

Hydrocarbon Upgrading Demonstration Program (HUDP)

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Upgrading Session 3
Telus Convention Centre
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Duke du Plessis

*Alberta Energy Research Institute
and
Alberta Employment Immigration and Industry*

Alberta Energy Research Institute (AERI)

(Energy Technology Arm of the Alberta Government)

Mission: Enhance the development of clean energy resources through research, technology and innovation.

Mandate:

- Position Alberta for the future in energy
- Add value to Alberta's energy resources

Strategy:

- Partnerships & International collaboration

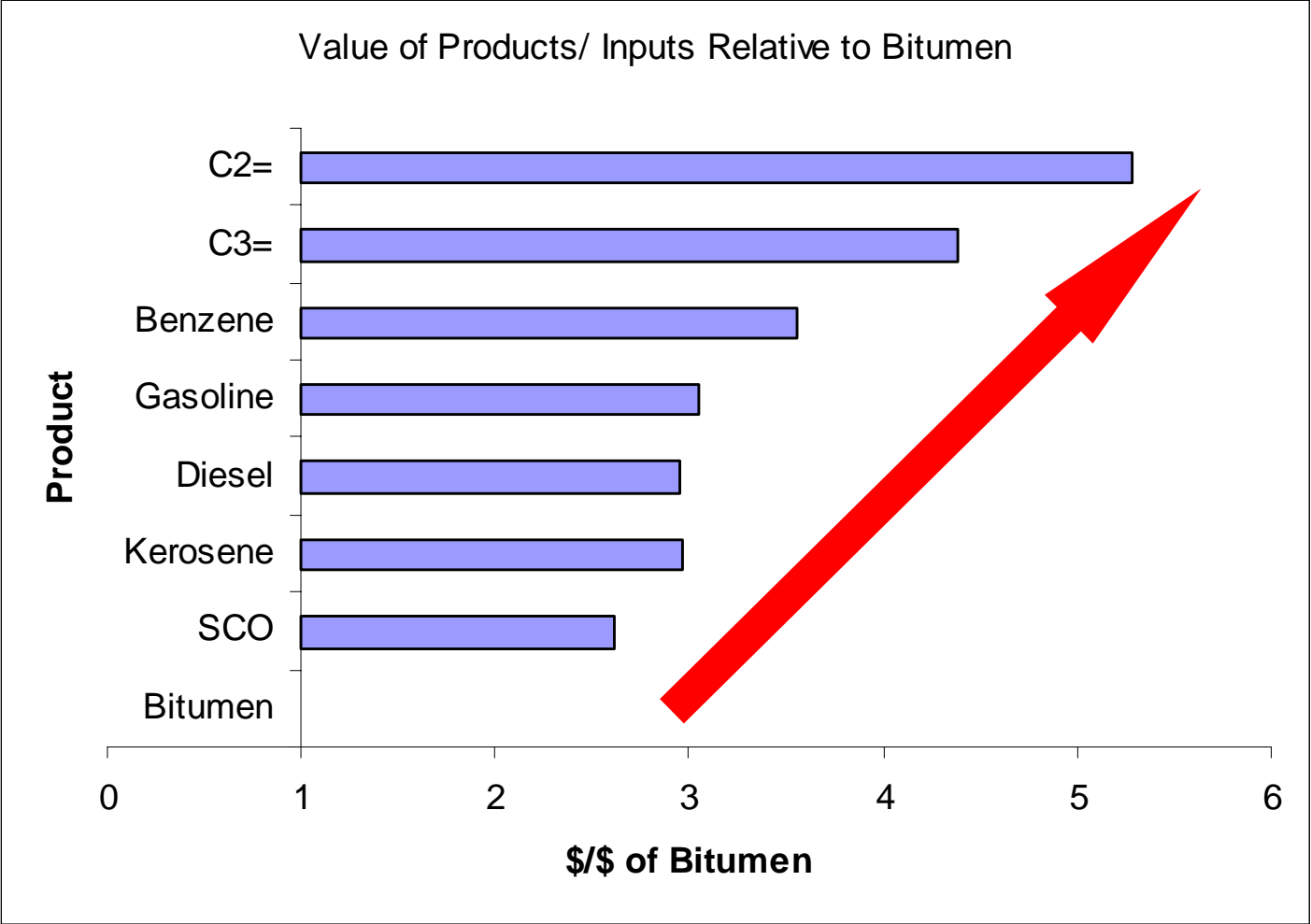
Focus:

- Technology Platforms; e.g. Gasification
- Innovation: e.g. Hydrocarbon Upgrading Demonstration Program (HUDP)

