

Digitalization of the European Chemical Industry



The Chemical Industry at the Heart of the Fourth Industrial Revolution

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Cefic Innovation

SPIRE cPPP Industrial R&I Advisory Board

PRACE HPC Industrial Advisory Committee – Materials/Chemistry



Challenges of globalization



- ✓ Climate Change & Energy
- ✓ Complex Security Challenges
- ✓ Demography
- ✓ Need for further Consolidation, Competitiveness and Cohesion
- ✓ **Digital (Industrial) Revolution 4.0**

The Future of European Economy

- ✓ Carbon-Neutral Economy
- ✓ Circular Economy
- ✓ **Digital Economy**

Digitization transforms the Chemical Industry rapidly across its entire horizontal value chain



Big-data/ advanced analytics in OpEx/ CapEx:

Big data-driven raw material analytics to optimize feedstock costs

End to end supply chain integration:

Production data sharing with suppliers/ real-time supply tracking

Process automation:

Sensor-based production control and real-time optimization of YETQ¹

Integrated lean system:

IT-based integrated lean system to drive manufacturing excellence

Engineering/ R&D 4.0:

Machine-learning-driven recipe and formulation improvements

New roads to market:

Using online/marketplace sales channels

Digitization of customer experience:

Customer self-service platform

Digital procurement tools: Digital tools enabling more efficient procurement processes

Predictive maintenance: Advanced analytics-based predictive and risk-based maintenance

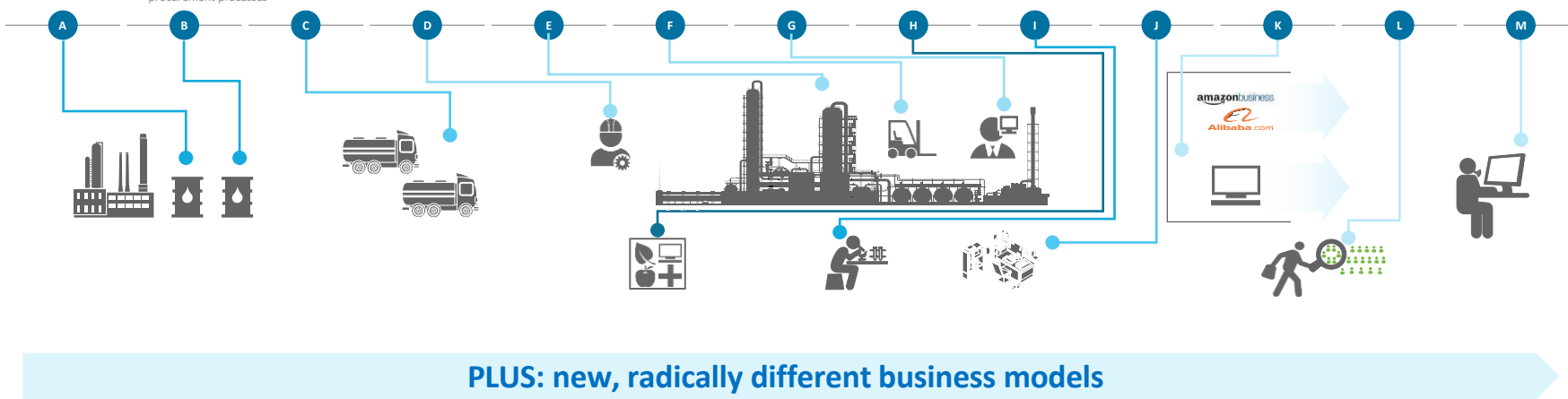
Digital manufacturing: Production automation by application of autonomous logistics, drone inspections

Risk management: Advanced analytics-based risk management/cyber security

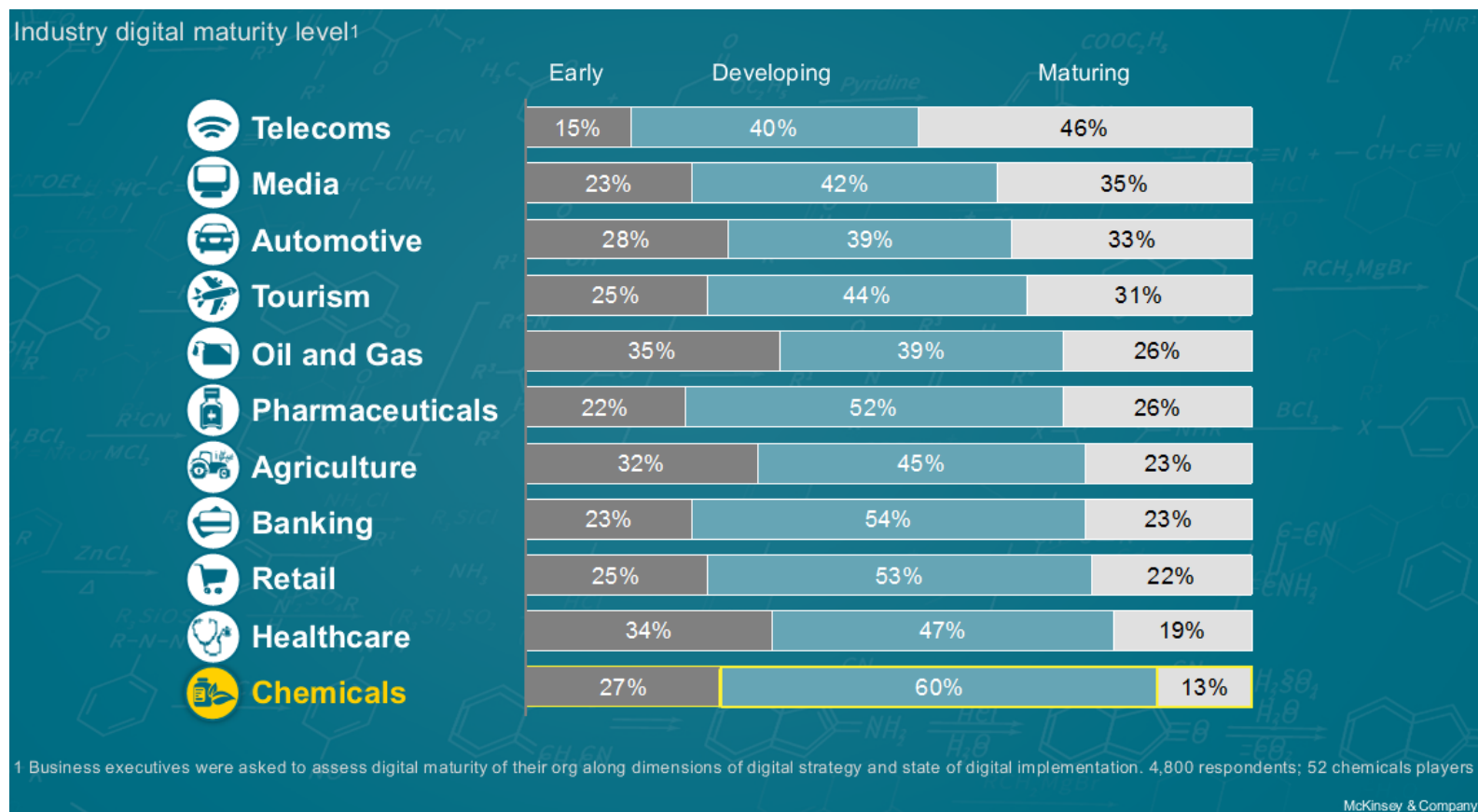
G&A 4.0: Back office automation, e.g., no touch orders

Commercial engines: Use advanced analytics for lead generation, etc.

