PRENFLO: PSG and PDQ

Latest Developments based on

10 years Operating Experience at Elcogas IGCC, Puertollano, Spain

Uhde

ThyssenKrupp

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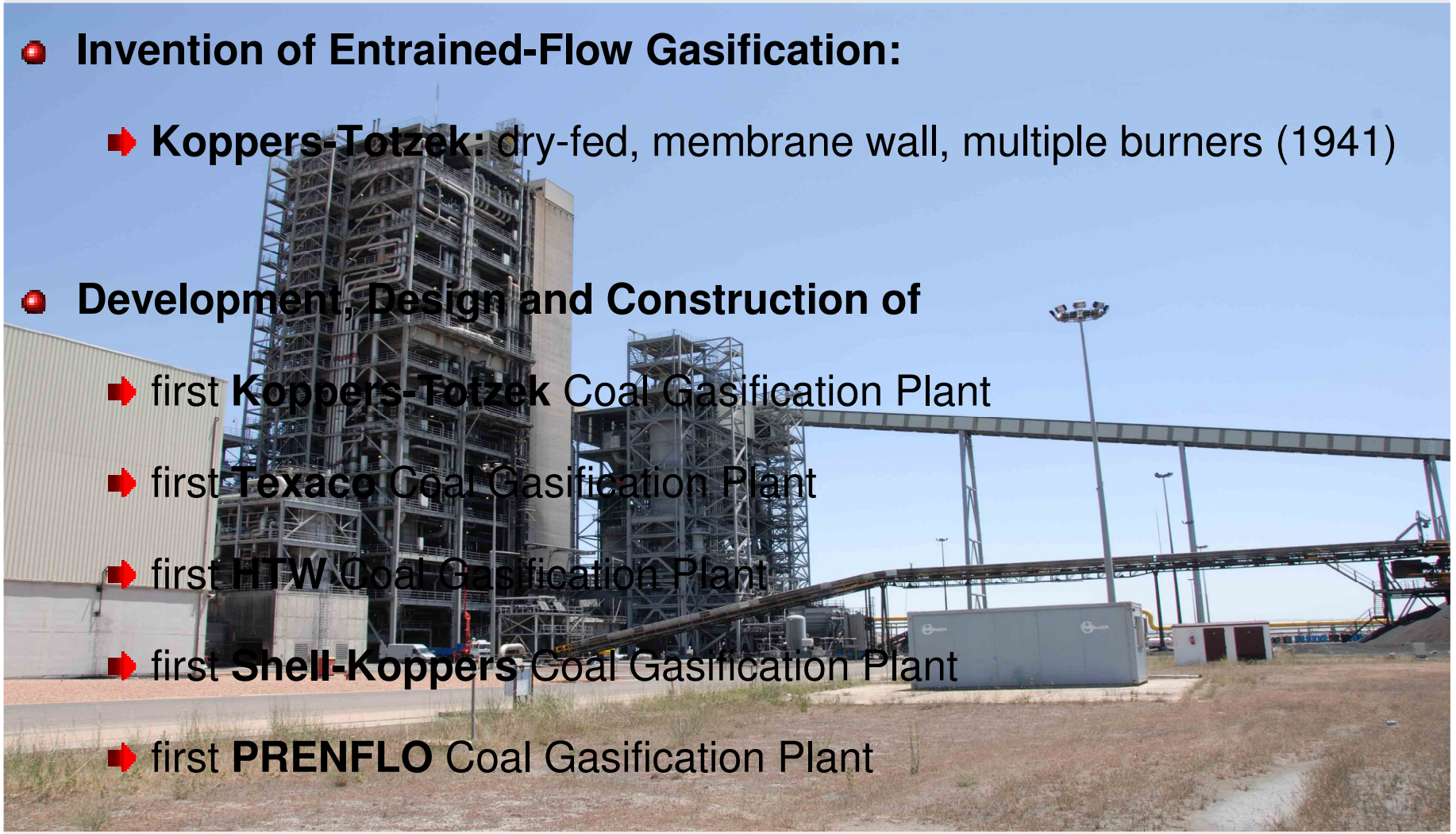
Max Hooper, Bill Richards; **Uhde Corporation of America**

Gasification Technologies Conference 2008
October 5-8 • Wardman Park Marlott In Washington, DC

Gasification Technologies Council

Uhde‘s Gasification Highlights – SUMMARY:



- **Invention of Entrained-Flow Gasification:**
  - **Koppers-Totzek:** dry-fed, membrane wall, multiple burners (1941)
- **Development, Design and Construction of**
  - first **Koppers-Totzek** Coal Gasification Plant
  - first **Texaco** Coal Gasification Plant
  - first **HTW** Coal Gasification Plant
  - first **Shell-Koppers** Coal Gasification Plant
  - first **PRENFLO** Coal Gasification Plant

- **Over 100 Gasifiers designed, built and put into successful operation by Uhde**

Uhde‘s proprietary Koppers-Totzek Gasification Process

First Entrained-Flow Gasification Technology

Koppers-Totzek gasification plant
Ramagundam, India
900 t/d of ammonia

Koppers-Totzek gasification plant
Modderfontein, South Africa
1,000 t/d of ammonia

