Universitat Autònoma de Barcelona

2020/2021

Ecologia Industrial

Codi: 42405
Crèdits: 9

Titulació	Tipus	Curs	Semestre
4313784 Estudis Interdisciplinaris en Sostenibilitat Ambiental, Econòmica i Social	OT	0	1

La metodologia docent i l'avaluació proposades a la guia poden experimentar alguna modificació en funció de les restriccions a la presencialitat que imposin les autoritats sanitàries.

Professor/a de contacte

Nom: Gara Villalba Mendez

Correu electrònic: Gara.Villalba@uab.cat

Utilització d'idiomes a l'assignatura

Llengua vehicular majoritària: anglès (eng)

Equip docent

Cristina Madrid López

Prerequisits

NO REQUIREMENTS

Objectius

This course is an introduction to the field of Industrial Ecology (IE) as a multidisciplinary effort to evaluate anthropogenic systems, minimizing their negative effect on our planet. The students are taught the methods, tools, and strategies within IE, aimed to recreate our industrial system in such a way that it can be sustainable and in harmony with the rest of the natural ecosystem.

Competències

- Analitzar, sintetitzar, organitzar i planificar projectes relacionats amb la millora ambiental de productes, processos i serveis.
- Aplicar la metodologia de recerca, les tècniques i els recursos específics per a investigar i produir resultats innovadors en l'àmbit dels estudis ambientals.
- Que els estudiants sàpiguen aplicar els coneixements adquirits i la seva capacitat de resolució de problemes en entorns nous o poc coneguts dins de contextos més amplis (o multidisciplinaris) relacionats amb la seva àrea d'estudi.
- Tenir coneixements que aportin la base o l'oportunitat de ser originals en el desenvolupament o l'aplicació d'idees, sovint en un context de recerca.
- Treballar en un context internacional i multidisciplinari.

Resultats d'aprenentatge

1. Analitzar els resultats de recerca per obtenir nous productes o processos i valorar-ne la viabilitat industrial i comercial per a transferir-los a la societat.
2. Aplicar els coneixements de les diferents eines d'ecologia industrial a sistemes independentment de l'escala.

3. Aplicar la metodologia de recerca, les tècniques i els recursos específics per a investigar i produir resultats innovadors en l'àmbit dels estudis ambientals.
4. Conèixer els principals elements de l'ecologia industrial: teoria de sistemes, termodinàmica, anàlisi de flux de materials i consum de recursos.
5. Conèixer els sistemes urbans i els seus indicadors per avaluar-los.
6. Conèixer les eines d'ecoinnovació aplicables a entorns urbans.
7. Interpretar i desenvolupar anàlisis de cicle de vida per a productes i processos.
8. Ser capaç d'aplicar els conceptes de la classe, avaluar i prendre decisions basades en els resultats.
9. Treballar en un context internacional i multidisciplinari.

Continguts

This course is an introduction to the field of Industrial Ecology (IE) as a multidisciplinary effort to evaluate anthropogenic systems, minimizing their negative effect on our planet. The students are taught the methods, tools, and strategies within IE, aimed to recreate our industrial system in such a way that it can be sustainable and in harmony with the rest of the natural ecosystem. To achieve this general goal, the module contains the following objectives:

- Understand the concepts of IE, its framework as a multidisciplinary area of research based on system theory; resources: environmental goods and services, externalities.
- Understand Material Flow Analysis (MFA), and be able to apply this tool to different systems, such as a product, process, or region.
- Understand Life Cycle Analysis (LCA) and how to implement methodology: goal and scope definition, inventory analysis, impact assessment and interpretation, to different real-life cases, such as products or services. Learn how to evaluate and interpret the results, assumptions and uncertainties in case studies
- Understand the concepts of urban metabolism, carbon footprint, including differences in scope, results, and policy implications.
- Understand both process-based approach, MFA-LCA (or Material Flow Analysis coupled with Life-Cycle Assessment) and EIO-LCA (or Economic Input-Output coupled with Life-Cycle Assessment).
- Learn how to use Open-LCA software with LCA databases such as Ecoinvent, SimaPro by means of a project or case study.

Metodologia

The key concepts of this class will be transferred through theory classes (33 hours), hands-on exercises in lab classes (21 hours), and a hefty load of autonomous and group work (120 hours).

