MASTER THESIS TOPICS - EXAMPLES

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

https://www.indecol.uni-freiburg.de/de/supervision-scheme

EXAMPLES - LIST OF MASTER THESIS TOPICS FOR THE YEAR 2023

(T1) Material stocks in buildings and infrastructure and their relation to urban form.
Buildings and infrastructure are major consumers of materials and contribute therefore indirectly also to global warming via material production. Major building materials include concrete, steel, wood, and plastics. Material production accounts for 23% of global GHG. We need to decarbonize material production but also use less of them. One major question here is to use materials more efficiently, not only when designing buildings an infrastructure but also when designing neighborhoods and entire cities!
The goal of this master thesis is to use a new high resolution (10x10m) dataset of material stocks for Germany and Austria (https://doi.org/10.1021/acs.est.0c05642) to find out how population density and urban form (road area, building height, mix of residential, commercial, etc. zones, …) influence materials stocks. How do material stocks change with population density, average income, and urban form in German cities? This thesis will be co-supervised by Dr. Johan Vélez.
Note: GIS skills are required for this thesis!

(T2) Environmental assessment of redox flow battery storage prototypes (in collaboration with Voith Redox Flow Batteries Freiburg)
Für die Energiewende mit Wind und Solarstrom sind für eine stabile und nachhaltige Elektrizitätsversorgung Pufferspeicher notwendig. Redox-Flow-Batterien sind eine vielversprechende neue Technologie, um große Speicherkapazitäten im Netz zu realisieren. Sie zeichnen sich durch eine lange Lebensdauer, eine gute Reparierbarkeit und einfache Recyclingfähigkeit aus.

Ziel der hier ausgeschriebenen Arbeit ist es, die Einflussfaktoren einzelner Subkomponenten und Technologieparameter, wie z.B. verschiedene Kombinationen von Reihen- und Parallelschaltung von Batteriezellen, Durchflussraten oder Materialwahl, auf die Ressourcen, Klima und Kostenbilanz zu analysieren und Handlungsoptionen für die Entwicklung zukünftiger Redox-Flow-Batteriespeicher zu erarbeiten. Hierzu passen Sie eine bestehende Modellierung zum Life Cycle Assessment der Redox-Flow-Batterie in der Software „GaBi“ bzw. openLCA an und identifizieren über eine Sensitivitäts-analyse relevante Stellgrößen für die Optimierung der Ökobilanz unter Berücksichtigung von Kosten und Effizienz.

Um Ihre Aufgabe erfolgreich zu bearbeiten, sind Sie eng in das Entwicklungsteam bei Voith Redox Flow Batteries hier in Freiburg eingebunden und werden interdisziplinär unterstützt.

The work can also be done in English. A relevant engineering degree (chemical engineering, electrical engineering) is a prerequisite. Please provide your BSc and MSc transcript of records! The start of the thesis work should be in April/May. Literature: Life cycle assessment of an industrial-scale vanadium flow battery, by Blume et al. (2022), https://onlinelibrary.wiley.com/doi/full/10.1111/jiec.13328

A social life cycle assessment of vanadium redox flow and lithium-ion batteries for energy storage, by Koese et al. (2022), Journal of Industrial Ecology, https://doi.org/10.1111/jiec.13347

(T3) Supply concentration and supply risk via global concentration for natural resources.

The EU is import-dependent on all four major raw material categories: biomass, fossil fuels, metal ores, and non-metallic minerals.

The hypothesis is that the current dependency on fossil fuel importers, although already severe from an energy policy point of view, is small compared to the dependency on metal (metal ore) importers, where both resources and refining capacities are much more concentrated in individual countries than for fossil fuels. This would have enormous policy consequences for the so-called onshoring of critical industries.

