Innovative Integration & High Availability at Air Products' Baytown, TX Polygeneration Syngas Plant

Chuck Higdon, Energy Engineering
Alan Anderson, Global Operations
Tom Jakubowski, Baytown Operations

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Presentation Outline

- **Original Syngas Plant: flexible product slate**
- **Plant Modification: addition of H_2 and steam co-products**
- **<u>Key Technology Innovations:</u>**
  - **ASU: Oxygen backup systems**
  - **TSA drier: Cold box freeze protection**
  - **Sweet shift reactor / sulfur removal**
  - **Low-Btu burner design**
- **High Unit Availabilities**
- **Lean Staffing**

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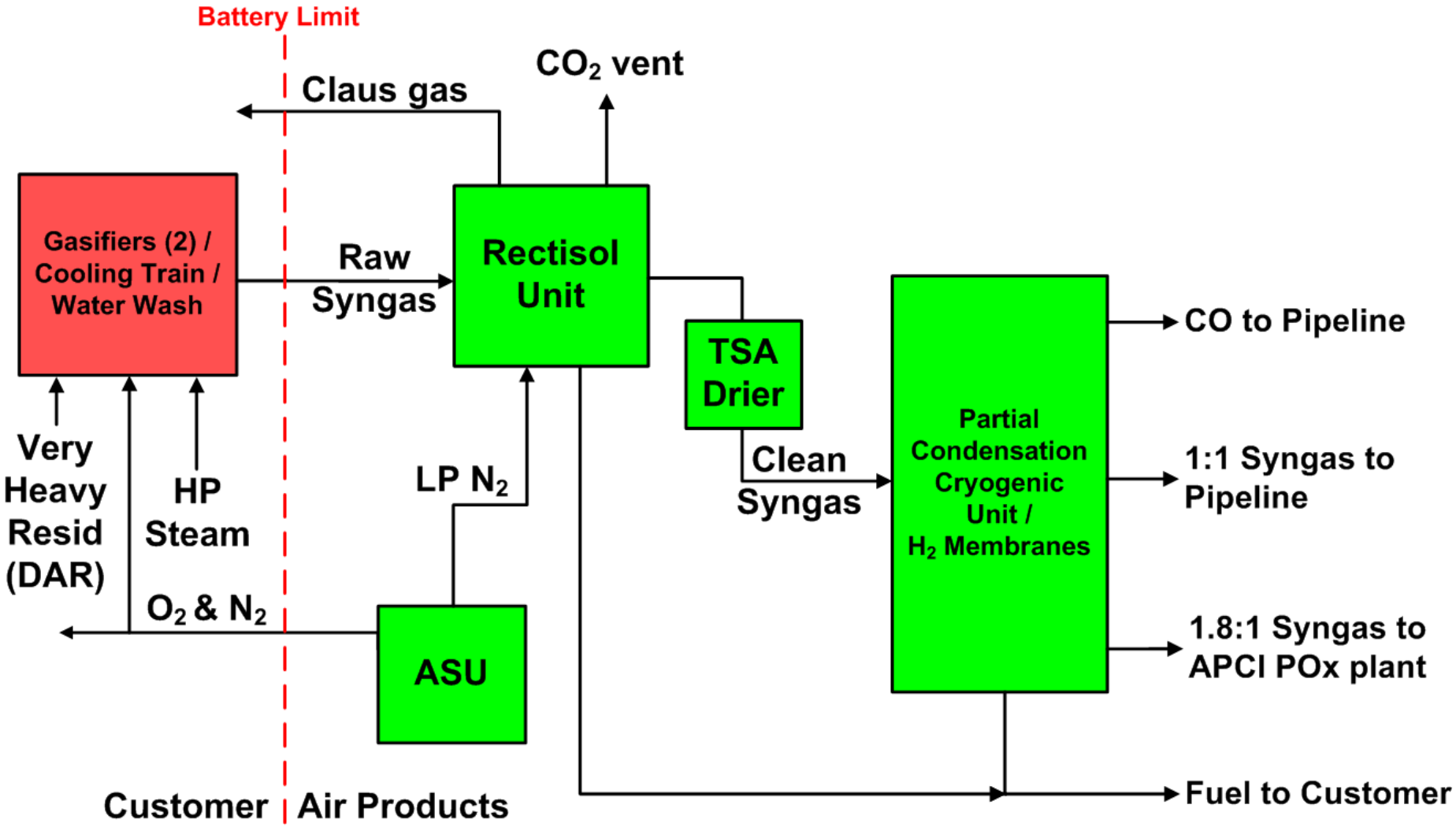
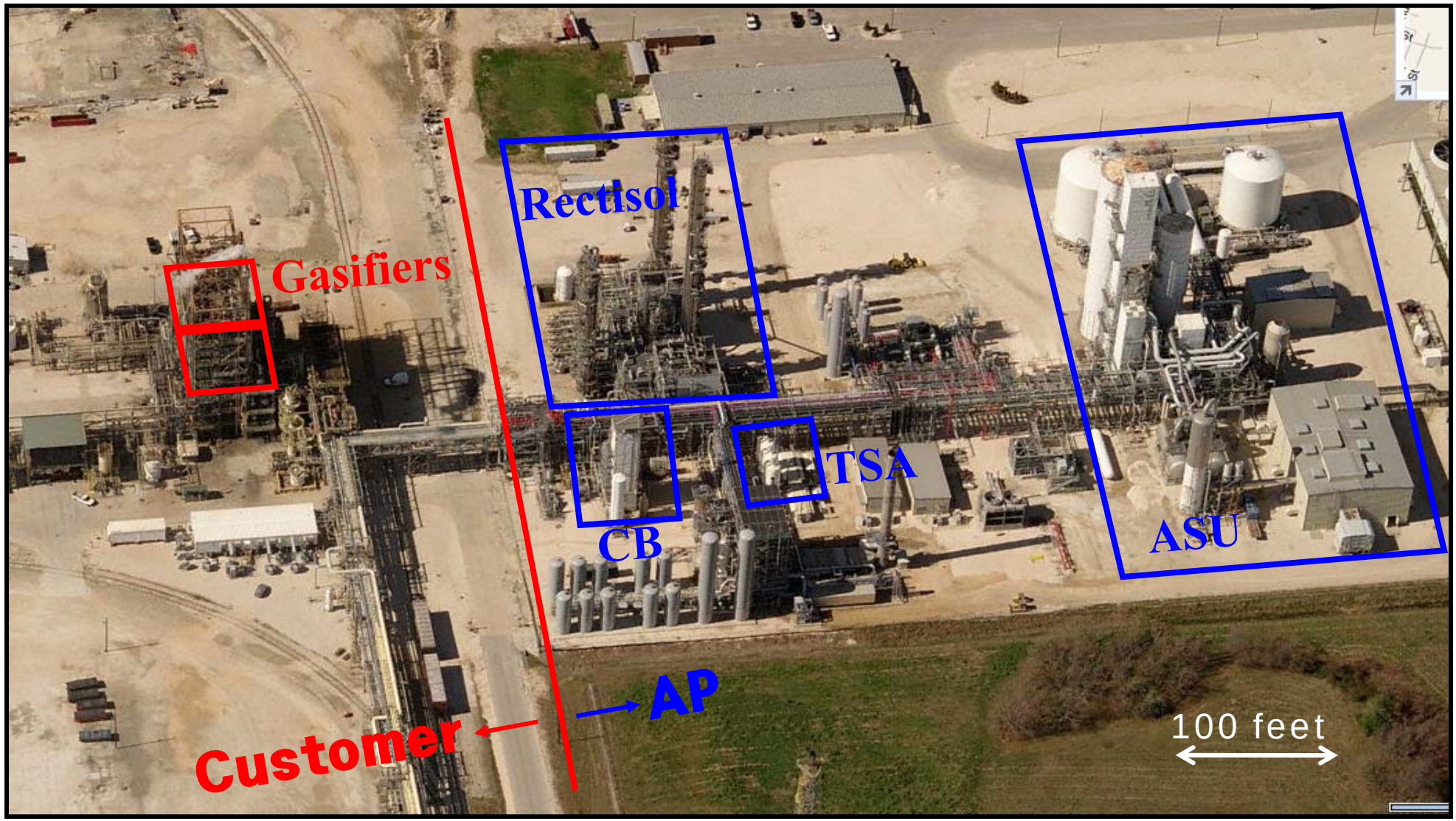
Original Syngas Plant Design – Flexible Product Slate



