Innovative approach for the development of established Refinery-Chemical cluster structures in Europe

- Presentation for the annual ÖGEW/ DGMK conference -

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Challenges for Refinery-Chemicals-Clusters in Europe

Case Study: “Chemiecluster 4.0” concept in North-Western Germany

Implementation levers
Many structures in the chemical industry were designed along vertically integrated value chains by single companies - and disintegrated later...

Industry trends

Development of key companies in the global chemical industry

1980 - 1989

1990 - 1999

2000 - today

Oil & Gas

Petro-chemicals

Other commodities

Specialty chemicals

Agro-chemicals

Pharmaceuticals

BASF

Hoechst

Dow

Bayer

DuPont

ICI

Aventis

Clariant

Ticona, Celanese

BASF

ICI

Solvay

Solvay

Celanese

Ticona

Solvay

Solvay

IPOs

Lanxess

Ineos

Bayer

Covestro

DuPont

AstraZeneca

Syngenta

With growing maturity vertical integration was often replaced by horizontal integration in order to achieve leading market positions in specialised segments

Source: BASF, allocate
Exception BASF: constant focus on value optimization along chemical value chains and „Verbund“ synergies - rather than on isolated economics only

Consideration of integrated margins from complete value chains

Ethylene Cash Cost curve for Europe (incl. logistic costs) in USD/t, 2020

- “Stand alone” economics of petro-/base-chemical production in Europe is in particular important if there is a direct competitive pressure through cheap product imports
- The structure of the embedding into larger integrated chemical cluster structures determines strongly the competitiveness against imports
- The competitiveness is generally high if a strong upgrading of base products to specialities is realized or if an “on site” processing is required for technical reasons (e.g. critical transport like with ethylene oxide)
- Application of new synergy and “win-win” models for chemical clusters with complex owner structures is key to success for EU chemical companies

- Strong physical integration also in other chemical clusters:
  > Historically developed structures with underlying rationale
  > Today owned by different owners with own interests

How can the benefits from an integrated chemical value chain optimisation be applied on heterogeneous owner structures in complex clusters?

Source: APPE, McKinsey, allocate,
Through transformation of formerly single owned sites into chemical parks & clusters some integration benefits were maintained

Industry trends

<table>
<thead>
<tr>
<th>„Closed“ single owned chemical sites</th>
<th>Chemical „parks“</th>
<th>Regional interlinking of chemical sites</th>
<th>Trans regional linking of chemical sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Hüls AG, Marl</td>
<td>• EVONIK, Marl</td>
<td>• CHEMSITE</td>
<td>• Chemieregio NRW</td>
</tr>
<tr>
<td>• Hoechst AG, FFM</td>
<td>• INFRASERV, div.</td>
<td>• CHEMCOLOGNE</td>
<td>• AR Cluster</td>
</tr>
<tr>
<td>• Bayer AG, Lev., div.</td>
<td>• CURRENTA, Lev., div.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key driver of the transformation: strategy change of chemical companies

Favourable and transparent framework conditions shall be created to catalyze investments and establishment of new product lines

Chemical product value chains are still an important aspect for the attractiveness of chemical sites

Intensive site marketing to attract new players and investments

This concept was rather successful - but new challenges may require a big next step to maintain competitive structures in the European chemical industry

Source: allocate
Negative investment trend in the chemical sector in the EU – this might finally cause a silent erosion of the asset substance

Investments in the EU Chemical Industry

The current re-investment ratio in the EU is insufficient to maintain the currently strong position of the chemical industry in Europe – new solutions for products, energy and raw materials are key.

Source: CEFIC, allocate
Despite the generally positive outlook for the chemical sector it is expected that investments in EU chemical sites will decrease further.

Investments in the chemical industry

Is the erosion of investments in the European chemical sector really an unavoidable fate – or is it possible to stimulate investment activity by the application of innovative approaches?

Source: VCI, allocate
Erosion trends in EU petrochemicals – mainly caused by enhanced international competition - are already visible

EU chemicals trade balance according to product categories

From our point of view it would be a questionable and non sustainable approach for EU chemical companies to accept this erosion over a longer period and to focus on speciality chemicals only

Quelle: CEFIC, allocate
The renaissance of the US petrochemical industry is triggered by cheap Ethane feedstock and low energy prices through Shale Gas

Impact of new feedstock availability

- Ethane is heavily favoured
  - BTU Basis
  - Ethylene cash cost
- NA ethylene is advantaged to global naphtha production
  - Operating rates remain robust

Like in the Middle East the focus of new investments in the US is based Ethylene based chemistry – in the US making most vale adding use of Ethane from Shale Gas

Source: IHS data, allocate
Low energy and raw material costs provided by Shale Oil & Gas a lot of benefits for the US economy – employment, value added and taxes

Benefits Shale Gas and Shale Oil production in the USA

- **Contribution to value-added GDP:** $1,400 per capita
- **Jobs supported:** 2.7 million
- **Salary currently supported by unconventionals:** 1.9 times the national median income
- **Annual savings from low-cost natural gas:** $800 per household
- **Federal tax revenue contribution:** Equal to a 13% reduction in the federal budget deficit

Note: Estimates include all direct extraction, transport, and refining of unconventional oil & gas, as well as activities that support this production, such as oil field services and local services. Value-added GDP figure expressed in 2012 dollars. Annual energy savings expressed in 2014 dollars. Federal budget deficit estimate for 2013.


