IGCC TECHNOLOGY

&

CO2 CAPTURE, STORAGE

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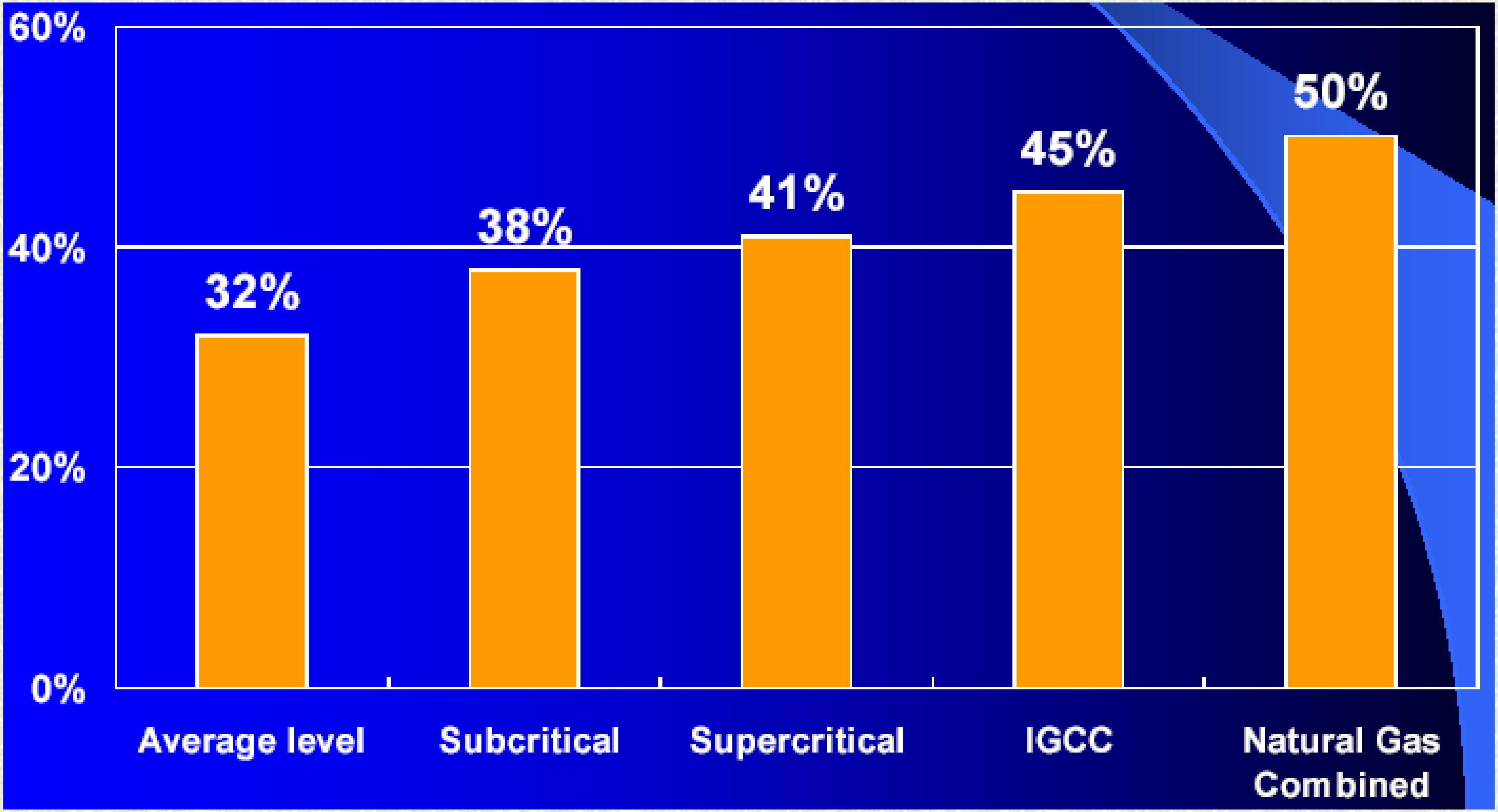
I.G.C.C. Technology

Net Plant Efficiency of Different Power Generation Systems

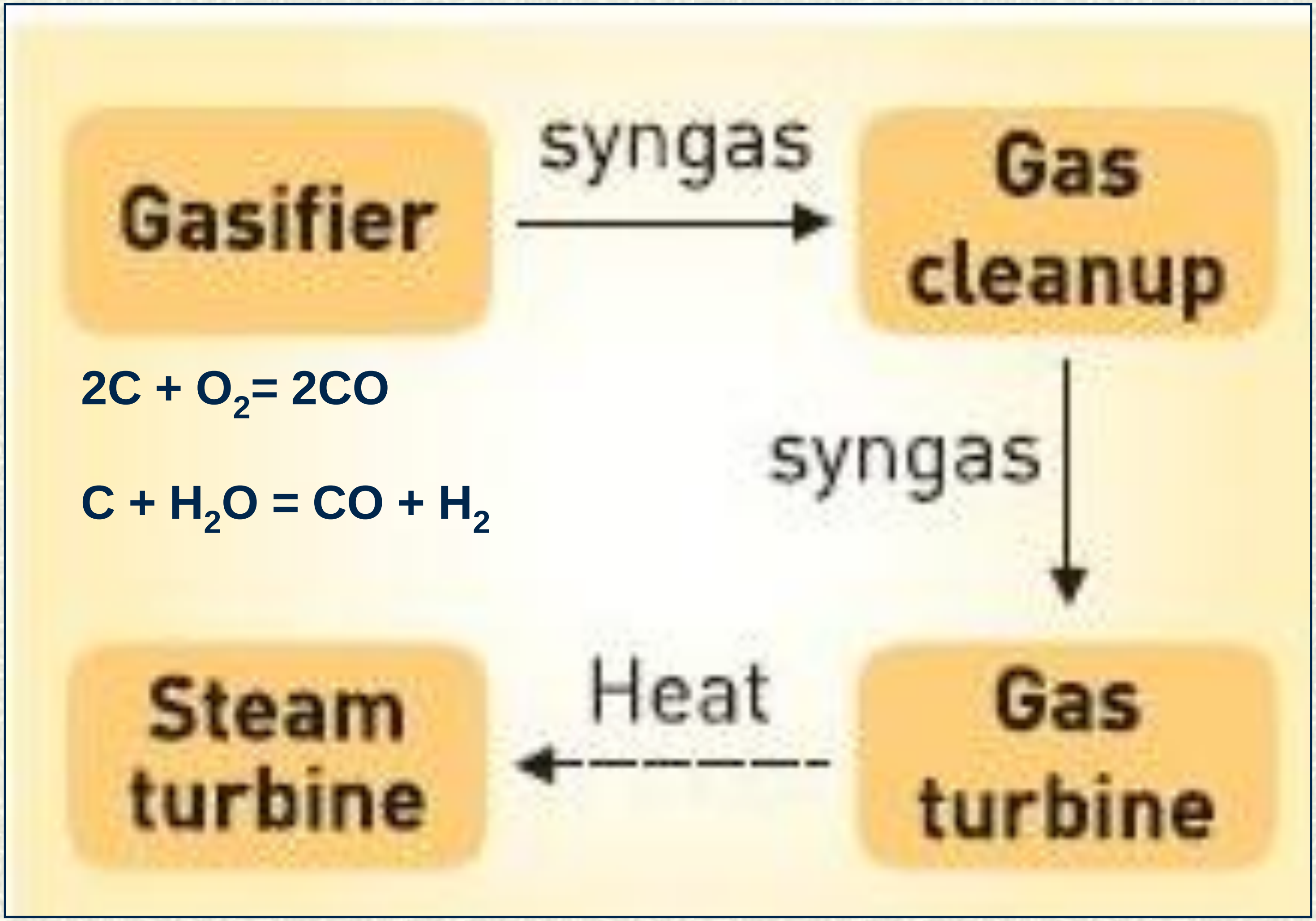


IGCC Process

❖IGCC is a process in which a low-value fuel such as coal, petroleum coke, biomass or municipal waste is converted to low heating value, high-hydrogen gas in a process called gasification.The gas is then used as the primary fuel for a gas turbine.

❖IGCC can also be viewed as the two-stage combustion of an opportunity feedstock. First, the feedstock is partially combusted in a reactor or gasifier. Then the combustion is completed in the gas turbine.

