3rd Oxyfuel Combustion Conference

GPU Pilot Operation and Energy Consumption

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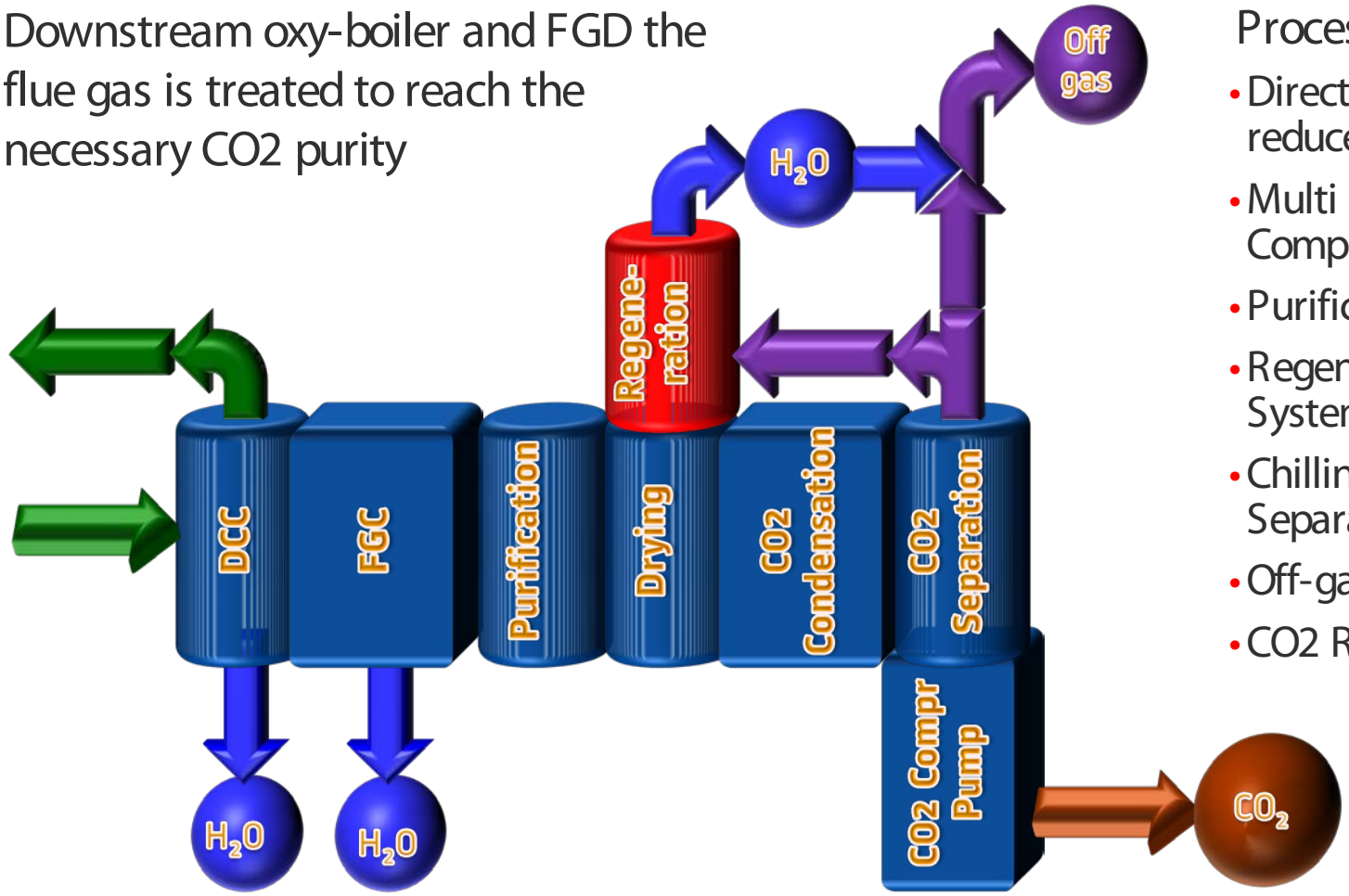
GPU Process

Downstream oxy-boiler and FGD the flue gas is treated to reach the necessary CO2 purity



Process steps :

- Direct Contact Cooling reduces H2O to <5%
- Multi Stage Flue Gas Compression to >28 bar
- Purification and Drying
- Regeneration Gas System
- Chilling and CO2 Separation
- Off-gas System
- CO2 Recompression

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GPU Concepts

- Autorefrigerated GPU for yields of 90%and above
  - Component solutions for
    - Saline Acquifer,
    - Enhanced Oil Recovery CO2 qualities

- Externally refrigerated GPU for yields of 80%and above
  - Component solutions for
    - Saline Acquifer,
    - Enhanced Oil Recovery CO2 qualities

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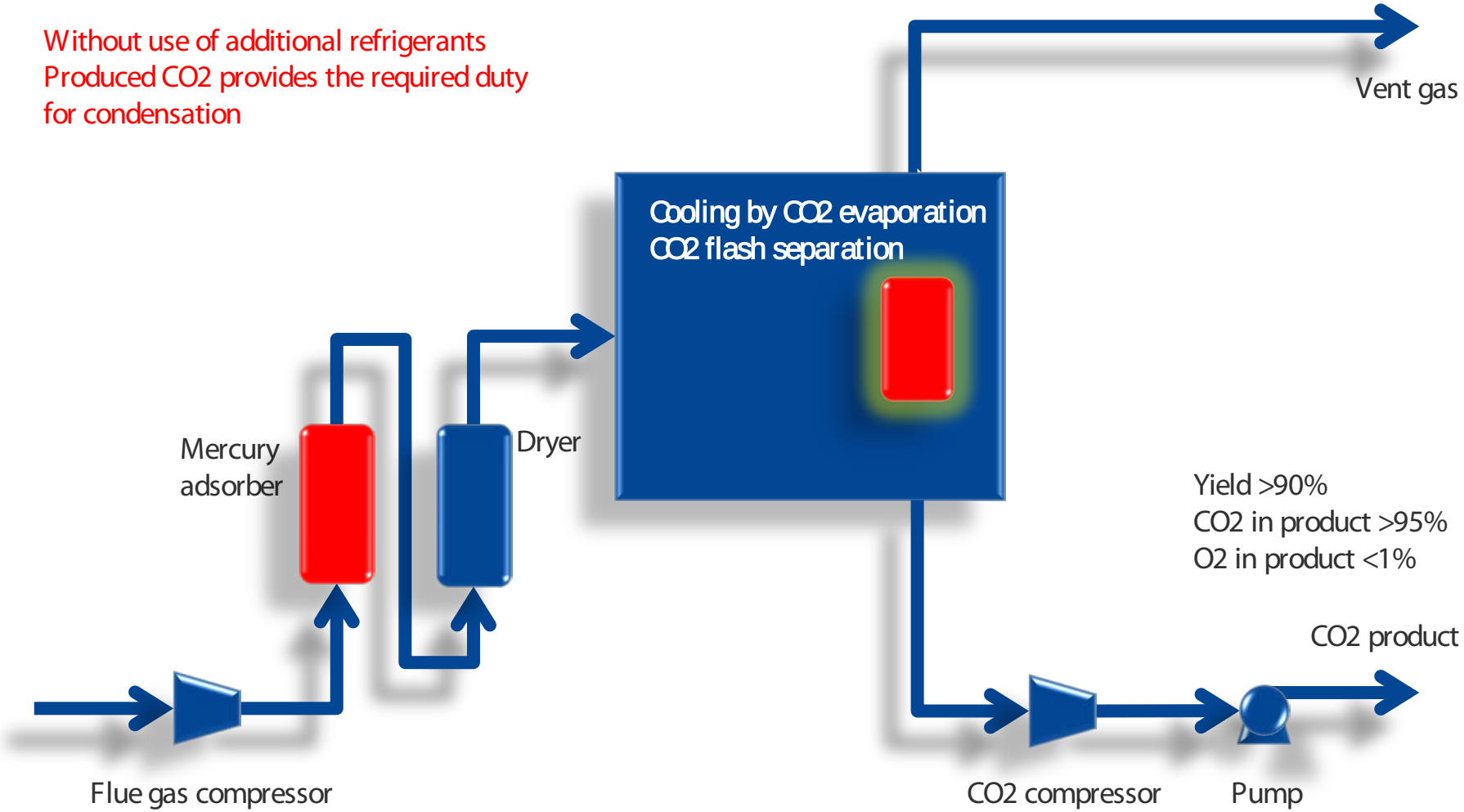
Auto-refrigerated GPU for SA Quality