How can European chemical producer reduce the advantage of foreign producers – by a package of measures including smart cost reduction, repositioning and leading edge innovation

Source: Michael Porter, Harvard University, BCG, allocate
The production of some chemicals is very energy intensive – thus low energy costs are a key factor for chemical site attractiveness

Energy costs in the chemical industry

**Table 1: Most important chemical processes in Europe**

<table>
<thead>
<tr>
<th>No.</th>
<th>Product / process</th>
<th>Process and steam emissions [Mt CO₂ equivalents]</th>
<th>Share</th>
<th>Cumulative share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nitric Acid</td>
<td>41 d</td>
<td>21.6%</td>
<td>21.6%</td>
</tr>
<tr>
<td>2</td>
<td>Cracker products (HVC)</td>
<td>35</td>
<td>18.4%</td>
<td>40.0%</td>
</tr>
<tr>
<td>3</td>
<td>Ammonia</td>
<td>30</td>
<td>15.8%</td>
<td>55.8%</td>
</tr>
<tr>
<td>4</td>
<td>Adipic acid</td>
<td>13 d</td>
<td>6.8%</td>
<td>62.6%</td>
</tr>
<tr>
<td>5</td>
<td>Hydrogen / Syngas (incl. Methanol)</td>
<td>12.6</td>
<td>6.6%</td>
<td>69.3%</td>
</tr>
<tr>
<td>6</td>
<td>Soda ash</td>
<td>10</td>
<td>5.3%</td>
<td>74.5%</td>
</tr>
<tr>
<td>7</td>
<td>Aromatics (BTX)</td>
<td>6.6</td>
<td>3.5%</td>
<td>78.0%</td>
</tr>
<tr>
<td>8</td>
<td>Carbon black</td>
<td>4.6</td>
<td>2.4%</td>
<td>80.4%</td>
</tr>
<tr>
<td>9</td>
<td>Ethylene dichloride / Vinyl chloride / PVC</td>
<td>4</td>
<td>2.1%</td>
<td>82.5%</td>
</tr>
<tr>
<td>10</td>
<td>Ethylbenzene / Styrene</td>
<td>3.6</td>
<td>1.9%</td>
<td>84.4%</td>
</tr>
<tr>
<td>11</td>
<td>Ethylene oxide / Monomethylene glycol</td>
<td>3.6</td>
<td>1.9%</td>
<td>86.3%</td>
</tr>
<tr>
<td>12</td>
<td>Cumene / phenol / acetone</td>
<td>1.2</td>
<td>0.6%</td>
<td>86.9%</td>
</tr>
<tr>
<td>13</td>
<td>Glyoxal / glyoxylic acid</td>
<td>0.4</td>
<td>0.2%</td>
<td>87.2%</td>
</tr>
<tr>
<td>14</td>
<td>Polyolefins (PE / PP / PS)</td>
<td>1.1</td>
<td>0.6%</td>
<td>87.7%</td>
</tr>
<tr>
<td>15</td>
<td>Butadiene</td>
<td>0.6</td>
<td>0.3%</td>
<td>88.1%</td>
</tr>
<tr>
<td>16</td>
<td>Dimethyl terephthalate / Terephthalic acid / Polycarbonate terephthalate</td>
<td>0.6</td>
<td>0.3%</td>
<td>88.4%</td>
</tr>
<tr>
<td>17</td>
<td>Propylene oxide</td>
<td>0.5</td>
<td>0.3%</td>
<td>88.6%</td>
</tr>
<tr>
<td>18</td>
<td>Others</td>
<td>1.1</td>
<td>1.4%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Source: [Ecofys, 2019]

Besides resource aspects energy costs are also strongly affected by EU and national legal energy policy – but there are still options to handle these specific framework conditions to some extend

Source: VCI, allocate
An increase of energy prices for industrial customers will sharply affect the investment appetite, in particular in energy intensive industries.

Impact of increasing energy prices on industrial investments

**Reaktionen der Industrie auf einen Strompreisanstieg** (Veränderung in % bei einem Strompreisanstieg von 20% in drei Jahren)

- **Investitionen verringern**
  - Energieintensive Unternehmen: 67,8%
  - Nicht-energieintensive Unternehmen: 38,7%
- **Beschäftigung verringern**
  - Energieintensive Unternehmen: 78,2%
  - Nicht-energieintensive Unternehmen: 48,2%
- **Absatz verringern**
  - Energieintensive Unternehmen: 77,9%
  - Nicht-energieintensive Unternehmen: 46,4%
- **Bestrebungen zur Verlagerung von Betriebsstätten erhöhen**
  - Energieintensive Unternehmen: 57,1%
  - Nicht-energieintensive Unternehmen: 36,9%
- **Innovationen verringern**
  - Energieintensive Unternehmen: 27,9%
  - Nicht-energieintensive Unternehmen: 16,7%

Energy prices are key for investments and employment in the industry – the „energy turnaround“ in some European countries creates a specific new challenge.

