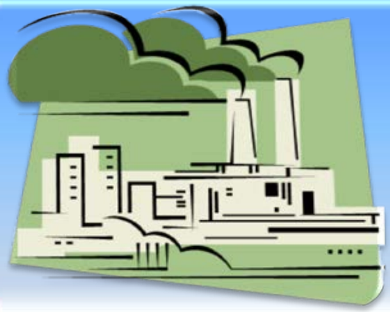
CO_2 Capture Technologies for Industry
Iron & Steel, Oil Refinery & Cement

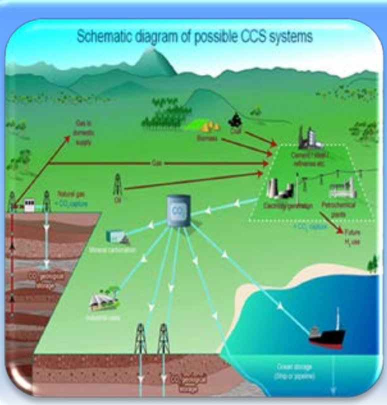
Dr. Prachi Singh, IEAGHG R&D Programme, UK

CO_2 Capture and Storage Regional Awareness-Raising Workshop, 13-14th June 2012, Ankara, Turkey

Outline



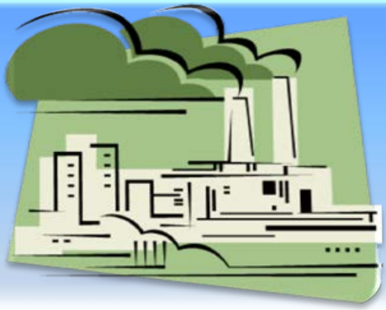
Overview of CO_2 Emission from Industry



CO_2 Capture from Industry

- Iron and Steel
- Oil Refinery
- Cement

Conclusions



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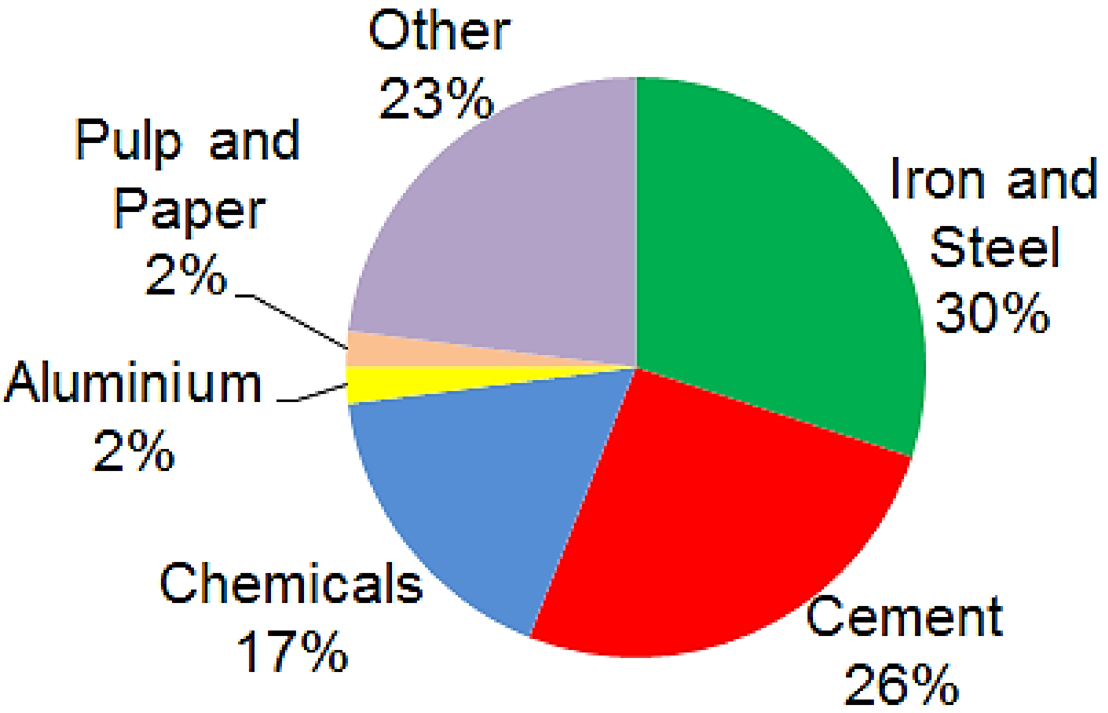
CO_2 Emission from Industry

IEA Energy Technology Perspective 2010

- Steel, Cement and Chemical Industries accounts for nearly 70% of the Direct CO_2 Emissions.
- These emissions are not only from combustion of fossil fuel related CO_2 emissions but also to include PROCESS RELATED CO_2 EMISSIONS

7.6 Gt CO_2, 2007

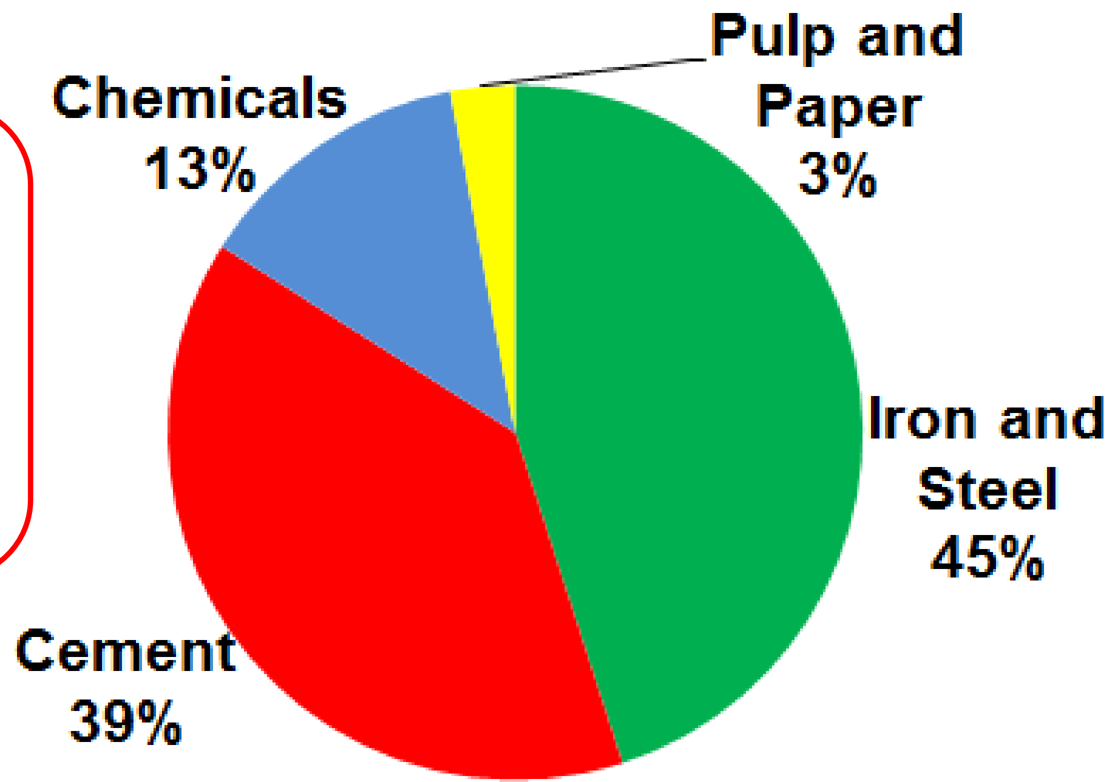


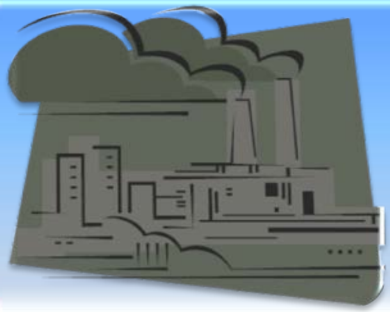
Industrial CO_2 Emission Reduction from CCS by 2050

IEA Energy Technology Perspective 2010

Reduction of 2.5Gt CO_2

There are important CO_2 reduction opportunity from Iron and Steel and Cement Industry





