Prospective life cycle assessment to avoid unintended consequences of net-zero solutions and its challenges

Monday, 3rd July - 13:00: Poster session 2 (Pieterskerk)

***Mohammad Ali Rajaeifar* [1] , *Oliver Heidrich* [1]**

1. School of Engineering, Newcastle University, Newcastle Upon Tyne, NE1 7RU, United Kingdom

Climate change has led to specific carbon reduction targets including net-zero ones that are set to help in mitigating climate change by governments and organizations. This is not only to mitigate but also to meet the growing demands of the global population while ensuring practical progress and implementation. In line with those targets, alternative low-carbon energy technologies as well as those that capture carbon from the atmosphere are being hailed as practical solutions. For example, the UK government has set the ambitious plan of reaching net zero by 2050 which requires renewable energy, nuclear, hydrogen, and other low-carbon fuels to be accelerated significantly, while increasing the share of carbon capture and storage (Rt HonChris Skidmore, 2022).

These require innovation beyond existing technologies, i.e. developing emerging technologies. Although there is an optimistic view on the use of emerging technologies- as they may reduce energy use and subsequently CO_2 emissions across different sectors-, such technologies require different materials than established technologies, which can introduce different types of emissions up and down the supply chain. Such burdens should be carefully studied from the raw material requirements to the life cycle environmental impacts in order to avoid unintended consequences of the technologies in the future (Melin et al., 2021).

Therefore, from the early stage of technology development prospective life cycle assessment (pLCA) should be employed to assess the environmental impacts of emerging technologies (Bergerson et al., 2020). However, since the knowledge and information on emerging technologies are limited and scattered, major challenges exist when performing pLCA, e.g. consistency in modeling foreground systems, data availability, and uncertainty (Thonemann et al., 2020; van der Giesen et al., 2020). Here, we demonstrate some additional challenges by exploring emerging technologies for organizations using an example of a defense setting. The focus of this study is not on war-related operations, but rather looking into the decarbonizing the Defence estates and infrastructure systems -that are used by the military- using some emerging technologies such as Hydrogen, Carbon Capture, Geothermal, Electric Vehicles, and Solar Photovoltaics.

Most of the literature studies on pLCA focus on a single emerging technology development and its plausible sustainability impacts in the future. However, for governments and organizations to achieve net zero targets, they usually need to implement an array of emerging low-carbon energy technologies, some of which need to be employed in parallel e.g. emerging low-carbon energy generation and energy storage systems. This adds further complications and challenges to the pLCA as economics, environment and variability related issues. Firstly, different emerging technologies have different temporal horizons in reaching commercial maturity and respected market and technology readiness level. Second, such assessments are complicated as finding the most optimal combination of different emerging technologies needs to balance the pros and cons of different technologies in terms of different sustainability impacts which makes the problem a kind of multi-criteria problem that involves a large number of variables (Torkayesh et al., 2022). Third, large deployment of emerging technologies would also imply some consequences on the marginal markets and that needs further consideration. Therefore, it is of great importance to assess emerging technologies on wider economic scales and consider the potential market share of them. Finally, there are some technology and market interventions that also need to be considered. All these challenges need proper remedies and further research when performing pLCA.