Market Outlook for LDPE and Technology Trends
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Agenda

- LYB Introduction
- Market Environment/GDP and Polyolefin Consumption per Capita
- Global LDPE Market Development
- Criteria for Competitive LDPE Investments
  - Manufacturing Cost Analysis
  - Product Differentiation
- Specific LDPE growth areas by application
- Specific *Lupotech* T Innovations
- Conclusion
Who We Are

- $44 billion market capitalization
- Global independent chemical company, incorporated under Dutch law
- Executive offices in London, Rotterdam, and Houston
- Products sold in ~100 countries

Global Market Positions

### Chemicals
- Ethylene
- Propylene
- Propylene Oxide

### Polymers
- Polyolefins (PE and PP)
- Polypropylene
- Polyethylene
- Polypropylene Compounds

### Oxyfuels
- MTBE and ETBE

### Technology and R&D
- Polyolefins Licensing

5-Year Total Shareholder Return vs. Peers

(1) Total shareholder return over period from Jan 1, 2012 to Dec. 31, 2016. Source: Factset.

(2) Source: IHS MARKIT, LYB. Reflects market positions of chemical-grade and polymer-grade propylene (not refinery-grade).
LyondellBasell licensing offering

Polyolefins Technologies

- **Spheripol**
  - Benchmark PP process

- **Spherizone**
  - Differentiated PP process

- **Lupotech**
  - LDPE/EVA processes

- **Spherilene**
  - LL/HDPE process

- **Hostalen**
  - Multimodal HDPE process

Chemicals Technologies

- **Olefins Recovery and Conversion**
  - Trans4m for Butadiene, Butenes, Isoprene, DCPD

- **Aromatics Extraction**
  - From Coke Oven / Pygas
  - Benzene, Toluene, Xylenes

- **Acetyl**
  - Glacido acetic acid process, 
  - Vacido vinyl acetate monomer (VAM) process

- **Oxiranes & Derivatives**
  - Propylene oxide, Styrene, Butenes
  - MTBE/ETBE, Butanediol

**A comprehensive portfolio of technologies for license**
Global trends create a growing demand for Polymer based products

Growing Population

- By 2030 global population will rise by more than 1 billion to 8.3 billion

Growing Urbanization

- 85% urban population growth by 2050
- 78 trillion in global infrastructure investment required over the next 10 years to accommodate growth

Growing Middle Class

- The world’s growing middle class will drive a 32% increase in vehicle sales by 2030
- Plastics consumption is expected to double over the next 20 years

Growing Demand for Resources/Improved Sustainability

- Global growth will increase demand for food, water and energy by 35, 40, and 50 percent respectively by 2030

Sources:
- PwC Global Megatrends Report, 2017
World Market Trend
Growth of middle class is driving Polyolefins growth

Growth driven by increase in per capita consumption

- Developing countries have typical higher growth rates for Polyolefines consumption
- Inline with stronger GDP growth and larger growth potential per capita

Significant investment required to match demand growth, mainly in Asia
Global Macro Trends
Demographics Driving Demand

Upper/Middle Class Households

Households, millions

2016 Polyolefins Consumption

Consumption, lb/person

Global Ethylene Cost Curves

Source: IHS MARKIT
Market Environment

- **Long term Growth of PE and PP**

- Growth rate for Polyolefins is about 4-5% p.a

Source: IHS MARKIT 2015
Global LDPE Market Development

- Global LDPE demand expected to grow about 3% p.a. during next 5 years
- 2-3 new LDPE lines required p.a. to match demand growth

Source: 2016 IHS MARKIT

Steady demand growth for LDPE will require new investments
Drivers for new LDPE Investment

- Continued demand growth is driver for new LDPE investments
- Local feedstock costs are important for project economics
- Cost for power and utilities remain a key driver in technology selection for projects
- Recovery of heat of polymerization reduces variable costs significantly
- Capability for value added products

Cash Cost Analysis LDPE

- 90% Fixed Costs
- 5% Power and Utilities
- 3% Chemicals and Additives
- 2% Monomer

Source: Internal LYB Estimates

This Technology selection for benchmark operating costs and revenue
Lupotech T - LDPE Tubular Technology

Leading high-pressure tubular reactor process for the production of LDPE and EVA copolymers

- Market leader with approximately 11 million tons of total licensed capacity
- Largest single line capacity up to 450 kt/a
- State-of-the-art world-scale plants (300-400 kt/a) in operation since many years
- Wide-grade slate, including higher density products and EVA copolymers up to 30% VA
- Largest EVA copolymer plant in operation
- Very low investment and operating costs
- Stable, flexible and optimized operability
LDPE Tubular Reactor Economics

