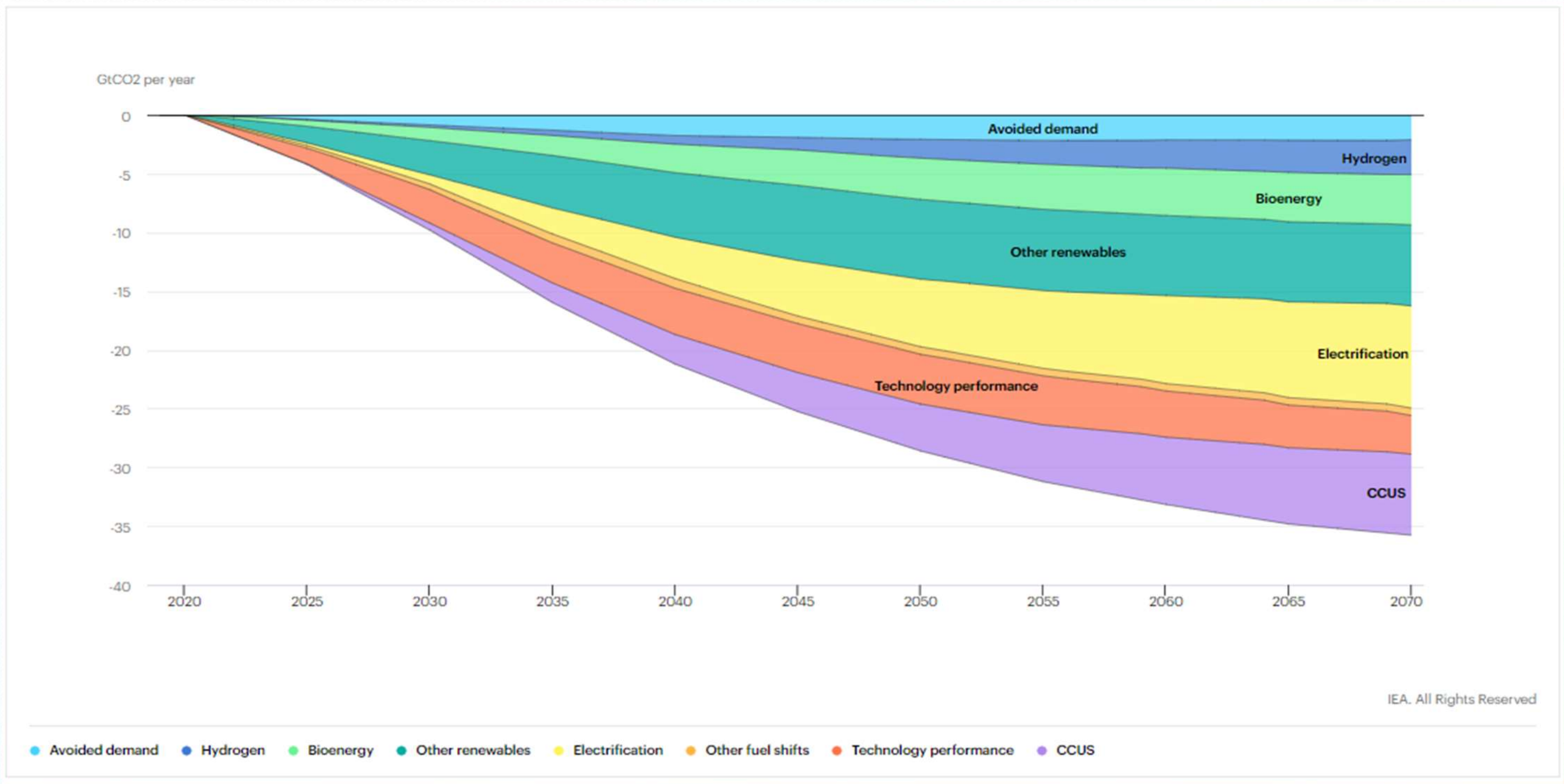
Flue Gas CO_2 Emission

Parameter	Coal Fired	Gas Fired
Flowrate (kg/s)	673.4	793.9
Temperature (K)	313	313
Pressure (bar)	1.1	1.1
Major Composition	Mol%	Mol%
H_2O	8.18	8.00
N_2	72.86	76.00
CO_2	13.58	4.00
O_2	3.54	12.00
H_2S	0.05	0.00
SO_x	5 mg/Nm^3	2 mg/Nm^3
NO_x	100 mg/Nm^3	55 mg/Nm^3

