Faculty for Environment and Natural Resources

Industrial Ecology Group

List of topics for MSc theses, 2017

The industrial ecology group in Freiburg (Stefan Pauliuk, Rio Aryapratama, Gilang Hardadi, and Stefanie Klose) is seeking for MSc thesis candidates and announces hereby the following list topics for MSc theses. The topics were designed to fit into the group's ongoing research activities so that students get a chance to contribute to cutting edge research. The language of the thesis can be German or English, but some of your potential co-supervisors do not speak German.

The renewable energy topics are mainly designed for REM students, the MRIO and MFA topics mainly for the students of environmental science.

The preferred starting date is April 2017, but a later start is possible for most projects.

Please check the following document for the guidelines for thesis supervision in the IE group:

http://www.omnibus.uni-freiburg.de/~sp1046/Documents/ScientificWork_IndEcolFreiburg_2016.pdf

LIST OF TOPICS

1) **"Environmental footprint of services. An MRIO analysis", co-supervisor: PhD cand. Gilang Hardadi**

Services account for more than 50% of GDP in some rich countries. Service provision is often seen as a way to boost the economy while reducing emissions and other impacts. In this analysis we study the supply chain of services and analyse the amount of energy, GHG, land, and water associated with service provision.

Methods: Analysis of EXIOBASE multiregional input-output table, study with global scope (48 regions and about 50 service sectors). Basic programming skills (Python, R, or others) are needed for the work on this topic, they can be acquired during the thesis work. Assistance on Python will be given.

Literature: http://shrinkthatfootprint.com/shrink-your-service-footprint

Please contact gilang.hardadi@indecol.uni-freiburg.de if interested.

2) **"Income-specific environmental footprints of German household consumption with MRIO", co-supervisor: PhD cand. Gilang Hardadi**

Study how household income affects the environmental (carbon, water, land, energy) footprint. Use census data on expenditure and the ecoinvent (LCA) and EXIOBASE (MRIO) databases of global supply chains

Basic programming skills (Python, R, or others) are needed for the work on this topic, they can be acquired during the thesis work. Assistance on Python will be given.

Literature: http://link.springer.com/10.1007/s10668-015-9649-7 and DOI: 10.1111/jiec.12371

Please contact gilang.hardadi@indecol.uni-freiburg.de if interested.

3) **"Dynamic Environmental Input-Output Analysis: Case Study for the environmental footprint of Germany", co-supervisor: PhD cand. Gilang Hardadi**

Study how various Economic Development Scenarios for Germany will affect its emission of greenhouse gases emissions. Use information from National Economic Development Plans and Input-Output Tables of Germany (or other IO Database; e.g. EXIOBASE). Advanced programming skills (Python, R, or others) are needed for the work on this topic, they can be expanded during the thesis work. Assistance on Python will be given. Please contact gilang.hardadi@indecol.uni-freiburg.de if interested.

Sample thesis work of Portugal: http://in3.dem.ist.utl.pt/master/thesis/99files/thesis01.pdf

4) **"Process inventories, scrap classification, and scenario analysis of waste management industries", co-supervisor: PhD cand. Stefanie Klose**

Recycling is a core sustainable development strategy, and it is often claimed that metals can be recycled indefinitely often. But the reality is not that rosy. How much valuable metals get lost or miss-sorted during waste management operations? This is the topic of this work. The task is to study how various metals and alloys get scrapped, which scrap classifications exist and quantify them for different countries. Compile country level data on metal scrapping by product, scrap type, and alloy produced, to estimate the total amount of losses by recycling in the EU. In this analysis in particular the waste management of copper, aluminium and steel are of interest. Material flow analysis will give insight into waste management of these metals and losses connected to it. A Sankey diagram can describe the scrapping of end-of-life products estimated for the EU. As an add-on you can estimate the costs and the environmental impacts of waste management of the respective metals by regression analysis and conduct a scenario analysis to estimate the total losses in the waste management industries.

Methods: MFA, Sankey diagram, data reconciliation, (LCA, regression analysis)

This study will be carried out with Excel. If you are interested and have basic programming skills Python can be used for additional analysis.

