Synergies in Air Liquide’s Syngas Technologies & Low Carbon Syngas Offer
Agenda

1. Air Liquide Overview
2. Syngas Technology Overview
3. Syngas utilization: HP ATR based methanol
4. Syngas utilization: OTF Gas Supply
5. Conclusion
1. Air Liquide Overview
Air Liquide - One business, several activities

The Air Liquide business is founded on technical and scientific expertise in essential small molecules for life, matter and energy, as well as on recognized operational know-how. Today, around 67,000 employees are working toward the shared goal of the Group’s sustainable development, driven by a true entrepreneurial spirit and the unrelenting desire for innovation that better serves our customers.

Air Liquide's value creation model works by integrating and sharing our industrial assets.

This efficient industrial system brings Air Liquide closer to its customers so that it can anticipate their needs and offer them innovative solutions. The Group currently serves more than 3 million customers and patients from a wide range of sectors.
Air Liquide climate objectives

A global approach

ASSETS
Reduce our carbon intensity in 2025 vs. 2015 by \(-30\%\)

CUSTOMERS
Act for clean industry by developing low-carbon solutions

ECOSYSTEMS
Contribute to a new low-carbon society
2. Syngas Technology Overview
# Air Liquide Hydrogen and Syngas Techno Portfolio

## Feedstock
- Natural Gas
- Biogas
- Refinery Offgas
- LPG
- Naphtha
- Residual Oil
- Renewable Electricity

## Gas Production
- SMR
- Gas POx
- ATR
- MPG
- Electrolyser

## Gas Conditioning & Purification
- CO Shift HT- / MT-
- CO Shift Isoth. / MT-
- CO₂ Removal Rectisol Cryocap
- aMDEA / MEA
- Membrane
- PSA

## Products
- H₂
- CO
- Syngas H₂ + CO
- CO₂
- H₂ & O₂

*Third party techno Operational and Integrator expertise*
Superior Syngas Solutions - Track Record

Lurgi Steam Reformer

- More than 145 Steam Reformer plants built

Lurgi Autothermal Reforming

- More than 30 Autothermal Reformer built

Lurgi POX Plants

- More than 30 POX plants built with more than 100 reactors (1)

The complete choice

- With GasPOX, Steam Reforming, Autothermal Reforming and combinations thereof we can offer ALL S/C ratios and ALL capacities

1) Includes Lurgi MPG®, Lurgi Gas POx, Shell licensed references
3.

Syngas utilization:
HP ATR based methanol
Today: Lurgi MegaMethanol™
10,000 mtpd methanol capacity at the US Gulf Coast

Texas: Natgasoline - October 2018
Louisiana: YCI-M1 - January 2019

Air Liquide: Technology Licensor, Engineering Partner and ASU Investor
Tomorrow: HP ATR based MegaMethanol Plant
10,000 mtpd methanol capacity in a single train
## Comparison of Combined Reforming and HP ATR based MegaMethanol Plant

<table>
<thead>
<tr>
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<th>Combined Reforming based MegaMethanol Plant</th>
<th>HP ATR based MegaMethanol Plant</th>
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<tbody>
<tr>
<td><strong>Production MTPD</strong></td>
<td>5 000</td>
<td>5 000</td>
</tr>
<tr>
<td><strong>Specific NG Consumption GJ/MT (mmBTU/MT) - LHV</strong></td>
<td>30.1 (28.7)</td>
<td>30.1 (28.7)</td>
</tr>
<tr>
<td><strong>Number of Reformer Tubes #</strong></td>
<td>288 (1)</td>
<td>-</td>
</tr>
<tr>
<td><strong>Amount of Oxygen Flow MTPD</strong></td>
<td>2 200 (1)</td>
<td>3 350 (1)</td>
</tr>
<tr>
<td><strong>Synthesis Compression Duty MW</strong></td>
<td>29.6 (2 compressors)</td>
<td>8.9 (1 compressor)</td>
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<tr>
<td><strong>Utility concept</strong></td>
<td>Self sufficient</td>
<td>Self sufficient</td>
</tr>
<tr>
<td><strong>CAPEX</strong></td>
<td>100%</td>
<td>90-95%</td>
</tr>
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(1) Specific to Natural Gas compositions
4. Syngas Utilization: OTF Gas Supply
Air Liquide Global Footprint

- **Global Owner Operator**
  - Air Liquide Group operates more than 90 Hydrogen, Syngas and CO Production Plants

- **Markets** catered to include,
  - **Refineries, Chemicals** (Isocyanates, acetic acid, oxo-alcohols, polycarbonate, nylon, H2O2, NH3 and others), **Metals, Electronics**
What outsourcing means...

Air Liquide will
- build, own, operate and maintain the plants, and
- sign a long-term contract (15-20 yrs) to supply products to customer through pipelines.
Avoided CO$_2$ emissions
A new driver for Syngas/H$_2$ production costs?

Air Liquide is committed to produce at least 50% of its Hydrogen for energy markets without CO$_2$ emissions by 2020. This is the Group’s “Blue Hydrogen” initiative.
Air Liquide Low Carbon Offering

**Retrofit SMRs to Syngas**
- Up to 60% emissions reduction

**Cryocap (HYCO Only)**
- Up to a 60% reduction in CO2 emissions

**CO Coldbox (HYCO Only)**
- ~40-90% footprint reduction

**Absorption Systems (Amine)**

Power Purchase Agreement
Menard County Wind Farm
Carbon Capture on Syngas/H₂ Production Unit

Solution 1: Amine Unit (aMDEA)

Solution 2: Cryocap™

Solution 3: Amine Unit (MEA)

~100% of CO₂ emissions

~40% of CO₂ emissions

~60% of CO₂ emissions

Steam Methane Reformer

Fuel Gas System

Shift

CO + H₂O → CO₂ + H₂

PSA

H₂/SYG/CO

18% of CO₂ emissions of CO₂ emissions
5. Conclusion
Conclusion

Technology + Operations

reliable
efficient
cost-effective

Solutions

Customer

Low Carbon World