Activitats formatives

Títol	Hores	ECTS	Resultats d'aprenentatge
Tipus: Dirigides			
Industrial Ecology- Theory Classes	12	0,48	
LCA-IOTables Theory Classes	9	0,36	
MFA - Theory Classes	12	0,48	
Tipus: Supervisades			
OpenLCA Computer Lab	21	0,84	
Tipus: Autònomes			

Input-Output tables and LCA	16	0,64
LCA projects - Readings, study, work in groups and preparation for presentations	30	1,2
MFA project - Readings, study, work in groups and preparation for presentations	37	1,48
OpenLCA project	38	1,52
OpenLCA project- Readings, study, work in groups and preparation for presentations	35	1,4

Avaluació

The daily quiz will be given at the beginning of class, and will serve to count assistance and timely arrival to the class. They will only last 10 minutes. There will also be peer evaluation that will be taken into account for the presentations.

Activitats d'avaluació

Títol	Pes	Hores	ECTS	Resultats d'aprenentatge
Individual daily quiz	15%	1,5	0,06	2, 3, 4, 8, 9
Final Exam	50%	11,5	0,46	1, 2, 3, 5, 6, 7, 8, 9
OpenLCA project presentation	20%	2	0,08	2, 4, 7, 8
input output exercise	15%	0	0	2, 3

Bibliografia

Reference articles for Industrial Ecology course:

Industrial Ecology General

Saavedra, Y.M.B., Iritani, D.R., Pavan, A.L.R., Ometto, A.R., 2018. Theoretical contribution of industrial ecology to circular economy. J. Clean. Prod. https://doi.org/10.1016/j.jclepro.2017.09.260

Dayeen, F.R., Sharma, A.S., Derrible, S., 2020. A text mining analysis of the climate change literature in industrial ecology . J. Ind. Ecol. 24, 276-284. https://doi.org/10.1111/jiec.12998

Kennedy, C., 2020. The energy embodied in the first and second industrial revolutions. J. Ind. Ecol. 24, 887-898. https://doi.org/10.1111/jiec.12994

Goldstein, B., Newell, J.P., 2019. Why academics should study the supply chains of individual corporations. J. Ind. Ecol. 23, 1316-1327. https://doi.org/10.1111/jiec.12932

Lindgreen, E.R., Salomone, R., Reyes, T., 2020. A critical review of academic approaches, methods and tools to assess circular economy at the micro level. Sustain. https://doi.org/10.3390/su12124973

Mallawaarachchi, H., Sandanayake, Y., Karunasena, G., Liu, C., 2020. Unveiling the conceptual development of industrial symbiosis: Bibliometric analysis. J. Clean. Prod. https://doi.org/10.1016/j.jclepro.2020.120618

Cordella, M., Alfieri, F., Sanfelix, J., Donatello, S., Kaps, R., Wolf, O., 2020. Improving material efficiency in the life cycle of products: a review of EU Ecolabel criteria. Int. J. Life Cycle Assess. 25, 921-935. https://doi.org/10.1007/s11367-019-01608-8

Ayres, R., and Ayres, L. Accounting for Resources, volumes I and II, Cheltenham, UK: Edward Elgar, 1998.

Ayres, R. Industrial Ecology: Towards Closing the Material Cycle. London: Edward Elgar, 1996.

Bringezu, S. And Y. Moriguchi, Material flow analysis, in A handbook of Industrial Ecology, RU Ayres, and LW Ayres, eds, Cheltenham, UK: Ewards Elgar, pp79-90, 2002.

Chertow, M.R., Esty, d.C. Thinking Ecologically. New Haven: Yale University Press, 1997.

Classics in systems theory:

Bertalanffy, L. Von: General Systems Theory, New York, George Braziller, 1968 and 1980.

Forrester, Jay W. Industrial Dynamics, MIT Press, Cambridge, MA 1961.

Boulding, K. General Systems Theory, the Skeleton of a Science, in Buckley W. (Ed) Modern Systems Research for the Behavioral Scientist, Chicago: Alaine, 1968.

Thermodynamics

Smith and Van Ness. Introduction to Chemical Engineering Thermodynamics. New York: McGraw Hill, 1996.

Szargut, Jan. Exergy analysis of thermal, chemical, and metallurgical processes. Hemisphere Publishing Corporation, 1988.

Ayres Robert U., and Leslie W. Ayres. 1999. Accounting for resources 2: The life cycle of materials. Cheltenham, UK and Lyme MA: Edward Elgar.

Baumgärtner Stefan. 2002. Thermodynamics of waste generation. In Waste in Ecological Economics, edited by K. P. Bisson, J. Cheltenham, UK and Nothampton, MA,USA: Edward Elgar.