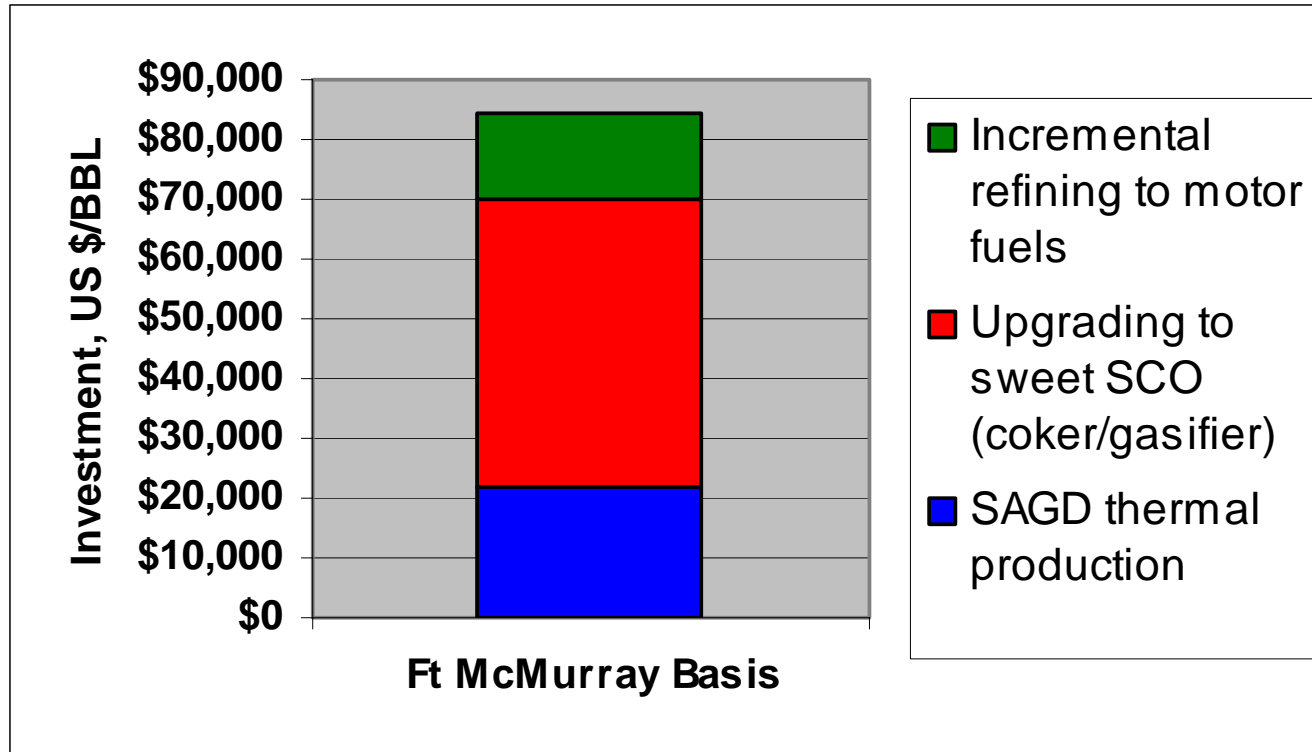
Hydrocarbon Upgrading and Demonstration Program (HUDP)

- Alberta “Vision” – paraphrased
 - Become a world leader in commercializing new technologies to utilize Canadian heavy hydrocarbons with positive economic, social and environmental impact
 - Demonstration Units: Accelerate commercialization of new technologies by closing the gap between pilot plant and commercialization
 - Training of skilled personnel
- HUDP Phase 1 commissioned by:
 - Alberta Energy Research Institute (AERI), Nova, Husky, Nexen, CNRL, Suncor, Peace River Oil, Shell Canada
- Identify and evaluate “next generation” technologies with “*breakthrough potential*”

Unlocking the Potential of Bitumen



Value Chain Investment



*Upgrading represents the largest portion of investment in the value chain
Significant incentive to improve upgrading technologies and economics*

Source: Jacobs Consultancy

Environmental

- Greenhouse gas and other emissions
- Stringent motor fuels specifications
 - Cetane, aromatics, sulfur and other



