LESSONS LEARNED FROM DEMONSTRATION PILOTS PRE-COMBUSTION CAPTURE TECHNOLOGY

Robert de Kler

Venice, 13 May 2015

LARGE SCALE DEMONSTRATION PROJECTS PRE-COMBUSTION (EU)

- ✓ C.GEN North Killingholme Power Project
- ✓ Don valley Power Project

Cancellations

- ➢ Nuon Multi fuel Magnum (only power unit on NG)
- ➢ RWE

RWE IGCC power project (Source RWE website).

RATIONAL FOR PRE-COMBUSTION PILOT PLANTS

Design verification

- Identify and mitigate potential risks
- Verify the technology performance and operation window
- Optimize technology selection and design
- Gather operating experience
- Prepare for large-scale application

Stakeholder management

- For internal approval process
- IGCC Power generation is unique and challenging technology, impact of CO2 capture unknown

TWO PRE-COMBUSTION PILOT TEST AT REAL IGCC PROCESS CONDITIONS

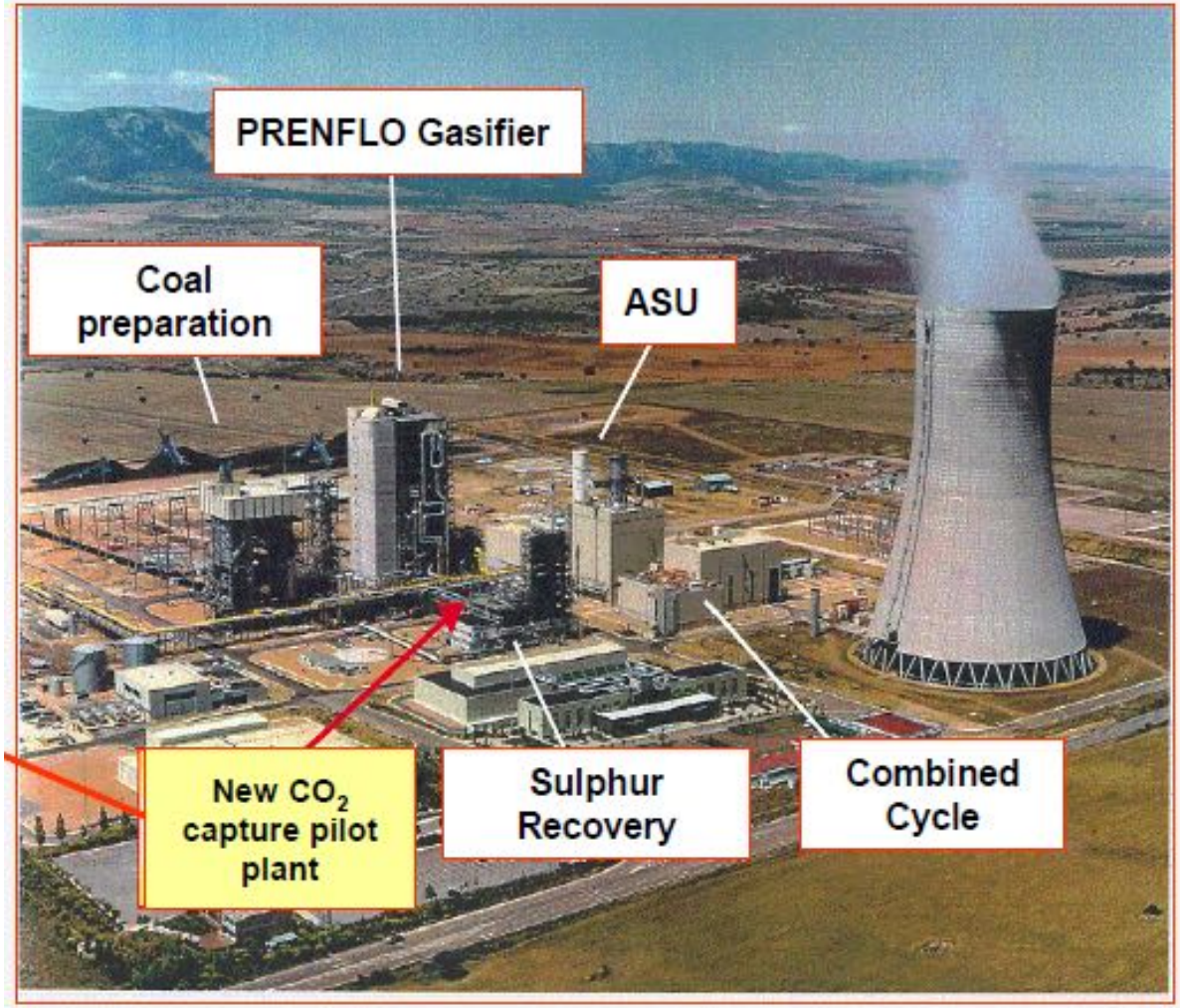
Puertollano IGCC

Company: ELCOGAS, S.A
Location: Puertollano, Spain
Feedstock: Coal and pet-coke
