ConocoPhillips

PROJECT DESIGNS FOR IGCC & SNG WITH CO2 SEQUESTRATION

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Introduction

- ConocoPhillips is developing projects that convert coal / petcoke to power and/or SNG, with and without CO2 sequestration
- Process schemes and technology selection are impacted by many factors, including:
  - Feedstock
  - Product and by-product specifications
  - Environmental permit limits
  - Site conditions
  - Technology experience, flexibility, reliability
- No common "best" answer for all projects
- Highlight key considerations from recent IGCC and SNG project configurations

Design Premise

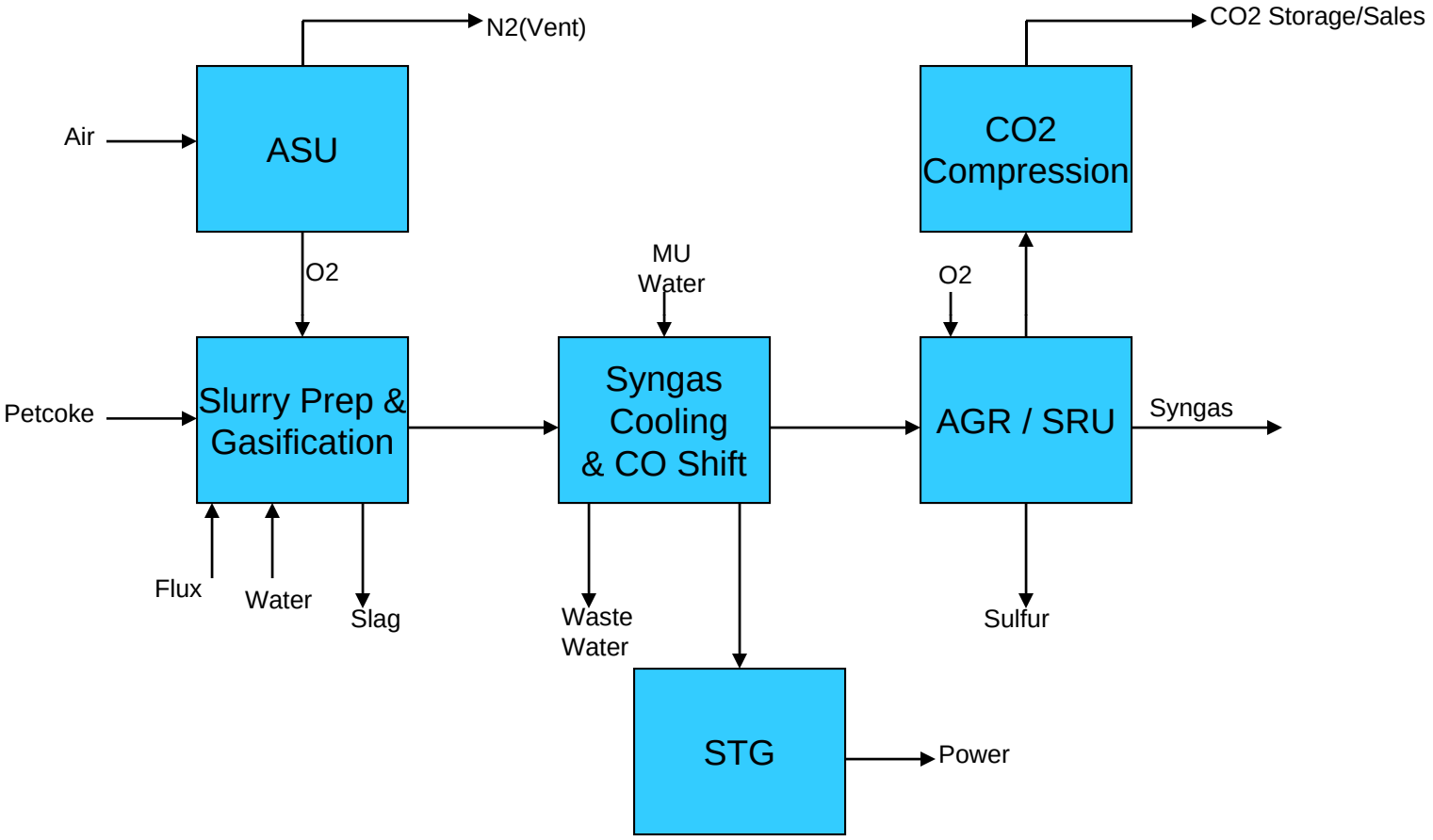
- Common Processes

Site location	U.S. Gulf Coast
Feedstock	Delayed Petroleum Coke
Air Separation	"Pumped" cycle, 2X50% trains w/O2 storage
Gasification	E-Gas™, 2X50% trains w/spare
CO Shift	2 Stages w/bypass (Level of shift varies with application)
Acid Gas Removal	Physical solvent, single train optimized
Sulfur Removal	2 train, Oxy-Claus, 3 stage (1 thermal, 2 catalytic)
CO2 Compression	Supercritical compression (2200 psig) – Flow varies
Process Cooling	Wet Cooling Tower

