Motivation of the project

- Competitiveness of the European chemical industry
- What could be done to reduce emissions while maintaining or increasing competitiveness?
- Implications and further considerations
In the long-run (2050) low-carbon economy makes economic sense and is necessary
• Economic equilibrium models affirm value of low-carbon economy
• However, equilibrium models, scenarios and roadmaps must not be mistaken for a transition plan

Transition dilemma
• Incremental changes vs. disruptions of business models
• Strategy within or outside existing industry boundaries
• Policy aspiration level and policy risk

In the short-run (2030) concerns about cost-competitiveness dominate
• The shale gas price differential between US/EU
• Electricity cost differentials
• Demand growth within the existing business models driven by Asian emerging middle classes
Contents

▪ Motivation of the project

▪ Competitiveness of the European chemical industry

▪ What could be done to reduce emissions while maintaining or increasing competitiveness?

▪ Implications and further considerations
# Production cost comparison

## USD/ton (except carbon fiber)

<table>
<thead>
<tr>
<th>Energy intensive products: Polyvinyl chloride (PVC)²</th>
<th>Feedstock intensive products: Polycarbonate</th>
<th>Regional products/processing: Rigid polyurethane</th>
</tr>
</thead>
<tbody>
<tr>
<td>-78% -54% -39%</td>
<td>-25%</td>
<td>-27%</td>
</tr>
<tr>
<td>191</td>
<td>2,089</td>
<td>2,283</td>
</tr>
<tr>
<td>404</td>
<td>2,153</td>
<td>2,896</td>
</tr>
<tr>
<td>533</td>
<td>2,268</td>
<td>2,899</td>
</tr>
<tr>
<td>868</td>
<td>2,480</td>
<td>3,141</td>
</tr>
<tr>
<td>878</td>
<td>2,555</td>
<td></td>
</tr>
<tr>
<td>1,058</td>
<td>2,610</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2,774</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Customer/service intensive products: Polyalphaolefins</th>
<th>Innovation/high-value products: Carbon fiber⁹ USD / kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>-28%</td>
<td>-35%</td>
</tr>
<tr>
<td>1,879</td>
<td>19-23</td>
</tr>
<tr>
<td>2,593</td>
<td>26-30</td>
</tr>
<tr>
<td>2,874</td>
<td>31-35</td>
</tr>
<tr>
<td>2,944</td>
<td></td>
</tr>
</tbody>
</table>

Europe generally has a cost disadvantage compared to other regions, mostly driven by raw materials and electricity vs. the US and Saudi Arabia, and by labor, maintenance and SG&A vs. China

**NOTE:** Results modeled based on market prices of utilities and benchmarked data by process and country; 1 Includes mainly fuel for heat and steam, but also catalysts, additives etc.; 2 Raw material costs can be negative as chlorine production generates by-product revenue from caustic soda; 3 Inland carbide with electricity from coal; 4 Ethylene with electricity at market price; 5 Coastal carbide with electricity at market price; 6 Asahi - buy BPA; 7 Phosgene - buy BPA; 8 Phosgene – buy phenol; 9 Estimate. **SOURCE:** McKinsey margin models
Examples of cost differences between Europe and other regions

**PVC USD/ton output**
- Raw materials: €136
- Electricity: €65
- Other variable cost: €84
- Labor: €18
- Maintenance & plant overhead: €45
- SG&A: €3

**Polyurethane USD/ton output**
- Raw materials: $406
- Electricity: $205
- Other variable cost: $286
- Labor: $13
- Maintenance & plant overhead: $205
- SG&A: $2,283

**SOURCE:** McKinsey margin models
Historical growth of the chemical industry across regions

Total gross output\(^1\), EURbn, nominal

North America
- 1990: 206
- 2000: 402
- 2011: 453

EU27
- 1990: 258
- 2000: 378
- 2011: 529

Middle East
- 1990: 9
- 2000: 23
- 2011: 68

Latin America
- 1990: 41
- 2000: 73
- 2011: 145

Africa
- 1990: 9
- 2000: 16
- 2011: 20

Asia-Pacific
- 1990: 196
- 2000: 444
- 2011: 1,332

EU27
- 1990: 258
- 2000: 378
- 2011: 529

World\(^2\)
- 1990: 730
- 2000: 1,360
- 2011: 2,635

\(^1\) Total chemical industry excluding pharmaceuticals; \(^2\) Also includes European non-EU27 countries (not shown on page)

SOURCE: IHS Economics
Europe maintains a trade balance surplus in chemicals corresponding to ~4% of total domestic production