Without use of additional refrigerants
Produced CO_2 provides the required duty for condensation



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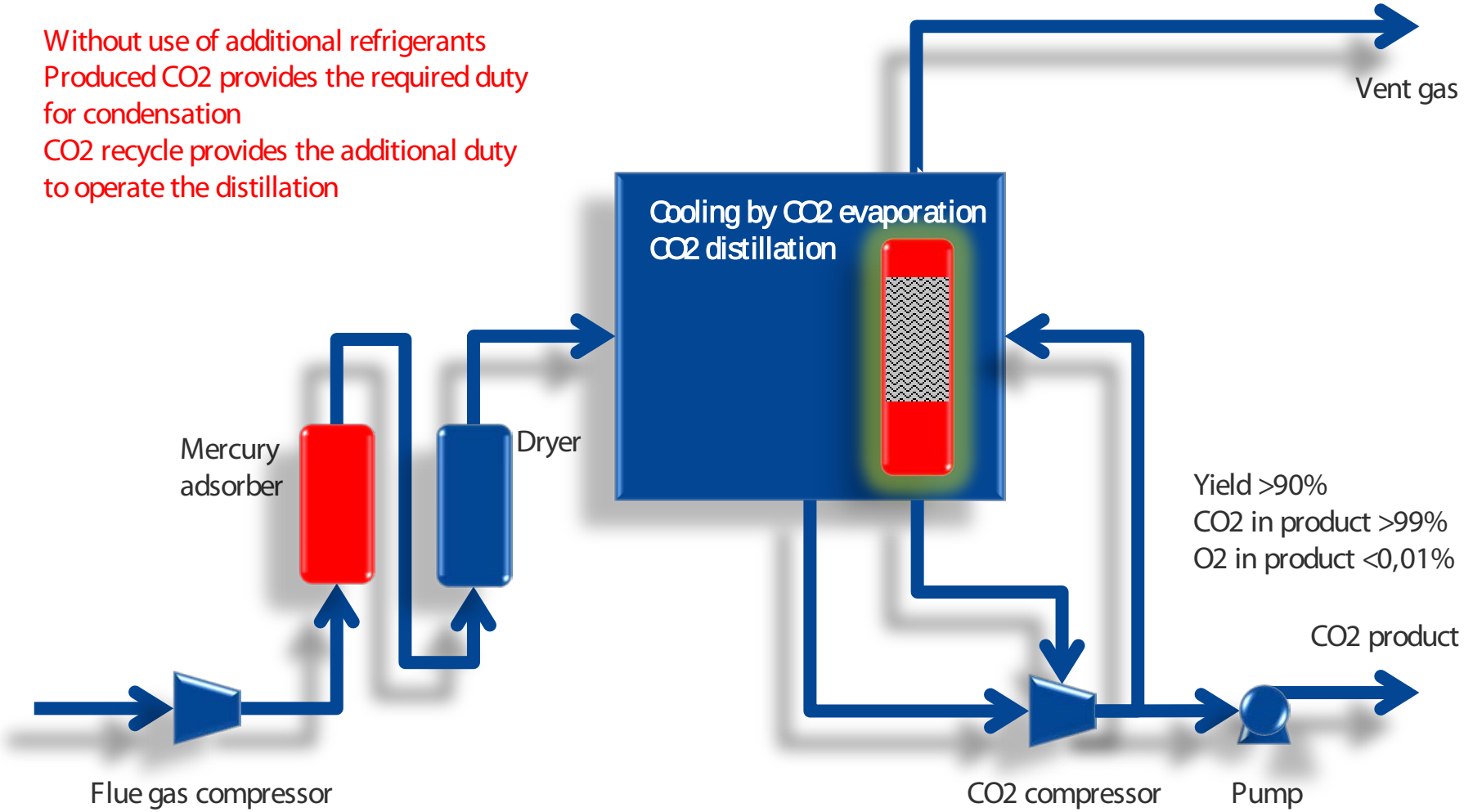
Auto-refrigerated GPU for EOR Quality

Without use of additional refrigerants
Produced CO_2 provides the required duty for condensation
CO_2 recycle provides the additional duty to operate the distillation