Source: Institut der Wirtschaft, allocate
Content

Challenges for Refinery-Chemical-Clusters

Case Study: “Chemie-cluster 4.0” concept in North-Western Germany

Implementation levers
Chemical clusters should create new perspectives with a stakeholder driven approach – beyond the shareholder perspective of companies

Aspects of a site perspective and a company perspective

**Site perspective**
- Local jobs
- Tax income generation
- Competitive position towards alternative sites
- Long term development perspektive and investments
- Independent from the interests of a single company
- Core interest of the local politics and the unions/employees

**Company perspective**
- Contribution to shareholder value
- Competitive position to produce specific products (cash costs)
- Optimal utilization of employed capital
- Optimal focus on market changes and customer requirements
- Direct deduction from the comprehensive corporate strategy
- Can be realized in autarcy without consideration of others

Chemical sites and the associated stakeholders need to contribute actively to site development from their own perspective – focus on already present companies is not enough

Source: allocate
Chemiecluster 4.0 Project in Germany: an innovative approach for chemical site development including a broad set of stakeholders

Intensive involvement of companies and stakeholders in site development

Quite complex challenge to realize coordinated site development and investments with players which to some extend have also diverging interests

Source: ChemSite, allocate
The project was structured along 7 key themes and tailored project modules

Key subjects to develop a Chemical Cluster

1. Further development of infrastructure across the entire cluster
2. Innovative solutions for competitive energy supply in the specific “Energy Turnaround” framework
3. New options to enhance the value from integrated product flows (new investments)
4. New opportunities through digitalization („Industry 4.0“)
5. Closer integration with customers (Chemical industry as industrial „Building Block“)
6. Additional feedstock and recycling options
7. Concept for a powerful implementation, investment and project development vehicle

Joint workshops with experts in order to identify profitable project and investment opportunities which cannot be realised by a single company alone

Source: allocate
20 identified development options for the refinery-chemicals-cluster were allocated to 3 general categories - which are partly interdependent

Categorisation project options

<table>
<thead>
<tr>
<th></th>
<th>Enhancement of competitiveness and site attractiveness as prerequisite for an adequate return on the investments</th>
<th>Optimisation of existing chemical value chains with adoption to changing market requirements</th>
<th>Systematic settlement of attractive growth businesses through creation and utilisation of ideal site conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Essential prerequisite for profitability and realisation of investments</td>
<td>Clear economic rationale with selective relevance for a specific site</td>
<td>Systematic understanding of the link between growth segments and specific site attractiveness factors</td>
</tr>
<tr>
<td></td>
<td>Rel. low „own“ investment requirements</td>
<td>Strengthening of existing chemical value chains &amp; enhancement of value creation</td>
<td>Deduction of a „Cluster USP“</td>
</tr>
<tr>
<td></td>
<td>According to our experiences only successful as a package („Site alliance/site deal“)</td>
<td>Adoption to changing market requirements and feedstocks</td>
<td>Focused dialogue with selected investors based on precise offering</td>
</tr>
<tr>
<td></td>
<td><strong>Not the „real“ objective of the project - but indispensable</strong></td>
<td><strong>Improvement of structures – even beyond the scope of the companies already located on the site</strong></td>
<td><strong>Based on a clear USP active offering of project development opportunities</strong></td>
</tr>
</tbody>
</table>

Source: allocate
The identified 20 project options were evaluated regarding realisation complexity and benefit

Categorisation of options in the benefit vs. realisation complexity matrix

Primary focus is on „Quick Wins“ – but the preparations for the realisation of some more challenging „High hanging fruits“ need to be started in parallel due to fast moving markets

Source: allocate estimate
Besides other factors Cash Costs are essential for competitiveness and future investments – and need to be addressed in parallel...

Comparison of site related Cash Costs

Investments and development of the chemical value chains cannot be separated from the cost efficiency of a specific site

Target cost to achieve an adequate investment return

Status: only few investments currently with good return

Source: allocate
An even stronger exploitation of synergies from deeply integrated chemical production supports the competitiveness of the sites.

Synergies through integration:
- Reduced logistic costs
- Lower utility costs through process integration
- Reduced costs of capital / reduced investment
- ...
**Conventional advantages of chemical cluster structures can be enhanced by digitalisation („Chemistry 4.0“)**