1 Total chemical industry excluding pharmaceuticals; 2 Wholesale price for Germany; 3 Average German import price
SOURCE: IHS Economics; Enerdata
<table>
<thead>
<tr>
<th>Region</th>
<th>Conventional economics</th>
<th>Other crucial factors</th>
<th>Integration/resilience</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost position</td>
<td>Local demand growth¹</td>
<td>Access to skilled labor²/education³</td>
</tr>
<tr>
<td>EU27</td>
<td>25-50% disadvantage compared to other regions</td>
<td>1-3%</td>
<td>17 / 14</td>
</tr>
<tr>
<td>US</td>
<td>10-40% advantage vs. Europe</td>
<td>2-4%</td>
<td>6 / 25</td>
</tr>
<tr>
<td>China</td>
<td>Higher cost than EU for some products, up to 50% lower cost for others</td>
<td>&gt;10%</td>
<td>44 / 54</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>Cost advantage (up to &gt;50%) for bulk chemicals</td>
<td>~8%</td>
<td>31 / 39</td>
</tr>
</tbody>
</table>

**NOTE:** Europe represented by Germany in rankings; 1 Calculated as production minus net exports between 2011-2016 using data from IHS Economics; 2 Rank in “Availability of scientists and engineers”, World Economic Forum (WEF); 3 Rank in “Quality of the Educational System”, WEF; 4 Rank in the World Bank’s ease of doing business index 2013; 5 Rank in Transparency International’s corruption perception index 2013

**SOURCE:** World Bank Doing Business 2014; IHS Economics; WEF Global Competitiveness Report 2013-2014; Transparency International
Investment trends for Europe and the US

Actual and announced investments compared to existing production volume
Petrochemicals only, USD/ton

- Translates to capacity growth of ~20% 2013-2018 for petrochemicals (~50% of industry)
- Petrochemicals likely to benefit most from shale gas – lower growth for other segments
- Too few announcements after 2018 to make projections

1 Data for petrochemicals only, excludes inorganics and specialties. Includes new investments and maintenance capex (maintenance calculated as 1.5% of replacement value), excludes cost of plant conversion (Europe has heavily converted chlorine plants and the US has converted crackers)
SOURCE: McKinsey models
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Key abatement levers across the value chain

**Use bio-ethylene as feedstock**
- Can technically substitute petrochemical based ethylene completely
- Bio-ethylene based on ligno-cellulosic biomass required, with uncertain feasibility in near to mid-term horizon
- Breakthrough dependent on local conditions, technology mature and economic viability

**Implement new technology in chlorine electrolysis**
- Continue shift from mercury cell electrolysis towards more energy efficient membrane cell and ODC electrolysis
- Compared to mercury cell, membrane cell has ~25% lower emissions. In ODC technology emissions are ~40% lower than mercury cell emissions

**Increase recycling rates with focus on pipes, fittings and window frames**
- Composite structures containing at least 70% of PVC can be recycled using, e.g., the VinyLoop process
- Availability of used PVC a short term barrier given lifetimes of up to 50 years and more
- Large potential from installed base in the coming decades from lead and cadmium free production since the 1980’s

**Switch to green energy throughout the value chain**
- Non-fossil energy share of total electricity production to be increased from today’s 46% to ~70%, reducing CO₂ emissions from electricity generation by ~50%

**Improve process and energy efficiency**
- Continuous efficiency improvements in multiple process steps leading to a 25% reduction by 2030 (~2% p.a.)
- Examples may include improved polymerization techniques and decomposition of GHGs

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1 Partnership between Solvay and Serge Ferrari; 2 Based on Enerdata Emergence case
SOURCE: Analysis based on industry reports and interviews
Mapping of abatement opportunities by competitiveness impact and complexity

Integration and governance complexity

1 Given the highly varying emission baselines for the five chemicals and thus varying absolute abatement potentials for the different levers, the analyses have been normalized to provide indicative ranges of the total opportunity. For the scope 3 opportunity, global multiplier effects are excluded in this calculation.
Industrial themes for the chemical industry

- Carbon leakage risk
- Tradeoffs
- Competitive opportunities stopped by non-economic barriers

Impact on competitiveness:

- Very negative: Could cause segments to relocate
- Negative: Puts stress on financial performance
- Neutral: No major effects on competitiveness
- Positive: Opportunities for growth
- Very positive: Could make segment a world champion

Integration and governance complexity

Innovation related opportunities
- Cross-sector collaboration
- Advanced materials innovation
- Circularity
- Cross-country/region
- Cross-process
- Single process
- Factor cost
- Integration and governance complexity

Advanced materials innovation
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The policy framework and the transition

Reduce own emissions and resource use in the current industrial structure
  - E.g., process and energy efficiency

Reshape industrial system to reduce own emissions and resource use
  - E.g., circularity, cross-sector collaboration

Provide advanced markets for novel low-carbon solutions
  - E.g., fuel efficiency standards for vehicles

Develop global solutions through innovation oriented policy
  - E.g., advanced materials innovation

Should Europe broaden its focus?
Thank you!

http://europeanclimate.org/europes-low-carbon-transition-understanding-the-chemicals-sector/

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