



Advanced Syngas Technologies

*A partnership between Afina Energy Inc. and
Weatherford International*

VALUE ENHANCEMENT THROUGH INNOVATION

Canadian Heavy Oil Association
December 4th, 2008



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- Process Overview
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 - Value creation
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Advanced Syngas Technologies

- 50/50 partnership between Afina Energy and Weatherford International
 - Jointly, apply Afina's "Enerkem" low severity gasification and gas conditioning technology to the heavy oil industry to deliver:
 - Cost reductions which increase producers' netback per barrel
 - Environmental improvements
 - reduce CO₂ emissions
 - improve energy efficiency of SAGD operations



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Weatherford International Ltd.

- Weatherford International Ltd. (NYSE: WFT) - one of the world's largest diversified upstream oilfield service companies.
 - \$8 billion in annual revenues,
 - 40,000 employees in over 100 countries, and
 - 87 manufacturing facilities supporting 730 service bases.
- Growth achieved with internal growth and acquisition of over 200 companies/technologies.
- Weatherford strives for efficiency and delivering results by leveraging off of its worldwide infrastructure.
- Noted as a sector leader in research and development



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Afina Energy

- Created to penetrate oil and gas market with Enerkem™ gasification technology
- Holds patents and exclusive license rights to proprietary gasification, gas conditioning and related integration schemes
- Expertise in business development and commercial structuring
- Strong financial backing
- Leading development and research team
 - **Esteban Chornet**, Ph.D., P.Eng., Chief Technology Officer
 - **Mark Weber**, Ph.D., P.Eng., Vice President, Engineering & Technology
 - Access to operating Pilot Plant and bench test facilities through Enerkem
- Strong engineering teams
 - Internal Team: technology development & application
 - External Team: Strong in SAGD, process and gasification applications



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Short History of Gasification

Two “gasification approaches” have developed through the years:

1. High severity gasification

- Requires high T >1200 °C and high P>20 bar
- O₂ is preferred to air since either synthesis gas, H₂ or medium calorific value gas (to use in gas turbines) are the objectives
- H₂O (as steam) is a key reactant
- Issues: difficult operations, high downtime, exotic materials

2. Low severity gasification (AFINA)

- Requires lower T <1000 °C and lower P<10 bar
- Air is used more often than O₂ since there is no need for high partial pressures of O₂ when fuel gas is the end product
- H₂O (steam) is a key reactant for char
- Issues: larger footprint, carbon conversion limited to 85%





How is “Afina/Enerkem Gasification” different?

- Temperature < 1000 °C = common materials = lower cost
- Pressure < 1000 kPa (150 psig) = lower material and fabrication costs
- Ability to use of air in place of oxygen = less complexity = easier to operate
- Lower equipment costs compared to other “typical” gasification systems


Summary: Afina’s system costs less to build and less to operate



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Background of Afina Energy

- Original roots from BioSyn Inc, established in the mid 80's as a subsidiary of Hydro-Québec
- In early 1990's, Hydro Quebec moved project to dedicated research team at University of Sherbrooke
- In 2000, Enerkem Technologies established, and begins developing its proprietary “thermo-catalytic steam reforming” approach to gasification
- Builds pilot plant
- 2000 – 2007 Enerkem Technologies advances technology & applies it in commercial projects worldwide (see next slide)
- December 2007: Enerkem Technologies Reorganized

 **Enerkem** Municipal Solid Waste (MSW) to Gas to Liquids

 **Afina** Fossil/oilfield solids to Gas to Liquids

- Afina Energy's focus is on developing projects using low severity gasification for Heavy Oil applications using Petcoke or Asphaltenes as primary feed
 - Established a partnership with Weatherford International



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Projects using Afina (Enerkem) Gasification