THE DIGITAL CHEMICAL COMPANY



Chemicals have lagged behind other industries in terms of digitalization



Profitability potential in functional areas - probably most in manufacturing and M&S



1 We see the biggest potential in commercial and operations but also in other functional areas
 EBITDA improvement potential by lever, p.p. (rough estimate – on top of what you can do already today, i.e., digitally enabled)

Manufacturing (4-6%)

“Transform Operations leveraging advanced analytics and design”

- Yield, Energy, Throughput management
- Predictive maintenance
- Robotics & automation
- Digital performance management

Marketing & Sales (4-6%¹)

“Leverage advanced analytics to better understand customer demands and increase return on sales & growth”

- Digital & omni-channel management
- AA-driven growth and margin improvements
- Digital customer experiences
- Digital commercial backbone

G&A Automation (0.5-1%)

“Automate G&A functions and improve decision support systems”

- AA-based decision support system
- RPA-based automation of G&A activities
- Digital performance management

Procurement (1-2%)

“Use big data to improve spend effectiveness”

- Spend visibility
- AA-enabled Sourcing
- Automation in purchase-to-pay
- Digital performance management

Innovation (0.5-1%)

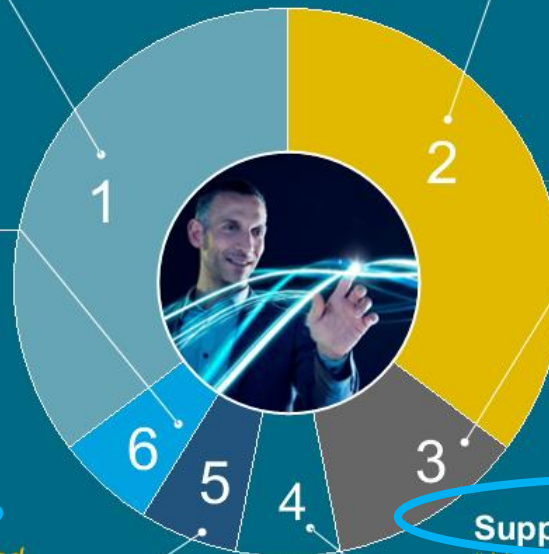
“Push innovation capabilities and reduce complexity through AA”

- Digital-enabled innovation
- Lab Research 4.0
- Smart formulation
- Digital ROI performance management

Supply Chain (0.5-1%)

“Use big data to improve supply efficiency end-to-end”

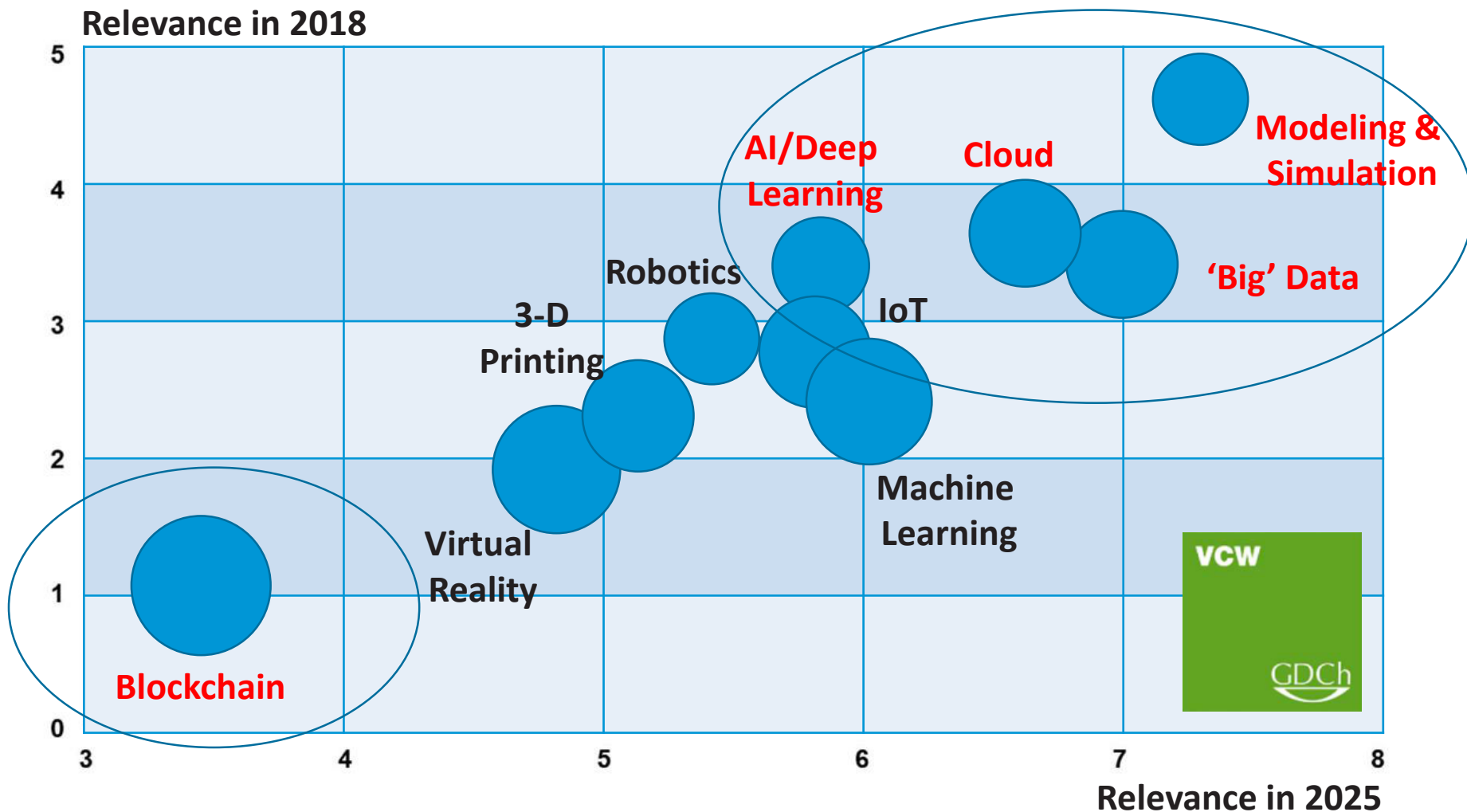
- Predictive supply chain analytics in demand planning
- Advanced robot-based logistics
- Digital warehouse
- End-to-end network optimization



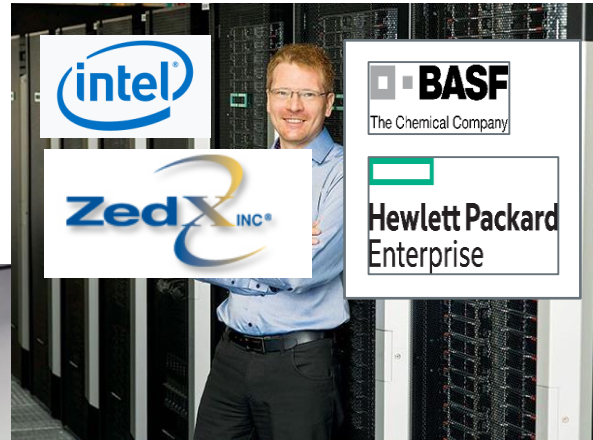
Return on Sales

McKinsey & Company 8

Expected development of disruptive digital technologies by 2018 -2025 – Modeling/Data/AI



Data-driven technologies in chemical industry – value creation through advanced data analytics



VALUE FROM DATA



Data Analytics

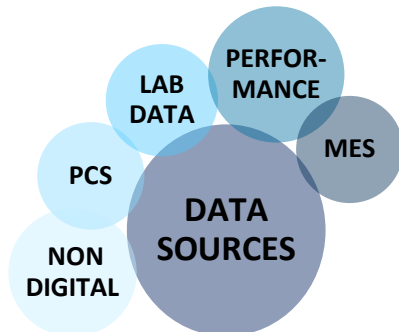
- Visualization
- Modelling
- Process Optimization
- Predictive Maintenance
- Performance prediction

Data Storage

- Data aggregation
- IT Infrastructure
- Platforms
- Cloud/ web based
- Data security

