Alberta Midstream Chemical Cluster
Site Requirements Study

Assessment of the Land Use, Infrastructure, and Logistics Requirements, Costs and Benefits for the Midstream Chemical Cluster in Alberta’s Industrial Heartland

Date: October 2009
Calgary and Edmonton
### Agenda

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The Study was conducted in a six-stage work program

**Approach**

1. **Stage 1:** Assemble and Integrate inputs from other studies
2. **Stage 2:** Understanding the Market potential and selecting products
3. **Stage 3:** Assess Best Practices from existing and emerging Clusters
4. **Stage 4:** Developing the Conceptual Midstream Cluster Concepts
5. **Stage 5:** Develop Land Use Infrastructure and Logistics plan
6. **Stage 6:** Socio-Economic Impact and Cost – Benefit analysis

**Objectives**

1. Integrate the findings of previous studies into the basis for the Land Use Study
2. Assess current and long term supply/demand for the products that could be produced in the Midstream cluster
3. Assess land use best practice in existing and emerging clusters and assemble key learnings
4. Develop the cluster configurations based on the feedstock scenarios for investment in the period 2010 to 2040
5. Develop the Land Use site plan and define the public and site specific infrastructure and logistics systems to move products to market
6. Conduct detailed Socio-economic Analysis the goal of establishing the cost-benefit to the Capital Region
The Midstream cluster will become an important producer of commodities and intermediates for the CoE Cluster and North American Market.

**Approach**

- **Upstream**
  - Upgraders, Integrated Gasifiers, Refineries
  - Gasification

- **Midstream Cluster(s)**
  - Gasification
  - Refinery Cracker(s)
  - Ethane Propane
  - Refinery Offgas
  - C1, C2, C3 Value Chains
  - C4, C6, C7/8 Value Chains

- **Syn Gas**
  - Urea
  - Ammonium Nitrate
  - Ammonia

- **Phase 2 Derivatives**
  - Fabrication
  - Compounding
  - R&D / Tech Centres
  - New Technologies

- **CoE Downstream**
  - Intermediates
  - Truck & Pipe to Downstream Cluster and domestic markets
  - Rail to US and West Coast
  - Potentially World Scale Volumes
Petcoke or Residues from Upgrading could be key to Value-Add in Alberta’s Midstream Chemical Cluster via a Poly-Gen configuration.
Agenda

1. Approach to Study
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10. Observations & Conclusions
The globally significant chemical clusters rely on several key sources of competitiveness:

- **Feedstock availability and flexibility**
- **Market proximity, diversity and critical mass**
- **Supply Chain efficiency (feedstocks and products)**
- **Cluster critical mass and operational efficiency**

Maximising the combination of these leads to “best in class”

Cluster “Attributes” — only manageable to a limited extent

Cluster “Key Performance Criteria” — mostly manageable
Globally significant Chemical Clusters were analysed to develop key learning points on infrastructure and logistics “Best Practice”
Summary of Key Findings of the analysis of globally significant clusters relevant to the Midstream cluster (1/2)

Cluster Planning and Design:

- All successful on-purpose clusters have benefited from directed master-planning of their clusters

- Phasing of development, has been favoured by the major on-purpose cluster developments to mitigate investment risk

Role of Government:

- Has played a central role in the development of on-purpose clusters

- Has begun to intervene in the vision, mission and strategies of the evolved clusters, consciously directing planning and investment in infrastructure to support regional cluster focal points and environmental initiatives

- Both government- and stakeholder-driven strategies are successfully employed. The common practice in both models is to follow a strongly consultative approach to the development of vision, mission, strategies and implementation
Summary of Key Findings of the analysis of globally significant clusters relevant to the Midstream cluster (2/2)

- **Infrastructure and Supply Chain**
  - Global Logistics Service Providers play a significant role in all successful clusters – this includes those clusters strongly directed by government.
  - The provision of pre-built infrastructure, and provision of utilities is considered fundamental to kick-starting clusters.

