

Managing Risk Through Modular Process Intensification

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Manufacturers are being forced to adapt to new risks posed by climate change, regulations, and customer and investor demands for more-sustainable products and processes. To remain competitive, organizations are working to navigate the risk landscape and understand how new technologies, including intensified and modular processes, can help to reduce risk. While risk is central to the business of insurance companies and investors, manufacturers are just now starting to understand and proactively respond to physical, transitional, and operational risks.

Physical risks for a manufacturer relate to its geographic footprint and the location of its plant sites, which could be exposed to sea-level rise, floods, hurricanes, and unpredictable weather events. Manufacturing sites might also be vulnerable to supply chain disruptions and instability in the utility grid and transportation infrastructure. All of these factors could potentially devalue existing assets.

Transitional risks are associated with changing technology or processes, such as integrating artificial intelligence (AI) and robotics in advanced manufacturing operations, changing energy or fuel sources, or switching to more-sustainable raw materials or new material sources. Utilizing new technologies and processes may also require staff to be retrained and supply chains to be restructured to enhance resilience, account for geopolitical considerations, and to suit policy and regulatory needs.

Operational risks relate to the efficiency of process operations. Measures of operational risk include resource consumption per unit output, product yield, waste or emissions generation, and required maintenance and downtime. Operational risk can be reduced by ensuring operations are robust, which can be enabled through redundancy and supply-chain management.

Insurers and investors are becoming acutely aware of these risks when assessing their portfolios. As a result, manufacturers must incorporate innovations that reduce risk to remain competitive. Modular chemical process intensification (MCPI) is among the innovations that manufacturers can consider for risk mitigation.

Modular manufacturing decentralizes processes that traditionally have large footprints and require high capital investments. Modular plants are small, scalable, and assembled in controlled factory settings. Modular facilities can be positioned and repositioned to enhance flexibility and shorten and protect supply chains. Manufacturers may choose to locate operations closer to raw material suppliers or at a customer site. A module could be positioned to

access sustainable or recycled feedstocks, take advantage of low-cost renewable energy, or minimize transportation of a hazardous product. Similarly, a manufacturer with an eye toward resilience might locate modular assets in geographic regions to reduce impacts from physical risks related to weather.

Because modular designs can be more easily duplicated at a lower cost than traditional processes, manufacturers can economically increase redundancy to decrease downtime. For example, a manufacturer might reserve a few spare process modules and quickly bring them online during maintenance cycles or in response to unexpected interruptions. In applications such as distributed waste-to-power, waste-to-products, or water treatment, modular systems can serve as platforms for routine production, as well as for emergency response during a crisis.

Process intensification (PI) can also contribute to sustainability objectives. PI can enable multiple operations or phenomena to be combined in a single unit operation. Intensified technologies offer many benefits, including lower capital cost, lower energy and operating costs, and higher production rates. PI significantly improves resource efficiency, making better use of raw materials and energy inputs, and reducing waste and emissions per unit of output.

Modularity and PI can be combined to develop MCPI technologies that enable cost-effective distributed manufacturing in industries previously reliant on large, centralized infrastructure. Combining PI technologies with modular process systems can provide opportunities for process electrification. These electrified processes can be integrated with renewable electricity generation to decarbonize manufacturing.

MCPI units can be deployed for distributed manufacturing to reduce transitional risks for manufacturers and communities that are impacted by the move from fossil to renewable energy. Small, low-cost modular manufacturing platforms could be deployed to regions that have traditionally relied on extraction and use of fossil raw materials. Instead of mining coal and extracting natural gas for steam production, modular systems could be deployed to convert these raw materials to high-value products in short and resilient supply chains. Such strategies as well as other technologies developed by the RAPID Manufacturing Institute and its members could help communities retain jobs and manufacturers weather the many challenges they may encounter in their quest for sustainability.

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