Revealing Strategies for Operation, Maintenance and Procurement to fully Evaluate Petrochemical Industry to Support Production Capacity
Perspective of an EPC Contractor- Resourcing- Labor & Equipment

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Overview- Ethylene Market/Projects
Unprecedented number of mega Oil & Gas projects in the US

- Since Q4 2011, approx. 10 MTA ethylene projects have been awarded, mostly as new grass root plants.

- There are initial indications for a “second wave” of grassroots ethylene plants in the US.

- Major revamps of existing Ethylene units are also under consideration, to use Shale derived Ethane.

- There are other projects in the US driven by Shale Gas- 
  - Monetization of natural gas (conversion of LNG import to export terminals),
  - PDH units for propylene production to replace propylene lost from naphtha crackers,
  - GTL projects in the planning phase.

Significant Competition for engineering, construction and fabrication resources in the US.
In the past, North America was a net exporter of Ethylene. In the recent years the ethylene market within North America was balanced between import and export.

By 2017, 30% additional ethylene production will be added to the US market. Large export of ethylene and derivatives will likely be needed.
Statistics - World Scale Gas based Ethylene Cracker

- Typical capacity for USGC - 1500 kta Ethylene
- Estimated investment for ISBL unit - $1.5 – $2.0 bn
- Plot Size - 960 ft X 930 ft (85000 - 100,000 sq. mt)
- Home office man-hours: 800,000 - 1,000,000

<table>
<thead>
<tr>
<th>Structural steel</th>
<th>6,500 to 10,000 tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground pipe</td>
<td>40,000 ft to 55,000 ln ft</td>
</tr>
<tr>
<td>Average dia of 7.0 to 7.8 in</td>
<td></td>
</tr>
<tr>
<td>Above ground pipe</td>
<td>650,000 to 750,000 ln ft</td>
</tr>
<tr>
<td>Electrical – power cable</td>
<td>300 km to 400 km</td>
</tr>
<tr>
<td>Instruments (ea)</td>
<td>9,000 to 11,000</td>
</tr>
</tbody>
</table>

Peak Construction Taskforce: 3000 persons
Typical Timeline: USGC Grass roots Ethylene Project

► Grass roots units

- PDP- 4-6 months
- FEED phases- Approx. 8-10 months
- Detailed Engineering & Procurement – 24 months, Construction- 30 months
- Overall EPC phase: 40-44 months

► Plant Expansions & Feed Flexibility Projects

- Overall schedule: EPC phase: 24-36 months
- Implementation is dependant on Turn-Around schedule
- Modifications rather than replacement of existing equipment, specially compressors, helps with the shorter schedules

Ethylene from plant expansion likely available to the market earlier than from grass roots units
Project Risks- US Ethylene Projects
Project Risks - Grass roots Ethylene in USGC

Risks

- Schedule Delay and Cost Over Runs resulting from:
  - Insufficient experienced resources with EPC contractors in the US to cover multiple projects – delay in design development
  - Delays in design delays Permit -application and grant- unable to begin construction
  - Lack of shop space with fabricators again due to multiple world scale projects
  - Shortage of skilled labor for construction resulting in increase in wage rates, Drop in productivity during construction phase

- Plant Performance and Reliability below expectation

Strategy needed to ensure Certainty of Outcome- Schedule /Costs/Reliability
Strategies to Mitigate Risks-
EPC Contractor’s perspective
Strategies to Mitigate Risks

Manage Schedule and Cost:

- Use “Reference Cracker” design
- Simplify engineering and procurement process
- Significantly Shorten PDP/FEED phase- leverage availability of technical data/knowledge
- Support permitting through ready technical data from Reference Cracker
- Place orders for Long Lead Equipment in FEED phase to tie down shop space, vendor costs
- Use Reference Cracker design to shorten cycle for issuing data sheets and requisitions, early placement of orders
- Use MTOs from Reference Cracker design- Certainty of quantities
- Reference Cracker plot layout allows early assessment of Constructability, planning for resources during construction
What is a “Reference Cracker Design”?

