Post-Doc Position: The Materials-Energy-GHG-Nexus in Social Metabolism of Global Production-Consumption Networks

The Institute of Social Ecology (SEC) at BOKU University, Vienna, announces a postdoctoral researcher position in the field of advanced socio-metabolic modelling of stocks and flows associated with global production-consumption networks. This position is part of the 'Emerging Fields' project '**Resilience and Malleability of Social Metabolism' (REMASS)**, a 5-year collaboration among six leading Austrian research institutions, funded by the Austrian Science Fund. REMASS aims to investigate the resilience and malleability of social metabolism in the face of **global supply chain disruptions,** caused by factors such as wars, conflicts, and climate extremes that affect resource use, inequality, and social well-being.

Context

The **accumulation of material stocks** (e.g. built structures, machinery or vehicles), requires large amounts of materials and energy, and therefore leads to large emissions of greenhouse gases (GHG). At the same time, stock patterns create lock-in phenomena: their use shapes patterns of material and energy use leading to additional GHG emissions. Changing patterns of investment in new stocks (e.g. built structures or machinery) can raise or reduce resource requirements for supplying key services for social wellbeing. Possible **future transformations towards more sustainable social metabolism** will hinge on investment decisions, government activities, changes in demand and a host of other factors, not least supply-chain disruptions, innovations, policies aiming to strengthen resilience and reduce dependency on energy resources such as fossil fuels. This may **induce non-linear dynamics, structural breaks and unexpected transition phenomena (tipping points)**. These systems can be understood as **complex networks**, spanning a multitude of sectors across many countries, which are ultimately tied to the use and consumption of final products and services in specific locations.

Tasks of the postdoctoral researcher: As a member of an interdisciplinary team at SEC, and within the REMASS consortium, the Postdoc researcher will **apply and further develop existing modelling approaches** dealing with energy-material nexus phenomena in the context of global production-consumption networks. This will require combinations of several modelling approaches: The **Material Inputs, Stocks and Outflows (MISO)** model available at SEC is key in this context. Links to other models available within the REMASS consortium (e.g., input-output models, network models, ecological macro-economic models or integrated assessment models) may also be relevant. We expect the Postdoc researcher to **develop an own agenda in analyzing the dynamics and future scenarios of the materials-energy nexus** using these and potentially other models, such as agent-based models, system-dynamic models, ecological macroeconomics or related approaches. Collaboration skills will be key, as the candidate will work closely with PhD candidates and other researchers in the REMASS consortium.

Responsibilities

- **Contribute to using and further developing the MISO model** to enable assessment of biophysical resource requirements, in particular with the aim of addressing the systemic interrelations between materials, energy and GHG emissions, and **accumulation of material stocks**. These assessments aim to explicitly consider thermodynamic consistency criteria, i.e. mass-balance all physical stock-flow processes.
- Develop approaches **to analyze future scenarios of the materials-energy nexus** and its implications for social wellbeing that address **non-linearities and potential tipping phenomena** related to disruptions of supply chains, in the context of efforts aiming at a more sustainable social metabolism.
- Contribute to methodological developments related to various modelling approaches.
- **Collaborate** with colleagues working in REMASS on the modelling of socio-metabolic resilience using big-data based network models and on social science research into provisioning systems for key services, e.g. nutrition, shelter & mobility.
- Set up and **maintain databases and code structures** ensuring accessibility through public repositories such as Zenodo or GitHub.
- Lead **drafting of manuscripts** for submission to international scholarly peer-review journals.

Qualifications

- Excellent doctoral degree in a relevant field (e.g., industrial ecology, ecological economics or related interdisciplinary sustainability sciences).
- Proficiency in programming. Knowledge of PYTHON, or ability to learn PYTHON quickly, will be crucially important.
- Experience in using and developing at least one or preferably some of the above-mentioned types of modelling approaches.
- Keen interest in sustainability, resilience, social metabolism, global supply chains, and tipping points.
- Enthusiasm for analytical thinking, data analysis and high-quality research.
- Demonstrated experience in academic writing and publishing.

We offer

- Being part of a cutting-edge research project that aims at new insights into global sustainability challenges.
- Working within a dynamic and interdisciplinary team of leading experts.
- A **2-year Postdoc position starting at the latest October 1st, 2025**, with an employment contract of 40 hours/week
- Elongation of the contract may be negotiable under certain conditions.
- Compensation is in accordance with the Austrian collective agreement for university employees, with a gross salary of circa 4,930 Euro per month, 14 annual pays.
- Excellent working conditions, modern facilities, and a friendly and supportive working environment.

If you are passionate about advancing socio-metabolic research in global supply chain assessments and sustainability, we invite you to apply. Please send your application, including your CV, a cover letter explaining your motivation for this position, university grades and certificates, examples of your work (e.g., PYTHON scripts, your GitHub account, Zenodo archives, a scientific manuscript), and contact information for two references to Prof. Helmut Haberl (helmut.haberl@boku.ac.at) **until May 19th, 2025** at the latest.