Baytown Site - original equipment



Satellite photo from Windows Live Search Maps

Original Design: Feed and Products
Start-up: June 2000

FEED TO SYNGAS PLANT	
Raw syngas to Rectisol	112 MMSCFD (125,000 Nm^3/hr)
Clean syngas exiting TSA	98 MMSCFD (109,000 Nm^3/hr)
H_2:CO ratio	0.98 – 1.10

FLEXIBLE PRODUCTION CAPACITY	
1:1 H_2:CO Syngas	Varies depending on customer demand
1.8:1 H_2:CO Syngas	
CO	

All SCF defined at 60°F and 1 atm absolute pressure

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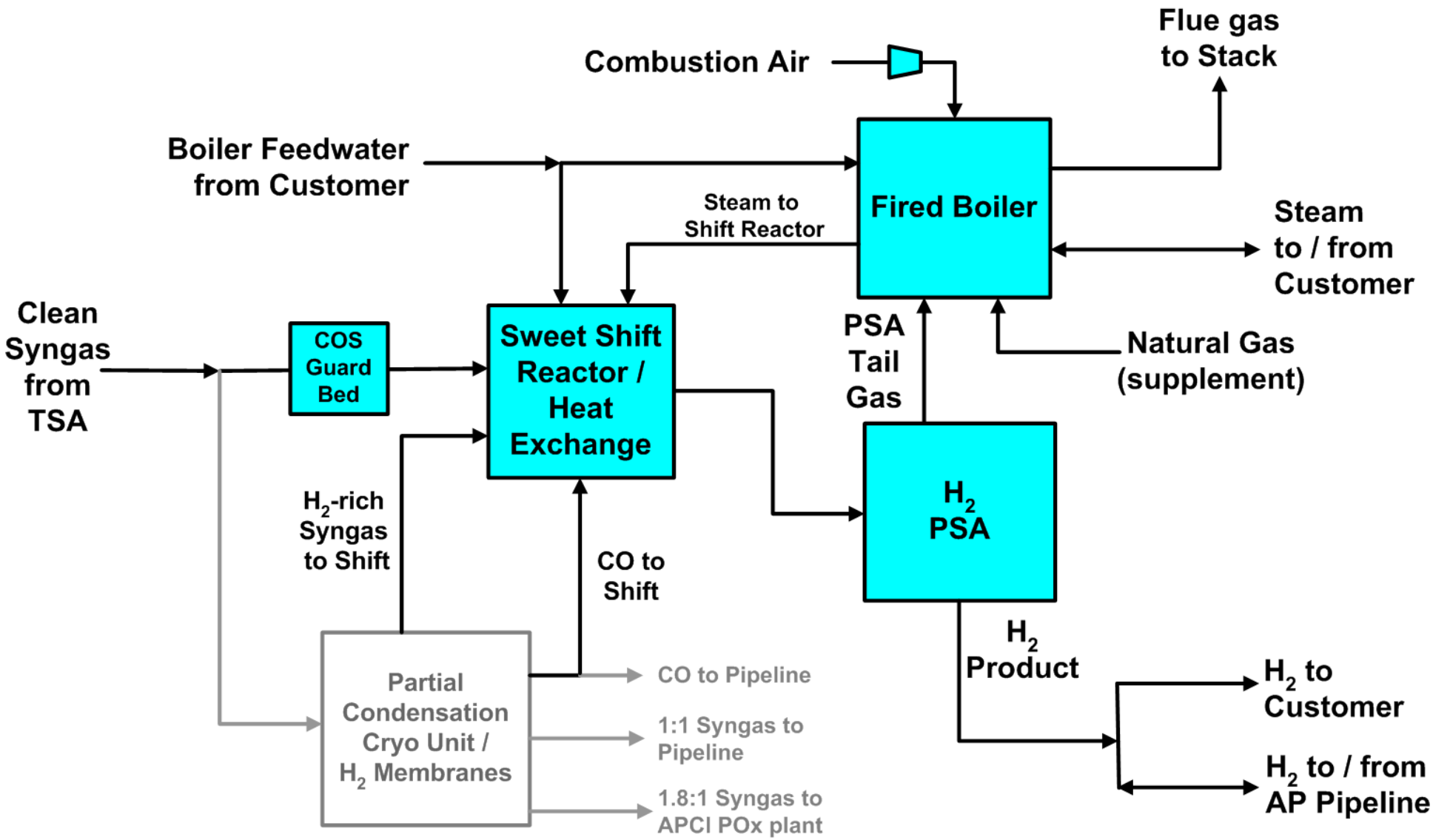
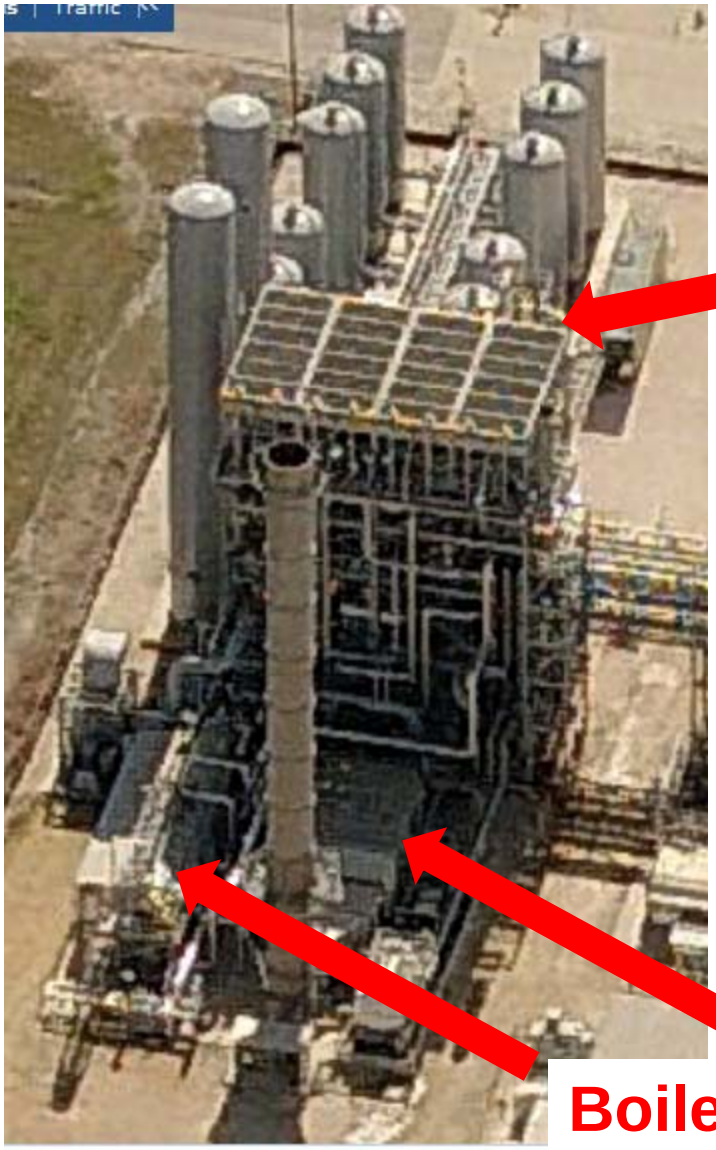
Addition of H_2 and Steam Products