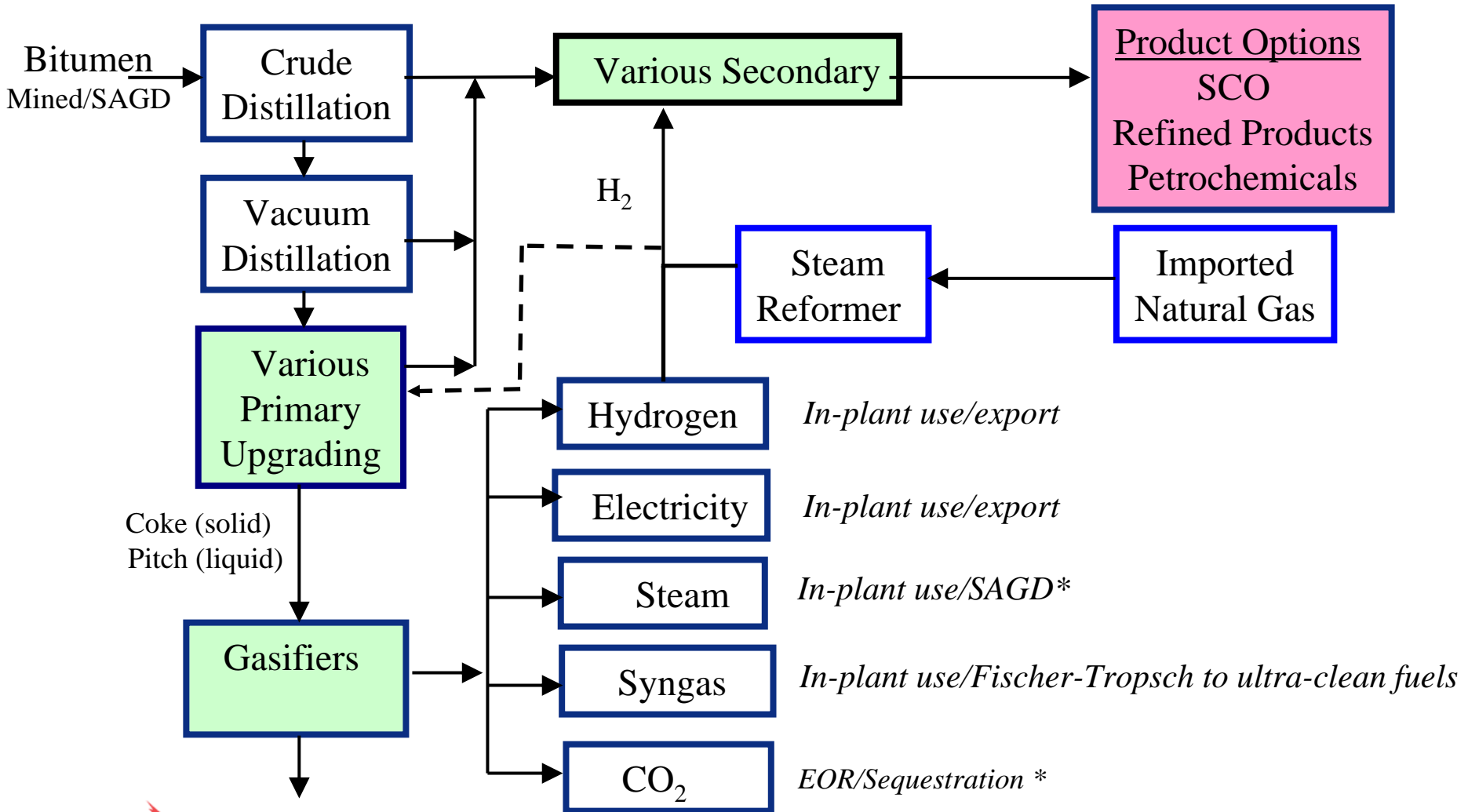
- Coke production and utilization
- Footprint
- Water usage and discharge

- *Increasingly stringent environmental issues add significant complexity and cost to the production and upgrading of bitumen*
- *Provides impetus for advanced “clean” technologies*

Hydrocarbon Upgrading Demonstration Program (HUDP) –Phase 1

- Screened 100 technologies and 25 licensors
- Evaluated 17 technology configurations:
 - conventional 200,000 bpd reference plant for SCO
 - Refined products & petrochemicals
- Selected technologies with best potential
- Technologies ranged from early stage conceptual to more mature, ready for demonstration processes

