SPIRE Roadmap 2050
Digital Innovations in Process Industry

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SPIRE Vision 2050

An integrated and digital European process industry fostering a “well-below 2°C” scenario and a fully circular economy.

More information:
The starting point to develop the Roadmap
Successful portfolio of SPIRE ‘Digital Projects’ in Horizon 2020

| ✓ production in **flexible, intensified continuous and batch plants** by introducing novel **online sensing equipment** and self learning **closed-loop control systems** |
| ✓ 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** |
| ✓ **Process intensification design and optimization** in processes in which solids are an intrinsic part |
| ✓ **Model-based optimization** for efficient use of resources and energy |
| ✓ **Advanced modelling and 3D-printing** of reactors |
| ✓ Management systems and **platforms enabling industrial symbiosis** |
Digitalisation Transforms the Chemical Industry Rapidly Across its Entire Value Chain

New SusChem SIRA:
http://suschem.org/newsroom
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<th>Innovation Programmes</th>
<th>Description</th>
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<td><strong>I. Digitalization of the design phase of processes and materials</strong></td>
<td>Digital R&amp;D processes: Topics covering digital tools in the early materials/process design phases. Advanced in-silico modelling and applying digital twins and other digital solutions to design materials and processes can speed up the design phase, shorten time-to-market, result in processes with higher energy and resource efficiency, and contribute to flexibility and enhanced safety of operations.</td>
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<td><strong>II. Digitalisation of plants</strong></td>
<td>Plant optimization for safe and efficient operation: Digital technologies such as advanced sensors (PAT), model predictive control (physics/data-based), real-time optimization are needed to operate in a flexible and agile manner and with higher efficiency and reliability. Reliable predictions of remaining lifetime and predictive maintenance will significantly reduce unplanned shutdowns and lead to improved efficiency. Digital support of operators and human-process interfaces.</td>
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<td><strong>III. Digitalization of connected processes and supply chains</strong></td>
<td>Digital technologies can improve the management of highly connected processes to ensure efficient use of production assets, resources, and energy while safeguarding quality, yield, and reliability. Supply chain digitalization will happen within a company or production chain, integrated with the upstream and downstream value chains, and across industries and within regions and municipalities (&gt;&gt;urban-industrial symbiosis).</td>
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SPIRE Roadmap 2050 - Digitalisation of Design Phase (I)
Programming ‘Digital Materials Design’

1. **Integrate computational tools** (including physics-based, data-based models, artificial intelligence) into materials design

2. **Platforms for data sharing along innovation ecosystems to foster knowledge- and data-driven collaborative R&D**

3. Digital technologies for full **product eco-design** by managing complex interactions and demands in-between different supply chains

4. Implement digital supported **life-cycle sustainability assessment** methodologies in early development phase
Modelling remains still a big bottleneck:

1. **Large-scale predictive dynamic simulations** (from physics-based to data-driven/AI-based)

2. **Platform design and implementation for model exchange and model-reuse** within and across companies and within the **whole ecosystem of the process industries**

3. Development of methods and mechanisms for **dynamic model adaptation** to the observed process behavior during the full life cycle of the plants with minimum intervention by semi-automatic procedures

4. Integrate **virtual reality tools** in a computationally efficient ways to enable **real-time visualization and large-scale scenario planning** into digital twins

5. **Digital twins of large-scale production processes**, including heterogenous (physics and data-based) models of different granularities
1. Intelligent sensors (PAT) and sensor networks for products, processes, plants, and environmental aspects
2. Pre-processing of all plant/process data
3. Automatic real-time extraction of knowledge from large amounts of process data
4. Early detection of equipment failures and techniques for predictive/prescriptive maintenance actions, coordinate maintenance actions with production scheduling
5. Integrate cognitive and site-wide maintenance solutions
6. Expanding process monitoring system by all relevant environmental and life cycle assessment aspects and initiation of counteractions
 SPIRE Roadmap 2050 - Digitalisation of Plants (II) Programming ‘Digital Plant Operation’

Combing advanced data analytics and rigorous modelling:

1. Establish an **ecosystem of ‘digital twins’** suitable for process control purposes
2. Decision support systems and **suitable operator interfaces** for processes that cannot be operated fully automatically
3. Fully **dynamic control of single processes/plants** integrating all aspects (quality, costs, environment)
4. Demonstration of **cognitive control** of typical classes of processes
5. **Machine learning/artificial intelligence** techniques suitable for cognitive process control - combining techniques from data analytics and rigorous modelling in order to develop **suitable models efficiently**
6. Integration of **anti-cyber attack solutions** into process control system
Please access:

1. Integrated planning, scheduling and plant/process management on sites and in connected value chains
2. Real-time REI and life cycle assessment
3. Concepts/platforms for data sharing along the supply chain in the process industries
5. Track-and-trace of material compositions, concepts, data formats, standards

1. Information platforms on waste (secondary resources) streams in Europe
2. Concepts for full digitalization of recycling value chains, e.g. plastics
3. Advanced sensing and automation for recycling of materials
4. Real-time management of wastewater and waste-heat networks
5. Real-time management and optimization of industrial/urban symbiosis
6. Integration of (climate neutral/green) energy grids into process industries operations

not exhaustive
Thank you!