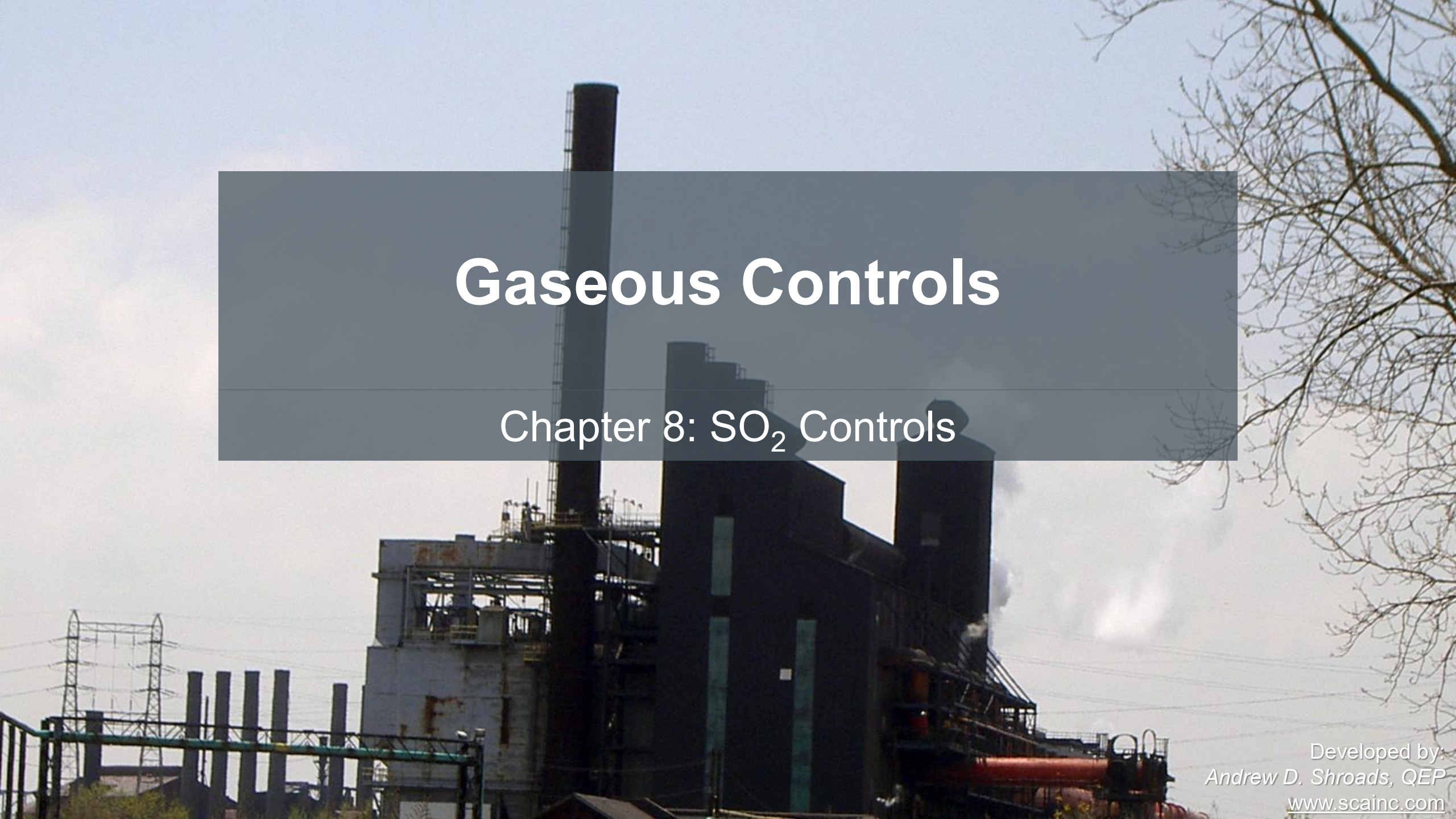


Gaseous Controls

Chapter 8: SO_2 Controls

Developed by:
Andrew D. Shroads, QEP
www.scainc.com

Chapter 8: SO_2 Controls
Objective

In this chapter, we will discuss:

- How do SO_2 control technologies operate?
- What are common types of SO_2 control technologies?
- What is the typical control efficiency for SO_2 control?
- What are common problems with SO_2 control technologies?