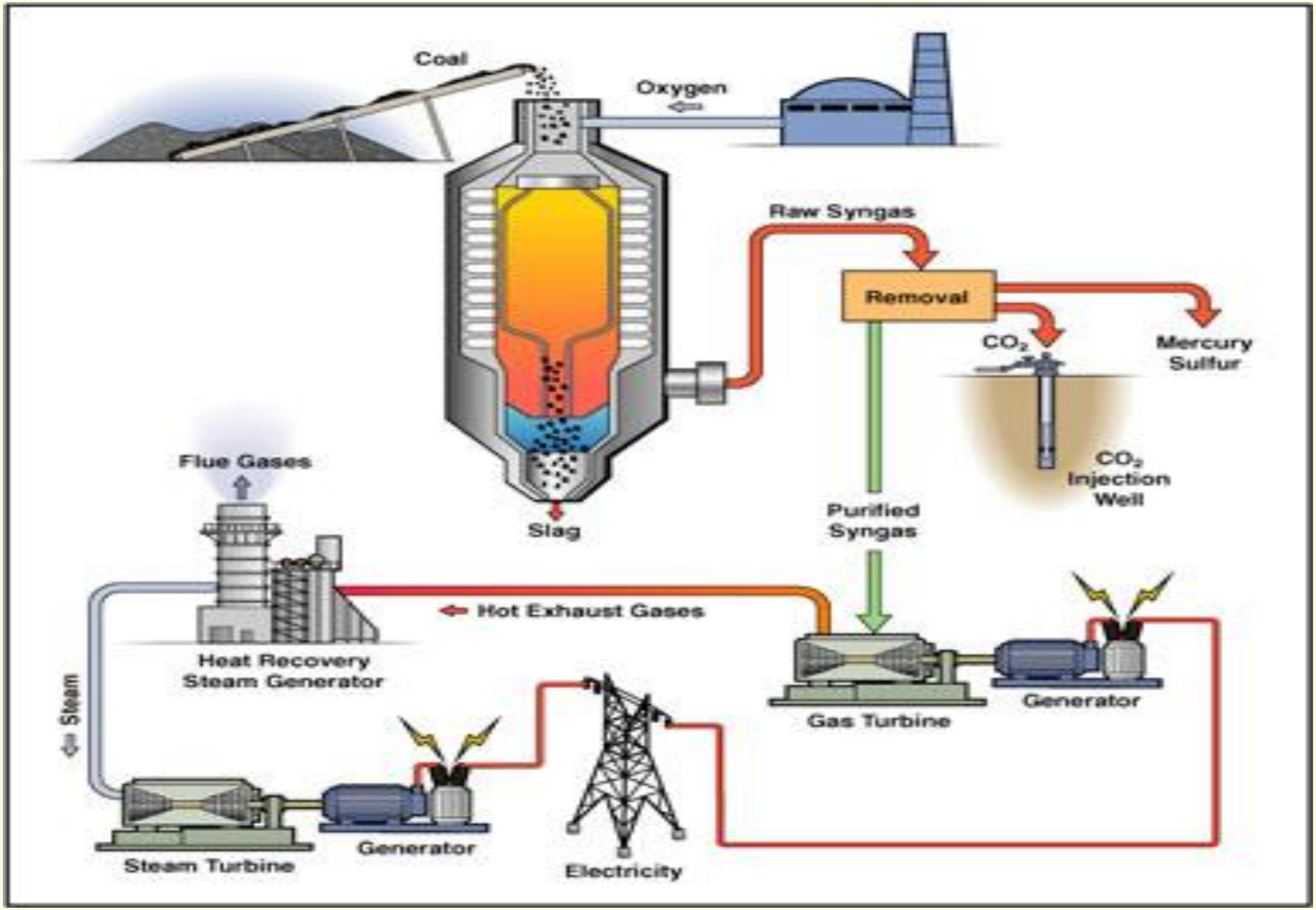
IGCC Process



$2C + O_2 = 2CO$

$C + H_2O = CO + H_2$

Typical Operating Cycle of IGCC Plant



Gasification

- **Cryogenic Air Separation**

A cryogenic air separation unit provides pure oxygen to the gasification reactor, often using or supplemented with post compression air bleed from the gas turbine.

- **Gasification in Reactor**

The most common technique partially oxidizes the feedstock with pure oxygen inside a reactor. The carbon and hydrogen from the feedstock are converted into a mixture composed primarily of hydrogen and carbon monoxide. This mixture is commonly called synthetic gas, or syngas. Syngas has a heating value of 1000 to 1100 kCal/Nm3, which is three to eight times lower than that of natural gas.

Syngas Cleanup

- The syngas from the reactor must be cleaned before it can be used as a gas turbine fuel. The cleanup process typically involves removing sulphur compounds, ammonia, metals, alkalytes, ash and particulates to meet the gas turbine's fuel gas specifications.

- To make IGCC more economically attractive, marketable products such as methanol, ammonia, fertilizers and other chemicals from the compounds you remove from the syngas. This process often further reduces the hydrogen content and therefore the heating value of the syngas

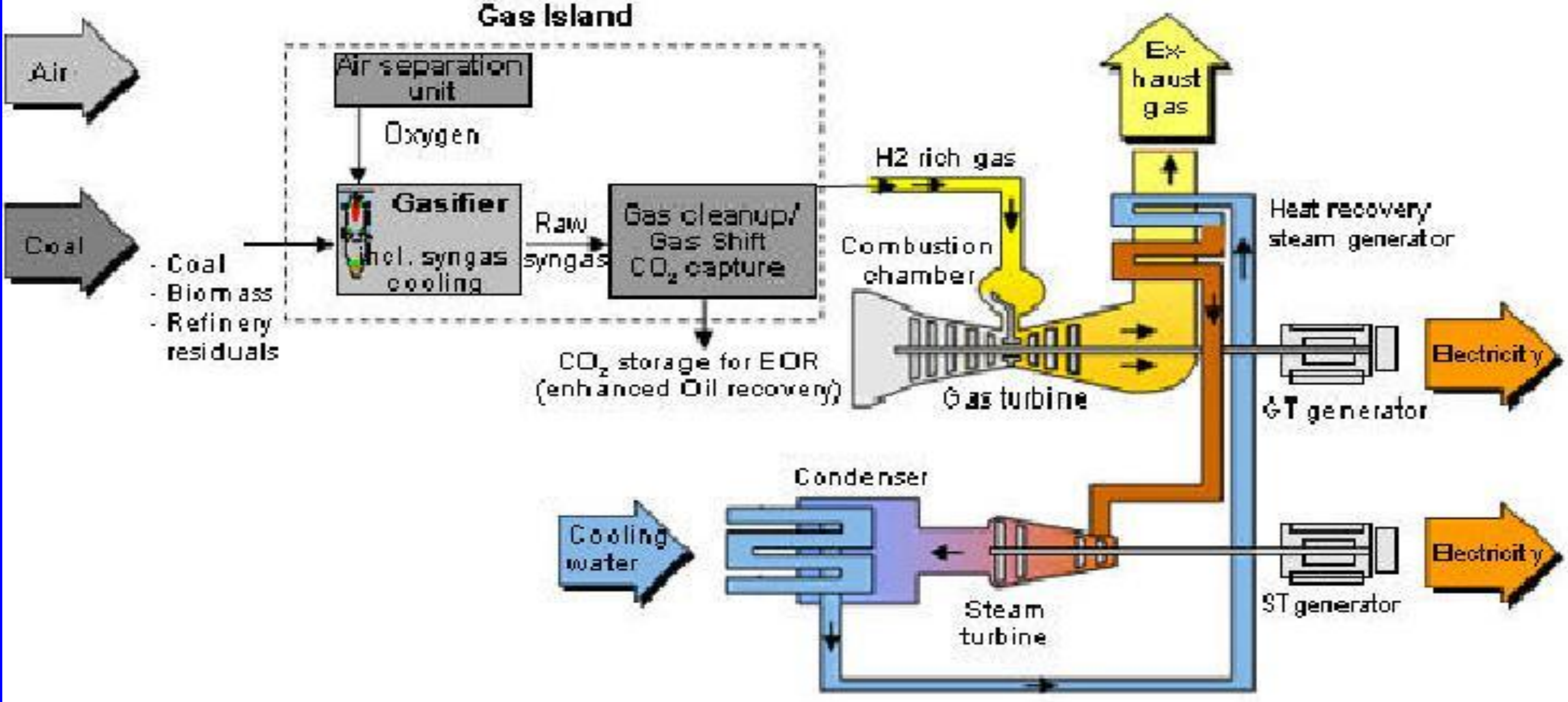
Power Block

The clean gas is then fed to the combined cycle power plant. Combined cycle power plant consists of a combustion turbine/generator, a heat recovery steam generator, and a steam turbine/generator. The exhaust heat from the combustion turbine is recovered in the heat recovery steam generator to produce steam. This steam then passes through a steam turbine to power another generator, which produces more electricity. Combined cycle is more efficient than conventional power generating systems because it re-uses waste heat to produce more electricity

Characteristics of Different Gasifier Types

Gasifier Type	Fixed Bed	Fluidized Bed	Entrained Flow
Temperature	425-600 (C)	900-1050 (C)	1250-1600 (C)
Oxidant demand	Low	Moderate	High
Ash conditions	Dry ash or Slagging	Dry ash or Agglomerating	Slagging
Size of coal feed	6-50 mm	6-10 mm	< 0,1 mm
Acceptability of fines	Limited	Good	Unlimited
Other Characteristic	Methane, tar, And oils present in syngas	Low carbon conversion	Pure syngas; high carbon conversion

Schematic Network of IGCC Scheme



Benefits of IGCC

- Gasification can proceed from any organic material, including biomass and plastic waste. The resulting syngas burns cleanly into water vapor and carbon dioxide. Alternatively, syngas may be converted efficiently to methane.

