Course syllabus

Circular economy (TEK680) is a 7.5 credit course given in study period 1 by the division of Environmental Systems Analysis (ESA) at Chalmers University of Technology.

Course webpage (in canvas): https://chalmers.instructure.com/courses/7432

Examiner: Associate professor Maria Ljunggren Söderman, maria.ljunggren@chalmers.se, 031-772 2132

Teaching staff:
Maria Ljunggren Söderman (MLS), ESA, maria.ljunggren@chalmers.se
Hampus André (HA), ESA, hampus.andre@chalmers.se, (course secretary)
Valentina Nakic (VN), ESA, nakic@chalmers.se
Árni Haldorsson (AH), Service Management and Logistics, arni.halldorsson@chalmers.se
Lars Almefelt (LA), Product Development, lars.almefelt@chalmers.se
Mélanie Despeisse (MD), Production Systems, melanie.despeisse@chalmers.se
Oskar Rexfeldt (OR), Design & Human Factors, rex@chalmers.se
Petra Bosch (PB), Service Management and Logistics, petra.bosch@chalmers.se
Sofie Hallstedt (SH), Strategic Sustainable Development, Blekinge tekniska högskola, sophie.hallstedt@bth.se

Real case lecturers:
Nina Wolf, Göteborgs stad; Lena Westerholm and Martin Björnmalm, ABB; Matilda Jarbin; Godsinlösen; Dominique Fularski, IKEA.

Aim
The course aims to provide students with a rich understanding of the merits and challenges of transitioning to a more resource-efficient and circular economy. Drawing from multiple disciplines, including engineering, management and sustainability sciences, students gain knowledge on underlying principles and visions as well as theory and tools that support the formulation and assessment of resource-efficient and circular measures. By exploring real-world examples, students synthesize and apply the knowledge gained.

Learning outcomes (after completion of the course the student should be able to):

- Describe historic and future projections of natural resource use and associated sustainability challenges
- Describe visions and underlying principles of various approaches to resource-efficiency and circular economy
- Critically discuss the implications of increased resource-efficiency and circularity for sustainable development
- Account for actors, their options, barriers and drivers for transitioning to a more resource-efficient and circular economy.
- Account for resource-efficient and circular physical measures, their potential benefits and limitations
- Formulate strategies towards increased resource-efficiency and circularity based on relevant theories, methods and tools from multiple disciplines.
- Assess strategies towards increased resource-efficiency and circularity based on relevant theories, methods and tools from multiple disciplines.
- Communicate orally and in writing the knowledge and skills acquired.

Content
A more circular economy is suggested as an essential contribution to a more sustainable, low carbon, resource-efficient and competitive economy. Strategies over the full life cycle – from design and production to use,

reuse, repair, remanufacturing and recycling – are suggested as a way of maintaining the value of products, materials and resources in the economy for as long as possible. This may, in addition, create new opportunities for and requirements on business, users and policy across various stages of the value chain. The course aims to provide a rich understanding of the circular economy, its opportunities and limitations as well as concrete examples of circular solutions put into practice. It covers theory, methods and tools from product design, production engineering, waste management, industrial ecology, supply chain and change management and policy, presented in the context of the circular economy. Designed for students of various disciplinary backgrounds, it aims to encourage students to combine previous and new knowledge into a comprehensive understanding of the circular economy.

The first theme presents roots, rationales and core elements of resource-efficiency and the circular economy. Applying a systems perspective, both physical resource flows and actors are traced over life cycles including options for and implications of change. Modules in this theme are Introduction and summary (I), Industrial ecology (IE) and Supply chain management (SC).

The second theme addresses in more detail design, manufacturing, use, reuse, repair, remanufacturing, recycling and waste management. Modules in this theme are Product design and development (PD), Production engineering (PE), User-oriented design (UD) and Waste management (WM).

The third theme deals with managing change in business and through public policy. Modules in this theme are Change management (CM) and Public policy (PP).

The fourth theme runs in parallel with the others throughout the course, in which real-world examples of resource-efficient and circular solutions are explored through various lenses, aiming for gradual synthesis and application of the course content. Modules are Project (P) and Real cases of circular economy (RC).