Chapter 8: SO_2 Controls
Principles of Operation

- Flue gas desulfurization (Chapter 5 – Absorption)
- Dry scrubber chemical reaction (Chapter 6 – Adsorption)
- Low sulfur fuels / fuel treatment
- Fluidized bed combustion

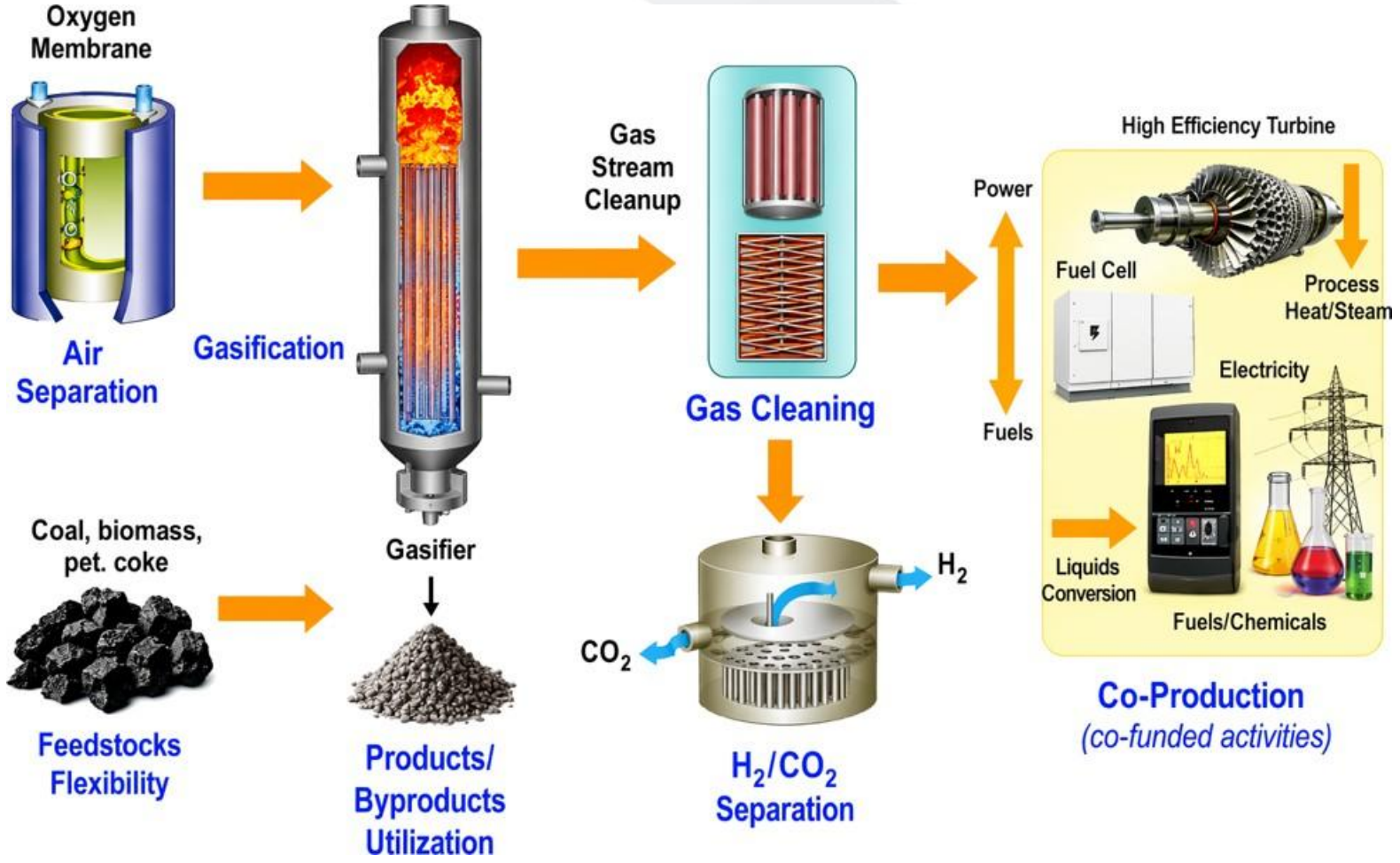
Low Sulfur Fuels / Fuel Treatment

- Desulfurization: Sulfur removal at processing plant
  - Liquid fuels: Refineries use hydrodesulfurization (HDS) to remove sulfur
    - Hydrocarbons mixed with hydrogen and heated to 570-750ºF with catalyst at high pressures (13-130 atm) to convert sulfur compounds to hydrogen sulfide (H_2S)
  - Gaseous fuels: Processing plants "sweeten" acid gases ("sour" gas)
    - Mixing with amine solutions or scavengers for a chemical reaction to remove sulfur
    - Converting H_2S to elemental sulfur via thermal and catalytic reactions
    - Membranes selectively separate components based on membrane permeability
    - HDS for downstream sulfur recovery
  - Solid fuels: Pre-combustion coal cleaning (fuel treatment)
    - Physical or chemical processes to remove sulfur from coal

Fuel Treatment: Gasification

- Coal is crushed into a fine powder
- Coal, oxygen, and steam are injected into gasifier
  - Heat partially oxidizes carbon and other molecules
  - Impurities turn into slag and gaseous compounds (H_2S)
- Coal transformed into syngas
  - Primarily hydrogen (H_2) and CO
  - CH_4, N_2 & CO_2 also formed, depending on process and coal feedstock
  - Gaseous impurities (H_2S) removed from syngas