- Inorganic components of the input material, such as metals and minerals, are trapped in an inert and environmentally safe form as ash, which may have use as a fertilizer.

- IGCC offers thermodynamically favorable conditions of high pressure, high concentration of contaminants and low volumetric flows of syngas – as little as 1/100 of combustion products.

Benefits of IGCC

- Integrated gasification combined -cycle (IGCC) systems are among the cleanest and most efficient of the emerging clean coal technologies.

- Biomass gasification could play a significant role in a renewable energy economy, because biomass production removes CO_2 from the atmosphere. Gasification runs on a wider variety of input materials, can be used to produce a wider variety of output fuels, and is an extremely efficient method of extracting energy from biomass.

Benefits of IGCC

- Very low air pollutant emissions
- Proven CO2 capture process
- Fuel flexibility
- Lower water use and solid waste production
- Can be integrated into polygeneration facilities

Why consider IGCC?

- **Technology:** IGCC technology produces air emissions that are already considerably lower than required by current Clean Air standards. Significant reductions in sulfur dioxide (SO_2), nitrogen oxides (NO_X) and carbon monoxide (CO) are possible, making IGCC plants more advantageous than conventional coal power plants.

- **Carbon dioxide reduction:** Carbon dioxide (CO_2), considered a major source of global warming, could be captured more economically with IGCC than with conventional technologies. The CO_2 could be sequestered or sold in part as a by-product.

- **Efficiency:** Overall efficiency is approximately 40 to 45 percent of the energy value of coal converted to electricity. In comparison, conventional coal plants are approximately 30 to 35 percent efficient.

Why consider IGCC?

❖ **Water requirements:** Water requirements are typically about 50 percent less for IGCC applications than for conventional coal generation.

❖ **By-products:** Marketable by-products from the IGCC process can be sold, such as sulfur.

What are the risks?

❖ **Cost:** IGCC facilities are more expensive to build than conventional coal plants. Only recently have suppliers begun to emerge that can offer comprehensive, integrated designs with packaged systems and compatible equipment. Due to the industry's limited experience with the technology, truly accurate cost estimates for construction and operating costs are not yet available for use in planning future facilities.

❖ **Maintenance:** IGCC technology requires more frequent maintenance with longer maintenance outages, requiring that power be purchased from other resources when the IGCC plant is unavailable.

What are the risks?

❖ **Performance guarantees:** The industry is encouraging suppliers to offer performance contracts for next-generation IGCC plants, but for now, the risk of reduced reliability and availability add significant cost to the project’s financing.

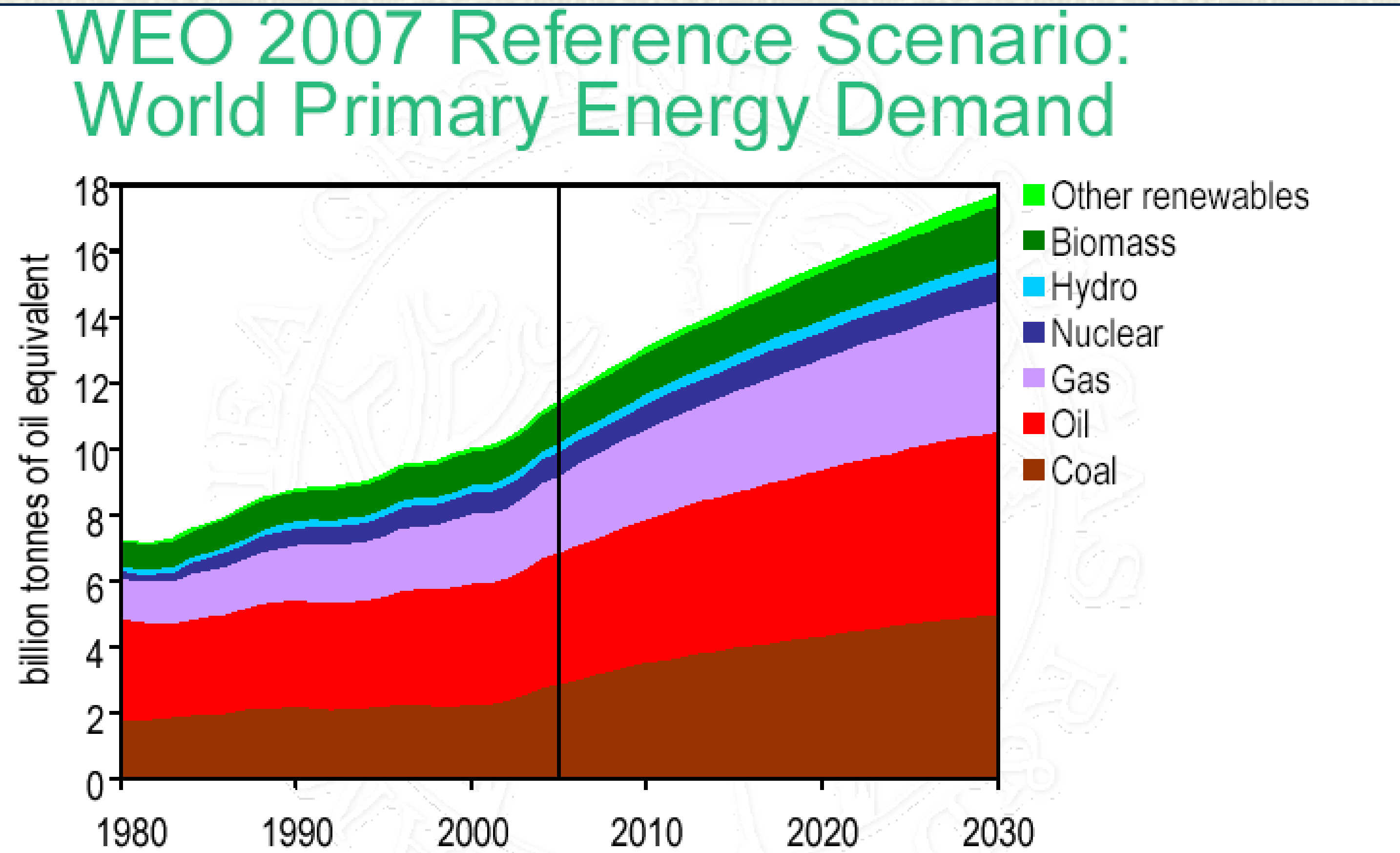
❖ **Unproven fuel experience:** Neither of the U.S.-based IGCC projects has used Powder River Basin, or western, coal, which is the type used most frequently in the Midwest.

Conclusion

No simple solution, we need all options:

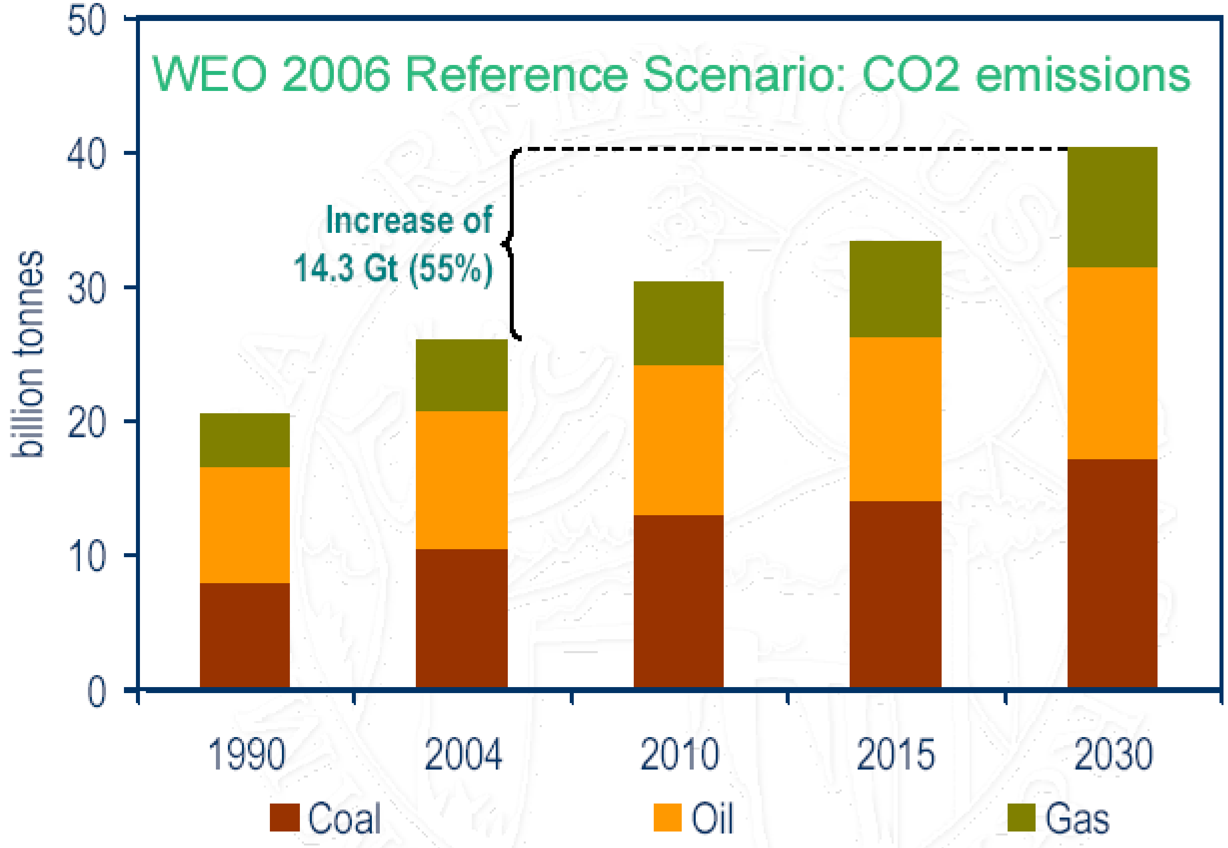
- energy saving
- increase of efficiency
- more renewable energy
- more nuclear power
- efficient coal and gas power plants
- Carbon Capture & Storage (CCS)
- consistent global climate policy

Global Growth of Primary Energy Demand



Global demand grows by more than half over the next quarter of a century, with coal use rising most in absolute terms

Projected Increase in CO2 Emission



Half of the projected increase in emissions comes from new power stations, mainly using coal & mainly located in China & India

World Energy Outlook 2007 Summary

• Global energy system is on an *increasingly* unsustainable path

• China and India are transforming the global energy system by their sheer size

• Challenge for *all* countries is to achieve transition to a more secure secure, lower carbon energy system

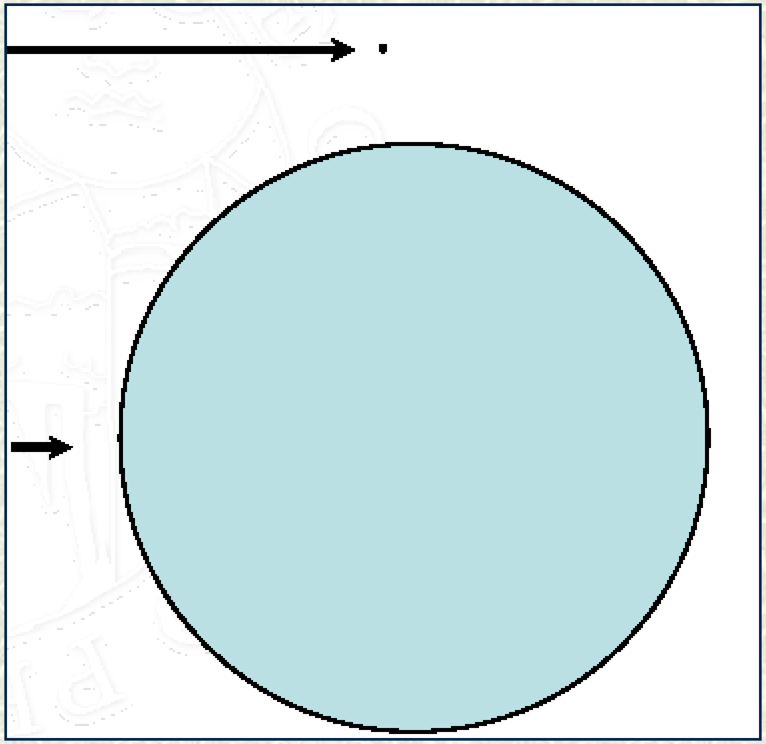
• New policies now under consideration could make a major contribution

• **Next 10 years are critical. The pace of capacity additions will be most rapid**

Size Matters!

Cumulative globally sequestered CO2

Cumulative global need to sequester CO2



CO_2 Emissions from Power Industry

- Fossil fuel accounts for over 90% of world energy consumption, CO_2 is the major product from coal / oil /gas combustion

- CO_2 emissions from fossil fuel-fired plants account for 34% of the total CO_2 emission worldwide in 2005

- CO_2 emission from fossil fuel-fired plants is approx. about 1.06 kg/kWh with 35-38% efficiency

World Bank Support

Support renewable energy development

Advices on legislation, policies and sector regulation

Challenges

Energy Security

Local Env Impacts

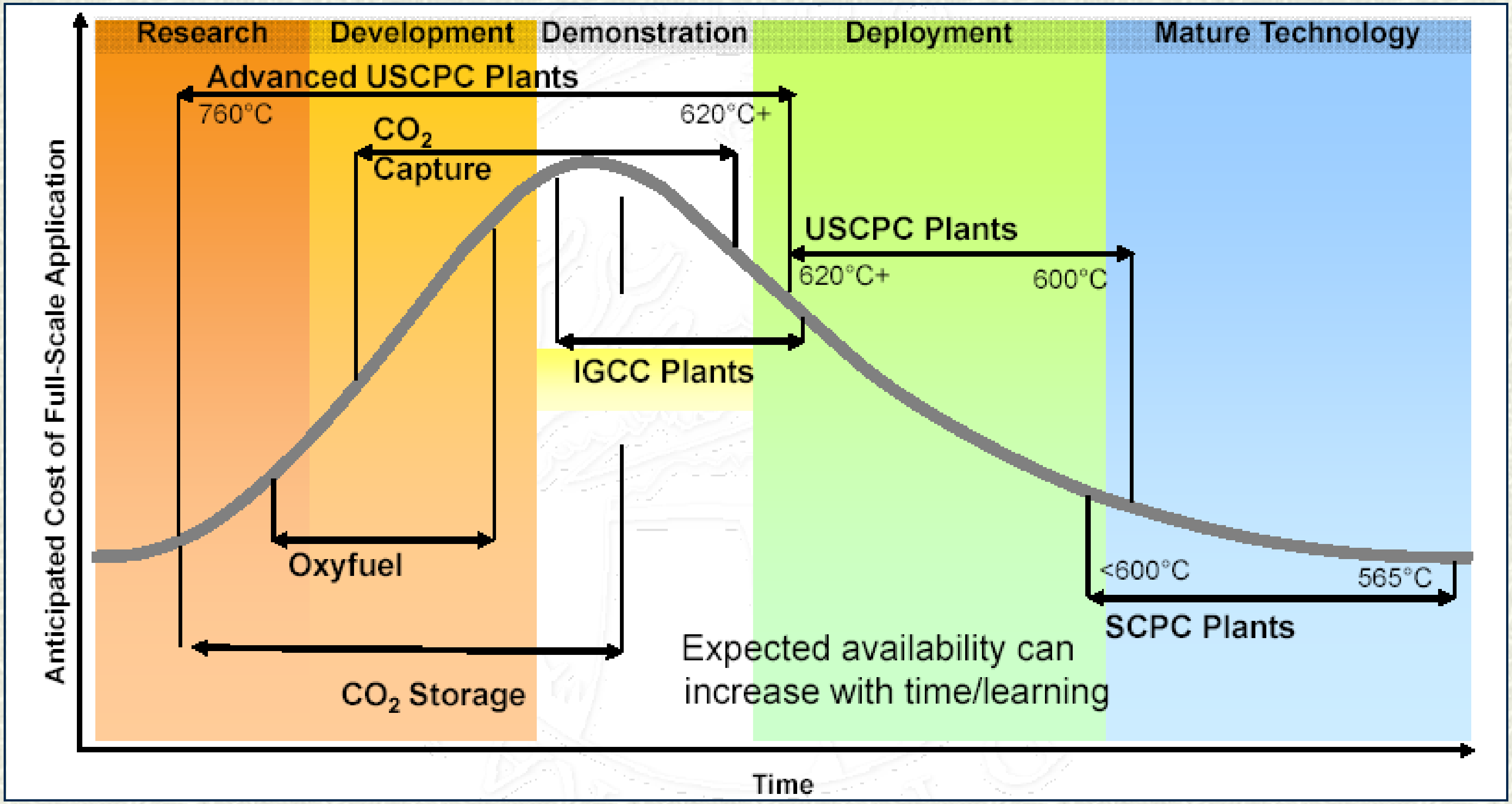
Climate Change

Support EE improvement

Thermal Power Efficiency Project

Support technology transfer & development **– clean coal & EE**

CCS in Coal-fired Power Generation



Not all technologies at the same level of maturity.