Organisation
The course is comprised by a series of lectures given by lecturers from various disciplines and by invited guests from industry and authorities. There are five major stand-alone exercises while shorter ones are integrated in the lectures. A project will be conducted in multi-disciplinary groups. Lectures, literature, exercises and project instructions are published at the course website.

Literature
The complete collection of articles and reports is listed at the end of this document. They are available electronically at Chalmers library, google scholar or at the course website in Canvas. All lectures (including guests) are part of the course requirements.

Examination and compulsory elements
The examination of the course comprises of an individual written exam and a group project.

The final course grade is determined by the exam and the group project, with a maximum of 60 credits to the exam and 40 credits to the project. The maximum summarized credits are 100, based on which the final course grade is set. Requirements for grades 3/4/5 are 60/70/85 credits. Details on the project grading are presented in Project instructions.

The following activities are compulsory: all project hand ins, attendance at one of three project seminars (October 23) and individual assessment of project group peers (see separate document Project instructions). If attendance at compulsory activities is impossible, contact the examiner for makeup assignments. All compulsory activities must be attended or completed before the course can be passed.

Schedule 2019

W	Day	Date	Time	Lecture	Action	Teacher	Room	Literature
1	Monday	Sept 2	8-10	I: Introduction		MLS	EA	1-5
			10-11	IE: Physical resources: challenges and trends		MLS	EA	6-9
			11-12	IE: Introductory exercise: Material flows – the big picture		HA+MLS+VN		
	Wednesday	Sept 4	10-12	IE: Circular measures		MLS	EA	10-12
			13-16	SC: Circular business models and supply chains I		AH	EA	13-16
			16-17	P: Introduction of project		MLS+HA+VN	EA	
2	Monday	Sept 9	8-10	SC: Circular business models and supply chains II		AH	EA	13-16
			10-12	IE: Resource efficiency and environmental impacts of circular measures I		MLS	EA	17-18
	Wednesday	Sept 11	10-12	IE: Resource efficiency and environmental impacts of circular measures II		MLS	EA	17-18
			13-15	SC+IE: Exercise: Find a circular business model that fits		MLS+HA+VN	EA	
			15-17	P: Project supervision incl. project pitch and peer review	Pitch	MLS+HA+VN	EA, EL41	
	Friday	Sept 13	13.00	P: Hand in of revised pitch and time plan	Hand in			
3	Monday	Sept 16	8-10	PD: Introduction to product development in general		LA	EA	-
			10-12	PD: Methods and tools for sustainable and resource-efficient solutions		SH	EA	19-21
	Wednesday	Sept 18	10-12	PD: From principles to synthesis of resource-efficient solutions		LA	EA	-
			13-15	PE: The role of production in sustainable development		MD	EA	22-23
			15-17	P: Project supervision		MLS+HA+VN+AH+LA	EA	
4	Monday	Sept 23	8-12	PE: Sustainable production enabling circular strategies		MD	EA	22, 24
	Wednesday	Sept 25	10-12	UP: The user perspective and circular consumption		OR	EA	25
			13-15	UP: Exercise: Consumption journey mapping		OR	ML11-12	
			15-17	P: Project supervision		MLS+HA+VN+OR	ML11-12	
5	Monday	Sept 30	8-10	UP: Exercise: Circular consumption ideation		OR	ML11-12	
			10-12	WM: Waste flows, treatment and actors		MLS	EA	26
	Wednesday	Oct 2	10-12	WM: Recycling		MLS	EA	27-29
			13-15	RC: Circular economy in practice		Guest 1 & 2	EA	
			15-17	P: Project supervision		MLS+HA+VN+MD	EA	
6	Monday	Oct 7	8-12	CM: Change Management		PB	EA	30-31
	Wednesday	Oct 9	10-12	PP: Public policy for a circular economy I		MLS	EA	32
			13-15	PP: Public policy for a circular economy II		MLS	EA	32
			15-17	P: Project supervision		MLS+HA+VN+PB	EA	
7				*No scheduled activities this week. Project work is suggested.*				
	Monday	Oct 14	8-12	*Indicated room is available for project work*		-	EF	
	Wednesday	Oct 16	10-17	*Indicated room is available for project work*		-	EA	
			17.00	P: Hand in of draft report	Hand in			
8	Monday	Oct 21	8-9	I: Final exercise: What is a circular economy?		HA+MLS+VN	EA	
			9-10	I: Course summary		MLS	EA	
			10-12	RC: Circular economy in practice		Guest 3 & 4	EA	
			17.00	P: Hand in of peer assessment of draft report	Hand in			
	Wednesday	Oct 23	10-12	P: Project seminar I	One	MLS+HA+VN	EA	
			13-15	P: Project seminar II	seminar is	MLS+HA+VN	ED	
			15-17	P: Project seminar III	compulsory	MLS+HA+VN	ED	
	Thursday	Oct 24	17.00	P: Final hand in of project report	Hand in			
	Friday	Oct 25	12.00	P: Individual assessment of group peers	Hand in			
		Oct 28	AM	Original exam				
		Jan 9	PM	Make-up exam 1				
		Aug 19	PM	Make-up exam 2				

