Digitization in the Chemical Industry

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Agenda

1. What is Cefic and the Chemical Industry in Europe

2. Our tools to support Innovation on a European level: The SPIRE Public Private Partnership and SusChem ETP

3. Industry 4.0 - Digitization in Chemical Industry - Where are we today?

4. HPC cases in the Chemical Industry

5. Summary: Were HPC can help our Industry further?
What is the European Chemical Industry Council
This is Cefic

Since its creation in 1972, Cefic has grown to become one of the largest industry trade organizations in Europe and in the world.

- Representing 29,000 chemical companies in Europe,
- 30 National Chemical Federations across Europe,
- Over 500 direct Company Members from Europe,
- More than 30 Associate Company Members from around the world,
- 50 Partner Companies & Associations,
- 23 European Affiliated Associations,
- Operates 91 Sector Groups focusing on 120+ product families and over 90 Strategy Implementation and Issue Teams dealing with the industry’s horizontal issues (REACH, International Trade, Energy & Climate Change, Research & Innovation, ...)
- About 5000 industry experts from companies and federations participate in the Cefic groups,
- Close cooperation with the other regions in the world through ICCA.
Profile of the European Chemical Industry

- Contributes to **17%** of the world’s chemical sales (2013)
- Represents **29,000 companies** (96% SMEs)
- Employs **1.17 million** people (2014)
- Generates **€ 527 billion** of revenues (2013)
- Creates a trade surplus of **€ 43.8 billion** in (2014)

EU sales 2013: €527 bn

Source: Cefic Chemdata International
Nearly two-thirds of EU chemicals are supplied to the industrial sector

Contribution of the chemical industry to the EU economy

Source: Eurostat data (Input-Output 2000) and Cefic analysis
Unless specified, chemical industry excludes pharmaceuticals
Unless specified, EU refers to EU 28
China: Number 1 chemicals maker

Source: Cefic Chemdata International
Chemical Industry: Our role in contributing to solve EU’s Societal Challenges
The European Dilemma

LESS RESOURCES

MORE NEEDS
Sustainability challenges are business opportunities

9 billion people will live on earth by 2050!
- How can we guarantee food and water supply for everyone?
- What are possible benefits and contributions of plant science?

67% of the world population will live in cities by 2025!
- What does future architecture look like?
- Which materials are needed to make energy consumption more efficient?

50% more primary energy needed in 2030!
- What is the ideal energy mix of the future?
- How big is the stake of renewable energy?

1.2 billion cars will drive on earth by 2020!
- How can we reduce emissions and fuel consumption?
- What will future cars be made off?
Key Enabling Technologies (KETs) – modeling of materials and processes is of high importance

Source: Final report of the High-Level Expert Group on Key Enabling Technologies, EC 2015
Example: Ammonia - the molecule against hunger

Global fertilizer NH$_3$ demand 2014: **138 million t**

Main drivers: population growth, biofuel production using cereals, sugar cane and oilseeds

Production required more than **5 exajoule**, equivalent to about 2% of the world total energy consumption

New Catalyst contributes to save energy

Significant change in ammonia synthesis after 100+ years – the new catalysts is 42% higher active than a standard catalyst

Assuming that all global ammonia production facilities would apply the new catalysts, we could save significant amount of energy

4000 GWH ANNUALLY

= ELECTRICITY CONSUMPTION OF 1.18 MILLION HOUSEHOLDS

HPC can help to further understand and design future catalyst's!

Source: Clariant
Our Tools to support Innovation
The SPIRE Public Private Partnership

Officially launched on 17 December 2013 in the framework of HORIZON 2020

First-ever 7-year innovation Public-Private Partnership (PPP) with process industry including 8 Sectors – chemicals, steel, water, minerals, ceramics, cement, non-ferrous metals, engineering

➢ While some of it is the same as in normal Horizon 2020:
  • The financial rules are those of Horizon 2020
  • Final responsibility for the Work Programme stays with the European Commission, but the SPIRE members provide proposals based on a structured process...
  • ....the implementation remains with the European Commission: selection of proposals, negotiation, review of progress and payments

➢ There are significant advantages:
  • Long-term commitment by European Commission to support the field – 900M Euro
  • Long-term commitment by industry to invest, with a need to demonstrate its fulfilment (monitoring & KPIs)
  • Roadmap-based strategy for the content of the calls – today 20% of the projects are ICT
SusChem European Technology Platform (ETP)

**SusChem** is the **European Technology Platform for Sustainable Chemistry**. It is a **forum** that **brings together** industry, academia, governmental policy groups and the wider society.