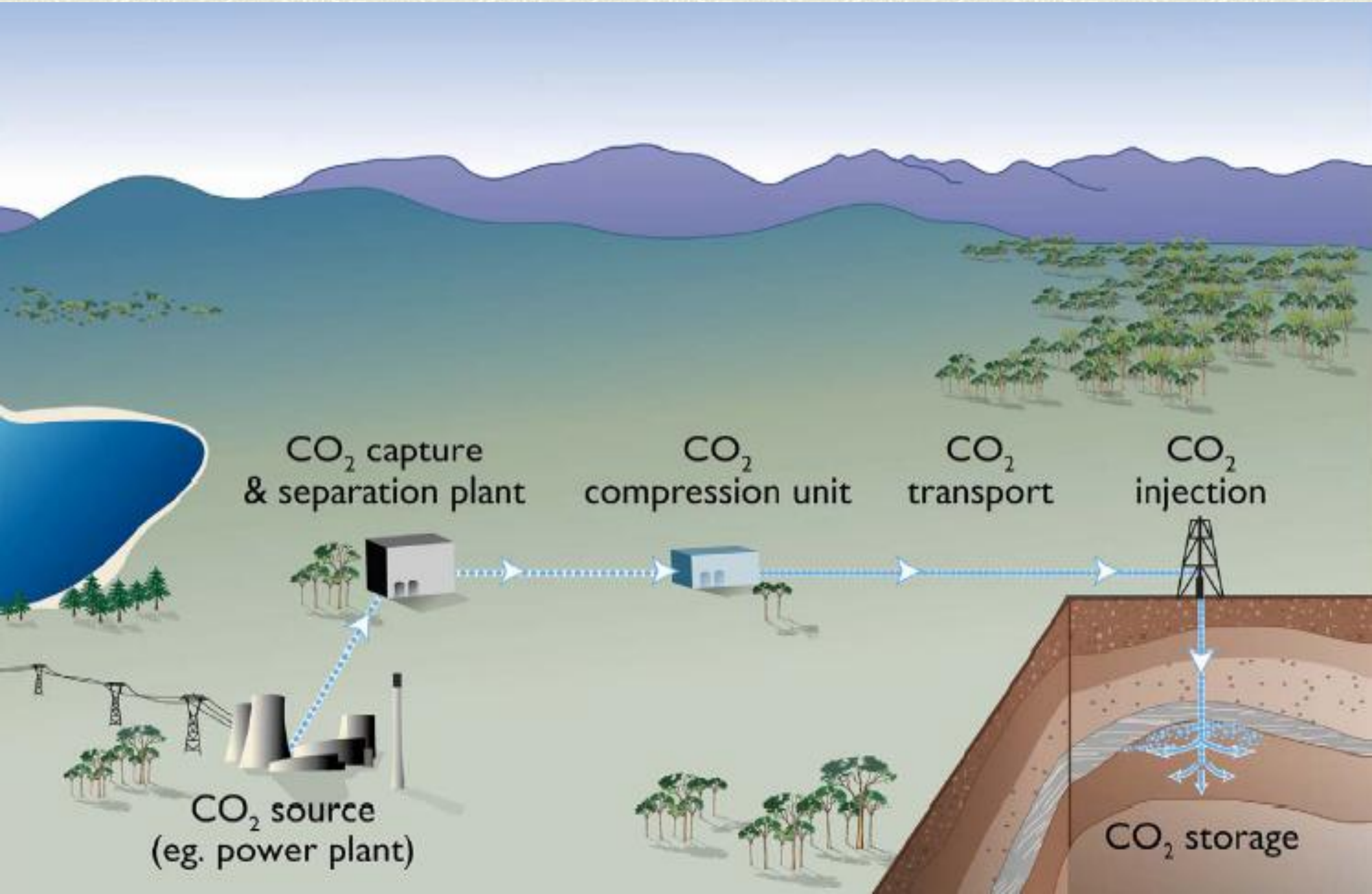
What is CO_2 Capture?

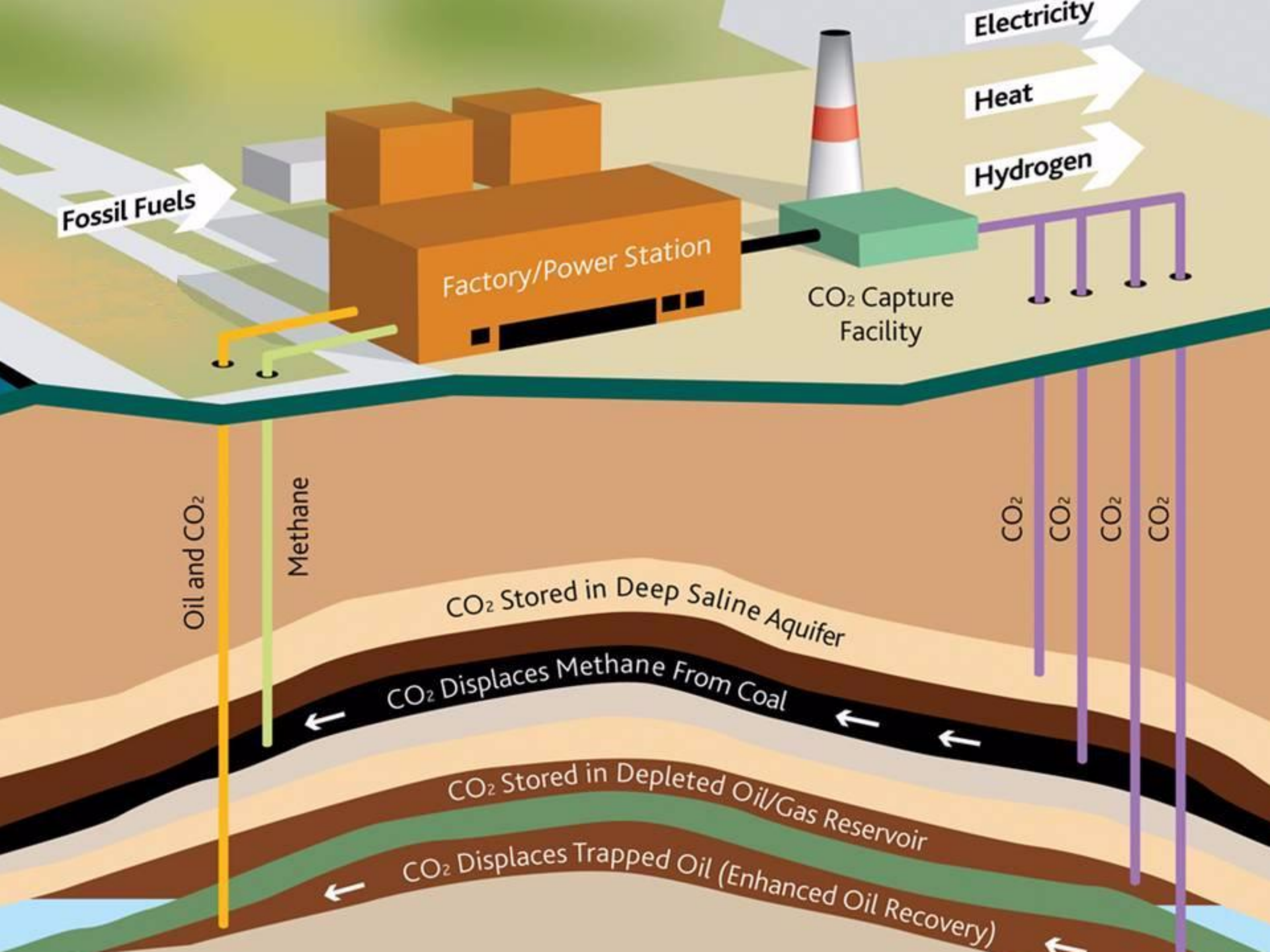
- The purpose of CO_2 capture is to produce a concentrated stream of CO_2 from emitted gases that can be easily transported to a CO_2 storage site– **a deep underground geological formation.**

-CO_2 capture applies mainly to large power plants fired with hard coal, lignite and natural gas.

-It also applies to large, single point emission processes such as refineries, cement plants, chemical plants and steel mills that can use the same or similar technology - as well as transport infrastructure – thus increasing the efficiency of the entire CCS system. It can even apply to biomass, paving the way for net *negative* emissions, because biomass also draws CO_2 down from the atmosphere whilst it is growing.

