Opportunities in Digital and Industry 4.0 in the chemicals industry

September 2017
The digital revolution is pervasive on a large scale

**Customers**

- Connected devices per household
  - 50 in 2022
  - 25 in 2017

- 90% of data have been generated in the last 2 years;
  - 2/3 of it by consumers but Companies use only
  - 0.5% of it

**Businesses**

- Growth in sales of industrial robots over 2015-18
  - 26 Bn
- Smart sensors installed by 2020

- Potential value realized in factory settings by 2025 via digital
  - US$ 3.7Tn

- Incremental revenue from digital by 2020
  - US$ 300Bn
- Annual spend on digital by 2020
  - US$ 500Bn

Source: Industry reports and research, BCG research and databases

Industry 4.0 in the chemicals sector Sep 2017.pptx
Industry 4.0 is the fourth level of the industrial (r)evolution

Development stages of the industry from the loom to cyber-physical-systems of tomorrow

1. Industrial revolution
   - Through introduction of mechanical production plants using water and steam power
   - Historical loom

2. Industrial revolution
   - Through introduction of work-division mass production using electrical energy
   - Automatic animal feeding system in mass production

3. Industrial revolution
   - Through use of electronics and IT to further automate production
   - Automated industrial robot in manufacturing

4. Industrial revolution
   - Based on cyber-physical systems (CPS) and dynamic data processing
   - Connection between physical and digital systems

Late 18th century | Early 20th century | Early 1970s | Today and in the near future

Draft—for discussion only
### Nine technology drivers: High impact upon future production

#### Advanced Robots
- Autonomous, cooperating industrial robots
- Numerous integrated sensors and standardized interfaces

#### Additive Manufacturing
- 3D printing, particularly for spare parts and prototypes
- Decentralized 3D facilities to reduce transport distances and inventory

#### Augmented Reality
- Augmented reality for maintenance, logistics, and all kinds of SOP
- Display of supporting information, e.g., through glasses

#### Simulation
- Simulation of value networks
- Optimization based on real-time data from intelligent systems

#### Horizontal/Vertical Integration
- Cross-company data integration based on data transfer standards
- Precondition for a fully automated value chain (from supplier to customer, from management to shop floor)

#### Industrial Internet
- Network of machines and products
- Multidirectional communication between networked objects

#### Cloud
- Management of huge data volumes in open systems
- Real-time communication for production systems

#### Cyber-security
- Operation in networks and open systems
- High level of networking between intelligent machines, products, and systems

#### Big Data and Analytics
- Full evaluation of available data (e.g., from ERP, SCM, MES, CRM, and machine data)
- Real-time decision-making support and optimization

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**Many application examples already exist for all nine technology drivers**

SOP – Standard operating procedure; ERP – Enterprise resource planning; SCM – Supply chain management; MES – Manufacturing execution system; CRM – Customer relationship management

Source: BCG Manufacturing
Core idea of Industry 4.0:
Integrated, automated and optimized production flow

Source: BCG Report "Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries"
Industry 4.0: Why now?

Digital Adoption

A. Falling prices
Industrial robots from $550k to $20k
Sensors (3D lidar) from $30k to $80

B. Increasing performance
Higher computing capacity
Efficiency of robots improving at ~5% p.a

C. Simplified utilization
User-centric softwares, easy programmation without specific skills, better accessibility

D. Seamless integration
Single digital platform to integrate unstructured data & connect multiple systems

1. 2007 to 2014
2. 2009 to 2014
3. BCG perspectives * How Robots Will Redefine Competitiveness*
Source: DTI Digital Enterprise White Paper by World Economic Forum, BCG research and publications
We are seeing step change performances

**>$30Mn savings**
**50% cost reduction**
**3 new businesses launched**
**~70% decrease in service costs**

**Leading Global Steel Company**
Network optimization and future proofing of supply chain through digitization and bespoke tools leading to >$30Mn savings

**Global Consumer Durables Company**
New future-proof flexible production line in Asia with 50% lower manufacturing cost and 50% quality increase

**Leading European Industrial Company**
Launch of 3 new digital businesses to harness data better from current businesses and create new platforms

**Leading Energy Company**
Predictive maintenance using machine Learning to drive service cost savings of ~70%, and 3% higher productivity in wind farm player with >100 turbines

Selected examples

Source: BCG project experience
Typical pain points across the chemicals value chain

**Inbound logistics**
- Logistics challenges incl. limited information sharing
- Challenges due to quality of procured RM
- Issues related to mix of feed into process

**Production planning, optimization**
- Gaps in planning and oversight for the entire value chain
- Inefficient usage of assets

**Outbound logistics**
- Lack of info on which of the many parameters drive productivity and quality

**Production related**

**Overarching**

**Maintenance challenges**
- Maintenance is often reactive, rather than preventive or even predictive
- Gaps in maintenance planning, spares management and inventory handling

**Energy and auxiliary support**
- Inefficiencies in Power / Steam generation and consumption
- Lack of info on areas of energy loss in operations
- Sub-optimal use and mix of fuel for powering boilers

**Manpower optimization**
- Low productivity driven by poor planning and low automation for auxiliary operations
- Low productivity in support services

**Safety challenges**
- Challenges in overall safety management and risk mitigation

**Plant Leadership**

**Maintenance, Energy**

**Engineering (Projects, construction)**

**HSEQ**

All

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Digital in Chemicals:
Definition of vision for future of Chemicals...