Literature: Luca Ciacci et al. (2016) Metal Dissipation and Inefficient Recycling Intensify Climate Forcing *Environmental Science & Technology* 2016 50 (20), 11394-11402 DOI: 10.1021/acs.est.6b02714 http://pubs.acs.org/doi/abs/10.1021/acs.est.6b02714?journalCode=esthag&quickLinkVolume=50&quickLinkPage=11394&selectedTab=citation&volume=50

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5) **"Process inventories, element-specific loss rates, and scenario analysis of metal scrap remelting", co-supervisor: PhD cand. Stefanie Klose**

Recycling is a core sustainable development strategy, and it is often claimed that metals can be recycled indefinitely often. But the reality is not that rosy. How much valuable metals get lost or miss-sorted during waste management operations? This is the topic of this work. The task is to study how various scrap types get remelted. Compile country level data on metal recycling by product, scrap type, and alloy

produced, to estimate the total amount of non-functional recycling (e.g., copper from electric wiring to construction steel) in the EU. In this analysis in particular the scrap remelting of copper, aluminium and steel are of interest. Material flow analysis will give insight into scrap remelting of these metals and non-functional losses connected to it. A Sankey diagram can describe the remelting of scrap to secondary metals estimated for the EU. As add-on you can estimate the costs and the environmental impacts of scrap remelting of the respective metals by regression analysis and conduct a scenario analysis to estimate total remelting losses and non-functional recycling.

Methods: MFA, Sankey diagram, data reconciliation, (LCA, regression analysis)

This study will be carried out with Excel. If you are interested and have basic programming skills Python can be used for additional analysis.

Literature: Luca Ciacci et al. (2016) Metal Dissipation and Inefficient Recycling Intensify Climate Forcing *Environmental Science & Technology* 2016 50 (20), 11394-11402 DOI: 10.1021/acs.est.6b02714 http://pubs.acs.org/doi/abs/10.1021/acs.est.6b02714?journalCode=esthag&quickLinkVolume=50&quickLinkPage=11394&selectedTab=citation&volume=50

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6) **"Comparative environmental assessment of renewable and non-renewable materials", co-supervisor: PhD cand. Rio Aryapratama. Group work (up to two students) possible.**

Use of biomass as material, for example in wooden buildings or in biopolymers, is seen as an important sustainable development strategy by many. But biomass, especially wood, is limited, so the question of optimal use strategies arises. The goal of this thesis is to study about the comparative environmental assessment of different alternatives of renewable and non-renewable materials (e.g. wood, fiber, cement, steel, etc.) to provide the same amount of service (stiffness, tensile strength, compressive strength, …). The collection of process and life cycle inventories, including GHG emissions, and land use, will be the key part of the work. A simple scenario analysis about the overall environmental effect of material substitution should be carried out as well. Knowledge and experience about mass and energy balance and life cycle assessment are expected.

Literature:

Pawelzik et al., 2013. Critical aspects in the life cycle assessment (LCA) of bio-based materials–Reviewing methodologies and deriving recommendations. *Resources, Conservation and Recycling*, 73, pp.211-228. (http://dx.doi.org/10.1016/j.resconrec.2013.02.006)

Vieira et al., 2016. Life cycle assessment (LCA) applied to the manufacturing of common and ecological concrete: A review. *Construction and Building Materials*, 124, pp.656-666. (http://dx.doi.org/10.1016/j.conbuildmat.2016.07.125)

Yang, et al., 2016. Comparative study of cement manufacturing with different strength grades using the coupled LCA and partial LCC methods—A case study in China. *Resources, Conservation and Recycling*, 119, pp.60-68. (http://dx.doi.org/10.1016/j.resconrec.2016.06.017)

Please contact rio.aryapratama@indecol.uni-freiburg.de if interested.

7) **"Material flow analysis of wood and wood products in Indonesia", co-supervisor: PhD cand. Rio Aryapratama**

Wood products play an important role for Indonesia growing economy. A wide range of sectors from small to large scale industries including furniture, pulp and paper, trading, energy and construction are benefited from wood products. This study will collect and build a dataset and quantitatively characterize the wood and wood product flows in Indonesia. Knowledge about material flow analysis and data handling are expected.

Literature:

Mantau, U., 2012. Wood flows in Europe (EU27).