PRENFLO

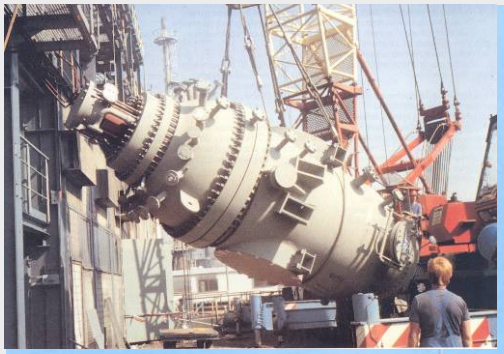
with Steam Generation

PSG

Pressurised Entrained Flow Demonstration plants

Shell-Koppers plant in
Hamburg / Germany

PRENFLO plant in
Fürstenhausen / Germany



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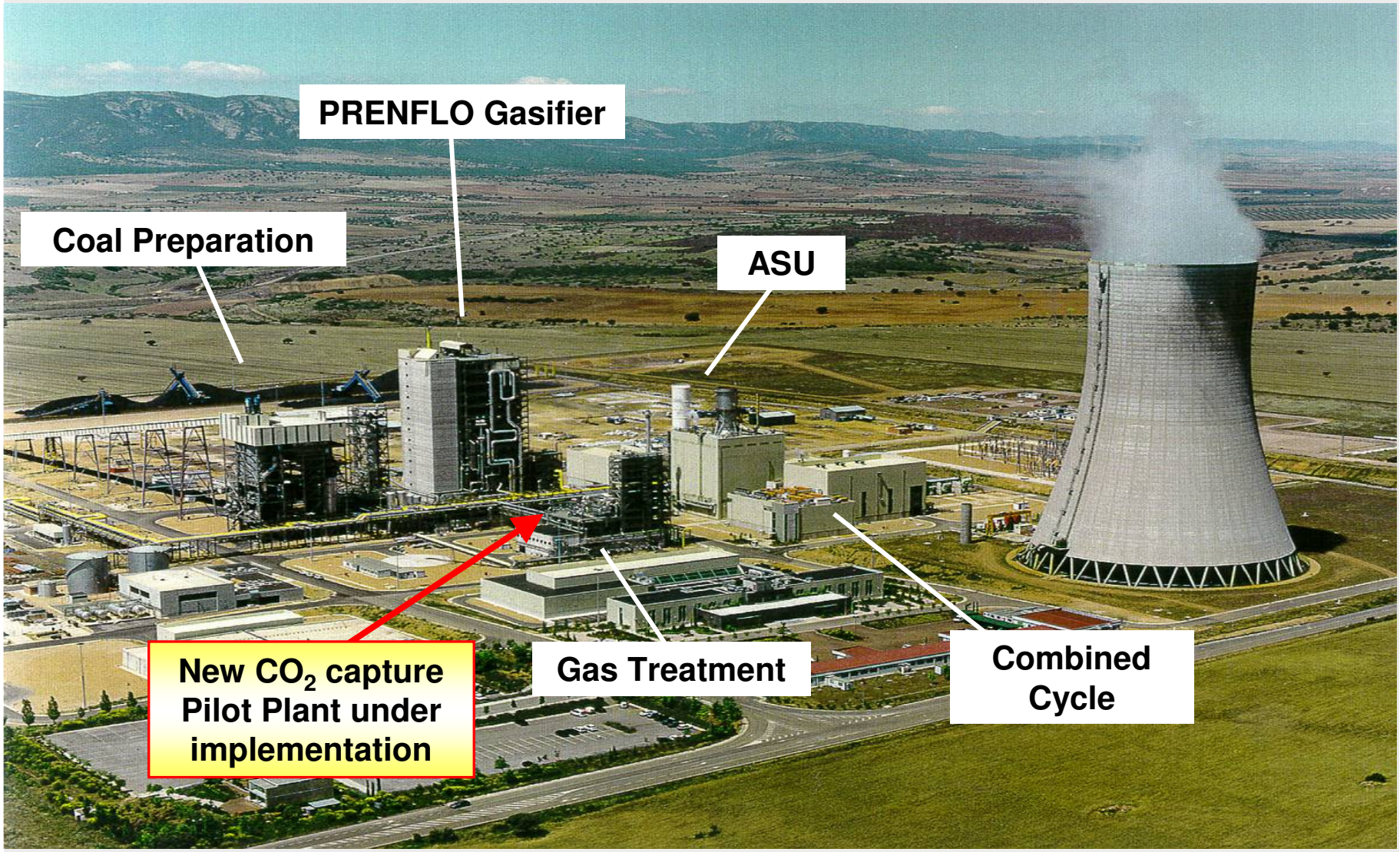
World‘s largest IGCC: Elcogas, Puertollano, Spain (300 MWe)

based on petcoke / coal feedstock



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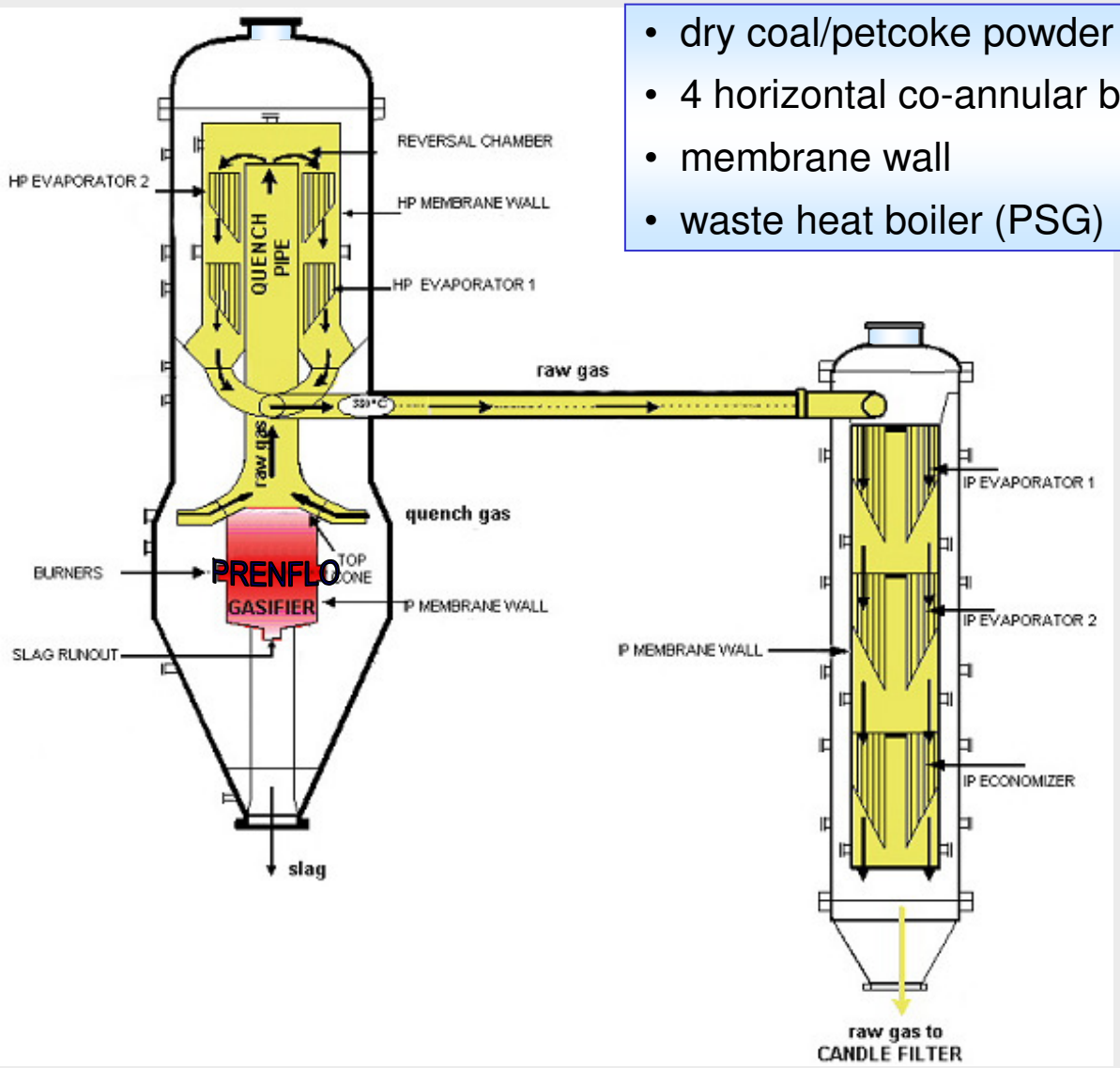
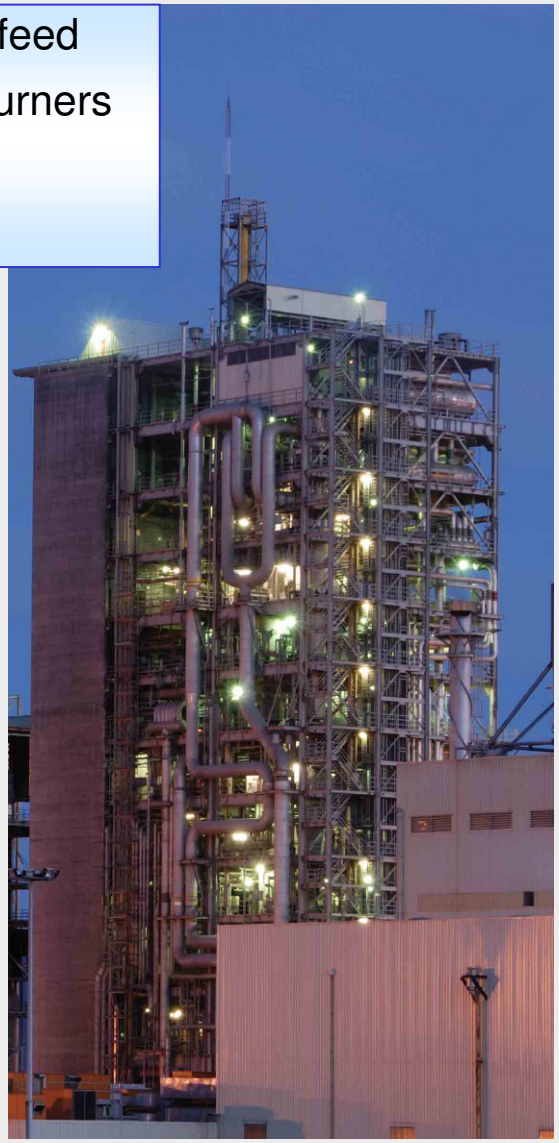
PRENFLO gasifier and waste heat boiler (PSG)