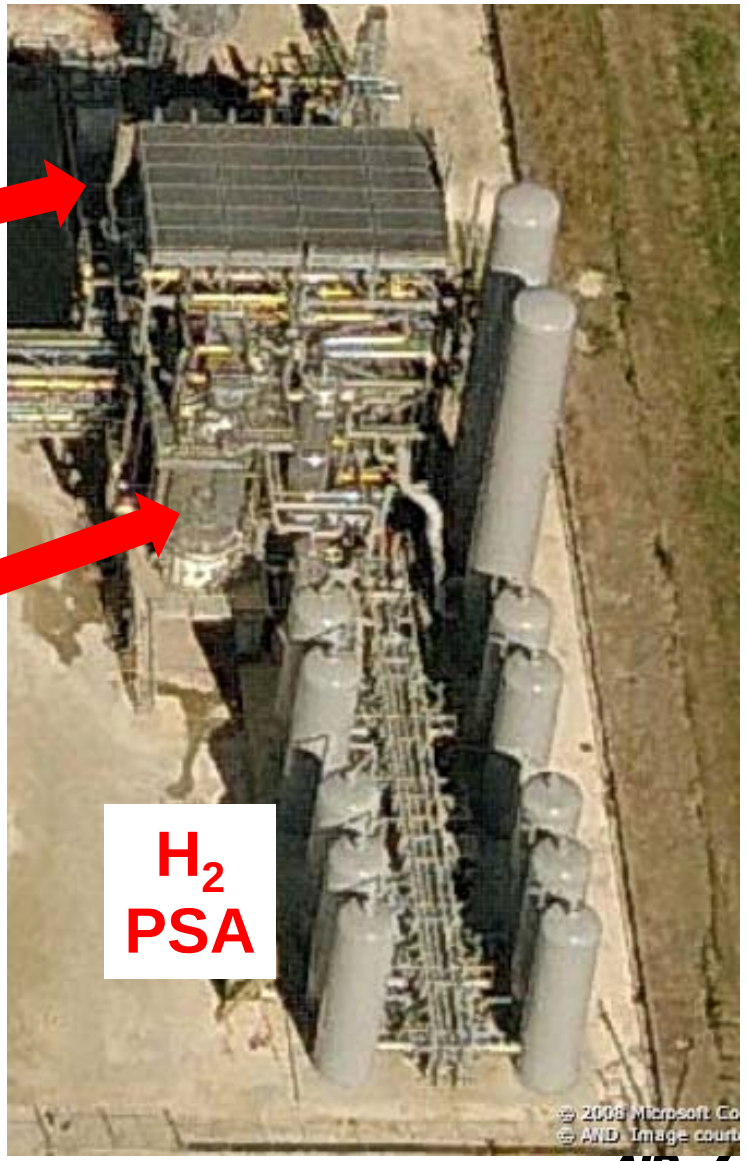


Added Equipment for H_2 and Steam Production



HX Structure

Shift Reactor



SCR

Boiler

H_2 + Steam Addition: Feed and Products Start-up: December 2005

FEED TO SYNGAS PLANT	
Raw syngas to Rectisol	127 MMSCFD (142,000 Nm^3/hr)
Clean syngas exiting TSA	112 MMSCFD (125,000 Nm^3/hr)
H_2:CO ratio	0.98 – 1.10

FLEXIBLE PRODUCTION CAPACITY	
1:1 H_2:CO Syngas	Varies depending on customer demand
1.8:1 H_2:CO Syngas	
CO	
Hydrogen	
Steam export	

All SCF defined at 60°F and 1 atm absolute pressure

Innovation: O_2 Back-up System

- **1200 psig liquid O_2 backup system selected**
  - **Pumps continuously cooled**
  - **Fully operational in 30 seconds**

- **Unique site benefit is 6-mile cross-tie pipeline under Houston Ship Channel to AP ASUs in LaPorte, TX**
  - **System serves multiple gasifier customers**
  - **Functions as large “volume bottle” to provide safety margin on sudden loss of Baytown ASU**
  - **Dynamic simulation validated design**

- **Pipeline allows 2-way flow of HP O_2 between both sites**
  - **Enhances reliability of oxygen system**
  - **Optimizes O_2 sourcing**

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Innovation: TSA Drier Design

- **Issue: trace methanol, CO_2 and H_2S/COS can freeze out in HyCO cryogenic unit ("cold box")**

- **Baytown solution:**
  - **Proprietary adsorbent (patented by Air Products)**
  - **Novel design mitigates wall effects during regeneration**

- **Results**
  - **3-year operation of HyCO cold box without pressure rise or defrost demonstrated**
  - **4-year turnaround interval is current target**
  - **No process or mechanical issues with TSA driers in 8 years**

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Innovation: Isothermal Shift Reactor for H_2 Production via $CO + H_2O \rightarrow H_2 + CO_2$

- **Sweet isothermal shift selected for retrofit application**
  - **Best solution for flexible product slate and high concentration of CO in reactor feed**
  - **Allows > 95% CO conversion in a single reactor**
  - **First-time use of Lurgi methanol reactor technology for isothermal shift service**