1 GW coal fired power station produces 30,000 tons of CO2 per day.

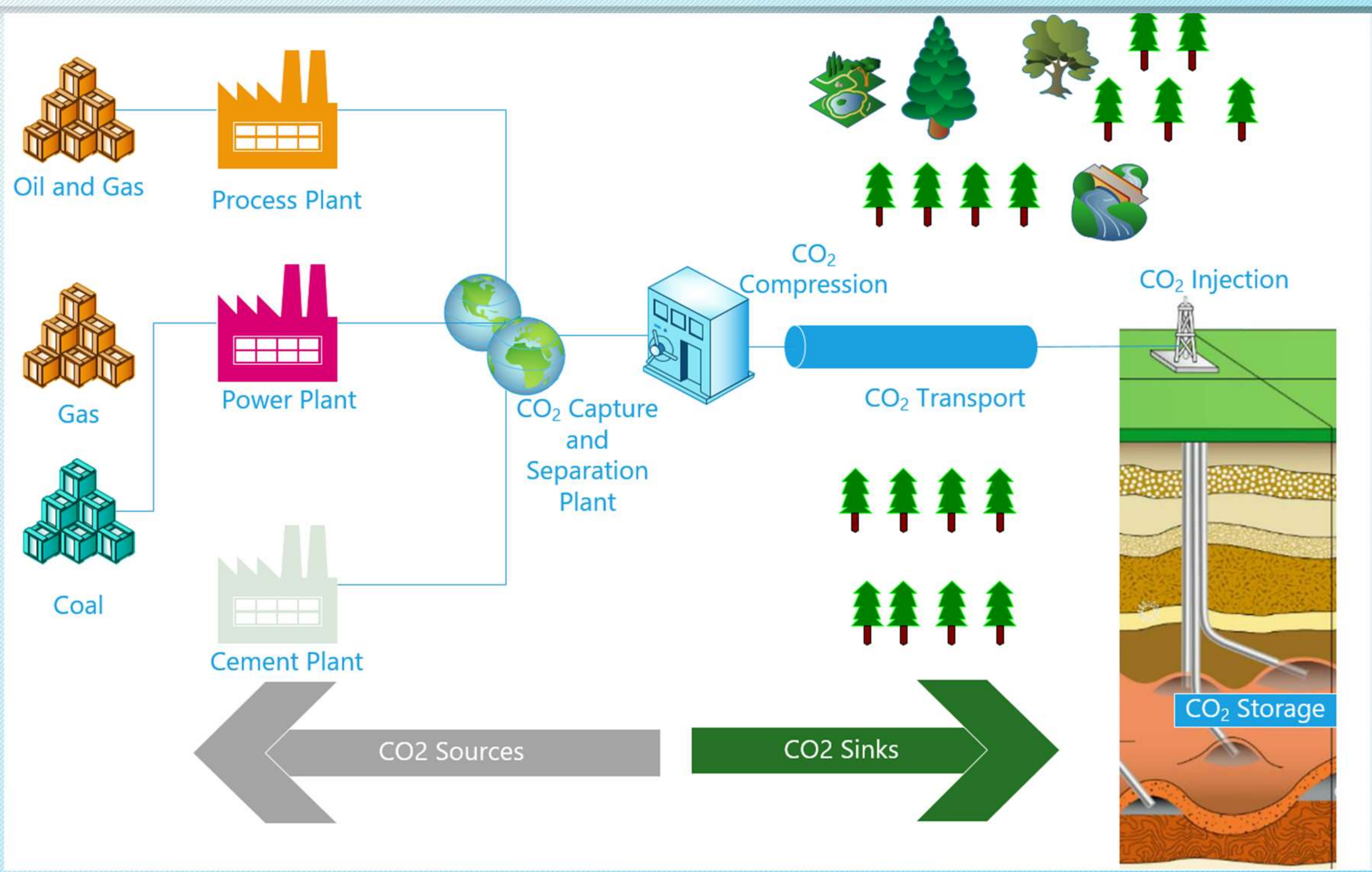
Currently 35 million tons of CO2 being emitted per year and as energy demand going up in future this figure will reach 80 million tons per year by 2095.