Data Availability

- Accessibility
- Connectivity

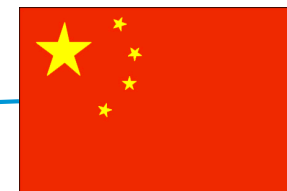
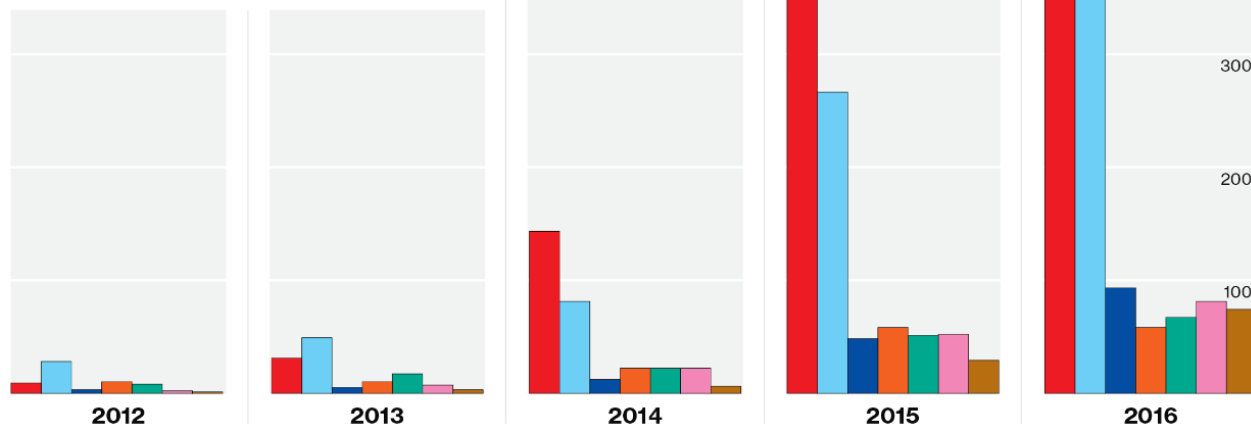


Research papers 2012-2016 with AI background



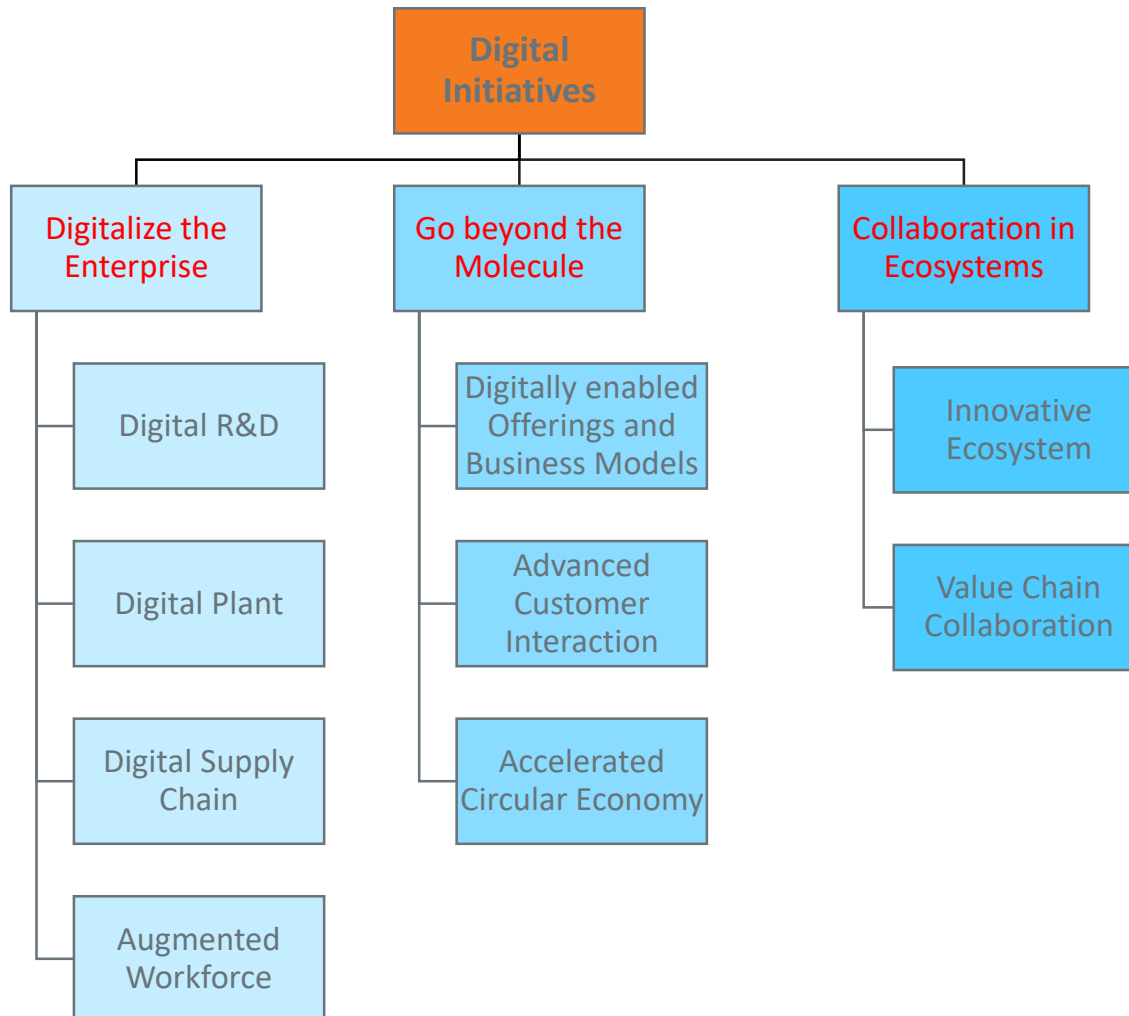
China Learns Quickly

Since 2014 China has published the most research papers per year on deep learning, an advanced form of artificial intelligence.



Chemical Industry: Government issued “*Intelligent Manufacturing Development Plan (2016-2020)*”, encouraging (petro)-chemical industry to develop *Intelligent Manufacturing*

Going digital structured: digital playgrounds and initiatives in the chemical industry



Digitalize the Enterprise - more efficient manufacturing chain



- a. **Real-time sensing capability** - provide correct process information to authorized users in real-time
 - b. **Feedback control** to detect deviations and adjust operations immediately decision support
 - c. **Asset performance management/predictive maintenance**
 - d. Advanced **operator support** (e.g., smart data visualization, augmented reality, gamification)
 - e. **'Digital Twin'** (dynamic virtual plant/process models) to predict the of impact of (design) decisions and to anticipate bottlenecks
 - f. **Integrated production** planning
 - g. Information **integration across operations** and enterprise technology layers
 - h. End-to-end **(financial) visibility** from top-floor to shop-floor
- ✓ Higher plant availability and throughput
 - ✓ Better predictability of manufacturing
 - ✓ Reduced lead-times
 - ✓ Higher flexibility and agility/remote operations
 - ✓ Less product quality issues
 - ✓ Less consumption of energy and raw materials
 - ✓ Less costs for lab-analyses
 - ✓ More efficient plant maintenance
 - ✓ More efficient allocation of staff
 -

Go beyond the Molecule – new revenue opportunities by enabling radically different business models



- a. **Pricing** excellence
- b. **Sales and service** excellence
- c. **Marketing** excellence
- d. **Marketing & sales channel** optimization