- **Utilities:**
  - Most clusters have multiple supplies of electrical power from a regional grid and from power stations within the cluster.
  - There is a clear trend toward centralisation of waste water management. In several cases government has played a significant role in directing and managing these activities.

- **Investment Attraction**
  - Attracting anchor investors in feedstock preparation, integrated chemical production, logistics, utilities and services is important to build momentum in the cluster.
  - Incentives are widely used, in many different forms, for investment attraction.
Worst Practices were also identified in the globally significant clusters...

- No formal master planning of clusters with respect to site layout, location of logistics, infrastructure and on-purpose synergies of utilities and services
- Mismatch of public and site infrastructure requirements resulting in increased cost of feedstocks or product movements to market
- Lack of energy supply and infrastructure coordination – leads to inefficiencies
- Linear cluster expansion leads to uneconomic movement of product between cluster plants and logistics centres
- Cluster designed and developed around feedstock push instead of a market pull
- Overuse of incentives leading to the wrong kind of investments
- Lack of upstream or downstream integration resulting in poor operational efficiency
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Long-term oil & gas price forecasts will allow the Capital Region to take advantage of feedstocks based on Upgrading

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<th>Off-gas</th>
<th>Syngas based on petcoke</th>
<th>Steam cracking from SCO</th>
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| - Provides a **key route to petrochemicals**  
- **Immediately available**  
- Augmented by **gasification and steam cracking** in future | - Highly attractive route to **globally competitive** methanol and ammonia and derivatives  
- The **stranded nature and large volumes of the residues** could lead to a global centre for C1-3 petrochemicals  
- A **zero or negative value of residues** will provide the basis for competing against other global advantaged locations  
- The transport cost from Fort Mc Murray to the AIH **needs to be optimised** in order to sustain this advantage | - Production of the C2, C3, C4 and C6/7/8 value chains and derivatives will be **highly competitive**  
- Naphtha could be in **oversupply in Alberta** due to new refineries being required mainly for diesel production – leading to a significant opportunity |
The growing stock-pile of Petcoke will be key to the development of a world scale chemical cluster.

- Inventory currently 57 million tonne
  - End 2008, source ERCB, July 2009
- Production ~ 6.0-6.5 million tonne pa
- Nominal third party sales
- Prime producers: Syncrude, Suncor
- Future producers to include existing expansions plus CNPL, Opti Nexen
- Forecast production:
  - 7 million tonne pa (Reference Case)
  - 16 million tonne pa (Realistic Case)
  - Stock-pile to reach over 500 million tonne by 2040 without gasification
In the Reference Case 10 million tpa gasification capacity is commissioned in 2016. No addition investment.

Petcoke production is 7 million tpa. Gasification capacity operates at 85%.

The accumulated petcoke stockpile reduces to zero post 2050.

Gasification continues based on ongoing production of 7 million tpa, e.g. 70% operating rate.
Realistic Case Concept: 14 million tonne gasification capacity initial investment with further 50% increase from 2025

- In the Realistic Case 14 million tpa gasification capacity is commissioned in 2016, 7 million tpa in 2025
- Petcoke production is 16 million tpa. Gasification capacity operates at 85-90% (average 87.5%)
- The accumulated petcoke stockpile reduces to zero post 2050.
- Gasification continues based on ongoing production of 16 million tpa, e.g. 76% operating rate
The two Feedstock Scenarios can be summarised as follows:

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<th>Attributes</th>
<th>Reference Case</th>
<th>Realistic Case</th>
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<td>Scale</td>
<td>Below world-scale c.a. 3 million tpa olefins</td>
<td>World-scale c.a. 10 million tpa olefins</td>
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<td>Integration</td>
<td>Replacement of existing natural gas feedstock for ammonia and methanol imports for formaldehyde production</td>
<td>Feedstock replacement plus expansion of fertilizer value chain and feedstock for formaldehyde and acetic acid production</td>
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<tr>
<td>Energy</td>
<td>600MW</td>
<td>1200MW</td>
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<td>Downstream</td>
<td>Limited derivative capability</td>
<td>Significant derivative capability</td>
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<tr>
<td>Pet coke</td>
<td>Stockpile reduced by 2050</td>
<td>Stockpile reduced by 2052</td>
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<tr>
<td>Refining</td>
<td>I major investment providing opportunity for world-scale steam cracker and derivatives</td>
<td>3 major investments allowing wide range of derivatives</td>
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<tr>
<td>Off-gases</td>
<td>Ability to develop world-scale polypropylene</td>
<td>Opportunity for 2 polypropylene plants plus additional C4 stream integration</td>
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- Significant upside to the Realistic Case is envisaged with higher levels of Upgrading investments
- The minimum world-scale petrochemical basis is regarded as 5-6 million tpa olefin equivalent
- The Reference Case concept is feedstock limited in terms of available petcoke for gasification
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Approach and assumptions used to identify the most attractive products for the Midstream cluster for both Feedstock Scenarios

- **A detailed Supply – Demand analysis** was conducted on the products identified for the Midstream cluster under both the Reference and Realistic cases:
  - Long term growth rates were based on demand scenarios
  - Impact of the global economic crisis and the capacity bubble in the Middle East have been considered
- **In both cases overall product demand within North America will require significant investment to meet demand**
  - Replacement of some existing capacity due to age and/or poor economics is anticipated
- **Imports** - North America is forecast to maintain, but not increase, existing levels of chemical imports
- **Premise** - Alberta is able to capture 20-30% of North American petrochemical growth and investment based on gasification through MTO/MTP and up to 20% of traditional refinery/steam cracking related product slates
Demand growth for commodity petrochemicals in North America is lower than the overall global demand yet the market is significant.

- Individual product demand in both the Reference and Realistic Cases have been derived from the projected commodity petrochemicals demand growth rates in North America using scenario analysis.
### Projected total number of world-scale plants required in North America to 2040 for the Reference Case

#### Product Selection

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Each coloured box represents one plant built in Alberta Midstream Cluster. Capacity stated as typical world-scale 2009 basis.

Post 2015 conventional feedstock (ethane/propane) will be limited and replaced by steam cracking (naphtha) and MTO/MTP.
The projected higher growth will require earlier phasing and an increase in the number of plants in the Realistic Case.

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Note: Post 2015 conventional feedstock (ethane/propane) will be limited and replaced by steam cracking (naphtha) and MTO/MTP.
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<tbody>
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<tr>
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<td>Observations &amp; Conclusions</td>
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The Reference Case is feedstock constrained resulting in relatively limited investment in the Midstream Cluster

Construction and timing of investments - (not linear)

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<th>Year</th>
<th>2015</th>
<th>2018</th>
<th>2020</th>
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<tr>
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Legend:
- Feedstock Process
- Product
- Third party Feedstocks
- 36 months construction assumed
The significant feedstock availability enables world scale investment in 3 phases in the Realistic Case.

**Construction and timing of investments - (not linear)**

<table>
<thead>
<tr>
<th>Product</th>
<th>2015</th>
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<th>2020</th>
<th>2025</th>
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**Legend**

- **Feedstock Process**
- **Product**
- **Third party Feedstocks**
- **36 months construction assumed**

**Gasification**

- Off-gases
- Polypropylene
- Methanol
- MTO/MTP
- Formaldehyde
- Power Hydrogen Syngas (NH3)

**Cluster Configurations**

- Upstream Refining
- Upstream
- Refining

**Additional Information**

- PP, PO and Acrylic Acid may be based on propylene derived from off-gases, MTP and steam cracking.
- Others include: Adipic Acid, Adiponitrile, Aniline MDI and Caprolactam.
- Ethylene may be used as a replacement feedstock for Polyethylenes and EO/EG (and LAOs) post 2025 rather than new builds.
## Agenda

