CACHE News, Feb 2015

Educational Modules for Sustainable Manufacturing: Case studies ready for dissemination on CACHE website

Debalina Sengupta, Research Associate and Mahmoud El-Halwagi, Professor

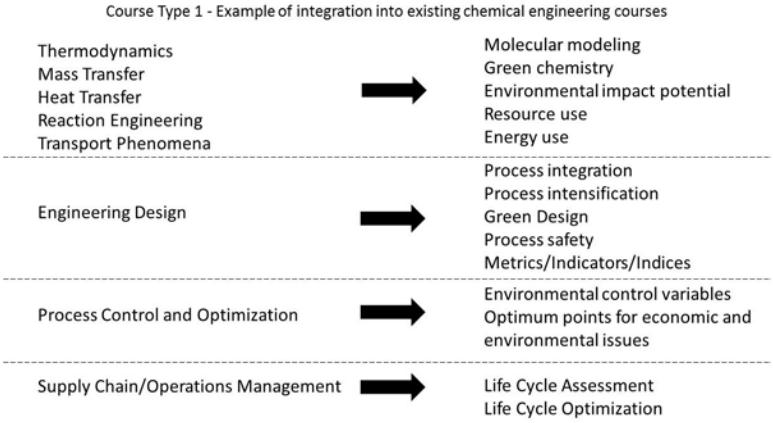
The preliminary educational modules for the NSF funded project Sustainable Manufacturing Advances in Research and Technology (SMART) Coordination Network are ready for dissemination to the engineering community through the CACHE website (cache.org). These modules cover different aspects of sustainable manufacturing such as life cycle assessment, green engineering, and integrating safety for sustainability root cause assessment.

Following the outcomes of the Workshop on SMART Roadmap Development in Cincinnati, 2013, Life Cycle Assessment (LCA) was identified as an essential knowledge requirement for sustainable manufacturing. Thus, the first module is based exclusively on LCA keeping undergraduate engineers in mind, where the knowledge and basic concepts are explained. This is supported with examples which emphasize the role of process engineers in the entire life cycle of a product. The case study accompanying this module shows how LCA can be used for determining whether new processes for methanol production via catalytic routes from carbon dioxide (a greenhouse gas) is better than a conventional process for methanol production. The case study was authored by Debalina Sengupta of Texas A&M University.

The second module covers key aspects in Green Design and Engineering, another area identified to achieve sustainability in the manufacturing sector. This module, authored by Jeff Seay of the University of Kentucky, introduces the concept of green chemistry as a guide for green design of processes, and gives three methods for assessing "greener" processes. These methods include the WAR Algorithm for computing the potential environmental impact (PEI) of a process, Life Cycle Assessment for assessing environmental and other impacts, and inherently safe process design. The case study for this module explores the production of acrolein via conventional fossil feedstock based route and compares it to bio-based route via the dehydration of glycerin, a by-product of biodiesel production. The module contains a pre-test on sustainability and five guided enquiry activities for material and energy balances, potential environmental impact assessment, life cycle assessment, inherently safe process design and detailed distillation column design.

The third module, authored by Helen Lou of Lamar University, introduces the concept of Sustainability Root Cause Analysis (SRCA) as a tool to determine the bottlenecks which prevent a system to progress towards sustainability. Stemmed from the popular quality assessment method of Root Cause Analysis (RCA), the SRCA framework is built on the combination of Pareto chart and the Fishbone diagram, in conjunction with a set of sustainability metrics (economics, environmental and safety) for conducting comprehensive sustainability assessment. The case studies in this module demonstrate the SRCA of steam reforming of methane, polygeneration of steam and power from various feedstock, and the production of LNG.

The modules can be used for three types of course structures for senior undergraduate, graduate education and professional training in industries. Instructors are provided with educational material for rationale, concepts, and supported with a case study description, homework problems, solutions, and supporting design files.

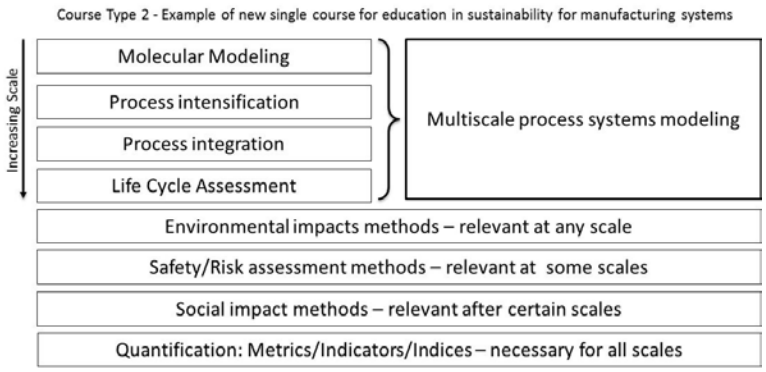


Course Type 1 – Integrating into Existing Coursework

- The approach for this module is to **COMPLEMENT** existing undergraduate engineering discipline course curriculum with sustainability approaches.

- Instructors of a particular subject may choose to incorporate the case studies in this module into the individual courses as they see fit.

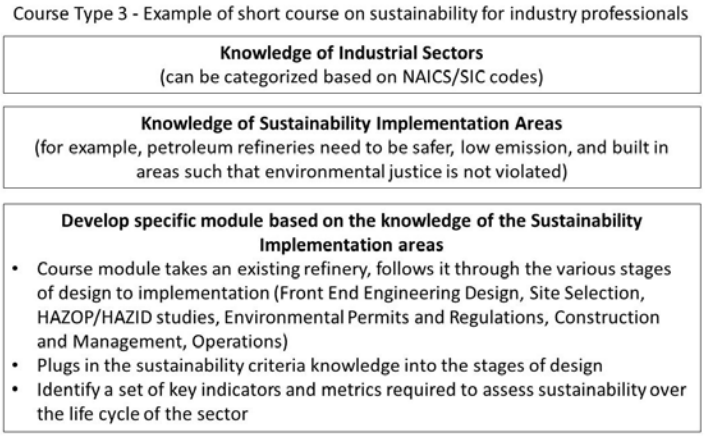
- Example core Courses from Chemical Engineering where the modules will fit include heat and mass transfer, reaction engineering, engineering design, process control and optimization and operations research.



Course Type 2 – Introducing New Curriculum on Sustainability

- The approach for this module is to **ADD** a curriculum to existing engineering discipline courses. This may be viewed at par with engineering design, and introduced at the graduate level.

- This course may be taught by a single instructor, or a group of instructors, specializing in the individual areas. The SMCS will be used by instructors to meet all the sustainability aspects.



- Example core components in the new sustainability curriculum ordered according to the delivery of the course include molecular modeling, process intensification, process integration and life cycle assessment.

Course Type 3 – Short Courses Directed towards Specific Manufacturing Sector

- The approach for this module is to **CATER to the needs of existing industry professionals to understand, integrate, and measure** sustainability approaches in their sector.

- This may be a classroom instruction course, **Massive Open Online Course** (MOOC), or standard slideshow based course

- Developing this module will require the knowledge of industrial sectors, sustainability implementation areas, and a plan to integrate sustainability themes into existing industry standards.

The next round of proposal solicitations will aim to complete the modules in Course Type 1, providing guidance on devising the Course Type 2, and create cases for Course Type 3. Various research, educational, and outreach activities are underway towards these goals. The project team strongly encourages interactive, graphically-oriented case study with supporting materials (e.g., data, models, simulations) that help the instructor and the student learn about the various aspects of sustainable manufacturing design.