- dry coal/petcoke powder feed
- 4 horizontal co-annular burners
- membrane wall
- waste heat boiler (PSG)





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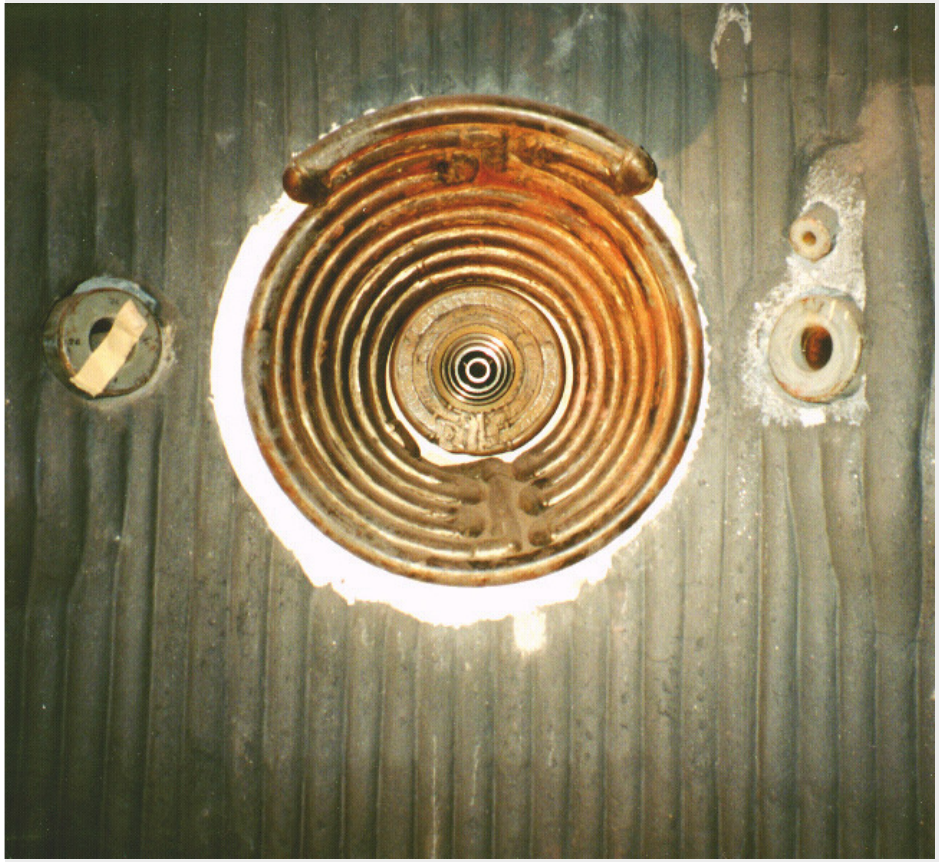
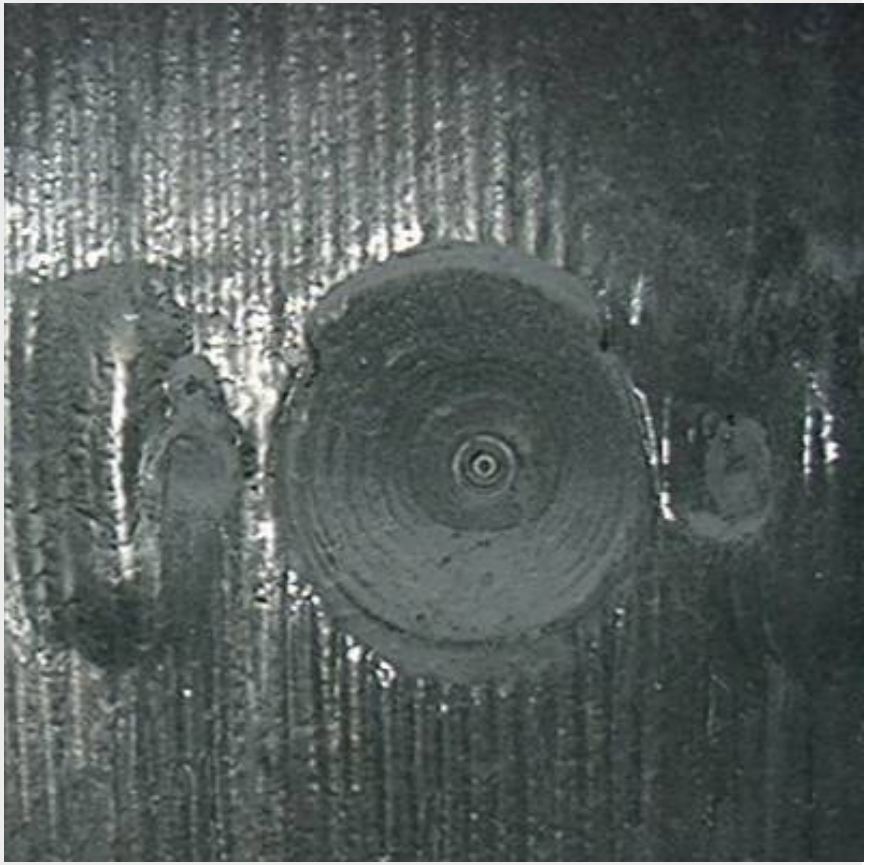
PRENFLO Membrane Wall protected by the slag layer

