Technologies and the Role of CCS & CCU in the Low Carbon Park

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What is Carbon Capture and Storage?

- CCS or CCCCTSVM?
  - Burn/gasify fuel (oil, coal, petcoke, gas, biomass, etc...)
  - Capture carbon dioxide (CO2)
  - Condition and compress to liquid
  - Transport
  - Store underground
  - Verification & Monitoring

- Produce power/heat/products
- Reduced CO2 emissions

Why CCS compared to renewables?

- Applicable to industry as well as power generation
  - Cement, steel, chemicals, fertiliser, paper, glass, CHP plant ...
  - Only option for elimination of 'process' CO_2 emissions from chemical conversion
- Nuclear is base load and inflexible
- Wind / solar is intermittent
  - Coal or gas with CCS is flexible
    - Back-up to renewables
- Biomass/biofuels – not enough available / competition with food / land use issues
  - Are they really low carbon?
- Hydro – not enough sites in many countries
- Other renewables not yet at comparable scale
- CCS allows continued use of fossil fuels and CO_2 emitting industries
  - Potential life-extension of existing assets
  - Avoids stranded assets in high-emissions sectors

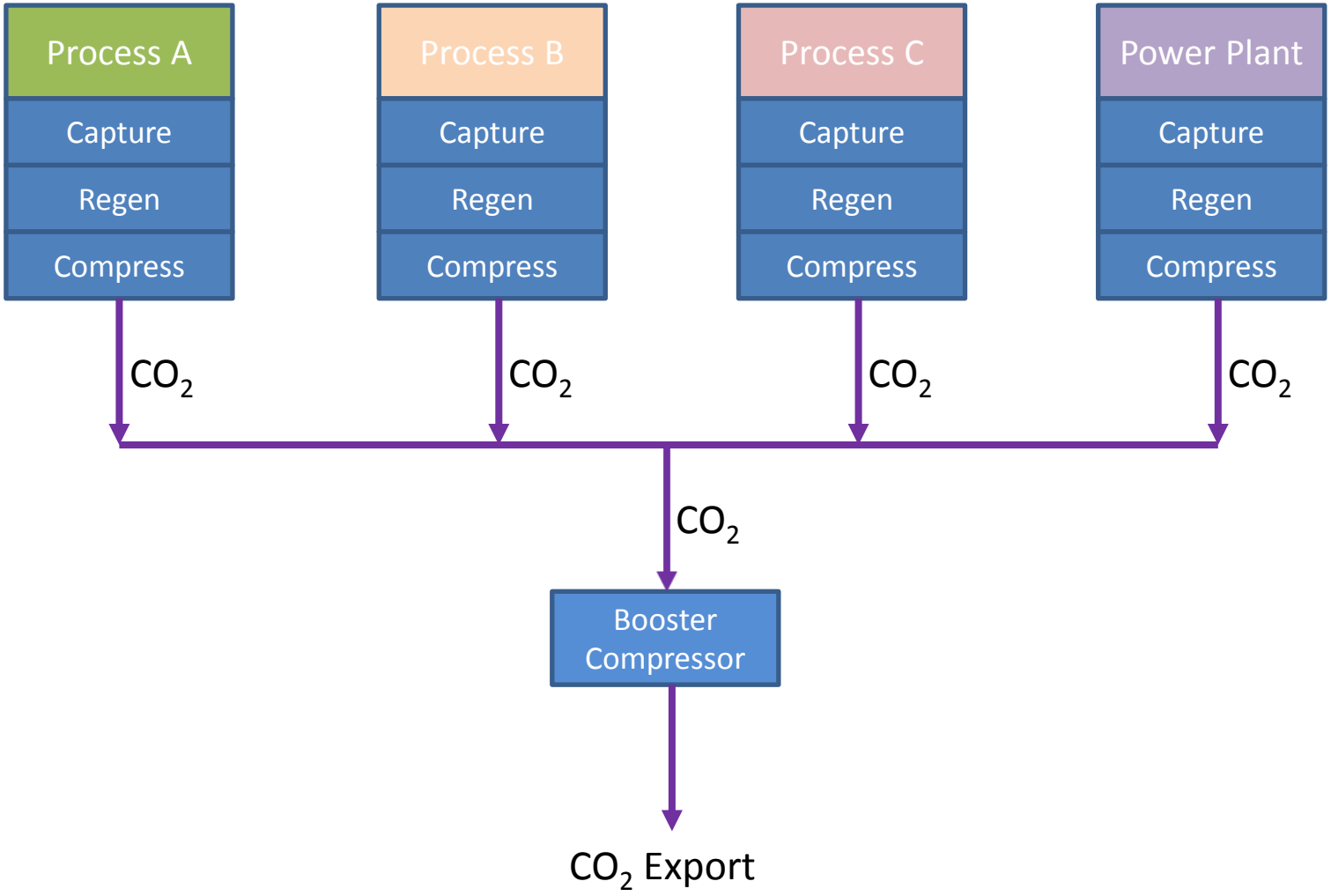
Industrial Applications of CCS

- Can apply CCS to most processes that produce CO_2 – but at a cost
- Oil and Gas industry – already in place
  - Sour gas sweetening & enhanced oil recovery already in operation at large scale: >3 Mtpa
- Steel – Ultra Low CO2 Steel (ULCOS) consortium
  - Oxy-combustion capture applied to steel
  - Steel is cheaper than standard steel because more efficient (ignoring CO_2 transport & storage cost)
- Cement
  - Post-combustion and oxy-combustion capture can be applied to cement process emissions
- Chemicals, fertiliser, coal-to-liquid industries
  - High-purity CO2 streams – low cost capture