SusChem has also established a network of National Technology Platforms in 12 countries (Belgium, France, Germany, Italy, Spain, United Kingdom, Slovenian, Romania, Czech Republic, Poland, Netherlands and Switzerland) across Europe that work on sustainable chemistry initiatives within their own country, support national engagement in EU collaborative projects and programmes and contribute to transnational collaborations.
Industry 4.0 – Digitization in Chemical Industry

“Ninety-five percent of chemicals industry respondents said they foresaw digital technology innovation at their company over the next three years, and 50 percent expected breakthrough or radical advances”

Source: Strategy&/pwc 2015
Digital will deeply impact the (chemical) industry

300 decision makers were surveyed, 30 CEOs interviewed, expert workshops held on:

The **four levers** of the digital transformation...

...and their impact on the **industrial heart** of Europe [bn GVA]

1) GVA = Gross value added, 2013, EU-15 states plus Norway, Turkey
2) Including energy systems

Source: Roland Berger
Industry 4.0 Dimensions

**vertical integration**
of all relevant business, production
and automation processes

**horizontal integration**
along the value added networks over
production processes

**integrated engineering**
on the project planning and the entire
life cycle of facilities and equipment

**integration of SAP, MES, PIMS, EMS, MM, WFM, DA etc.**

**digital engineering, integrated engineering, creation of modular and reusable design data, integration of the plant operators, customer integrated engineering**

**integration of customers, supply chain, data recording of the whole process**

Source: Clariant
ICT enables to manage various processes from raw materials to customers in the chemical industry.

**Raw Material Sourcing**
- Supplier management
- Inbound logistic
- Warehouse management

**Manufacturing Operations**
- Production planning
- Quality management
- Blending/customizing
- Optimization
- Maintenance

**Distribution**
- Filling/packaging/labeling
- Order processing
- Outbound logistic
- Warehouse management
- Claims/returns management

**Delivery**
- Transport management
- Customer relationship
- Differentiated service

**Supply Chain Management Software**
- PCS, ERP, SAP-APO, MES, CAD, CAE
- ERP, MES, LES, Labeling, RFID, GPS

**IT Solutions**
- CAD: Computer Aided Design
- CAE: Computer Aided Engineering
- ERP: Enterprise Resource Planning
- GPS: Global Positioning System
- LES: Logistics Execution System
- MES: Manufacturing Execution System
- PCS: Process Control Systems
- RFID: Radio Frequency Identification
- SAP-APO: Advanced Planner & Optimizer
Advance the production of high-value products that meet high quality demands in flexible intensified continuous plants: Not possible without fast and accurate online sensing of key product and process parameters including closed-loop control and online optimization.

**Characteristics**
- Miniaturized equipment
- Intensified heat & mass transfer
- Possibly modular setup

**Benefits**
- Product uniformity
- Sustainability
- Fast adaption to market demand
- Innovative products

Source: CONSENS
Teaming-up is necessary to solve the challenges ahead: Project partners in the CONSENS project

Source: CONSENS
Process Control addresses specific challenges

Compared to batch processes, there are significant benefits of flexible intensified continuous processes in many cases.

Specific challenges:
- Small dimensions → fast sensors & closed-loop control needed
- Higher quality levels → more accurate sensors needed
- Complex phenomena → PAT and model-based control necessary
- Innovative products → fast design, engineering and optimization
- Fouling and clogging → needs special attention

Integrated PAT-based Process Control copes with these challenges:
- Fast and accurate online sensing of key product and process parameters
- PAT and model based closed-loop control and online optimization
- Tools for design, monitoring, and optimization of the process and of its control system

Source: CONSENS
HPC Cases in the Chemical Industry
1. Simulation of Hazardous Chemicals

As a worldwide leader LONZA supplying the pharmaceutical and biotechnology industries with biopharmaceuticals.