Coal Gasification

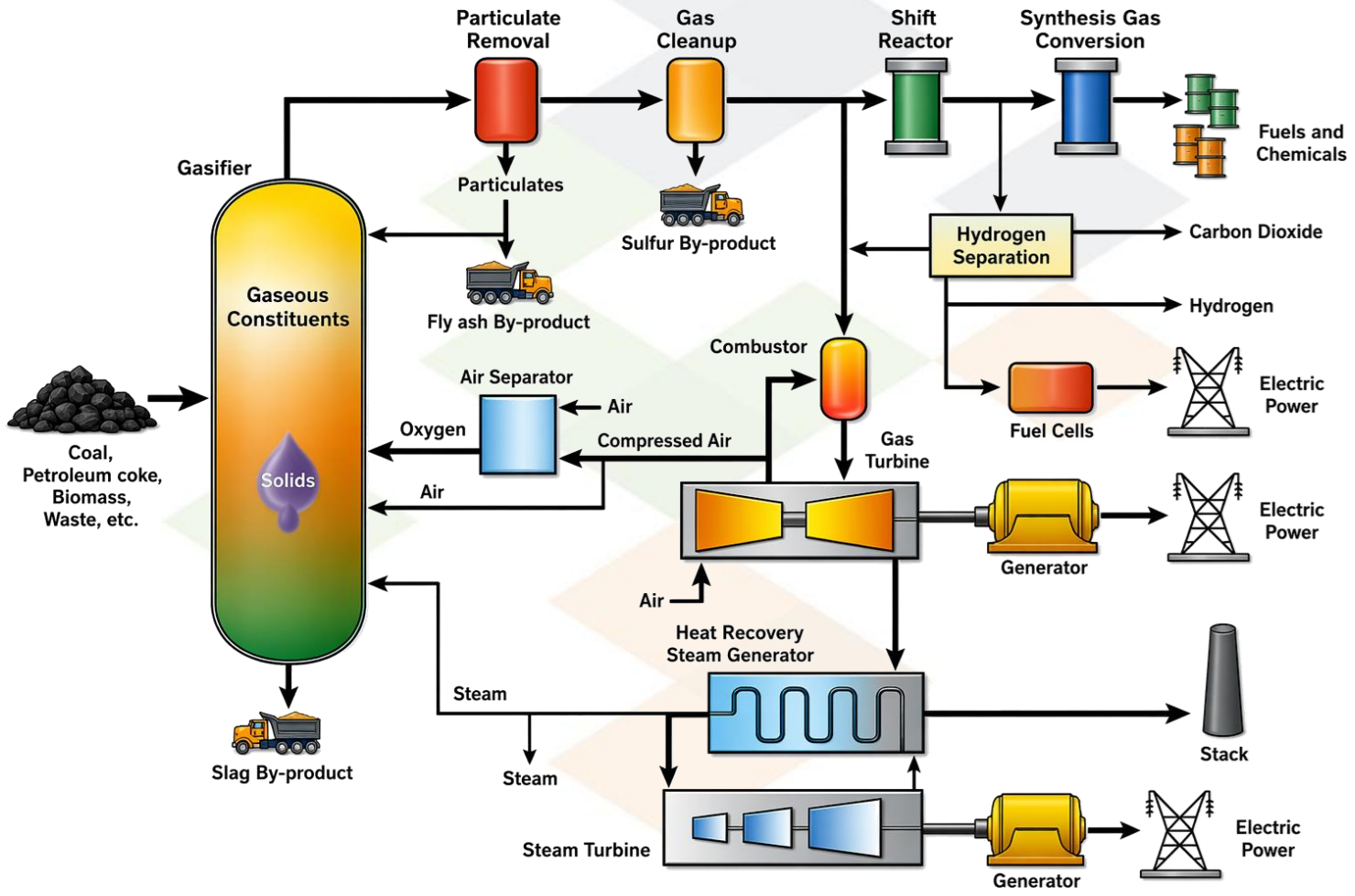


Fuel Treatment: Liquefaction

- Coal is crushed into a fine powder and mixed with a solvent
- Paste is heated and pressurized in a reactor
  - Hydrogen gas and catalyst are added to reactor
  - Thermal energy breaks coal down into smaller fragments