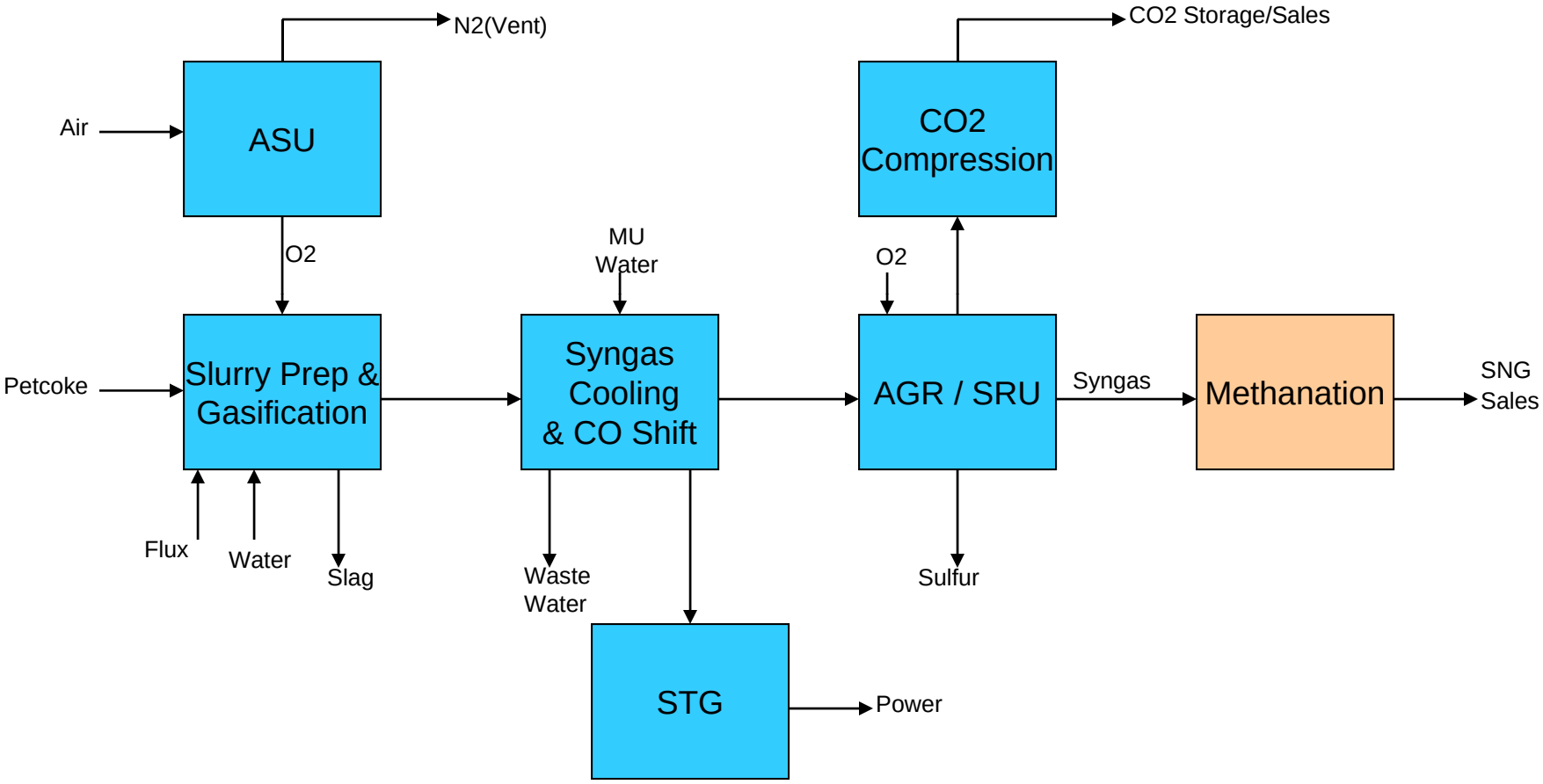
- Additional Processes

For SNG Product	1 Train, 4 Stage TREMP™ Methanation
For IGCC	2 on 1 F-Class GTG CC, w/ASU integration