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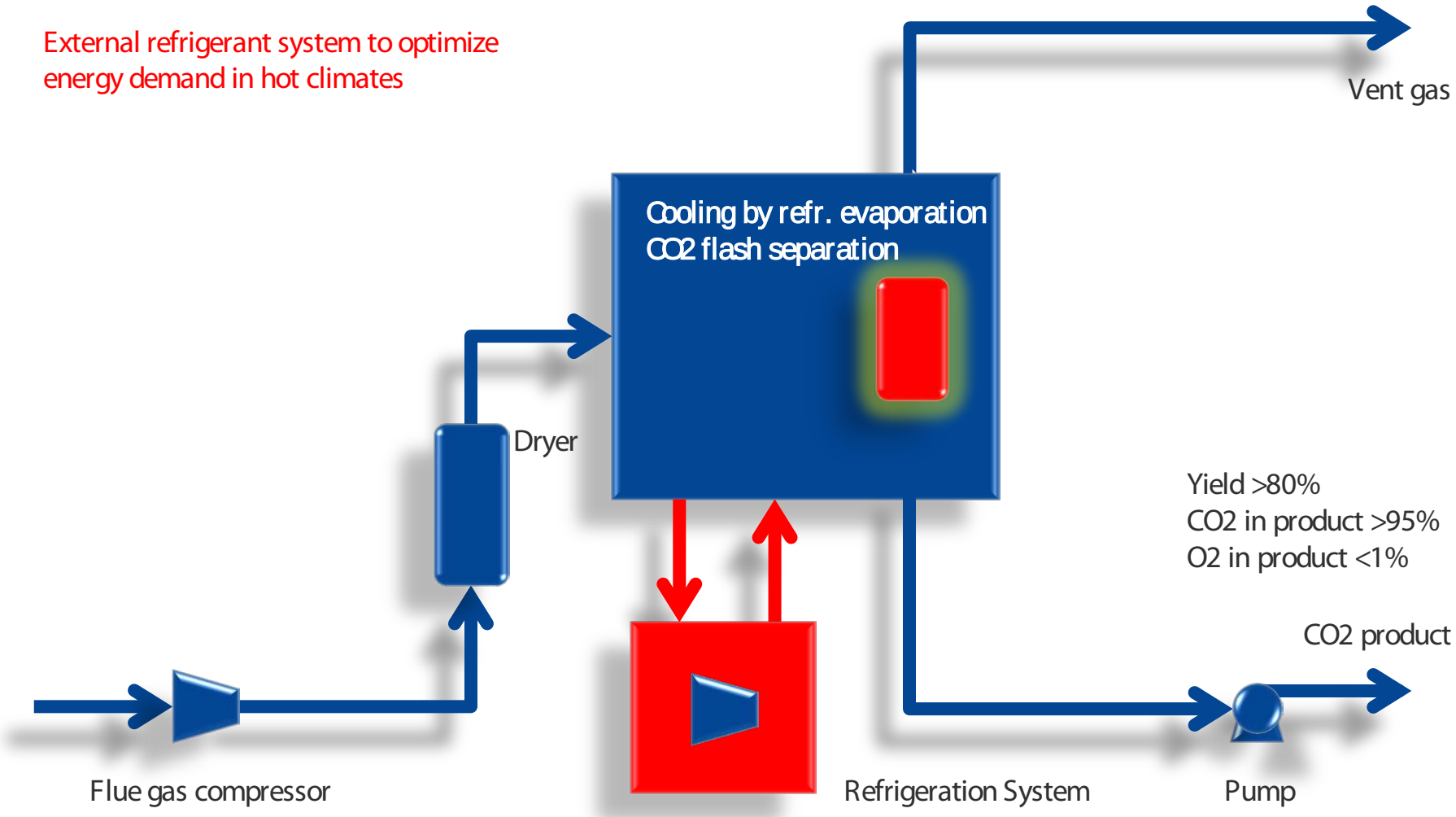
Externally Refrigerated GPU for SA Quality

External refrigerant system to optimize energy demand in hot climates



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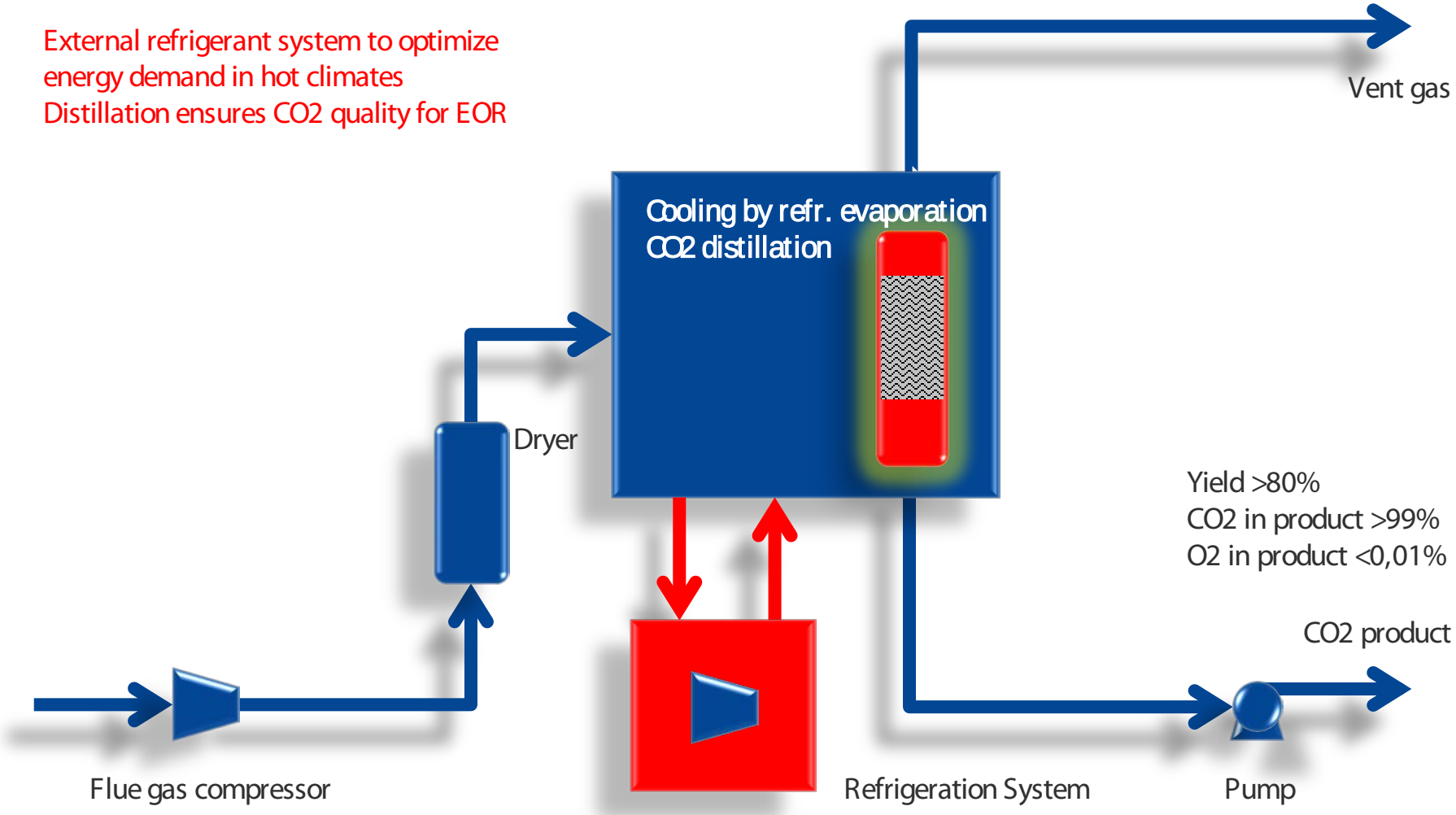
Externally Refrigerated GPU for EOR Quality

External refrigerant system to optimize energy demand in hot climates
Distillation ensures CO_2 quality for EOR