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CO_2 Capture from Industry

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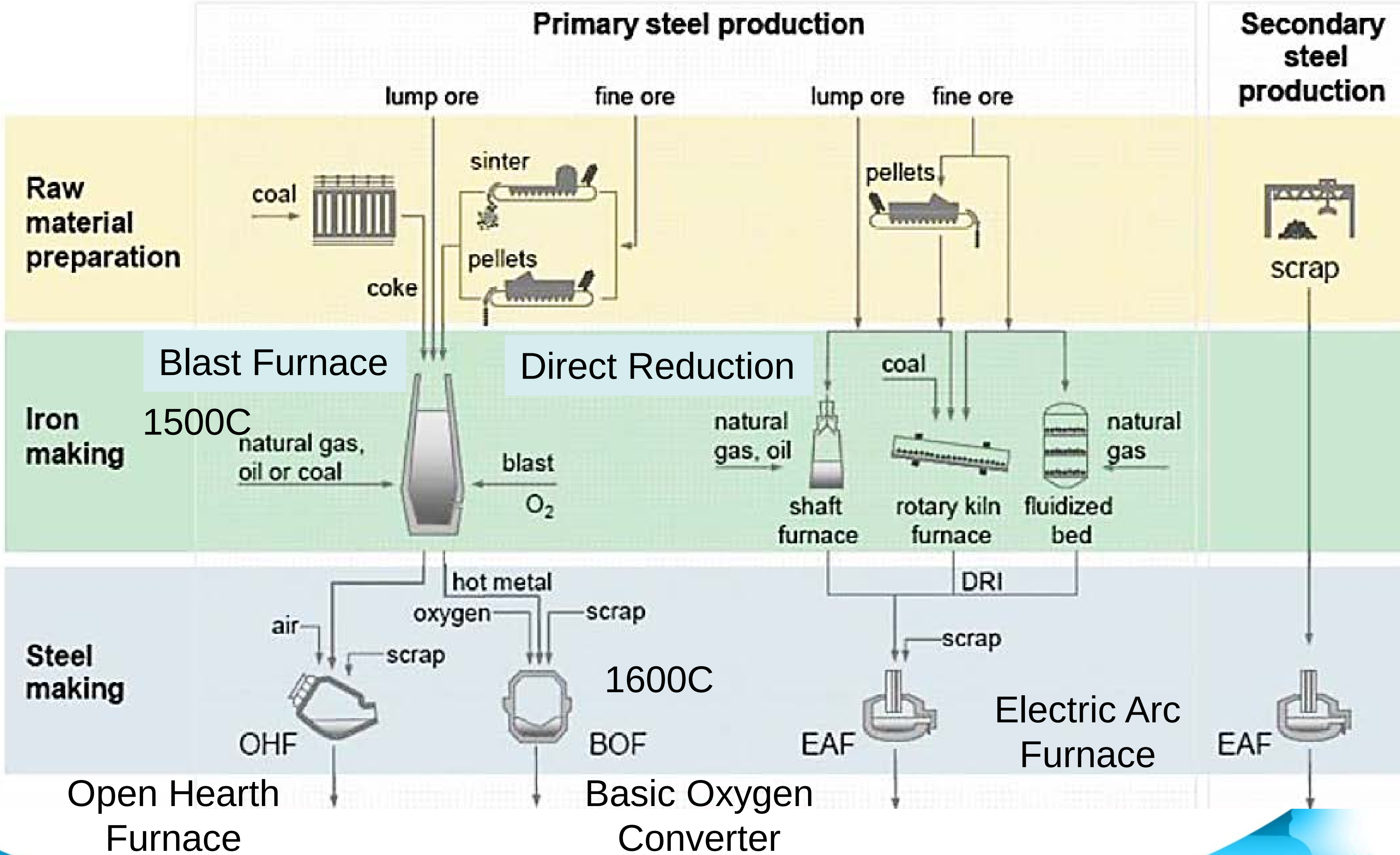
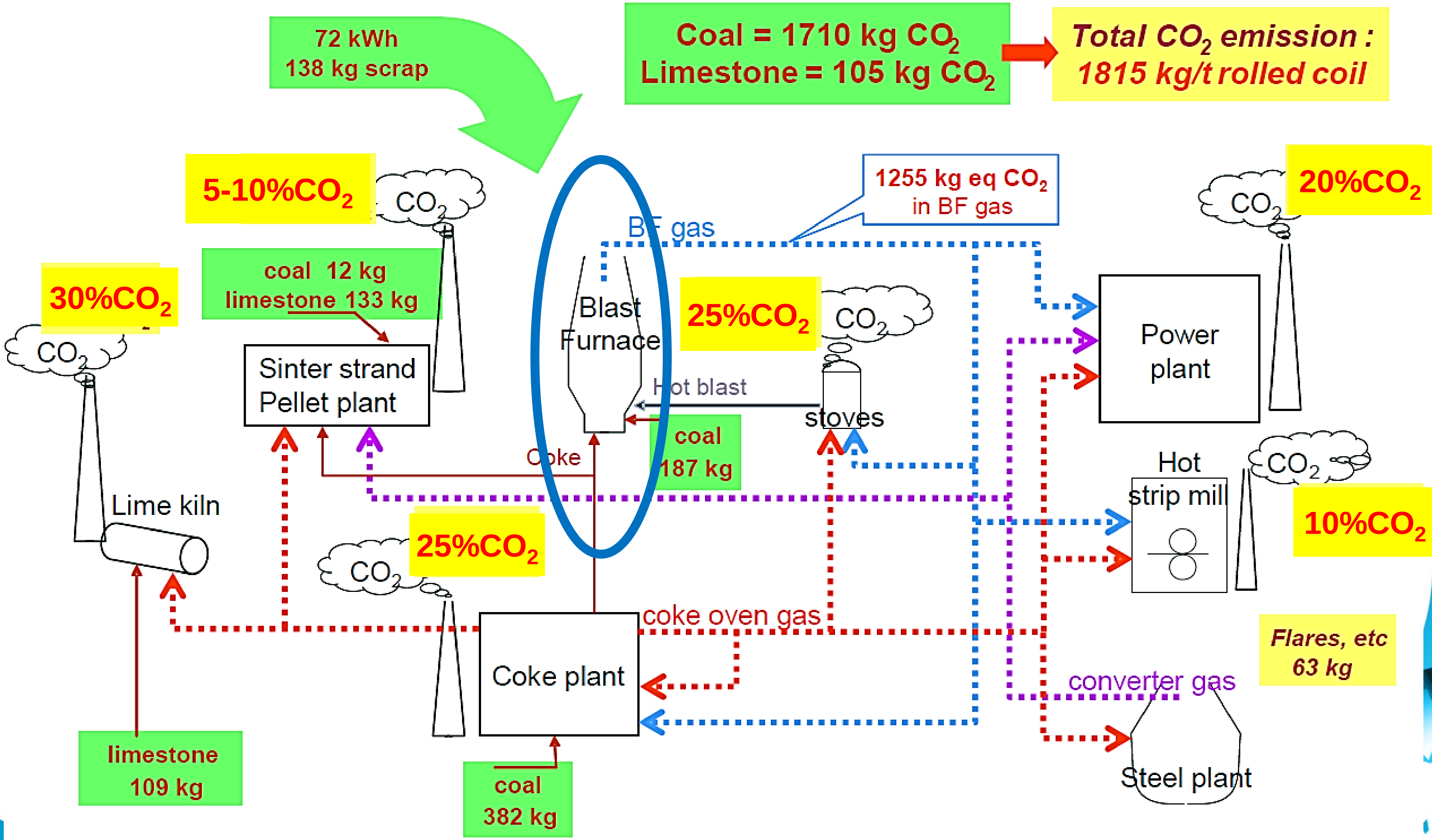
Steel Plant



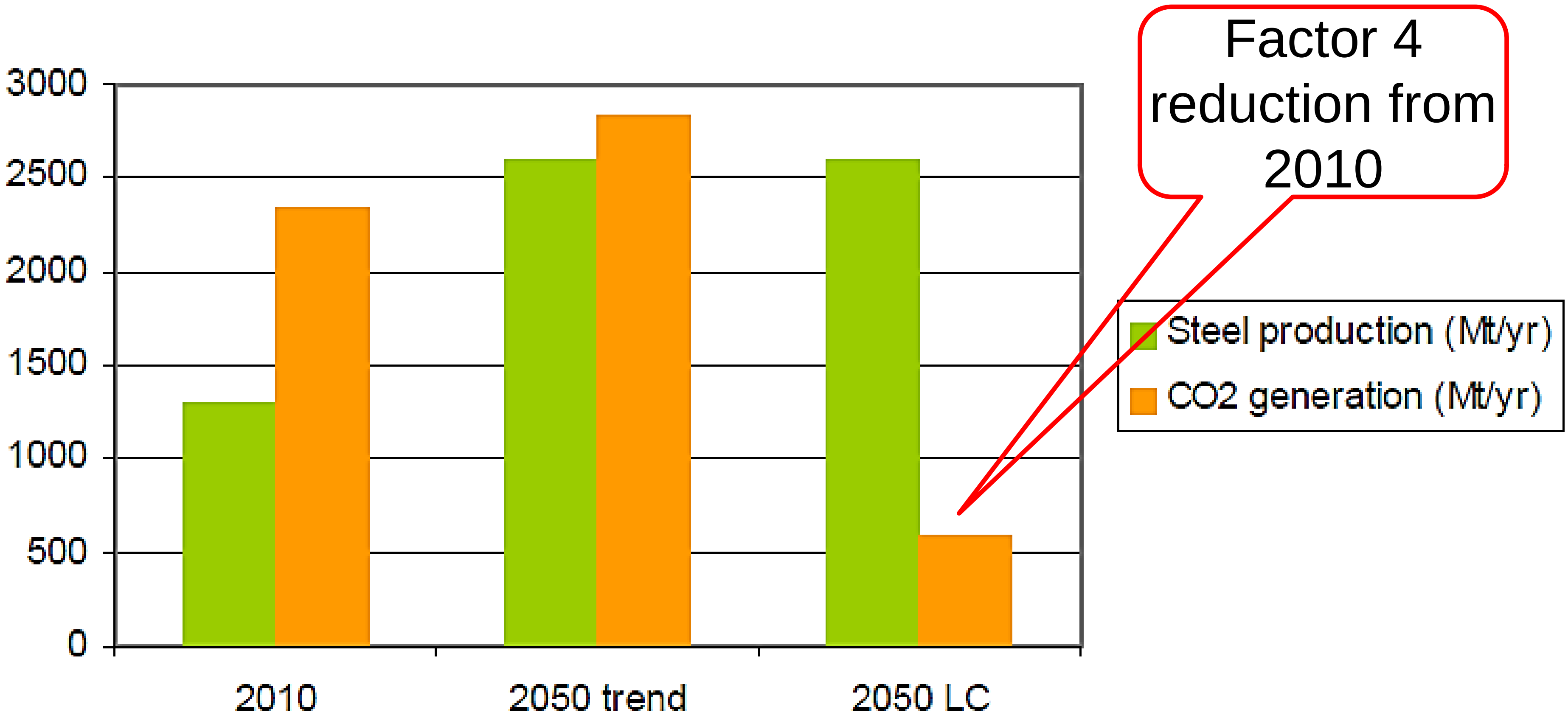
Source UNIDO 2010

CO_2 emission from Steel Plant



Source UNIDO 2010 $\%CO_2$ is the concentration in the flue gas

Projection of CO_2 emission from Steel sector



30% by EAF & 70% by BF

Steel production doubled, 60% EAF & 40% by BF

Source UNIDO 2010

Strategy to Control CO_2 Emission

Reducing energy demand from Blast Furnace (BF)

Using more Scrap Metal

Major Source of CO_2 emission from still mills will remain ore based route

Largest EU R&D programme since 2004

Ultra Low CO_2 Steelmaking (ULCOS)