„Chemistry 4.0“ for chemical cluster structures

<table>
<thead>
<tr>
<th>Function</th>
<th>Traditional Verbund</th>
<th>Maximum savings</th>
<th>New Verbund</th>
<th>Key focus</th>
<th>On top savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logistics</td>
<td>• On site synergies</td>
<td>60%</td>
<td>• Self organized and leveraged</td>
<td>CPS, Cloud based and virtual</td>
<td>10-20%</td>
</tr>
<tr>
<td></td>
<td>• Multi purpose logistics assets</td>
<td></td>
<td>• Predictive S&amp;OP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Initial value chain integration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>• Upstream integrated</td>
<td>30%</td>
<td>• Leveraging market liquidity</td>
<td></td>
<td>5-15%</td>
</tr>
<tr>
<td></td>
<td>• Fossil energy</td>
<td></td>
<td>• Including renewable and smart</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Base load focus</td>
<td></td>
<td>• Demand side management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>• Time based services</td>
<td>10%</td>
<td>• Predictive and sensor based</td>
<td></td>
<td>3-10%</td>
</tr>
<tr>
<td></td>
<td>• Partly outsourced</td>
<td></td>
<td>• Performance related</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Frame contract or insourced</td>
<td></td>
<td>• Scalable and on demand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procurement</td>
<td>• Strategic sourcing</td>
<td>15%</td>
<td>• Category strategies</td>
<td></td>
<td>5-15%</td>
</tr>
<tr>
<td></td>
<td>• Supplier development</td>
<td></td>
<td>• Crowd sourcing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Limited compliance</td>
<td></td>
<td>• Learning procurement IT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>• Push and product focused</td>
<td>10%</td>
<td>• Pull and eco system extended</td>
<td></td>
<td>10-30%</td>
</tr>
<tr>
<td></td>
<td>• Organically</td>
<td></td>
<td>• Open innovation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Chemistry and Physics</td>
<td></td>
<td>• Applications and combinations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR</td>
<td>• Organization and processes</td>
<td>20%</td>
<td>• New competences and business</td>
<td></td>
<td>5-10%</td>
</tr>
<tr>
<td></td>
<td>• Resources</td>
<td></td>
<td>• MINT talents</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• STEM* capabilities</td>
<td></td>
<td>• Smart and customer centric</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clients</td>
<td>• Customer requirements</td>
<td>30%</td>
<td>• Customers of customers</td>
<td></td>
<td>10-20%</td>
</tr>
<tr>
<td></td>
<td>• One face to the customer</td>
<td></td>
<td>• Crowd based customer services</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Initial value chain integration</td>
<td></td>
<td>• Predictive demand</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: ChemManager April 2016, Deloitte

*Science, Technology, Engineering and Mathematics

Application of new technological options in the context of digitalisation to enhance the competitiveness of larger chemical clusters – even beyond the scope of individual companies
The changes in the energy sector create challenges – but the chemical industry can provide a toolbox of innovative solutions & benefits

Toolbox for the Chemical Industry to provide innovative energy solutions

<table>
<thead>
<tr>
<th>„Power to Chemistry“</th>
<th>Energy solutions for complex industrial clusters</th>
<th>Innovative products for energy applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric arc synthesis – on-off flexible C₂ chemistry</td>
<td>Demand-Side-Management – for plants with Swing Producer potential</td>
<td>Innovative energy storage facilities (z.B. solid-state batteries, V-Redox)</td>
</tr>
<tr>
<td>H₂ from Renewable Energy for different hydrogenation synthesis</td>
<td>Industrial gases (N₂, O₂) as energy storage option</td>
<td>Innovative basic materials for energy efficiency &amp; generation</td>
</tr>
<tr>
<td>„Power to Gas“: Methane (and perhaps other HCs) via H₂ (reg. energy) + CO₂</td>
<td>Heat integration of plants and export of heat to district heating grid</td>
<td>Nano technology for LEDs etc.</td>
</tr>
<tr>
<td>Methanol: Hydrogenation of CO₂</td>
<td>Substitution of fossile energy through Renewable Energy</td>
<td>.....</td>
</tr>
<tr>
<td>.....</td>
<td>.....</td>
<td>.....</td>
</tr>
</tbody>
</table>

Developing a master plan to specifically adopt a chemical cluster to new challenges and opportunities arising around energy supply and energy solutions
An integrated cluster wide approach for the application of new energy solutions is essential – because benefits occur distributed, not isolated.

Example for the need for integrated evaluation of innovative energy solutions

Example: utilisation of CO₂ as chemical feedstock (e.g. for CH₄ or CH₃OH)

<table>
<thead>
<tr>
<th>„Stand alone“ evaluation</th>
<th>„Integrated“ evaluation</th>
<th>„Integrated“ evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>High energetic input – low utilisation rate</td>
<td>Szenario A: Energy supply based on Renewable</td>
<td>Szenario B: New integration of „traditional“</td>
</tr>
<tr>
<td>for electricity from Renewable Energy sources</td>
<td>Energy sources would require cost</td>
<td>energy</td>
</tr>
<tr>
<td>Alternative applications for Renewable Energy</td>
<td>intensive energy storage or much overstretched</td>
<td>+ Economic supply of base load with fossil</td>
</tr>
<tr>
<td>are more efficient – potential misallocation</td>
<td>generation capacity</td>
<td>energy will maintain its basis/acceptance</td>
</tr>
<tr>
<td>Except from very specific cases (Covestro)</td>
<td>No realisation of highly efficient heat-power</td>
<td>+ Simultaneous coverage of the demand for</td>
</tr>
<tr>
<td>unlikely to be profitable under current</td>
<td>combination (CHP) – would require additional</td>
<td>heat with high efficiency</td>
</tr>
<tr>
<td>and future framework conditions</td>
<td>separate heat generation</td>
<td>+ No/ red. CO₂ emissions and reduced fees</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- High Conversion costs</td>
</tr>
</tbody>
</table>

As an „isolated“ project almost no chance

Much higher energy costs/eroded competitiveness

Many of the new challenges around industrial energy supply can only be resolved with a cluster wide integrated approach – not by single parties alone
## Identification of optimisation opportunities in chemical value chains – finding a good link between „Bottom up“ vs. „Top Down“

### Wertschöpfungskettenoptimierung

#### 1) Optimised backward integration („Upstream“)

- **a)** Change of cracker feedstocks (conventional – heavy feedstocks)
- **b)** Ethylene import ex Shale Gas
- **c)** „New“ sources of raw material (biomass, recycling,...)
- **d)** Convergence with energy value chain („Power to Chemistry“, CO₂-feedstock, electric arc,...)
- **e)** ...