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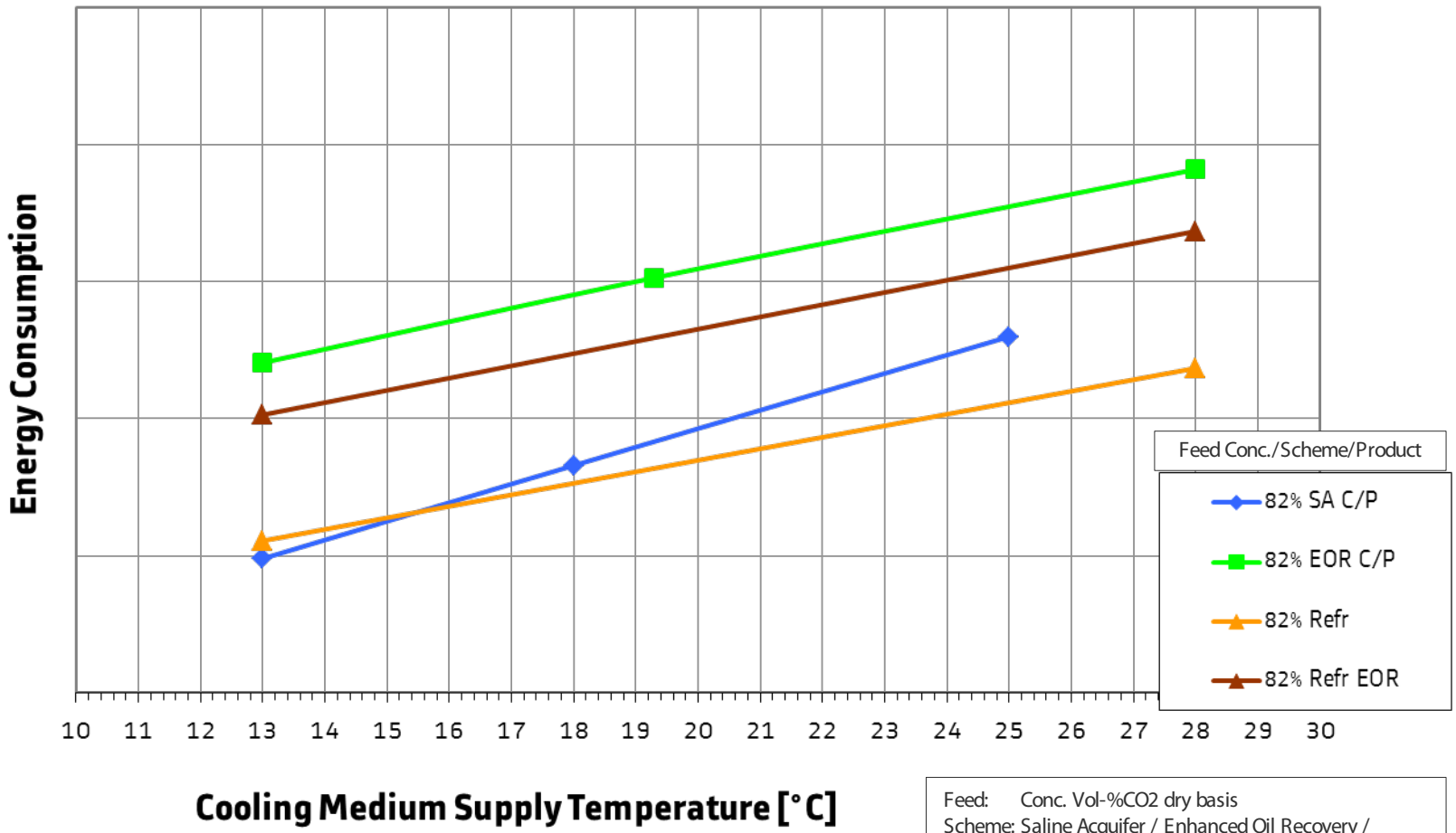
Energy Consumption



Feed: Conc. Vol-%CO2 dry basis
Scheme: Saline Acquifer / Enhanced Oil Recovery / Refrigeration system
Product: handling by Compressor with Pump system or pumping only

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Conclusions

- Autorefrigerated GPU for recovery rates of 90%and above
  - CO_2 as refrigeration media
  - SA and EOR quality CO_2
  - Not too high cooling water temperatures (SA <25°C EOR <28°C)
  - More sensitive to trace substances, e.g. Hg reaction with Aluminum

- Externally refrigerated GPU for yields of 80%and above
  - Separate refrigeration media
  - SA and EOR quality CO_2
  - Less sensitive to cooling water temperature
  - No mercury removal required
  - Robust design using mainly simple materials like carbon steel

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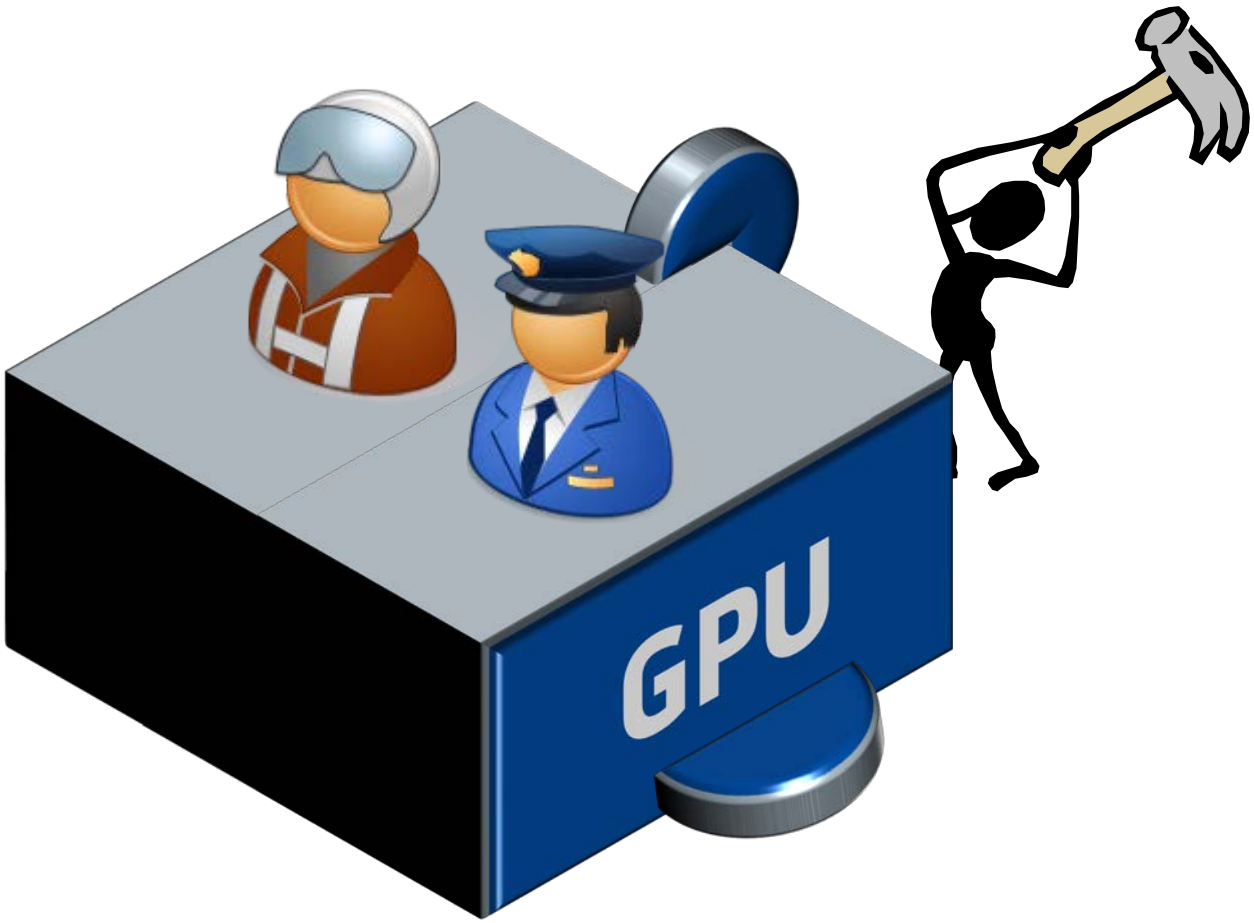
GPU Pilot Testing



