*How can we use **learning curves** to predict future **environmental impacts** of new technologies?*

Level: Bachelor or Master
Start: Anytime
Project duration: 8 to 10 weeks for a bachelor project, 20 to 30 weeks for a master project
Project form: Literature research, data collection, data analysis and modelling, life cycle assessment
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Background: The growing consumption of goods and services by the ever expanding human population has put strain on our natural environment. Life cycle assessment (LCA) is a tool with which the environmental performance of products and services can be examined, to quantify their impacts on our environment. This tool considers the complete product chain from resource extraction to waste disposal. With the results from an LCA, we can analyze the environmental consequences of our consumption behavior and prioritize our efforts for impact reduction through targeted strategies. This is not only interesting for reducing impacts of existing products and services, but also creates potential to reduce future impacts of new technologies that are currently under development. To perform a meaningful LCA of a product or service, a detailed inventory of all material and energy flows is required. For new technologies, two challenges arise when using LCA as a tool in making decisions on environmental impact reduction:

1) For new technologies, data are scarce and therefore estimations and extrapolations are needed to fill the gaps in the data. Consequently, the results of an LCA are relatively uncertain.
2) New technologies are at risk to be outperformed by established technologies in comparative LCA studies. This is because environmental impacts often decrease with increased levels of development. When not correcting for the difference in level of development, the full potential of a new technology might be missed.

At the department of Environmental Science, we seek ways to improve LCA as a tool by investigating how to comprehensively and fairly compare the environmental impact of technologies at different levels of development. We do this by making systematic estimates of future developments through the use of industry targets and by analyzing historic patterns. For the latter, learning curves are of particular interest to us, since they can be used to analyze historic progress rates of development, which can subsequently be extrapolated into the future. The concept of learning curves, first described by T.P. Wright,[1] is almost a century old and has proven its value in many fields, most notably in economics. Here, (log)linear correlation was found between cumulative production and the associated costs of making a product. We at the department of Environmental Science hypothesize that environmental impacts of product also adhere to Wright's law and that these impacts reduce (log)linearly as production volumes increase. Some pioneering works[2,3] on selected technologies confirm this hypothesis so we would therefore like to expand on these works.

Description of the project: Starting with the knowledgebase described above, we want you to investigates what is needed to construct environmental learning curves for a variety of goods and services. These can be very wide-ranging and would preferably contain common goods and services that are used in many of the technologies that we study. You could for instance study particular base materials (e.g. steel, plastics), common services (e.g. electricity, transport) or broad technology groups (e.g. photovoltaics). You will be expanding on on-going theoretical research by gathering additional literature on (environmental) learning curves and collecting data required to construct your own environmental learning curves. Relevant data sources would be reports from industry and all available LCA studies for the product(s) or service(s) of interest. Depending on the progress and available time, we would like you to apply your constructed environmental learning curve(s) in a prospective LCA to showcase the applicability in predicting future environmental impacts of a new technology currently under development. Additionally, environmental learning curves for different categories of environmental impact could be constructed and compared.

Literature:

[1] Wright, T. P. (1936). Factors Affecting the Cost of Airplanes. *Journal of the Aeronautical Sciences, 3*(4), 122–128. https://www.doi.org/10.2514/8.155
[2] Caduff, M., Huijbregts, M. A. J., Althaus, H.-J., Koehler, A., & Hellweg, S. (2012). Wind Power Electricity: The Bigger the Turbine, The Greener the Electricity? *Environmental Science & Technology, 46*(9), 4725–4733. https://www.doi.org/10.1021/es204108n
[3] Bergesen, J. D., & Suh, S. (2016). A framework for technological learning in the supply chain: A case study on CdTe photovoltaics. *Applied Energy, 169*, 721–728. https://www.doi.org/10.1016/j.apenergy.2016.02.013