(https://www.unece.org/fileadmin/DAM/timber/meetings/20150311/Wood_flows_in_Europe_Mantau.pdf)

Mantau, U., 2015. Wood flow analysis: Quantification of resource potentials, cascades and carbon effects. Biomass and Bioenergy, 79, pp.28-38. (http://dx.doi.org/10.1016/j.biombioe.2014.08.013)

"Indonesia forestry outlook study" (http://www.fao.org/docrep/014/am608e/am608e00.pdf)

FAO statistics: http://www.fao.org/forestry/statistics/84922/en/

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8) **"The relation between EIA and LCA – An analysis of the practice in your home country", co-supervisor: Prof Barbara Koch**

Reserved for Kavya Madhu

Environmental Impact Assessment (EIA) is a process of evaluating the likely environmental impacts of a proposed project or development, taking into account inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse. EIA is a procedure that has been standardized in many countries. There are many methods that can be applied in an EIA, and one particular important scientific assessment method is life cycle assessment, which is a technique to assess environmental impacts associated with all the stages of the project's life cycle from cradle (installation) to grave (decommissioning). The task of the student is to review applications of LCA in EIA in his or her home country, to identify cases where application of LCA would have been beneficial and potentially have led to a different outcome, and to give specific recommendations for future combinations of LCA and EIA. This topic is especially suitable for students to wish to work in consultancies or administrations dealing with environmental impact assessment.

Requirements: Course in environmental impact assessment or life cycle assessment (optimally both) at the BSc or MSc level.

9) **"Life cycle analysis of renewable energy value chains". Group work (up to five students) possible.**

Biofuels and electricity are the main energy sources for sustainable transportation. Which of the two will prevail in the long run? The midterm and longterm development of the vehicle fleet has tremendous consequences for the car manufacturers, the energy infrastructure, and land use. LCA and cost studies of the different supply chains for transportation energy abound, but a systematic comparative analysis is lacking. With the help of literature values a comprehensive LCA and LCC of renewable energy value chains is to be developed. Special attention needs to be given to the storage and distribution infrastructure for the energy. The main challenge is to have a comprehensive system boundary across the different sub-projects.

Specific topics include:

+ LCA/LCC of land to transport: PV/Battery/Electric vehicle

+ LCA/LCC of land to transport: PV/Electrolysis/Fuel cell vehicle

+ LCA/LCC of land to transport: PV/Electrolysis/Synthesis/ICE vehicle (gaseous and light liquid fuels: H2, CH3OH, CH3OCH3, C2H5OH)

+ LCA/LCC of land to transport: PV/Electrolysis/Synthesis/ICE vehicle (liquid fuels: Gasoline and Diesel)

+ LCA/LCC of land to transport: Biofuels/Refinement/ICE vehicle (EtOH, Diesel)

+ LCA/LCC of land to transport: Biofuels/Gasification/ICE vehicle (gaseous and liquid fuels)

+ LCA/LCC of land to transport: Biofuels/Combustion/Battery/Electric vehicle

Please contact stefan.pauliuk@indecol.uni-freiburg.de if interested.

10) **"The role of Diesel engines in environmentally sustainable transportation" Review/ simple LCA**

While some condemn diesel as a dead technology, others claim it is the future of sustainable transportation. Time to get the numbers right and put them into context.

Method: Literature review combined with comparative LCA

Please contact stefan.pauliuk@indecol.uni-freiburg.de if interested.

11) **"Efficient individual transport patterns in cities"**

Which behaviour, which technology, and which incentives can have the biggest impact in reducing passenger transport demand in cities (smart parking, automated driving, car pooling).

Method: Comparative LCA. It is possible to focus on a single strategy and make a sound assessment.

Please contact stefan.pauliuk@indecol.uni-freiburg.de if interested.

12) **"Sustainable food consumption with regional supply chains. Group work (up to three students) possible."**

Organic agriculture and regional consumption receive much attention these days. While a healthy lifestyle, support of local farmers, and high local environmental quality are clearly desirable, the question remains how sustainable the current food consumption trends among environmentally concerned people actually are. Scientific concerns include the scalability of organic farming practices in light of a growing global population and possible comeback of agricultural pests and diseases. Another area of concern is the conflict between regionalization and globalization of food supply chains.

The goal of this work is to put numbers on what previously were guesses or feelings only by performing an environmental systems analysis on specific regional agricultural supply chains. The scope of this topic is not specified yet to leave freedom for own reflections and the interest of the student. This topic requires a highly motivated and skilled student.

Requirements: Course in life cycle assessment at the BSc or MSc level. High level of motivation to identify gather new data.

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