► An optimized plant design based on proven technology

- The reference plant is derived from successful gas cracker designs for the world’s three large ethylene units – safe, operable proven

✔ 1270kta Canadian cracker and 1300Kta in the Middle East in successful operation & 1500 Kta cracker designed for USGC

- Incorporates specific requirements for the current USGC projects

- Incorporates the current USGC permitting requirements

- Design that conforms to the relevant codes and standards

► Plant design documentation that is readily available

- Technical data/knowledge and experience can be leveraged to develop a fast track project
Reference Design Cracker – T-shape Plot Layout
Reference Cracking Furnace

► Standard Design of Cracking Furnace

- Enables early procurement of long lead equipment
- Provides ready information to plan/simplify erection processes
- Mechanical completion of all furnaces can be planned to be 2-3 months ahead of mechanical completion of balance of plant
Benefits of Reference Cracker design

- A proven ethylene plant capacity
- Early confirmation of basic plant configuration to minimize potential changes to process basis of design
- Equipment sizing leading to better project cost estimates, Allows early procurement for LLIs
- Equipment arrangement and preliminary plot plan available early
- Lowers front-end engineering cost
- Shorter overall project implementation schedule
Manage Availability of Home Office Resources

► Grass roots Ethylene Plant Home Office Services
   ▪ Typical Home Office Manhours- 800,000- 1,000,000
   ▪ Peak Staffing in the range of 350

► Manage Engineering and Procurement Resources:
   ▪ Leverage Engineering resources in multiple centers and share work. Maximize use of High Value Engineering Centers outside US
   ▪ Technip has Ethylene Plant Design resources in:
     ✓ Houston and Los Angeles in the US
     ✓ Paris and Rome in Europe
     ✓ Chennai, Delhi and Mumbai in India

As an example: 200 Ethylene Process Design Engineers Experts available worldwide in Technip. 100 out of these are in the US
Early Procurement for Long Lead Equipment

► Maximize placement of orders for LLE during FEED and lock-in shop space and delivery schedule

► Typical Delivery times:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cracked Gas Compressor</td>
<td>20-24 months</td>
</tr>
<tr>
<td>Refrigeration Compressor</td>
<td>18-22 months</td>
</tr>
<tr>
<td>Expander</td>
<td>16-20 months</td>
</tr>
<tr>
<td>Large Pumps</td>
<td>14-18 months</td>
</tr>
<tr>
<td>Quench Water Pumps</td>
<td></td>
</tr>
<tr>
<td>VHP BFW Pumps</td>
<td></td>
</tr>
<tr>
<td>Cold Box</td>
<td>12-16 months</td>
</tr>
<tr>
<td>C_2 Splitter</td>
<td>16 months</td>
</tr>
<tr>
<td>Quench Column</td>
<td>12 months</td>
</tr>
<tr>
<td>Reactors</td>
<td>14 months</td>
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</tbody>
</table>
Long lead items - Impact on Design & Construction

▶ Compressors and associated turbines and expanders

▶ Compressors (CGC, C3R, C2R) and expander are longest lead equipment (18 to 24 months)

- These equipment are the most critical in overall design activities (piping, building) and operation standpoint

- Limited number of suppliers: Overloading of the workshop is a major issue in case of numerous ethylene projects

- Early procurement activity feasible when using a Reference Design

▶ Large towers

▶ Very large towers (C2 splitter/C3 splitter) are the second long lead equipment

- Large towers required specific logistic for transportation

- Large towers required specific lifting which might delays other construction activities (HSE)
Cracking furnaces components require early procurement

- Radiant coils and TLE’s: Few suppliers
- Convection section generally supplied as modules to simplify construction activities. Multiple components- Alloy/SS/CS tubes, tube sheets, alloy intermediate tube sheets, finning - All required to be delivered to module fabricators
- Early design activities needed to satisfy environmental permitting needs
- Using reference furnace designs can help minimize risk of delay in placement of orders
Construction phase

Projects Schedule is mostly driven by construction

- Early definition of the mobilization for the construction using benchmark design for quantities

- Accurate MTO’s and the corresponding delivery on site to confirm mobilization

- Investigate modularization of part of the plant to minimize work on site and therefore minimize risks due to mobilization of labor on site
Examples of Modularization-
Cracking Furnaces & Balance of Plant
Mega Modular Construction
Mega Modular Construction
Module Configuration - Balance of Plant

Recent Designs for USGC:
- Transportation envelopes of 120ft x 45ft x 45ft
- Numbers of pipe-rack modules approx. 50-55
- Numbers of process modules approx. 33-35
- Maximum weight of module approx. 650 st

Modularization will help to optimize site risks. However, Module configuration adds significant additional steel to the plant
Conclusions

- Multiple World Scale Ethylene Projects in the USGC will strain EPC/Construction resources.

- Several Strategies can be used to mitigate risk of schedule delays/cost overruns.

- Utilizing reference plant designs, can help to accelerate development of technical deliverables:
  - Early permitting activity
  - Early procurement of long lead equipment

- Mitigate Construction risks through modularization.