Emission Mitigation Measures



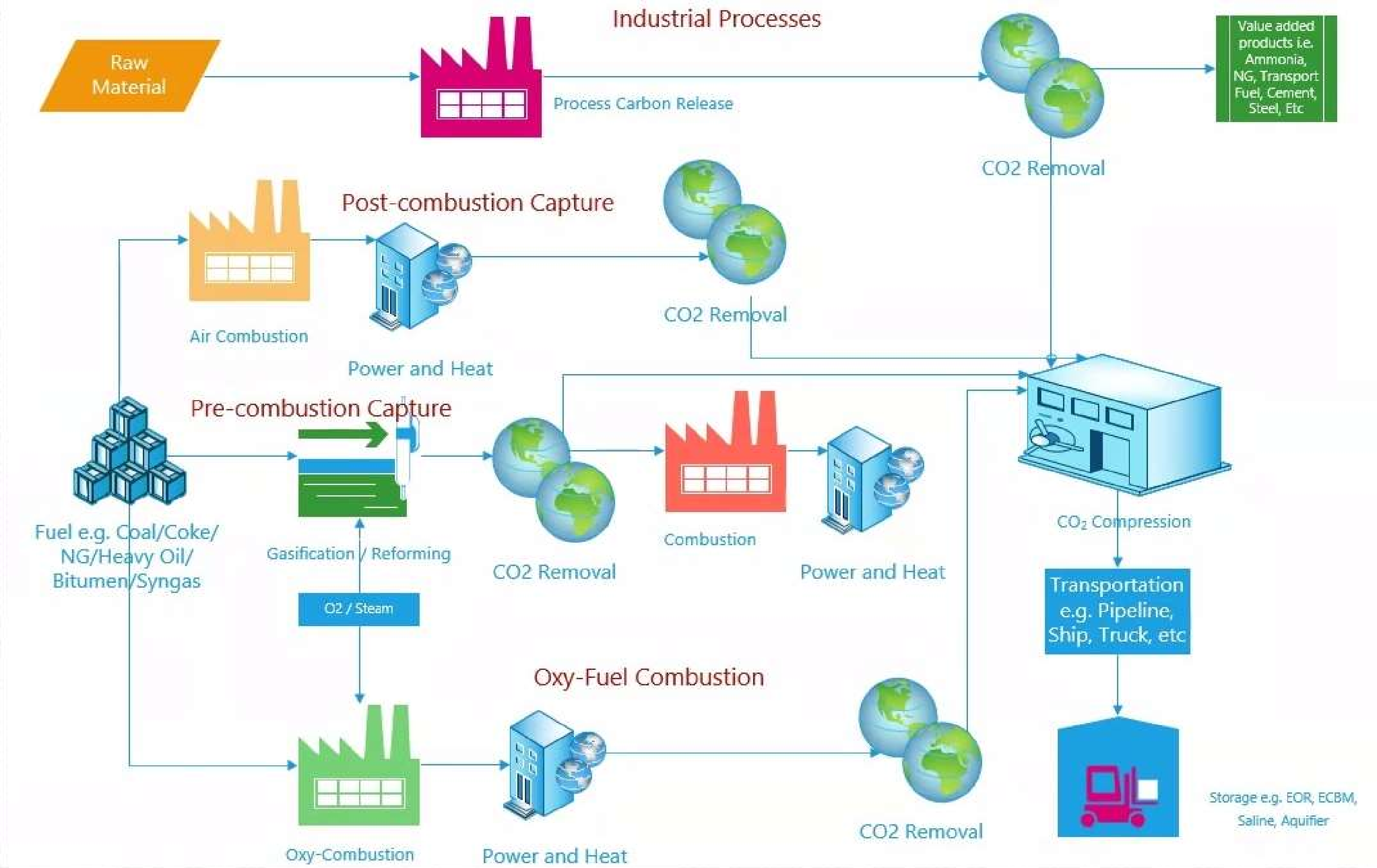
Courtesy: IEA

What is CCS



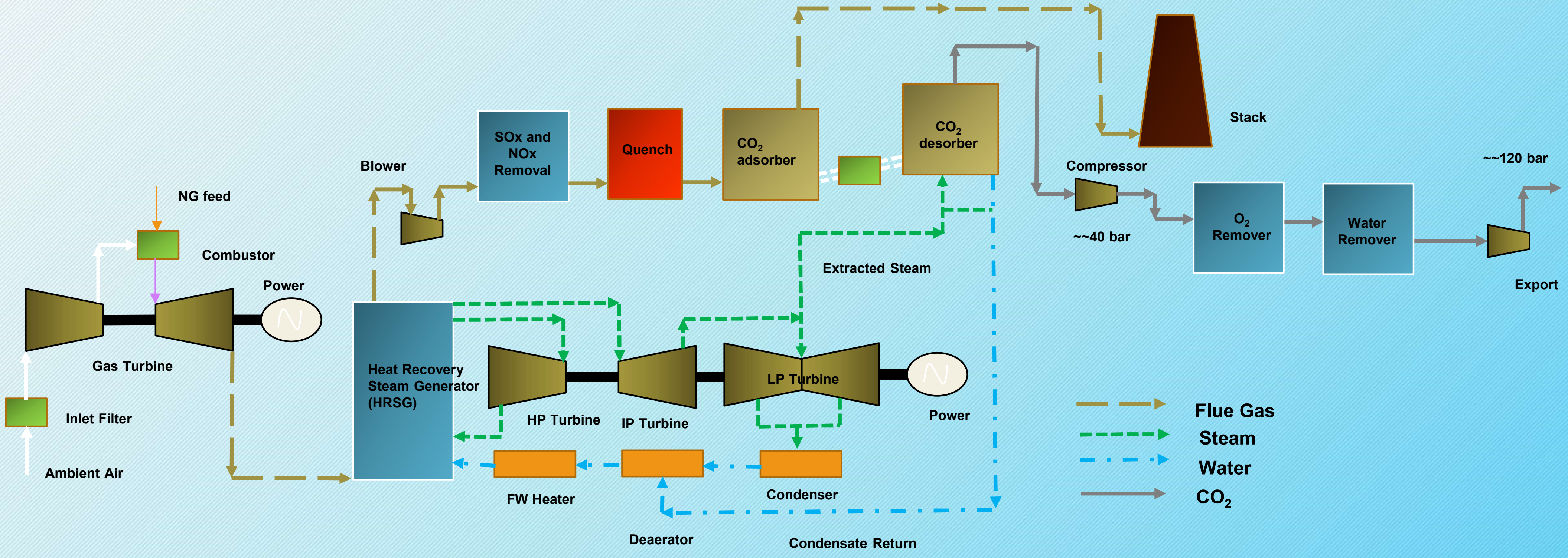
Oil and Gas
Process Plant
Gas
Power Plant
Coal
Cement Plant
CO_2 Capture and Separation Plant
CO_2 Compression
CO_2 Transport
CO_2 Injection
CO_2 Storage
CO2 Sources
CO2 Sinks