Goal of this thesis is to review and compile major indicators for supply chain vulnerability/centralisation for fossil energy / biomass / metal ores / non-metallic minerals such as phosphorous. Supply centralization shall be assessed both at the resource supply side (like copper ore) and at the refining side (like copper metal) where suitable. Next to determining the centrality of resource supply (in terms of production capacity), an additional policy risk weighting step shall be introduced by applying certain mining investment risk or political stability indicators to the different resource supplying countries.

See also:
https://www.diw.de/de/diw_01.c.862070.de/publikationen/weekly_reports/2022_49_2/germany_can_increase_its_raw_material_import_security_of_supply.html

This work will likely directly lead to a scientific publication and is therefore recommended for students who would like to continue with academic writing after their thesis work! The start of the thesis work should be in April/May.

This thesis will be co-supervised by Christian Hauenstein.

(T4) Environmental and social benefits of negative emissions technologies.

Removal of atmospheric GHG with technologies such as direct air capture (DAC) is a costly and resource intensive process. But is it also socially beneficial?

This explorative thesis shall take a critical perspective on negative emissions technologies and the companies/start-ups that promote such technologies.

The guiding question is: How can we make sure that negative emissions technologies are not just a compensation tool for rich people to offset the GHG emissions of their energy and resource-

intensive lifestyle? Or, if it where that way: what would be a socially optimal price for those technologies?
Is such a form of offset-based DAC for rich people an efficient emissions reduction strategy, or are there better ways how their money should be spent? Like tax-based money collection and subsequent investment in energy efficiency, public transport, or low-carbon energy supply. For this thesis, LCA-based calculations shall be combined with cost assessments and ethical considerations.

(T5) Scenarios for the German fleet of trucks, busses, bicycles, trams, and trains.

This analysis shall contribute to a larger research effort on the estimation of future energy and material demand for transport, both for new vehicles and for operating them. While passenger vehicles are already well covered by the scenarios, we also need scenario studies on the future demand (total mileage) of the other transport modes, including trucks, busses, trams, trains, and bicycles. A simple occupancy model shall then be used to estimate the number of vehicles needed to provide the mileage, and stock dynamic model shall be used to estimate the number of new vehicles needed each year to support the operating fleet. LCA calculations can then be used to estimate the energy and material demand of the fleet and of the new vehicles produced. A number of improvement and circular economy strategies can be assessed, for example modal shifts, higher vehicle occupancy rate, longer vehicle lifetime, and higher recycling rates.

See also the article: Material efficiency and its contribution to climate change mitigation in Germany A deep decarbonization scenario analysis until 2060, DOI 10.1111/jiec.13091.

This thesis will be co-supervised by Christian Hauenstein.

(T6) Environmental footprints of lifestyles. It is common to study how different income levels translate into different levels of service demand and then assess their energy consumption and GHG emissions. Here, not income or expenditure shall be used as descriptor or proxy for different services consumed, but the assessment shall be based on different lifestyles, which translate into consumption baskets. The hypothesis is that disposable income is a strong predictor for the average environmental footprint but that the variation within a given income bracket is large and depends on lifestyle patterns and choices. Here, the literature shall be screened for what we know about different lifestyles in terms of their consumption patterns (what basic, what habitual, what induced, and what luxury consumption).
This work will use LCI data on the energy, GHG, material, land, and water footprint of different services compiled by Dr. Johan Vélez and will be co-supervised by him. For orientation, see https://doi.org/10.1016/j.gloenvcha.2020.102168

(T7) STÄDTISCHER KLIMASCHUTZ IM TRANSPORTSEKTOR
EINE SZENARIOANALYSE FÜR FREIBURG

Die Treibhausgas (THG)-Emissionen im Transportsektor in Deutschland steigen nach wie vor. Für eine Trendwende in Richtung eines emissionsarmen Transportsektors sind sowohl rasche Technologiewechsel als auch ambitionierte regulatorische und planerische Mahnahmen nötig. Der seit Oktober 2022 vorliegende Klimamobilitätsplan (KMP) der Stadt Freiburg listet eine Reihe von Zielen und Maßnahmen zur Reduktion von Treibhausgas (THG)-Emissionen im Verkehrssektor der Stadt auf. Die Stadt Freiburg hat sich darüber hinaus zu einer Klimaneutralität im Jahr 2035 verpflichtet.