Szargut, J.;,D.R.; Morris, and F. R.; Steward. 1988. Exergy analysis of thermal, chemical, and metallurgical processes. New York: Hemisphere Publishing Corporation.

Conelly, Ll. and C.; Koshland. 2001. Exergy and industrial ecology. Part 2: A nondimensional analysis of means to reduce resource depletion. Exergy, an International Journal 1 (4):234-255.

Ayres Robert U., Katalin Martinás, and Leslie W. Ayres. 1998. Exergy, waste accounting and life cycle analysis. Energy 23 (5):355-363.

Ayres, Robert U., Andrea Masini, and Leslie W. Ayres. 2001. An Application of Exergy Accounting to Five Basic Metal Industries. Fontainebleau, France: INSEAD.

Van Gool, W. 1992. Exergy analysis of industrial processes. Energy 17 (8):791-803.

Szargut, J.;, A.; Ziebik, and W. Stanek. 2002. Depletion of the non-renewable natural exergy resources as a measure of the ecological cost Energy conversion and management 43:1149-1163.

MFA

Matthews, E., Amann, C., Bringezu, S., Hüttler, W., Ottke, C., Rodenburg, E., Rogich, D., Schandl, H., Van, E., Voet, D., Weisz, H., Billings, H., 2000. The Weight of Nations - Material Outflows from Industrial Economies. WORLD RESOURCES INSTITUTE.

Eurostat, 2013. Economy-wide Material Flow Accounts (EW-MFA) Compilation Guide. European Commission, Office for Official Publications of the European Communities, Luxembourg.

Graedel, T.E., 2019. Material Flow Analysis from Origin to Evolution. Environ. Sci. Technol. 53, 12188-12196. https://doi.org/10.1021/acs.est.9b03413

Persson, L., Arvidsson, R., Berglund, M., Cederberg, C., Finnveden, G., Palm, V., Sörme, L., Schmidt, S., Wood, R., 2019. Indicators for national consumption-based accounting of chemicals. J. Clean. Prod. 215,1-12. https://doi.org/10.1016/j.jclepro.2018.12.294

Calvo, G., Valero, Alicia, Valero, Antonio, 2018. Thermodynamic Approach to Evaluate the Criticality of Raw Materials and Its Application through a Material Flow Analysis in Europe. J. Ind. Ecol. 22, 839-852. https://doi.org/10.1111/jiec.12624

LCA

Klöpffer, W., Grahl, B. 2014. Life Cycle Assessment (LCA): A Guide to Best Practice | Wiley.

Finkbeiner, M., Ackermann, R., Bach, V., Berger, M., Brankatschk, G., Chang, Y.-J., Grinberg, M., Lehmann, A., Martínez-Blanco, J., Minkov, N., Neugebauer, S., Scheumann, R., Schneider, L., Wolf, K., 2014. Challenges in Life Cycle Assessment: An Overview of Current Gaps and Research Needs. Springer, Dordrecht, pp. 207-258. https://doi.org/10.1007/978-94-017-8697-3_7

Guinée, J. B., Heijungs, R., Huppes, G., Zamagni, A., Masoni, P., Buonamici, R., Ekvall, T., & Rydberg, T. (2011). Life Cycle Assessment: Past, Present, and Future. Environmental Science & Technology, 45(1), 90-96. https://doi.org/10.1021/es101316v

Visentin, C., Trentin, A.W. da S., Braun, A.B., Thomé, A., 2020. Life cycle sustainability assessment: A systematic literature review through the application perspective, indicators, and methodologies. J. Clean. Prod. https://doi.org/10.1016/j.jclepro.2020.122509

Palazzo, J., Geyer, R., Suh, S., 2020. A review of methods for characterizing the environmental consequences of actions in life cycle assessment. J. Ind. Ecol. 24, 815-829. https://doi.org/10.1111/jiec.12983

Beloin-Saint-Pierre, D., Albers, A., Hélias, A., Tiruta-Barna, L., Fantke, P., Levasseur, A., Benetto, E., Benoist, A., Collet, P., 2020. Addressing temporal considerations in life cycle assessment. Sci. Total Environ. https://doi.org/10.1016/j.scitotenv.2020.140700