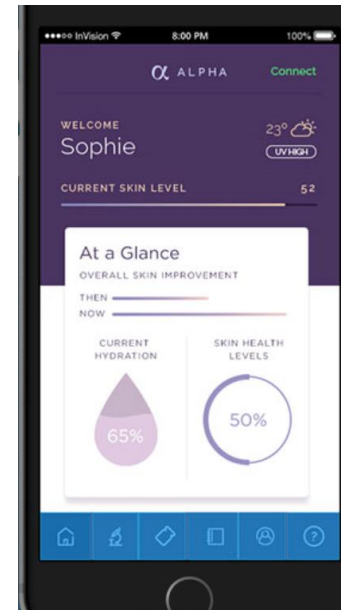
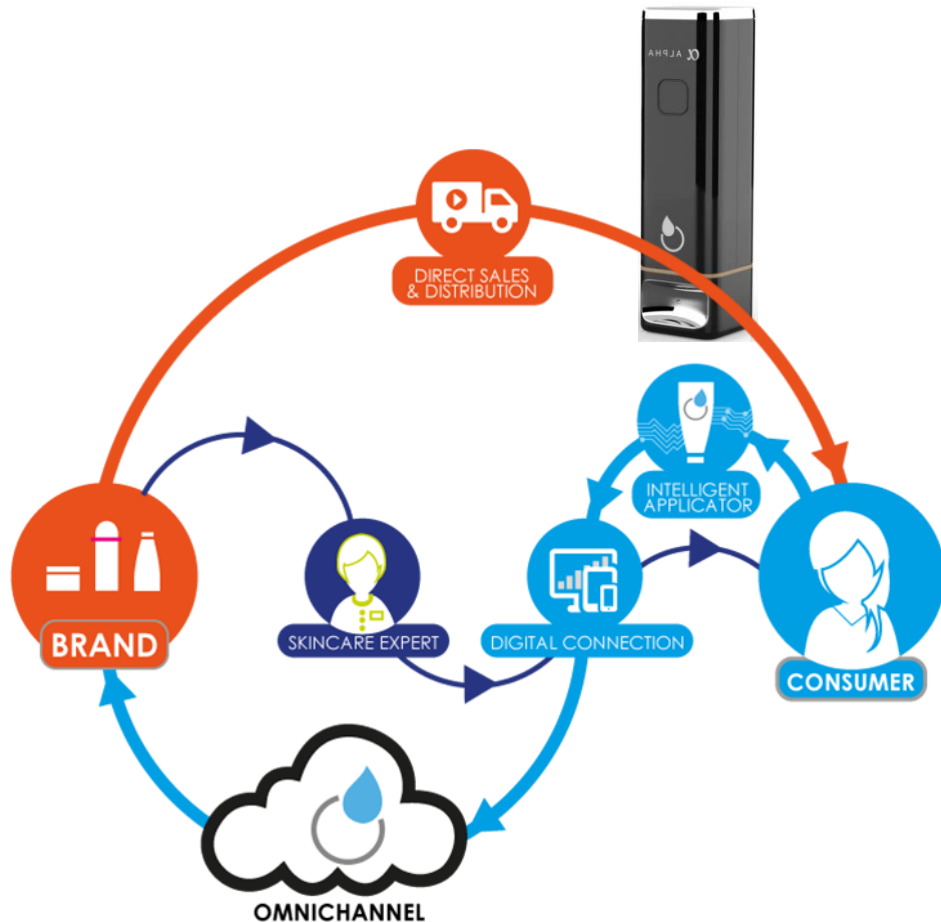
- ✓ New business models
- ✓ Increase revenue/decrease cost-to-serve
- ✓ Seamless multi-channel experience
- ✓ Better understanding of evolving market needs
- ✓ Improved insight into the competitive landscape
- ✓ Ability to more quickly react to market demand and cyclicity
- ✓ Tailored products
- ✓ Customer awareness

Digital enabled offerings and business models – examples of going beyond the molecule



TODAYS SELL	TOMORROWS GUARANTEE
Products/formulations such as cosmetics ingredients	<u>optimum skin</u> care through a digital service
Products such as seeds, fertilizer etc.	a certain <u>yield</u>
Water-treatment <u>chemicals</u>	<u>quantity</u> of clean water
Industrial lubricants	guaranteed <u>machine hours</u>
Paints	years of <u>preservation</u>
Treatment <u>chemicals</u>	quantity of noxious <u>substances removed</u>
Fixed pricing	value-based pricing <u>depending on outcome</u>
Fixed quantities	automatic <u>refill</u> , fluid as a <u>leased service</u>

Example: personalized skin care for consumers



A Physical Device

A Digital Service



Measure

A device that knows your skin



Application

Smart cartridge delivers perfect application



Connected

Data that monitors your experience



Advising

Professionals to perfect the results

Companies moving into B2B chemical sales platforms, both existing and new



CheMondis

Alibaba for chemicals

WILL BEACHAM BARCELONA

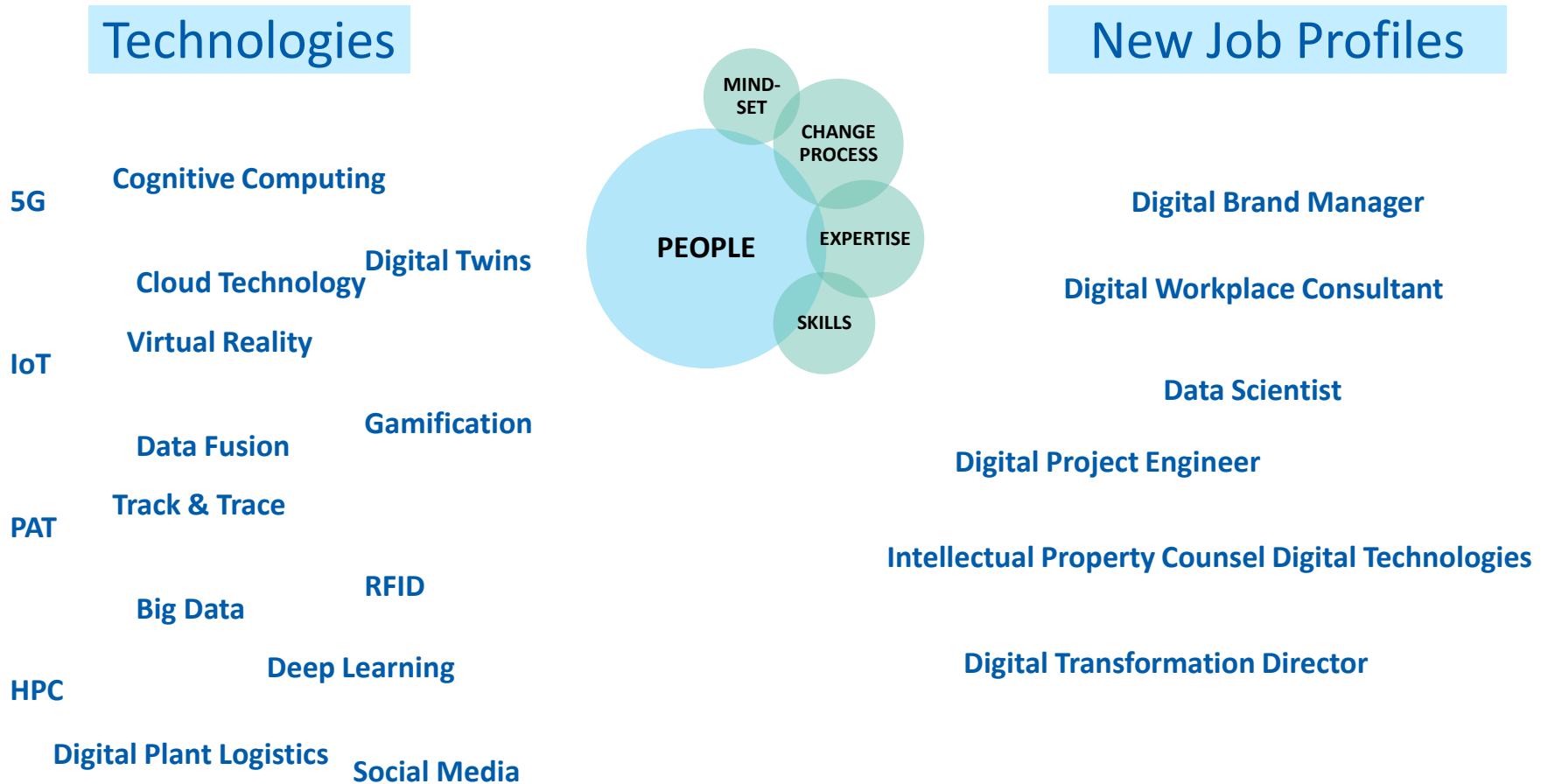
Sector is at last embracing e-commerce in a big way as the world's largest chemical company, BASF, joins up with Alibaba along with Covestro as they seek new paths to customers