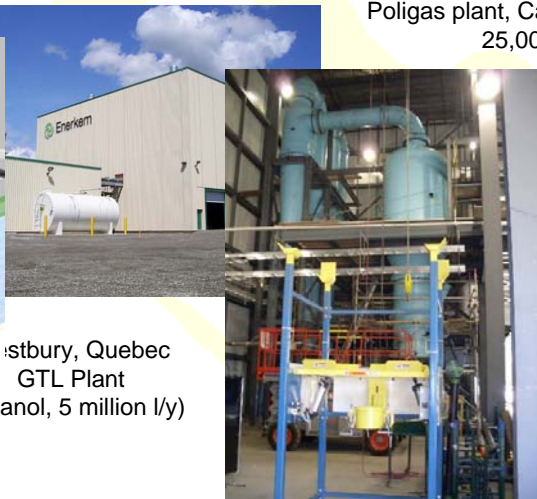
Pilot & Test Facility:
Sherbrooke, Quebec



Poligas plant, Castellon (Spain)
25,000 t/y



NOVERA ELSEF's project -12.5
tonnes/h RDF (SRF) gasification and
power generation in London, UK



Stsbury, Quebec
GTL Plant
(Ethanol, 5 million l/y)



Edmonton, Alberta:
Solid Waste Project
(100,000 t/y)



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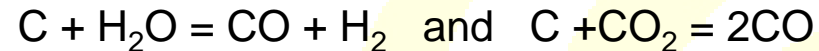




Process Description

1. Reactivity of petcoke and asphaltenes

The fundamental reactions to convert C into the desired CO and H₂ are:



The kinetics of these reactions at 950 - 975°C are dependent on the structure of the carbon matrix. To reach reasonably high carbon conversions (~ 80%) into syngas at the reaction times characteristic of bubbling fluid beds, we need an appropriate combination of particle size and partial pressure of reactants H₂O and CO₂.

2. Sulfur removal

Sulfur will be converted, at relatively low severities, to H₂S (with some COS). At 800°C, 97.7% of the S in petcoke is in the gas phase. At 950°C, essentially all the S is in the gas phase. Removal of H₂S requires a specific unit operation to be added to the gasification train. H₂S recovery will lead to the recovery of sulfur.



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Process Description

3. CO₂ conversion

Under normal conditions, approximately 17% of the carbon is converted into CO₂. Further CO₂ conversion can be obtained by a “shift” reaction, where the CO in the syngas is converted to CO₂. The amount of shift is controlled to a predetermined level, where the amount of CO converted to CO₂ can range from 20% to as much as 95%, depending on the desired result.

4. CO₂ removal

CO₂ is removed in the gas conditioning island via a chilled alcohol process. Up to 95% of the CO₂ present is removed and ready for other uses. The result is a syngas with significantly reduced CO₂ and, hence, low emissions.

5. Metals removal

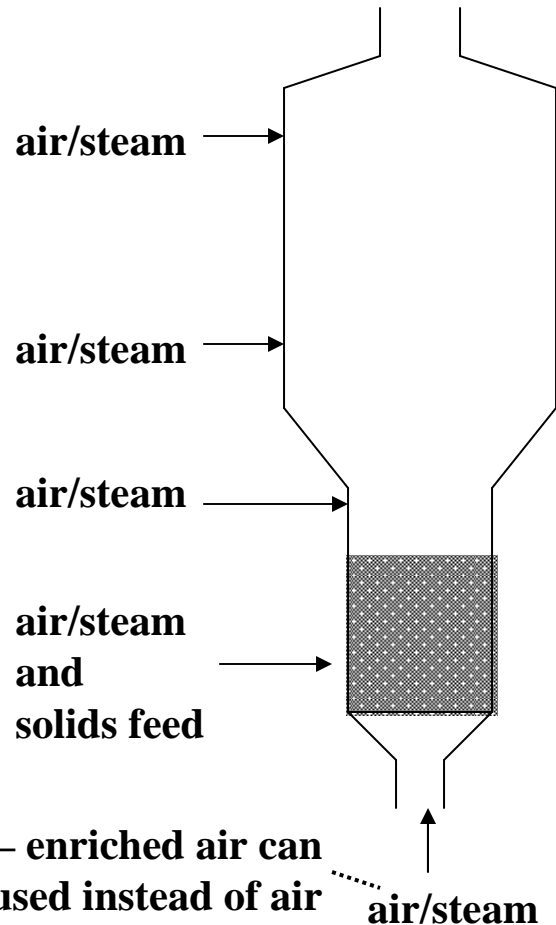
Metals present in petcoke and residues are recovered in the final solid matter.



