Life Cycle Assessment of Electronics Supply Chains

Lead supervisor: Professor Frances Wall, University of Exeter

Co-supervisors: Professor Xiaoyu Yan, University of Exeter, Dr Jordan Lindsay, Minviro, Sahin Alacacayir, Minviro, Dr Evi Petavratzi, British Geological Survey

Project Highlights:

- Electronics are essential to modern life, two thirds of the elements in the Periodic Table, often with very short life and little recycling of many of the critical materials
- Using knowledge of geological resources whole supply chain environmental sustainability quantitative assessment.
- Investigate ownerships models, or dig deeper into supply chains and more metals.

Overview:

Electronics are ubiquitous in modern life. The number of gadgets we own is growing and most industrial and household products contain electronic controls. The rate of change of electronic products is high, and many are discarded after just a couple of years. Some find their way to recycling, few are retained in the higher value loops of re-use and remanufacture, and many other items languish in drawers or are thrown away. Although the problems are well-known, the solutions are not so easy to find. Reducing the environmental impact of these short product cycles is a particular challenge that this research project will address.

The number of elements required to manufacture electronics is huge; some two thirds of the Periodic Table to make a smartphone. Many of the elements are classed as critical minerals – economically important but at risk of supply disruption.

This project builds on research on different raw materials e.g., lithium-ion batteries and rare earths at the University of Exeter, its spin-off company Minviro, who have become a leader in working with industry using life cycle assessment (LCA) to improve the environmental, social and governance (ESG) performance of mining, recycling and product life throughout the value chain, and BGS who have been leading work on critical minerals, including stocks and flows modelling, life cycle assessment and foresight modelling.

The research will start at the beginning, researching the original raw materials and choosing signature elements to follow through the value chain. Examples of potential signature elements include tin, silicon, tantalum, rare earths, indium, gallium, germanium, arsenic, copper, gold. The allocation of LCA credits and burdens is inconsistent in the existing literature for electronics materials, many of which are produced as co- and by-products. The aim is to propose solutions for this, with direct industry applications. The researcher will then have the opportunity to develop more sophisticated LCA models for circular economy, taking into account multiple lives in a series of products, or work on a wider range of raw materials.

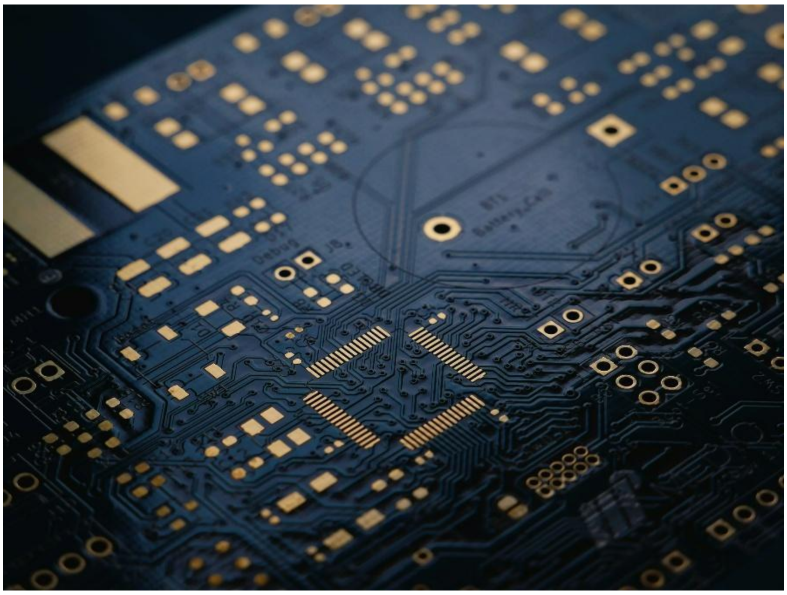

Figure 1: .The PhD study will consider materials supply and stewardship for the fast-moving electronics industry. (Image Vishnu Mohanan, Unsplash).

Methodology:

At first the method will follow approaches established by Minviro and the University of Exeter for other raw materials, including rare earths, battery materials and semiconductors (e.g. Minviro, 2024, 2025a, b; Halkes et al., 2024). A literature review of manufacturing, supply chains, ore deposits and recycled sources of electronic components, will complement a review of the challenges of LCA calculations. Together with industry consultation, and the possibility for site visits, this information will be used to narrow down the elements of interest and LCA focus. Calculations will use the Minviro XYCLE LCA software, and have access when appropriate to their inventories, as well as databases such as Ecoinvent and information direct from industry. The research will then take a deeper dive into novel aspects of LCA, with some choice about studying and proposing novel circular economy business models for electronics, or tackling particular issues of LCA relevant to electronics.