Mendoza Beltran, A., Cox, B., Mutel, C., Vuuren, D.P., Font Vivanco, D., Deetman, S., Edelenbosch, O.Y., Guinée, J., Tukker, A., 2020. When the Background Matters: Using Scenarios from Integrated Assessment Models in Prospective Life Cycle Assessment. J. Ind. Ecol. 24, 64-79. https://doi.org/10.1111/jiec.12825

García-Pérez, S., Sierra-Pérez, J., Boschmonart-Rives, J., 2018. Environmental assessment at the urban level combining LCA-GIS methodologies: A case study of energy retrofits in the Barcelona metropolitan area. Build. Environ. 134, 191-204. https://doi.org/10.1016/j.buildenv.2018.01.041

Urban metabolism

Wolman, A., 1965. The metabolism of cities. Sci. Am. 213, 179-190.

González-García, S., Dias, A.C., 2019. Integrating lifecycle assessment and urban metabolism at city level: Comparison between Spanish cities. J. Ind. Ecol. 23, 1062-1076. https://doi.org/10.1111/jiec.12844

Jeong, S., Park, J., 2020. Evaluating urban water management using a water metabolism framework: A comparative analysis of three regions in Korea. Resour. Conserv. Recycl. 155, 104597. https://doi.org/10.1016/j.resconrec.2019.104597

Hu, G., Mu, X., 2019. Analysis of urban energy metabolic system: An ecological network framework and a case study for Beijing. J. Clean. Prod. 210, 958-969. https://doi.org/10.1016/j.jclepro.2018.11.088

Chen, Q., Su, M.,Meng, F., Liu, Y., Cai, Y., Zhou, Y., Yang, Z., 2020. Analysis of urban carbon metabolism characteristics based on provincial input-output tables. J. Environ. Manage. 265, 110561. https://doi.org/10.1016/j.jenvman.2020.110561

Bibliography- more specific

Adriaanse, A., S. Bringezu, A. Hammond, Y. Moriguchi, E. Rodenburg, D. Rogich, H. Schütz 1997. Resource Flows: The Material Basis of Industrial Economies. Washington DC: World Resources Institute.

Ayres, R. U. (1978): Resources, Environment and Economics. Applications of the Materials/ Energy Balance Principle. New York: John Wiley & Sons

Ayres, R. U. and Kneese, A. V. (1969): Production, Consumption and Externalities. In: American Economic Review 59(3), pp. 282-297

Ayres, R. U. and U. E. Simonis 1994. Industrial Metabolism: Restructuring for Sustainable Development. Tokyo, New York, Paris: United Nations University Press.

Ayres,R.U. and Ayres,L.W., 1999. Accounting for Resources, 2, The Life Cycle of Materials. Edward Elgar, Cheltenham, UK and Lyme, US.

Baccini, Peter and Brunner, Paul H. (1991): The metabolism of the anthroposphere. Berlin: Springer.

Barbiero, G., Camponeschi, S., Femia, A., Greca, G., Tudini, A., and Vannozzi, M. (2003): 1980-1998 Material-Input-Based Indicators Time series and 1997 Material Balances of the Italian Economy. Rome: ISTAT

Brunner, Paul H. and Rechberger, Helmut (2004): Practical Handbook of Material Flow Analysis. New York: Lewis Publishers.

Bullard, C. and Herendeen, R. A. (1975): The Energy Costs of Goods and Services. In: Energy Policy 3(4), pp. 268-278

Dietzenbacher, E., 2005. Waste Treatment in Physical Input-Output Analysis. Ecological Economics, 55, 11-23.

Duchin, F. (1992): Industrial Input-Output Analysis. Implications for Industrial Ecology. In: Proceedings of the National Academy of Science 89, pp. 1-5

Duchin, F. (1998): Structural Economics: Measuring Change in Technology, Lifestyles, and the Environment. Washington: Island Press

Eurostat 2001. Economy-wide Material Flow Accounts and Derived Indicators. A methodological guide. Luxembourg: Eurostat, European Commission, Office for Official Publications of the European Communities.

Eurostat (2002): Material use in the European Union 1980-2000. Indicators and Analysis. Luxembourg: Eurostat, Office for Official Publications of the European Communities, prepared by Weisz, H., Amann, C., Eisenmenger, N., Hubacek, K., and Krausmann, F.

Fischer-Kowalski, Marina (1998): Society's Metabolism. The Intellectual History of Material Flow Analysis, Part I, 1860 - 1970. In: Journal of Industrial Ecology 2(1), pp. 61-78.