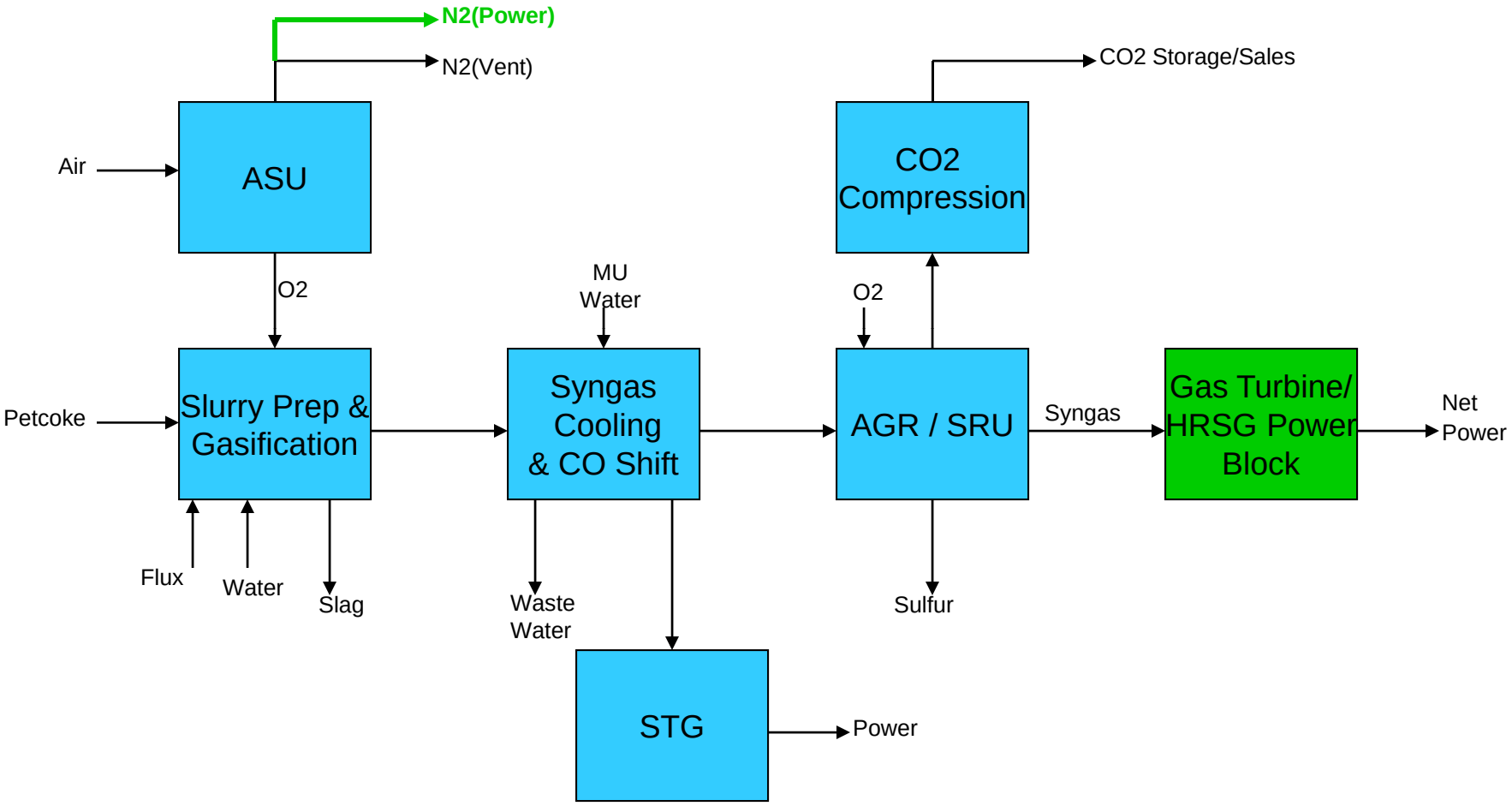
Common Processes



SNG Configuration



IGCC Configuration



Design Considerations - Product Specifications

SNG Product Specifications – Typical Ranges

Spec	Value Range	Units
HHV	1098 - 970	Btu/scf
Tot S	5 – 1.2	gr/100 scf
H_2S	0.25 - 0.2	gr/100 scf
CO_2	2 - 0.5	vol%
N_2	3 - 1	vol%
H_2O	5 – 0.7	gr/100scf
H_2	1 - 0	vol%
O_2	1 – 0.01	vol%