Carbon Capture Pathways



CO2 Capture

Post Combustion CO2 Capture



CO_2 Removal

CO2 removal Technologies

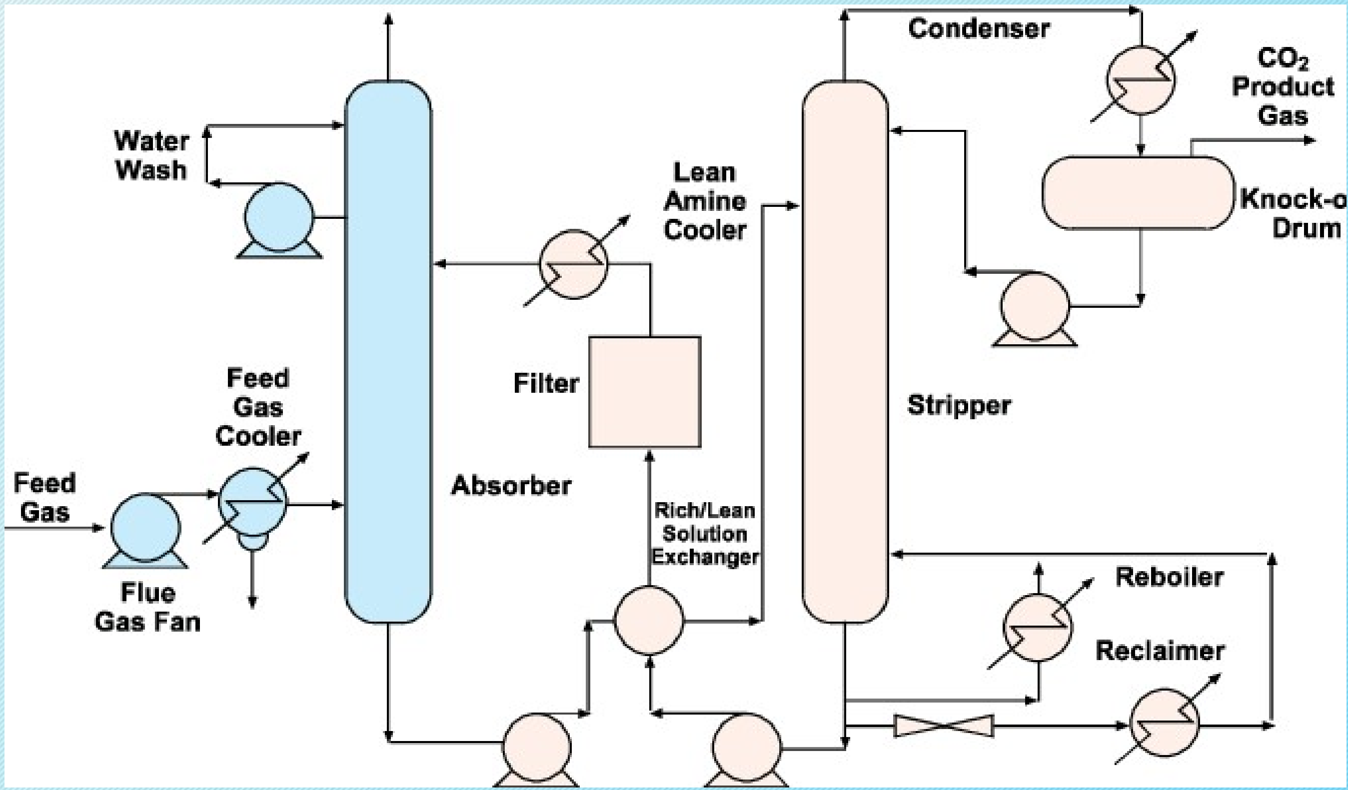
- ❑ Chemical Solvent (Aqueous Amines)
- ❑ Physical Solvent
- ❑ Chilled Ammonia
- ❑ Membrane Separation Process
- ❑ Adsorption
- ❑ Cryogenic Separation

As the CO2 concentration is not high enough the membrane and cryogenic processes are not used in this application.

