An overview of global megatrends and regional industry sector trends relevant for chemicals management and sustainable chemistry innovation

Regional Perspectives on Sustainable Chemistry Innovation and the Global Chemicals Outlook II: Understanding Trends, Risks and Opportunities

Regional Expert Workshop

Bangkok, 25 – 26 April 2018
There are more people living inside this circle than outside of it.
Factor 1

OVERVIEW OF MEGATRENDS WITH GLOBAL AND REGIONAL IMPACT
What is a megatrend?

• Major global forces with significant and lasting impact
• Generating growth in new markets up and down the value chain and prompting unprecedented shifts in the industry.
• Creating disruption and opportunity for chemical companies over the next decade.
• No consensus definition; 3 to 30 megatrends found in the literature.
Overview of megatrends and drivers

Global economic shifts

- “Economic G3”?
- USA, China, EU dominating global economy
Overview of megatrends and drivers

Demographic transition

Figure 3. Population by region: estimates, 1950-2015, and medium-variant projection, 2015-2100

Overview of megatrends and drivers

Demographic transition

Figure 3. Population by region: estimates, 1950-2015, and medium-variant projection, 2015-2100

Overview of megatrends and drivers

Urbanisation

Asia 2018: 49.6 % urban population (of 4.54 billion)

By 2025: 7 of 10 largest cities in Asia

By 2050: 66 per cent of the world’s population projected to be urban

Asia 63%
Overview of megatrends and drivers

Urbanisation

Overview of megatrends and drivers

Urbanisation

Figure 2.
Urban and rural population of the world, 1950–2050

A majority of the world’s population lives in urban areas

Overview of megatrends and drivers
Changing consumption patterns

- Middle class growing worldwide, Middle class spending in Asia multiply by 6 times until 2030
- Increasing consumer-driven demand for more goods and services, many chemicals-intensive
- Increasingly demanding sustainable and healthy alternatives
Overview of megatrends and drivers

Changing consumption patterns

- Middle class growing worldwide, more than double in Latin America by 2030
- Increasing consumer-driven demand for more goods and services, many chemicals-intensive
- Increasingly demanding sustainable and healthy alternatives

Overview of megatrends and drivers

Resource competition and pollution

Pollution Kills 3x As Many As AIDS, TB & Malaria Combined

Global estimated deaths by major risk factor and cause in 2015

- Total pollution (air, water and soil): 9.19m
- Tobacco smoking: 7.17m
- AIDS, malaria and tuberculosis: 3.04m
- Alcohol use risk: 2.31m
- Malnutrition (child and maternal): 1.41m
- Road accidents: 1.36m
- Drug use risk: 0.49m
- War and murder (interpersonal violence, 2015): 0.41m
- Ebola*: 0.01m

* 2014

Sources: The Lancet, NPR

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Overview of megatrends and drivers

Resource competition and pollution

- Industrial energy demand rises by about 25 percent by 2040, led by growth in the chemicals sector
Overview of megatrends and drivers

Technological changes

Disrupting economies & societies over next 10 – 15 yrs

- Internet of Things
- Big data analytics
- Artificial intelligence
- Neurotechnologies
- Nano/microsatellites
- Nanomaterials
- Additive manufacturing
- Advanced energy storage technologies
- Synthetic biology
- Blockchain

Source: OECD Science, Technology and Innovation Outlook 2016, 40 key and emerging technologies for the future
Overview of megatrends and drivers

Technological change

- On average, CAS has registered one substance every 2.5 minutes since 1965.
- In 2016, this has increased to one new substance every 1.4 seconds.
# Overview of megatrends

## Global economic shifts
- Strong growth in emerging economies
- Shifts in innovation capabilities
- Complex international value chains

## Demographic transition
- Growing population (esp. South Asia and Africa)
- Ageing populations (esp. in OECD countries)

## Technological change
- Digitalization
- Acceleration of innovation pace
- Additive manufacturing

## Urbanisation
- Massive move from rural to urban areas
- Construction boom (housing and infrastructure)
- Changing transportation needs

## Resource competition and pollution
- Scarce resources: Minerals, land, etc.
- Impacts of climate change
- Impacts of pollution (air, water, soil)

## Changing consumption patterns
- Rapidly growing consumer/middle class
- Individualisation
- Lifestyles on sustainability and health
## Megatrends likely to have high impact