Ziel der hier beschriebenen Arbeit soll eine quantitative Systemanalyse einer Reihe von Transformationspfaden für eine klimaschonende Mobilität in Freiburg sein.
Insbesondere sollen folgende Aspekte berücksichtigt werden:

- Welche Modalverteilungen (zwischen PKW, ÖPNV, Fahrrad, Fuß) und welche Antriebstechnologien (Batteriefahrzeuge, E-Bikes, …) sind erforderlich, um die nötigen THG-Reduktionen für verschiedene Zeithorizonte zu erreichen? Anhand von 4-8 archetypischen Modalverteilungen sollen weiter analysiert werden. Insbesondere sollen die Randbedingungen des Gutachtens „Prüfung eines Szenarios für ein schnelleres Erreichen der Klimaneutralität bis 2035“ des Öko-Instituts beachtet werden, welches den Rahmen für eine Emissionsreduzierung um 85% definiert.
- Was für einen quantitativen Effekt auf die Klimabilanz der Stadt Freiburg hätte ein Transitverbot für LKW über 12t für die B31? (ist es sinnvoll, das Transitverbot einzuschränken auf Fahrten außerhalb von 75 km Radius?)
- Welche Infrastruktur, welche Investitionen und welche Regulierungsmaßnahmen sind für die Umsetzung der identifizierten archetypischen Modalverteilungen erforderlich?
- Was sind die sonstigen Auswirkungen dieser typischen Transformationspfade, vor allem in Bezug auf Flächenverbrauch und Materialverbrauch? Sind die Transformationspfade plausibel, v.a. auch für die unterschiedlichen Stadtteile und deren Entfernung zu den verschiedenen zentralen Einrichtungen der Stadt?
- Wie viele Pkw werden in Zukunft benötigt, um die Transportaufgaben in den verschiedenen Szenarien zu gewährleisten? (Welche Zahl ist optimal mit Hinblick auf graue Energie?)
- Was folgt aus diesen Analysen für die Umsetzbarkeit der einzelnen typischen Transformationspfade?

Hinweis: Solide Deutschkenntnisse sind erforderlich, da eine Reihe von Dokumenten zur Verkehrspolitik und Verkehrsplanung auf städtischer, Landes- und Bundesebene auszuwerten sind. Das Startdatum für diese Arbeit sollte im April/Mai liegen. Es ist außerdem geplant, die Ergebnisse dieser Arbeit als Arbeitspapier für verschiedene Organisationen und EntscheidungsträgerInnen zu veröffentlichen.

(T8) The potential impact of wealth redistribution on carbon emissions.

This master thesis aims to investigate the potential impact of wealth redistribution on carbon emissions through the use of multi-regional input-output analysis (MRIO). The research will involve a review of currently implemented (or discussed) taxing schemes (e.g. taxes on labour/capital income, VAT), and a quantitative analysis evaluating the economic and environmental consequences of different scenarios of wealth redistribution using MRIO. The results of this analysis will provide insight into the potential effectiveness of different wealth redistribution policies in reducing carbon emissions and mitigating the negative impacts of climate change. This research will contribute to the growing body of knowledge on the role of income inequality in driving environmental degradation and climate change, and offer potential policy recommendations for addressing these issues.

Literature:

Pottier, Antonin. "Expenditure Elasticity and Income Elasticity of GHG Emissions: A Survey of Literature on Household Carbon Footprint." Ecological Economics 192 (February 1, 2022): 107251. https://doi.org/10.1016/j.ecolecon.2021.107251.

Highly recommended course in the summer term:

Elective module "Global Supply Chain Modelling, Indicators and Responsibility"

This thesis will be co-supervised by Simon Schulte and Dr. Johan Vélez.