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Process Description



Main chemical reactions

- Condensation reactions → secondary tar
- CO₂ / carbon (char)
- Steam / carbon (char)
- Steam reforming of intermediates

- Partial oxidation
- Thermal decomposition

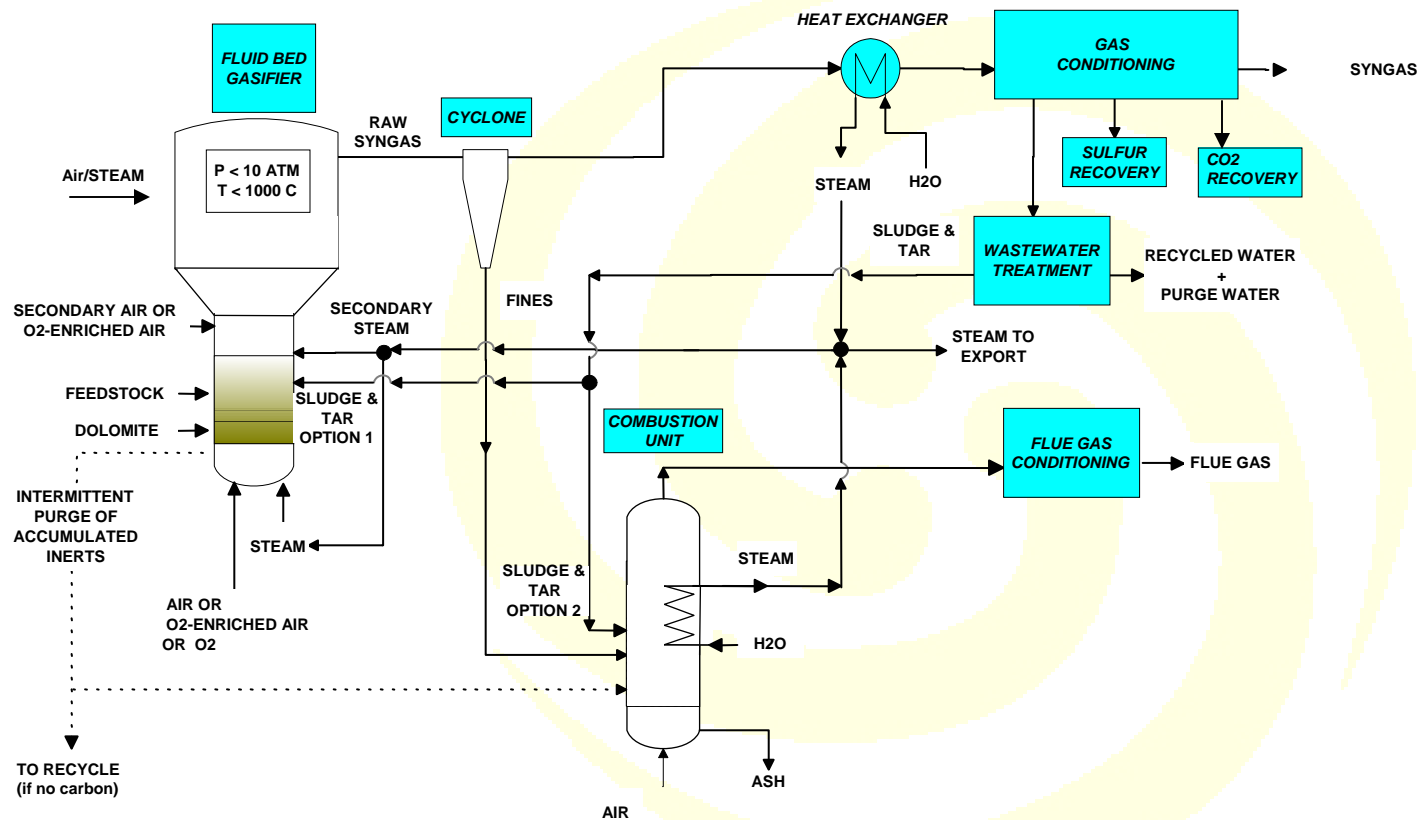
The key point in gasification is how to control the complex chemistry involved in the above reactions to maximize carbon conversion to gaseous species.