<table>
<thead>
<tr>
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<th>Contents</th>
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<tbody>
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Summary of Personnel, Land Use and Capex for the Reference Case
Logistics systems

<table>
<thead>
<tr>
<th></th>
<th>Logistics Personnel requirements</th>
<th>Logistics Land Use requirements (ha)</th>
<th>Logistics Capex requirements (USD$m) excluding railcars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids</td>
<td>100</td>
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<td>30</td>
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<td>Liquids Site</td>
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<td>25</td>
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<td>Rail Site (solids)</td>
<td>Included in solids</td>
<td>Off site</td>
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<td>Liquids Central (AILC)</td>
<td>150</td>
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<tr>
<td>Pet coke</td>
<td>50</td>
<td>55</td>
<td>150</td>
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<tr>
<td>Rail Central (Marshalling)</td>
<td>Included in liquids central</td>
<td>65</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>380</strong></td>
<td><strong>151</strong></td>
<td><strong>607</strong></td>
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</table>
## Summary of the Personnel, Land Use and Capex requirements for the Realistic Case logistics systems

<table>
<thead>
<tr>
<th></th>
<th>Logistics Personnel requirements</th>
<th>Logistics Land Use requirements (ha)</th>
<th>Logistics Capex requirements (USD$m) excluding railcars</th>
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<tbody>
<tr>
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<td>200</td>
<td>12</td>
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<tr>
<td>Fertilizers</td>
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<td>Gasification</td>
<td>Included in Solids</td>
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<td>Liquids Site</td>
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<td>Rail Site (solids)</td>
<td>included in Rail Central</td>
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<td>Liquids Central (AILC)</td>
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<td>Rail Central (Marshalling)</td>
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<td><strong>Total</strong></td>
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<td>Observations &amp; Conclusions</td>
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</table>
The Public and Site Specific Infrastructure have been defined independently of the location of the Upstream/Midstream location.

### Concept Site Plans

<table>
<thead>
<tr>
<th>Public (OSBL to the cluster)</th>
<th>Site Specific (ISBL to the cluster)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Utilities:</strong> water, electricity, waste water, CO₂ pipelines</td>
<td><strong>Utilities:</strong> electricity, steam, natural gas, condensate, water</td>
</tr>
<tr>
<td><strong>Infrastructure:</strong> infrastructure corridors between clusters, pipe bridges, pipelines, roads, rail, marshalling yards</td>
<td><strong>Infrastructure:</strong> pipe bridges, pipelines, roads, rail</td>
</tr>
<tr>
<td><strong>Environmental:</strong> waste water, storm water, CO₂ capture</td>
<td><strong>Environmental:</strong> waste water, storm water, solid effluent, flue gases, liquid effluent, CO₂ capture, flares</td>
</tr>
<tr>
<td><strong>Land Use:</strong> roads, rail, marshalling yards, utilities</td>
<td><strong>Industrial gases:</strong> oxygen, nitrogen, syngas, CO, H₂</td>
</tr>
<tr>
<td>Upstream to Midstream to Downstream <strong>Cluster inter-linkages</strong></td>
<td><strong>Land Use:</strong> plants, infrastructure, maintenance corridors</td>
</tr>
<tr>
<td></td>
<td><strong>Emergency services:</strong> fire-brigade, medical</td>
</tr>
</tbody>
</table>
Reference Case Concept Site Plan 2015-2020

Concept Site Plans

Reference Case 2015 - 2020
Cracker complex could be independent from the gasification development

- Secure Area
- Prime Pipe Corridor (40m)
- 2015
- Emergency Services
- CN/CP Rail Line
- Rail Spur
- SWMF, Water and Wastewater Servicing
- Flaring
- Product Pipe
- Road (30m)
- Highway System *

*Could include highways 38, 15, 43, 540, 832, 830, and/or 83.

