A safe transition towards sustainable decarbonized processes

Valerio Cozzani, Federica Ricci, Matteo Iaiani, Alessandro Dal Pozzo, Alessandro Tugnoli

LISES – Laboratory for Industrial Safety and Environmental Sustainability, Department of Civil, Chemical, Environmental and Materials Engineering, University of Bologna, Italy

E-mail: valerio.cozzani@unibo.it

Global change and climatic crisis call for a progressive decarbonization of energy and of manufacturing processes, including those of the chemical industry. The decarbonization of energy-intensive manufacturing processes and the introduction of green chemical energy vectors is a critical challenge, affecting the future landscape of the chemical engineering domain. A transformative innovation is crucial to advance the electrification and integration of green value chains in order to shape a sustainable chemical industry.

The transition to decarbonized processes still requires a relevant advancement of technologies. Technology Maturity Level of decarbonized technologies is usually lower than state-of-the-art solution. Thus, a relevant effort is required to progress decarbonized concepts to industrial full-scale sustainable processes. However, when focusing on the development of decarbonized processes, specific challenges emerge, related to safety and environmental impact.

Most of the green energy vectors considered for energy delivery to end-user, as hydrogen or ammonia, introduce inherent substance hazards in the decarbonized value chains. Electrified concepts result in inherently more hazardous reactors or heat transfer equipment than conventional solutions. A clear risk trade-off is thus present when scaling-up decarbonized processes and value chains.

Therefore, process development and scale-up to decarbonized solution requires specific process system engineering tools to identify, assess and control the risk trade off associated with the new concepts introduced.

The present contribution focuses on specific approaches addressing the ex-ante safety and sustainability assessment. Quantitative tools were developed to address the inherent safety and sustainability footprint of technology concepts. Specific strategies for the integration in early design of safety and sustainability drivers were obtained. The methodologies were tested by case-studies concerning the decarbonization of manufacturing processes and value chains. The results show the potential criticality of the risk trade-off, and the useful guidance provided by the application of the early design assessment tools developed.

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