  - Hydrogen increases formation of hydrocarbons
- Output is separated into liquid distillates, gas products, and vacuum bottoms (solid residues)
- Liquefaction can also be done on syngas (coal gasification)

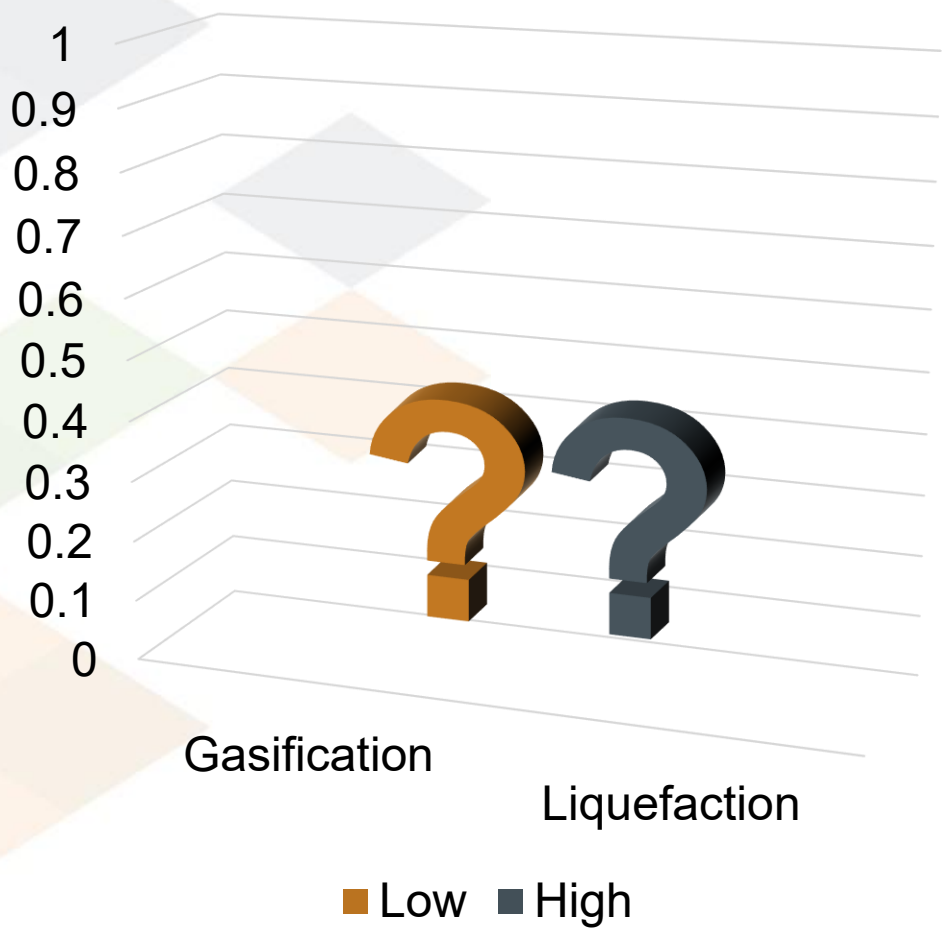
Chapter 8: SO_2 Controls
Principles of Operation