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Realistic Case Key Plan Midstream Cluster 2015 - 2040

Concept Site Plans

Key Plan Midstream Cluster Concept 2015 - 2040

- CN/CP Rail Line
- Road
- Highway System *
  *Could include Highways 38, 15, 45, 613, 825, 830, and/or 831

- C1-3 Sub-cluster
- Cracker
- Fertilizer
- Logistics
- SWMF, Water and Wastewater Servicing
- Naphtha
- Syngas
- Hydrogen
- Offgas
- CO2
- Products Pipeline
- Petcoke Input

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By 2040 under the Reference Case the Midstream Cluster could generate annual revenues of $4.7 billion and taxes of $350 million.

- Total investment is in period 2015-2020 with no additional growth envisaged.
- Cracker and derivatives provides 28% sales volumes but 69% revenues, 42% capex.
- Off gas availability (propylene) is utilised for polypropylene production.
  - Incremental ethane/ethylene is used to supplement existing polyethylene and ethylene glycol facilities - not as new investments.
- Impact on proposed CoE Cluster function of Cracker and derivatives investments.
- Proportion of syngas feedstock used to replace existing NG feedstock at established fertilizer production (Agrium) and for power requirements.
- Taxation includes income, corporation, land and property related taxes.

### Socio Economic Analysis

<table>
<thead>
<tr>
<th>Sales</th>
<th>Revenues</th>
<th>Capex</th>
<th>Jobs</th>
<th>Land Use</th>
<th>Taxation</th>
<th>Infrastructure</th>
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<tbody>
<tr>
<td>11.9 million tonne pa</td>
<td>$4.7 billion pa</td>
<td>$11.4 billion</td>
<td>1125 direct</td>
<td>886 ha</td>
<td>$353 million pa</td>
<td>$1.2 billion cumulative</td>
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<td>$8.5 billion cumulative</td>
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</table>
In the Realistic Case Revenues could reach $18.4 billion and taxes $1.15 billion per year

Majority of investment is in period 2015-2025 with additional growth envisaged

Cracker and derivatives provides 35% sales volumes but 65% revenues, 50% capex

Off gas availability (propylene) is utilised for polypropylene production
- Incremental ethane/ethylene is used to supplement existing polyethylene and ethylene glycol facilities - not as new investments but could be alternative cracker option

Major impact on proposed CoE Cluster function of Cracker and derivatives investments

Proportion of syngas feedstock used to replace existing NG feedstock at established fertilizer production (Agrium) plus new fertilizer investment and for power requirements

Taxation includes income, corporation, land and property related taxes

Socio Economic Analysis

<table>
<thead>
<tr>
<th>Sales</th>
<th>Revenues</th>
<th>Capex</th>
<th>Jobs</th>
<th>Land Use</th>
<th>Taxation</th>
<th>Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>33.4 million tonne pa</td>
<td>$18.4 billion pa</td>
<td>$35.4 billion</td>
<td>2353 direct</td>
<td>2419 ha</td>
<td>$1.15 billion pa</td>
<td>$2.3 billion cumulative</td>
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<td>$18.9 billion cumulative</td>
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<td>Approach to Study</td>
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<td>Feedstock Scenarios</td>
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<td>4</td>
<td>Market Supply/Demand</td>
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<td>6</td>
<td>Logistics &amp; Infrastructure</td>
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<tr>
<td>7</td>
<td>Concept Site Plans</td>
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<td>Socio Economic Analysis</td>
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<tr>
<td>9</td>
<td><strong>Cost Benefit Analysis</strong></td>
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<tr>
<td>10</td>
<td>Observations &amp; Conclusions</td>
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</tbody>
</table>
The Cost Benefit is based on the cumulative revenue earned by Government against the investment in infrastructure to support the cluster.