Possible Timeline

Year 1: Literature review of key critical minerals in electronics and their life cycles, including circular economy strategies. Learn the techniques of Life Cycle Assessment using XYCLE. Including joining relevant University courses, attending research seminars, working with Prof Yan, Minviro and BGS. Choose which elements / materials to concentrate on. Learn concepts of materials flows and circular economy models, concepts of major elements and co-products/b-products and the ‘metals wheel’.

Year 2: Deeper dive into life cycle sustainability assessment, including with other industry partners (contacts of Camborne School of Mines, University of Exeter and/or Minviro, BGS). Comparing different geological deposits and extraction techniques, compared to recycling and other CE reverse loop strategies.

Year 3: Deeper dive into ownership models, resource-as-a-service, supply chain integration and/or Social Life cycle assessment, new materials. Consolidation of LCA models and data points into a new high-quality database for the electronics supply chain.

Training and skills:

TARGET researchers will participate in a minimum of 40 days training over the 3.5 years of study composed of:

- an annual one-week workshop dedicated to their year group, and tailored to that cohort's needs in terms of skills development – *for the first three years of their study*;
- an annual all-TARGET workshop with cross-year interactions, advanced training and opportunities to specialise in particular areas – *all years of study*;
- a number of one-day workshops;
- additional online events and in-person workshops attached to relevant conferences.

This project will provide comprehensive training in life cycle assessment, via University of Exeter, Minviro, including use of Minviro's proprietary Xycle software and BGS. The researcher will be able to learn about ore deposits and related ESG issues via Camborne School of Mines courses and about wider issues of metals sustainability including circular economy through events and courses in the University of Exeter UKRI-funded Critical Minerals Challenge Centre – accelerating the green economy. These will be complemented by interactions with BGS and the work undertaken on critical minerals, ESG and the circular economy, as well as the Critical Minerals Intelligence Centre

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Partners and collaboration (including CASE):

Minviro is the case partner and will be involved throughout the project. They will provide a three to six month paid internship for the student to work with the Minviro team (based in London with the possibility for hybrid working arrangements). They will also provide access to their proprietary XYCLE LCA software and relevant inventories throughout the project, and help with contacts to their extensive list of industry partners in the electronics, mining and recycling industries.

BGS will collaborate in this project and provide insights and support to the student where needed. Access to data, reports, contacts to industry and one to one meetings as well as an opportunity for the student to spend time and work with BGS for up to three months to support their PhD will be available to the student.

Further reading:

Halkes, RT, Hughes, A., Wall, F., Petavratzi, E., Pell, R., Lindsay, JJ (2024) Life cycle assessment and water use impacts of lithium production from salar deposits: Challenges and opportunities, Resources, Conservation and Recycling, 207, 107554, doi.org/10.1016/j.resconrec.2024.107554.

Minviro (2024) Circular Economy Shaping the Future of Lithium-Ion Batteries, https://www.minviro.com/resources/guides/the-circular-economy-lithium-ion-batteries.

Minviro (2025a) The Climate Change Impact of Recycled vs. Virgin Metals in Lithium-ion Batteries. https://www.minviro.com/resources/guides/recycled-vs-virgin-metals-whitepaper

Minviro (2025b) Path to Product Semiconductors. https://www.minviro.com/resources/guides/path-to-product-semiconductors.

Pell R, Tijsseling L, Goodenough K, Wall F, Dehaine Q, Grant A, Deak D, Yan X, Whattoff P (2021) Towards sustainable extraction of technology materials through integrated approaches Nature Reviews Earth & Environment2(10):665-679, DOI: 10.1038/s43017-021-00211-6

Wall F, Rollat A, Pell R. (2017) Responsible sourcing of critical metals, Elements, volume 13, number 5, p 313-318, DOI:10.2138/gselements.13.5.313.

Further details:

Please visit https://target.le.ac.uk/ for additional details on how to apply.

Project contact details: Professor Frances Wall F.Wall@exeter.ac.uk