Size: 14 MWth of 335 MW plant; 100 tons/day
Capture Technology: Pre-combustion IGCC (90% capture)
CO2 Fate: Recycled back to the IGCC process
COST: 18 M€
Remarks: feasibility and capture rate of at least 90% and reduce capture cost to 30€/ton, hydrogen production

Buggenum IGCC

Company: Nuon (Vattenfall)
Location: Buggenum (Roermond), Netherlands
Feedstock: Coal and biomass (15%)
Size: 5 MWth of 253 MW plant; 30 tons/day
Capture Technology: Pre-combustion IGCC (80% capture)
CO2 Fate: Recycled back to the IGCC process
COST: 40 M€
Remarks: Main objective prepare for Large scale deployment bulk removal of CO2 at Nuon Multi fuel Magnum IGCC plant

IGCC PLANTS PRE-COMBUSTION PILOTS



Puertollano IGCC site is available for pre-combsution pilot test runs.

LESSONS LEARNED

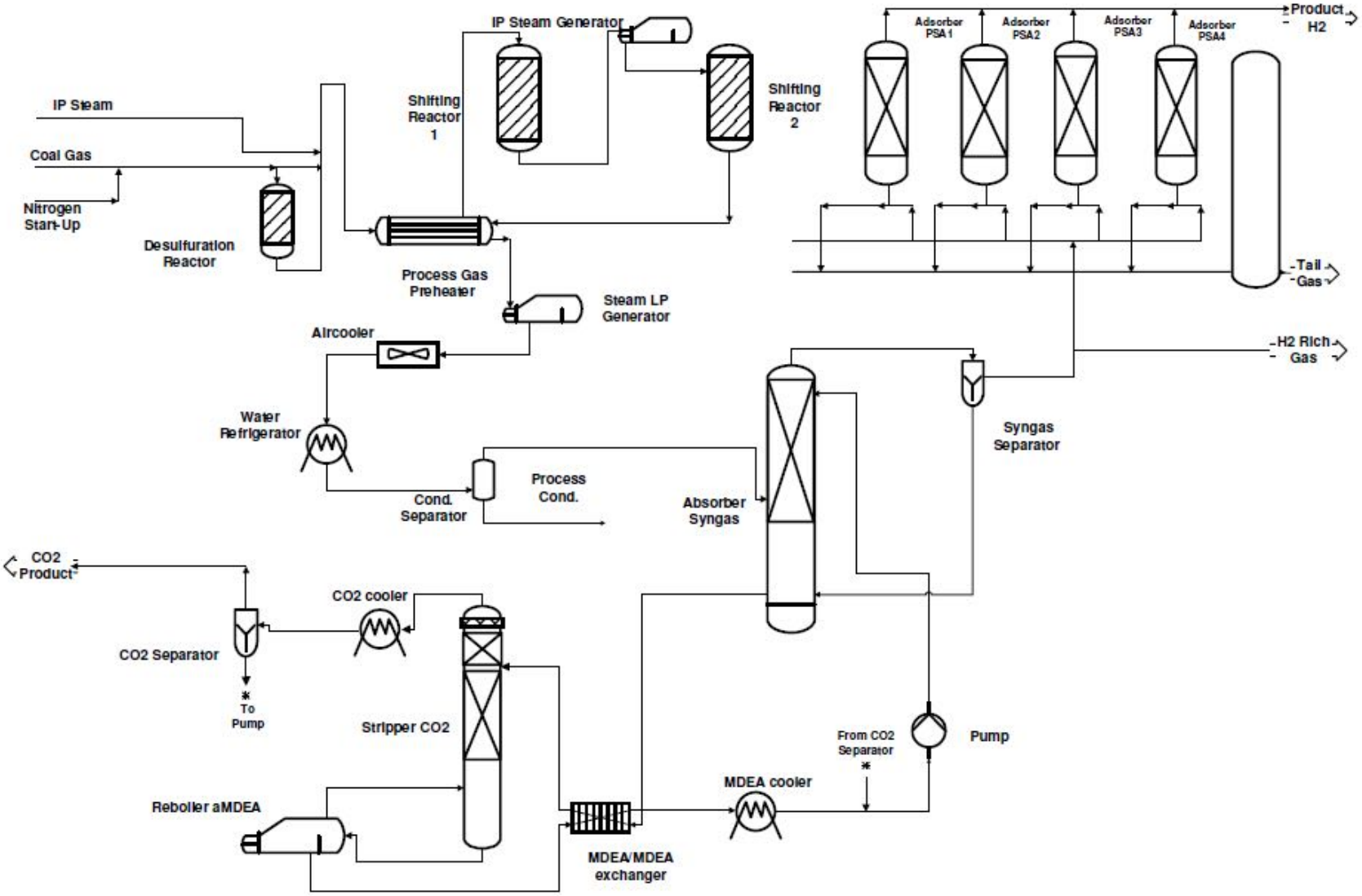
Both pilot test demonstrations collected an extensive mount of information, although it is a know technology and available at commercial scale.