CCS Technology Components





Electricity
Heat
Hydrogen
Fossil Fuels
Factory/Power Station
CO2 Capture Facility
Oil and CO2
Methane
CO2
CO2
CO2
CO2
CO2 Stored in Deep Saline Aquifer
CO2 Displaces Methane From Coal
CO2 Stored in Depleted Oil/Gas Reservoir
CO2 Displaces Trapped Oil (Enhanced Oil Recovery)

CO_2 Capture Technologies

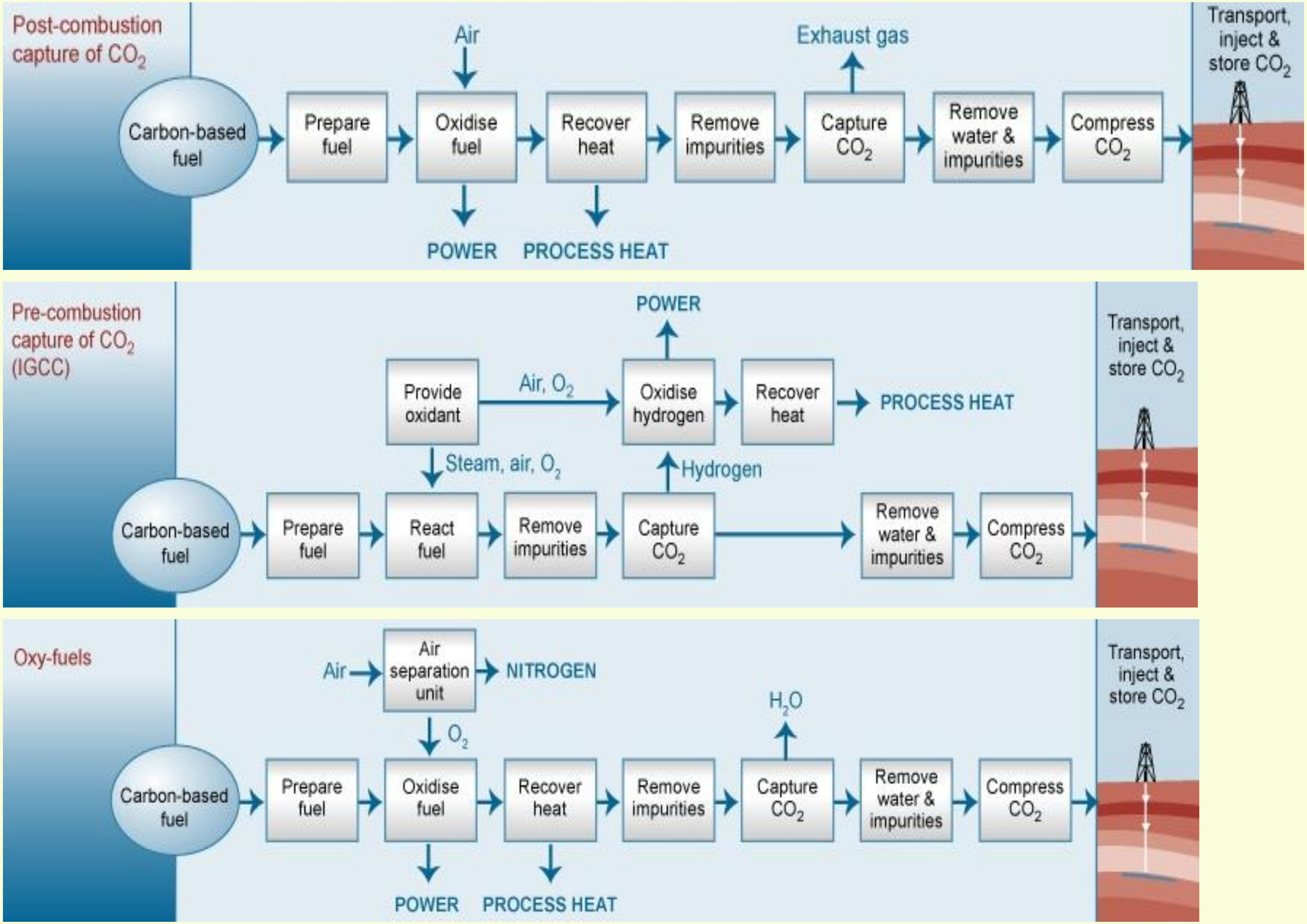
There are three main technology options under development:

❖ ***Post-combustion*** systems separate CO_2 from the flue gases produced by combustion of a primary fuel (coal, natural gas, oil or biomass) in air. This can be retrofitted to existing power plants, as well as new builds.

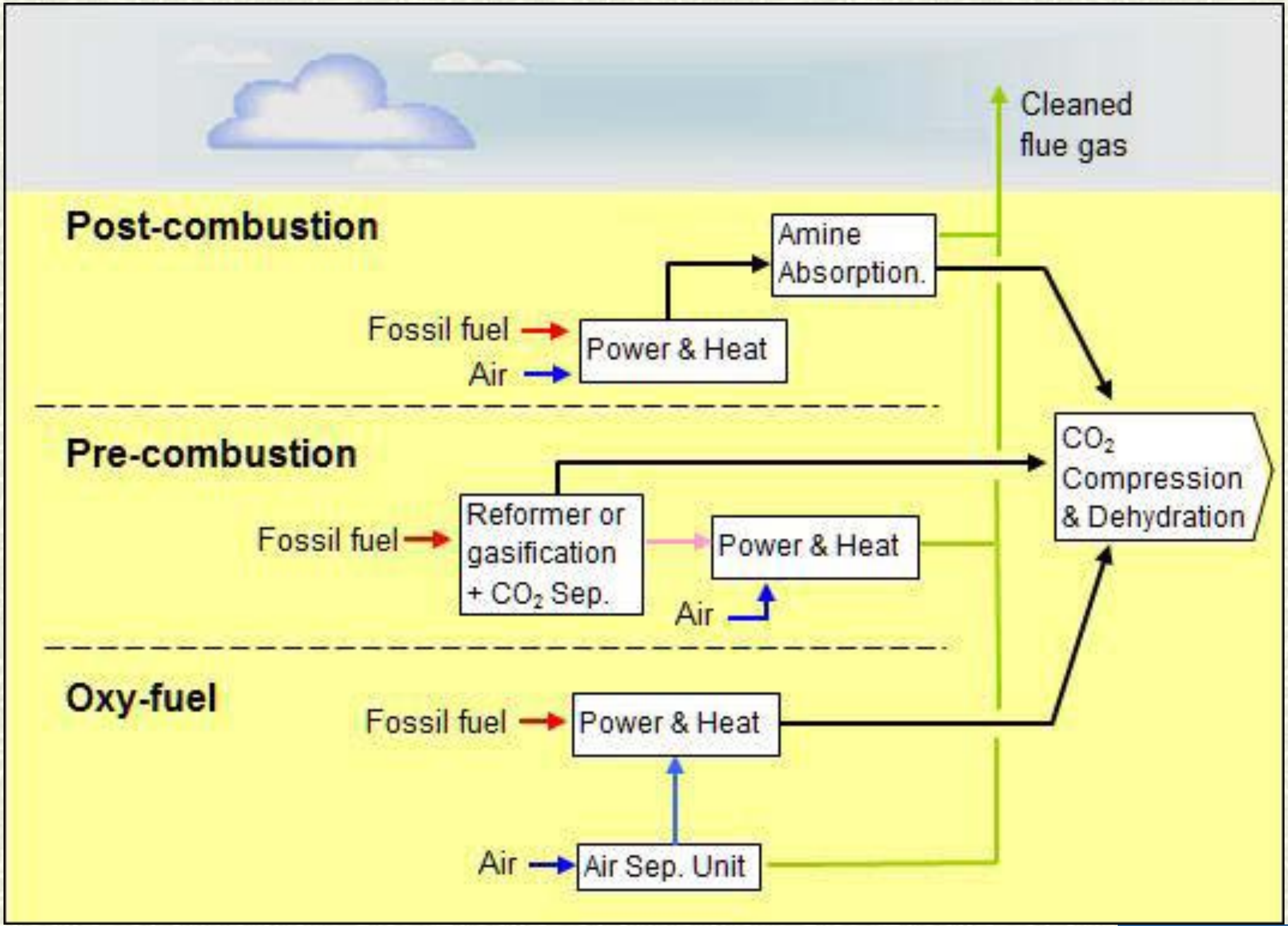
❖ ***Pre-combustion*** systems process the primary fuel (natural gas or synthetic gas from coal) in a shift reaction to produce streams of CO_2 and hydrogen which can be separated. ***The hydrogen can then be used for either electricity or as a fuel - accelerating the transition to a hydrogen economy.***

