Oxy-fuel Technology for CCS

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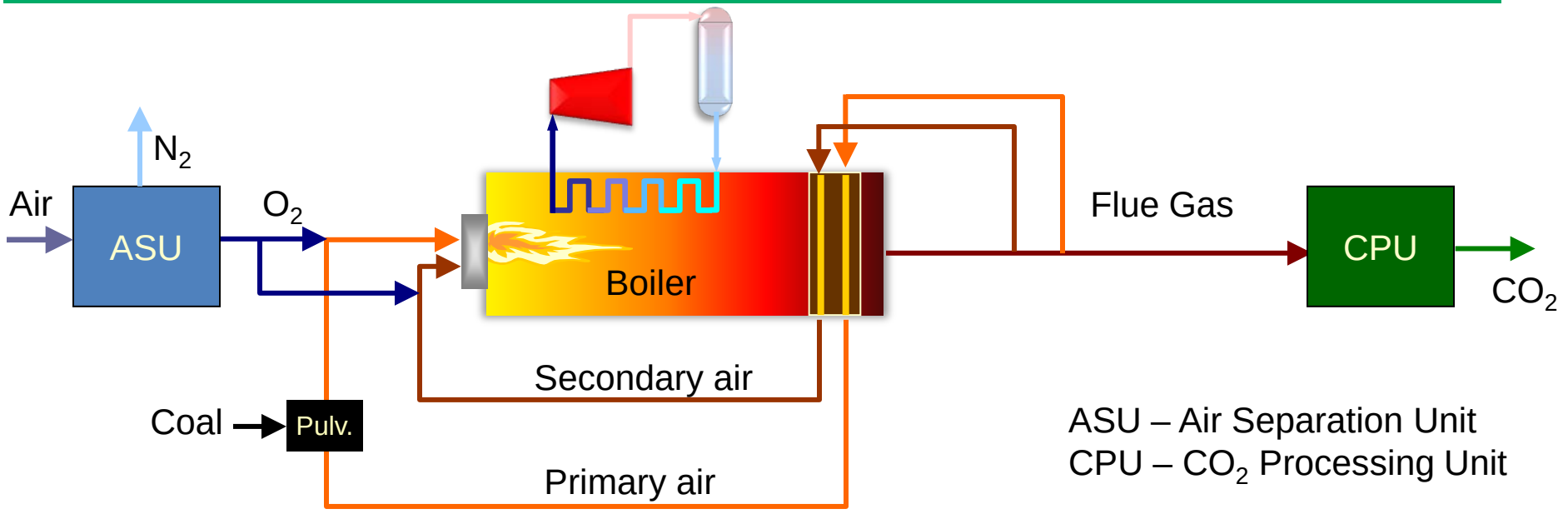
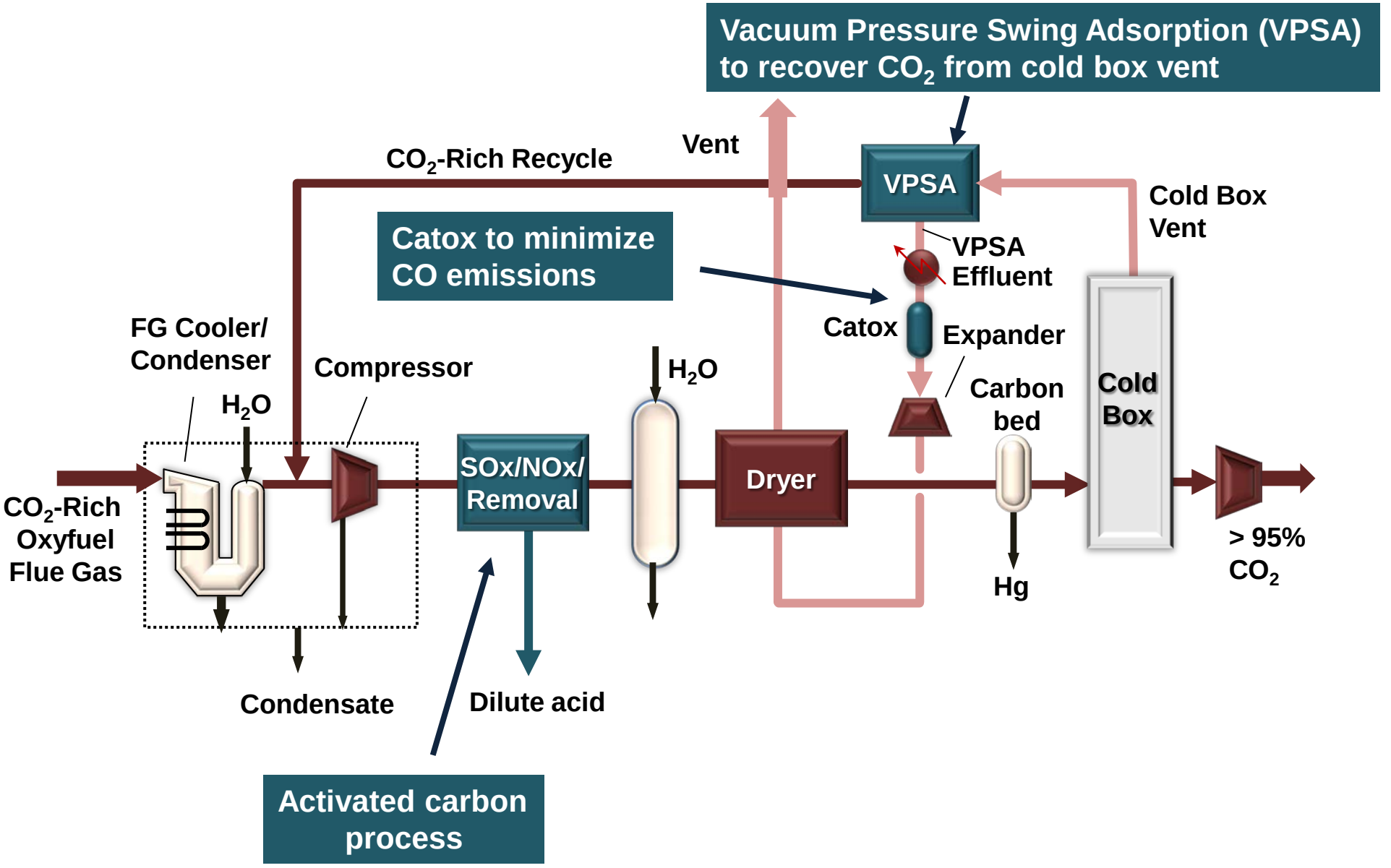
Oxy-fuel Power Plant