<table>
<thead>
<tr>
<th>End markets</th>
<th>Resource scarcity and competition</th>
<th>Green/sustainability/circular economy</th>
<th>New patterns of consumption</th>
<th>Demographic changes</th>
<th>Technology changes and disruptions</th>
<th>Urbanisation</th>
<th>Global economic shifts</th>
<th>Human health and pollution concerns</th>
<th>New patterns of mobility</th>
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<tbody>
<tr>
<td>Construction</td>
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<td>Paper and packaging</td>
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<td>Transportation</td>
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<td>Nutrition</td>
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<td>Machinery</td>
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<td>Apparel and textiles</td>
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<td>Mining and metals</td>
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Factor 2

THE CHEMICALS INDUSTRY
# Global chemical shipments/turnover

<table>
<thead>
<tr>
<th>Region</th>
<th>2016 (in billion US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>870.1</td>
</tr>
<tr>
<td>Latin America</td>
<td>216.0</td>
</tr>
<tr>
<td>Western Europe</td>
<td>1,048.9</td>
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<tr>
<td>Central &amp; Eastern Europe</td>
<td>109.5</td>
</tr>
<tr>
<td>Africa and Middle East</td>
<td>161.0</td>
</tr>
<tr>
<td>Asia-Pacific</td>
<td>2,792.1</td>
</tr>
<tr>
<td><strong>World Total</strong></td>
<td><strong>5,197.6</strong></td>
</tr>
</tbody>
</table>


Chemical industry – Focal sectors (outlook 2035)

Global chemical market more than doubling till 2035; agrochemicals and engineering plastics delivering strongest growth

Issues to focus on:
1. Access to & cost of feedstocks
2. Shifts in chemical manufacturing hubs (China, India, others)
3. Development of policy & regulatory framework → levelling playing field?
4. Shifts & relocations in application manufacturing
5. Shifts in terms of new products demands as well as markets
Chemical industry in Asia

Development of shares in different segments in Asian chemical sector (in %)

Source: Chemdata International, VCI

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Factor 3

INDUSTRY SECTOR TRENDS
Chemical industry – Focal sectors

Source: Deloitte, 2011 „End market alchemy Expanding perspectives to drive growth in the global chemical industry“
Construction

- Worldwide construction output will grow by 85% by 2030, when the construction industry will produce an astonishing $15.5 trillion in total revenue (Global Construction 2030)
- Research indicate that construction industry already responsible for 23% of the United States’ air pollution, 40% of its water pollution, and 50% of its landfill waste
- In Asia share between residential, industrial and infrastructural projects is almost evenly distributed.
- Almost all Asian countries expected to increase budgets for infrastructure in the next five years.
- With increased spending of about 7% China, India and Vietnam are about to take the lead by 2020.
- Outlook reflected by global geopolitical trends seeing the BRIC region making way for ICASA (India, China, Africa, Southeast Asia)

Construction outlook

Floor area additions to 2060 by key regions

Notes: OECD Pacific includes Australia, New Zealand, Japan and Korea; ASEAN = Association of Southeast Asian Nations.
Construction
Emerging concepts and focal areas

• Extending the Lifespans of durable building materials
• Considering buildings as “material banks, lining with building information modeling (BIM)
• Modular pre-fabrication
• Incorporating „healthy living“
• Elimination/substitution of „Red list substances“
• Energy efficiency in construction and living

Source: Green Building Council of Australia (GBCA)
Construction

Example 1: Building energy codes by country, state and province, 2016

Example 2: LEED certification outlook

Top 5 countries for LEED certification (outside USA), 2017
1. China
2. Canada
3. India
4. Brazil
5. Korea

Automotive and mobility

- Global transportation demand growing about 25% between 2015 – 2040 Personal mobility demands continuing to increase, but more efficient vehicles leading to a peak and eventual decline in light-duty vehicle (LDV) energy demand
- Growth in economic activity and personal income drives increasing trade of goods and services, leading to higher energy demand in the commercial transportation sectors
- Heavy duty growth largest by volume, but marine and aviation grow the largest by percentage
- As per International Transport Forum (ITF), number of cars increasing to 2.4 Billion vehicles by 2050 => GHG emission increasing by 60% by 2050 under “business as usual” scenario

Source: Exxon Global Energy Outlook
Automotive and mobility

Greater emphasis on emission reductions and tighter regulatory norms for automobiles and trucks
- More focus on improving fuel efficiency and alternative fuels, weight reduction of vehicles
- e-mobility outlook high in selected markets (China, India, Europe)

Changing consumer behaviour
- Car ownership significantly increases in the non-OECD with rising incomes
- Shared economy concepts among younger generation, particularly in urban areas)
- Sustainable mobility market 2016: 412 Billion Euros, 2025: 988 billion Euros (highest growth in alternative power train technologies)
Some key industry trends