Modules: I= Introduction and summary, IE=Industrial ecology, SC=Supply chain management, P=Project, PD=Product design and development, PE=Production engineering, UP=User perspective, WM=waste management, RC= Real cases, CM= Change management, PP=Public policy

Teachers: Maria Ljunggren Söderman (MLS), Hampus André (HA), Valentina Nakic (VN), Árni Haldorsson (AH), Lars Almefelt (LA), Mélanie Despeisse (MD), Oskar Rexfelt (OR), Petra Bosch (PB), Sophie Hallstedt (SH)

Real case lecturers: Göteborgs stad, ABB, Godsinlösen, IKEA.

Literature

Module	Literature (chronological order, see schedule)
Intro	1. Benton, D., Hazel, J. and Hill, J. (2014) The guide to the circular economy. Capturing value and managing material risk, Oxford: DoSustainbility, pp 17-55. (Canvas) 2. Stahel, W. R. (2016). The circular economy. Nature News, 531(7595), pp 435-438. (Chalmers lib.) 3. Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling, 127, pp 221-232. (Chalmers lib.) 4. Reike, D., Vermeulen, W. J., & Witjes, S. (2018). The circular economy: New or refurbished as CE 3.0?—Exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options. Resources, Conservation and Recycling, 135, pp 246-250. (Google scholar) 5. Ellen MacArthur Foundation (2013) Towards the Circular Economy Vol. 1, pp 6-12. (Canvas)
IE	6. IRP (2019). Global Resources Outlook 2019: Natural Resources for the Future We Want. Implications for business leaders. International Resource Panel. United Nations Environment Programme. Nairobi, Kenya. (Canvas) 7. Sonderegger, T., Dewulf, J., Fantke, P., de Souza, D. M., Pfister, S., Stoessel, F., Verones, F., Vieira, M., Weidema, B. & Hellweg, S. (2017). Towards harmonizing natural resources as an area of protection in life cycle impact assessment. The International Journal of Life Cycle Assessment, 22(12), pp. 1912-1916. (Chalmers lib.) 8. Tilton, J. (2003). On Borrowed Time: Assessing the threat of mineral depletion. New York: Routledge, pp 18-24. (Canvas) 9. European Commission (2019) Critical raw materials for Europe overview. (Canvas) 10. Ellen MacArthur Foundation (2013) Towards the Circular Economy Vol. 1, pp 21-62. (Canvas) 11. Tillman, A-M, Willskytt, S., Böckin, D., André, H., Ljunggren Söderman, M. (2019) What circular economy measures fit what kind of product? accepted for Handbook of the Circular Economy, Elgar Publishing. (Canvas) 12. Reike, D., Vermeulen, W. J., & Witjes, S. (2018). The circular economy: New or refurbished as CE 3.0?—Exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options. Resources, Conservation and Recycling, 135, pp 253-261. (Google scholar)
SC	13. Blackburn, J.D., Guide Jr., V.D.R., Souza, G.C. & Van Wassenhove, L.N. (2004), Reverse Supply Chains for Commercial Returns, California Management Review, vol. 46, no. 2, pp. 6-22. (Chalmers lib.) 14. Lüdeke-Freund, F., Gold, S. and Bocken, N. M. (2019), A Review and Typology of Circular Economy Business Model Patterns. Journal of Industrial Ecology, vol 23, pp. 36-61. (Chalmers lib.) 15. Mishra, J. L., Hopkinson, P. G. and Tidridge, G. (2018), Value creation from circular economy-led closed loop supply chains: a case study of fast-moving consumer goods, Production Planning & Control, 29:6, 509-521 (Chalmers lib.) 16. Carbone, V., Rouquet, A., and Roussat, C. (2018), A typology of logistics at work in collaborative consumption, International Journal of Physical Distribution & Logistics Management. (Canvas, to be uploaded)