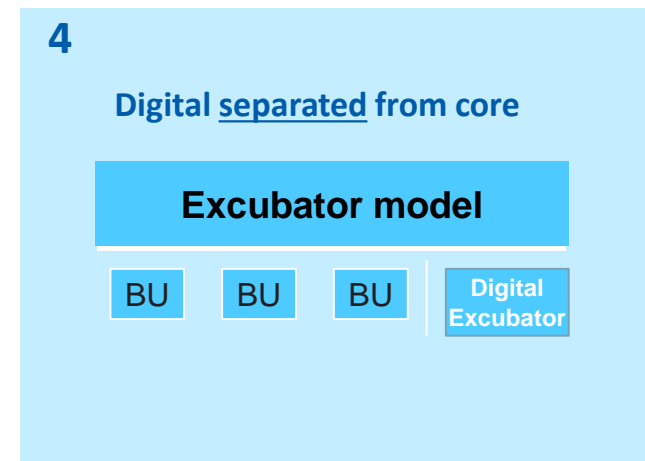
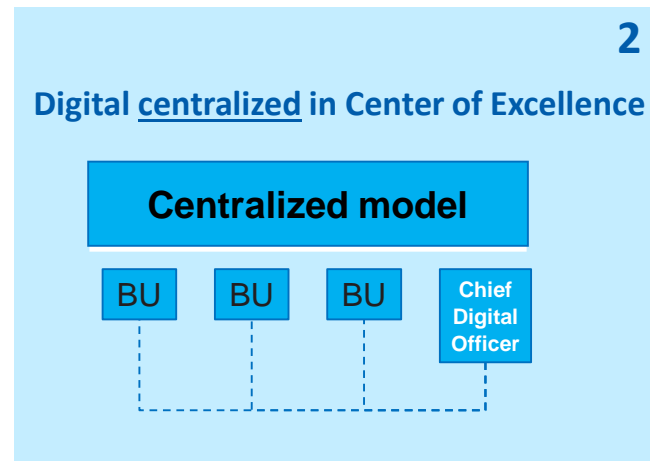
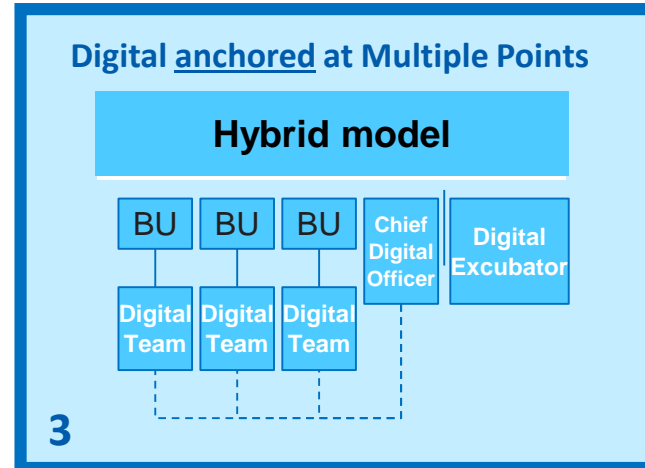
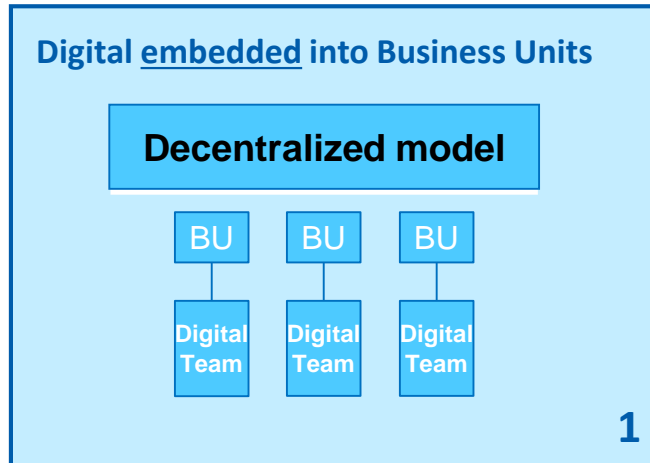
Covestro moves beyond R&D

Company strategy pairs traditional research and development with innovation related to digitisation and process improvement. All employees are encouraged to participate