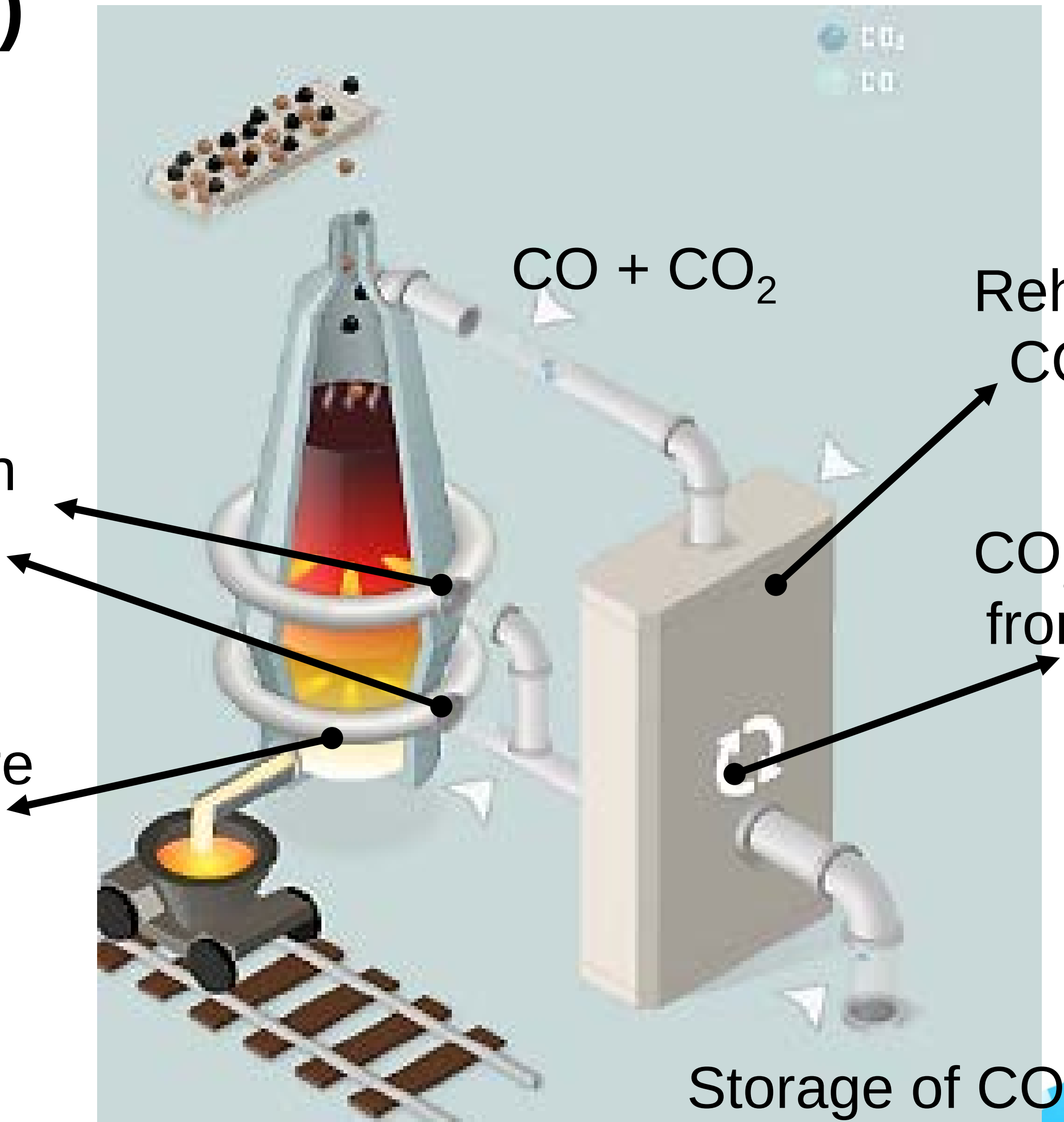
Ultra Low CO_2 Steel making (ULCOS)

- Three major CO_2-lean process routes:

1. Decarbonizing: Shifting away from coal, replacing carbon by Hydrogen or Electricity,
2. Using Hydrogen reduction of ore or Electrolysis of iron ore
3. Introduction of CCS technology or the use of sustainable biomass.

- In near term Top Gas Recycling Blast Furnace (TGR-BF) is most promising and can be retrofitted

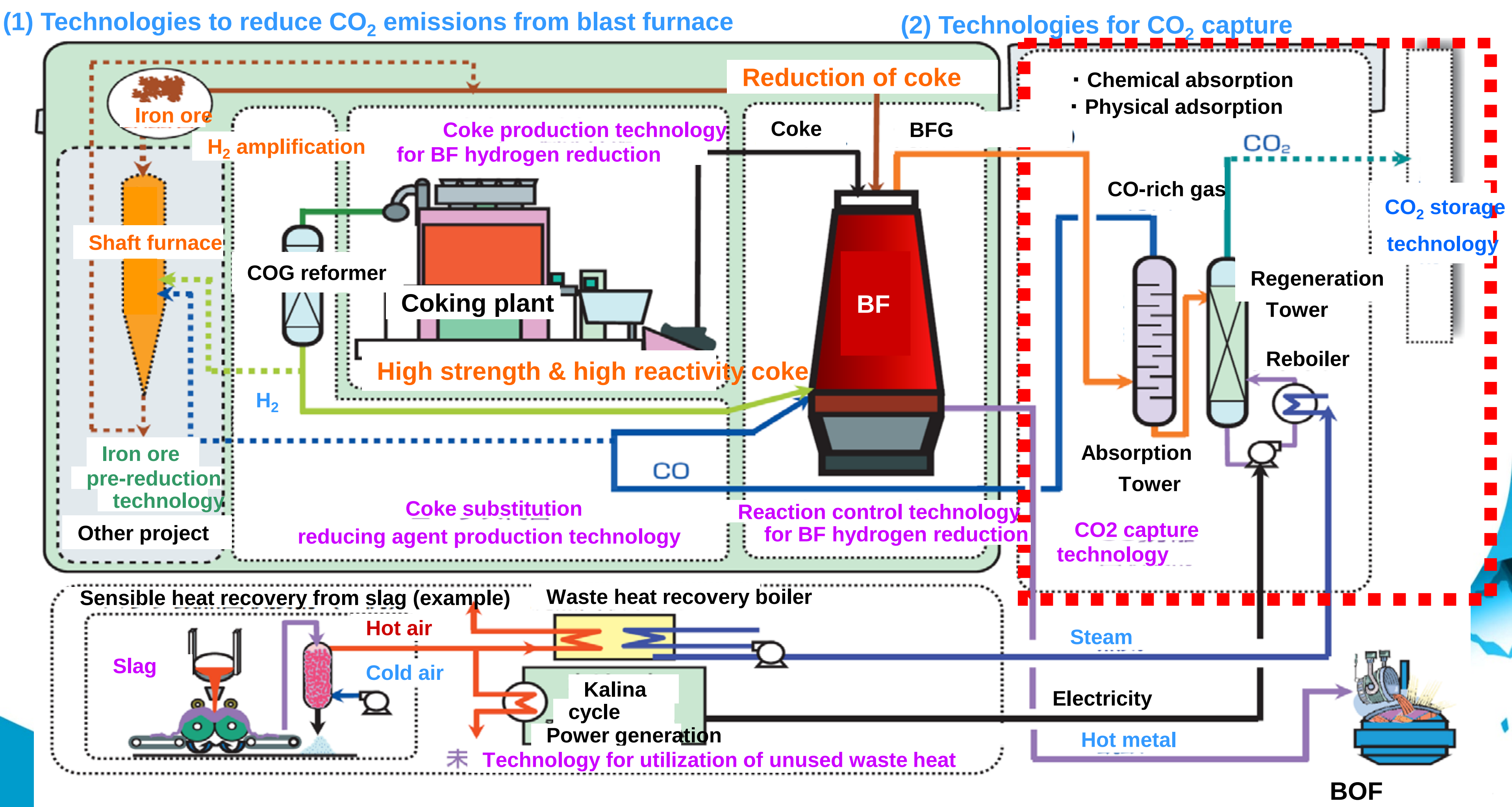
Top Gas Recycling Blast Furnace (TGR-BF)



Source ULCOS

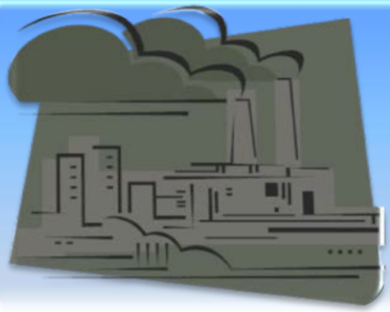
Japanese “Course 50 Programme”

COURSE50 ／ CO_2 Ultimate Reduction in Steelmaking Process by Innovative Technology for Cool Earth 50



Major gaps and Barriers

- ***There are no steel mill in this world which are alike...***
  - Steel are produced with different processes
  - Steel are produced with different type of finished or semi-finished products
  - Steel are produced with different grades
  - ...
- Cost of CO_2 capture
- Timeline
- Extra burden from CO_2 purity



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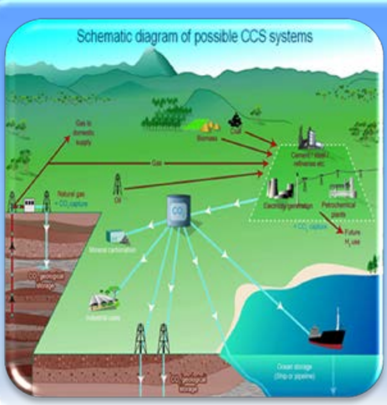

CO_2 Capture from Industry

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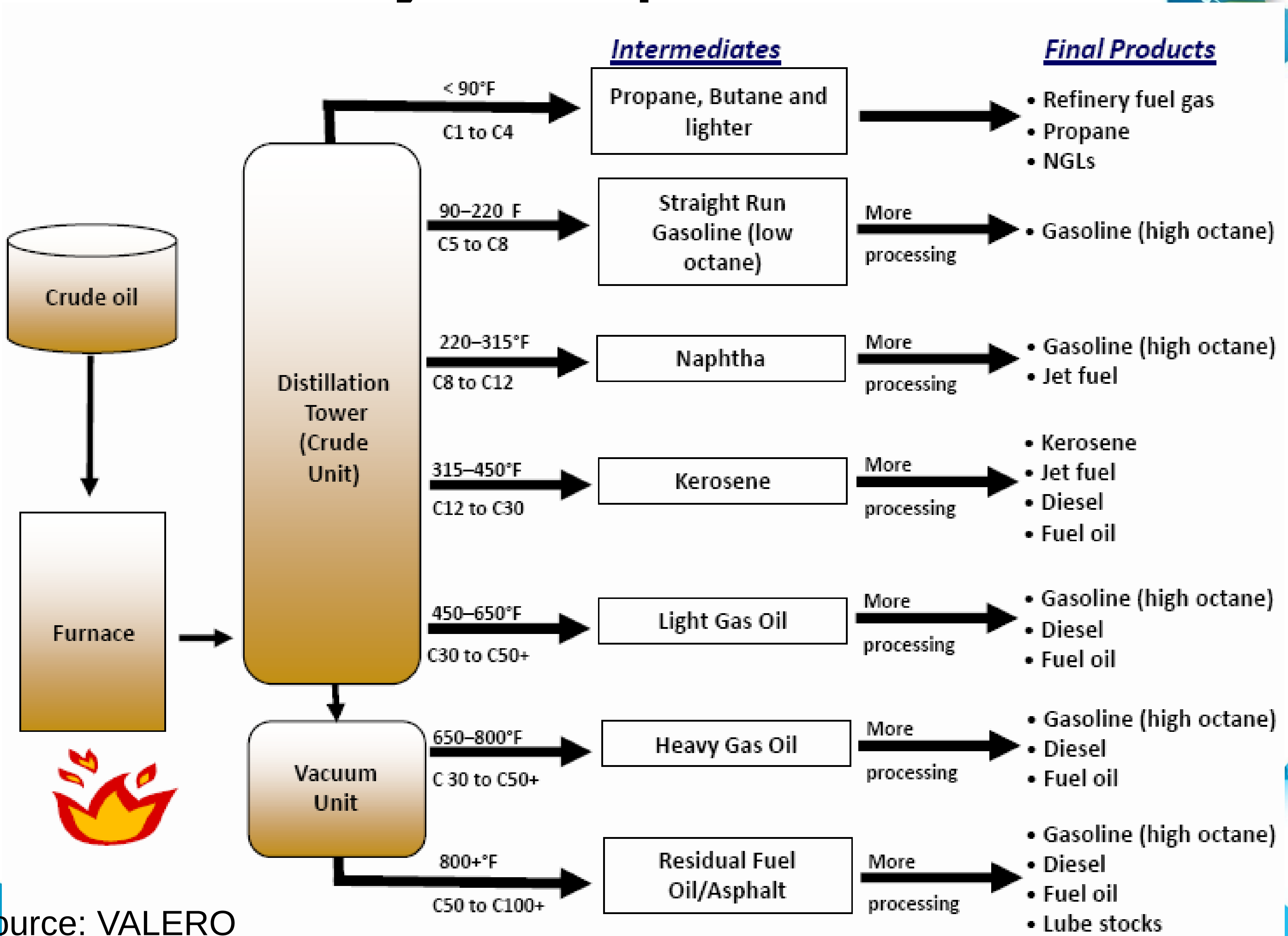
- **Oil Refinery**
- Cement