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ALSTOM GPU Pilot
Compression and Purification Units

- Commissioned with synthetic flue gas at ALSTOM Technology Center, Växjö (Sweden)

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ALSTOM GPU Pilot – Main Features

- Capacity equivalent to 300 kW_{th}
- Synthetic flue gas capabilities
  - Aux systems: gas mixing station, humidifier, exhaust system
  - Ability to simulate various flue gas compositions including transients

- 4 stage reciprocating compressor (max 40bar), inter coolers and separators after each stage)
- 8 channel on-line gas analyser
- Pilot installed in two containers

- Third container for analyser
- Fourth container with synthetic gas mixing equipment

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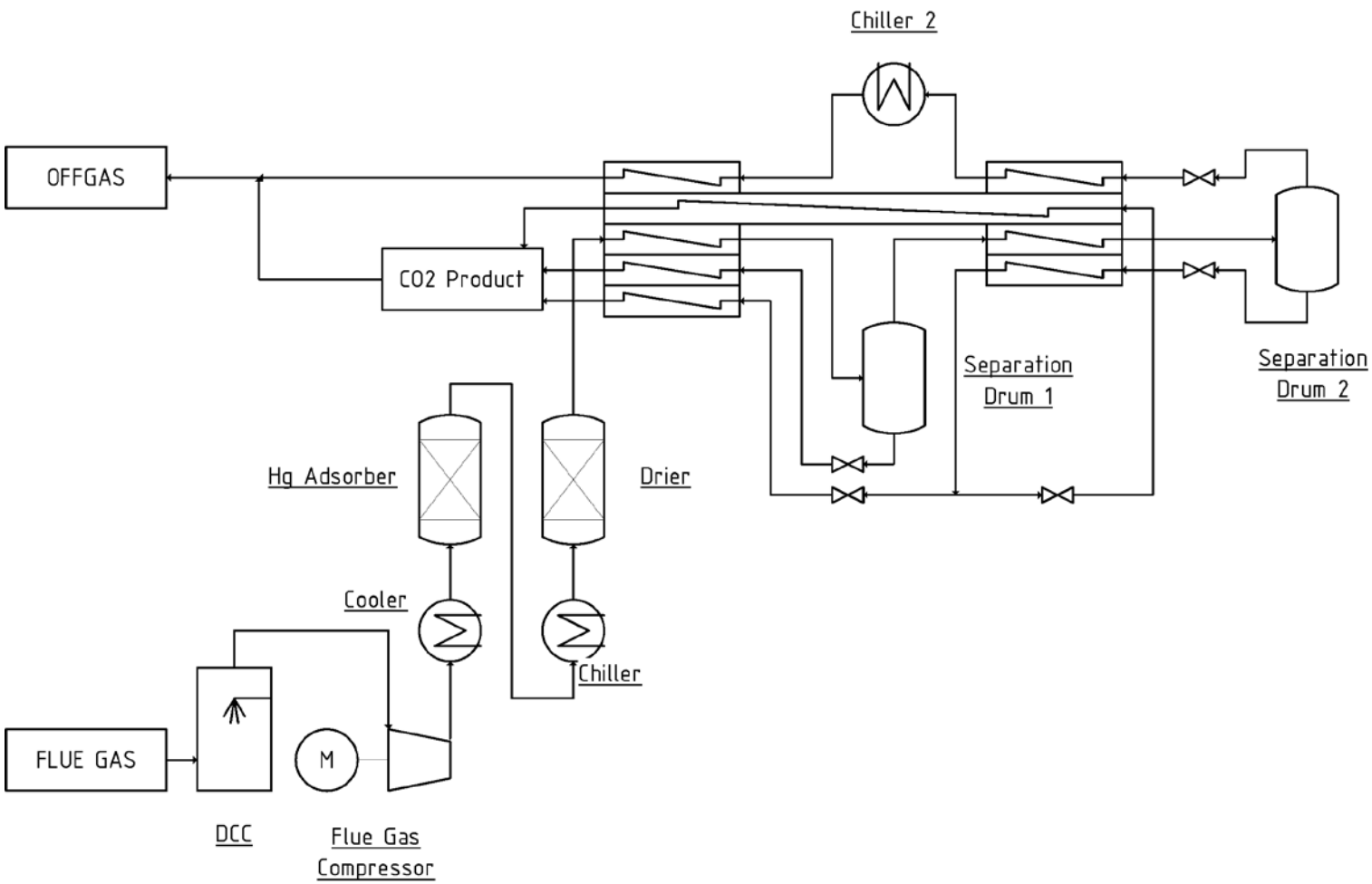
GPU Pilot
Simplified Flow Sheet