**Fortissimo 2 –2015-2018** builds on the success of Fortissimo and aims to extend and demonstrate the business potential of an ecosystem for HPC-Cloud services, specifically for applications involving simulation of coupled physical processes or high-performance data analytics.

Partners: University of Paderborn, University of Stuttgart (HLRS).

**HPC-Cloud-based simulation of hazardous chemicals**

Benefits demonstrated: By using HPC-Cloud-based molecular simulation Lonza is able to save more than €80k (>80%) of the usual costs gathering physical properties for designing of a distillation column (Lonza designs more than 5 distillation processes per year).

Source: Fortissimo Case Studies
Repsol produces oil and gas, and operates refineries, petrochemical plants, and service stations in Europe.

Repsol is breaking ground with seismic processing technology and growing its exploration and production operations, with major discoveries in Brazil and a ramp up in operations in the US and elsewhere.

Using seismic processing technology, the company interprets images 10 miles below the earth and through nearly two miles of sea water. These techniques help pinpoint targets where wells are drilled and help the company refine the picture of operating oil fields. The techniques used in seismic processing require huge amounts of processing power, including extensive data cleansing in order to filter out the noise measured along with the signal received by detectors.

Source: Repsol Public Information
3. Supply Chain Management

Royal DSM is a global science-based company active in health, nutrition and materials. By connecting its unique competences in life sciences and materials sciences DSM is driving economic prosperity, environmental progress and social advances to create sustainable value for all stakeholders simultaneously.

Source: DSM
3. Method successful in DSM supply chain challenges

Discrete Event Modeling advantages of scalable models
✓ Flexible (different supply chains)
✓ Scalable (via data, number of products and orders)
✓ Fast & lower cost

Strong Business results
✓ 10-20% increase in perfect order rating
✓ 10-20% reduction in supply chain costs
✓ 20-50% reduction of inventory
✓ More efficient, flexible & responsive supply chains

Further improvement and development needed
✓ Incorporate responsive dynamic market behavior
✓ Expand to more complex network setups

Source: DSM
4. Data Management for Process Design and Control over the whole Value Chain

Sources → Data Cube → Analysis → Decision

- Raw materials
- R&D
- Supplier Data
- Plant
- History
- Process
- Customer Data
- Electr. Lab Journal

Optimization Loop

Innovation or Optimization

Source: Clariant
Were HPC can help our Industry further?
HPC will impact...

1. ‘Modeling, Simulation and Forecast’: Integrate modeling of single processes into production routes by new and accurate models in combination with statistical approaches, modeling of materials, reactions, reactors, thermodynamics and dynamic phenomena.

2. ‘Cognitive Plants’: Intelligent self-learning systems, integrated automation solutions related to complete process routes by taking into account all aspects of automation (e.g. monitoring, diagnosis, assistance systems, process control, process supervision, tracking, logistics, etc.). Cyber-physical systems and systems of systems.

3. ‘Condition based ‘Advanced Maintenance’: Allowing remote control of equipment, prediction and prevention of failures.

4. ‘Resource and Energy’: Enable monitoring of environmental targets, energy consumptions, industrial symbiosis.

5. ‘Digital Business Models’: Digital support to replace physical customer support, digital customer solution design.

6. ‘Cloud Technologies’: Using cloud based networks to communicate, on sensor, plant, site, remote -site levels, up and down the value chain.

7. ‘Plant Life Cycle Planning’: Digital enabled plant design over the whole life cycle.
Summary

✓ The European chemical industry **strongly contributes to the economic roots of the European economy** by transforming raw materials into intermediate as base for end-user products

✓ **Chemical production uses more and more digital innovations** such as novel sensors, data-capturing, planning and control, modeling and simulation (materials, processes, infrastructure), cloud computing and (big-) data analytics

✓ As consequence of more data generated and stored, **data analytics will gain importance**

✓ In addition, **smart materials** developed by our sector enable new and higher performing ICT developments in printable-, wearable-, nano-electronics or 3D printing techniques and also allow more sustainable manufacture of new electronic devices. **Materials modeling** will gain further importance

➢ But: Bridging the **gap** between the **huge possibilities which HPC can offer and our industry needs** will be required to be further explored together