#### 2) Integration of intermediates („Midstream“)

- **a)** Better mass balance for C4-olefins and aromatics (internal supply gap in the cluster)
- **b)** Creating upgrading options for new raw materials (e.g. Acetylene chemistry, surfactant chemistry with native oils,...)
- **c)** Capacity expansion of exist. Activities at sites with space reserves
- **d)** .....  

#### 3) Optimised forward integration („Downstream“)

- **a)** Further upgrading of intermediates (e.g. higher olefins ex pygas to Neoprene,...)
- **b)** Integration/ adoption of new attractive market opportunities (e.g. batteries) to existing chemical value chains
- **c)** Closer integration with customer industries (e.g. „just in time“ production, customization
- **d)** .....  

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**Dynamic synchronisation of the “Bottom up perspective (product related options) with the “Top Down” perspective (market related opportunities) – utilizing integration as key site advantage**

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Source: allocate
The relative importance of oil products as chemical feedstocks will increase – the value of refinery-chemicals integration grows

Oil products as feedstock for the chemical Industry

Oil demand and usage [bn tons Oil Equivalents (TOE)]

<table>
<thead>
<tr>
<th>Year</th>
<th>Chemical Industry</th>
<th>Other industries</th>
<th>Mobility</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>18%</td>
<td>4%</td>
<td>53%</td>
<td>15%</td>
</tr>
<tr>
<td>2012</td>
<td>15%</td>
<td>12%</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>2025</td>
<td>13%</td>
<td>16%</td>
<td>8%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Exploiting all opportunities to adopt structures to changing demand pattern – even if this does not compensate for loss in volumes this compensates through more value - from energy to chemicals
Example INEOS: plausible strategy to make best use of new feedstock through import of shale gas based Ethylene and close integration

**INEOS strategy to reduce ethylene supply costs**

- **C₂T: Ethylene Terminal Antwerp**
  - 1 m tonne Ethylene import facility in heart of Europe, connected to INEOS’s main sites and the ARG
  - A “virtual cracker” at a fraction of the cost
  - Gives INEOS unique feedstock sourcing flexibility
  - Under construction and ready end 2012

- **Import of shale gas based Ethylene could significantly contribute to maintain the competitiveness of the European chemical sites – altogether with best possible plant integration**

Source: INEOS
Due to the global trend to use more Ethane as Cracker feedstock the share of higher olefins is decreasing – a chance for EU producers!

Global projection for product yields of olefins

Impact of a higher share of Ethane feedstock on the relative yield of higher olefins

Strategic option: taking the opposite route - European chemical sites can enhance the value generation from “by products” rather than from Ethylene
Shaping the cracker product portfolio towards higher olefins – thereby creating a less vulnerable structure and better demand match

Optimisation of the cracker production

1. Shift of the product yield towards higher olefins, e.g. through heavier feedstocks

<table>
<thead>
<tr>
<th>Current production¹ kta</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
</tr>
<tr>
<td>Ethylene</td>
</tr>
<tr>
<td>Polyethylene</td>
</tr>
<tr>
<td>Ethylene Oxide</td>
</tr>
<tr>
<td>MEG/DEG/TEG</td>
</tr>
<tr>
<td>C3</td>
</tr>
<tr>
<td>Propylene</td>
</tr>
<tr>
<td>Acrylo Nitrile</td>
</tr>
<tr>
<td>Propylene Oxide</td>
</tr>
<tr>
<td>MPG/DPG/TPG</td>
</tr>
</tbody>
</table>

2. Proximity/integration with customers reduces the substitution and logistics risk – in addition “De-Commoditisation” of Commodities

- EO: etoxilates, surfactants
- PO: polypropylene glycol, polyurethanes
- LDPE: Focus on high performance grades

3. Systematic upgrading of products, stand alone or in cooperation with partners

- Closer butadiene-rubber integration with ….
- C4 olefins upgrade in alliance with ….
- Aromatics upgrade with I……

4. Establishing a much more intensive cooperation with selected partners across neighbouring clusters in order to optimise infrastructure and services at lower costs

“Resolving two challenges simultaneously”: reduced vulnerability towards Ethane/Shale Gas crackers – and better opportunities for product upgrading within the cluster

Source: allocate
The mode of cracker operations with big impact on the product yield pattern – this lever can be used to optimize chemical value chains

Utilizing operation flexibility for value enhancement of chemical value chains

<table>
<thead>
<tr>
<th>Cracking severity and cracker products</th>
<th>Cracking severity and C4 cut ingredients</th>
</tr>
</thead>
</table>

**Impact of Cracking Severity on product yield (Naphtha Cracker)**

<table>
<thead>
<tr>
<th>Product yield (in mass %)</th>
<th>Cracking Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>medium</td>
</tr>
<tr>
<td>Hydrogen and Methane</td>
<td>15,5</td>
</tr>
<tr>
<td>Ethylene</td>
<td>24,4</td>
</tr>
<tr>
<td>Propylene</td>
<td>19,5</td>
</tr>
<tr>
<td>C4-Cut</td>
<td>12,7</td>
</tr>
<tr>
<td>Pyrolysis gasoline (C5+ &gt;200°C)</td>
<td>24,9</td>
</tr>
<tr>
<td>Pyrolysis resid</td>
<td>3</td>
</tr>
</tbody>
</table>