- Enhancing safety and user comfort
- e-vehicles, e-scooters, e-light commercial vehicles
- Growing adoption of “green” vehicles
- Stronger, lighter weight and different materials as key response to the megatrend of green/sustainability issues and circular economy

Intervention areas (GreenTech Environment Atlas)
- Alternative drive technologies
- Renewable fuels
- Technologies to increase efficiency
- Transportation infrastructure and traffic management

(Source: BMUB, GreenTech Environment Atlas)
Energy production and consumption

Energy underpins economic growth

- Middle class more than doubling in next 15 years
- Demand for energy increases with more people expecting **access to air-conditioned homes, cars and home appliances like refrigerators, dishwashers and smartphones**
- Continuing urbanization in China and India, with people moving from rural areas to cities, will add to economic growth
- As per IEA, 37% of world energy supply from renewable source by 2040
As per IEA, **37%** of world energy supply from renewable source by 2040

- Market for PV growing by 7.9% between 2016 - 2025
- Market for energy storage growing by 16.1%

**Challenges in end-of-life management**

- e.g. leaching of hazardous substances (as lead and cadmium), losses of conventional material resources (as aluminium and glass), and losses of precious and scarce metals (as silver, gallium, indium, germanium).
### Related market developments and outlooks

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>• Renewable energies (PV, wind, geothermic, water)</td>
<td>• Energy efficient production technologies</td>
</tr>
<tr>
<td>• Enviromentally sound use of fossile fuels (combination of gas and steam, CCS, waste heat utilisation)</td>
<td>• Energy efficiency in building and construction (insulation, automation, heating, ventilation, air purification)</td>
</tr>
<tr>
<td>• Efficient distribution networks and systems (Internet of energy, control and monitoring systems, heat and cooling nets)</td>
<td>• Energy efficiency and ratings of equipment and tools (e.g. household gadgets, green IT, illumination, entertainment and communication electronics)</td>
</tr>
<tr>
<td>• Energy storage (mechanical, electro chemical, thermal, Power2X)</td>
<td>• Cross-sectoral components (pumping systems, electrical drives, heat exchangers, compressors and vacuum technology)</td>
</tr>
</tbody>
</table>
Agriculture & food industry

- **Upward demand for food production** (incl. more diverse food diets, particularly with growing disposable income)
- **Increasing demand in post-farm segments efficiency** → preservation, packaging, productivity enhancing investments in cold-chain & storage facilities, food preparation away from home
- **Transformation of rural on-farm and non-farm economy** → emergence of local food industries and processing facilities
- **Need and opportunity for urban/vertical farming** and non-traditional food production
Exhibit

We have identified 24 hot spots where agribusiness investment is likely to focus.

Opportunity matrix

Composite risk index

2012–13 projected global average GDP growth = -3%

Expected growth, compound annual growth rate, 2011–20

1Growth segments (horizontal axis) are low, <3%; medium, 3–7%; high, >7%. Risk (vertical axis) is measured as the sum of scores across 4 types of risk assessed: execution, geopolitical, regulatory and market, and technological.

2Seeds from genetically modified organisms have high regulatory risk in some regions and high acceptance in others (e.g., North America).

3Palm oil has higher risk in sub-Saharan Africa, where most growth will come.

4Agriculture products used for construction and pharmaceuticals (not cotton, energy, food, tobacco, or wood).

Source: Ag2020: Growth and investment opportunities in food and agribusiness, a joint report from McKinsey and Paine + Partners, 2013

Source: McKinsey on Investing Number 2, Summer 2015
Cross-sectoral issues and market segments
Circular economy and resource efficiency

- Worldbank study => Business as usual 11 Mil tons of solid waste per day (in 2100)
- Most waste generated in North America and Europe (highest peak by 2050)
- Economic development in other region resulting in increase (East Asia peak in 2075)
- Expenditures on solid waste management about 205 Bil. USD per year (not considering ecological cost)
- Same time: DERA Resource list => 114 of 300 monitored raw materials considered with high potential procurement risk

Potential market segments
(2016: 110 billion Euros => 2025: 210 billion Euros)

- Waste collection, transport and segregation
- Recycling (mechanical, raw material recovery, secondary raw materials)
- Energy recovery (electricity, heat)
- Waste disposal (construction and mining of disposal sites, rehabilitation)
Cross-sectoral issues and market segments – Land and resource use