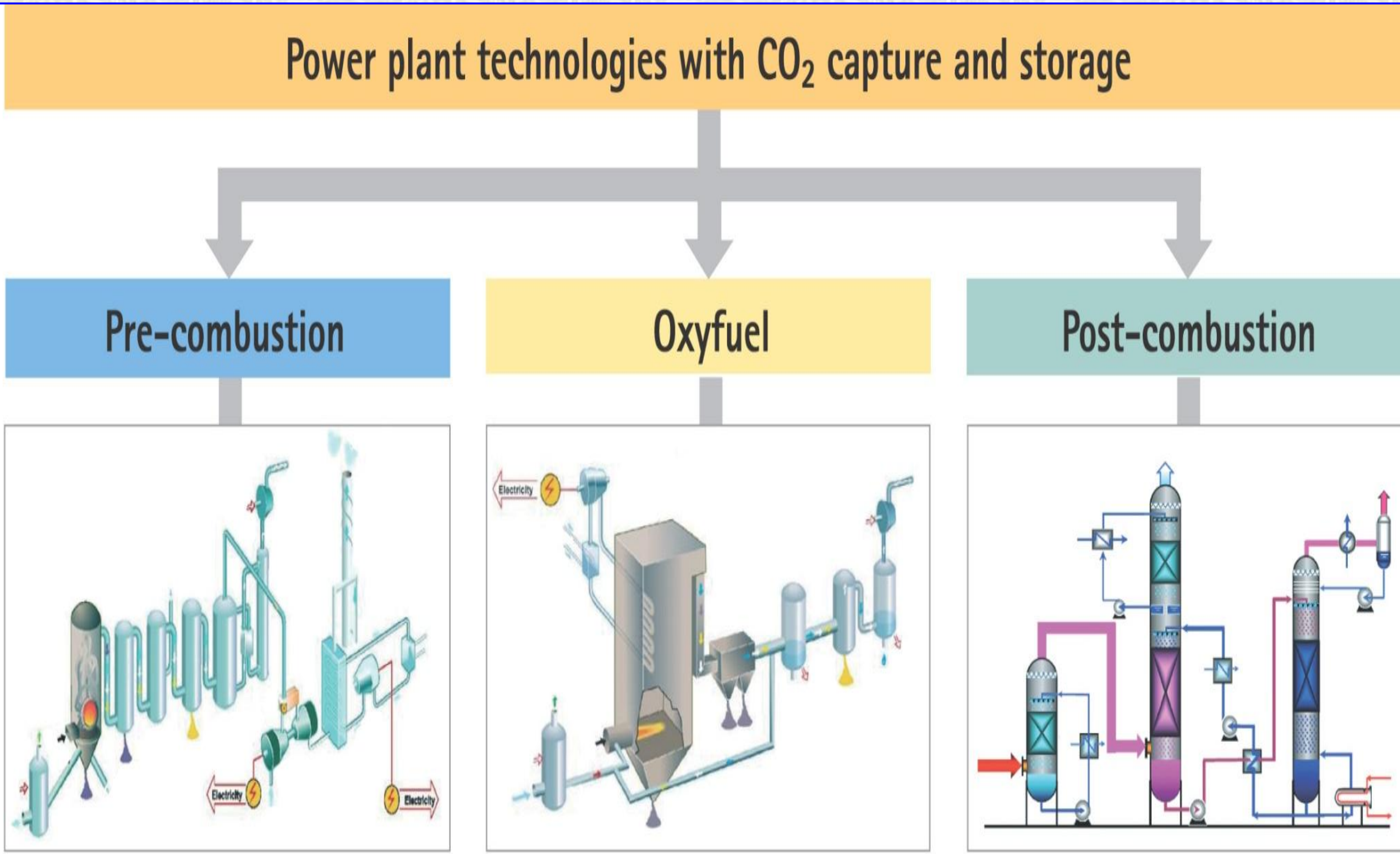
❖ ***Oxy-fuel combustion*** systems use oxygen instead of air for combustion, producing a flue gas that is mainly H_2O and CO_2, which can be easily captured after the water vapour is condensed.

CO2 Capture Processes



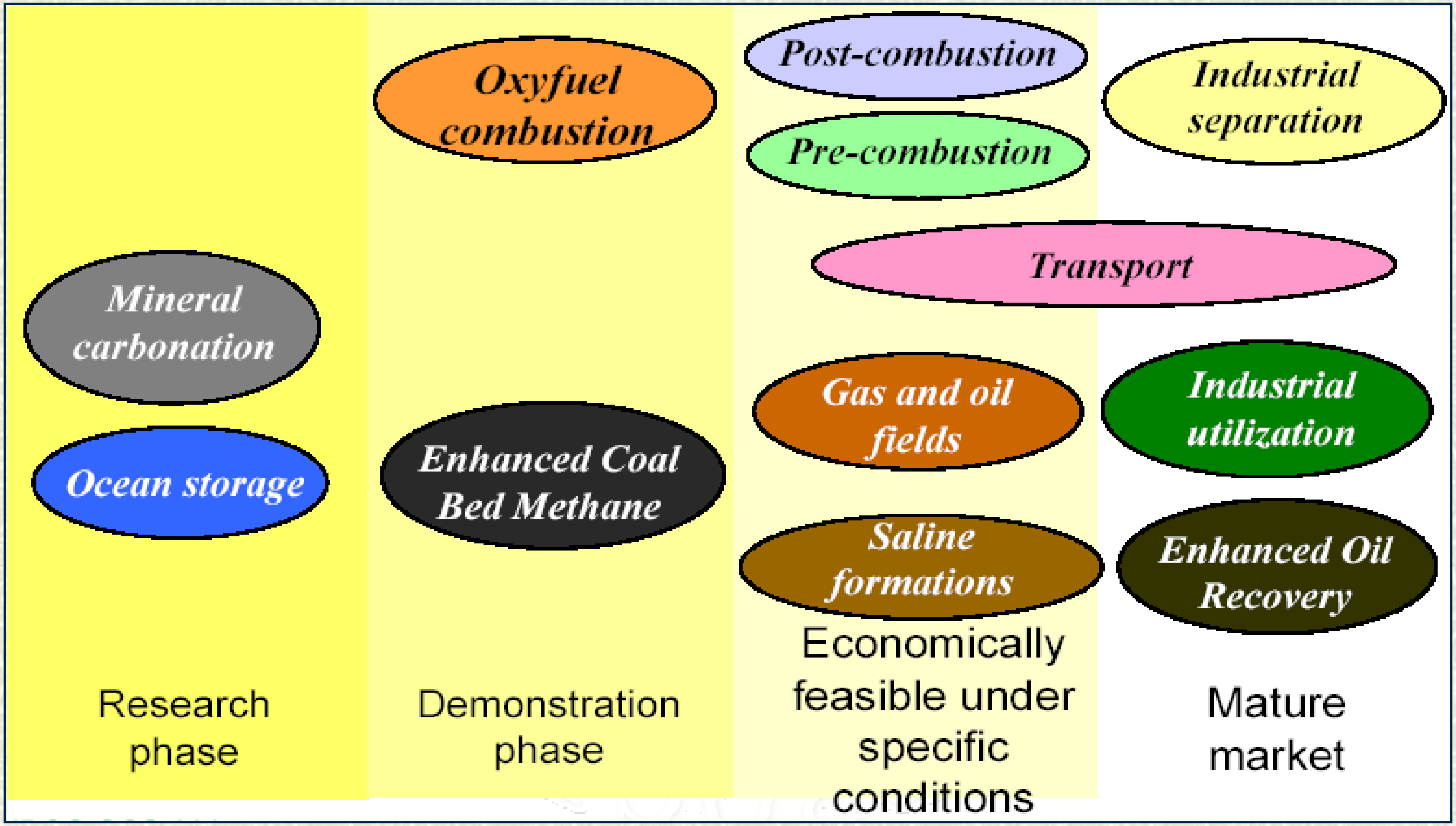
CO2 Capture Technologies





Efficiency losses: 5 to 14 % points

Maturity of CCS Technology



Realizing the Vision : zero Emission Power Plants by 2020

-The case for CO_2 capture and storage technology (CCS) is clear: without its urgent implementation, experts predict that CO_2 emissions will result in the average global temperature rising by anything from 1.4ºC – 5.8ºC between 1990 to 2100.

-- In order to avoid such a high temperature increase, it has stated categorically that global greenhouse gas (GHG) emissions must be reduced by 50% - 80% by 2050 (compared to 1990 levels).