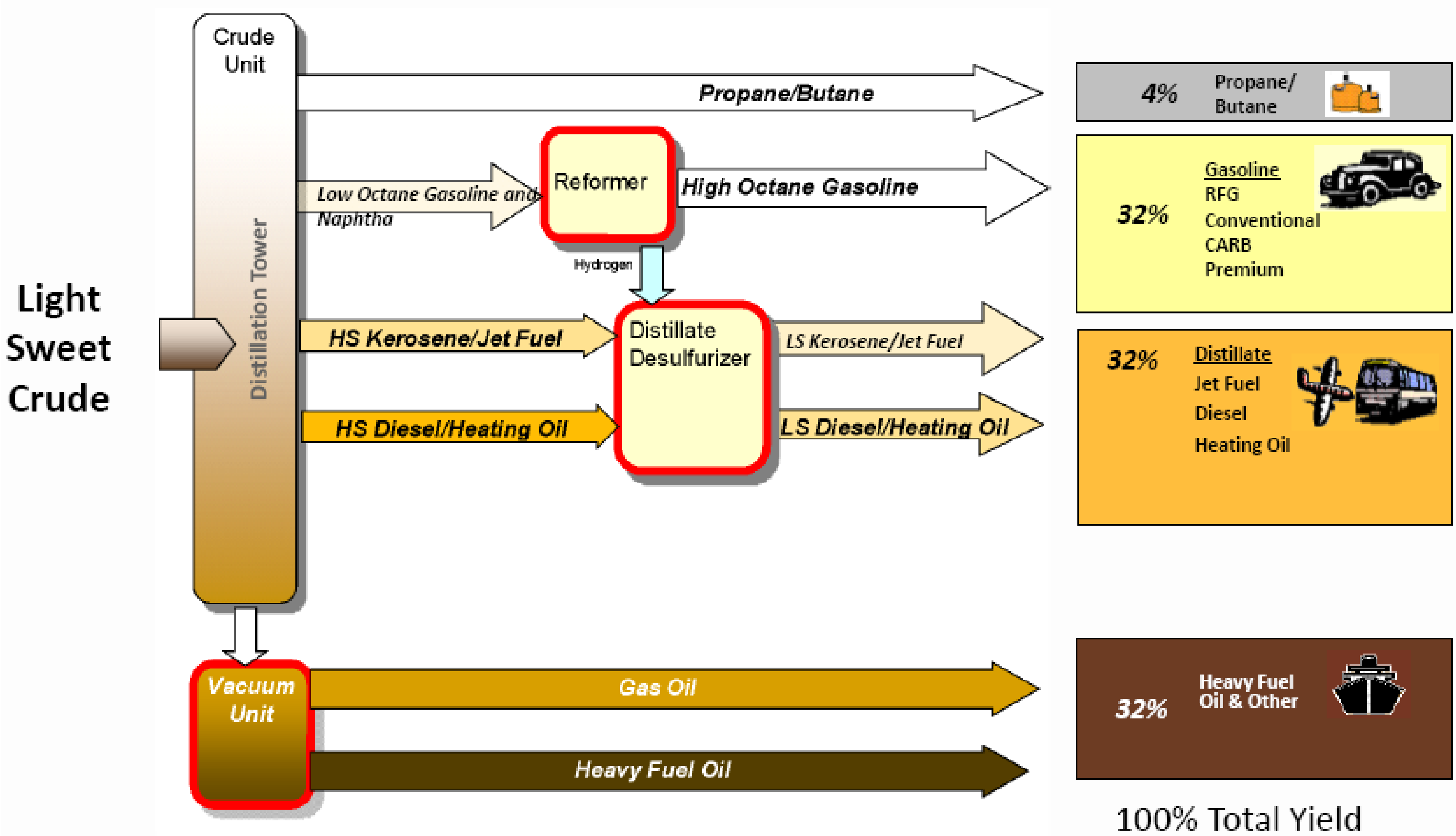
Conclusions

Basic Refinery Concept



Source: VALERO

Hydroskimming/ Topping Refinery

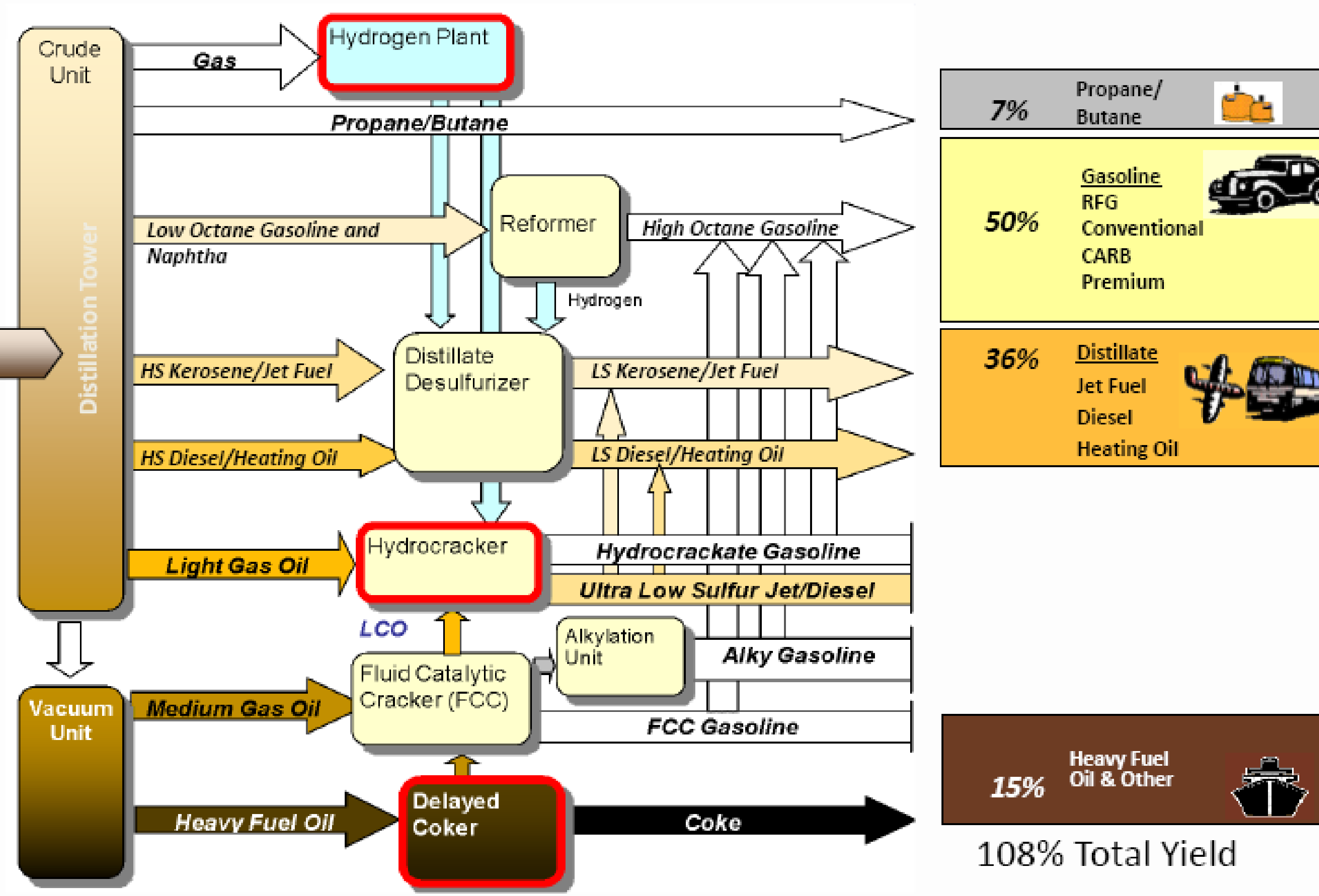


Simple, low upgrading capability refineries run sweet crude

Source: VALERO

High Conversion: Coking Resid Distruction

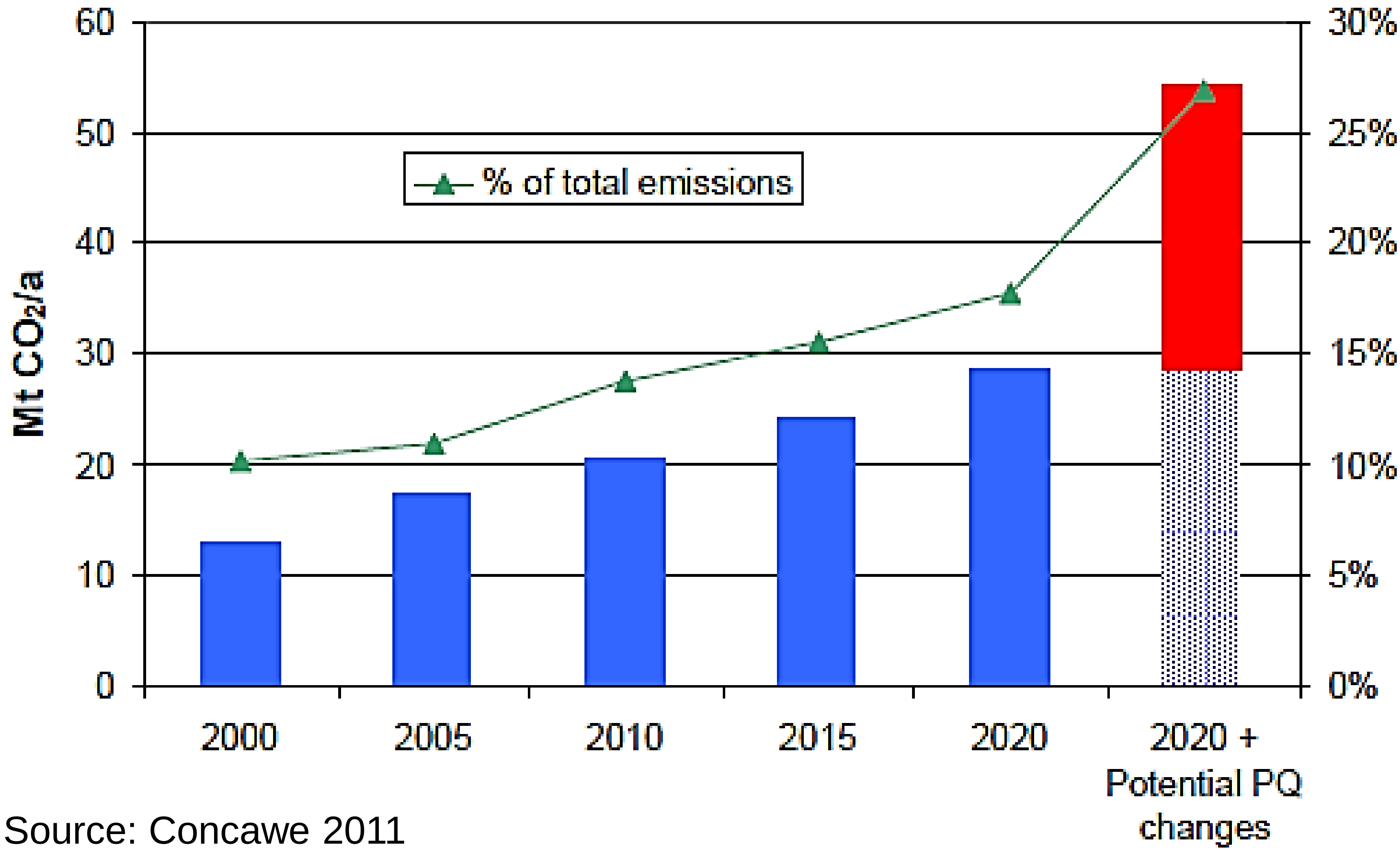
Medium/ Heavy Sour Crude



Source: VALERO

Complex refineries can run heavier and more sour crudes while achieving the highest light

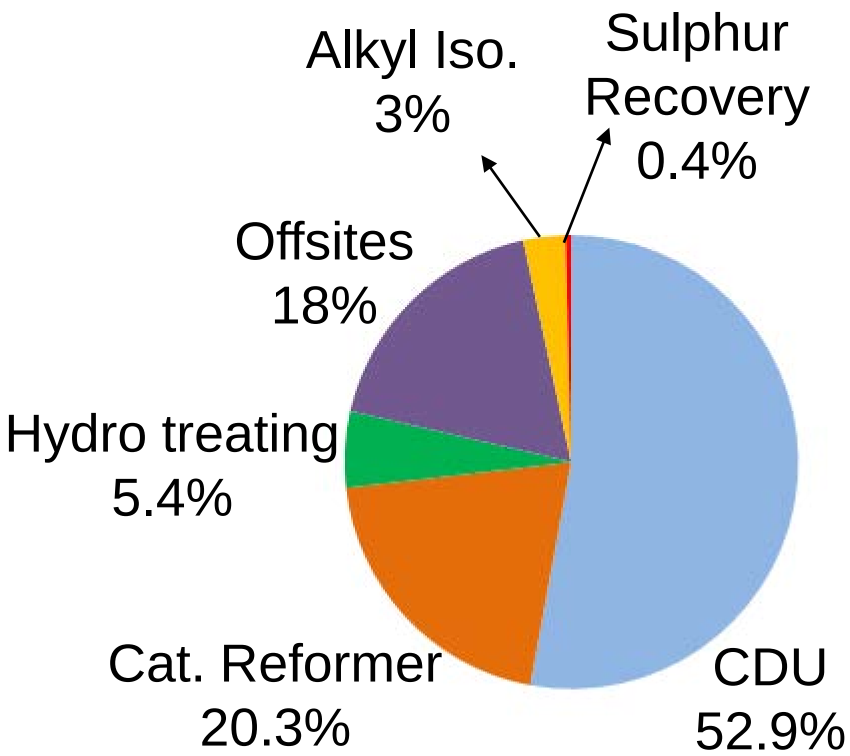
Forecast EU refinery CO_2 emissions in 2020