HUDP Phase 1- Representative Process Schemes and Products

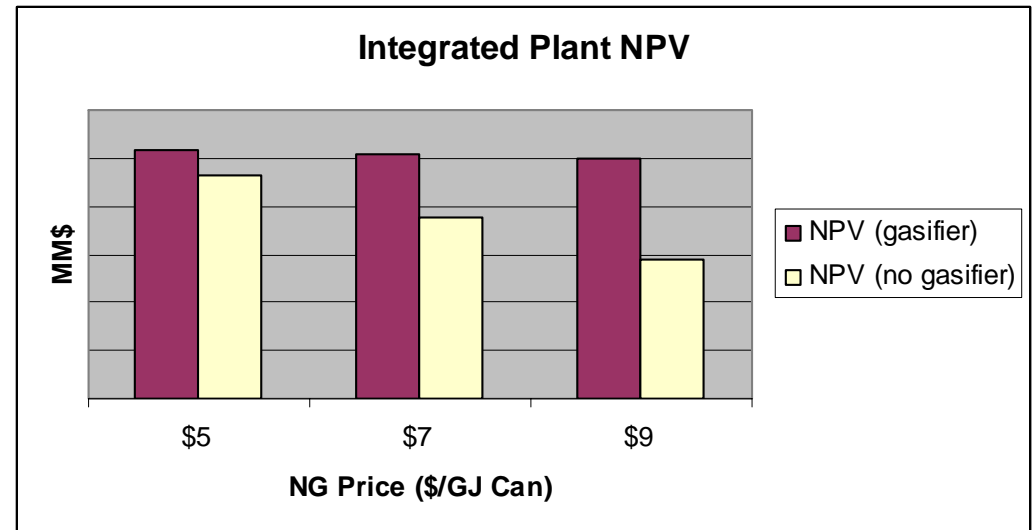
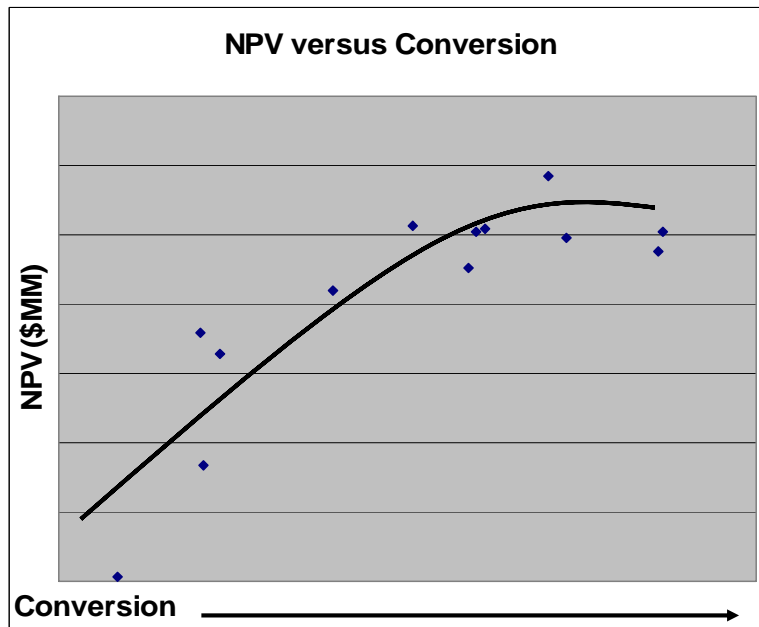