Estimated *Lupotech T* Operating costs

<table>
<thead>
<tr>
<th>Power</th>
<th>Initiator &amp; Chemicals</th>
<th>Extruder Additives</th>
<th>Steam</th>
<th>Export</th>
</tr>
</thead>
<tbody>
<tr>
<td>-30</td>
<td>-20</td>
<td>-10</td>
<td>0</td>
<td>10</td>
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</tbody>
</table>

### CAPEX Saving

<table>
<thead>
<tr>
<th>Differential benefits</th>
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<tbody>
<tr>
<td>Reactor: Smaller plot, Uniform diameter, Short radius bends, Simplified innovative PX dosing system, Lower design pressure</td>
</tr>
<tr>
<td>Cooling system: No need for extensive chilling unit</td>
</tr>
<tr>
<td>HP compressor: Optimized Operating pressure, Single crankshaft machines up to 450 KTA, Smaller motor</td>
</tr>
<tr>
<td>Others: Reduced HP recycle system, Low number of degassing silos</td>
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Source: Consultant report, LYB analyses

- *Lupotech T* specific process features with a potential for significant savings on running costs
- Up to 10% savings on capital investment due to specific *Lupotech T* differential elements

Favorable Economics based on competitive power & utilities costs
**Lupotech T Advancements**

**Efficiency Increases**

- Monomer losses reduced up to 40%
- Initiator reduction by 50%
- Energy reduction by 20%

- Scale up factor > 5 in 30 years
- Today: Up to 500 kt/a

Source: LYB

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**Increase of Plant Efficiency of Lupotech T lines**

**Relative Reduction of critical Consumption and Losses**

- 1975: 100%
- 1985: 90%
- 1995: 80%
- 2005: 70%
- 2015: 60%

Source: LYB

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**Design Capacity of new installed Lupotech T Lines**

- 1980: 50 KTA
- 1990: 100 KTA
- 2000: 150 KTA
- 2005: 200 KTA
- 2010: 250 KTA
- 2016: 300 KTA

Source: LYB
Use of Plant Service Programs for increasing Plant Efficiency

- Significant reduction of monomer losses through:
  - Introduction of service programs which allow to keep ethylene inventory to a large extent within plant when experiencing operational disturbances (applied in case of non critical process/plant disturbances)
  - Reduction of number of plant shut downs up to 60%
  - Increased plant availability

**Lupotech T Configuration**

**Reactor Depressurization during Service Program**

Higher monomer efficiency and increased plant availability
Lupotech T Advancements

Use of a High Strength Steel as Reactor Tube Material

- Significant reduced reactor tube wall thickness (20%)
- Improved heat transfer through reactor walls
- Thinner wall thickness leads to improved fracture mechanics (leak before break behaviour)
- Reduced Investment (ca.40% material savings)
- Selected material is 3,5 Nickel steel according ASME SA 723, modified

Optimization of Reactor Design Pressure results in further Savings

<table>
<thead>
<tr>
<th>Tube Design Pressure: 3600 bar</th>
<th>Tube Design Pressure: 3200 bar</th>
</tr>
</thead>
<tbody>
<tr>
<td>181 mm</td>
<td>136 mm</td>
</tr>
<tr>
<td>75 mm</td>
<td>75 mm</td>
</tr>
</tbody>
</table>

Increased Process Conversation Rate (up to 5%)
Reduced Investment for reactor Tubing (up to 20%)

Source: LYB
**Lupotech A – Autoclave Polyethylene Technology**

Autoclave process for the production of LDPE and very high EVA copolymers

- Well-proven technology
- 44 reactors in operation
- 1.8 million tons licensed capacity
- 4 licenses granted in 2013 (4 x 100KTA)
- High reliability
- EVA content up to 40 wt % for specialty application
- Optionally Ethylene/Acrylic Copolymers
- Broadest line of LDPE resins
- Specialty products based on unique long-chain branching structures

LDPE  High EVA
Source Basell PO GmbH
Typical High EVA Applications

- **Films**
  - Food Packaging
  - Greenhouse
  - Photovoltaic

- **Moldings**
  - Footwear
  - Profiles

- **Hot Melt Adhesives**
Photovoltaic Market Growth

- Global Annual Market Growth of Photovoltaic Installations

Lupotech process provides potential for significant reduction of running costs

Data: IHS MARKIT. Graph: PSE 2017
Conclusion

- Investments in new LDPE plants will continue based on steady market growth.
- New Investments in LDPE capacity are focused to areas with advantaged feedstock or above average market growth.
- Areas with advantaged feedstock position are favoring investments in large scale commodity plants.
- Investments designated for local markets are typically focusing on value added specialty grades.
- Significant differentiation of manufacturing costs by selecting processes with optimized heat integration and reduced power consumption.
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