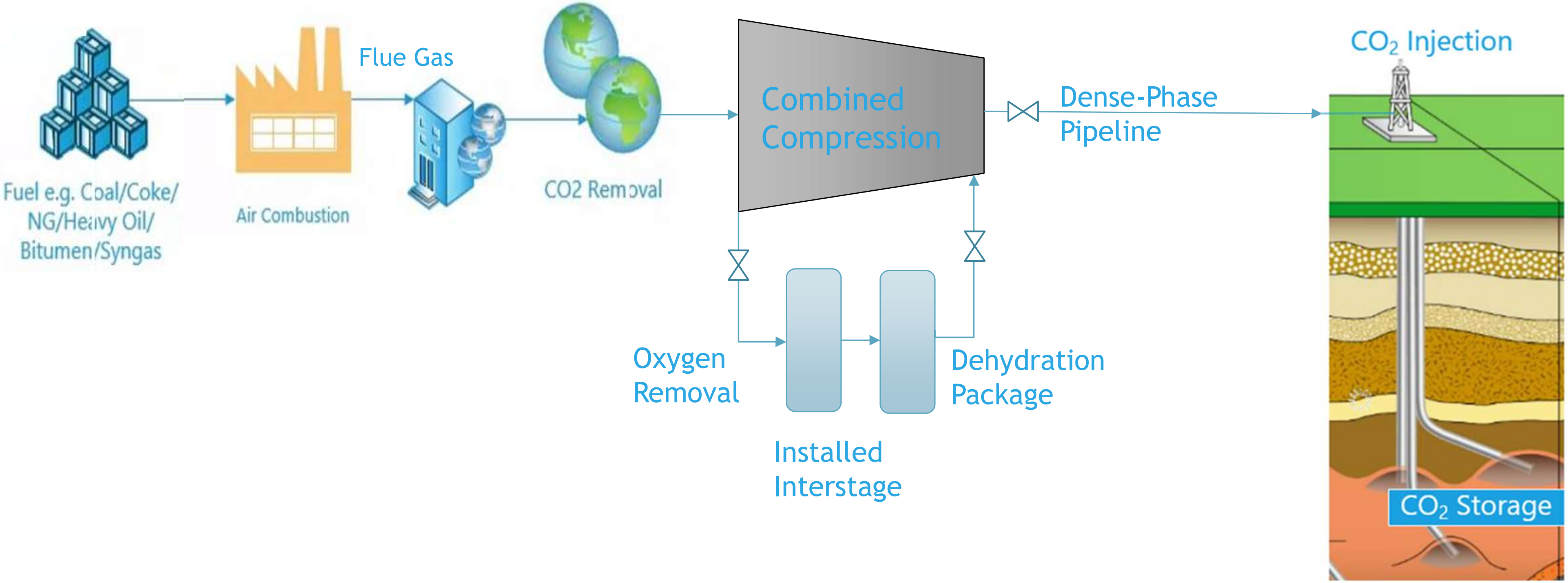
Normally aqueous amine solvent process is used for CO_2 removal from flue gas

CO_2 Removal

CO_2 recovery from flue gas with aqueous amines (alkanol amines)



CO_2 Conditioning



CO_2 Conditioning

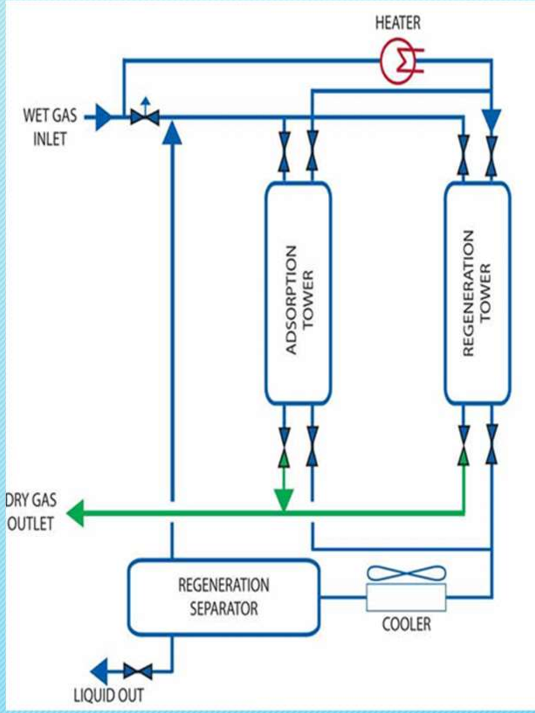
Dehydration

Dehydration by cooling the CO2 stream

- Cooling (e.g. compressor inter-stage cooling)
- Refrigeration (gas cooling with a refrigerant)
- Dehydration by Expansion across a J-T Valve or an expander.

Dehydration by Solid Desiccants

- Silica gel (SiO2)
- Activated alumina (Al2O3)
- Acid Resistance Molecular Sieves