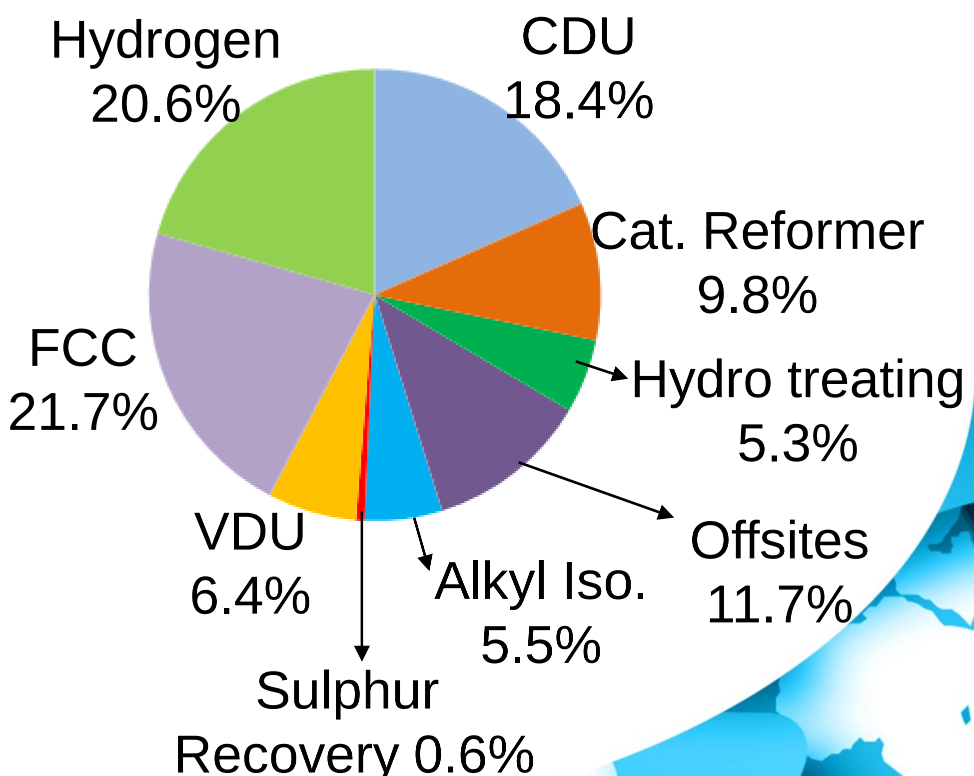
Source: Concawe 2011

CO_2 Emission Breakdown by Process

Hydroskimming Refinery 0.6MtCO_2/annum

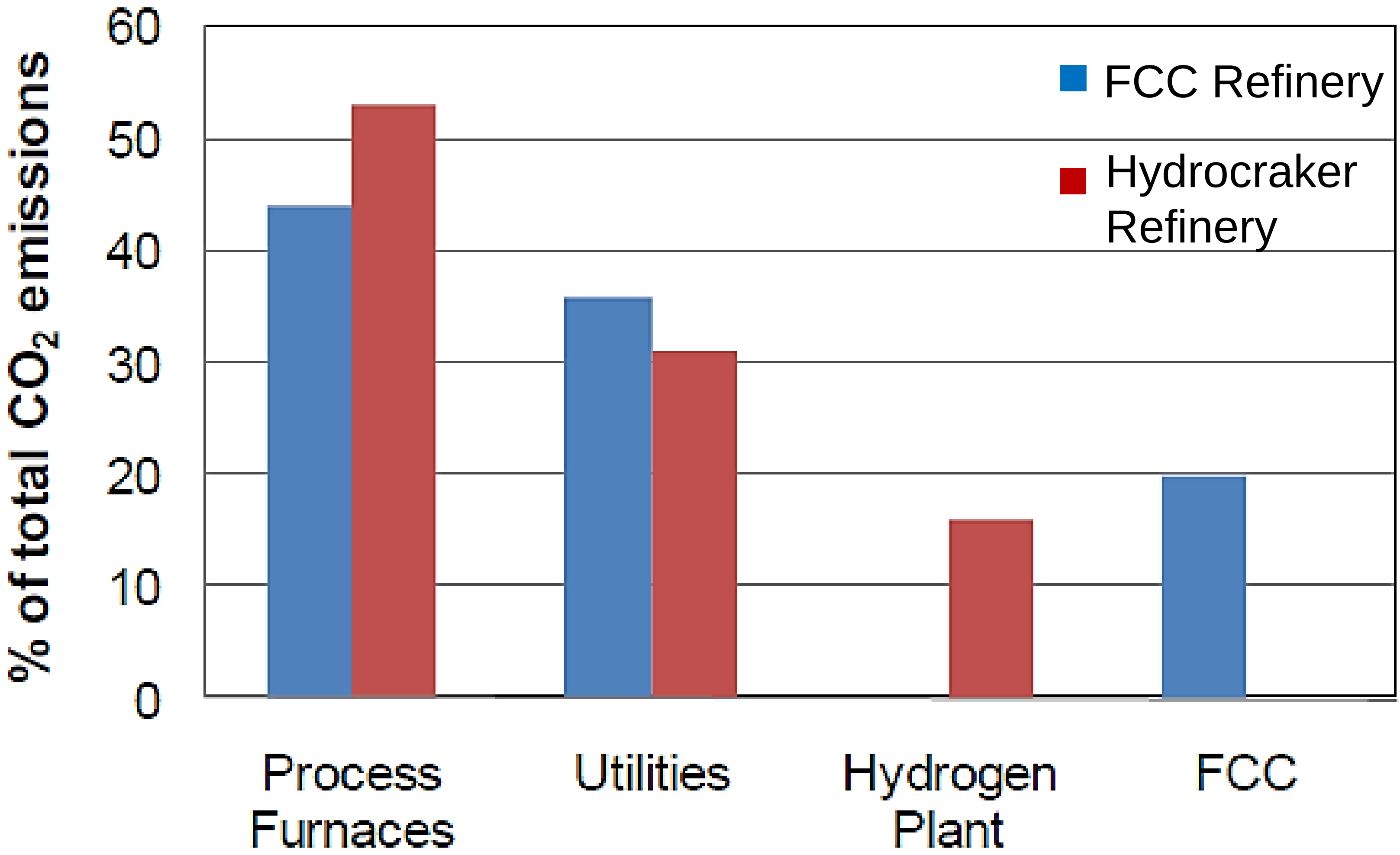


Conversion Refinery 1.4MtCO_2/annum



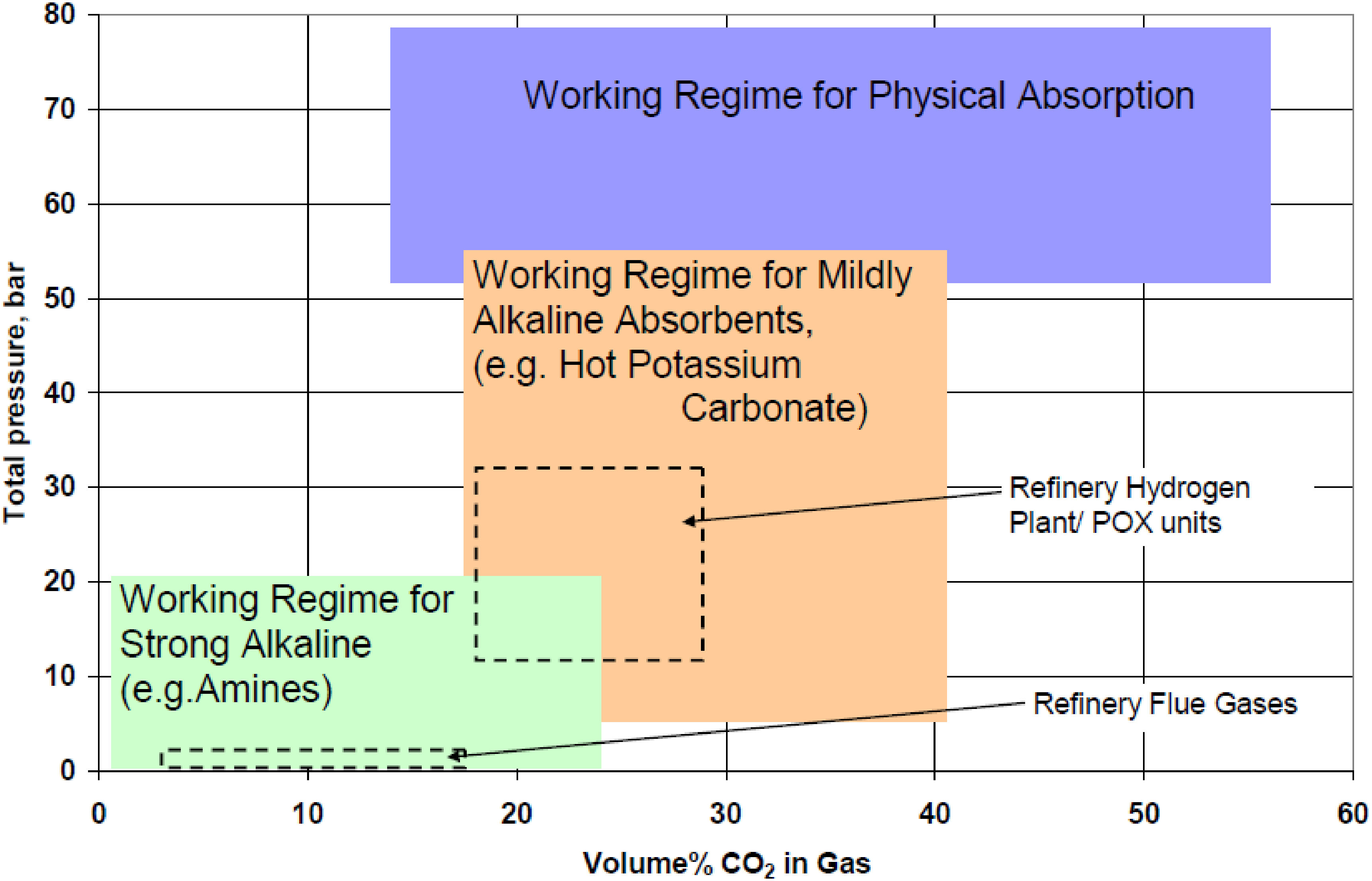
Source: Concawe 2011

Distribution of CO_2 emission by Source in a Complex Refinery



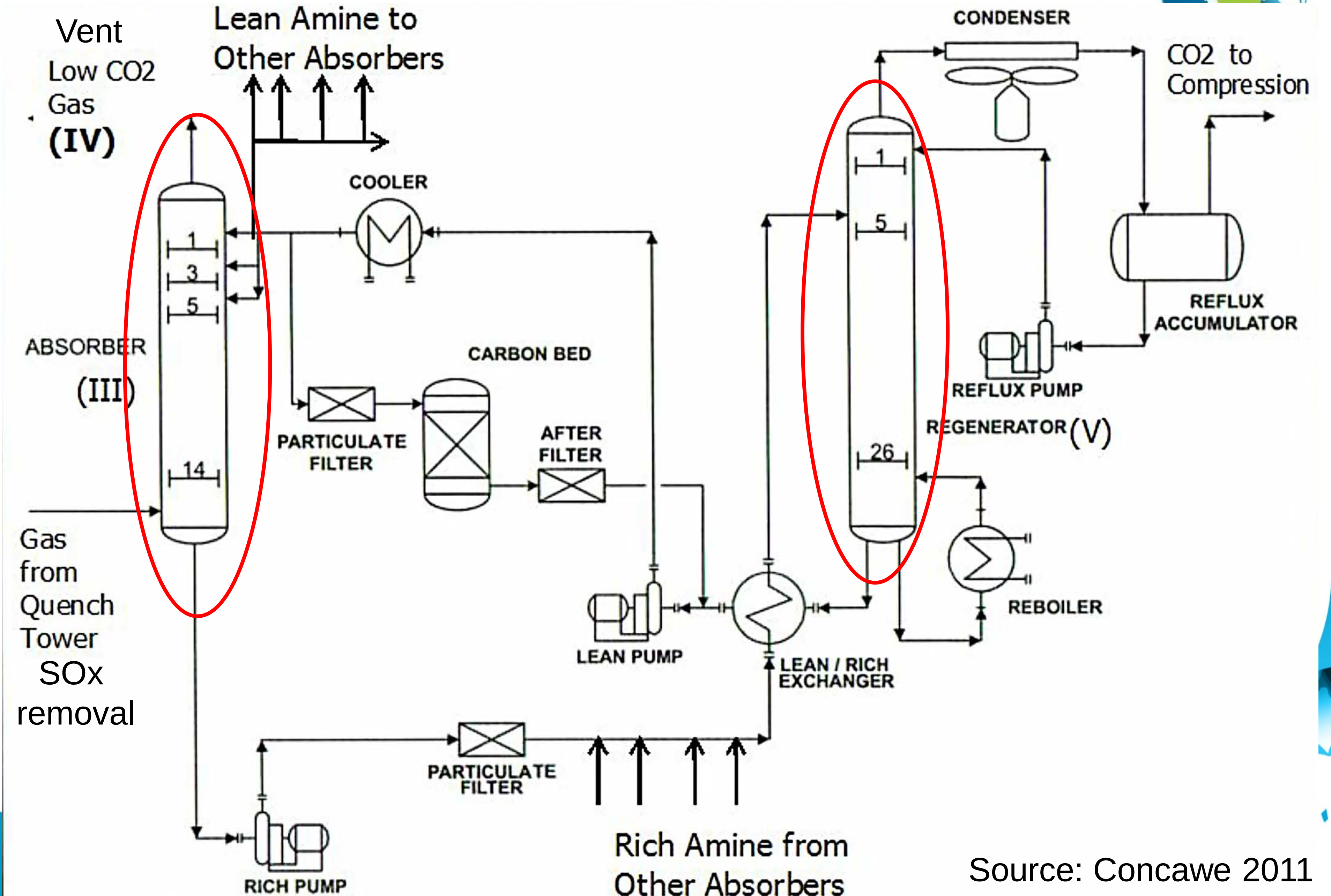
Source: Concawe 2011

Technology Selection for CO_2 capture



Source: Concawe 2011

Possible Refinery CO_2 Capture



Source: Concawe 2011

Alternative CO_2 Capture Technology

Oxyfuel Combustion

- FCC unit air is replaced with pure oxygen diluted by recycled CO_2 to maintain thermal balance and catalyst fluidization will produce 95% CO_2