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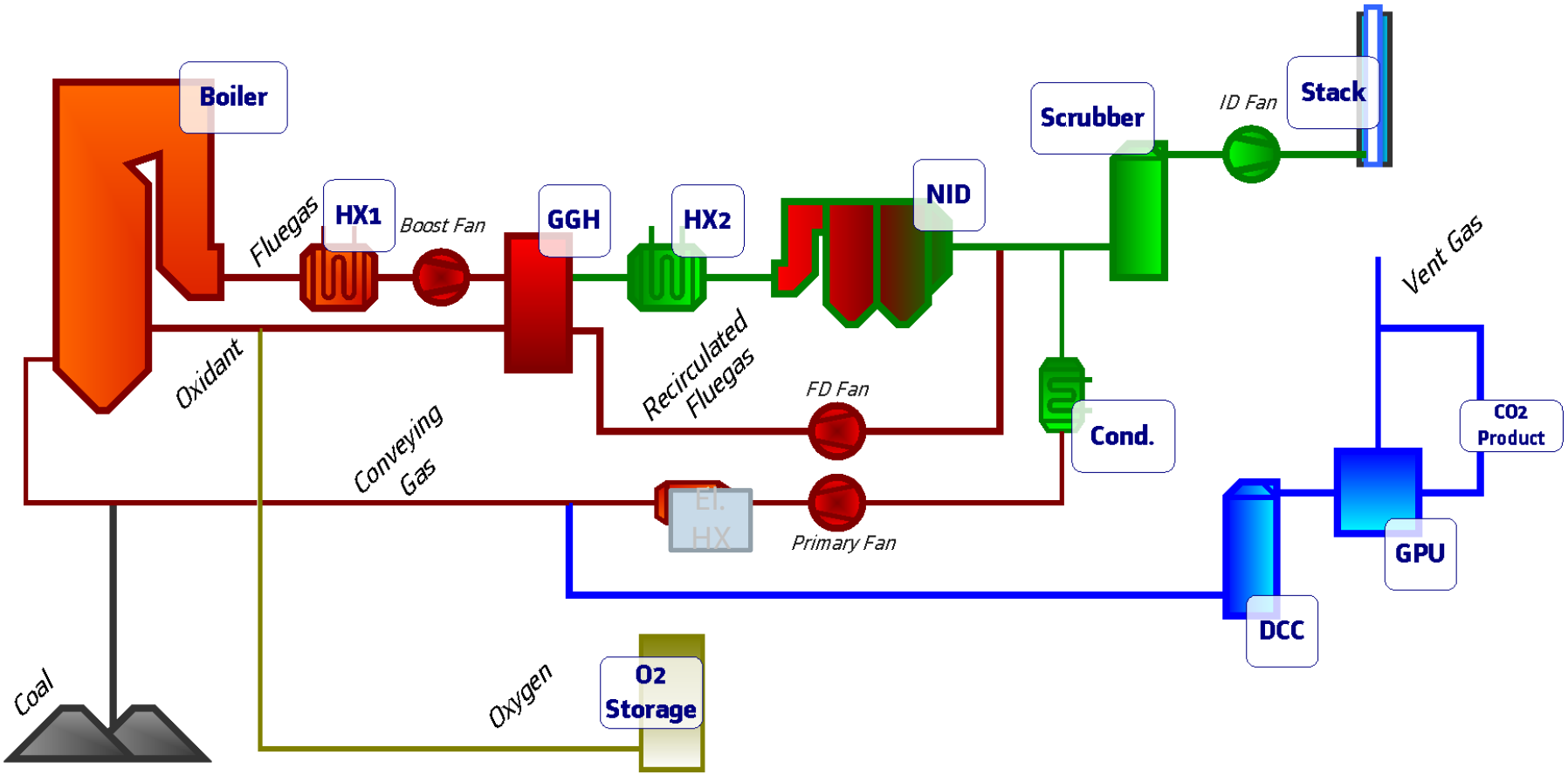
ALSTOM BSF Test Facility, Windsor (US) Arrangement



Abbreviations:

GGH = Q-Pipe Heat exchanger
NID = Dry Desulfurization System
DCC = Direct Contact Cooler
HX# = Heat Exchanger with Bypass
ID-Fan = ID-Fan
GPU = Gas Processing Unit

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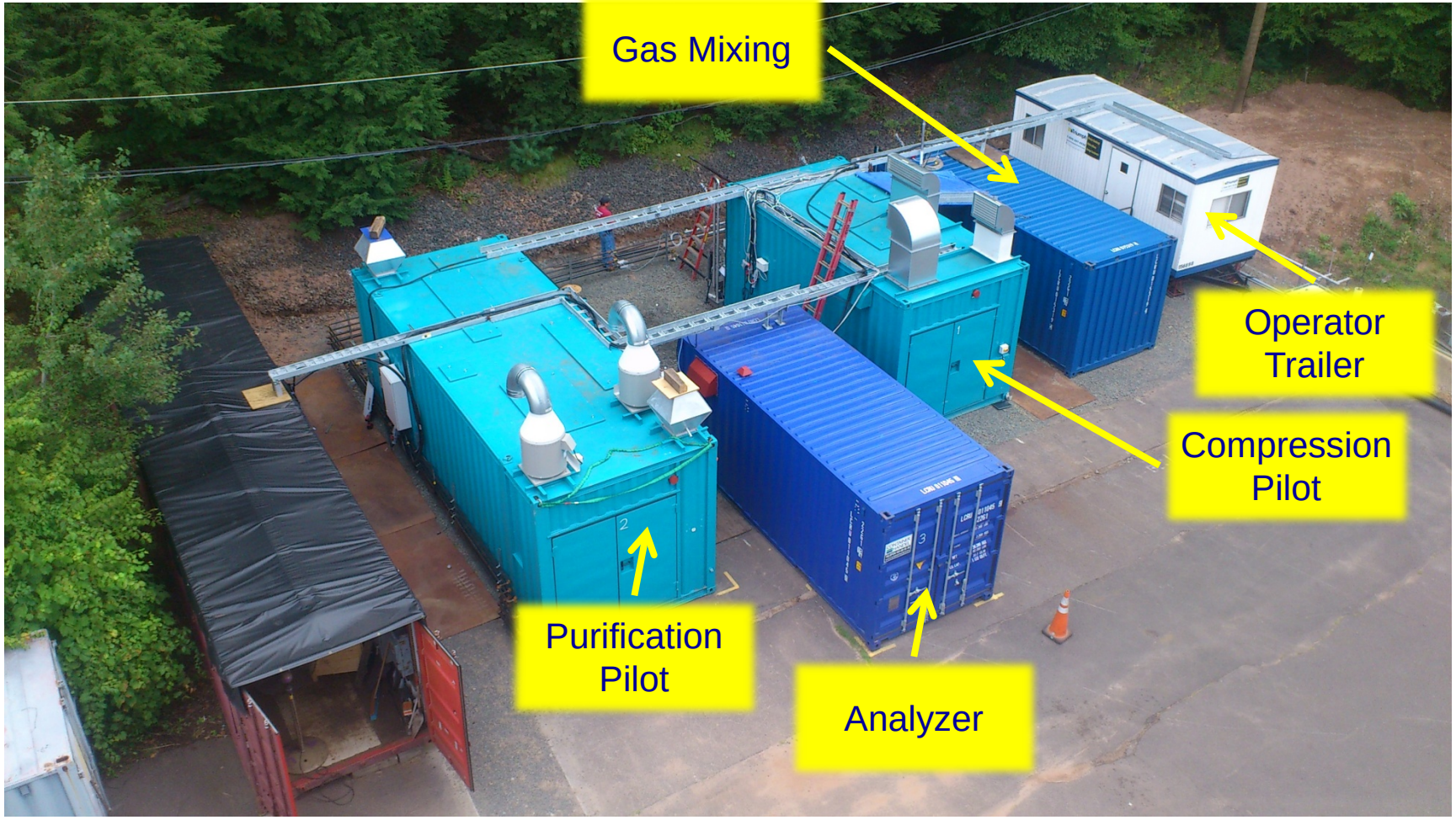
GPU Arrangement at ALSTOM Windsor (US) BSF Site



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GPU Pilot Test Boundaries

- Two different types of coals tested, low sulfur sub-bituminous and high sulfur bituminous
- Variation of the inlet concentration for key components

– CO2	70 Vol%	-	86 Vol%
– SOx	60 ppm	-	145 ppm
– NOx	100 ppm	-	365 ppm
– Mercury (upstream Adsorber)	>9.9 µg / Nm^3 25 ng/Nm^3	-	650 ng / Nm^3