* not included in Phase 1 of AERI/Industry study

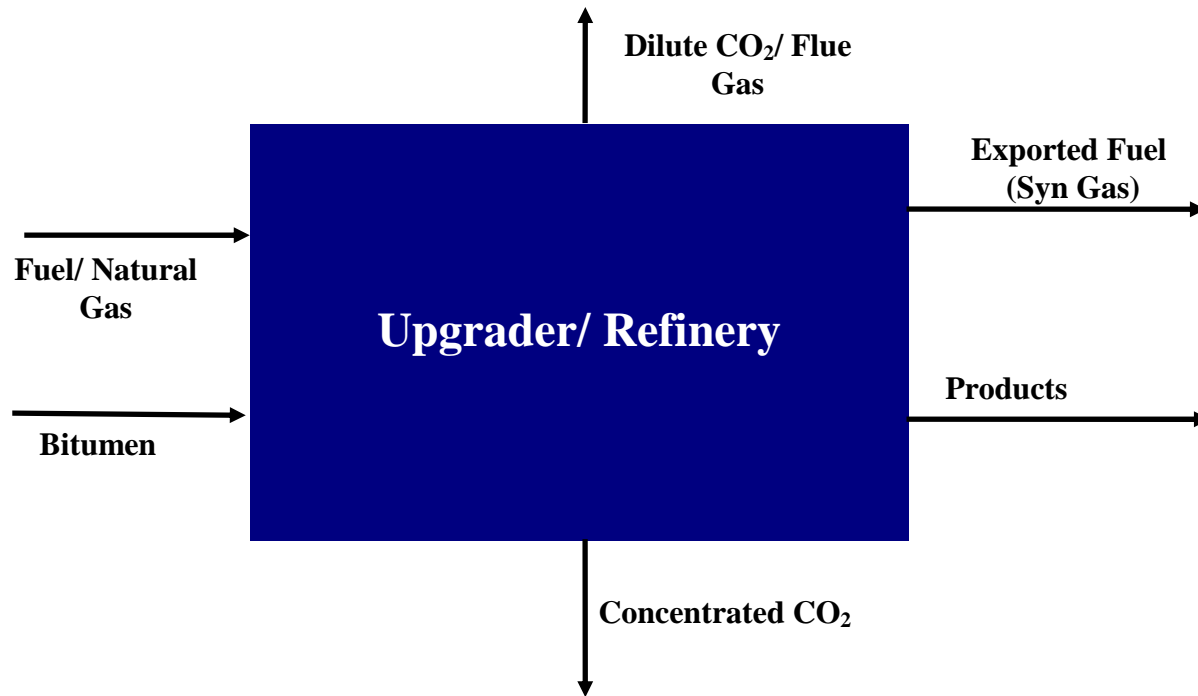
HUDP Phase 1

General Conclusions

- Overall conversion improves economics to a point
 - Optimum residue make versus capital and operating cost
- Gasification economics attractive especially at high NG prices
 - Challenges - capital cost and reliability



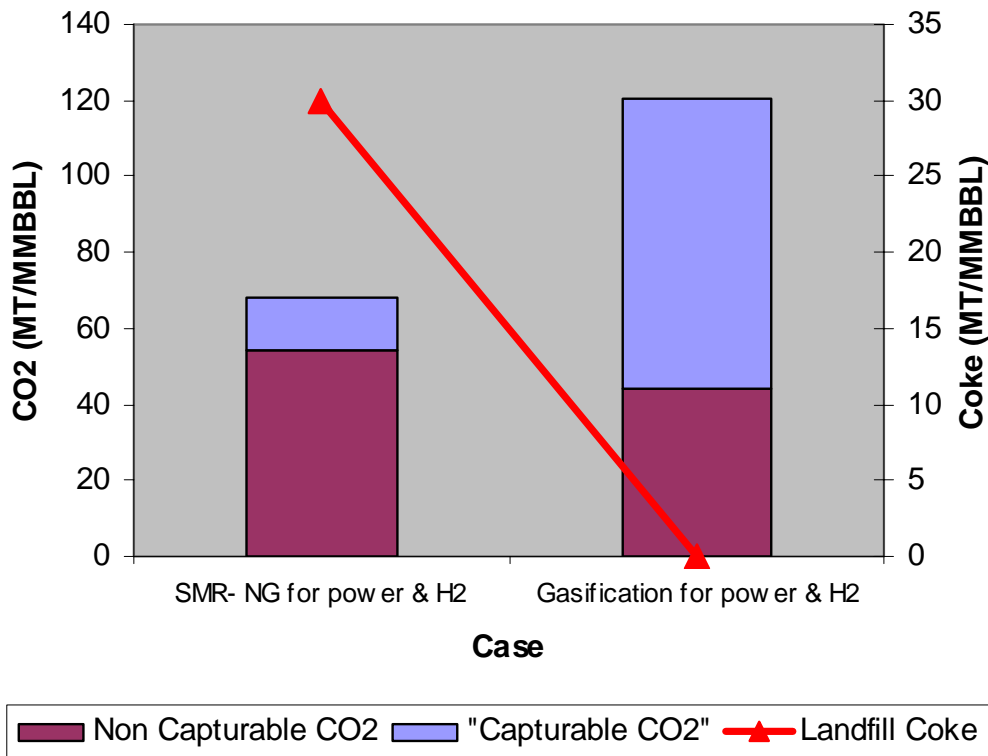
CO2 Emissions: Capturable and Non-Capturable



Capturable CO₂ = Concentrated CO₂
Non-capturable CO₂ = Dilute CO₂ + Exported

Environmental Gasification versus SMR

Upgrader Coke and CO₂ emissions



- Upgrader producing finished products
- Gasification reduces
 - non-capturable CO₂
 - Coke storage

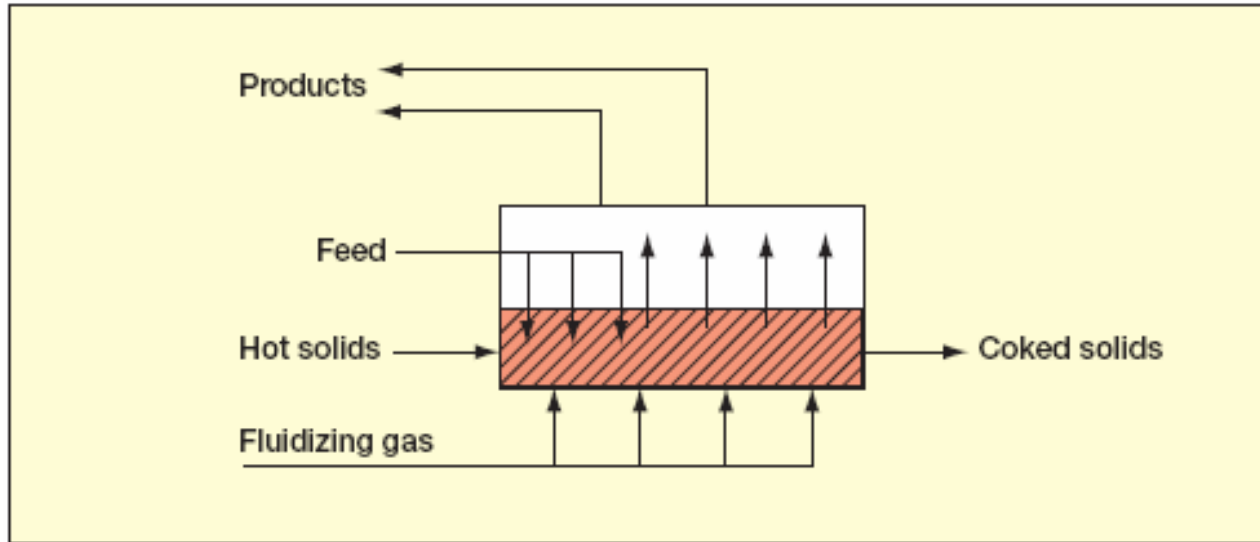
Gasification Reduces the Environmental Footprint of Upgrading

