Hybrid methods for incorporating changes in energy technologies in an input-output framework

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Future energy technologies will be key for a successful reduction of man-made greenhouse gas emissions. Worldwide, electricity and heat production account for 43% of industrial CO2 emissions. With demand for electricity in particular projected to increase significantly in the future, climate policy goals of limiting the effects of global atmospheric warming can only be achieved if power generation processes are profoundly de-carbonised, leading to a drastic reduction of CO2 emissions in this sector.

In this work we use financial information as well as specific primary data for technical processes and emissions to conduct a hybrid life-cycle assessment (hybrid LCA) of four key energy technologies: wind power, supercritical pulverized coal with carbon capture and storage, integrated gasification combined cycles (IGCC) and nuclear power generation. A particular emphasis will be on the comparison of different methodological approaches. Hybrid LCA generally aims to combine the specificity of process analysis with the comprehensiveness of input-output analysis and has been applied to energy analysis since the 1970s.

We investigate the effectiveness and suitability of three different techniques: input-output-based hybrid LCA, integrated hybrid LCA and the novel path exchange method for the analysis of emerging energy technologies in the United Kingdom. We use an updated set of UK supply and use tables with a sector resolution of 123 as the basis for the input-output part in each approach. Input-output-based hybrid LCA is performed by disaggregating the electricity generation sector into several sub-sectors representing the aforementioned power generation technologies; varying degrees of market penetration are assumed in different scenarios. In integrated hybrid LCA we augment the monetary input-output tables with process matrices based on the primary technical data, Finally, in the path exchange method we first perform a structural path analysis of the UK electricity sector, quantifying the CO2 emissions associated with upstream production processes, and subsequently replace relevant paths with corresponding primary process data to improve the accuracy of the calculation. We compare and discuss the results from the three approaches and consider uncertainty implications.