(T9) Environmental rebound effect of consumer-oriented product-service systems (PSS).

Circular economy (CE) seek to decouple economic growth from the resource's depletion and emissions by a wide range of strategies commonly known as the 9R (e.g., repair, reuse, recycle). This new system thinking is gain momentum and has started to be promoted by several governments and business around the world. In business, product-service systems (PSS) i.e., provide determined service e.g., mobility, reducing the consumption of resources and emissions by increasing the quality and longevity of the products linked to it, by schemes such as renting, upgrading, redesigning, or lending, are gaining popularity in our society (e.g., Airbnb, Lime, Share now, Swapfiets). However, although positive benefits are expected, there is a rising concern about the unintended consequences of such strategies on the environment. This is because such strategies or business models can potentially increase the overall consumption of goods and services, partially or fully offsetting the expected benefits. This phenomenon is known as the rebound effect (RE). The rebound effect has been well studied in energy economics and it has been translated in the recent years to other fields such as industrial ecology and CE. The remaining questions is to

what extend CE and PSS promotes sustainable development and how their potential REs can be effectively mitigated.

This analysis shall compute footprints using both, process-based databases (ecoinvent) and input-output databases (EXIOBASE) and ideally but not restricted application of surveys.

(T9.1) What are the potential benefits of sharing and renting washing machines in a residential building? And how the potential monetary benefit can effectively be translated into positive benefits to the environment?

(T9.2) Estimating the benefits and rebound effect of renting electric scooters and bikes e.g., lime. Departure point. https://www.researchgate.net/publication/242416956_Using_life_cycle_approaches_to_evaluate_sustainable_consumption_programs_Car-sharing

This thesis will mainly be supervised by Dr. Johan Vélez, and possibilities of cooperation with researchers of Utrecht and TU Denmark university are possible. For orientation, see:

- Prioritising low-risk and high-potential circular economy strategies for decarbonisation: A meta-analysis on consumer-oriented product-service systems. https://doi.org/10.1016/j.rser.2021.111858
- Circular Economy Rebound https://10.1111/jiec.12545
- Circular Economy: The Concept and its Limitation https://doi.org/10.1016/j.ecolecon.2017.06.041
- Product/Service-Systems for a Circular Economy https://doi.org/10.1111/jiec.12747

(T10) Employment effects of circular economy strategies in the buildings and car sector.

Circular economy (CE) strategies (e.g., building renovations, car sharing,…) can make significant contributions to mitigate greenhouse gas emissions by reducing energy and material demand. However, changes in production and consumption patterns will also lead to changes of the economy and could impact employment substantially. For example, reduced car ownership will affect the automobile sector, while increased housing renovation rates could increase demand for related jobs. This master thesis aims to investigate implications of different circular economy strategies on employment in the buildings and car sector. Questions include, which sectors might experience decreasing employment, and where and what type of jobs are required to implement CE strategies. Answering these questions can help to address required structural changes early on and contribute to lift CE potentials for climate change mitigation.

The research will involve a review and compilation of employment factors for different production systems and economic activities. This will be followed by quantitative assessments of employment (and further economic) effects of CE strategies.

Literature for orientation:

- Pauliuk, Stefan, and Nico Heeren. 2021. “Material efficiency and its contribution to climate change mitigation in Germany: A deep decarbonization scenario analysis until 2060.” *Journal of Industrial Ecology* 25:479–493. https://doi.org/10.1111/jiec.13091.
- Repp, Lars, Marko Hekkert, and Julian Kirchherr. 2021. “Circular Economy-Induced Global Employment Shifts in Apparel Value Chains: Job Reduction in Apparel Production Activities, Job Growth in Reuse and Recycling Activities.” *Resources, Conservation and Recycling* 171 (August): 105621. https://doi.org/10.1016/j.resconrec.2021.105621.

This thesis will be co-supervised by Christian Hauenstein.