HUDP Phase 2

- AERI requested expressions of interest for “Next Generation Carbon/Hydrocarbon Upgrading Technologies
- Received 23 proposals.
- Selected 8 for stage-gated funding
 - Residue Upgrading (3)
 - Gasification (3)
 - Bitumen to Petrochemicals (1)
 - CO2 capture (1)
- Some examples follow

Examples

- ETX Cross Flow Coking



- Claims:
 - Improved conversion compared to delayed coking
 - Lower coke yields
 - Improved product yield and same qualities
 - Capital savings
- Development Path:
 - Stage-gated piloting and commercial demonstration

UOP - Residue Upgrading

- Claims:
 - 90+% conversion of bitumen to 525°C and lighter products
 - Optimum Integration with secondary upgrading (hydrotreating/hydrocracking)
- Development path
 - Stage-gated piloting, process optimization and demonstration

NOVA NHC and ARORINCLE

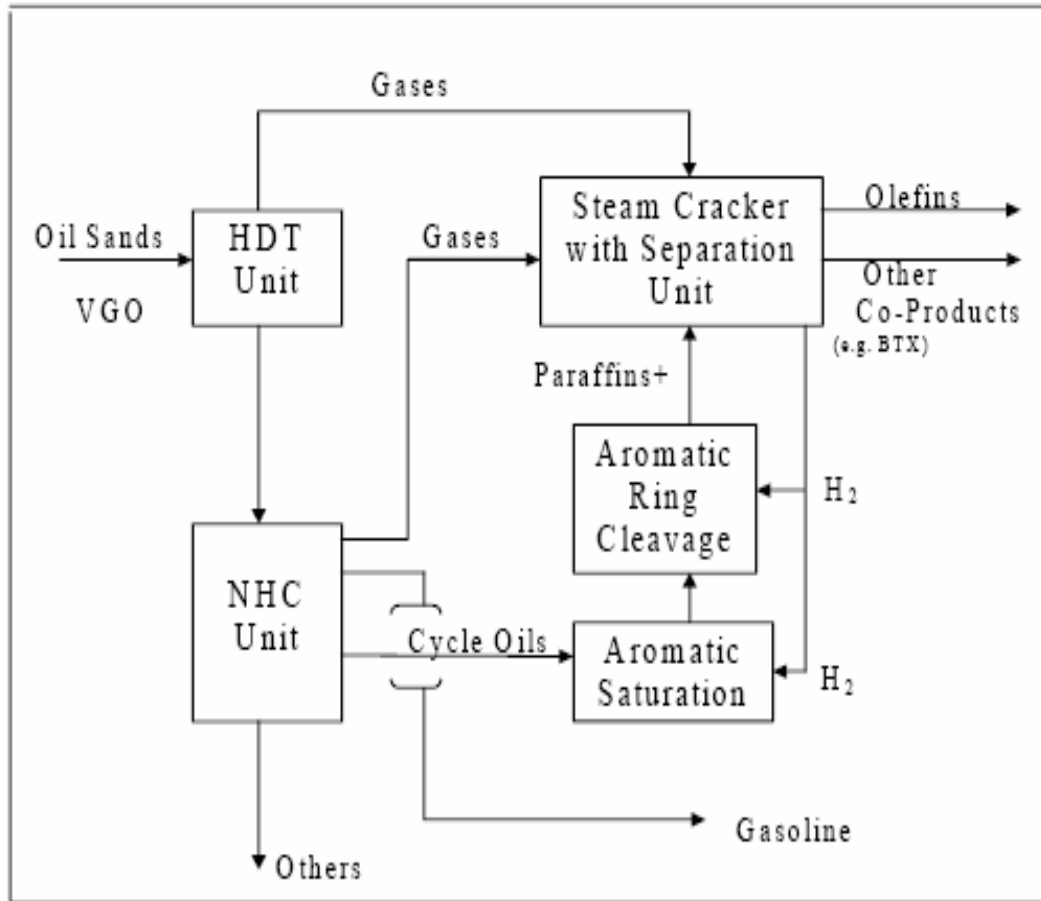


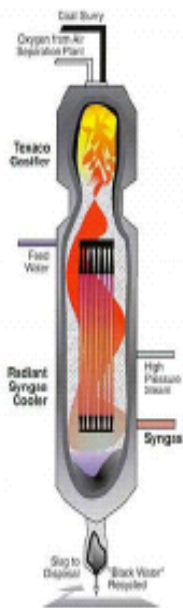
Diagram is courtesy of NOVA Chemicals

- **Claims:**