Chemical Looping Combustion

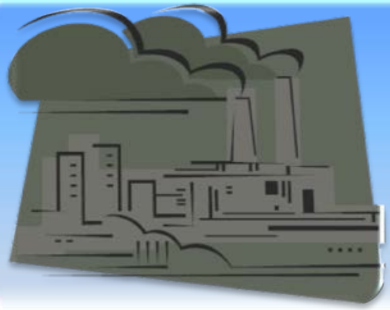
- Continuous Fluidized circulation of oxygen career in FCC

Pre Combustion

- Can be applied to gasify the carbonaceous feed to produce Hydrogen and pure CO_2

Challenges and Barriers

- Refinery retrofit is complex and expensive
- CO_2 Capture needs Utilities → require more energy production from utilities
- Increases Capex and Opex
- Different CO_2 capture cost will be achieved with different refinery Specification
- Require CCS design guideline for new Refinery



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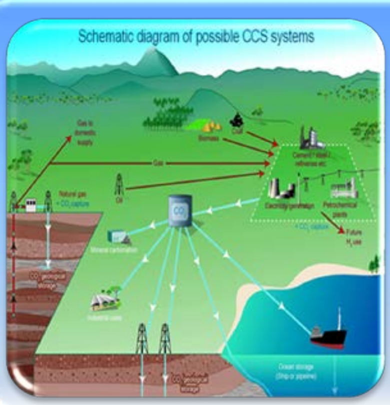