The pilots provided value input for large scale deployment:

- ✓ Measurement and optimization of plant performance,
- ✓ Mass balance reviewed (water balance control has been checked),
- ✓ Dynamic operation, validation of paradigmatic models of pre-combustion capture technology,
- ✓ Relevant perturbations has been reviewed, such as syngas quality changes due to feedstock changes, power plant cycling modes,
- ✓ Catalyst deactivation has been monitored,
- ✓ Solvent foaming and entrainment has been monitored,
- ✓ Identification of corrosion issues.

Technology suppliers prefer to sell standardised solutions to keep down costs. Based on the pilot plant and validated paradigmatic models it is possible to identify unnecessary conservatism and performance bottlenecks in the context of a specific equipment, and use static and dynamic optimisation applied to dynamic physical models to remove them.

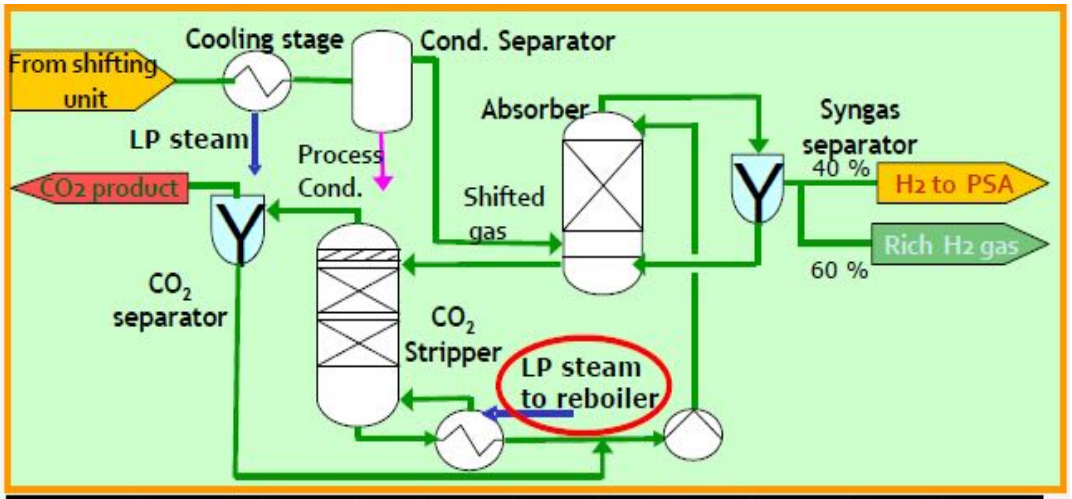
PUERTOLLANO IGCC PILOT



LESSONS LEARNED

Peurtollano pilot
- ✓ Capture rate = 90%
- ✓ Steam/co ratio = 2.9 (design)
  = 2.2 (min.)

