Valorisation of Lithium-Ion Batteries from Electric Bikes in Lausanne

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Introduction

In recent years, the use of electric bicycles (e-bikes) has surged across Switzerland, driven by both a growing consumer environmental consciousness in sustainable mobility and the implementation of targeted subsidy programs. At the national level, annual e-bikes sales increased by an average of 20% between 2017 and 2022.[1] This growth is expected to continue, with a compound annual growth rate (CAGR) of 1.15% forecast for the period 2025-2029, reaching annual sales of 259,000 units.[2] Cost remains one of the main barriers, if not the main barrier, to e-bike adoption, so the success of subsidies in boosting sales shows their effectiveness.[3]

In Lausanne, within the framework of the *Plan Climat*, the city has taken proactive steps since 2016 to promote soft mobility and reduce car dependency, notably through a subsidy program in partnership with Equiwatt. Supported by the Fonds pour l'Efficacité Énergétique (FEE) and aligned with the national "Energy Strategy 2050", this initiative offers at least a 15% discount on new e-bike purchases. It also provides financial support (300 CHF) for battery replacements, contingent on the return of the used battery for recycling. These subsidies apply to new bikes, new batteries, and reconditioned bikes (usually equipped with new batteries), but not to second-hand batteries.

Locally, the impact is significant: in 2018, Lausanne granted 744 e-bike subsidies, rising to 891 in 2019 and 1,372 in 2020. Battery subsidies were also granted and account for around 50 per year.[4] This growth throughout the late 2010s to early 2020s, coupled with the typical Li-ion electric battery lifespan of 5 to 9 years, suggests that Lausanne should expect a significant wave of end-of-life batteries in the coming years. This represents not only an environmental challenge but also a major opportunity for circular economy innovation, as these batteries contain critical raw materials such as lithium, cobalt, manganese, and nickel that can be recovered and reused.

Key Points

- Lausanne's subsidy scheme and growing e-bike use offer a key opportunity to develop sustainable strategies for spent Li-ion batteries.
- The current Batrec recycling process is already efficient; municipal influence lies more in user behavior than technical improvements.
- Tailored subsidies could promote second-hand battery adoption by matching performance needs to commute profiles.
- A battery passport could enhance tracking and reuse, preventing premature disposal.
- Public awareness campaigns and gamified incentives could boost battery return rates from below 20% to the 80% national target.

Globally, the demand for critical raw materials is rising sharply, yet the supply is concentrated and problematic. For example, in the cobalt extraction from the Democratic Republic of Congo, where mining operations frequently raise human rights and ethical concerns, or the lithium extraction, whose ton requires up to 2 million litres of water, intensifying water scarcity in already vulnerable regions. Moreover, supply chains for materials like lithium lack resilience, as shown in Figure 1. Even if lithium is mined in Europe, it must currently be exported for refining, due to limited regional processing capacity. Closing this gap in the value chain is crucial.

For these reasons, Lausanne now has the chance to pioneer a sustainable, circular solution to the growing e-bike battery waste stream. This will allow a recovery of valuable and scarce materials, reducing the need for virgin resource extraction and Switzerland's dependency on imports.

In the next sections some proposals will give an overview about battery recycling and management in Lausanne, and identify solutions that the municipality of Lausanne could implement, specifically within the *Plan Climat*, to promote reuse and second-life applications. That way the city can position itself as a model for other municipalities seeking for sustainable development and resource security.

[1] Velosuisse (2024). *Entwicklung Schweizer Fahrrad- und E-Bike-Markt, 2005 bis 2024.* URL: https://www.velosuisse.ch/wp-content/uploads/2025/03/Gesamtstatistik2005-2024.pdf

[2] Statista (2024). *Electric Bicycles - Switzerland.* Accessed May 2025. URL: https://www.statista.com/outlook/mmo/bicycles/electric-bicycles/switzerland

[3] Shimano (2020). *State of the Nation Report.* Tech. rep. Shimano Europe

[4] Fonds pour l'efficacité énergétique (2020). *Mobilité électrique.* Accessed May 2025. URL: https://www.lausanne.ch/portrait/durabilite/rapport-activite-fdd-fee/projets-fee/mobilite-electrique.html#on-en-parle-05