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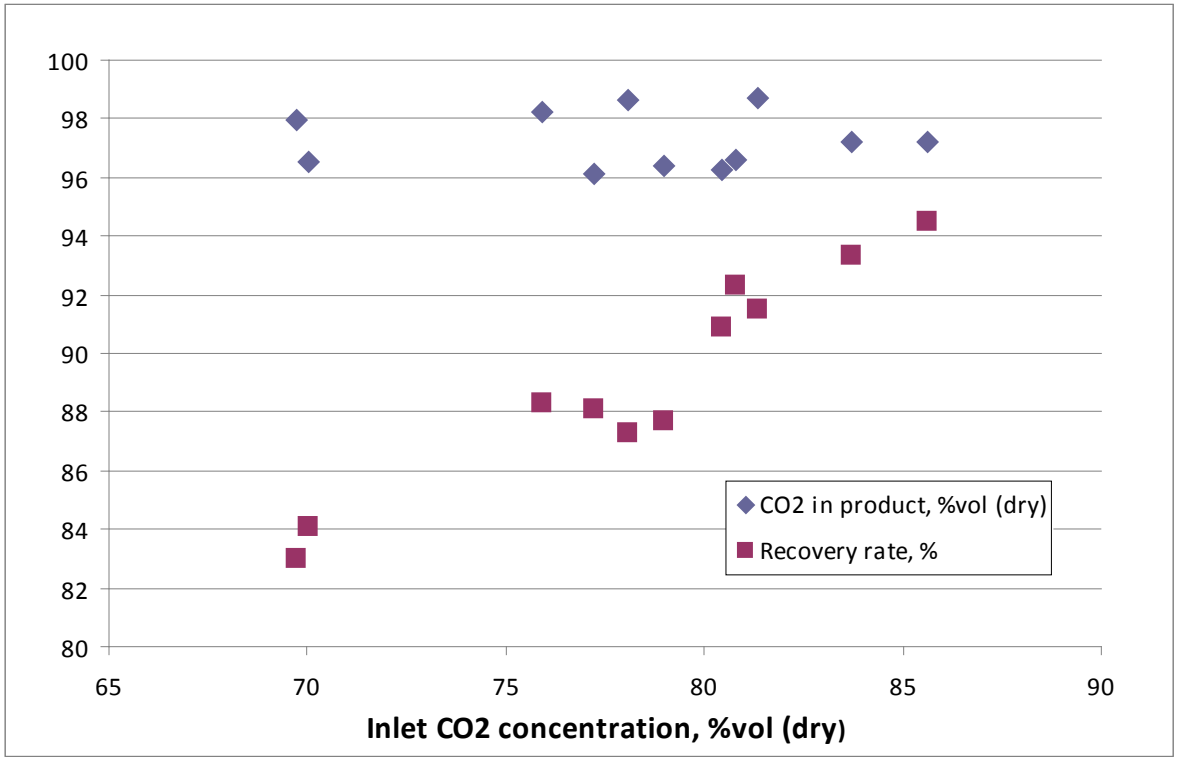
CO2 Recovery Rate and Purity



Targeted recovery rate of >90%reached at CO2 inlet concentrations of 80%
Design point regarding CO2 inlet concentration is 82%
Commercial unit performance higher due to reduction of heat losses.

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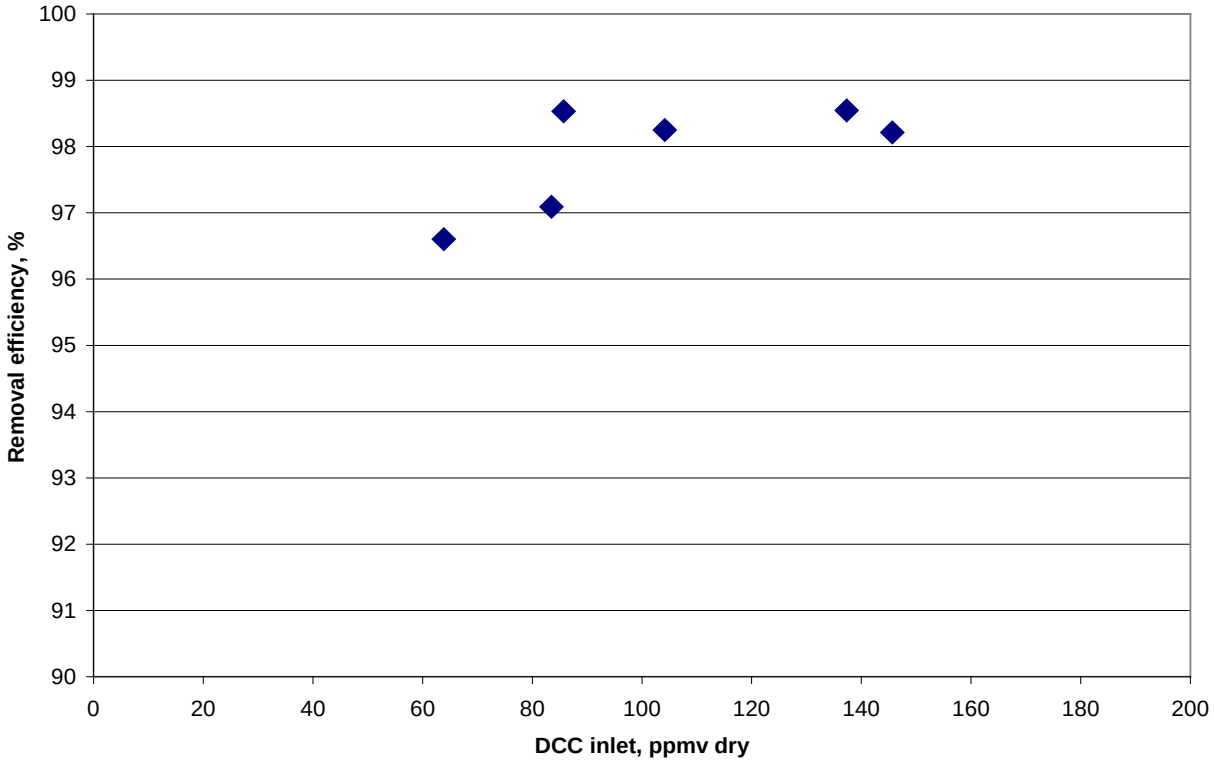
SO2 Removal in DCC



High performance SOx scrubbing ensures relaxed operating conditions in the compression section and reduced corrosion risks.