University of Natural Resources and Life Sciences Vienna seeks to increase the number of its female faculty and staff members. Therefore, qualified women are strongly encouraged to apply. In case of equal qualification, female candidates will be given preference unless reasons specific to an individual male candidate tilt the balance in his favor.

People with disabilities and appropriate qualifications are specifically encouraged to apply.

We regret that we cannot reimburse applicants travel and lodging expenses incurred as part of the selection and hiring process.

Relevant references:

Krausmann, F., Wiedenhofer, D., & Haberl, H. (2020). Growing stocks of buildings, infrastructures and machinery as key challenge for compliance with climate targets. *Global Environmental Change*, *61*, 102034. https://doi.org/10.1016/j.gloenvcha.2020.102034

Wiedenhofer, D., Streeck, J., Wieland, H., Grammer, B., Baumgart, A., Plank, B., Helbig, C., Pauliuk, S., Haberl, H., & Krausmann, F. (2024). From extraction to end-uses and waste management: Modeling economy-wide material cycles and stock dynamics around the world. *Journal of Industrial Ecology*, *28*(6), 1464–1480. https://doi.org/10.1111/jiec.13575

Wiedenhofer, D., Streeck, J., Wiese, F., Verdolini, E., Mastrucci, A., Ju, Y., Boza-Kiss, B., Min, J., Norman, J., Wieland, H., Bento, N., León, M. F. G., Magalar, L., Mayer, A., Gingrich, S., Hayashi, A., Jupesta, J., Ünlü, G., Niamir, L., … Pauliuk, S. (2024). *Industry Transformations for High Service Provisioning with Lower Energy and Material Demand: A Review of Models and Scenarios*. https://doi.org/10.1146/annurev-environ-110822-044428

Binder, C. R., Athanassiadis, A., Bristow, D., Haberl, H., & Kennedy, C. (2025). Tipping points towards sustainability: The role of industrial ecology. *Journal of Industrial Ecology*, *doi: 10.1111/jiec.70000*, in press. https://doi.org/10.1111/jiec.70000

Meerow, S., & Newell, J. P. (2015). Resilience and Complexity: A Bibliometric Review and Prospects for Industrial Ecology. Journal *of Industrial Ecology*, *19*(2), 236–251. https://doi.org/10.1111/jiec.12252

Laber, M., Klimek, P., Bruckner, M., Yang, L., & Thurner, S. (2023). Shock propagation from the Russia–Ukraine conflict on international multilayer food production network determines global food availability. *Nature Food*, *4*(6), 508–517. https://doi.org/10.1038/s43016-023-00771-4

Haberl, H., Schmid, M., Haas, W., Wiedenhofer, D., Rau, H., & Winiwarter, V. (2021). Stocks, flows, services and practices: Nexus approaches to sustainable social metabolism. *Ecological Economics*, *182*, 106949. https://doi.org/10.1016/j.ecolecon.2021.106949

Seto, K. C., Davis, S. J., Mitchell, R. B., Stokes, E. C., Unruh, G., & Ürge-Vorsatz, D. (2016). Carbon Lock-In: Types, Causes, and Policy Implications. *Annual Review of Environment and Resources*, *41*(1), 425–452. https://doi.org/10.1146/annurev-environ-110615-085934

Creutzig, Felix, Sofia G. Simoes, Sina Leipold, Peter Berrill, Isabel Azevedo, Oreane Edelenbosch, Tomer Fishman, u. a. „Demand-Side Strategies Key for Mitigating Material Impacts of Energy Transitions“. *Nature Climate Change* 14, Nr. 6 (Juni 2024): 561–72. https://doi.org/10.1038/s41558-024-02016-z.

Sugiyama, Masahiro, Charlie Wilson, Dominik Wiedenhofer, Benigna Boza-Kiss, Tao Cao, Joyee S. Chatterjee, Souran Chatterjee, u. a. „High with low: Harnessing the power of demand-side solutions for high wellbeing with low energy and material demand“. *Joule* 8, Nr. 1 (17. Januar 2024): 1–6. https://doi.org/10.1016/j.joule.2023.12.014.

Jiang, Meng, Ranran Wang, Richard Wood, Kajwan Rasul, Bing Zhu, und Edgar Hertwich. „Material and Carbon Footprints of Machinery Capital“. Environmental Science & Technology 57, Nr. 50 (19. Dezember 2023): 21124–35. https://doi.org/10.1021/acs.est.3c06180.

Wang, Ranran, Edgar G. Hertwich, Tomer Fishman, Sebastiaan Deetman, Paul Behrens, Wei-qiang Chen, Arjan de Koning, u. a. „The legacy environmental footprints of manufactured capital“. *Proceedings of the National Academy of Sciences* 120, Nr. 24 (13. Juni 2023): e2218828120. https://doi.org/10.1073/pnas.2218828120.

Wiedenhofer, D., Fishman, T., Plank, B., Miatto, A., Lauk, C., Haas, W., Haberl, H., & Krausmann, F. (2021). Prospects for a saturation of humanity's resource use? An analysis of material stocks and flows in nine world regions from 1900 to 2035. *Global Environmental Change*, *71*, 102410. https://doi.org/10.1016/j.gloenvcha.2021.102410