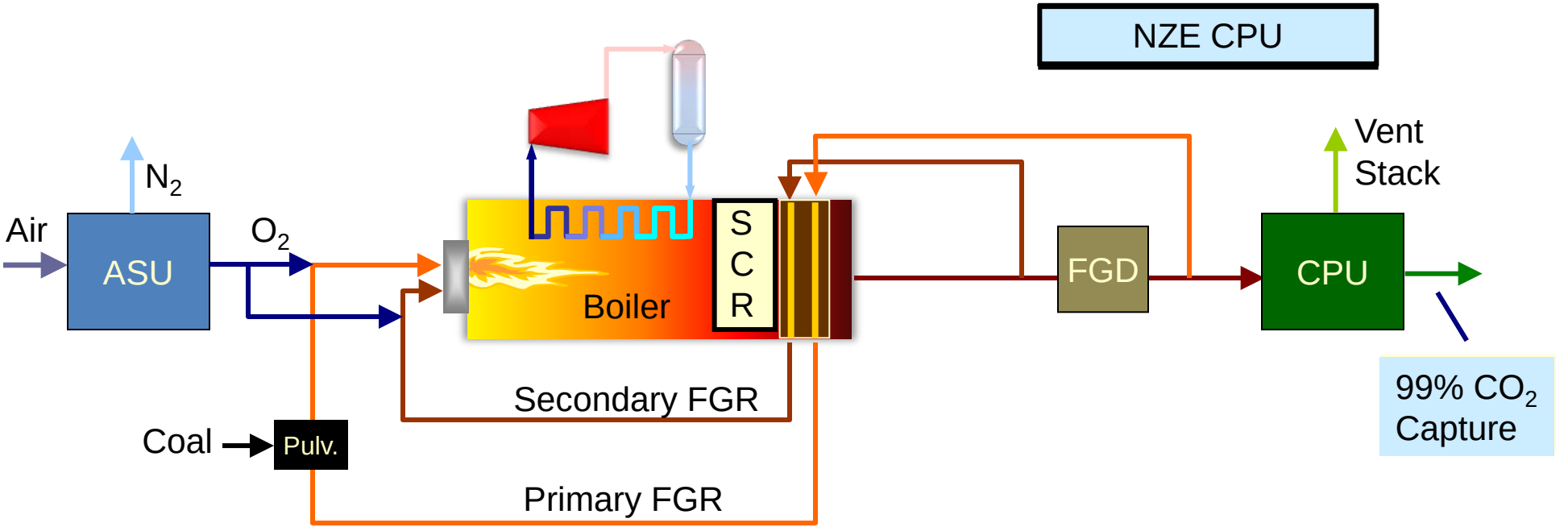


- **Operation similar to air-fired boiler**
- **No change in steam cycle**
- **Near zero emissions of SOx/NOx/Hg & 99% CO_2 capture**
- **Cleanest – no solvents needed**
- **Applicable for retrofits as well as new plants**