Coal Gasification



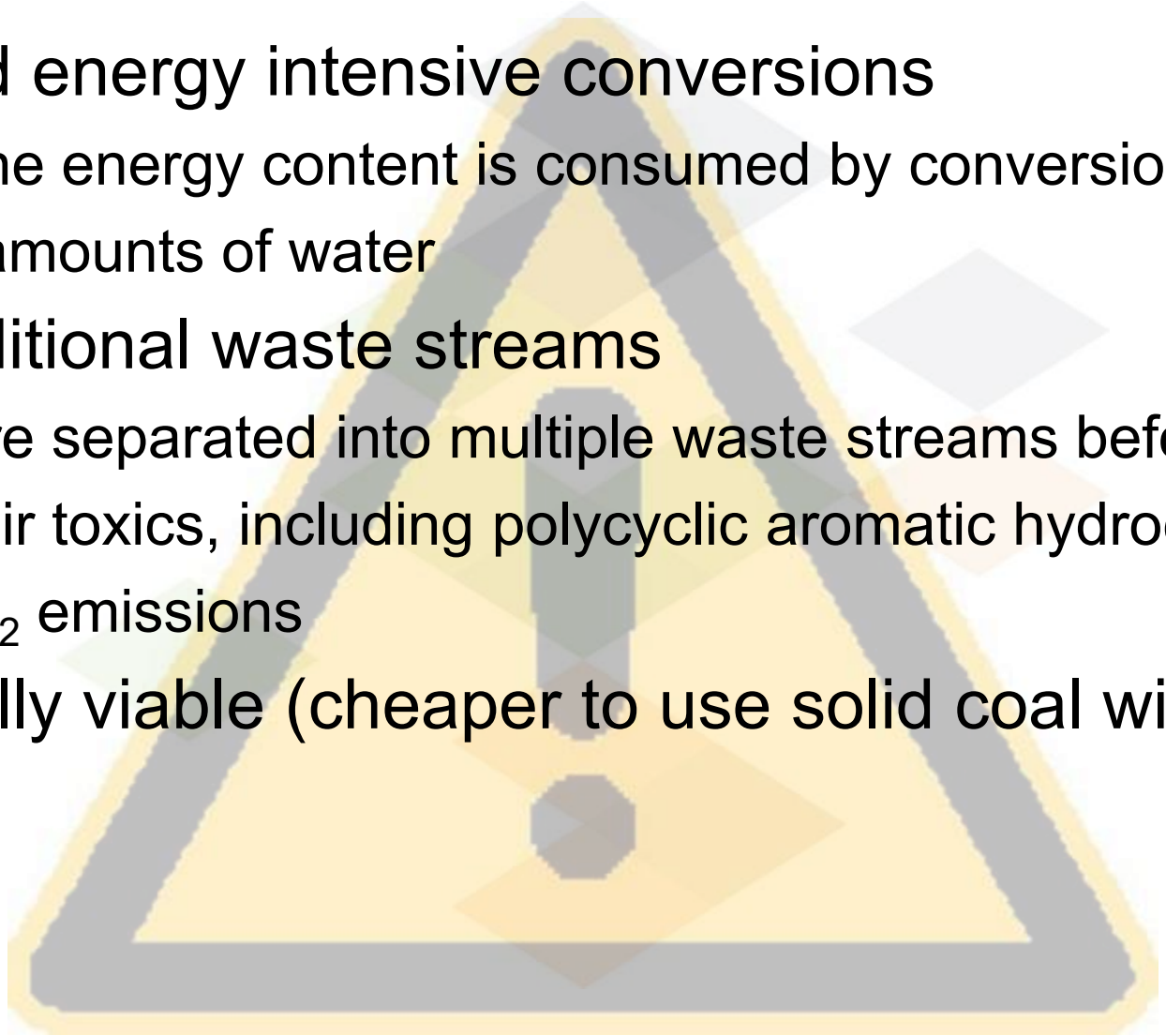
Control Efficiency

- Removing sulfur before combustion reduces sulfur from combustion, but still generates sulfur from processing plants
- Syngas / liquefaction can create 99+% purity products



Chapter 8: SO_2 Controls
Operating Problems

- Material and energy intensive conversions
  - 25-40% of the energy content is consumed by conversion process
  - Uses large amounts of water
- Creates additional waste streams
  - Impurities are separated into multiple waste streams before combustion
  - Generates air toxics, including polycyclic aromatic hydrocarbons (PAH)
  - Massive CO_2 emissions
- Not financially viable (cheaper to use solid coal with add-on controls)



Fluidized Bed Combustion

- Calcium-based sorbents added during combustion
  - Limestone or dolomite added with solid fuels