PRENFLO Gasifier Membrane Wall

View of gasifier membrane wall
before 1st operation (PRENFLO burner)



View of gasifier membrane wall
after operation (PRENFLO burner)



Perfect slag layer protecting membrane wall

PRENFLO Gasifier - erection of internals (Puertollano)

Lifting of PRENFLO Gasifier / HP-Boiler (Puertollano)

Puertollano IGCC: Operating Experience

General

- Gasification is **flexible** with broad range of **solid fuels**
  - high-ash hard coal and petroleum coke
  - addition of biomass successully demonstrated
- Flexible **load change** behaviour
- Nearly **constant** gas **heating value** irrespective of fuel
- **No formation** of **higher hydrocarbons**, methane < 0.1 vol. %
- **Non-leachable slag** production
- **Fly ash** sold to cement industry
- Elcogas statistics show that the vast majority of down-times was caused by **non-gasifier** related issues

Puertollano IGCC: Lessons Learned

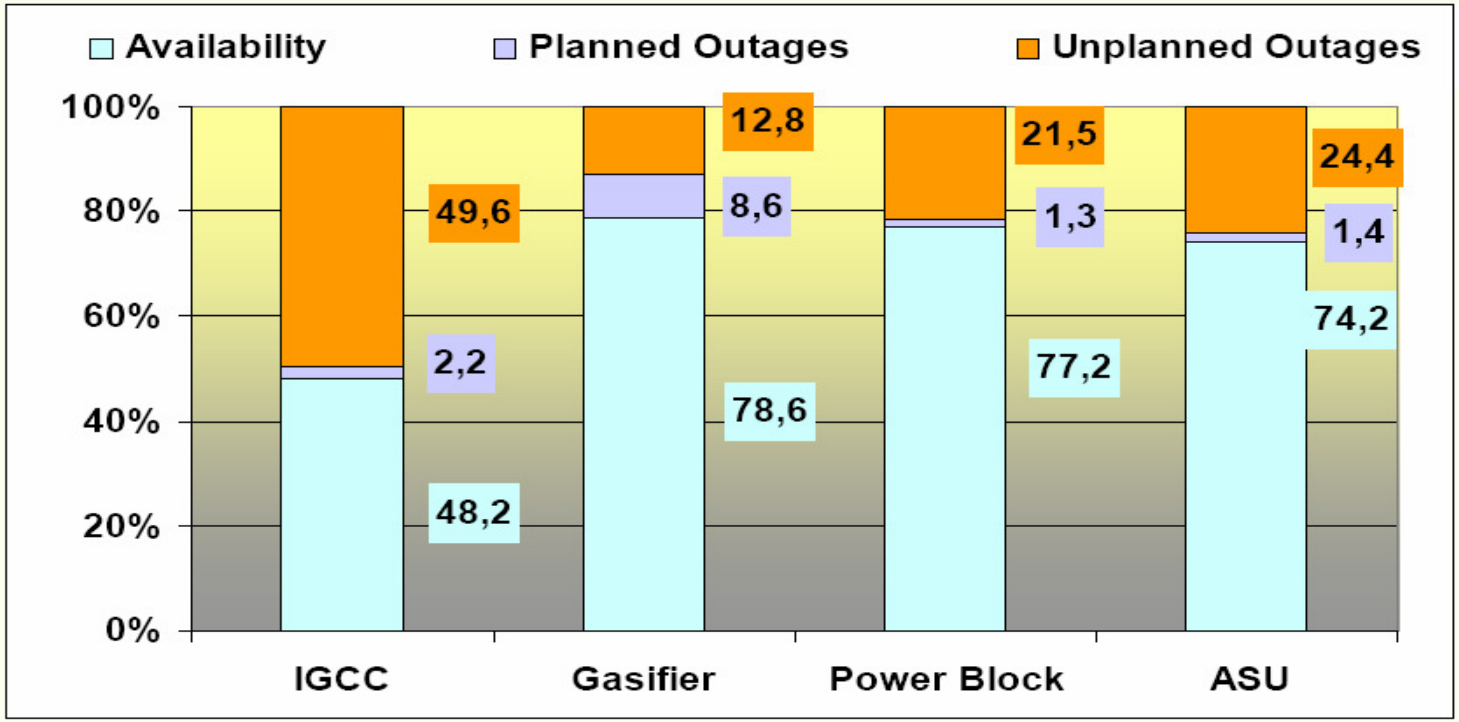
Major Problems and Solutions

Source: Elcogas, 2008

System	Problem	Solution
Overall plant	100% ASU integration restricts plant operation	start-up compressor required (future plants)
Gas turbine	burner & combustor overheating	various modifications
Coal preparatio		
Gasifier		
Slag		
Slag		
Waste heat boil		
Fly ash		
Overall plant		

ELCOGAS

AVAILABILITY 2007



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Puertollano IGCC: Lessons Learned

Operating Data: IGCC is least cost power generation

Fuel mode	Fuel	Heat rate (kJ_{HHV}/kWh)	Fuel cost (€/GJ_{HHV})	Partial cost (€/MWh)	Total cost (€/MWh)
GT	Natural gas	18504	7,20	133,25	133,25
NGCC	Natural gas	9375	7,20	67,51	67,51
NGCC + ASU	Natural gas	10900	7,20	78,49	78,49
NGCC+ASU+ Gasifier by flare	Natural gas	10280	7,20	74,03	90,84
	Coal	2232	2,46	5,50	
	Petcoke	5999	1,89	11,32	
IGCC	NG auxiliar consumption	389	7,20	2,80	22,26
	Coal	2582	2,46	6,36	
	Petcoke	6941	1,89	13,10	

Note: Data for the year 2007

Source: Elcogas, 2008. Costs are real total average 2007.