- **Johnson Matthey KATALCO$_{JM}$™ 83-5 catalyst**
  - **4 year life projected**

- **Novel use of COS adsorbent in guard bed to protect catalyst**
  - **Adsorbent never previously used in syngas service**
  - **Total sulfur in feed to reactor must be < 20 ppbv**

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Isothermal Shift Reactor

(before insulation)

Key challenge for H_2 addition: Low-Btu Tail Gas from PSA

- **Tail gas is difficult to burn in conventional boiler**
  - **Tailgas is > 70% CO_2 and < 5 psig**
  - **Lower heating value is ~80 Btu/SCF**
  - **Preliminary assessment showed very high cost for supplemental fuel**
- **CO content, though low, still eliminates venting option**
  - **Incineration too costly due to natural gas consumption**

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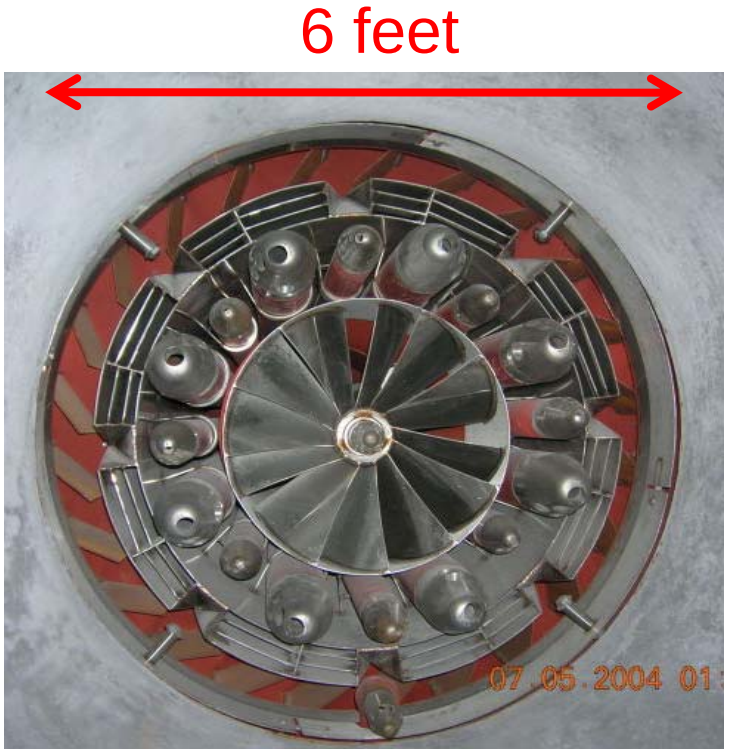
Innovative solution: Collaboration with Coen



- **Coen burner technology proven in less-demanding applications**
- **New, more complex burner design minimizes supplemental natural gas fuel**
  - **Allows use of conventional D-type boiler**
- **Results**
  - **Stable combustion with minimal supplemental natural gas (mixed fuel LHV < 125 Btu/SCF)**
  - **NO_x in flue gas < 3.5 ppmv when firing PSA tail gas**
  - **Seamless transition to firing only NG on PSA trip**