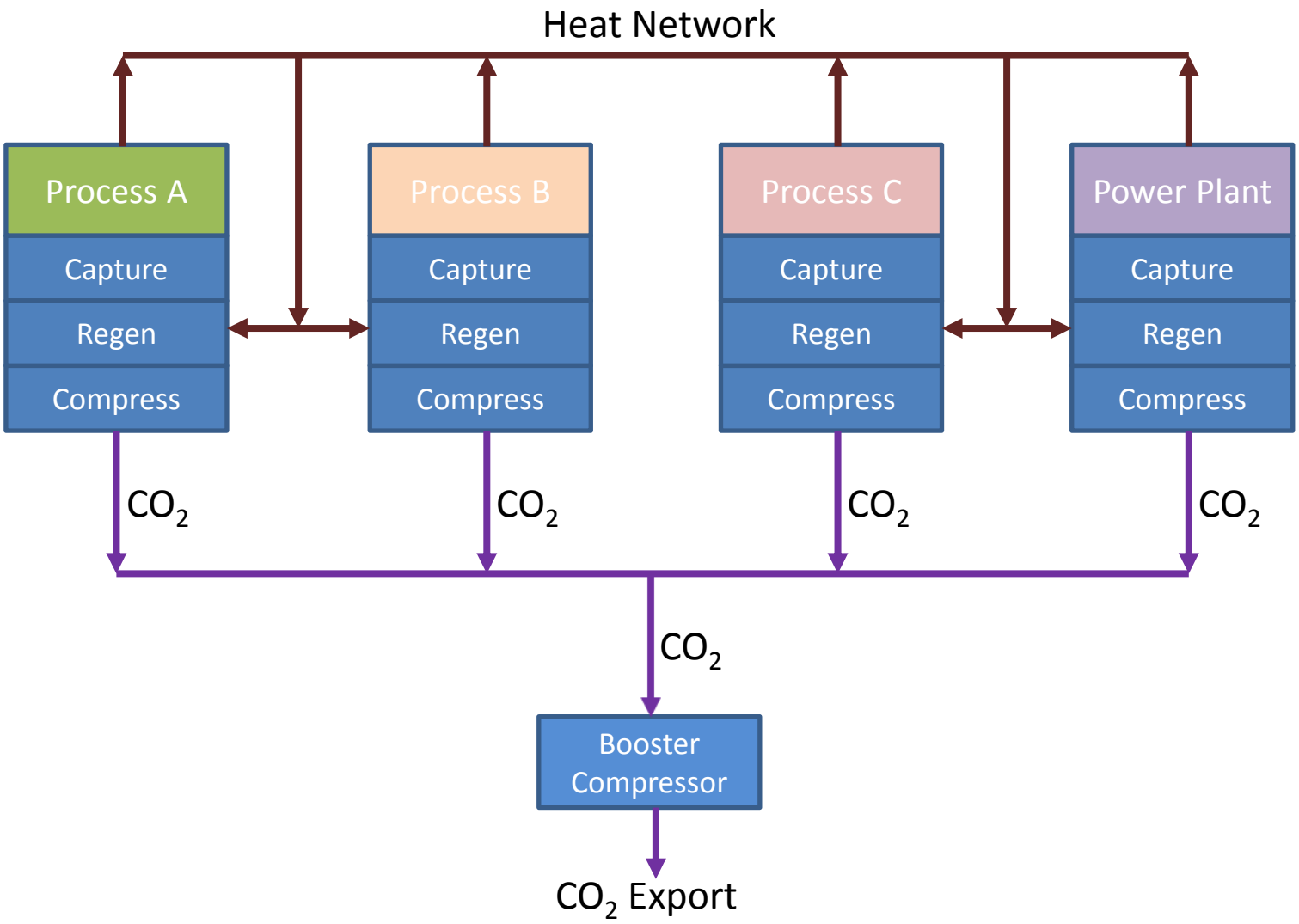
Challenges for Industrial CCS

- CCS increases the capital and operating costs of any industrial facility to which it is applied
- It will always be cheaper to emit CO_2 than transport and store it (in reality, ignoring economic drivers like taxes)
  - CCS is only economical if CO_2 has a value
    - Carbon tax or credits
    - Sale of CO_2 for utilisation; e.g. Enhanced Oil Recovery, fertilisers, chemicals, mineralisation
    - Premium price for 'green' products
- Risk of 'carbon leakage' of industrial manufacture to locations outside of the EU ETS remit
- Magnitude of CO_2 emissions from many industries too small to support stand-alone full-chain CCS system
  - 'Clustering' to share transport and storage infrastructure
  - Industrial parks offer the opportunity to go further through integration and synergy
    - Cost reduction, efficiency improvement, performance advantage