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Enerkem Gasification Technology



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Dry Syngas Composition

Syngas composition showing shift capability. 90% Carbon emissions avoided as compared to Natural Gas.

	Air/Steam Gasification	Reduced CO ₂ Syngas (Air/Steam Gasification)	O ₂ /Steam Gasification	Reduced CO ₂ Syngas (O ₂ /Steam Gasification)
H ₂	14.4	37.5	37.3	89.1
CO	21.1	3.5	52.1	7.6
CO ₂	7.2	1.3	8.5	2.7
CH ₄	0.5	0.1	1.0	0.1
C2, C3	0.3	0.1	0.5	0.1
>C4	0.1	0.0	0.2	0.0
N ₂	55.6	56.8	0.4	0.4
Ar	0.7	0.7	0.0	0.0
HHV (MJ/Nm ³)	4.6	5.3	11.5	12.4
HHV (Btu/scf)	116	132	292	315



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Deliverables and Opportunities

- Deliverable:
 - To provide long term, secure energy source to oil operations
 - To reduce the environmental impact of energy usage
 - To increase energy efficiency to the entire oil operations
 - To reduce long term operating costs
 - To increase the value of the produced oil.

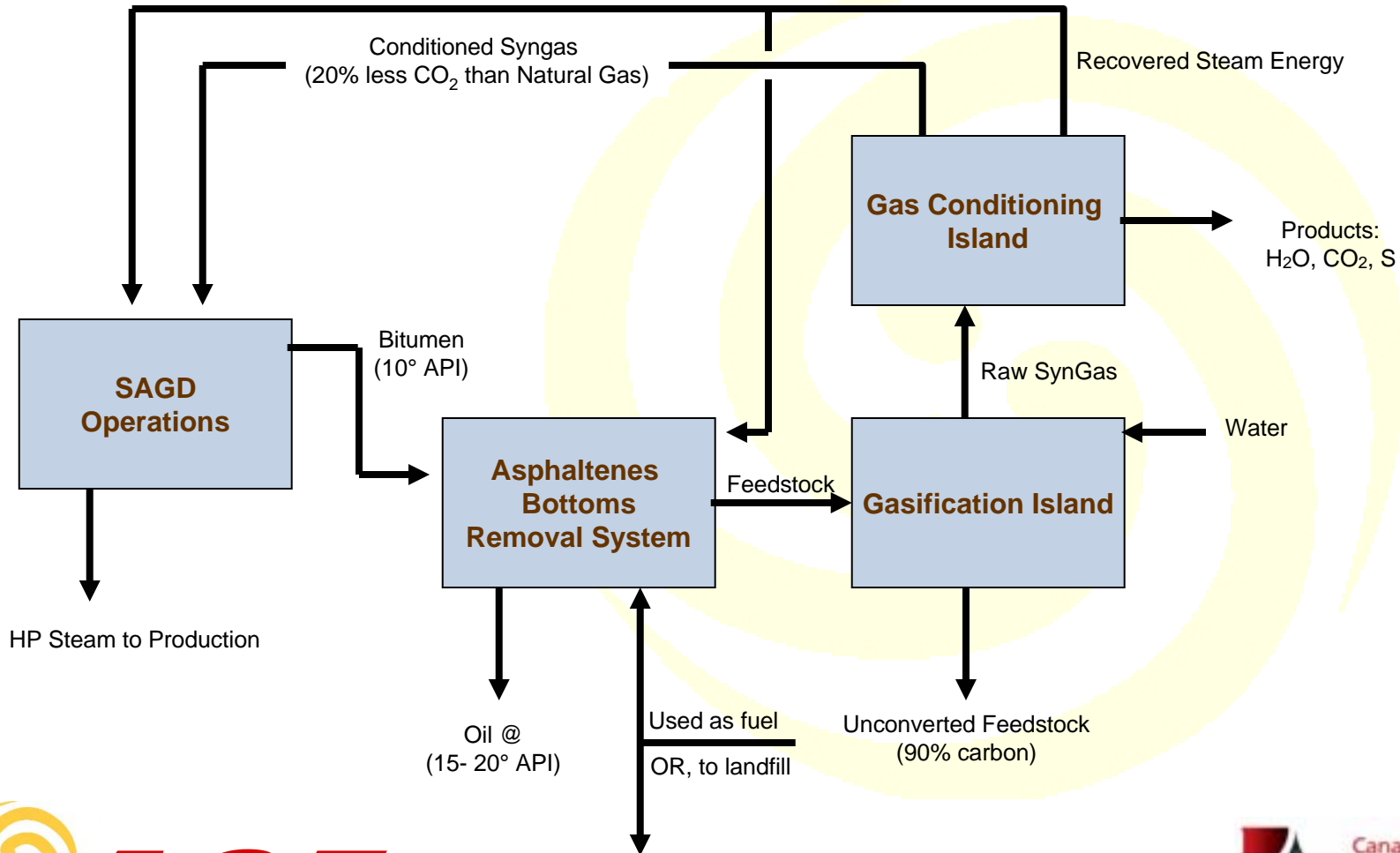
- Opportunity
 - Syngas is a direct substitute to natural gas usage
 - Potential to tie input energy costs to price of crude
 - Creates natural hedge for producers
 - Escalations according to oil prices or CPI:
 - Utilize a low-value or negative value feed stock
 - Environmental enhancement
 - Demonstrates potential of “GREEN-er” SAGD operations
 - Syngas combustion results in equivalent or lower carbon footprint than natural gas