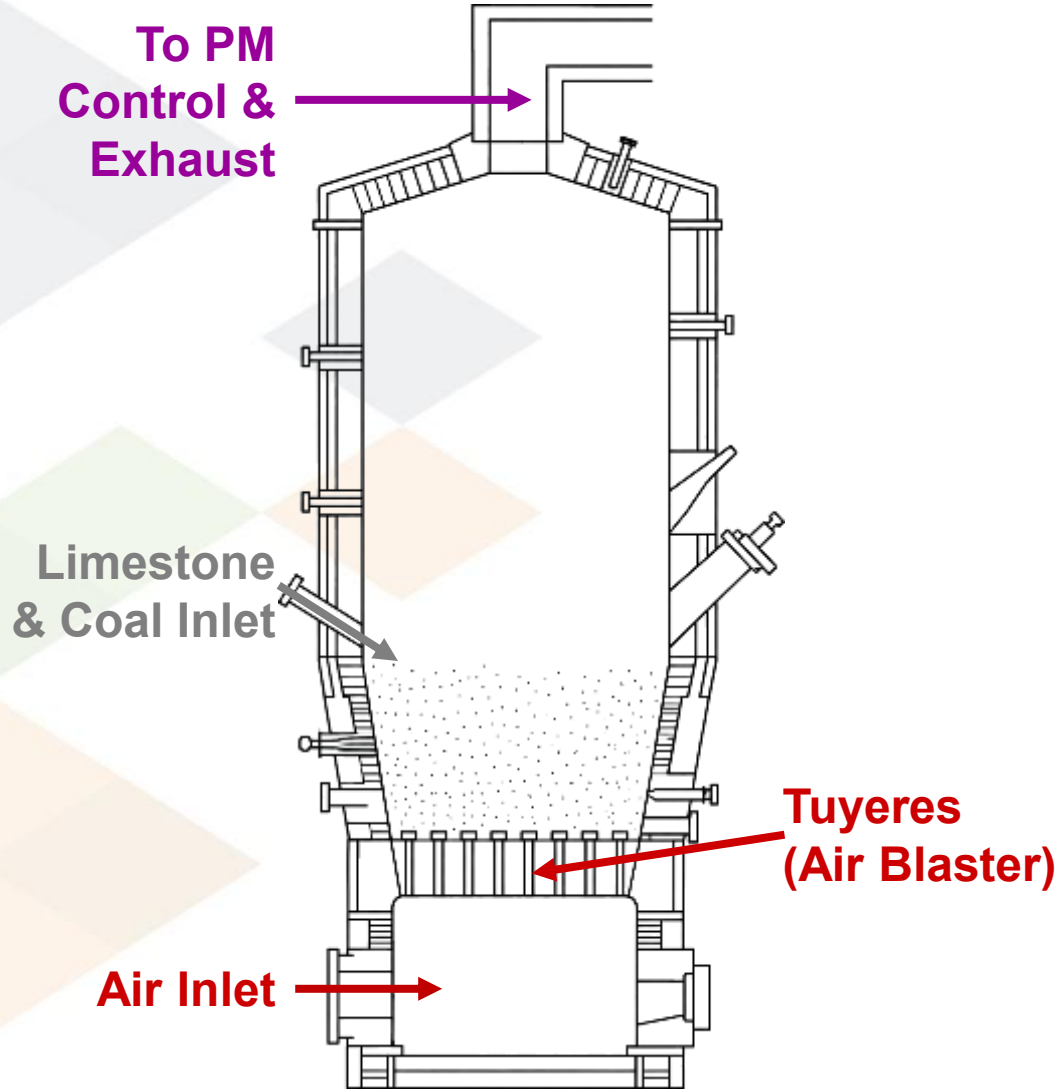
$$CaCO_3 \rightarrow CaO + CO_2$$

$$2CaO + 2SO_2 + O_2 \rightarrow 2CaSO_4$$

- Removes need for SO_2 add-on controls (wet, semi-dry, or dry scrubber)