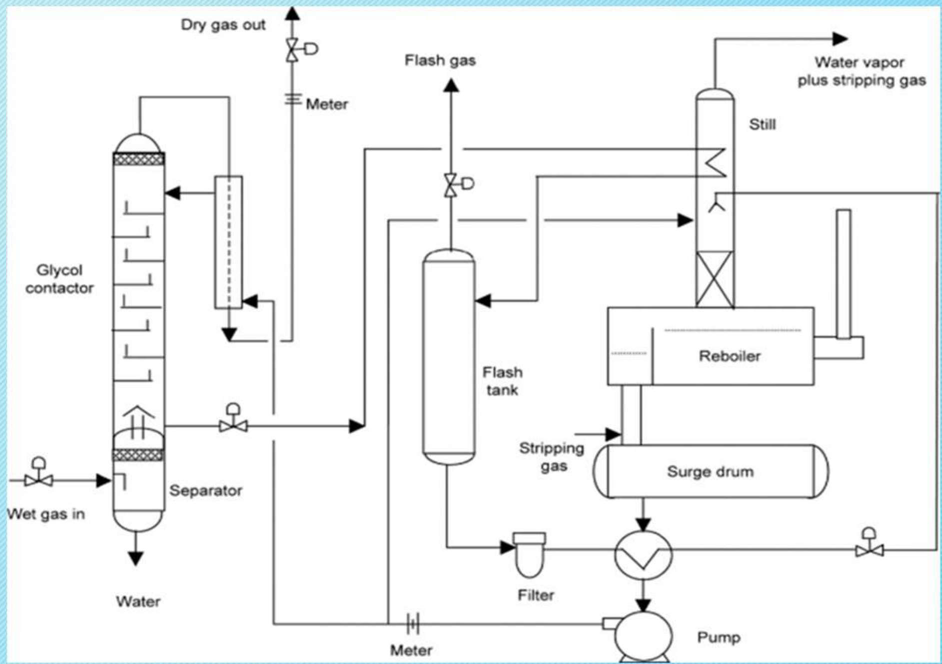


CO_2 Conditioning

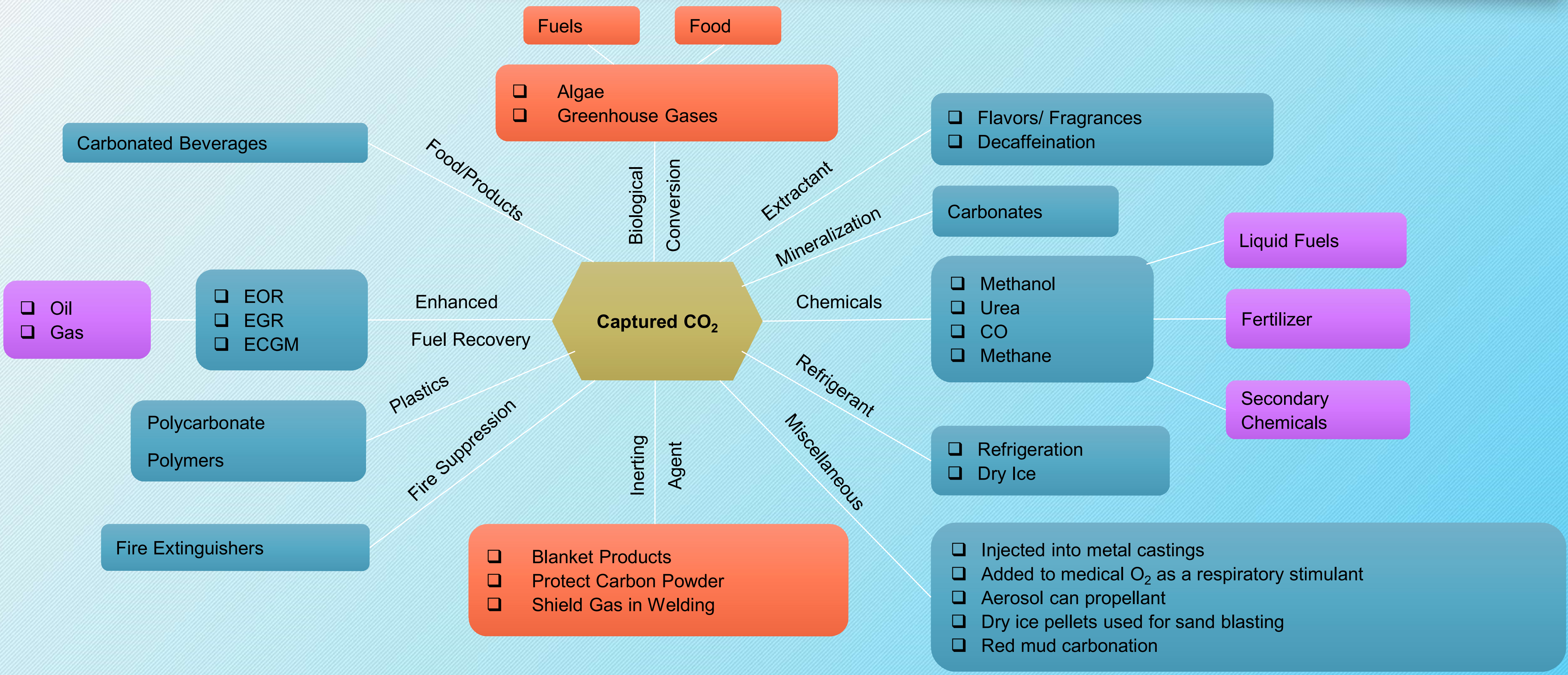
Dehydration by Liquid Desiccants (MeOH, Glycerol or TEG)

➢ Glycol dehydration (using tri-ethylene glycol, TEG)

1. The wet CO_2 gas is brought into contact with the dry glycol (TEG) in an absorber or contactor. Water is absorbed in the glycol and consequently, the dew point of CO_2 gas reduces.
2. The wet rich glycol then flows from the absorber to a regeneration system in which any entrained gas is separated. The heating allows removal of the absorbed water and the water-dry lean glycol is cooled (via heat exchange) and pumped back to the absorber for continuous operation.
3. Can achieve 50 ppmV spec.