 - High yield of C2, C3 (including olefins) and BTX from bitumen
 - FCC based NHC, 2-stage fixed bed hydrotreating based ARORINCLE
- Extensive catalyst development and bench scale testing
- **Development path:**
 - Stage-gated piloting and demonstration

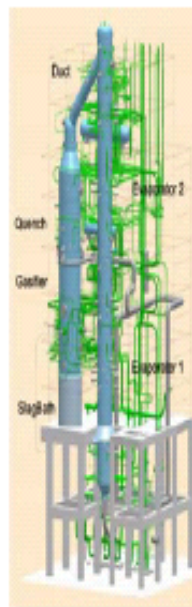
Pratt and Whitney-Rocketdyne (PWR) Gasification- Claims

- Based on rocket engine design
- High mass flux
- Advanced materials
- Size and cost reduction
- Development path
 - Stage-gated piloting, scale-up and demonstration

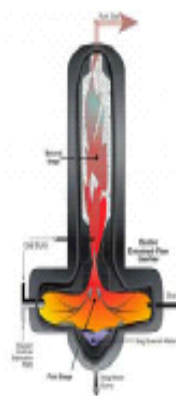
GE Gasifier



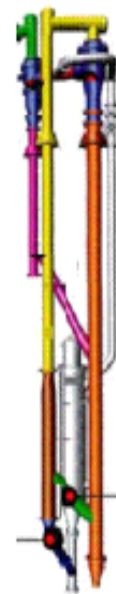
Shell Gasifier



Conoco Phillips Gasifier



Transport Gasifier



PWR Gasifier



90% Size Reduction Provides Significant Advantages

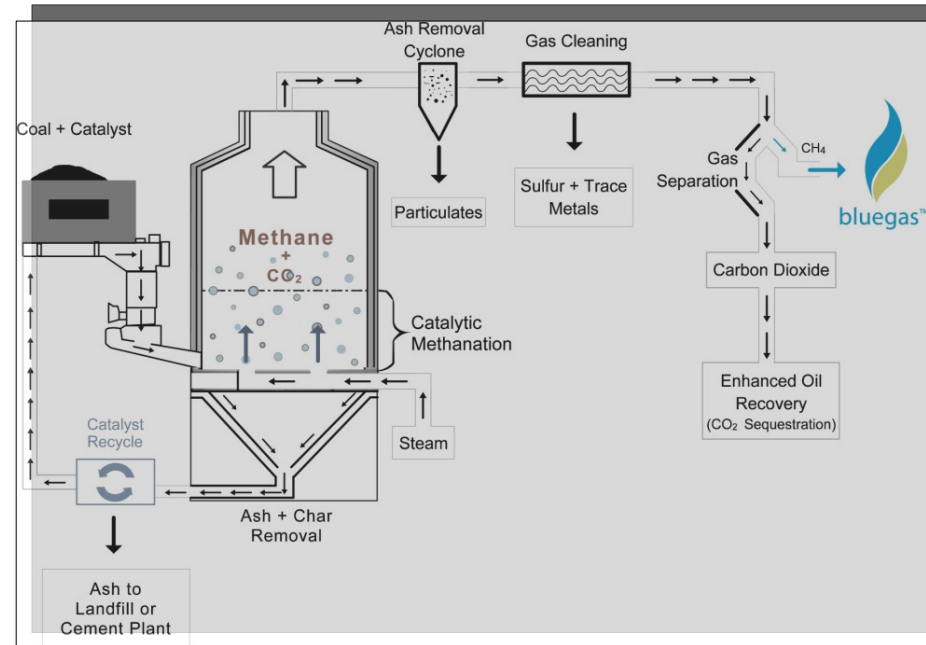
• Capital Cost	Base	>Base	Base	Base	<50%
• Availability	0.90	0.85 ↑	0.82 ↑	?	0.99
• Cold Gas Efficiency	0.77	0.83	0.83	0.75	0.85
• Fuel Flexibility	Fair	Good	Fair	Poor	Good
• Product Flexibility	Good	Fair	Fair	Poor	Good