Near Zero Emissions (NZE) CPU



Conventional vs. NZE CPU

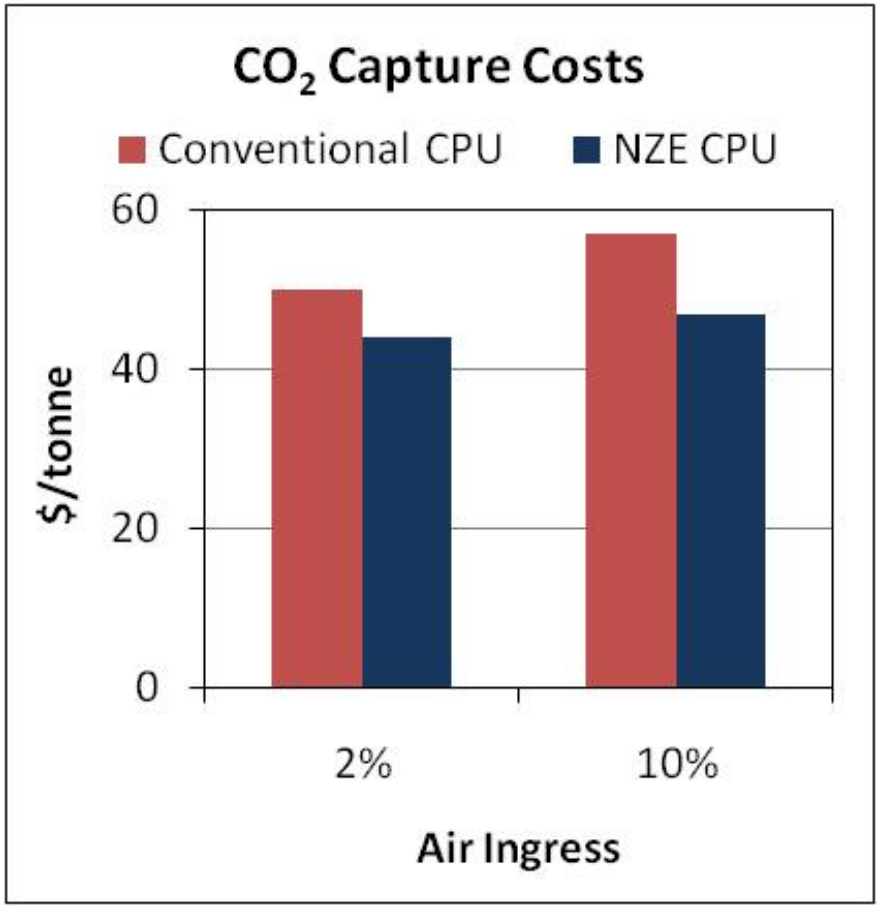


NZE CPU will

- **Eliminate SCR (selective catalytic reduction) unit**
- **Require smaller FGD (flue gas desulfurization) unit**
- **Achieve higher capture rate**

Cost Comparison

- **Lower capture costs for NZE CPU are due to:**
  - **Smaller FGD and elimination of SCR**
  - **Higher CO_2 capture rate compared to conventional CPU**



Note:
1 tonne = 1000 kg
CO_2 purity >99.9%
CO_2 pressure 153 bar
CO_2 transportation and storage costs included

Technology Status

- **ASU**
  - Advanced process cycles identified
  - 20 – 25% lower power compared to current state of art
  - Advanced oxy-coal ASU design could be available by 2015

- **CPU**
  - Activated carbon process and VPSA performance demonstrated at bench scale
  - Near zero emissions technology is now ready for integrated CPU demonstration at 10 – 50 tpd scale
  - Design for commercial scale plants could be available by 2015

Summary

- **Oxy-fuel technology is a viable CCS option**
- **Mature ASU technology is being significantly improved**
- **Praxair CPU technology will achieve high CO_2 recovery, high purity CO_2 and near zero stack emissions while lowering capture costs**

Backup Slides

Air Separation Unit

- **Requirements for oxy-fuel power plant:**
  - **7,000 – 9,000 tpd O_2 for 500 MW plant**
  - **Low pressure (0.3 – 0.6 barg)**
  - **Low purity (95 – 97% O_2)**
  - **Turndown to 35%**
  - **Ramp rate of 3 – 5%/min**

- **Mature technology**
  - **Built plants up to 4000 tpd**
- **Significant improvements possible at larger scale**
  - **More complex equipment technology with higher efficiency can be used**
  - **20 – 25% lower power compared to current state of art**

Near Zero Emissions CPU Performance

- High purity CO_2 relatively free of trace impurities
- Near zero stack emissions
- High capture rate even for plants with high air ingress

Compositions			
Vol. % or ppm	CPU Feed	Purified CO_2	CPU Vent
CO_2, %	~61%	>99.99%	~7%
SOx, ppm	1875 ppm	2 ppm	0
NOx, ppm	156 ppm	11 ppm	9 ppm
CO, ppm	280 ppm	0	< 10 ppm
O_2, +N_2 + Ar	~12%	<10 ppm	~93%

CO_2 Capture Rates		
Air Ingress	2%	10%
Conventional CPU	90%	75%
NZE CPU	99%	97%