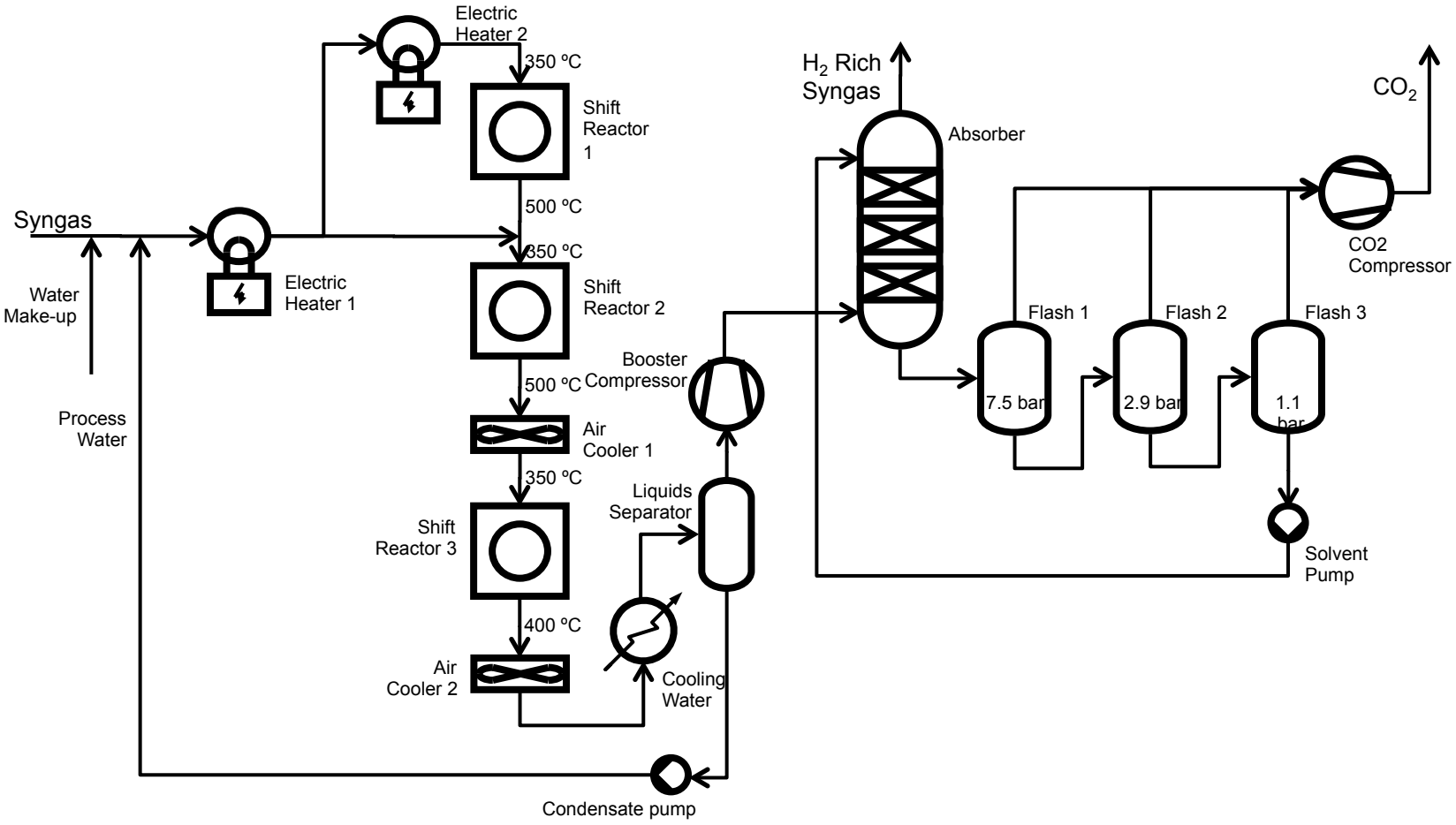
- ➢ Sour catalyst lower energy consumption
- ➢ Catalyst robust
- ➢ 1000 ton CO2 captured
- ➢ Energy penalty 2350 MJ/tonCO2
- ➢ Capture cost @ 26 €/ton