CO_2 Capture from Industry

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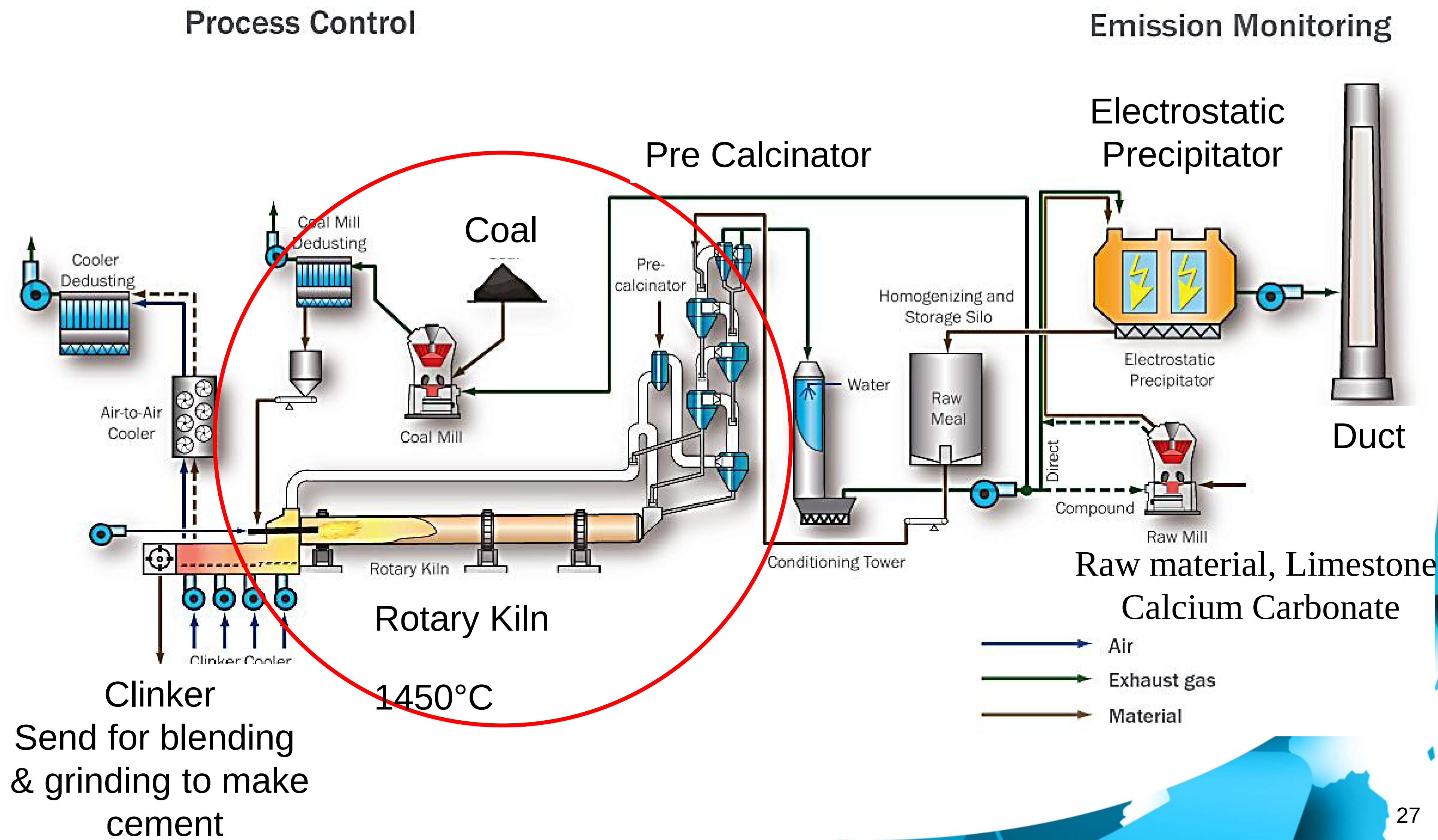
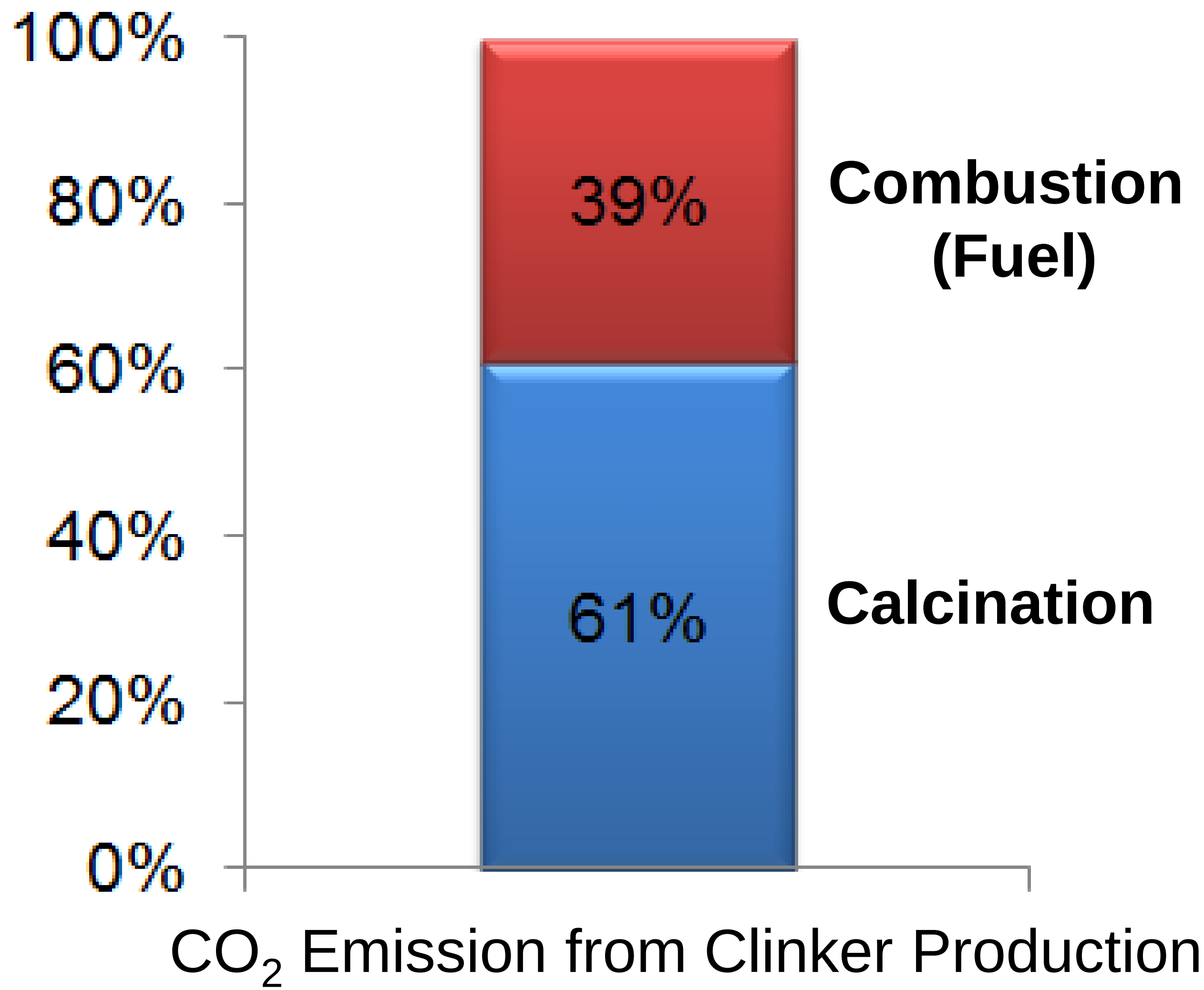
Conclusions

Cement Industry



Direct CO_2 Emission- Clinker



CO_2 Emission Reduction Strategy

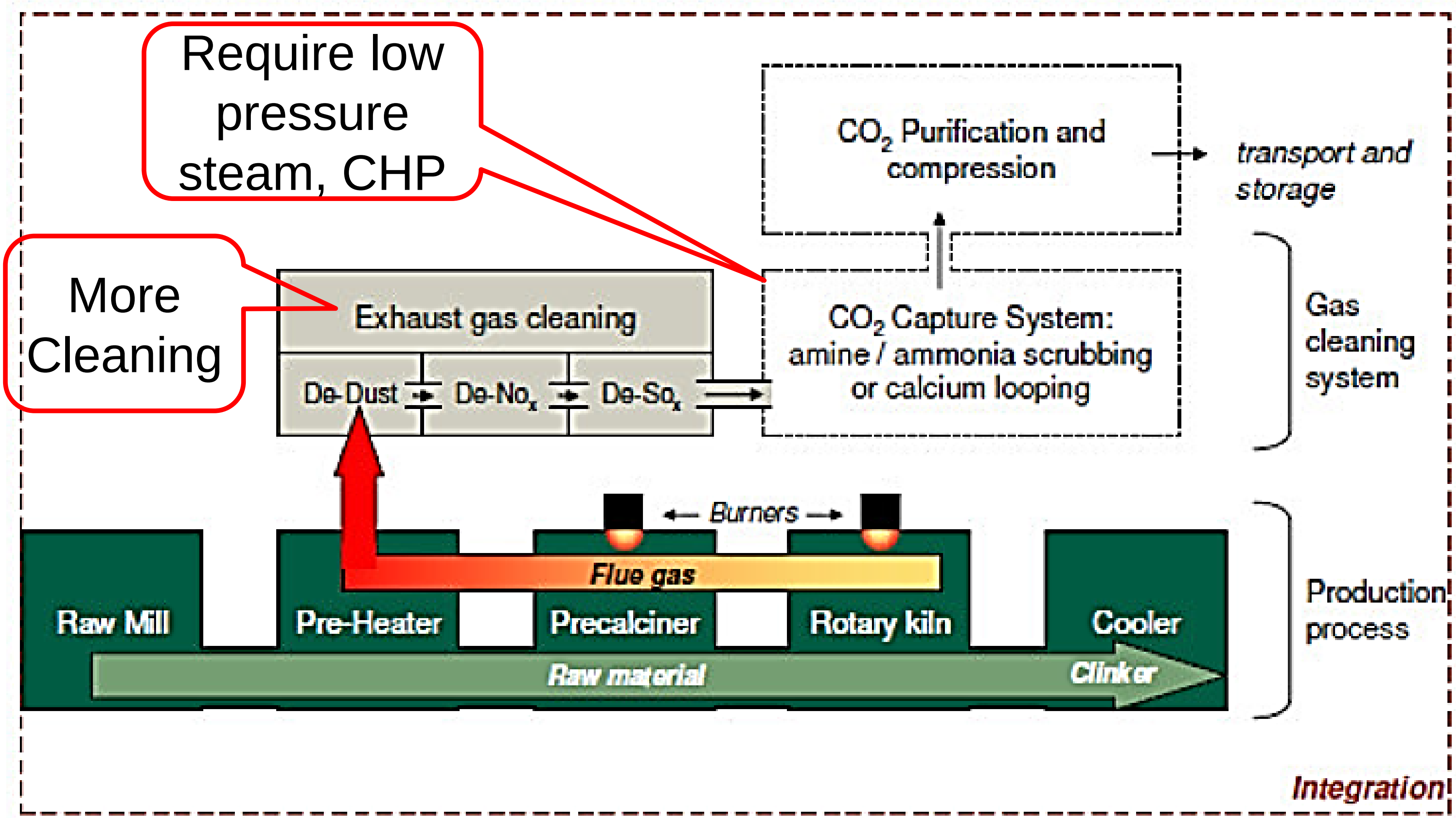
Improving Thermal and Electrical Efficiency

Using Alternative Fuel e.g. Municipal waste, Discarded tyre, Plastic, textile, paper, Biomass

Substitution of Carbon-Intensive Clinker by using blast furnace slag, fly ash from coal power plant

Capturing CO_2 before emission to atmosphere by CCS from fuel combustion and kiln by Post and Oxy Combustion Capture