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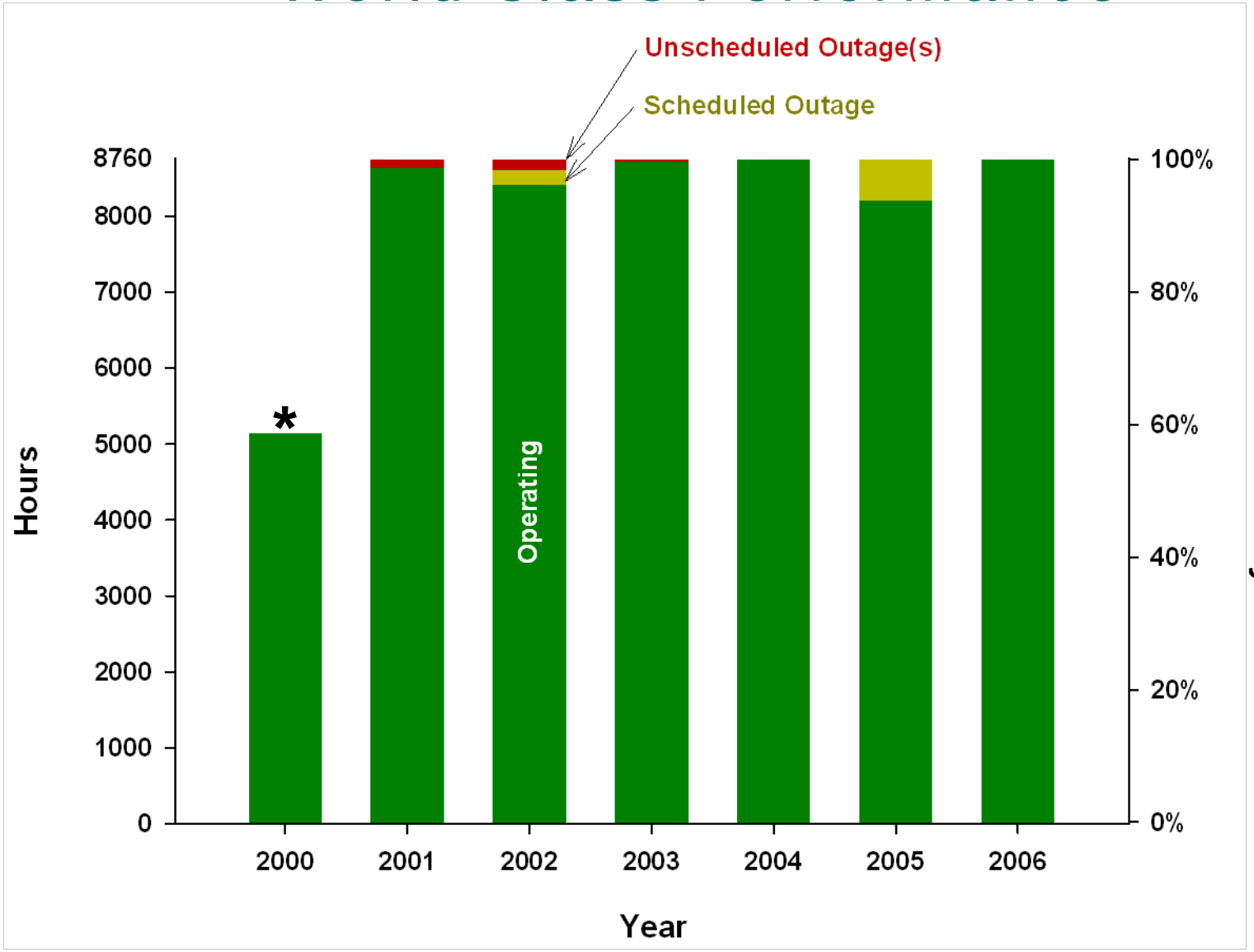
Rectisol Availability in Baytown Facility: World Class Performance



* Start-up in June 2000; no outages in 2000.

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Rectisol Availability at Baytown Facility

- **Air Products' detailed design team enhanced availability of robust Lurgi design**

- **Rectisol unit runs smoothly even on loss of syngas**
  - **Pressure and low temperature are maintained**
  - **Pumps continue to circulate methanol solvent**

- **Planned outages**
  - **10 days in 2002, 23 days in 2005 (extended due to hurricane)**

- **Only 4 unplanned outages since 2000 start-up**
  - **2001: 4-hour outage due to electrical problem**
  - **2001: 126-hour outage due to exchanger plugging**
  - **2002: 157-hour outage due to pipeline incident**
  - **2003: 4-hour outage due to electrical problem**

Design for Lean Staffing

- **At night, entire facility is run by only 2 operators**
  - **Including ASU, Rectisol unit, shift system, CO cold box, H_2 PSAs and multiple compressors**
- **Design strategies for lean staffing include:**
  - **Auto-start back-up pumps on most services**
  - **Highly redundant instrumentation and control architecture**
  - **Advanced control systems for ASU and syngas plants including model-predictive control (MPC)**
  - **Extensive cross-training of operators**
- **Design for lean staffing contributes to high availability**

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The Baytown Air Separation / Syngas Facility demonstrates:

- **Integration of innovative technologies**
- **Flexible polygeneration of syngas, CO, H_2 and steam**
- **High availability**
- **Lean staffing**

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Thank you