PRENFLO

with Direct Quench

PDQ

The PRENFLO process with Direct Quench (PDQ)

Targets

- Integrate **Lessons Learned** from 10 years operation of Puertollano IGCC
- Optimize PRENFLO technology for **chemical** and **hydrogen** applications
- Identify areas of **significant Capital Cost Reduction**
- **Water Quench** instead of Gas Quench and Waste Heat Boiler
- Keep **commercially proven elements** of PRENFLO technology
- Design of a **robust system**

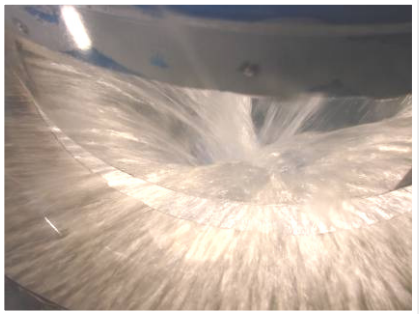
The PRENFLO process with Direct Quench (PDQ)

Process characteristics

- Pressurized entrained-flow gasification
- Dry coal dust feeding
- Multiple co-annular burners (horizontal, tangential arrangement)
- Membrane Wall, no refractory
- Operation pressure flexible to requirements
  - approx. 25 - 40 bar
- Raw gas temperature outlet of quench
  - approx. 200 - 250 °C
- Slag lock-hopper system

PRENFLO Gasification

Direct Quench Pilot Tests Germany



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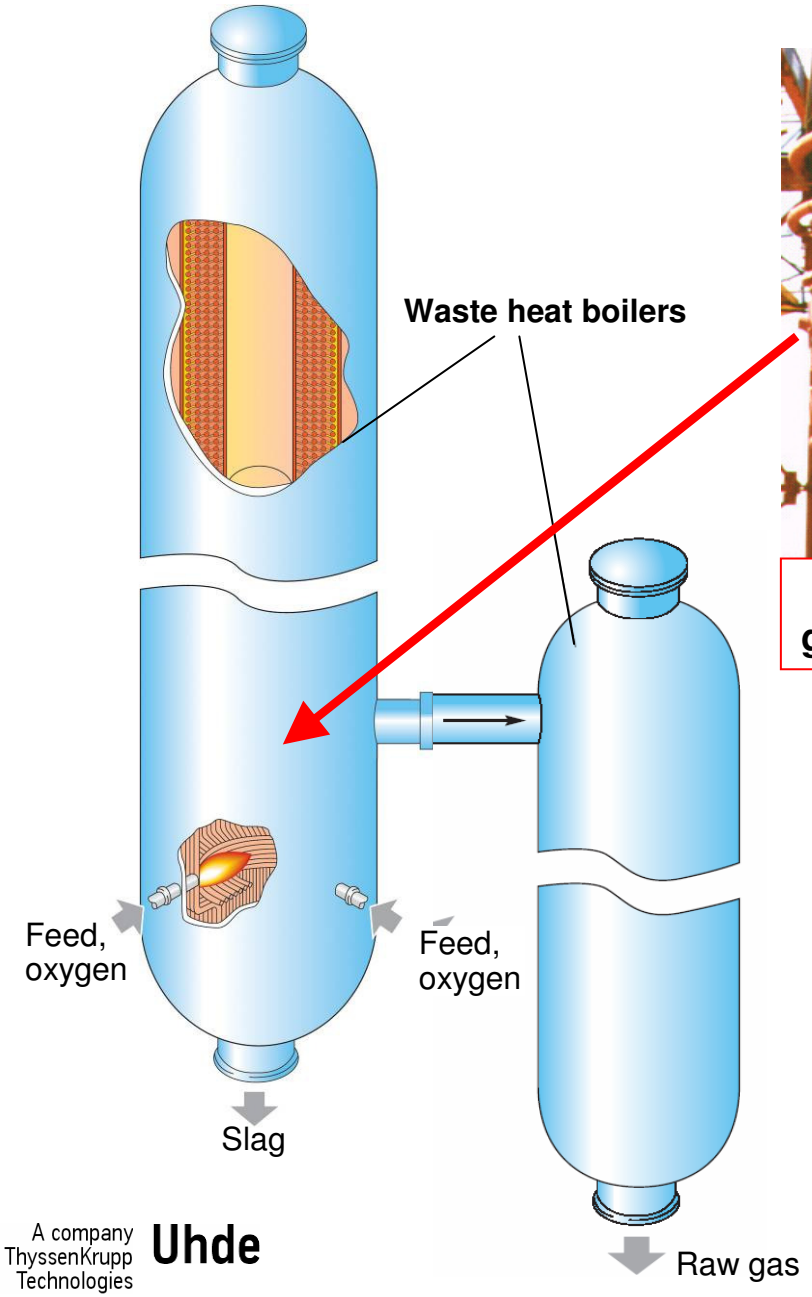
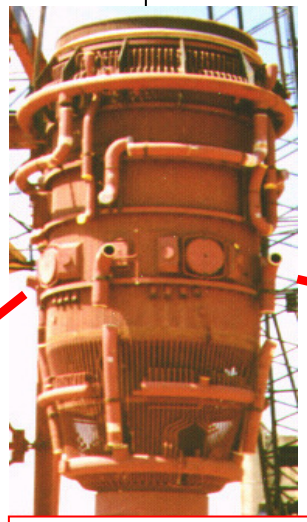
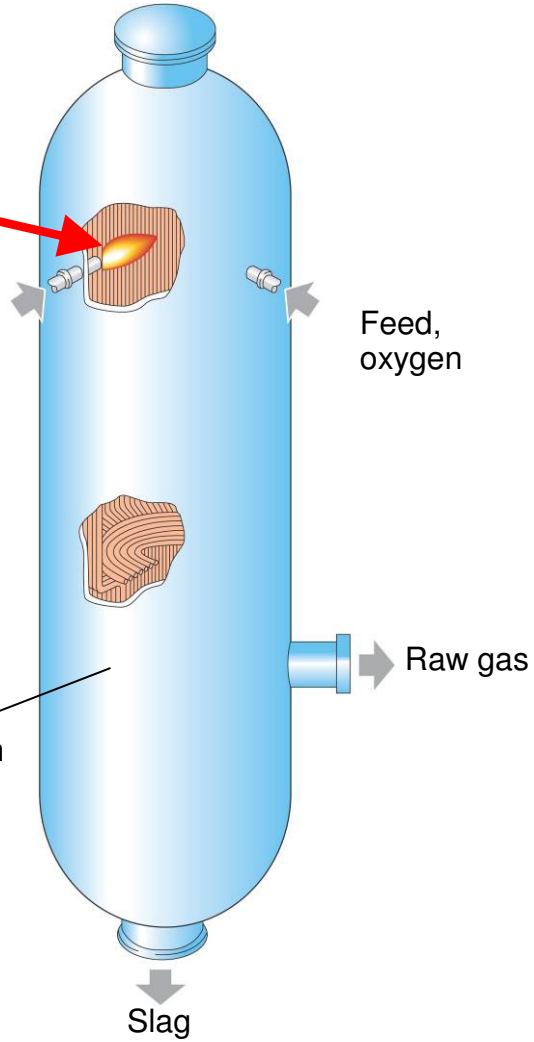
PRENFLO gasifier with Steam Generation (PSG)