New skills are required to reap the full benefits of digital technologies

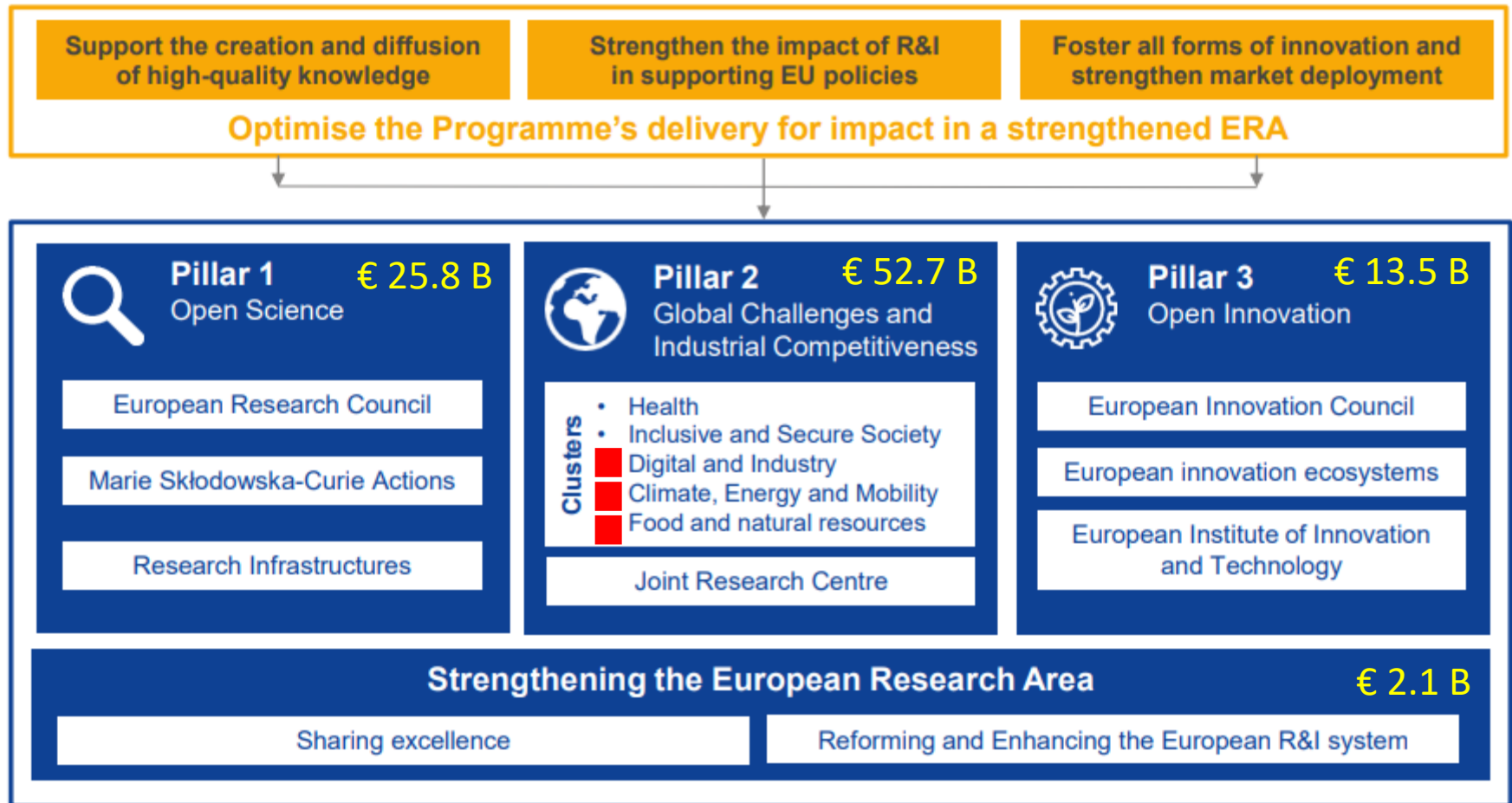


Different strategies/operating models are implemented by industry to go digital



Horizon Europe: evolution not revolution

Specific objectives of the Programme



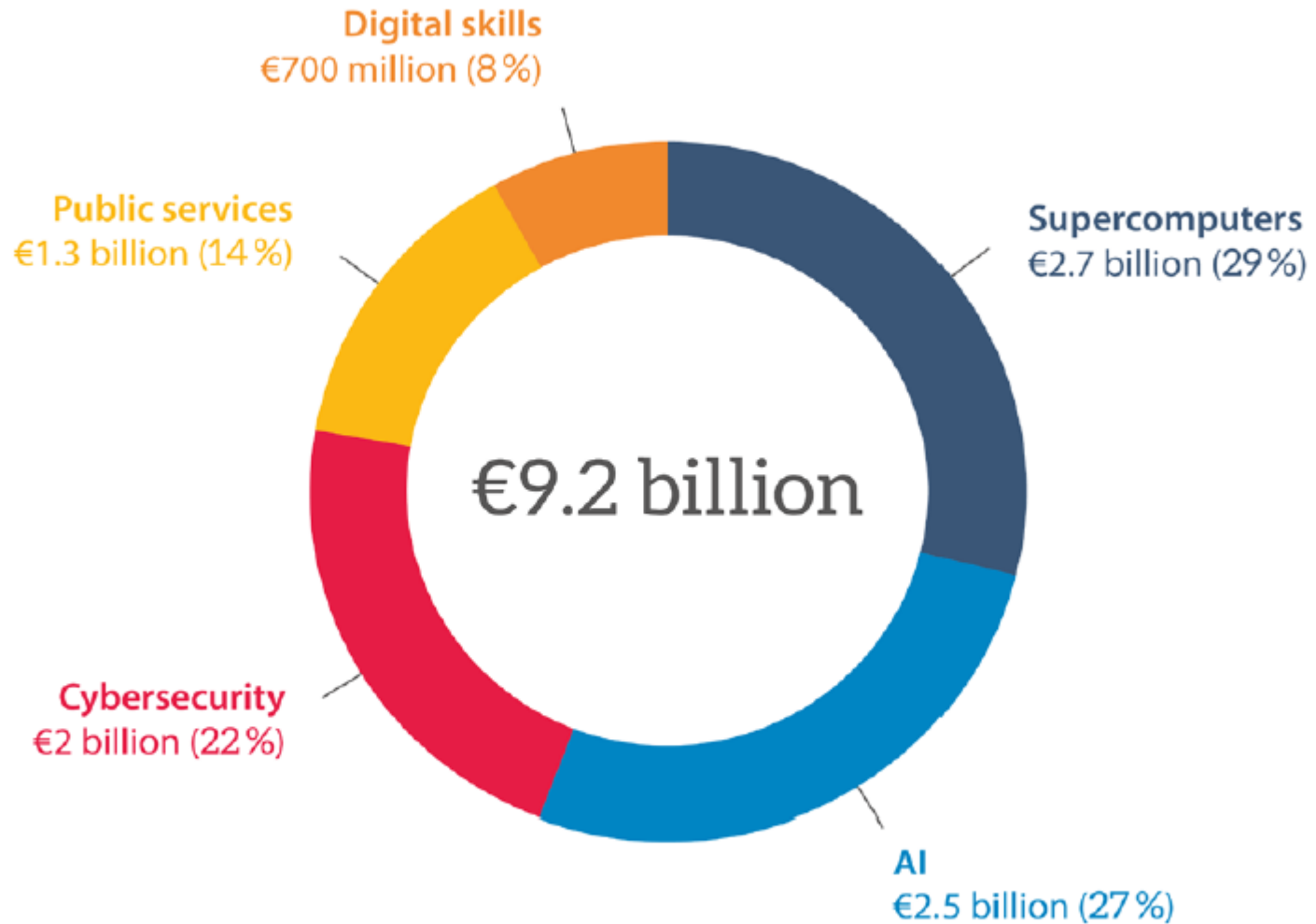
Horizon Europe – proposal by the EC



Clusters in 'Global Challenges and Industrial Competitiveness'

Clusters	Areas of intervention	
Digital and Industry € 15 B	<ul style="list-style-type: none">* Manufacturing technologies* Advanced materials* Next generation internet* Circular industries* Space	<ul style="list-style-type: none">* Key digital technologies* Artificial intelligence and robotics* Advanced computing and Big Data* Low carbon and clean industry
Climate, Energy and Mobility € 15 B	<ul style="list-style-type: none">* Climate science and solutions* Energy systems and grids* Communities and cities* Industrial competitiveness in transport* Smart mobility	<ul style="list-style-type: none">* Energy supply* Buildings and industrial facilities in energy transition* Clean transport and mobility* Energy storage
Food and Natural Resources € 10 B	<ul style="list-style-type: none">* Environmental observation* Agriculture, forestry and rural areas* Food systems* Circular systems	<ul style="list-style-type: none">* Biodiversity and natural capital* Sea and oceans* Bio-based innovation systems

Digital Europe Programme

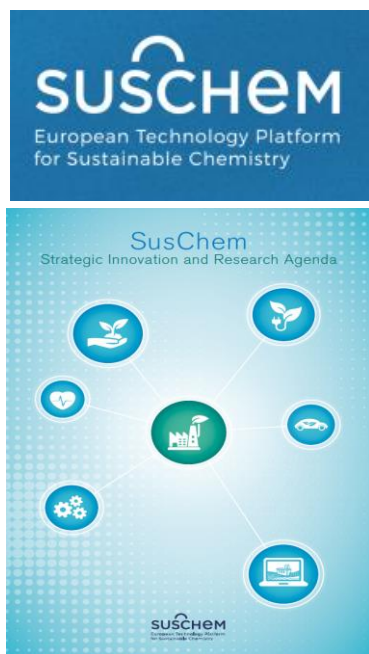


Data source: [European Commission](#), 2018.

Main innovation initiatives on European level supporting R&I funding in the area of technology the chemical sector



European Technology Platform



Horizon 2020



Horizon Europe



Public-Private Partnership

The SPIRE (Sustainably Process Industry through Resource and Energy Efficiency) Public/Private Partnership



2014 – first-ever PPP with **process industry** comprising 8 sectors

2015 – first SPIRE projects launched, today project **portfolio of 81 projects**

EC budget (7 years period) – **€ 900 million**

Participation under **Horizon 2020** rules



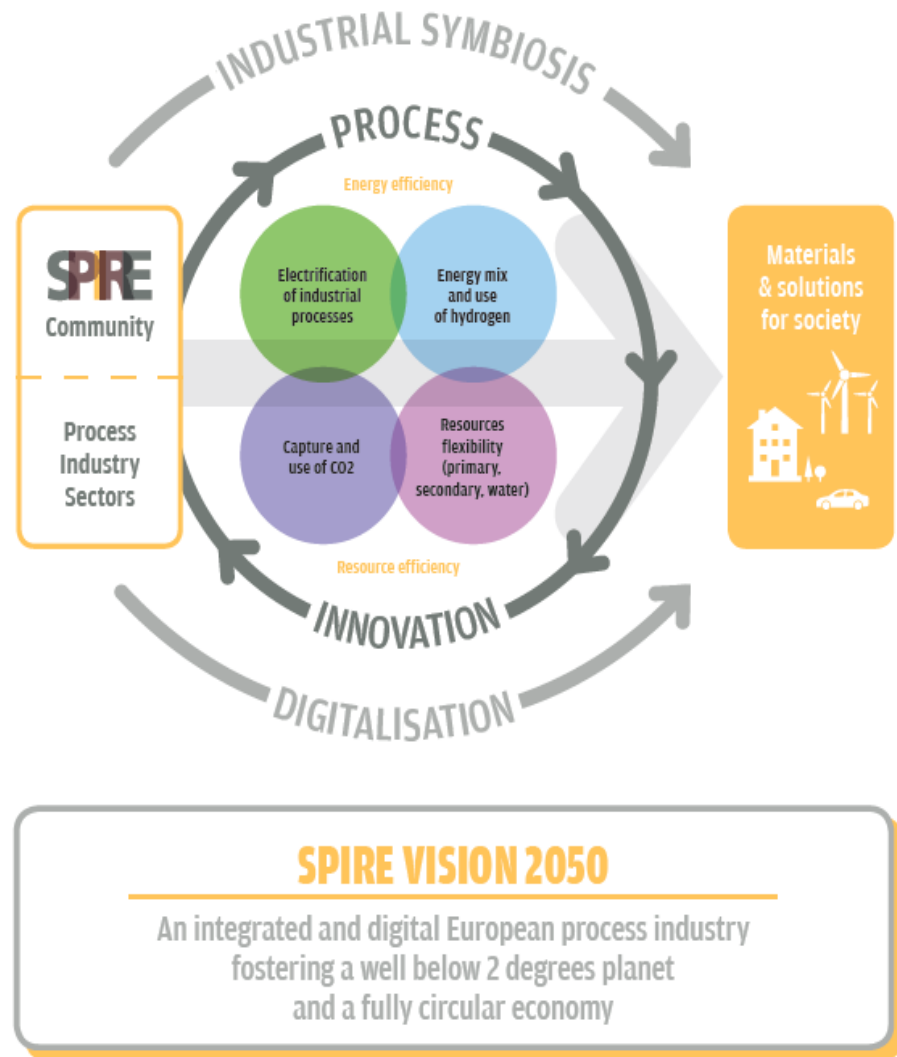
Digital in the SPIRE cPPP 2050 Vision



*“An integrated and **digital**
European process industry*

*fostering a “well-below 2°C” scenario
and a fully circular future
for our planet and society.”*