CO_2 Utilisation



CCS Challenges

Following challenges in regards CCS

- Economic viability without further use of CO_2 for EOR or for synthetic chemical manufacture
- Fracture control /fracture propagation in dense phase CO_2 pipelines
- Continuous monitoring of the quality of gas is critical to avoid pipeline corrosion (due to moisture content).
- If the pressure at the compressor discharge is more than 180 barg there could be a limitation on pigging due to poor lubrication characteristics of CO_2, this needs to be further understood as there could be limited pigging vendors available who could do this.
- OLGA and PIPESIM are used for hydraulic simulations. It would be good to compare with the GERG equation of state within Pipesim with viscosity prediction based on Peng Robinson Penoloux EOS and Pedersen's correlation. (Span-Wagner equation for pure CO_2 and MultiFlash generated TAB file using the GERG equation of state for CO_2 with impurities)
- As the CO_2 injection is in dense phase (behaves as liquid) it is recommended that the wellhead closing time is adjusted according to the pressure surge caused by the water hammer effect (WANDA simulation package).
- Very low temperatures during blowdown (high JT coefficient)
- Understanding of dense phase plume migration.
- CO_2 hydrate formation under supercritical conditions knowledge evolving.
- Federal governments not making funds available (economic incentives) for CCS project
- The federal governments should provide adequate legal and regulatory framework. So far the most advanced and comprehensive legislative CCS frameworks are in place only in countries like USA, Canada, Australia, UK and European Union.
- One concern in some oil and gas fields is the impact of any abandoned production wells, since improperly sealed wells may provide an escape route for CO_2. Addressing this concern requires analysing prior drilling activity in the area and ensuring that closed wells are properly sealed.
- As there are chances of CO_2 leakage from storage leading to major environmental damage (reduction in O_2 level), there cannot be infinite level of storage.

Way Forward

Way Forward

- Artificial photosynthesis in line with Carbon Cycle (natural photosynthesis). Artificial photosynthesis is the future of renewable fuels and chemicals. Only alternative that can produce enough renewable hydrocarbons to meet future world demand with net carbon zero.
    - Two routes make sense
        - Hydrogen electrolysis + reverse water-gas shift
        - CO2 electrolysis

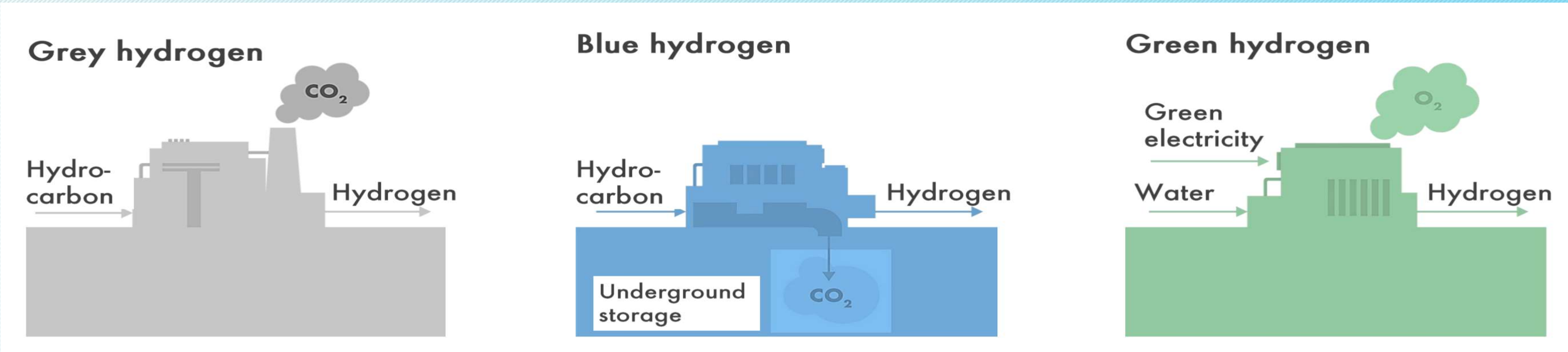
CO2 conversion options

- CO2 to methanol (gasoline)
- CO2 to syngas to Fischer-Tropsch products (diesel and jet fuel)
- C02 to methane (LNG).

Enabling the conversion of waste CO2 into cleaner, high-value materials with significant performance, cost and carbon footprint improvements.