**Impact of Cracking Severity on C4 cut ingredients**

<table>
<thead>
<tr>
<th>Product yield (in mass %)</th>
<th>Cracking Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low</td>
</tr>
<tr>
<td>1,3 Butadiene</td>
<td>26</td>
</tr>
<tr>
<td>i-Butene</td>
<td>32</td>
</tr>
<tr>
<td>1-Butene</td>
<td>20</td>
</tr>
<tr>
<td>Trans-2-Butene</td>
<td>7</td>
</tr>
<tr>
<td>Cis-2-Butene</td>
<td>7</td>
</tr>
<tr>
<td>n-Butane</td>
<td>4</td>
</tr>
<tr>
<td>Vinyacetylene</td>
<td>0,2</td>
</tr>
<tr>
<td>Rest: i-Butene, 1,2 Butadiene, Ethylacetylene,...</td>
<td></td>
</tr>
</tbody>
</table>

A different mode of cracker operations can a powerful lever to value enhancement – however, only if the modified product yield pattern can be ideally upgraded, may be by a cooperation partner

Source IFP, allocate
composition of the C4 cut from steamcrackers depending on the feedstock used

Typical C4 production from various cracker feedstocks [pounds per 100 pound of ethylene]

An expansion of C4 olefin production can be a value adding option – if sufficient upgrading capacity exists

Source: HIS. allocate
Example: systematic value upgrading of pyrolysis gasoline – creation of chemical “specialities” rather than “dumping” in the gasoline pool

More value from C5+ olefins

Project example

Understanding todays by-products as valuable resources with upgrading potential – converting commodities to specialities together with partners
Example for completely new product categories: Li based battery production will increase 4 times within only 5 years....

Planned expansion of Li battery production capacity, status July 2016

Source: ChemManager, Enerkeep, based on the announcement of 15 Li battery producers regarding capacity expansions.

Strong market pull for ideally located Li battery production sites – specific site attractiveness factors need to be addressed systematically.
Content

Challenges for Refinery-Chemical-Clusters

Case Study: “Chemiecluster 4.0” concept in North-Western Germany

Implementation levers
The identification of opportunities is only the first step in a comprehensive project development process – managed from idea to realisation

Phases of industrial project development – Tasks & Responsibilities

<table>
<thead>
<tr>
<th>Development phase</th>
<th>Strategy &amp; Identification of Opportunities</th>
<th>Feasibility Study</th>
<th>Project financing &amp; partnering concept</th>
<th>Design &amp; Engineering</th>
<th>Building &amp; Start up</th>
<th>Optional Exit strategy &amp; Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Business/Market analysis</td>
<td>Technical feasibility study</td>
<td>Evaluation of partnering/joint venture concepts</td>
<td>Technical design and engineering</td>
<td>Construction Start up/Testing of facilities</td>
<td>Exit strategy</td>
</tr>
<tr>
<td></td>
<td>Competitor analysis</td>
<td>Financial modelling (business model)</td>
<td>M&amp;A opportunities</td>
<td>Application of technologies</td>
<td>...</td>
<td>Transfer of assets/facilities</td>
</tr>
<tr>
<td></td>
<td>Supply/Demand profiles</td>
<td>SWOT analysis</td>
<td>Financial engineering/packaging</td>
<td>Technology licensing</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>Development of high-level scenarios</td>
<td>Profiling of risk potentials</td>
<td>Pooling of expertise</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>Pre-screening of potential partners</td>
<td>...</td>
<td>Blueprint/Formation of SPC (Special purpose comp.)</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Preferred partners

- Management consultants
- Technical/Management consultants
- Financial/M&A/Legal advisors
- Engineering company
- Technical project developers/Construction Comp.
- Technical/Management consultants
- Financial/M&A advisors

Tasks & Responsibilities

- Project Office – “Pre-Phase”
- “Special Purpose Entity”
- “Special Purpose Entity”
Creating a development roadmap and master plan - example Saudi Arabia – systematic development of the Al Jubail chemical cluster

Identification of “Gaps” and new business options in the Al Jubail Oil-Chemicals cluster