Same gasifier design

PRENFLO gasifier with Direct Quench (PDQ)



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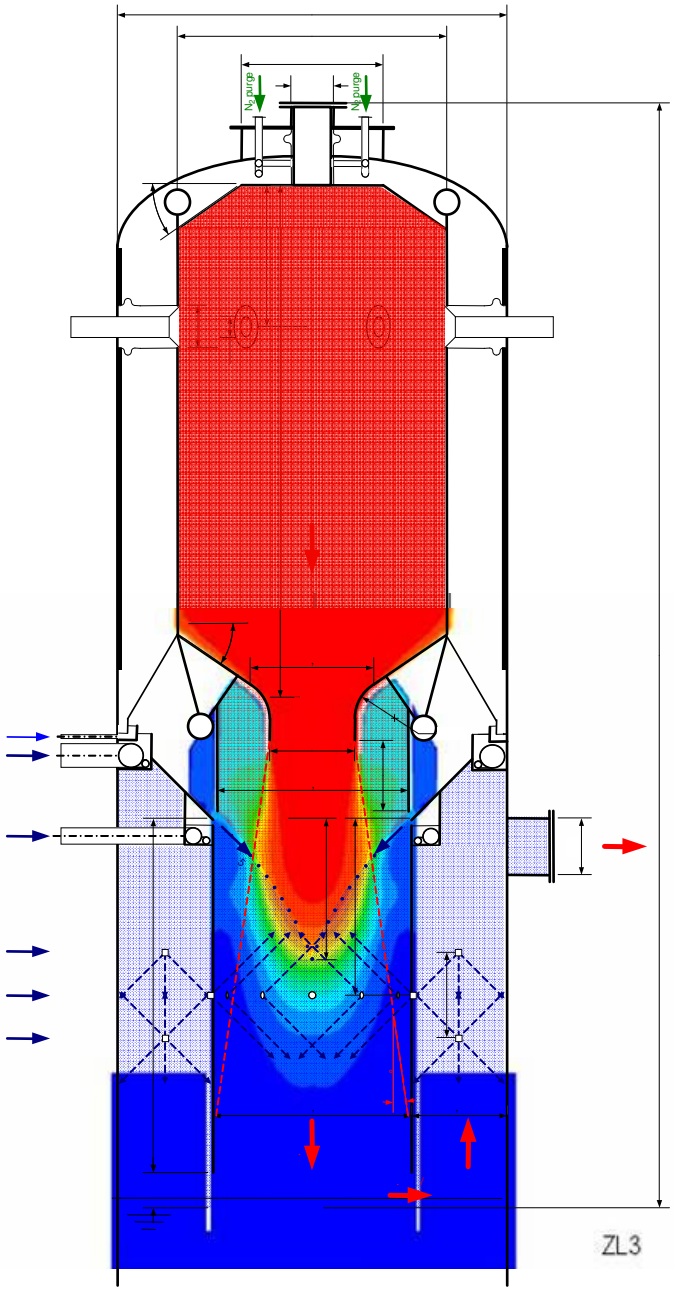
PDQ – Design Aspects



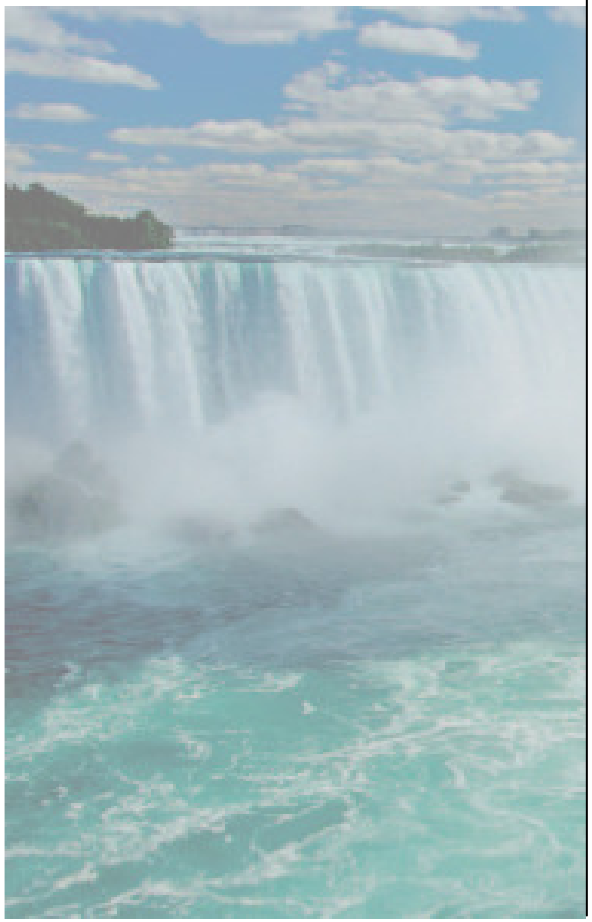
- ✓ **Slag Drip Edge** is Required (Proven Design)
- ✓ Install Slag Drip Edge at **Dry/Hot Location** ("No Water Contact!")
- ✓ All Downstream Surfaces **Permanently Wetted** (Protective Water Film)
- ✓ Defined Minimum Residence Time to Ensure **Proper Cooling**