		Flow kg/h	P bar	T °C	CO %	H_2 %	CO_2 %	H_2O %	H_2S %	COS %
Shifted gas to absorber	Sweet	5,318	15.9	45	2.9	49.7	37.3	0.7	0.0	0.0
	Sour	5,318	19.7	45	2.46	49.7	37.69	0.62	0.51	0.0
Process condensated	Sweet	3,414	15.9	45	0.0	0.0	0.0	100	0.0	0.0
	Sour	3,387	19.7	45	0.0	0.0	0.0	100	0.0	0.0
CO_2 product	Sweet	4,185	1.5	40	0	0.18	95.32	4.47	0.0	0.0
	Sour	4,295.5	1.55	40	0.01	0.21	94.02	4.47	1.27	0.0
H_2 to PSA	Sweet	481.7	15.2	40	4.63	79.37	0.5	0.48	0.0	0.0
	Sour	457.3	19.1	40	4.02	80.44	0.5	0.39	0.0001	0.0
Rich H_2 gas	Sweet	1,190.1	15.6	40	4.63	79.37	0.5	0.48	0.0	0.0
	Sour	1,135.2	19.4	40	4.02	80.44	0.5	0.39	0.0001	0.0
LP Steam to reboiler	Sweet	4,763	4.1	144	0.0	0.0	0.0	100	0.0	0.0
	Sour	4,797	4.1	144	0.0	0.0	0.0	100	0.0	0.0

Test results at Peurtollano pilot, source from ELCOGAS report, 2013

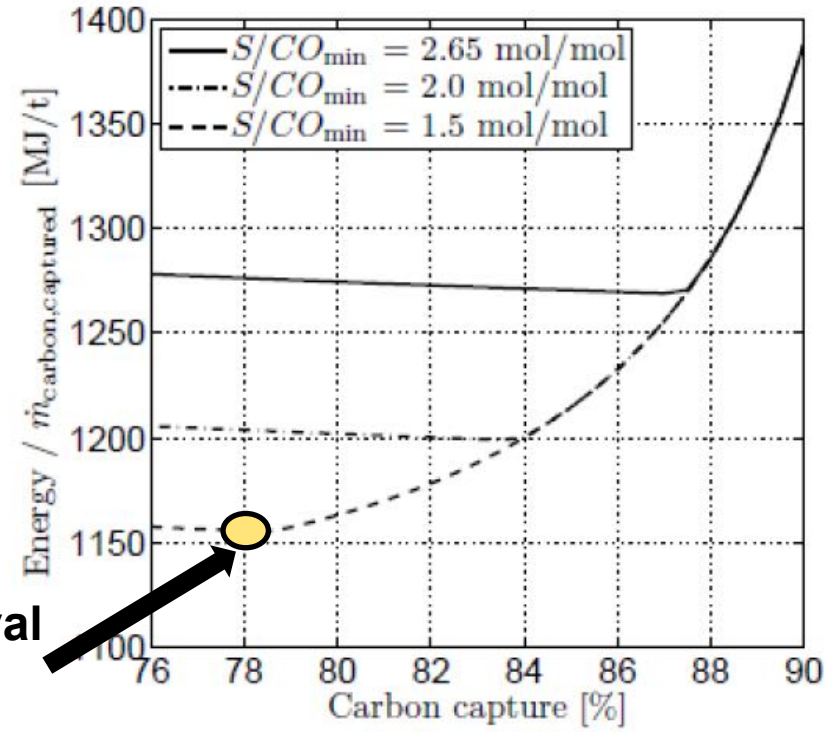
BUGGENUM IGCC PILOT



LESSONS LEARNED

Buggenum pilot
Capture rate = 78%
Steam/co ratio (molar) = 1.5

- Random packing better performance
- Impact water content is small
- Solvent performance was not deteriorating
- Catalyst robust (no Carbiding)
- Confirm the three stage WGS concept
- 4478 tons of CO2 captured
- Energy penalty 1150 MJ/tonCO2



Confirmed bulk removal
Operational point

Test results at Buggenum pilot, source from ECN report, H.A.J. van Dijk et al. 2013

IN SUMMARY

Both pilot programs supported a better understanding for a large scale application:

1) select the optimal product quality and yields,
2) select the optimal catalyst for the desired conversion rate and lifetime,
3) select a solvent for the optimal capacity, selectivity, and minimal foaming,
4) select the optimal packing type (structured vs. random) and size depending on desired capture rate and solvent capacity,
5) select the optimal trade-off for capture rate vs. energy consumption.

Tools has been developed and validated to scale-up the shift reactors and the absorber for optimal conversion rate and capture rate with minimal CAPEX.

Main corrosion-prone locations has been analysed to be able to select optimal materials and define maintenance intensive plant parts and establish optimal maintenance procedures.

Crucial tool for stakeholder management

ACKNOWLEDGEMENTS