Notes
Additional limits on > C1 paraffin, olefin content, non-hydrocarbons, combined inerts may exist

Specifications are met with process optimization and syngas cleanup

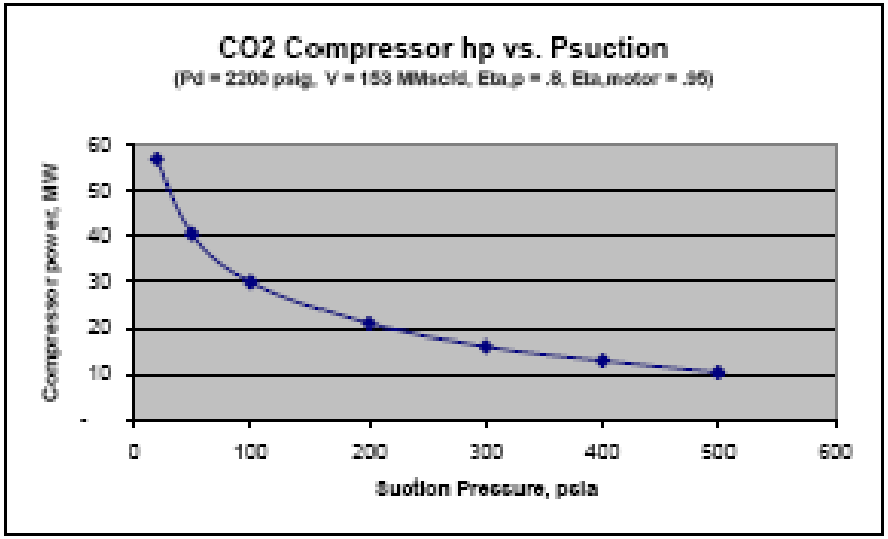
Design Considerations - By-product Specifications

CO_2 By-product requirements – Typical Ranges

- Example Pipeline specifications

Spec	Value Range	Units
CO2	95 - 97	vol%
H2	1 - 4	vol%
CH4	1 - 4	vol%
N2	0.5 - 4	vol%
H_2O	250 - 500	ppmw
CO	1000 – 5000	ppmw
O2	2 – 100	ppmw
H2S	10 – 1500	ppmw
Total S	10 – 1450	ppmw

- Determine CO2 destination
- AGR selection impact:
  - Water content impacts equipment or materials of construction
  - Suction pressure impacts compressor power
- CO2 specification – varies by location and end-use



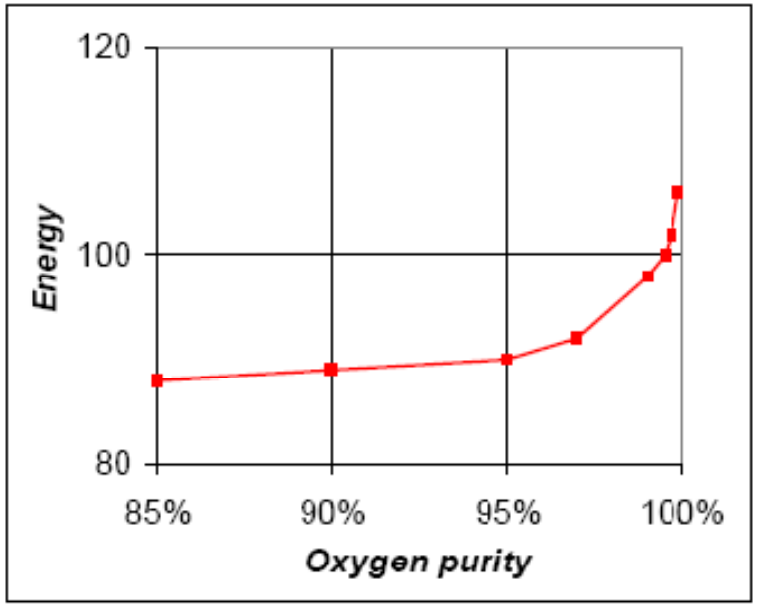
Air Separation Unit (ASU) Considerations

General

- Oxygen storage reduces facility-wide trips

SNG

- Oxygen purity selection impacts capital and operating cost
  - SNG at 99.8% purity to accommodate SNG pipeline spec



Ref. IGCC experience and related Technology Improvements for ASU, Giovanni Massimo, Air Liquide Engineering

IGCC

- O2 Purity is typically 95% purity (knee of curve)
- N2 compression required
- Increased HP column pressure
- Air integration with combustion turbine generator

E-Gas™ Technology Battery Limits (TBL)