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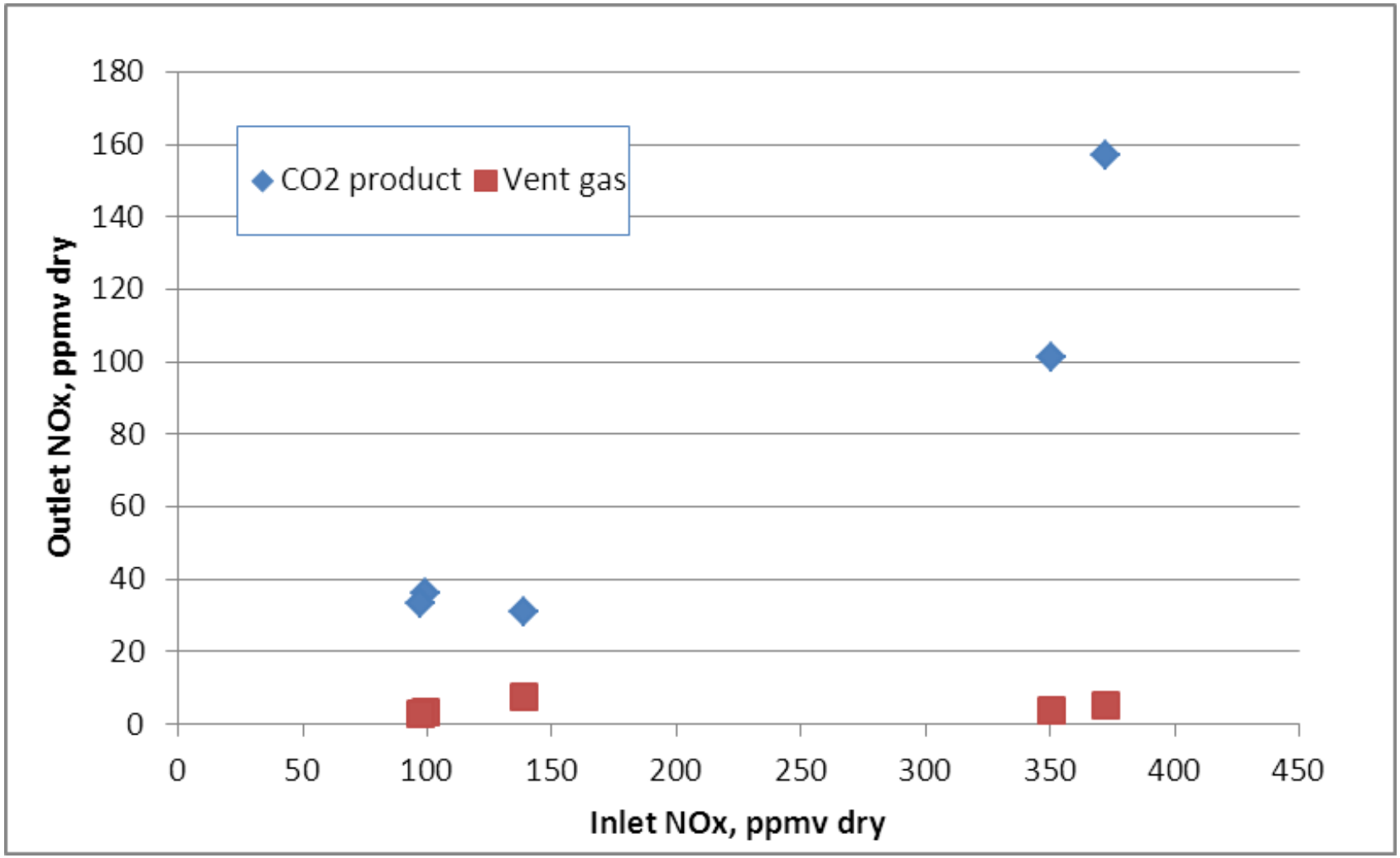
NO_x Removal in GPU



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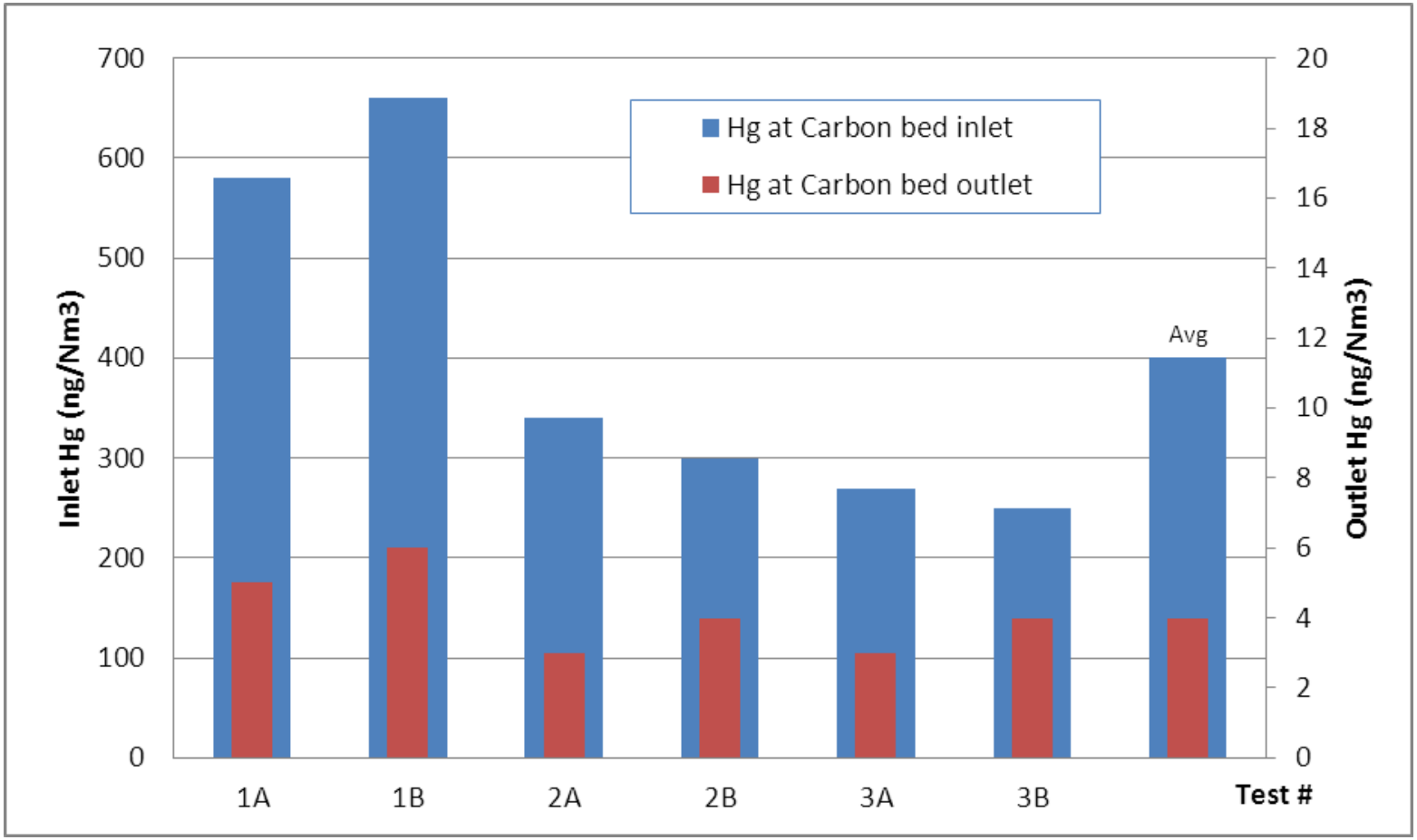
Hg Removal in Activated Carbon Bed



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Conclusions

- Successfully demonstrated operation of GPU pilot with oxy coal combustion flue gases
- Main targets for CO2-capture and purity achieved
  - CO2 purity > 95%
  - CO2 capture > 90 %
- SO2 is efficiently removed in the DCC
- NOx may need special attention depending on CO2 product specification
- Required Hg-removal achieved (< 10 ng/Nm3)

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