Fischer-Kowalski, Marina and Haberl, Helmut (1993): Metabolism and Colonization. Modes of Production and the Physical Exchange between Societies and Nature. In: Innovation - The European Journal of Social Sciences 6(4), pp. 415-442.

Fischer-Kowalski, Marina and Hüttler, Walter (1999): Society's Metabolism. The Intellectual History of Material Flow Analysis, Part II: 1970-1998. In: Journal of Industrial Ecology 2(4), pp. 107-137.

Fleissner, P., Böhme, W., Brautzsch, H. U., Höhne, J., Siassi, J., and Stark, K. (1993): Input-Output-Analyse. Eine Einführung in Theorie und Anwendungen. Wien, New York: Springer Verlag

Giljum, S. and Hubacek, K., 2004. Alternative Approaches of Physical Input-Output Analysis to Estimate Primary Material Inputs of Production and Consumption Activities. Economics Systems Research, 16(3): 301-310.

Giljum, S., Hubacek, K., and Sun, L. (2004): Beyond the simple material balance: a reply to Sangwon Suh's note on physical input-output analysis. In: Ecological Economics 48(1), pp. 19-22

Griffin, J. (1976): Energy Input-Output Modeling. Palo Alto: Electric Power Research Institute

Haberl, Helmut, Fischer-Kowalski, Marina, Krausmann, Fridolin, Weisz, Helga, and Winiwarter, Verena (2004): Progress Towards Sustainability? What the conceptual framework of material and energy flow accounting (MEFA) can offer. In: Land Use Policy 21(3), pp. 199-213.

Hubacek, K. and Giljum, S. (2003): Applying physical input-output analysis to estimate land appropriation (ecological footprints) of international trade activities. In: Ecological Economics 44(1), pp. 137-151

Japan Environment Agency (1992): Quality of the Environment in Japan 1992. Tokyo: Japan Environment Association.

Konijn, P. J. A., de Boer, S., and van Dalen, J. (1997): Input-Output analysis of Material flows with applications to iron, steel and zinc. In: Structural Change and Economic Dynamics 8, pp. 129-153

Leontief, W. (1936): Quantitative input-output relations in the economic system. In: Review of Economics and Statistics 18, pp. 105-125

Leontief, W. (1941): The Structure of American Economy. New York: Oxford University Press

Leontief, W. (1970): Environmental Repercussions and the Economic Structure. An Input-Output-Approach. In: Review of Economics and Statistics 52, pp. 262-271

Machado, G., Schaeffer, R., and Worrel, E. (2001): Energy and Carbon embodied in the international trade of Brazil: an input - output approach. In: Ecological Economics 39(3), pp. 409-424

Mäenpää, I.and Muukkonen, J. (2001): Physical Input-Output in Finland: Methods, Preliminary Results and Tasks Ahead. Paper presented at Workshop on Economic growth, material flows and environmental pressure, 25th - 27th April, Stockholm, Sweden.

Matthews, E., C. Amann, M. Fischer-Kowalski, S. Bringezu, W. Hüttler, R. Kleijn, Y. Moriguchi, C. Ottke, E. Rodenburg, D. Rogich, H. Schandl, H. Schütz, E. van der Voet, H. Weisz 2000. The Weight of Nations: Material Outflows from Industrial Economies. Washington, D.C.: World Resources Institute.

Miller, R. E. and Blair, P. D. (1985): Input-Output Analysis: Foundations and Extensions. New Jersey: Prentice Hall Inc.

Pedersen, O. G. (1999): Physical Input-Ouput Tables for Denmark. Products and Materials 1990. Air Emissions 1990-92. Kopenhagen: Statistics Denmark

Pedersen, O. G. (2002): DMI and TMR for Denmark 1981, 1990, 1997. An assessment of the Material Requirements of the Danish Economy. Statistics Denmark

Proops, J. L. R. (1977): Input-output analysis and energy intensities: a comparison of some methodologies. In: Applied Mathematical Modelling 1(March), pp. 181-186

Stahmer, C., Kuhn, M., and Braun, N., 1998. Physical Input-Output Tables for Germany, 1990. Eurostat Working Paper No 2/1998/B/1, European Commission , Luxembourg.

Suh, S. (2004): A note on the calculus for physical input-output analysis and its application to land appropriation of international trade activities. In: Ecological Economics 48(1), pp. 9-17

Weisz, Helga and Duchin, Faye (2006): Physical and monetary input-output analysis: What makes the difference? In: Ecological Economics 57(3), pp. 534-541.