<table>
<thead>
<tr>
<th>Feed Stock</th>
<th>Primary</th>
<th>Secondary</th>
<th>Downstream Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naphtha</td>
<td>Benzene</td>
<td>Cumene</td>
<td>Polymethyl Metacrylate</td>
</tr>
<tr>
<td>Gas Oil</td>
<td>Toluene</td>
<td>Phenol</td>
<td>Methyl Isobutyl Ketone</td>
</tr>
<tr>
<td>Mixed Xylene</td>
<td>Acetone</td>
<td>Acetone</td>
<td>Polyurethane Foam</td>
</tr>
<tr>
<td>N-Paraffin</td>
<td>Bis Phenol A</td>
<td>N- Olefin</td>
<td>Trinitrotoluene</td>
</tr>
<tr>
<td>Cylohexiane</td>
<td>Adipic Acid</td>
<td>Acetone</td>
<td>Polyurethane Foam</td>
</tr>
<tr>
<td>Adiponitrile</td>
<td>Adipic Acid</td>
<td>Acrylonitrile</td>
<td>Dichloromethyl Phtalate</td>
</tr>
<tr>
<td>Adipic Acid</td>
<td>Hexamethylenediamine</td>
<td>N- Olefin</td>
<td>Butyl Phtalate</td>
</tr>
<tr>
<td>Di- Salt</td>
<td>Methyl Metacrylate</td>
<td>M- Xylene</td>
<td>Diethyl Phtalate</td>
</tr>
<tr>
<td>Caprolactum</td>
<td>Bisphenol A</td>
<td>Isophthalic Acid</td>
<td>Alkyd Resin</td>
</tr>
<tr>
<td>AH</td>
<td>Cyclohexane</td>
<td>O- Xylene</td>
<td>Phenyleneterephthlate</td>
</tr>
<tr>
<td></td>
<td>N- Paraffin</td>
<td>P- Xylene</td>
<td>Solvents &amp; Thinner</td>
</tr>
<tr>
<td>Naphtha</td>
<td>Ethylene Oxide</td>
<td>Ethylene Oxide</td>
<td>Unsaturated Polyester Resin</td>
</tr>
<tr>
<td>Butane</td>
<td>Acetone</td>
<td>Ethylene Oxide</td>
<td>Polyvinylchlorid</td>
</tr>
<tr>
<td>LPG and</td>
<td>Acetone Dichloride</td>
<td>Acetone</td>
<td>Trihaloformates</td>
</tr>
<tr>
<td>Natural</td>
<td>Acetone</td>
<td>Acetone</td>
<td>Polybutylene Terephthlate</td>
</tr>
<tr>
<td>Butene</td>
<td>Vinyl Chloride</td>
<td>Vinyl Chloride</td>
<td>Polybutene-1</td>
</tr>
<tr>
<td>Butene</td>
<td>Monomer</td>
<td>Vinyl Chloride</td>
<td>Methyl Ethyl Ketone</td>
</tr>
<tr>
<td>Butane</td>
<td>Ethanol Amines</td>
<td>Vinyl Chloride</td>
<td>Butylated Hydroxytoluene</td>
</tr>
<tr>
<td>Butane</td>
<td>Ethanol</td>
<td>Vinyl Chloride</td>
<td>2,6 Di tert. Butylphenol</td>
</tr>
<tr>
<td>1 Hexene</td>
<td>Butane</td>
<td>Vinyl Chloride</td>
<td>P-Tert Butylphenol</td>
</tr>
<tr>
<td>N &amp; iso Butylaldehydes</td>
<td>1 Hexene</td>
<td>Vinyl Chloride</td>
<td>Ethyl Tert. Butylether</td>
</tr>
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<td>Allyl Chloride</td>
<td>Butane</td>
<td>Vinyl Chloride</td>
<td>Benzylether</td>
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<td>Glycerine</td>
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<td>Isopropyl Ether</td>
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<td>Propylene Oxide</td>
<td>Propylene Oxide</td>
<td>Vinyl Chloride</td>
<td>Tertiary Butyl Ether</td>
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<td>Acrylic Acid</td>
<td>Vinyl Chloride</td>
<td>Polyisobutylene</td>
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<td>Acrylonitrile</td>
<td>Maleic Anhydride</td>
<td>Vinyl Chloride</td>
<td>Butylyl Rubber</td>
</tr>
<tr>
<td></td>
<td>1.4 Butanediol</td>
<td>Vinyl Chloride</td>
<td>Isopropyl Rubber</td>
</tr>
<tr>
<td>Octane</td>
<td>1 Hexene</td>
<td>Vinyl Chloride</td>
<td>Nitrile Rubber</td>
</tr>
<tr>
<td>Sec. Butanol</td>
<td>Polypropylene</td>
<td>Vinyl Chloride</td>
<td>Polychloroprene Rubber</td>
</tr>
<tr>
<td>Isoprene</td>
<td>Polypropylene</td>
<td>Vinyl Chloride</td>
<td>Butadiene Rubber</td>
</tr>
<tr>
<td>Tert. Butyl Alcohol</td>
<td>Polypropylene</td>
<td>Vinyl Chloride</td>
<td>Styrene Acryl</td>
</tr>
<tr>
<td>Chloroprene</td>
<td>Polypropylene</td>
<td>Vinyl Chloride</td>
<td>Acrylonitrile Butadiene</td>
</tr>
<tr>
<td>Ethylenenitrile</td>
<td>Polypropylene</td>
<td>Vinyl Chloride</td>
<td>Styrene</td>
</tr>
<tr>
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<td>Polypropylene</td>
<td>Vinyl Chloride</td>
<td>Styrene Butadiene Latex</td>
</tr>
<tr>
<td>Styrene</td>
<td>Polypropylene</td>
<td>Vinyl Chloride</td>
<td>Styrene Butadiene Rubber</td>
</tr>
<tr>
<td>Styrene</td>
<td>Ethylene</td>
<td>Urea</td>
<td>Styrene Acrylonitrile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carbon Monoxide</td>
<td>Na Styrene Acrylonitrile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Formaldehyde</td>
<td>Styrene Acrylonitrile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Methyamine</td>
<td>Styrene Acrylonitrile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Methyl Chloride</td>
<td>Styrene Acrylonitrile</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acetic Acid</td>
<td>Trimethylisopropanen</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Melamine</td>
<td>Bonite, RDX</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hexamethylenetetramine</td>
<td>Single Cell Protein</td>
</tr>
<tr>
<td>N-Butanol</td>
<td>Polymethyl Acetate Monomer</td>
<td>N-Methyl Pyroldione</td>
<td>Lactic Acid</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>Polyvinyl Alcohol</td>
<td>N,N Dimethyl Acetamide</td>
<td>Cellulose Alcohol</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>Butyl Alcohol</td>
<td>N,N Dimethyl Formamide</td>
<td>Polyvinyl Alcohol</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>Ethylene</td>
<td>Urea Formadehyde Resin</td>
<td>Chloroform &amp; Carbonitrilchloride</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>Ethylene</td>
<td>Melamine Formaldehyde Resin</td>
<td>Cellulose Acetate</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>Ethylene</td>
<td>Phenol Formaldehyde Resin</td>
<td>Polyvinyl Alcohol</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>Ethylene</td>
<td>Formaldehyde Resin</td>
<td>Formaldehyde Resin</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>Ethylene</td>
<td>Acetal Resin</td>
<td>Formaldehyde Resin</td>
</tr>
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<td>Polypropylene</td>
<td>Ethylene</td>
<td>Pentanaphthol</td>
<td>Formaldehyde Resin</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>Ethylene</td>
<td>Naphthol</td>
<td>Formaldehyde Resin</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>Ethylene</td>
<td>Glycol</td>
<td>Formaldehyde Resin</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>Ethylene</td>
<td>Carbon Black</td>
<td>Formaldehyde Resin</td>
</tr>
</tbody>
</table>
Investors indicate interest in investment projects in the cluster framework – if some essential prerequisites can be fulfilled