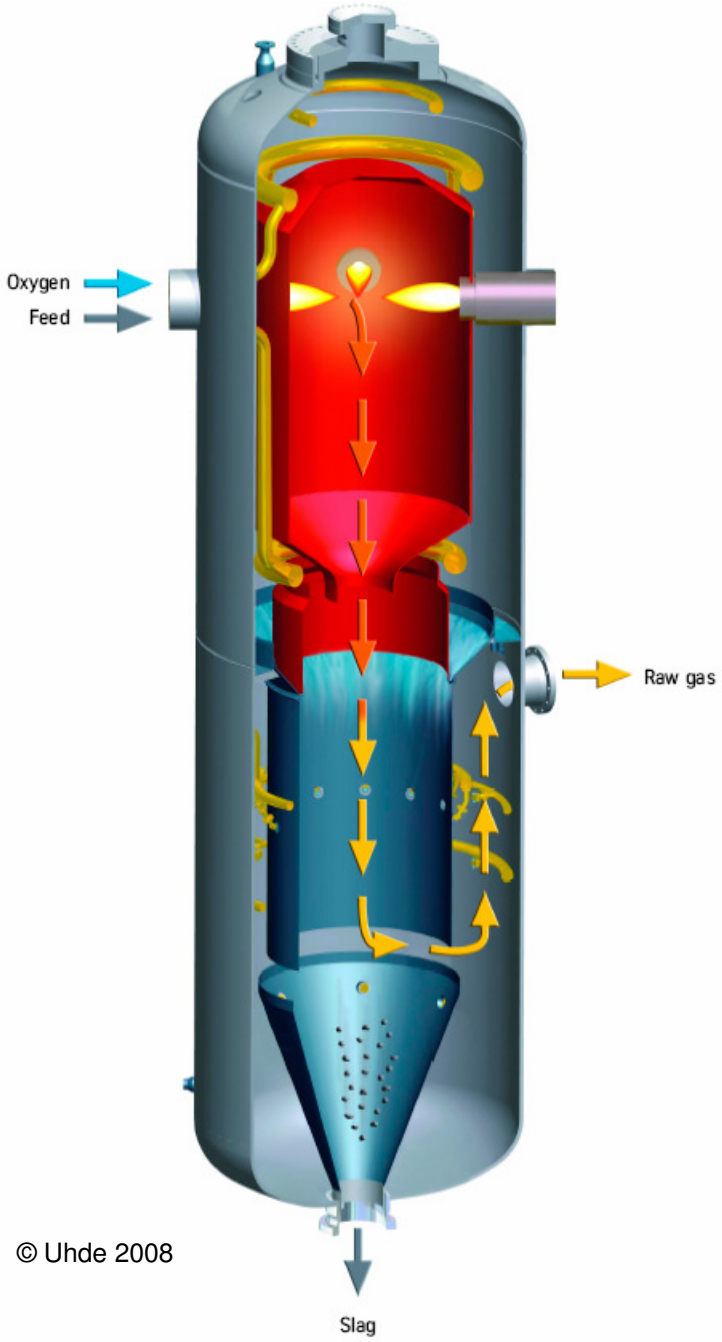
Quench water:
➡ **perfect distribution**

Temperature zones:
➡ **optimal dry/hot vs. wet separation**

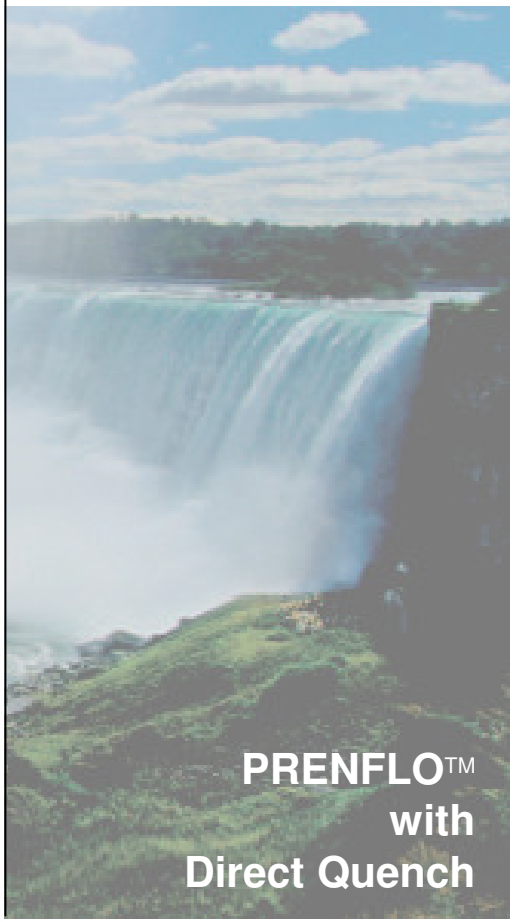
PRENFLO
with Direct Quench

1000 MW_{th}, 40 bar





PDQ



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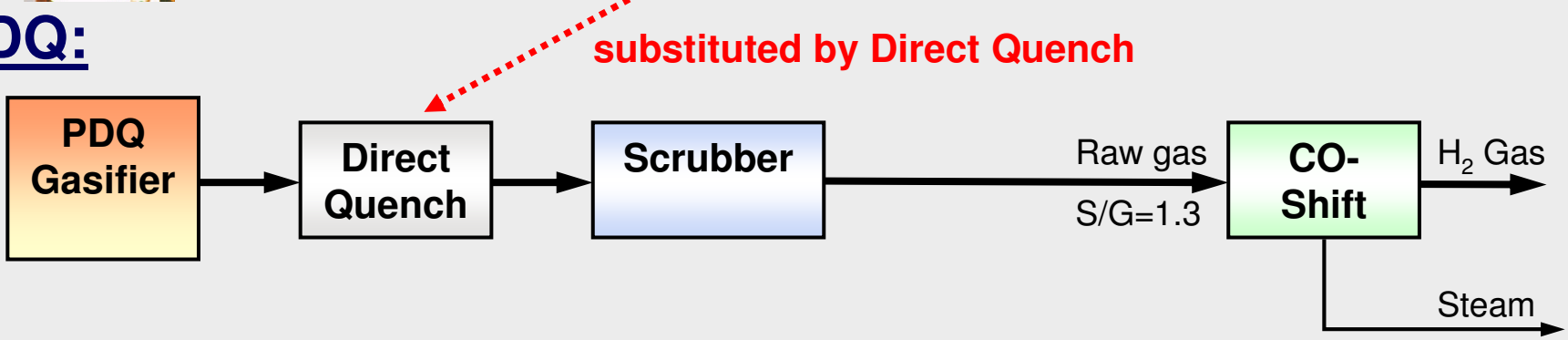
PRENFLO PSG vs. PRENFLO PDQ

Impact on Cost: Process Configuration (e.g. H_2 plant)

PSG:

PDQ:



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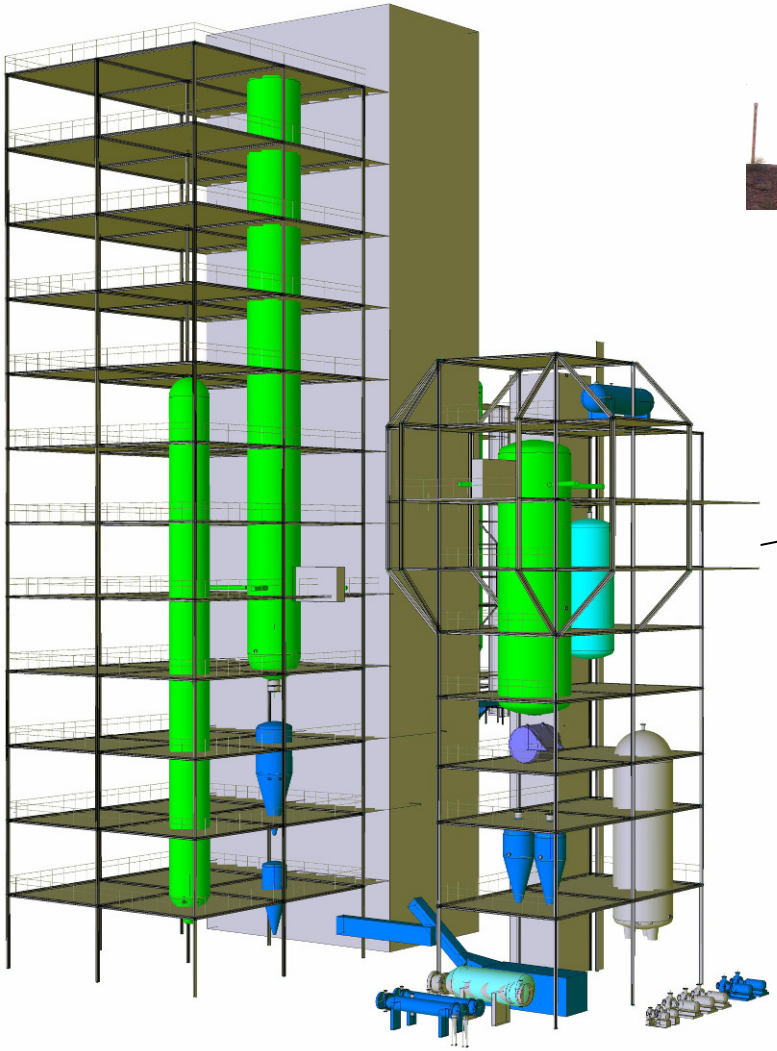
PRENFLO PSG vs. PRENFLO PDQ

Impact on Cost: Plant Layout

PRENFLO (PSG)



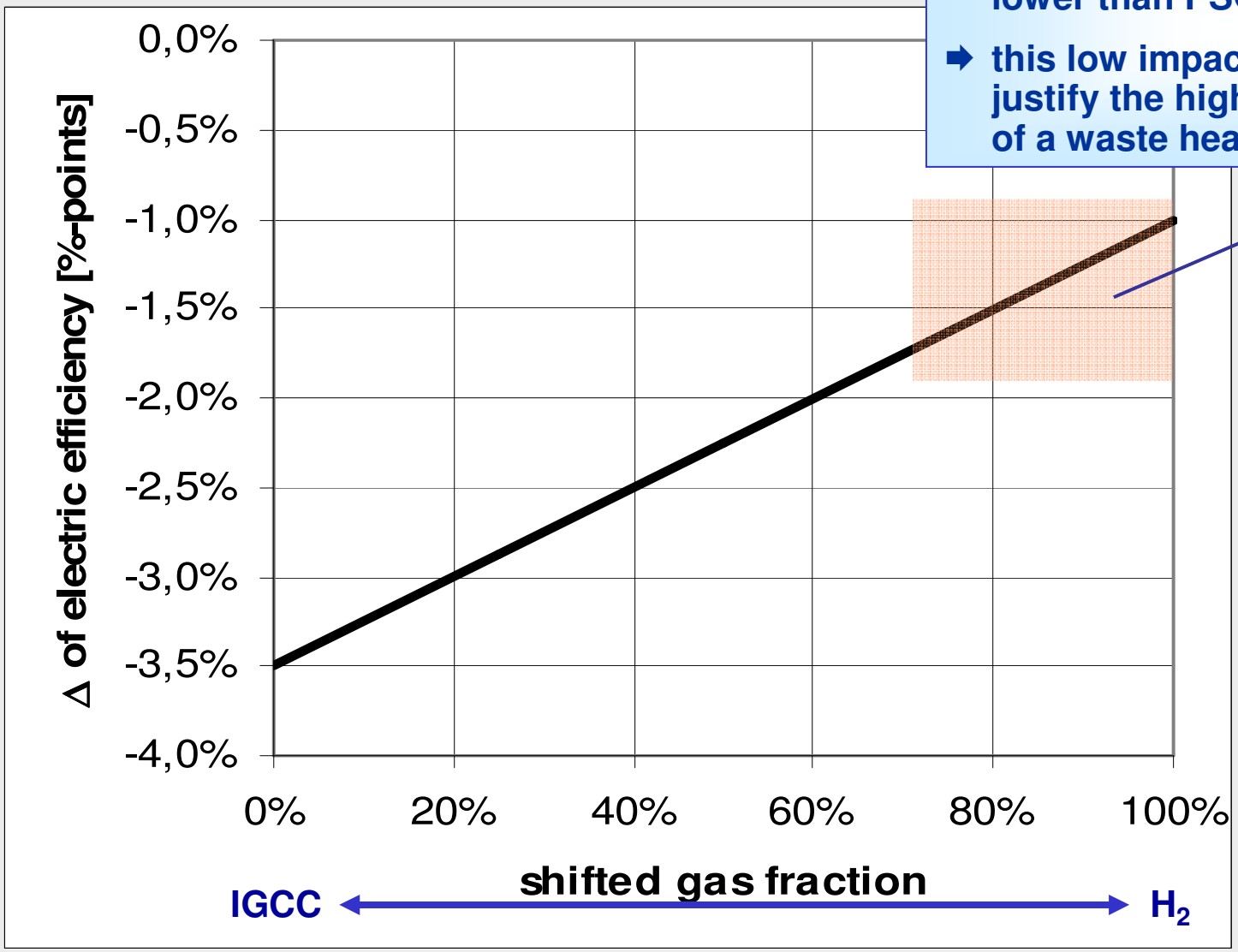
PRENFLO (PDQ)

EPC cost savings: ~30 %

PRENFLO PSG vs. PRENFLO PDQ

Impact on Efficiency

- In the targeted applications, PDQ is -1.0 to -1.8 %-points lower than PSG
- this low impact does not justify the higher capital cost of a waste heat boiler design



- CTC
- CTL
- IGCC-CCS

Summary

- **Lessons Learned** from 10 years operation of the Puertollano plant and **decades of experience in coal gasification** and all related down-stream processes are fully integrated in PRENFLO.
- As a technology-driven engineering company, Uhde can act as **integrated Licensor, E, EP or EPCM contractor –** PRENFLO is a **commercial product**
- PRENFLO is available with conventional steam generation **(PSG)** or direct quench mode **(PDQ) with significant cost savings**
- **PDQ Gasification** was launched in **February 2008.** By **October 2008,** PDQ has been selected around the world for approx. **15,000 MW_{th} new plant capacity**

Thank you for your attention.

PRENFLO IGCC, Puertollano, Spain
Summer 2008

www.prenflo.com

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