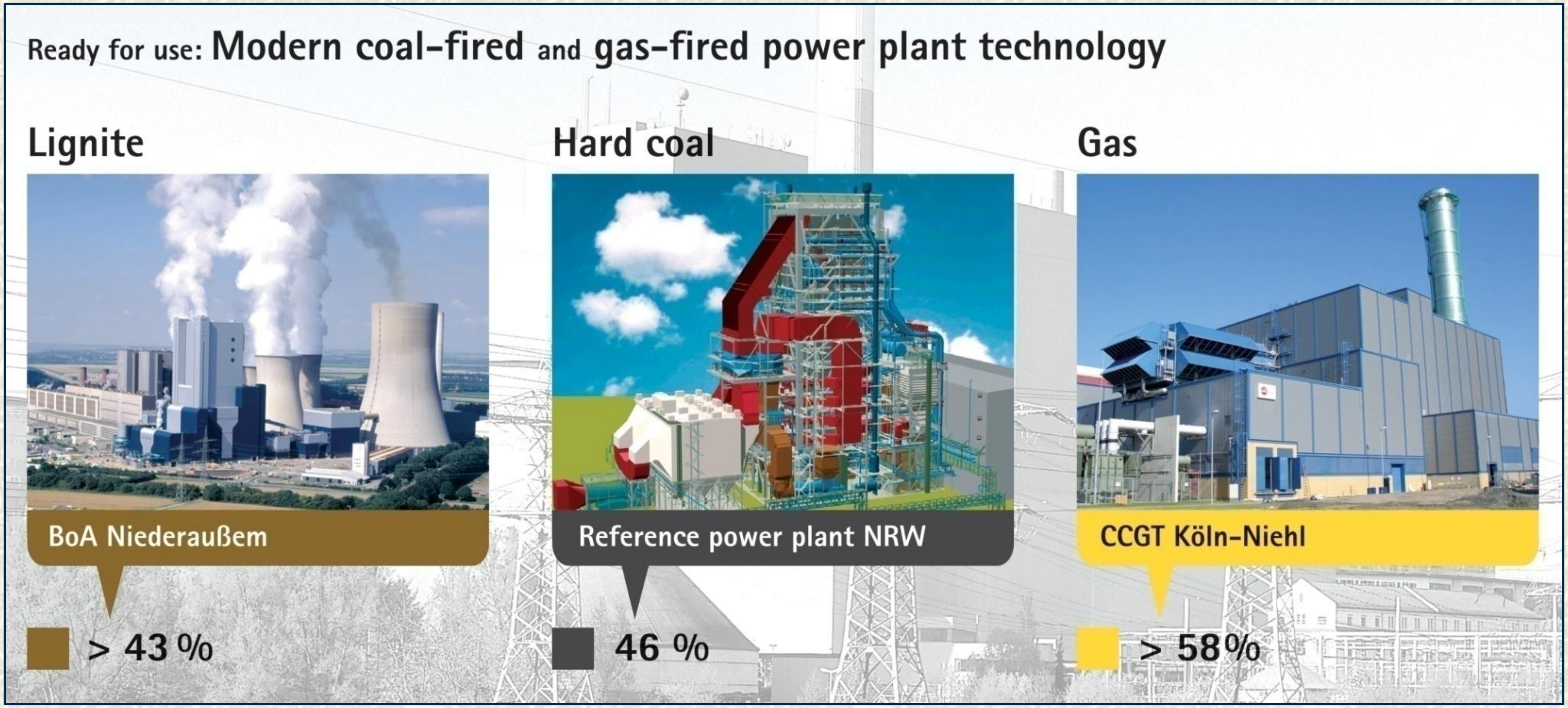
- Yet with world energy demand predicted to increase by 60% between year 2002 and 2030, and renewable energies to make up only a third of the energy mix by 2050, the immensity of the challenge becomes clear. Clearly, fossil fuels - coal, oil, gas must remain the primary energy resource for a long time to come.

CCS Goal

- A portfolio of solutions is therefore essential, including renewable energies, improved energy efficiency and nuclear power..
- Indeed, power plants equipped with this technology will emit less than 10% of their produced CO_2. If deployed to its full potential, it means CCS could reduce CO_2 emissions in the EU by 56% by 2050, compared to today.
- **As a safe and efficient method of capturing and storing millions of tonnes of CO_2 emissions underground for thousands of years, CCS represents the bridge to a sustainable energy system.**

CCS could reduce CO_2 emissions in the EU by 56% by 2050

Energy Mix & Options



Implementation Clean Coal Technologies step-by-step

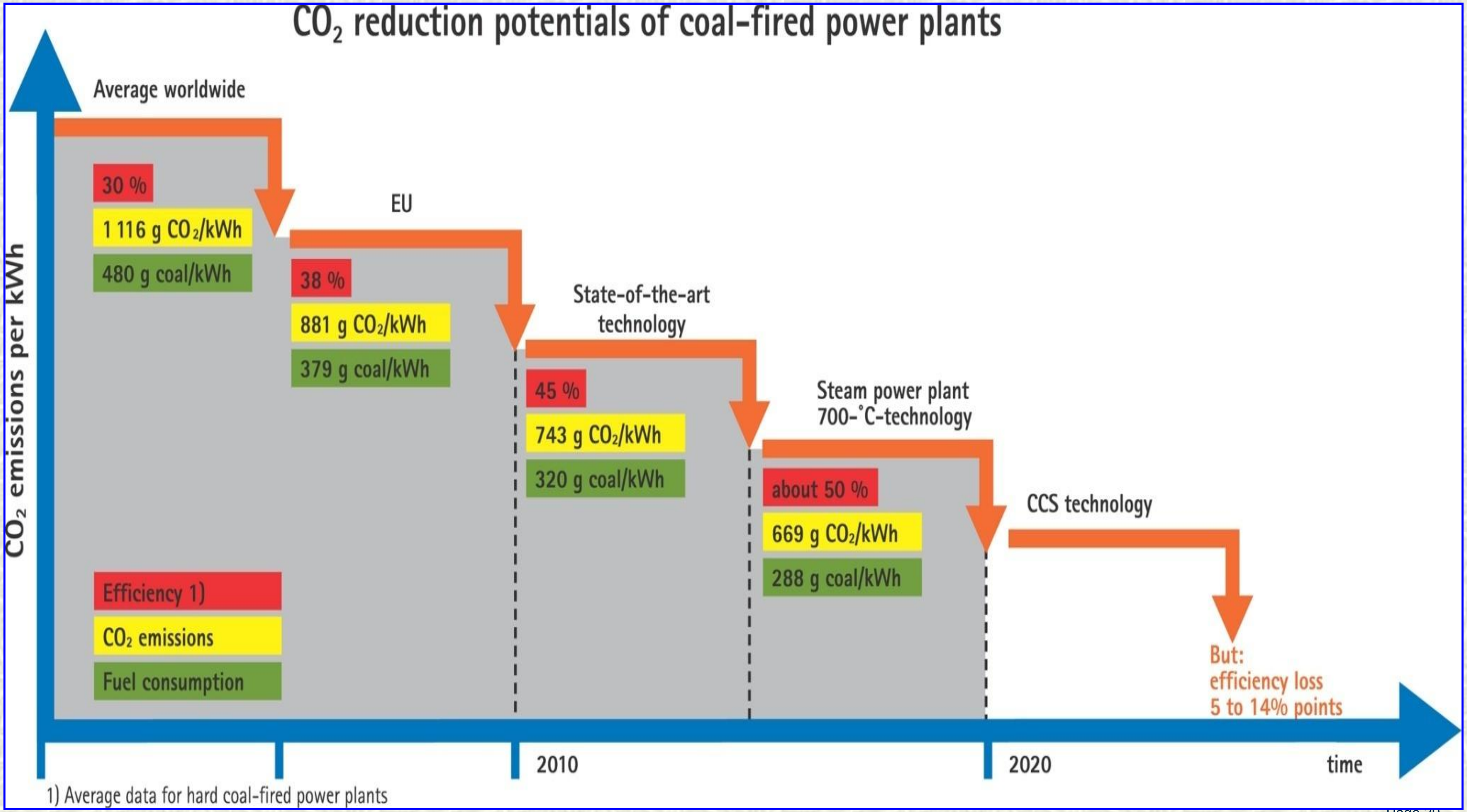
- **Step 1:** State of the art-technologies are replacing older units.

- **Step 2:** Start of 700 °C-technology which is under development. Start-up of first unit expected in 2014.

- **Step 3:** CCS-technology.
  Several demonstration units are in the pipeline.

1% increase in Efficiency reduces CO2 emission by 3%

CO_2 Reduction Potentials of Coal-fired Power Plants



Cost of CCS ?

For the world scale, estimates are commonly about: 2% of Global Domestic Product. That is one year of normal growth.

Cost Estimate In U.K.:
Cost for capture, liquefaction and storage in North Sea aquifers are about 20 pounds/ton.

Concerns And Issues

- New methodology, hence risk of approval
- High Cost of Technology
- High payback period
- In case of retrofit refurbishment, emission reduction depends on old components reliability, wear and tear, external factors like grid disturbance,coal quality, maintenance, etc.


THANK YOU