IE	*17. Extra reading: Helander, H., Petit-Boix, A., Leipold, S., & Bringezu, S. (2019) How to monitor environmental pressures of a circular economy: An assessment of indicators. Journal of Industrial Ecology. https://doi.org/10.1111/jiec.12924 (Google Scholar)* 18. Tillman, A-M, Willskytt, S., Böckin, D., André, H., Ljunggren Söderman, M. (2019) What circular economy measures fit what kind of product? accepted for Handbook of the Circular Economy, Elgar Publishing. (Canvas)
PD	19. Schulte, J. and Hallstedt, S., (2018) Workshop method for early sustainable product development. International Design Conference - Design 2018 Dubrovnik - Croatia, May 21-24, 2018. (Google Scholar) *20. Extra reading: Hallstedt S. (2017) Sustainability Criteria and Sustainability Compliance Index for Decision Support in Product Development, Journal of Cleaner Production. vol. 140, 251–266. (Chalmers lib.)* 21. *Extra reading: Hallstedt S. and Isaksson O. (2017) Material criticality assessment in early phases of sustainable product development. Journal of Cleaner Production. vol.161, 40-52. (Chalmers lib.)*
PE	22. Frosch, R. A. & Gallopoulos, N. E. (1989) Strategies for manufacturing. Scientific American. 261 (3), 144–152. (Google Scholar) 23. World Business Council for Sustainable Development (1996) Eco-efficient leadership for improved economic and environmental performance. Geneva, Conches. (Canvas) 24. Sarkis, J. & Rasheed, A., (1995) Greening the manufacturing function. Business Horizons. 38 (5), 17–27. (Chalmers lib.)
UD	25. Selvefors, A., Rexfelt, O., Renström, S., & Strömberg, H. (2019). Use to use – A user perspective on product circularity. Journal of Cleaner Production, 223, 1014-1028. (Canvas)
WM	26. Avfall Sverige (2019) Waste Sweden Management 2018 (Canvas) *27. Extra reading: Graedel, T. E., Allwood, J., Birat, J. P., Buchert, M., Hagelüken, C., Reck, B. K., Sibley, S. F. & Sonnemann, G. (2011). What do we know about metal recycling rates?. Journal of Industrial Ecology, 15(3), 355-366. (Chalmers lib.)* 28. Haupt, M., Vadenbo, C., & Hellweg, S. (2017). Do we have the right performance indicators for the circular economy?: Insights Into the Swiss Waste Management System. Journal of Industrial Ecology, 21(3), 615-627. (Chalmers lib.) 29. Andersson, M., Söderman, M. L., & Sandén, B. A. (2019). Challenges of recycling multiple scarce metals: The case of Swedish ELV and WEEE recycling. Resources Policy, 63, 101403. (Google Scholar)
CM	30. Perey, R., Benn, S., Agarwal, R., & Edwards, M. (2018). The place of waste: Changing business value for the circular economy. Business Strategy and the Environment, 27(5), 631-642. (Chalmers lib.) 31. Hopkinson, P., Zils, M., Hawkins, P., & Roper, S. (2018). Managing a complex global circular economy business model: opportunities and challenges. California Management Review, 60(3), 71-94. (Chalmers lib.)
PP	32. Peck, P. (Ed.), Richter, J. L. (Ed.), Delaney, K. (Ed.), Peck, P., Richter, J. L., Dalhammar, C., Voytenko, Palgan, Y. (2019). Circular Economy - Sustainable Materials Management: A compendium by the International Institute for Industrial Environmental Economics (IIIEE) at Lund University. (Version 02 Draft 2019-01-15 ed.) Lund: The International Institute for Industrial Environmental Economics, sections 4.1 and 4.3-4.5. *Replacing Milios, L. (2016). Policies for Resource Efficient and Effective Solutions, pp 35-69. (Canvas)*