SPIRE 2050
Our Value Proposition



2015-2019: SPIRE cPPP 'Digital Project' portfolio >100 M Euro EC funding



	<p>✓ production in flexible, intensified continuous and batch plants by introducing novel online sensing equipment and self learning closed-loop control systems</p>
	<p>✓ Integration of local control into overarching real-time plant optimization and scheduling systems through online data analytics and model based predictive control (data- and first-principle models), symbiosis of operators and computer-based control algorithms</p>
	<p>✓ Process intensification design and optimization in processes in which solids are an intrinsic part</p>
	<p>✓ Model-based optimization for efficient use of resources and energy</p>
	<p>✓ Advanced modelling and 3D-printing of reactors</p>
	<p>✓ Management systems and platforms enabling industrial symbiosis</p>

Example innovation in process digitization



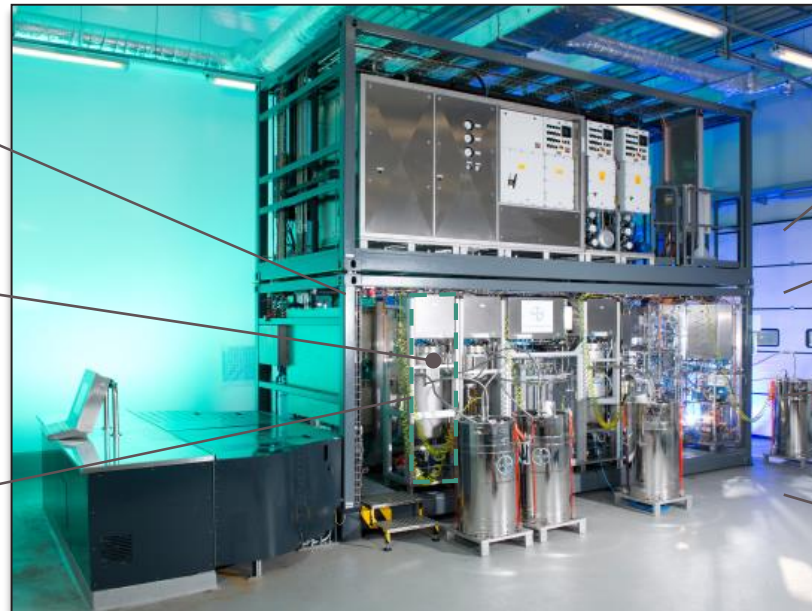
Advance the production of high-value products that meet high quality demands in flexible intensified continuous plants: Not possible without fast and accurate **online sensing of key product and process parameters including closed-loop control and online optimization**

Characteristics

Miniaturized equipment

Intensified heat & mass transfer

Possibly modular setup



Benefits

Product uniformity

Sustainability

Fast adaption to market demand

Innovative products

SPRE Sustainable Process Industry through Resource and Energy Efficiency

Example: SPIRE cPPP project



INEOS in Cologne CoPro use case – network optimisation



Generation of an optimal schedule for the operation of the plants in the ammonia network

- Time horizon one month or more
- Includes logistics
- Optimization of plant loads and cold storage
- Improved resource usage
- Demand side response

Improving the coordination of strongly coupled production plants

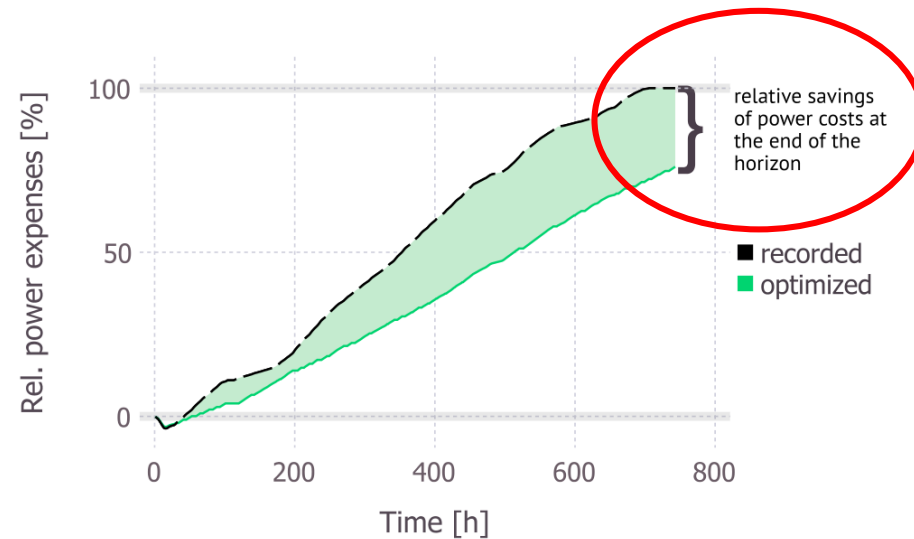
CoPro use-case: INEOS in Cologne– NH₃ network optimisation



The optimisation model contains:

- ✓ Mass balances
- ✓ Operational constraints
- ✓ Equipment limitations
- ✓ Logistic constraints
- ✓ Production targets
- ✓ Negotiated deliveries

Simulation results were obtained for a 31 days scenario



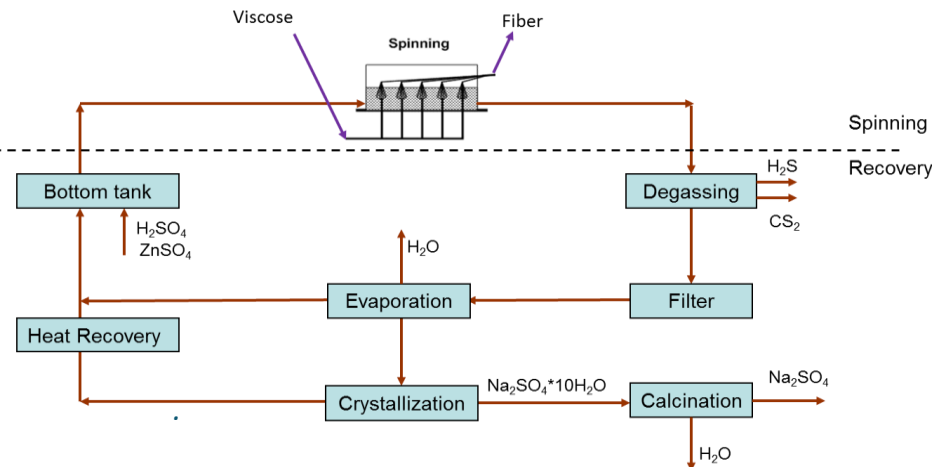
Large saving potential identified if the network operations are performed in an optimal fashion compared to recorded data



CoPro use-case: Lenzing spinbath recovery system



Cross-unit and cross-functional coordination of the recovery cycle in Europe's biggest cellulose fiber plant



The recovery cycle of Lenzing's viscose fibre plant in Upper Austria

Objectives:

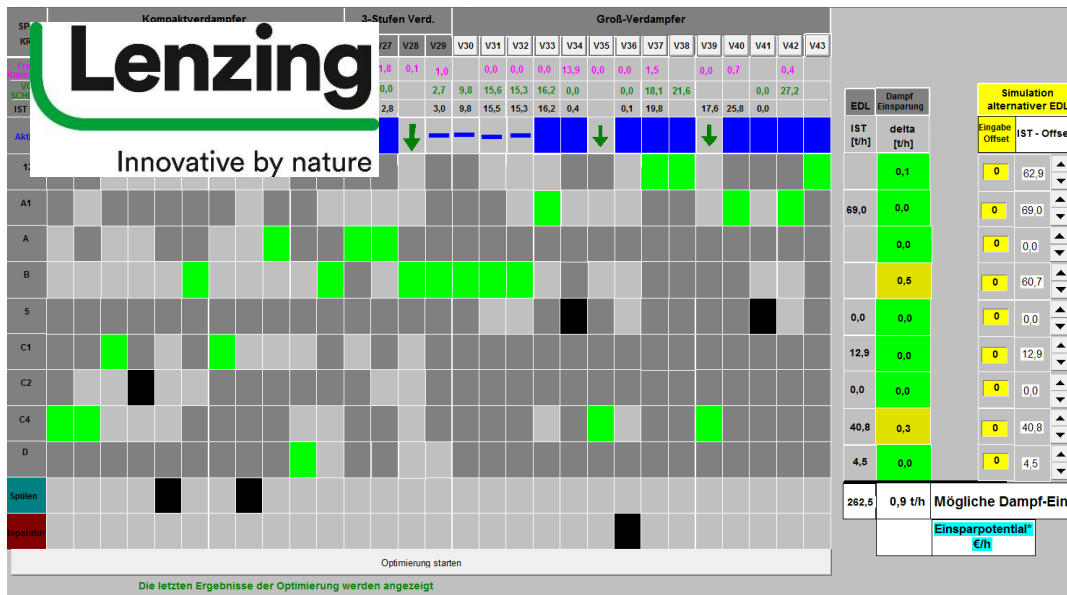
- Efficient load allocation in the multi-unit evaporator network
- Cleaning sequence coordination for the evaporator and heat recovery section
- Optimized cooling water distribution in the recovery cycle



Lenzing USE CASE: Decision support system



Lenzing & TUDO developed a model based decision support system for a more efficient evaporator load allocation

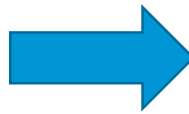
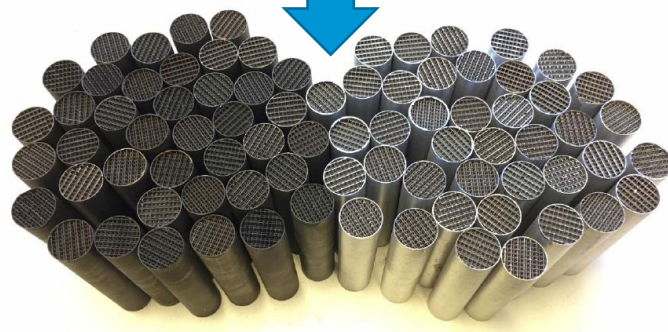
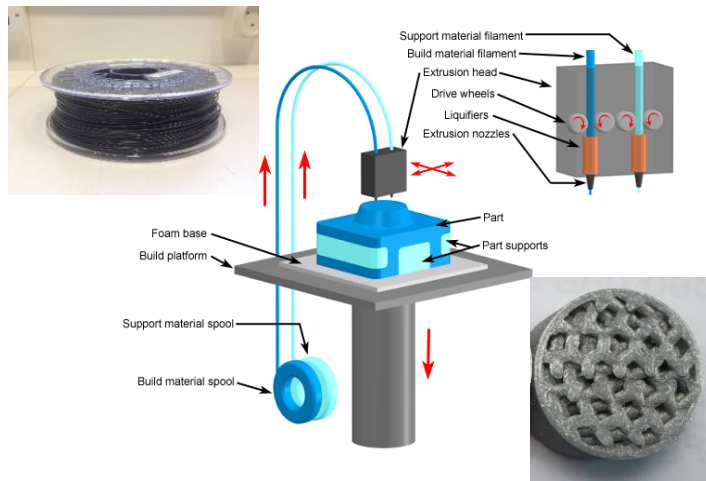


- ✓ Fully implemented in the control room in August 2018
- ✓ 1.8% more efficient operation
- ✓ Steam savings around 1200 t/month
- ✓ ≈ 250.000 €/year savings
- ✓ v2.0 Update with semi automatic control currently under development

HMI of the Decision Support System implemented in Lenzing control room

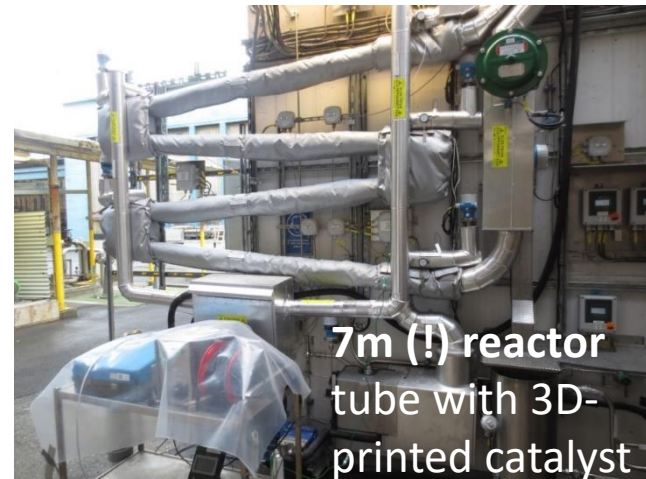


Example: Process Intensification through adaptable catalytic reactors made by multi-level modeling and by 3D-Printing



PRINT CREDIT

first European initiative purely dedicated to study the effect of 3D printing of (reactors) in the chemical industries



Example: Industrial Symbiosis platforms

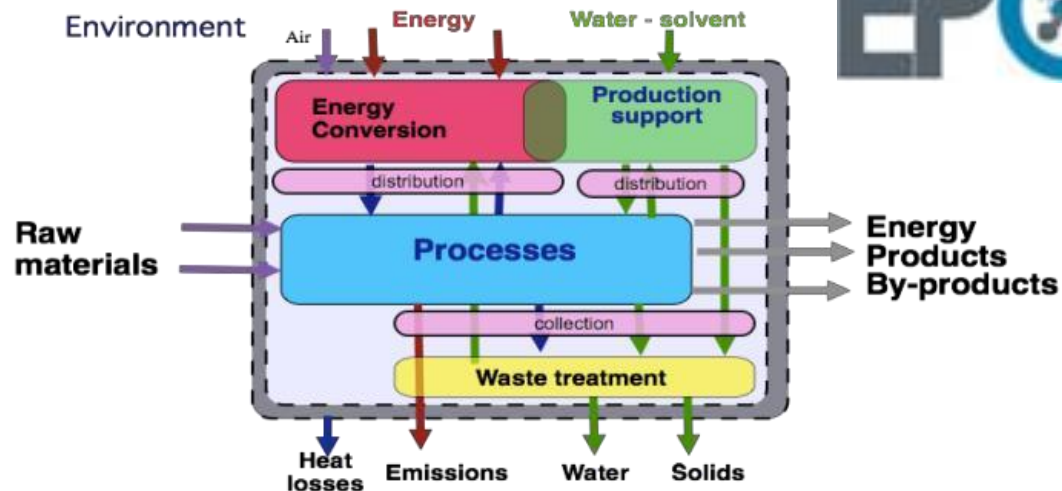


IS implies that information must be shared between process sites: site blueprints which characterize and visualize typical processes, units and utilities for each sector including virtual profiles for heat, electricity and material streams represent a plant in operation in a given sector, thus prompting for options to collaborate.

EPOS developed virtual sector profiles for rapid screening of nearby industry sites spotting unaware opportunities to collaborate. It drives the search for new business potential in and across process sectors.

powerful software
calculation engine:

uses optimization to
calculate and quantify a
set of optimal
integration scenarios
amongst symbiosis
partners



Conclusions



1. **Digital** is seen by most chemical players as **clear growth opportunity - chemical value chains known by today might change completely** through digitalization, products and related process getting more personalized creating and delivering **higher value for customers** through empowering of local, **more specialized value chains**
 2. Digital will further **improve operations**, e.g. **cognitive plants, advanced maintenance, digital process** and **plant design** through dynamic digital twins, **plant/site wide control**
 3. Many companies have **built-up significant resources and additional organizational structures** to start capture the full range of digital opportunities - but **different digital operating models** in place. **New technologies** and **collaboration** is becoming a key success factor
 4. New type of **education and job profiles** will be required to transform the industry, digital is not limited to the use of digital tools and devices, but must become a **company mindset** instead
- Innovation policy and funding in Horizon Europe: Investments in further **industrial innovation is required** to support the **development/demonstration/ implementation** of **fast emerging digital technologies** related to a **industrial competitiveness, circular economy, higher energy- and resource-efficiency**
 - **SusChem and SPIRE cPPP** have both initiated processes to develop their HE roadmaps together with experts from academia, RTOs and industry

Thank you for your attention



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