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Integrated Objective

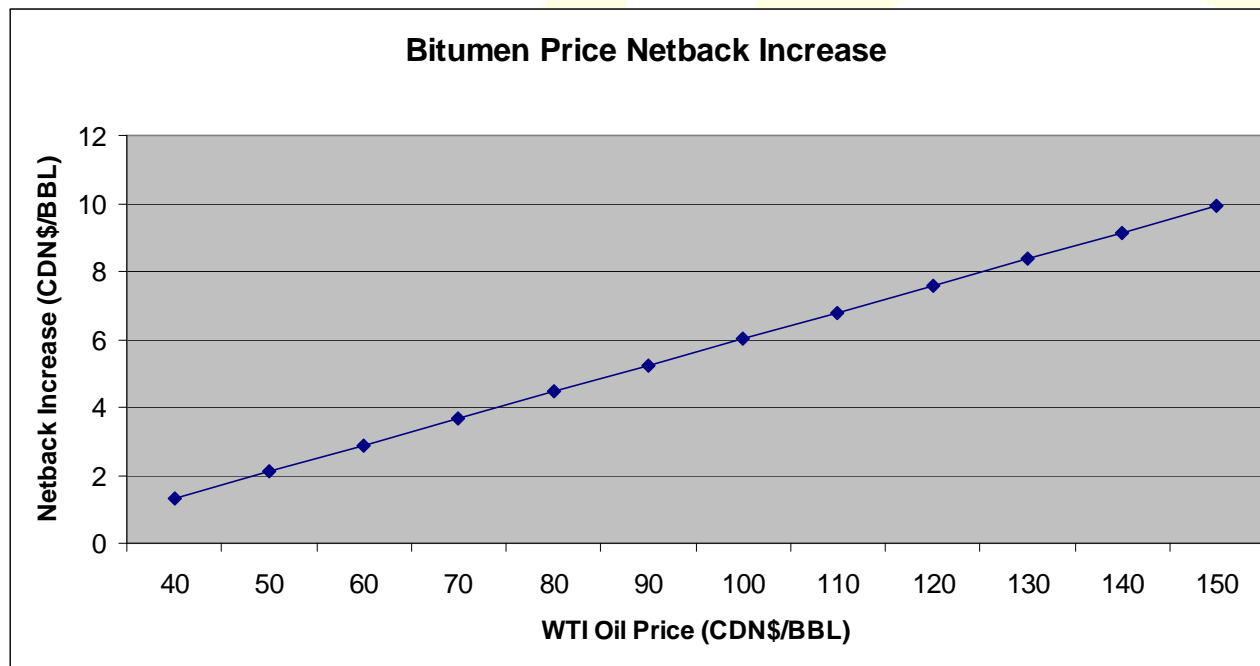


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Commercial Potential

- Significant commercial benefit using gasification as the platform
 - Fully integrated system to use bitumen bottoms as feedstock



Assumptions: Integrated CapX \$225 million, NG @ 1/8 WTI, DE-A process, C5+ @ 1.05 WTI, DilBit @ 75% WTI, 50% less S in DOA, Bitumen @ 10 °API, Dilbit @ 20 °API

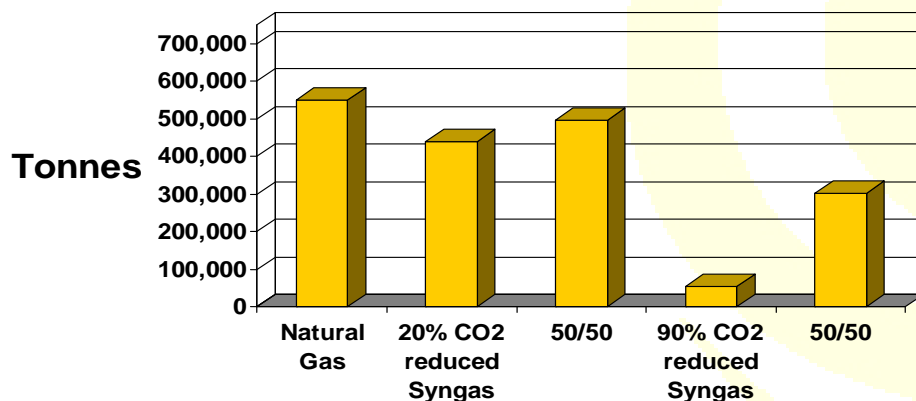


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Environmental Benefit

**Tonnes of Annual CO₂ for a
10,000 BPD SAGD**



@ 100 kgs CO₂/bbl Bitumen

Using Petcoke, asphaltenes, coal or oilfield waste as fuel

Long term CO₂ emissions reductions

Gasification system allows for “distributed carbon capture”

Potential to convert CO₂ to produce a “solid” carbon product

Potential to exceed expected Carbon Reduction requirements

Potential to create upwards of 300,000 GHG credits per year



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Summary of Benefits to Producer

- AST Proposal delivers
 - Quantifiable Environmental Benefits
 - Cuts GHG emissions by ½
 - “Clean” SAGD operations
 - Decouple energy input costs from natural gas to crude price
 - Reduces exposure to natural gas price volatility
 - Reduces exposure to diluent requirements
- Producer has option to retain participation in project
- Increases value of SAGD project
 - Increased oil netback
 - “Greens” SAGD operations



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Advanced Syngas Technologies

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