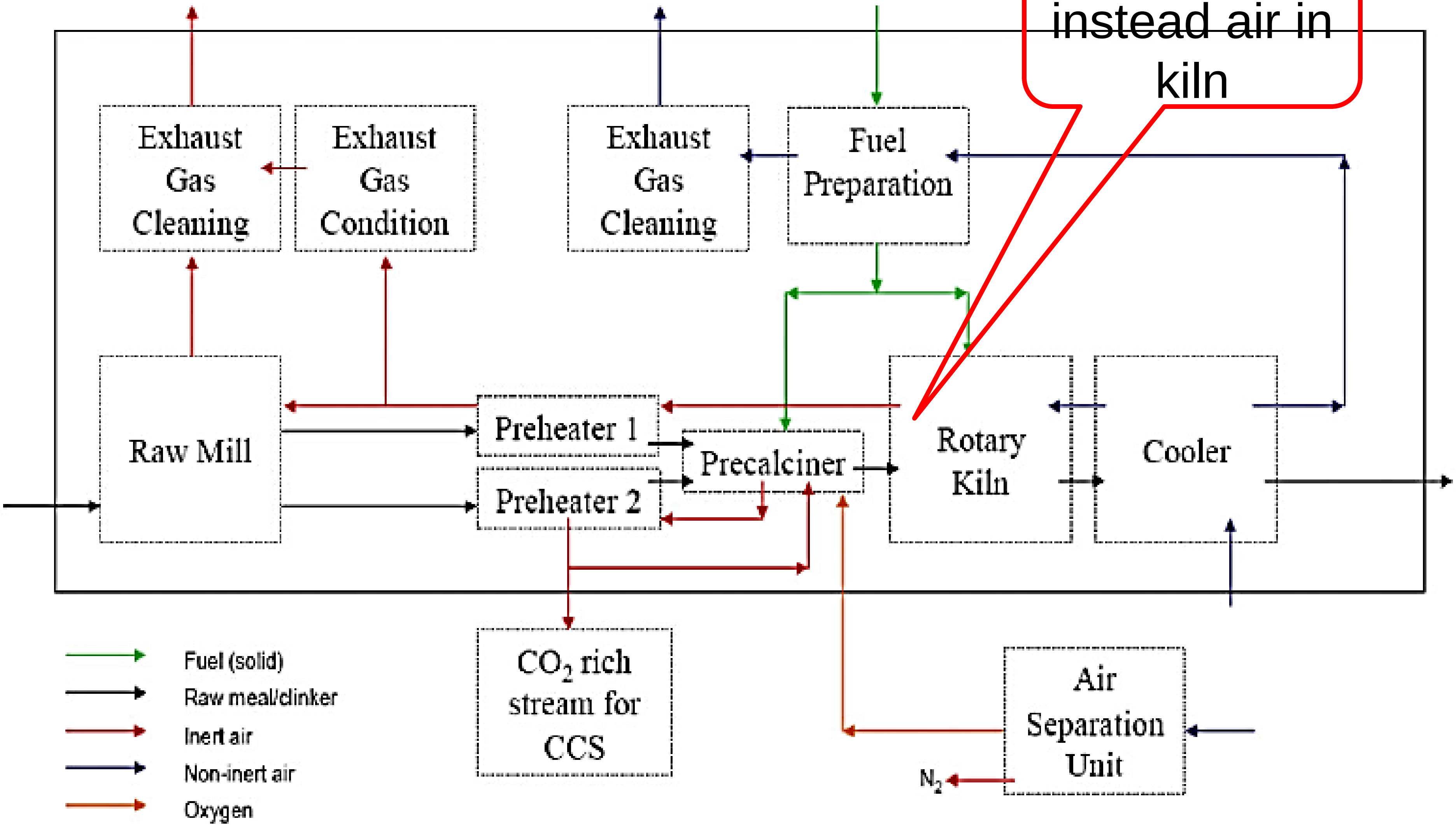
Post Combustion at Cement plant



Source: Mott MacDonald 2010

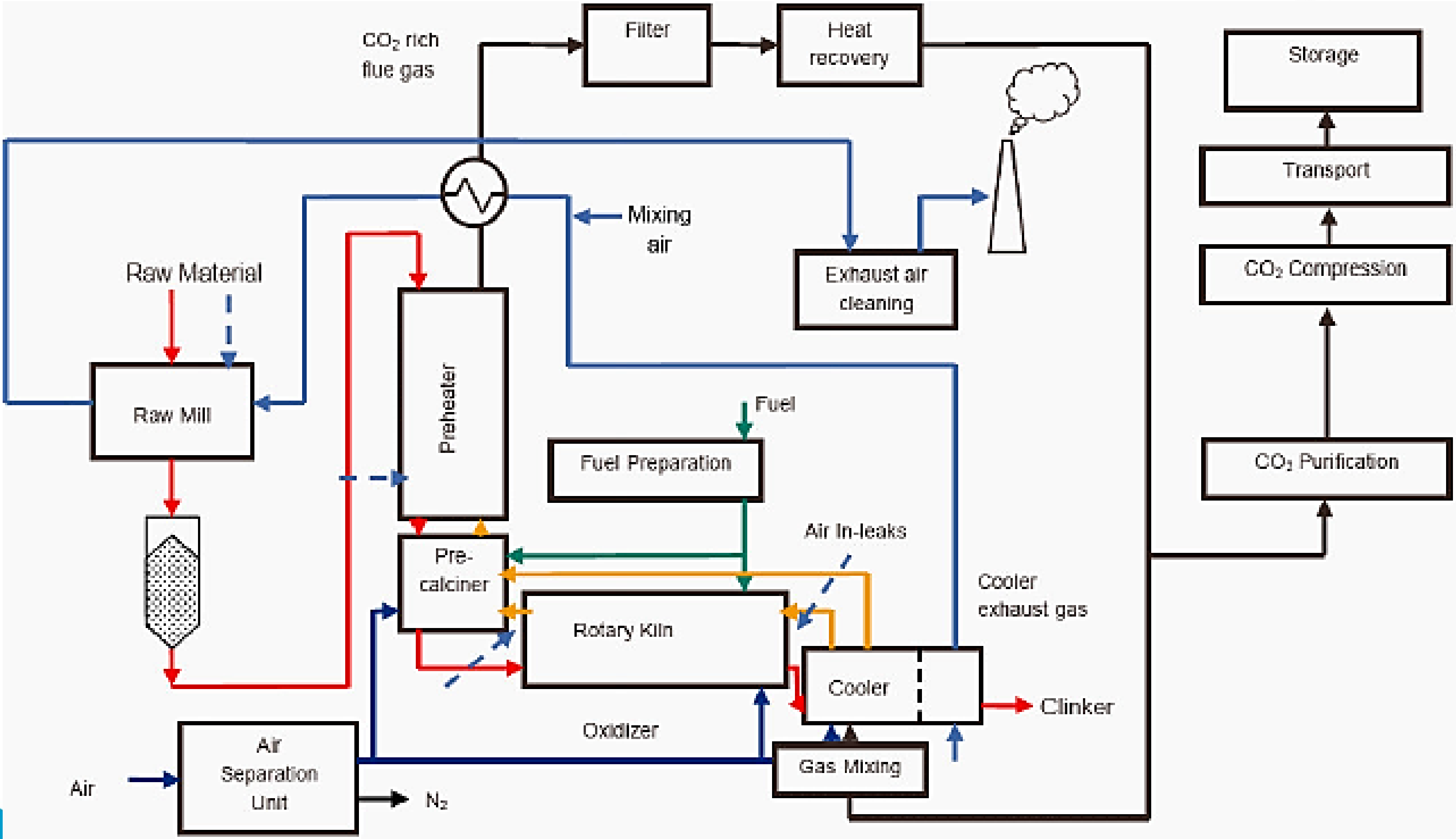
Oxy fuel Combustion at Cement plant: Partial Capture

Using O_2 instead air in kiln



Source: Mott MacDonald 2010

Oxyfuel Combustion at Cement plant: Total Capture



Source: Mott MacDonald 2010

Gaps and Challenges for Cement Industry

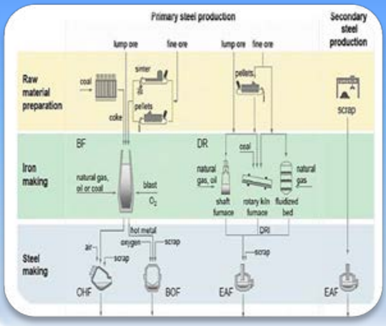
- **Low SO_2 and NO_2 concentration** in flue gas for post combustion.
- Overall **plant integration** is required.
- **Steam requirement** for solvent regeneration may be an issue in countries like India
- Increase requirement of **land use**
- **Influence of O_2/CO_2** atmosphere on the design and operation of the preheater, pre-calciner and kiln
- Oxyfuel **changes the product quality**
- **Reliability issue** due to change in combustion characteristic

Gaps and Challenges for Cement Industry

- Main bottleneck for CO_2 Capture is the **cost**
- Cement Kilns are mostly located at limestone quarries which may **not be near to storage site**.
- **Increase water demand** with CO_2 capture unit may represent significant challenge based on site
- **Intermittent operation** of the cement plant due to market demand
- Technical and financial implication for cement industry is not well understood **require more R&D**.
- Carbon capture technology in the cement industry will **not be ready before 2020**.

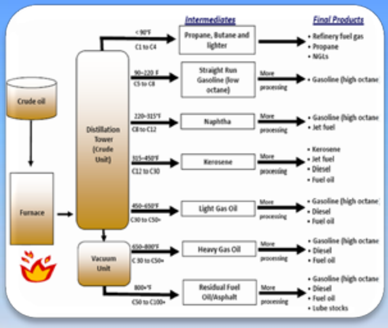
Source: Mott MacDonald 2010

Current CCS Activities in Industry



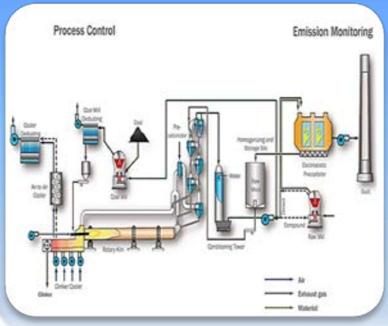
Top Gas Recycle, Pilot Plant for 24% CO_2 reduction, 2007, LKAB, Lulea, **Sweden**

Top Gas Recycle Demo Plant 2010 & 2015, Arcelor Mittal, **Germany and France**



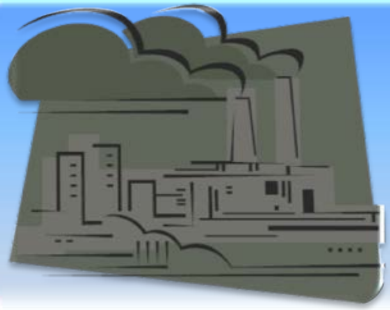
Pre-combustion, Pilot 0.4mtCO_2 /annum, 2010, Shell, **The Netherlands**

Mongstad Refinery TCM, Pilot 0.3 mt CO_2 / annum Bergen, **Norway**



European Cement Research Academy **(ECRA) Phase III, IV and V** CCS project: Demo plant

DOE Funded **CEMEX** Demo Plant, **USA**



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Concluding Remark

- ***CCS represents the most important new technology*** option for reducing direct emissions in Industry
- Development of ***CO_2 transportation and Storage needs to be coordinated between sectors*** to lower the cost
- Greater ***investment from Government and Industry is needed*** for research, develop, demonstrate and deploy CCS
- ***Clear and Stable long term policies*** that put a price on CO_2 emissions will be required when industry is to implement the technology for deep emission reduction

Thank you

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