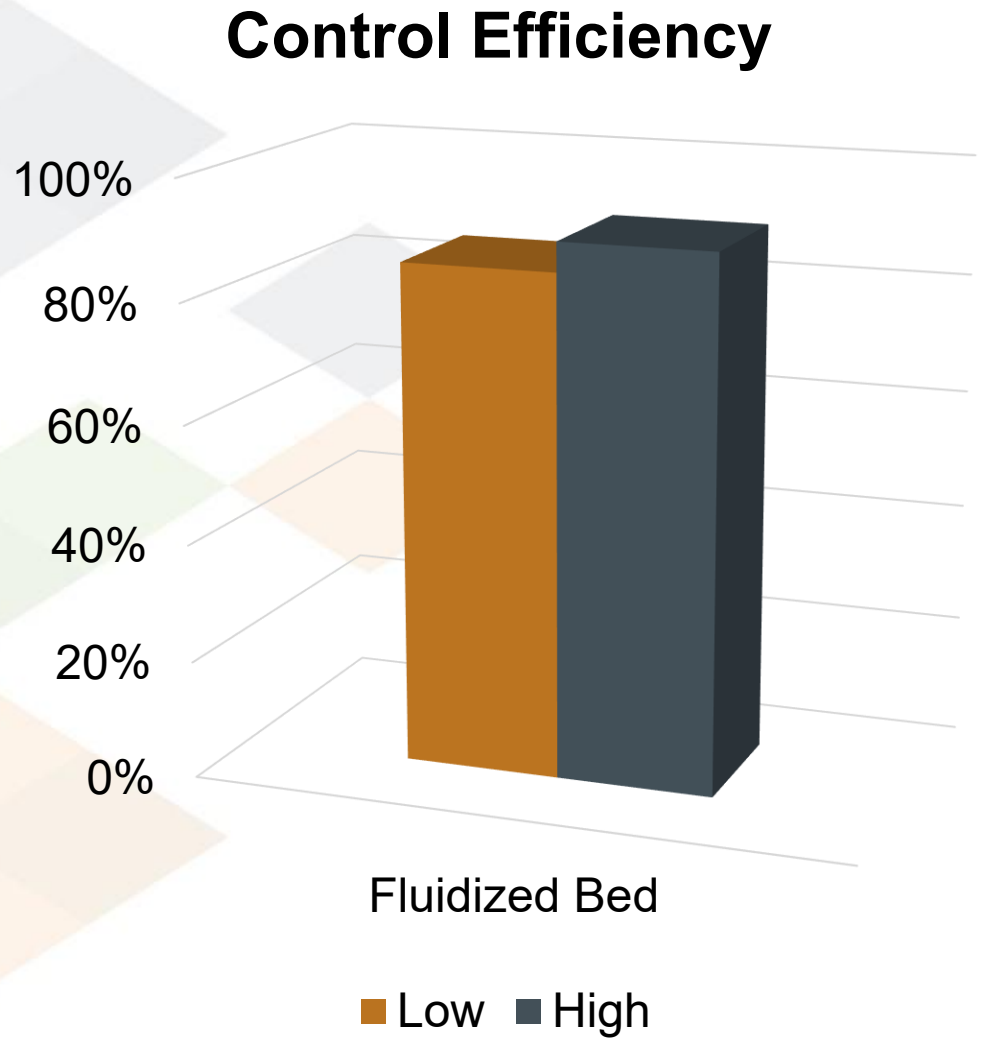
Fluidized Bed Combustion

- Tuyere: Distributes combustion air to fluidize fuel/sorbent bed
- Ash and spent sorbent are part of exhaust
  - PM Control: Removes spent adsorbent ($CaSO_4$) and fly ash



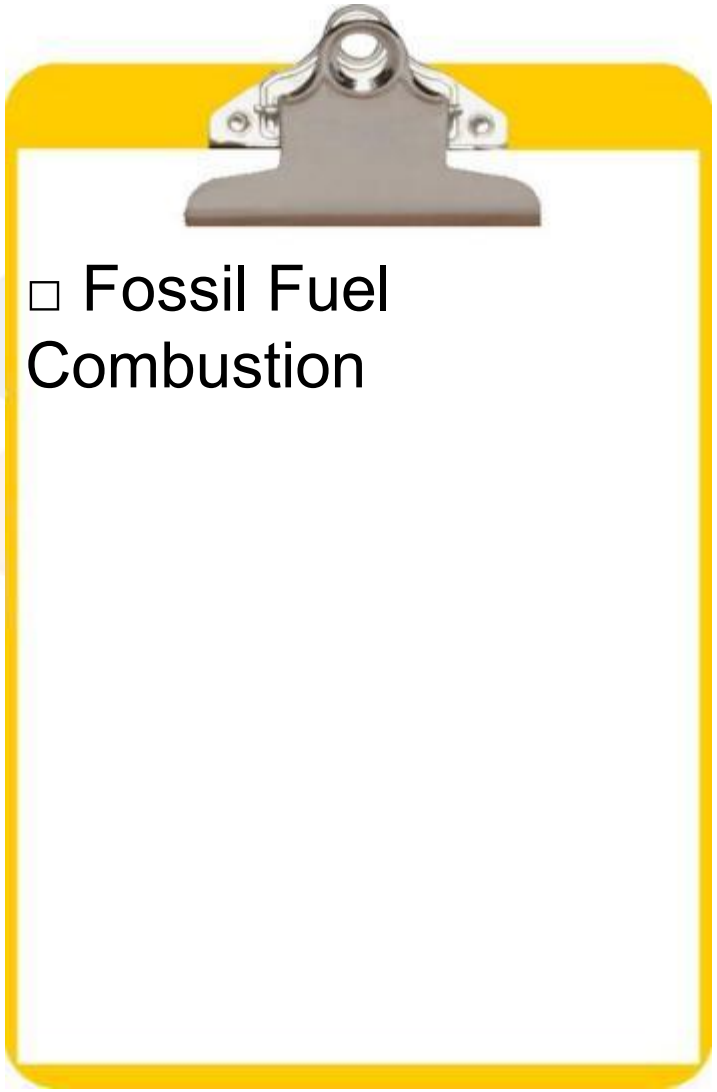
Control Efficiency

- Typically 85-90%
- Depends on temperature, residence time, and calcium to sulfur ratio



Inspection Parameters

- Same as for any fossil fuel combustion source
  - Fuel sulfur
  - Sorbent feed
  - Calcium / sulfur ration
  - Bed temperature
  - Pressure differential
  - PM Controls



Chapter 8: SO_2 Controls
Recap

In this chapter, we discussed:

- How SO_2 control technologies operate
- Common types of SO_2 control technologies
- Typical achievable control efficiencies
- Common problems with SO_2 control technologies