<table>
<thead>
<tr>
<th>Value in MHa</th>
<th>2005</th>
<th>2050</th>
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</thead>
<tbody>
<tr>
<td>Food supply</td>
<td></td>
<td>+ 71 - 300</td>
</tr>
<tr>
<td>Biofuel crops</td>
<td>20</td>
<td>+ 48 - 80</td>
</tr>
<tr>
<td>Bio materials</td>
<td></td>
<td>+ 104 - 215</td>
</tr>
</tbody>
</table>

Example Biomaterials (2016: 65 billion Euros => 2025: 200 billion Euros)

In 2016:
- 19% bioenergy
- 18% dyes and paints
- 17% cosmetics
- 14% bio polymeres
- 13% composite materials
- 11% bio based feedstocks

Factors affecting land use
- Constrained yield increases
- Population growth
- Urbanisation
- Changing diets
- Renewable energy and land use
- Biomaterials
- Climatic impacts

Segments to look out for:
- Organic electronics (71 billion EUR by 2025)
- Nanotechnology (142 billion EUR by 2025)
- Urban mining
- Carbon capture and utilisation
Cross-sectoral issues and market segments

Example: Land and resource use

<table>
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</table>

Source: IEA 2011

Note: Assuming 50% of biofuels will use organic wastes and residues and excluding land-use reduction for biofuel co-products. “Biojet” is advanced, synthetic aviation fuel.
Cross-sectoral issues and market segments

The 4R Nutrient Stewardship

Example of framework be used to guide development and application best management practices across diversity of rapidly evolving social, economic and environmental conditions

Summary

Mega trends

1. Natural resources and environment
2. Demographics
3. Globalization
4. Regulation and activism
5. Technology and innovation
6. Consumption patterns

Examples of future growth platforms

<table>
<thead>
<tr>
<th>Alternative feedstock</th>
<th>Alternative energy</th>
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<tbody>
<tr>
<td>Bio and renewable feedstock</td>
<td>Shale gas, photovoltaic, and solar thermal</td>
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<tr>
<td>Coal to liquid</td>
<td>Wind energy</td>
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<td>Urban mining</td>
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<thead>
<tr>
<th>Environmental technology</th>
<th>Efficiency</th>
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<tr>
<td>Clean air and water</td>
<td>Lightweight materials</td>
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<td>Waste treatment</td>
<td>Insulation</td>
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<td>Urban mining</td>
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<th>Energy storage</th>
<th>Nutrition</th>
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<td>Li-Ion batteries</td>
<td>Advanced biotech</td>
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<td>Fuel cells</td>
<td>Food chain efficiency</td>
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<th>Intelligent materials</th>
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<tr>
<td>Nano materials</td>
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<td>Functional textiles</td>
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Source: A.T. Kearney analysis
Drivers for Sustainable Development
Six lead markets for environmental technology and resource efficiency and their market segments

EUR 2,536 billion – That is how much the world's green tech markets were worth in 2013. The cross-sector industry is continuing to expand and will probably increase its global volume to EUR 5,385 billion by 2025.

<table>
<thead>
<tr>
<th>Lead markets</th>
<th>Market segments</th>
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<tbody>
<tr>
<td>Environmentally friendly power generation, storage and distribution</td>
<td>• Renewable energy</td>
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<td>• Ecofriendly use of fossil fuels</td>
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<td>• Storage technologies</td>
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<td>Energy efficiency</td>
<td>• Energy-efficient production processes</td>
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<td>• Energy-efficient buildings</td>
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<td>• Energy-efficient appliances</td>
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<td>Material efficiency</td>
<td>• Cross-sector components</td>
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<td>Sustainable mobility</td>
<td>• Material-efficient processes</td>
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<td>• Cross-application technologies</td>
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<td></td>
<td>• Renewable resources</td>
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<td>Waste management and recycling</td>
<td>• Protection of environmental goods</td>
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<td>• Climate-adapted infrastructure</td>
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<td>Sustainable water management</td>
<td>• Transportation infrastructure and traffic management</td>
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<td>• Landfill technologies</td>
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<td>• Increasing the efficiency of water usage</td>
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Source: Roland Berger

Global growth forecasts for GreenTech sector in its six key segments; Source: BMU (Germany) GreenTech Atlas, Roland Berger (2018)
Drivers for Sustainable Development

Global growth forecasts for GreenTech sector in its six key segments 2016 - 2025, Source: BMU (Germany) GreenTech Atlas, Roland Berger (2018),