General

- Full slurry quench
- Sub-bituminous, bituminous and petcoke flexible

	IGCC	SNG
• Gasifier Operating P, psig	665[1]	720
• SG Cooler steam P, psig	2000[2]	1000[3]
• SG CO/H_2 ratio (molar)	~1.7	~2.1
• SG CH_4 content	Low	High

Notes

1) $P_{op} = P_{GTG\ inlet} + \Delta P$
2) Set by bottoming cycle hp steam (IGCC)
3) Set by practical STG throttle level, 900 psig/900 F, allowing for some bypass of steam to the Shift Unit (SNG)

E-Gas 2nd stage provides flexible syngas composition allowing high carbon capture for IGCC or increased methane for SNG

CO Shift Area

	IGCC	SNG	
No of stages	2	2	[1]
Overall CO conversion, %	~90	~60	[2]
Feed bypass, %	0	~30	
Steam/dry gas ratio(1st stg outlet)	~0.4	~0.4	[3]

Notes

[1] second stage is utilized in SNG case with higher bypass to optimize AGR for CO2 capture (capital cost vs. operating cost tradeoff)

[2] for IGCC this value could be reduced depending on the level of CO_2 capture required; for SNG, the level is determined by the CO/H_2 ratio required for methanation

[3] Values can vary greatly, depending on the CO Shift catalyst employed

E-Gas Technology takes advantage of low steam/dry gas ratio for significant power savings

Acid Gas Removal (AGR) Considerations

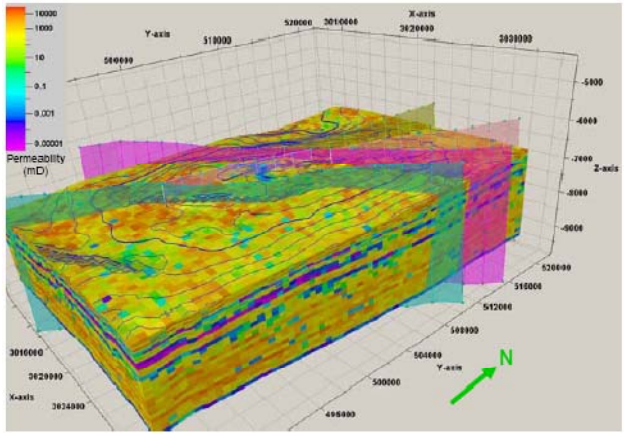
General
- Environmental impact of solvent losses
- Trainage based on AGR selection
- Solvent cost
- CO2 specifications and venting considerations

IGCC
- Generally higher CO2 recovery
- More flexible CO2 spec in the syngas [reduced AGR cost]
- All gas shifted [separate COS hydrolysis not required]
- Generally Selexol™ is preferred for IGCC case

SNG
- Nitrogen content critical for HHV and pipeline spec
- Tight sulfur spec for methanation unit (Sulfur guard bed cost)
- CO shift by-pass requires COS mitigation
- Generally Rectisol® preferred for SNG case

CO2 Sequestration Considerations

- EOR requires CO_2 > min. miscible pressure (MMP), impacted by impurities
  - H_2, N_2, O_2, Ar, CO, and CH_4 increase MMP
  - H_2S, SO_2, and > C1 paraffin decrease MMP
  - High sulfur CO_2 may not be appropriate for sweet EOR Ops
- Storage must consider long term geochemical interaction
  - Analyze reactions & kinetics for damaging (or beneficial) rock-water interaction
  - Evaluate near wellbore reactions (possible downhole plugging)
  - Consider impact of S and O2 species promoting bacterial impacts
- Regulatory factors
  - Rules & liability
  - Economic incentive or subsidy



Summary

- Technologies associated with gasification and CCS are ready for commercial deployment
- ConocoPhillips is developing projects that convert coal / petcoke to power and/or SNG
- Experience drawn from these projects reinforces that:
  - Optimization among process areas is key to meeting product specifications and by-product requirements
  - Flexibility of the E-Gas™ Technology facilitates optimization
  - Process AND operations knowhow from each technology area are important to successful design optimization
  - Design and operations knowhow in drilling, transportation and injection of gases is critical to developing effective CO2 sequestration schemes
- Future E-Gas™ applications will benefit from these project development activities

Sweeny IGCC/CCS Project Update

- 2+1 E-Gas™ Technology gasifiers with 3CGT x 1ST
- 6,900 st/sd petcoke to 693 MW(net)
- 85% CO_2 capture – store 5 million Te/yr
- Filing air permit with TCEQ 1Q 2010