Courtesy PWR

Great Point Energy (GPE) Catalytic Gasification

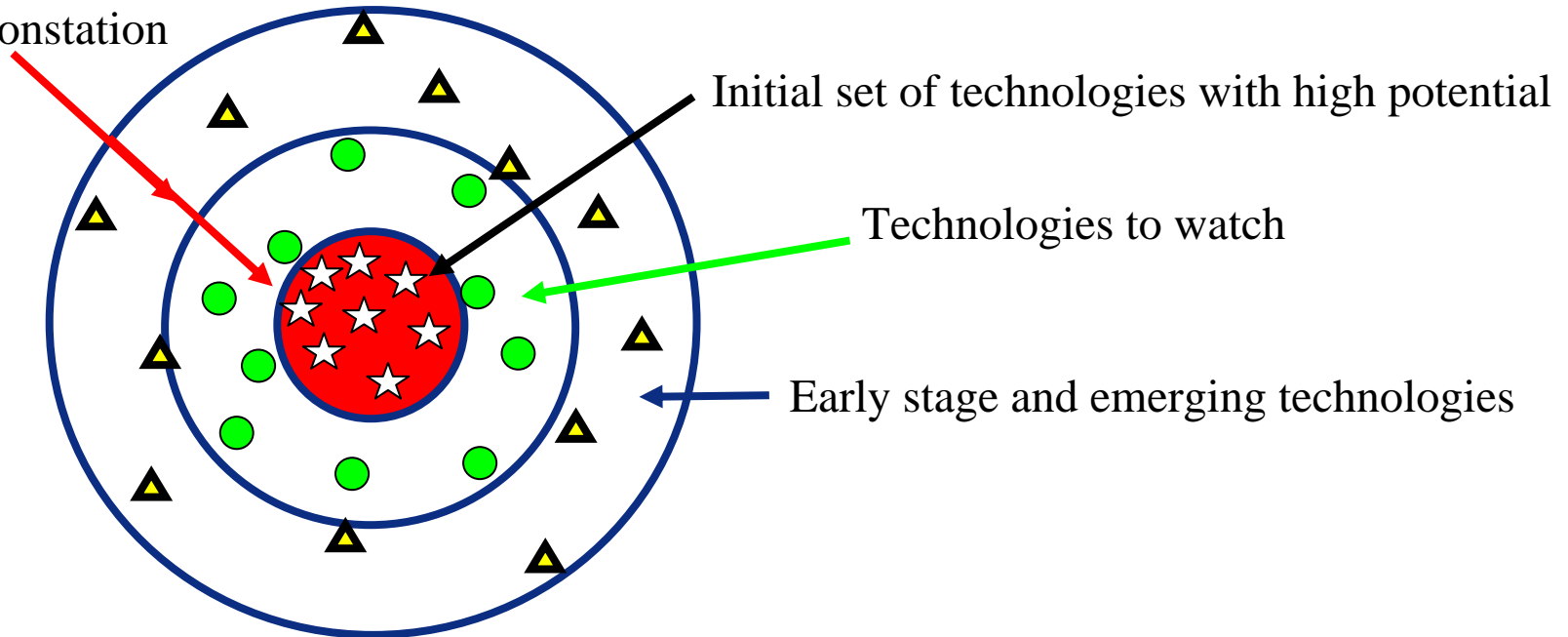
Claims

- Converts petcoke/coal to methane (SNG) in single stage reactor
- Steam instead of oxygen saves cost
- SNG cost at low end of NG market price
- SMR of SNG lower capital cost than gasifier with shift and PSA
- Development path:
 - Stage-gated piloting (in progress)
 - Scale-up and commercial demonstration



On-going innovation and monitoring of emerging technologies

New candidates
for development
and demonstration



Summary

- HUDP: Joint Government-Industry initiative to share risk of developing and demonstrating next generation clean upgrading technologies
- Phase 1: Completed late 2006
 - Identified and evaluated wide range of technologies
 - Selected initial set of promising candidates
- Phase 2: Started early 2007
 - Expressions of interest broadened the list of candidates
 - Started stage-gated development of the first set of technologies
- Phase 3: 2008 and beyond
 - Build and operate plants to demonstrate commercial readiness
- Projects have different development time frames and levels of risk
- Some may not pass all gates and reach Phase 3
- Need on-going optimization and innovation during all phases.

Acknowledgement

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Alberta Energy Research Institute(AERI), CNRL, Husky, Nova, Nexen, Suncor, Peace River Oil, Shell Canada