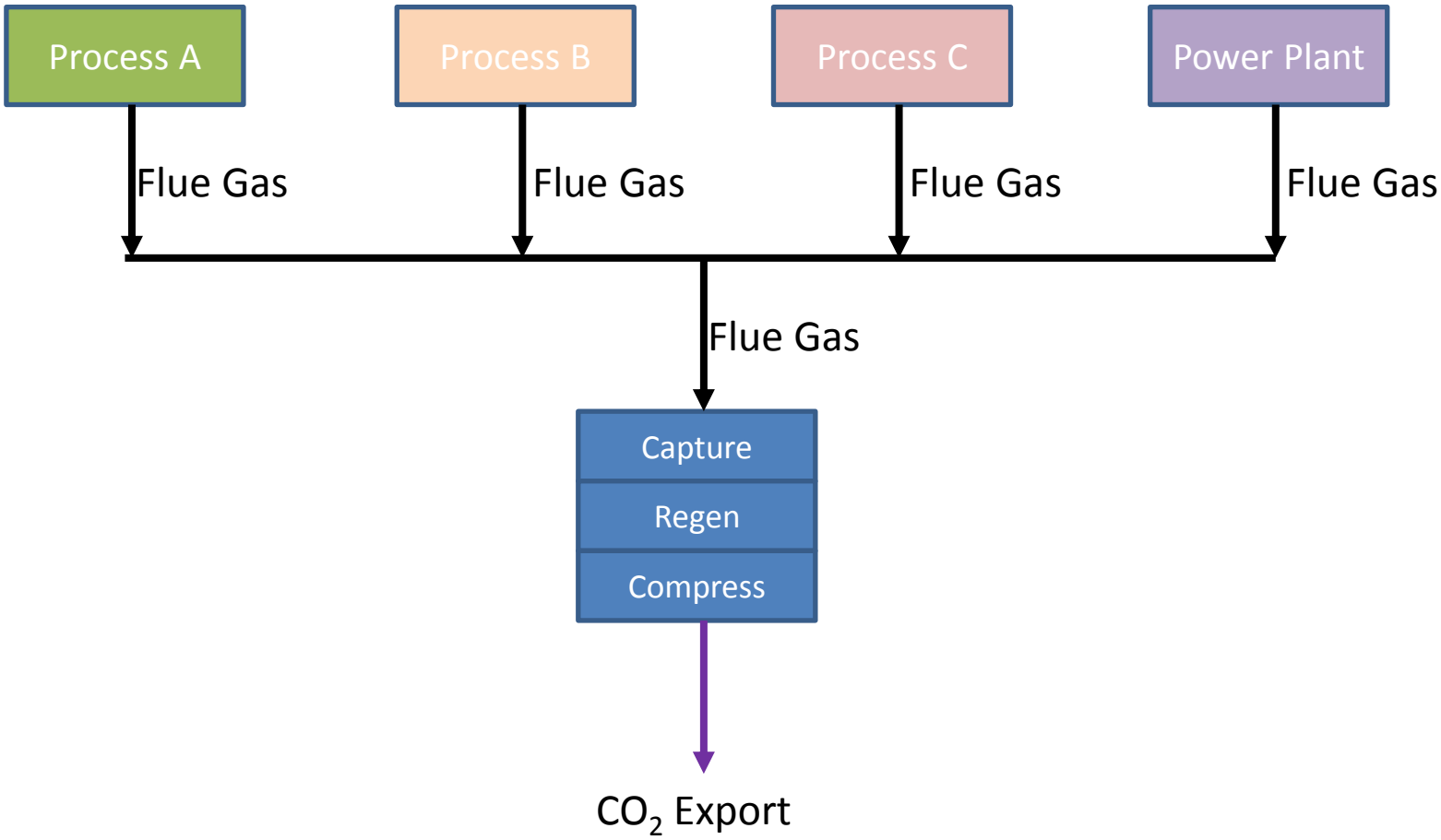
CCS Cluster within an Industrial Park



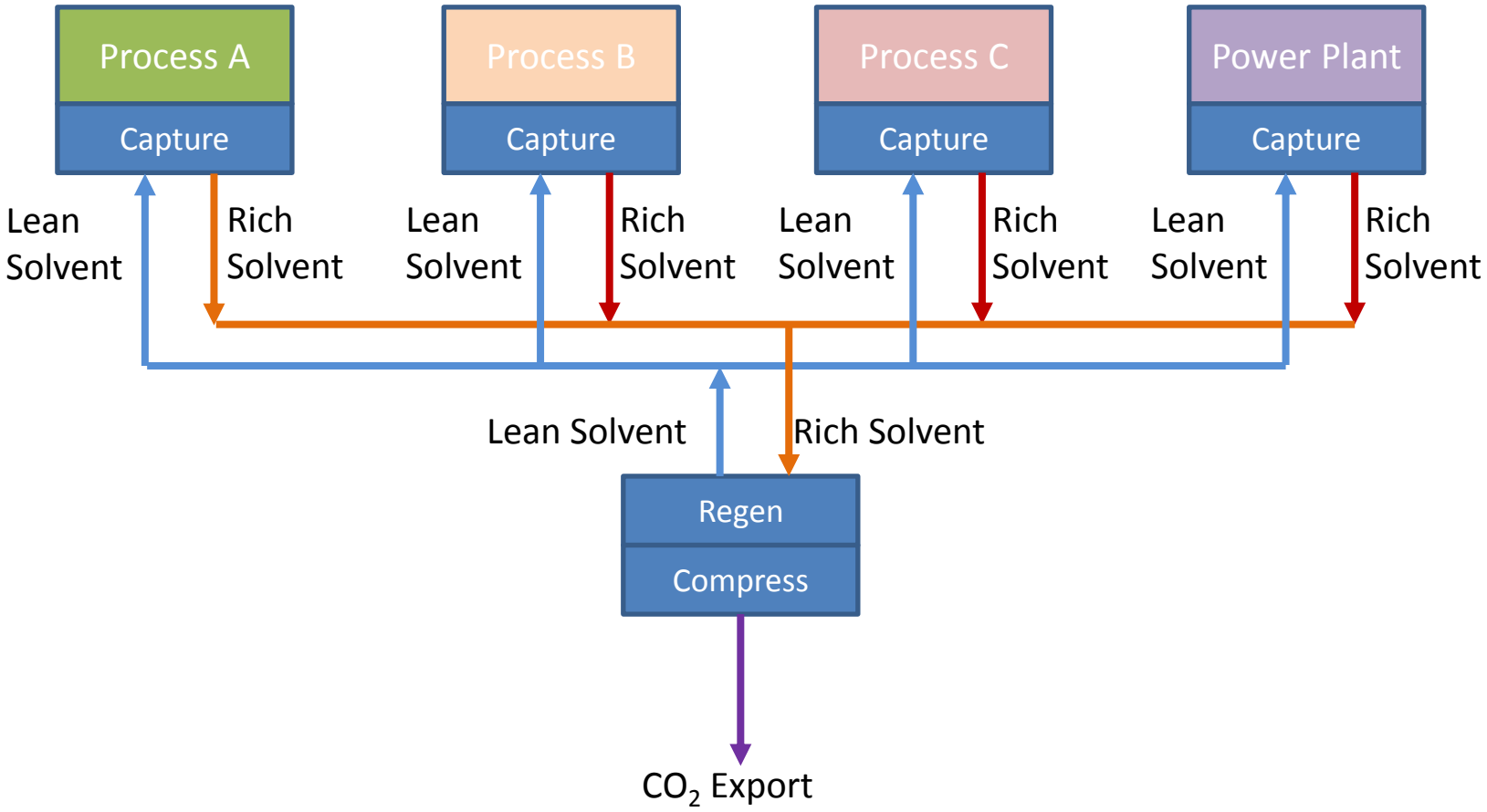
Heat Integration for CCS



Flue Gas Manifolding for CCS Integration



Solvent Distribution for CCS Integration



Conclusions

- CCS provides a mechanism for a high degree (>90%) of CO_2 emissions reduction from fossil fuel power generation and industrial processes
- Cost, and the lack of financial benefits from implementation, remain significant barriers to the application of CCS in industry
- Within an integrated industrial park, there are several opportunities for synergy, facilitating the implementation of CCS at reduced cost and with reduced impact on efficiency and performance
- Access to an existing CCS network could become a positive differentiator for an industry park looking to attract new industries for whom low carbon is key, adding to existing synergistic advantages of the integrated park concept