Considering the investors’ perspective

**Attractiveness for Chemical Cluster project options from Investors’ point of view**

**Convincing Business Case**
- Return on employed capital above
- Market rationale & growth potential
- Customer focus & proximity
- ....

**Operational Feasibility**
- Good Mgt.-team/ operatorship
- Professional project implementation
- Partnership with local companies

**Manageable Risks**
- LoIs with suppliers Lieferanten and customers
- Transparency & controlable costs
- Reliable stable regulatory framework
- ....

**Generally attraktive environment**
- Close cooperation with authorities with regard to approval etc.
- Access to qualified staff
- Good infrastructure & logistics

**Generally sufficient investment capital searching for opportunities, due to low interest rates moderate „Hurdle Rates“ for investments – but also clear expectations and requirements**
Managing new investments in complex clusters - applying proven models for the establishment of project companies with different parties

Project development company and SPV design

Tailor made design to consider the very specific situation of a project – much more flexibility than with conventional investments
Replacement of existing plants can be realised smoothly with varying shareholder constellations

Replacement of old plants

Optimised realisation of replacement investments

<table>
<thead>
<tr>
<th>Performance</th>
<th>Peak load</th>
<th>Part load</th>
<th>Redundancy</th>
<th>BIS¹ Peak load</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td></td>
<td></td>
<td>2 x 100%</td>
<td>Investment new site</td>
</tr>
<tr>
<td>Disinvestment old site</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Challenges

- Replacement investment within “bottleneck” site to be without decline in output
- Redundancy within overlapping period unavoidable
- Disinvestment depends on bringing into service of new site
- Mostly no subsequent use for old site within current business model
- Sales strategy for overcapacity (occurring due to replacement investment) required
- Recycling, disposal and deconstruction concepts have to be derived from superior strategy
- Transformation of abandoned industrial site into new utilization has great implications financials

Intelligently resolving investment tailbacks – if useful in new shareholder constellations
Certain phases in the life cycle of chemical plants – e.g. change of ownership – can be planned right from the beginning

Managing ownership transitions in the life cycle

- **Project ownership with the Project Development Entity**
- **Project ownership with the relevant operational experts**

### Project Phases

1. **Assessment**
   - a) Set-up
   - b) Data Collection
2. **Strategic Development**
   - c) Development of Strategic Options
3. **Implementation**
   - d) Implementation Planning

### Involvement

**Project Development Entity (PDE)**

- Project ownership with the PDE until the transition of ownership
- New owners

Conditioned LOIs can be agreed with investors in an early stage – an essential factor for further discussions with financing banks
Beyond consulting allocate is prepared to act as entrepreneurial partner

Overview

Executive Search/HR Consulting
- HR – Strategy
- Search
- Management Audits
- Compensation
  - Retainer / Fixed component
  - Success Fee

Management Consulting
- Corporate Strategy
- Operational excellence
- P&L value improvements
- Interims-Management
  - Fixed fees
  - Success fee (where applicable)

Transactions/(M&A) deals
- Search of targets/buyers
- Due diligence
- Valuation
- Post Acquisition Management
  - Success fees
  - Cost coverage/small retainer

Project development/Investments
- Creating opportunities
- Funding/financing
- Formation of consortia
- Programme Management (BOOT)
  - Success fees
  - Cost coverage/small retainer
  - Own investment¹

¹ Limited investment by allocate if requested

Commitment for long-term entrepreneurial partnership alongside with leading edge service orientation
Selected project experiences in some key sectors

Experiences in key sectors

Some project references are personal references of individual allocate team members.