Synergy analysis:

Sodium-ion battery [draft version]

Sodium-ion batteries inherently satisfy the decarbonisation aspect of sustainability. However, there are social, economic and environmental challenges to the existing battery industry that requires consideration early on in a planning process, for a new line of battery development to be truly sustainable.

The “ARC Methodology” (Haukenes, 2022) is a stricter approach to sustainability assessment by considering systemic aspects rather than selected indicators. We assess progress by a new approach to measuring sustainability, a Synergy Based Approach (SBA), based on a framework established at the Arctic Centre for Sustainable Energy (ARC/UiT). The methodology aims at an ideal goal of *actual sustainability,* asviewed from a paradigm of *strong sustainability* (Giddings et al., 2002).

The strong sustainability paradigm acknowledges the existence of planetary boundaries and that the neoclassical view on economic sustainability stands in opposition to ecological sustainability (Janeiro & Patel, 2015; Neumayer, 1999). The methodology develops solutions that supply the required societal services within ecological boundaries and constraints.

# Some words about economic sustainability

There is much talk about circular economy in relation to sustainability. However, the world runs on neoclassical economic principles, which come with their own distinct environmental philosophy. ‘Natural capital’ is considered *substitutable* with ‘produced capital’ and the idea of circularity does not apply in the same way as in the science-based strong paradigm of sustainability, where circularity must align with ecological cycles of regeneration and resilience.

Neoclassical economy incentivises investments by realising profit for shareholders and owners. It is easier to raise funds for large scale projects when money is concentrated, rather than distributed. However, a decentralized distribution model brings more taxes to local communities and governments (large companies in Norway are often taxed as low as 1 or 2% while smaller, local businesses are taxed 20-30%).

If revenue circulates within the local economy rather than being exported abroad, the value of money increases. Therefore, the decentralised model can be economically advantageous for towns, communes and regions although the immediate cost for a product or process might seem higher. Especially compared to the alternative of outsourcing work to regions with weaker economies and frameworks that do not protect nature. This strategy, however, defeats the purpose of both social, cultural and environmental sustainability.

# Environmental sustainability

The main ecological challenges for sodium ion batteries are related to the mining of supplicant metals to the sodium. Mining often conflicts with indigenous rights and territorial interests. The second main challenge is the potential for recycling, since layered materials are hard to disassemble and retrieve materials in forms that are reusable.

Below is a preliminary chart of synergies involved in this project, that have yet to be properly ordered and weighted.

# Synergy chart

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Synergy category** | | **Score (NB: example scores to illustrate the process)** | | |
| **Synergies** | **Dis-synergies** | **Scores** | | |
| Local sourcing of materials | | Positive | | Negative |
| * Early collaboration with indigenous peoples minimise conflict potential * New solutions can be found when indigenous interests are taken into account * The unavoidable strain on nature is more acceptable if it directly gains indigenous interests (like well thought through infrastructure for electric snow scooters) * The incentive for nature restoration is higher for local ownerships than international ones, due to emotional and cultural connection to the landscape * Especially if indigenous peoples have shares in the business ventures | * More expensive * Smaller scales * No advantages due to relative currency values (of course this is really positive, since these are usually due to colonial heritage) * More regulations for workers, emissions and natural concerns in high income countries (also, really positive, just not in a neoclassical economic paradigm) * (…) | 10  5  20  10  25 | | 10  20  10  10 |
| Decentralised recycling lines | |  | | |
| * Battery recycling is tedious, not suitable for economies of scale – well suited for decentralised facilities…? * Battery recycling and reuse can establish new local businesses * Increases resilience for small and decentralised Arctic indigenous and rural societies * Not as connected to a globalised growth-based paradigm of economy * Connects to a local resilience-based economy |  | 15  10  20  20  10 | | [to be discussed]  [to be discussed] |
| Regional assembly lines | |  | | |
| * Satisfies some of the requirements to compete within an economy of scales * but remains connected to the cultural foundations for where batteries are used * Less transport of goods |  | 10  10  5 | | [to be discussed] |
| Decentralised economy | |  | | |
| * Easier for existing models of trade and commerce amongst indigenous societies to be sustained * Allows profits to be circulated in the local community, rather than exported abroad * Profits are distributed more evently * Generates more tax revenue |  | 10  10  25  10 | | [to be discussed] |
| Supplementary metals to sodium | |  | | |
| * Cobalt not required for efficiency as ion * Efficient with metals that are not disputed (yet) | * Presumes some damage to natural habitat * Mountains and areas that are mineral rich are often considered sacred or especially valuable * Indigenous peoples can have ways of life that require continuous areas (like rein deer herding) * Existing mining lobby routinely and consciously compromises indigenous rights (Glencore, BHP, (Kirsch, Mining Capitalism)) | 25  20 | | 5-100  15  10  30 |
| Sodium | |  | | |
| * Abundant and readily available * Naturally clumps together (salt lakes, caves, mines) * Non-toxic | * Highly reactive with oxygen and water * Energy intensive if electrolysis is used for separation * Biological separation…? * [Is there toxic byproduct from biological separation?] | 30  25  15 | | 10  15  5  5 |
| Sodium-ion | |  | | |
| * Loses relatively little charge in cold temperatures * Low cost * Safe with the right isolation structure | * Low energy density * Unstable (?) | 30  20 | | 15  20 |
| Partial sums | | 350 | | -200 |
| **Total sum** | | | **150** | |

**Sources**

Giddings, B., Hopwood, B., & O’Brien, G. (2002). Environment, economy and society: Fitting them together into sustainable development. *Sustainable Development*, *10*(4), 187–196. https://doi.org/10.1002/sd.199

Haukenes, O. A. (2022). *The ARC-Methodology: A synergetic approach to sustainability assessment*. https://uit.no/research/arc/project?pid=795909&p\_document\_id=774283

Janeiro, L., & Patel, M. K. (2015). Choosing sustainable technologies. Implications of the underlying sustainability paradigm in the decision-making process. *Journal of Cleaner Production*, *105*, 438–446. https://doi.org/10.1016/j.jclepro.2014.01.029

Neumayer, E. (1999). *Weak versus strong sustainability : exploring the limits of two opposing paradigms / Eric Neumayer*. Edward Elgar.