Relative roles of Design for Re-X methods, Renewable Energy, and Industrial Symbiosis in the transition of the chemicals and materials industry and its products to a sustainable circular economy

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Approaches and frameworks such as Design for Re-X, Circular Economy, and Industrial Symbiosis are expected to help transform industry and its products to meet challenges posed by changes in resource availability and prices, economic policies, and environmental changes. Guiding the development and adoption of appropriate technologies and approaches requires methods and software tools for choosing the sequence of changes that is best at addressing the trade-offs between economic and environmental goals. This talk will describe a framework for modeling the current industry and emerging technologies and identifying the most promising combination of technologies and their life cycles for meeting various economic and environmental goals. It will specifically focus on the role that Design for Re-X technologies such as recycling, reuse, remanufacturing, and recovery, Renewable Energy, and Industrial Symbiosis could play in the transition to net-zero greenhouse gas emissions. This framework relies on an open-access model of the chemicals and materials industry, which contains about 150 currently used processes and 220 emerging technologies. This materials flow analysis model also includes data about emissions, energy use, and costs, and it may be integrated with life cycle inventory data. For emerging technologies, their technology readiness level provides information about the time period in which the technology may become available for commercial use. Multiobjective optimization is used to determine cost-effective pathways for transforming the selected industry or product to meet environmental goals such as net-zero emissions in the short-, medium-, and long-term. Marginal abatement cost curves help identify alternatives that could provide win-win solutions and the magnitude of their role in reaching net-zero. Application to the chemicals (plastics, solvents, fertilizers, fuels, etc.) and materials (iron and steel, cement, pulp and paper, glass, aluminum, etc.) industry helps identify the importance of Design for Re-X technologies (remanufacturing, recycling, reuse, etc.), industrial symbiosis, and renewable energy. The integrated chemicals and materials industry model also conveys the importance of technologies that cut across multiple sectors such as use of plastic waste and carbon dioxide from the chemical industry in steel and cement industries. The ability of this framework to guide the transition to products with net-zero emissions will be illustrated by application to products such as carbon fiber reinforced plastics and polyester textiles. A user-friendly software will also be introduced.