H_2 as Energy Source

Gray, Blue and Green Hydrogen



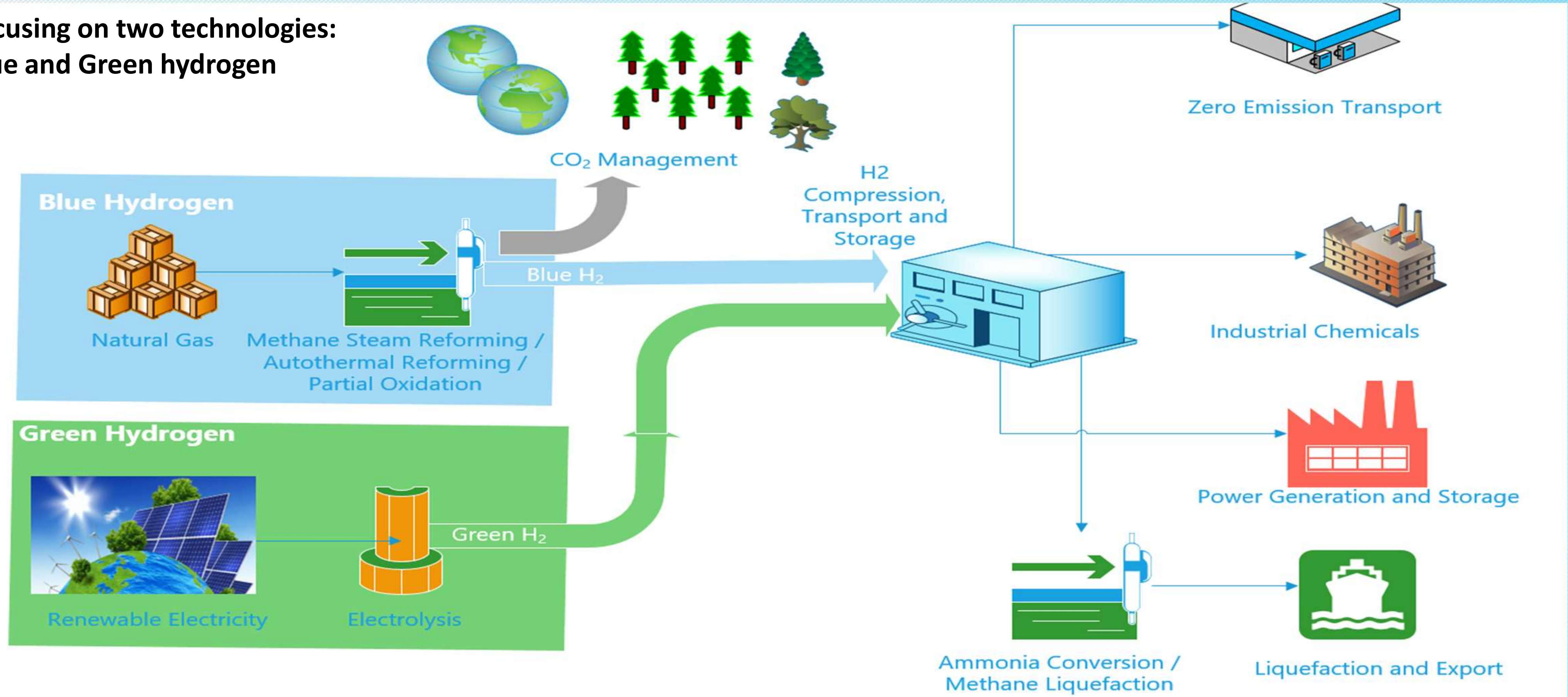
- Split natural gas into CO_2 and H_2
- CO_2 emitted to atmosphere

- Split natural gas into CO_2 and H_2
- CO_2 is stored and reused

- Split water into H2 by electrolysis powered by wind and sun
- No CO2 is emitted

H_2 Supply Chain

Focusing on two technologies:
Blue and Green hydrogen



Blue H_2 as Energy Source

Blue Hydrogen might stay as major energy source in future till Green Hydrogen production cost is reduced

- Huge potential for using hydrogen for heat (boilers) and fuel for transport vehicles
- Hydrogen blending in the gas grid
- Require a new H2 licence or extension of the existing gas distribution / transmission licence

Assessment of H_2 Firing

- Modifications to be made to burner system to run on natural gas diluted by hydrogen (Low levels of dilution achieve little CO2 abatement)
- Limited experience with 95% hydrogen firing . Conversion to full (95%) H2 firing requires both high CAPEX and high OPEX requires a full GT change out

H2 Bus


Powered by hydrogen fuel cell – zero emission bus
WSH62996
hydrogen
bus
Another red bus
going green for LONDON

Challenges for H2

Challenges / Work in progress worldwide

- Lower ignition energy level required and large span between LEL and UEL.
- The flammability of hydrogen will require specialized maintenance with specific tools and more precaution. Potential leakages of a gas and its flammability danger leads to a risk contour around a pipeline. Hydrogen is classified as chemical and thus has different regulation than natural gas pipelines leading to higher risk calculations and contours. There is little research on the dangers of hydrogen in and outside of the risk contours, effects of a rupture and radiation effects. In the absence of new regulation regarding the risk contours parts of the grid cannot be converted to hydrogen due to possibility of buildings and inhabitants coming within the risk contour.
- Hydrogen has an energy intensity (higher heating value) of 12 MJ/Nm3 compared to approximately 35-40 MJ/Nm3 for natural gas. The existing facilities and pipeline infrastructure (booster compressors) will not be sufficient to generate similar power requirement.
- The gas speed in the network at the moment is limited by regulation at 20 m/s while the transport of hydrogen would require 30 m/s to meet the same energy capacity as natural gas. A regulatory change is therefore needed.
- Anything new will be subject to suspicion (education and communication, town gas in UK early 60s, due to LNG accident in 1944 in USA around 120 people killed, the work on LNG stopped for next 30 years)
- H2 Transportation (venting directly or with N2, CO limit, H2 Embrittlement, higher leakage losses through O-rings and gaskets)
- BLEVE (Boiling Liquid Expanding Vapor Explosion) modelling in liquid hydrogen storage tanks exposed to fire (rapid phase transitions)
- QRA (establishing leak frequencies, Consequence of explosion, venting as mitigation)

Challenges for H2

Challenges / Work in progress worldwide

- Fear factor of H2 when we are taking H2 from Industrial area to public domain
- H2 Carrier Options such as Ammonia or LOHC (Liquid Organic Hydrogen Carriers). Most beneficial H2 carrier
- Liquid hydrogen storage (at a temperature below -252.9°C) is feasible for larger consumers. The conversion losses are approximately 15%.
- Colourless H2 flame (adding colorant)
- Odorising of H2 (it has to be odorised same level as NG from safety perspective)
- Regulatory approach (minimum safety standards –risk based approach, HAC standards, min distance between electrolyser, storage etc.)
- Platform to be made available for sharing the experience from operators, design engineers and consultants

Thank you very much

Contact: +44 7411651906
Email: vishwas.shinde@elixiruk.com
Website: www.elixiruk.com