Course syllabus for

P54: - Circular Economy and Industrial Systems

Syllabus adopted 2021-02-17 by Professor Bengt-Göran Rosén, Produktion2030 Head of Education

Credits	7.5 hec
Grading scale	Satisfactory/not satisfactory
Education cycle	Third-cycle
Examiner	Professor Amir Rashid, amirr@kth.se Department of Production Engineering, KTH Royal Institute of Technology
Course administrator	Dr Sayyed Shoaib-ul-Hasan, ssuh@kth.se Department of Production Engineering, KTH Royal Institute of Technology
Eligibility	A Master's degree in Production Engineering or equivalent
Aim:	The aim of this PhD course is to provide the foundations of the circular economy paradigm and its implementation. This aim can be further specified into the following sub-aims: - Provide conceptual frameworks necessary to understand the foundations of the CE and its implementation - Give insights into current industrial trends regarding CE - Provide the policy rationale for CE
Intended learning outcomes:	After completion of the course, the course participant should be able to - Describe and analyse the conceptual frameworks necessary to understand the foundations of the CE; - Describe current industrial trends regarding CE;

- Based on a system perspective suggest implementation of CE strategies in industry and society and discuss opportunities and barriers in implementation efforts;
- Describe and critically review the policy rationale for CE.

Course content

The course will be a combination of lectures, industry talks, group discussions and course assignments. An important mechanism for learning is individual reflections and relating theory to practice. This PhD course will cover six CE related themes.

- **Theme 1: Circular Economy - The concept and its imitation in a sustainability perspective**
  The objective of this address is to make sense of the actual concept of circular economy from the perspective of sustainable development. Further, the contribution will identify and discuss some of the main limitations and challenges of the concept in light of corporate sustainability and strategic considerations within corporate sustainability management.

- **Theme 2: A systems approach for developing a theoretical base for CE studies**
  Established methodologies such as life-cycle assessment and simulations build upon systems analysis, which serves to aggregate and analyze multiple variables and complex systems. A theoretical foundation is in a profound need of a multidisciplinary research. This theme highlights the critical approaches needed in understanding the area at a theoretical level and for monitoring and evaluating CE initiatives.

- **Theme 3: Closed loop manufacturing in the context of circular economy**
  Closed loop systems are characterized by integration of forward and reverse supply chains where the loop of product flow is closed by intention or design. This approach implies that for efficient and effective reuse of resources the products should be designed for multiple lifecycles and marketed through business models where both the value delivery and recovery are planned as parts of the system.

- **Theme 4: Operations and supply chain management in a circular economy**
  Given a shift towards a circular economy, how will this impact operations and the supply chain? What are the unique managerial challenges in reverse operations (e.g.

remanufacturing and recycling) and what business opportunities await on the other side of these challenges? This theme focuses on strategy and managerial decisions at the functional level and reflects on the challenges in implementing ambitious corporate visions

- **Theme 5: Designing circular industrial systems and the need for innovation management**
  As also stated above, designing the industrial systems is one core in developing circular industrial systems. In this theme, we look into the design principles for closing material loops but focus even more on the innovation capabilities of firms. Managing for disruptive innovation is a clear need in a transition to circular economy.

- **Theme 6: Chemical engineering for resource recovery in a circular economy**
  Creating economically and environmentally sustainable processes for resource recovery from primary and secondary raw materials is one of the challenges in realizing a circular economy. There is a need to develop new techniques and processes for resource recovery. This includes using biochemical tools for resource recovery from wastewater and hydrometallurgy for recovery of valuable elements from consumer products and other waste streams (e.g. NiMH batteries and red mud).

Course organisation

The course is organized in 6 meetings spread over 3 months with students own work before, in between and after the meetings. Observe that pre-reading and individual/group work is expected before the first meeting as well as during the course so allocate time before the first meeting. Attendance in all activities is mandatory. The major assignments for students taking the course are to review literature in the area, analyse an industrial case and write a paper/essay relating to trends in circular economy, challenges for a transition or on a specific circular economy problem, which could be considered as a first draft of an academic paper, if so preferred.

Preliminary schedule*

Meeting 1	13 April 2021	Foundations of the CE: themes and conceptual frameworks
Meeting 2	14 April 2021	Foundations of the CE: themes and conceptual frameworks + Industry speakers: CE in practice

Meeting 3	17 May 2021	Peer review reports and group discussions on Assignment 1
Meeting 4	16 June 2021	Learnings from the CE implementation projects
Meeting 5	17 June 2021	Circular business strategy workshop
Meeting 6	18 June 2021	Student seminars and peer discussion on Assignment 2

Course registration deadline: March 31, 2021.
*Some changes in schedule may be expected and will be communicated in due time

Examination

A successful completion of this course will be judged on the following items:

- Attendance
- Participation in class and group activities
- Two Assignments

Literature

Students must read following eight articles and prepare answer to the questions sent by email before first course meeting