Market development in six key Greentech segments

<table>
<thead>
<tr>
<th>Segment</th>
<th>2016</th>
<th>2025</th>
<th>Value in billion EUR</th>
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<tbody>
<tr>
<td>Environmental sound production, storage and distribution of energy</td>
<td>667</td>
<td>1164</td>
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<tr>
<td>Energy efficiency</td>
<td>837</td>
<td>1491</td>
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</tr>
<tr>
<td>Raw material and material efficiency</td>
<td>521</td>
<td>1048</td>
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</tr>
<tr>
<td>Sustainable mobility</td>
<td>412</td>
<td>988</td>
<td></td>
</tr>
<tr>
<td>Circular economy</td>
<td>110</td>
<td>210</td>
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<tr>
<td>Sustainable water management</td>
<td>667</td>
<td>1001</td>
<td></td>
</tr>
</tbody>
</table>

Average annual change for period 2016 - 2025 in %:

- Environmental sound production, storage and distribution of energy: +6.4%
- Energy efficiency: +6.6%
- Raw material and material efficiency: +8.1%
- Sustainable mobility: +10.2%
- Circular economy: +7.4%
- Sustainable water management: +4.6%

Prepared by adelphi
Top market segments with five priority technology lines in respective target markets

Source: BMU (Germany) GreenTech Atlas, Roland Berger (2018)

<table>
<thead>
<tr>
<th>Brasil</th>
<th>Canada</th>
<th>Mexico</th>
<th>USA</th>
<th>China</th>
<th>India</th>
<th>Japan</th>
<th>Russia</th>
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<tbody>
<tr>
<td>1</td>
<td>Composite material</td>
<td>1</td>
<td>Composite materials</td>
<td>1</td>
<td>Electronic storage of energy</td>
<td>1</td>
<td>Increasing efficiency of internal combustion engine</td>
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<tr>
<td>2</td>
<td>Energy efficient illumination</td>
<td>2</td>
<td>Energy efficiency in food industry</td>
<td>2</td>
<td>Nanotechnology</td>
<td>2</td>
<td>Hybrid engine systems</td>
</tr>
<tr>
<td>3</td>
<td>Chemical process engineering</td>
<td>3</td>
<td>Regeneration of hydrogen</td>
<td>3</td>
<td>Increasing efficiency of internal combustion engine</td>
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<td>Bioethanol</td>
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<tr>
<td>5</td>
<td>Bio technology</td>
<td>5</td>
<td>Electric motors</td>
<td>5</td>
<td>Energy efficient illumination</td>
<td>5</td>
<td>Energy efficiency in food industry</td>
</tr>
</tbody>
</table>

Based on answers of 2560 German GreenTech companies (Source: Roland Berger 2017)
Summary

- Growing and aging world population as overall metatrends
- Faster distribution and dissemination of technologies and knowledge
- No bottleneck in energy and raw materials by 2030
- Environment and climite considerations gain even further importance
- Changes in raw material base for chemical industry with gradual shift from fossil towards renewable sources => critical issue: Competition in use raw material vs nutrition
- Intensification in R&D (e.g. in renewable source, specialty chemicals) increasing from 10 Billion Euro (2013) to 17 Billion Euro (2030)
“Everything is possible. The impossible just takes longer”
(Dan Brown)

„A chemical plant to go, please!“
Sessions 2: Overview of Chemical Sector and Sustainable Chemistry Innovation in Asia & Pacific

• Do the findings meet your experiences and expectations for the Asia & Pacific region? Please give us your comments and ideas.

• Are there any (mega)trends that are of particular importance because they bring special challenges and/or opportunities to the region?

• Do you know any examples or best practices that highlight the relevance of these (or other) (mega)trends for the region?
Sessions 2: Overview of Chemical Sector and Sustainable Chemistry Innovation in Asia & Pacific

• What are the most important industry sectors regarding the risks in chemicals management and the opportunities for sustainable chemistry innovation?

• Based on your scientific expertise and the prioritized sectors: What are the two sectors we should discuss today and tomorrow to learn about challenges and sustainable chemistry innovation opportunities? We want to learn from you for the future work of the ISC3 and for the GCO II.
Sessions 2: Overview of Chemical Sector and Sustainable Chemistry Innovation in Asia & Pacific – Breakout Groups

Guiding questions:
1. What are potential impacts of relevant megatrends on the sector?
2. How will the expected trends in the industry sector affect chemicals production, use, disposal and exposure?
3. What are chemicals-related opportunities (e.g. jobs, economic growth) and risks (health, and environment) associated with these trends?

Task:
• Identify three main risks and its innovation opportunities with regard to importance