Digital use cases along six domains
- Asset maintenance optimization
- Production process optimization
- Supply chain decision making
- Trading decision making
- Field operator/technician productivity
- Material management

... and identification of digital use cases to progress towards future
## Opportunities to address pain points across six key areas

<table>
<thead>
<tr>
<th>Domains</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1 Asset maintenance optimization</td>
<td><strong>Prediction of equipment failures and performance variations</strong>&lt;br&gt;Advanced analytics to monitor process and equipment performance in order to identify patterns for prediction of breakdowns and performance variations</td>
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<tr>
<td>2 Production process optimization</td>
<td><strong>Improved analysis of existing data to identify optimal plant settings</strong>&lt;br&gt;Analytics/process control to identify optimal plant settings enhanced by online material analysis/sensors as well as real-time optimization</td>
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<tr>
<td>3 Supply chain decision making</td>
<td><strong>Advanced algorithms for better planning &amp; scheduling accuracy</strong>&lt;br&gt;Digitization of activities to run simulations, automated update of production plans/schedules as well as advanced analytics to optimize planning &amp; scheduling</td>
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<td>4 Workplace safety</td>
<td><strong>Wearables and sensor detection hardware to monitor health and safety metrics</strong>&lt;br&gt;Sensors attached to clothing, gear, or wristbands, complemented with sensor detection hardware and analytic software to monitor conditions and predict hazards to avoid accidents</td>
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<td>5 Field operator / Technician productivity</td>
<td><strong>Provisioning of additional, more targeted information to support field operators</strong>&lt;br&gt;Smart field operators/maintenance assistants supported by mobile devices/augmented reality and drones/inspection robots providing all relevant information</td>
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<td>6 Material management automation</td>
<td><strong>More efficient management of spare part and warehousing activities</strong>&lt;br&gt;Integration with spare part suppliers, automated registration/dispatch of goods via RFID, augmented reality in the warehouse as well as additive manufacturing</td>
</tr>
</tbody>
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*Source: BCG*
Asset maintenance optimization – Example 1:
Analysis of fouling level at IGCC¹ gasifier cones

**Description:** Prediction of fouling level at IGCC¹ gasifier cones

Development of intelligent algorithm with machine learning technology that analyzes actual and historical data to predict fouling level indicating maintenance need.

**Challenge:** Reliable prediction of maintenance need at gasifiers

- Breakdown of gasifiers requires stoppage of entire IGCC
- Current preventive approach at gasifiers with shorter cycles than other IGCC units

**Approach:** Development and testing of predictive maintenance algorithm

- Algorithm is built based on historical process and asset data (e.g., pressure, feed characteristics, % of soot) and understands key correlation between parameters
- Algorithm is built with 2/3 of data and tested on other 1/3

**Impact:** Reduction of unplanned maintenance and increase of maintenance cycles

- Reduced unplanned maintenance events as gasifiers already increasing production margins (~5m € annual production losses due to unplanned breakdowns before application of predictive maintenance)
- Increased uptime of gasifiers and maintenance cycles of gasifiers developing towards cycles of remaining IGCC units leading to increased uptime of entire IGCC

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¹ Integrated gasification combined cycle
Source: BCG project experience

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Asset maintenance optimization – Example 2: Reduced service cost by 70% at wind turbine manufacturer

Client situation: Operational cost impacted by breakdowns and failure
Wind turbine manufacturer and operator using mainly corrective maintenance
Expensive ad-hoc usage maintenance and direct impact of breakdown outage time on production

Pain points: Large amount of data not utilized
Multiple continuous data feeds from each turbine
Currently data not used to full extend

Approach: Pattern analysis and prediction
Sequence of fault messages analyzed
Machine learning with random forest model to predict breakdowns
Predictive model within 7 day window

Value delivered: Large OPEX savings

OPEX reduction of ~50% possible
• Service costs are > 75% of OPEX
• Cost saving potential ~70% of service costs; plus 3% higher performance

Established client ability to expand in-house activities
• Build and implement tool and upgrade interfaces
• Tool is prerequisite for moving from outsourced to self-managed service
• Support client as performance partner hands-on to implement new operating model

Source: BCG experience
**Workplace safety:**
Wearables tracking location/condition improve safety standards

**Description**
- Wearable sensors attach to employees’ clothing and gear to collect data and provide monitoring of employee health, safety, productivity, and other workforce metrics

**Requirements**
- Sensors attached to employees’ clothing, gear, or wristbands
- Sensor detection hardware
- Analytic software to monitor conditions and predict hazards

**Benefits**
- Monitoring of employee vital signs to predict long-term health concerns
- GPS tracking for proximity alarms in danger zones, location during emergencies, and productivity analysis based on time spent per location
- Faster detection of harmful gasses

**Illustration**
- Fire erupts at facility, activating workforce emergency system
  - Geo-location sensors notify crisis team of employees at risk; Operator 3 non-responsive to calls
  - Rescue crews routed to Operator 3’s exact location based on sensor GPS signal
**Field operator/technician productivity:**
Future field personnel will work different from today

- **Augmented reality devices** displaying plant performance while maneuvering in the field (e.g., while changing settings)
- **Wearable safety sensors** monitoring:
  - Location
  - Vital functions
  - Air contamination
  and are connected to the control room
- **Real-time video communication** with experts such as:
  - Shift manager
  - Control room
  - External experts
- **Smart, portable devices** displaying all relevant information such as:
  - Performance data and current plant settings
  - Information about past events
  - Part specifications
  - Instructions to perform activities
  - Information from other functions

Source: BCG
Some learning lessons

Senior level commitment – it has to be a top management priority

Coordinate and phase it out – you can’t get step change results with many small efforts, focus on a few and get impact

Focus on your pain points – not what is technically possible, but what will bring value

Get started – don’t wait for the perfect data, infrastructure

Think beyond technology – do you have the right people, organisation? Are your people with you in this journey

Keep updated – technology is moving fast
Thank you