1. Korhonen Jouni, Antero Honkasalo, and Jyri Seppälä. "Circular economy: the concept and its limitations." Ecological economics 143 (2018): 37-46. (Theme 1)
2. Korhonen, J., Nuur, C., Feldmann, A., & Birkie, S. E. (2018). Circular economy as an essentially contested concept. Journal of cleaner production, 175, 544-552. (Theme 1)
3. Harris, Steve, Michael Martin, and Derek Diener. "Circularity for circularity's sake? Scoping review of assessment methods for environmental performance in the circular economy." Sustainable Production and Consumption (2020). (Theme 2)
4. Rashid, Amir, Farazee MA Asif, Peter Krajnik, and Cornel Mihai Nicolescu. "Resource conservative manufacturing: An essential change in business and technology paradigm for sustainable manufacturing." *Journal of Cleaner production* 57 (2013): 166-177. (Theme 3)
5. Lieder, Michael, and Amir Rashid. "Towards circular economy implementation: a comprehensive review in context of manufacturing industry." *Journal of cleaner production* 115 (2016): 36-51. (Theme 3)
6. Östlin, Johan, Erik Sundin, and Mats Björkman. "Importance of closed-loop supply chain relationships for product

remanufacturing." *International Journal of Production Economics* 115, no. 2 (2008): 336-348. (Theme 4)

7. Bocken, Nancy MP, Samuel W. Short, Padmakshi Rana, and Steve Evans. "A literature and practice review to develop sustainable business model archetypes." *Journal of cleaner production* 65 (2014): 42-56. (Theme 5)
8. Zhang, Xiaoxiao, Li Li, Ersha Fan, Qing Xue, Yifan Bian, Feng Wu, and Renjie Chen. "Toward sustainable and systematic recycling of spent rechargeable batteries." *Chemical Society Reviews* 47, no. 19 (2018): 7239-7302. (Theme 6)

Additional readings

Theme 1

9. Chizaryfard, Armaghan, Paolo Trucco, and Cali Nuur. "The transformation to a circular economy: framing an evolutionary view." Journal of evolutionary economics (2020): 1-30.)

Theme 2

10. Malinauskaite, J., and H. Jouhara. "The trilemma of waste-to-energy: A multi-purpose solution." Energy policy 129 (2019): 636-645.
11. Elia, Valerio, Maria Grazia Gnoni, and Fabiana Tornese. "Measuring circular economy strategies through index methods: A critical analysis." Journal of Cleaner Production 142 (2017): 2741-2751.

Theme 3

12. Asif, Farazee MA, Michael Lieder, and Amir Rashid. "Multi-method simulation based tool to evaluate economic and environmental performance of circular product systems." *Journal of Cleaner Production* 139 (2016): 1261-1281.
13. Lieder, Michael, Farazee MA Asif, and Amir Rashid. "Towards Circular Economy implementation: an agent-based simulation approach for business model changes." *Autonomous Agents and Multi-Agent Systems* 31, no. 6 (2017): 1377-1402.

Theme 4

14. De Angelis, Roberta, Mickey Howard, and Joe Miemczyk. "Supply chain management and the circular economy: towards the circular supply chain." *Production Planning & Control* 29, no. 6 (2018): 425-437.
15. Lapko, Yulia, Paolo Trucco, and Cali Nuur. "The business perspective on materials criticality: Evidence from manufacturers." *Resources Policy* 50 (2016): 93-107.

Theme 5

16. Joyce, Alexandre, and Raymond L. Paquin. "The triple layered business model canvas: A tool to design more sustainable business models." Journal of cleaner production 135 (2016): 1474-1486.
17. Ghisellini, Patrizia, Catia Cialani, and Sergio Ulgiati. "A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems." Journal of Cleaner production 114 (2016): 11-32.
18. Ritzén, Sofia, and Gunilla Ölundh Sandström. "Barriers to the Circular Economy–integration of perspectives and domains." Procedia Cirp 64 (2017): 7-12.

Theme 6

19. Lee, Jason CK, and Zongguo Wen. "Pathways for greening the supply of rare earth elements in China." Nature Sustainability 1, no. 10 (2018): 598-605.
20. Dietrich, Karolin, Marie-Josée Dumont, Luis F. Del Rio, and Valérie Orsat. "Producing PHAs in the bioeconomy—Towards a sustainable bioplastic." Sustainable production and consumption 9 (2017): 58-70.
21. Arshi, Praneet S., Ehsan Vahidi, and Fu Zhao. "Behind the scenes of clean energy: the environmental footprint of rare earth products." ACS Sustainable Chemistry & Engineering 6, no. 3 (2018): 3311-3320.
22. Raza, Zulfiqar Ali, Sharjeel Abid, and Ibrahim M. Banat. "Polyhydroxyalkanoates: Characteristics, production, recent developments and applications." International Biodeterioration & Biodegradation 126 (2018): 45-56.