### Cost Benefit Analysis

<table>
<thead>
<tr>
<th>Investment and Revenues for the period 2015 -2040</th>
<th>Units</th>
<th>Reference Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capex for Infrastructure</td>
<td>CAD $m</td>
<td>1,159</td>
</tr>
<tr>
<td>Tax from Land use and Infrastructure ((\Sigma)(tax from land use, property tax, logistics and piperacks, services))</td>
<td>CAD $m</td>
<td>4,908</td>
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<tr>
<td>Corporation Tax</td>
<td>CAD $m</td>
<td>3,252</td>
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<tr>
<td>Personal Income Tax</td>
<td>CAD $m</td>
<td>323</td>
</tr>
<tr>
<td><strong>Total Tax</strong></td>
<td>CAD $m</td>
<td>8,483</td>
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<tr>
<td><strong>Tax earned per CAD spent on Infrastructure (Capex)</strong></td>
<td></td>
<td><strong>7.32</strong></td>
</tr>
</tbody>
</table>

Assumes ROE of 1 for CAD:USD
The Cost Benefit is based on the cumulative revenue earned by Government against the investment in infrastructure to support the cluster

<table>
<thead>
<tr>
<th>Investment and Revenues for the period 2015 - 2040</th>
<th>Units</th>
<th>Realistic Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capex for Infrastructure</td>
<td>CAD $m</td>
<td>2,297</td>
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<tr>
<td>Tax from Land use and Infrastructure</td>
<td>CAD $m</td>
<td>9,872</td>
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<tr>
<td>Corporation Tax</td>
<td>CAD $m</td>
<td>8,441</td>
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<tr>
<td>Personal Income Tax</td>
<td>CAD $m</td>
<td>547</td>
</tr>
<tr>
<td><strong>Total Tax</strong></td>
<td><strong>CAD $m</strong></td>
<td><strong>18,861</strong></td>
</tr>
<tr>
<td><strong>Tax earned per CAD spent on Infrastructure (Capex)</strong></td>
<td></td>
<td><strong>8.21</strong></td>
</tr>
</tbody>
</table>

Assumes ROE of 1 for CAD:USD
## Agenda

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</table>
Observations and Conclusions (1/3)

- The **Reference Case** will enable only a modest Midstream cluster.

- The **Realistic Case** provides for a significant cluster in global terms second only to Jubail Industrial City in scale.

- **Upgrader offgases will not provide sufficient critical mass** to support a stand-alone cluster.

- **Petcoke provides a globally significant feedstock** source which will elevate Alberta to one of the largest petrochemical based clusters worldwide with stranded feedstock economics (Realistic case).

- **A diversified gasification platform** could provide energy, hydrogen, natural gas replacement for fertilizers and world-scale petrochemicals via MTO.

- **Investment in refining** will satisfy growing diesel demand and provide **naphtha** feedstock.
Observations and Conclusions (2/3)

- The North American chemical market provides a robust demand opportunity enabling a market share of ca. 30% of the incremental growth in demand to 2040 to be achieved.

- The cluster configurations for both the Cases are primarily driven by market demand in North America balanced against the feedstock supply.

- The cluster configurations recognise that a single cluster producing ca 50 million tpa of final products cannot be viably organised into a single entity and the phasing will be required.

- The cluster configurations build in the principles of EID, making maximum use of integration and synergy opportunities within the cluster.

- Centralisation of logistics infrastructure, where it can easily be expanded with the growth of the cluster, leads to the most efficient operation.
Logistics services will be mostly outsourced in the cluster – preferably to more than one party for each activity.

The petcoke logistics system presents some challenges, which will need to be addressed at an early stage by government.

Rail is the primary transport mode for final products to market. Competitive movement of products is key to success.

The socio-economic analysis, provides a realistic basis for further development of the Midstream Cluster.

Both the Reference and Realistic Cases provide the region with an attractive cost benefit opportunity (Reference Case limited).
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