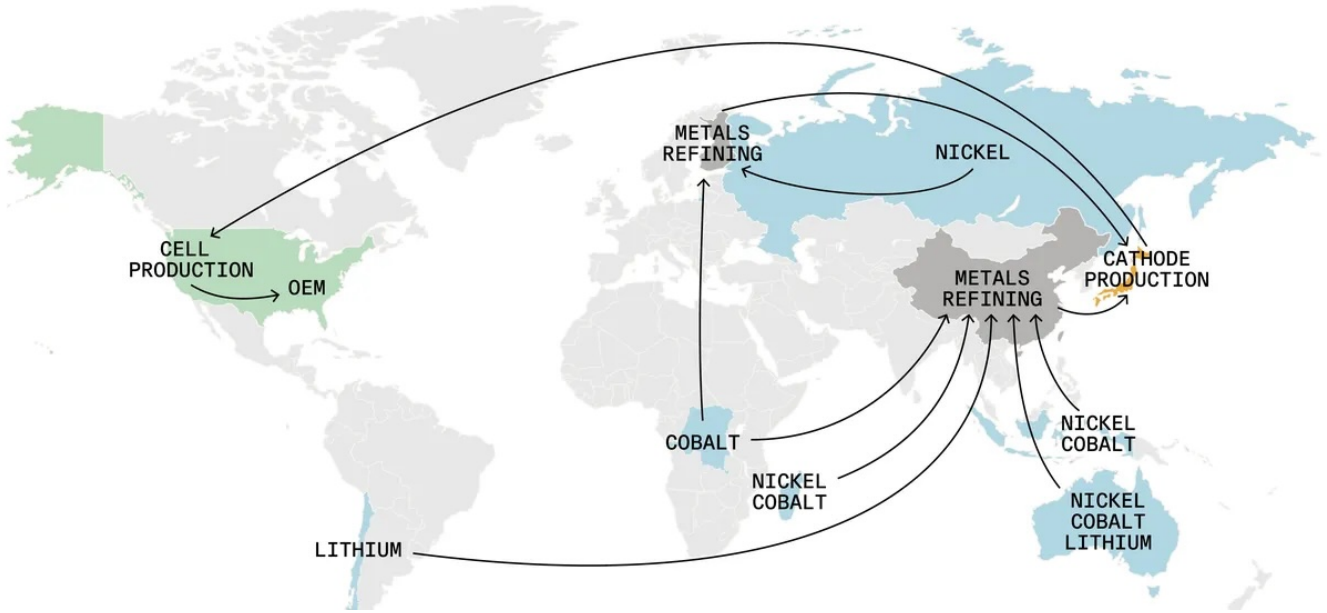

Figure 1. Supply chain for Li-ion battery critical raw materials

The Current State of Battery Recycling in Lausanne

In Lausanne, it is the responsibility of the consumer to return spent Lithium-ion batteries from their electric bikes to the point-of-sale or to designated collection facilities within the municipality. These are all collected and shipped 150km to the Batrec Industries AG facility, where they are manually discharged, shredded to extract the critical mineral-rich black mass, Copper, and Aluminum. These components are separated, and the black mass is dissolved and precipitated into a mixed-hydroxide precipitate (MHP) which contains the valuable Lithium, Nickel, Cobalt and Manganese to be recycled. The MHP is shipped mainly to Asia, where it is refined for the production of new batteries.

Thankfully, the current battery recycling pre-processing facility operated by Batrec is at no risk of reaching its current capacity. The manual discharge and mechanical grinding and separation of these batteries can be relatively easily scaled to meet a higher waste volume while maintaining cost effectiveness.

However, this anticipated growth in demand for battery recycling offers the opportunity to implement and test new strategies and policy initiatives to identify more sustainable recycling practices. To this end, the following sections present areas for innovation, both in the pre-existing battery recycling process but, more importantly, at the consumer, vendor, and municipal level, targeting the reuse, repurposing, and traceability of batteries currently in circulation, and awareness at the consumer level.

1. Improving the Current Battery Recycling Process

Batrec Industries AG's Li-ion recycling process is highly efficient. Prioritizing Copper recovery, up to 98% of this material is recovered, with Aluminum following close behind. The main source of waste in this process is in its energy and water intensiveness, but implementing such changes is far outside of the scope of the Municipality of Lausanne.

Furthermore, the shipping of critical minerals-rich MHP to Asia is a significant source of waste. MHP could instead be sent to BASF's prototype facility in Schwartzheide, Germany, or to Eramet & Suez's facility slated to open in 2025 in Dunkirk, France. This would reduce the length of the journey drastically and restrain the circulation of these critical materials to Europe. Given that the hydrometallurgical separation and refinement process for black mass minerals is most economical and least wasteful at much larger scales, centralizing this process is far preferred to funding its construction locally. However, reducing the shipping distance of MHP introduced to this process would greatly contribute to the reduction of emissions associated with Li-ion battery recycling. Such a change is also outside the munici-

pal scope, and although grassroots movements to encourage the transition from Asian to European refinement facilities could be supported at the municipal level, this does not necessarily translate to direct municipal policy action.

Ultimately, the reality is that recycling is the least effective means of reducing a spent battery's environmental footprint. More impactful alternatives which target batteries earlier in their life cycle, and involve more effective and sustainable solutions implementable at a municipal scale, do exist; these are discussed in the following sections.

2. Improving Circularity at the Municipal Level through Reuse and Repair

Knowing the high energy demands, the moderate efficiencies, and the fact that the valuable black mass from recycling is exported back to Asia before having to reimport batteries from overseas again, there may be better alternatives to keep these critical materials circulating on our territory for longer. This would not only reduce our reliance on overseas imports, but could foster the local economy and create new jobs.

The circular economy offers a transformative framework for rethinking how materials and products are managed throughout their life cycles. Unlike the traditional linear model of "take, make, dispose," a circular approach prioritizes keeping products and materials in use for as long as possible through strategies such as reuse, repair, and refurbishment. In the context of e-bike batteries, this means shifting focus from end-of-life recycling to maintaining value through second-life applications, component recovery, and system upgrades. By embracing these principles, municipalities can reduce resource extraction, lower emissions, and support more resilient, low-carbon urban mobility systems.

One way to do this would be by promoting reuse of batteries. As a matter of fact, most e-bike batteries are currently sent to recycling long before they have reached their actual end-of-life. This can be attributed to multiple causes.

Firstly, if the capacity of the battery does not suffice for someone's commute, the battery will be deemed expired by the user. Nevertheless, someone with a shorter commute could still benefit from this battery if a proper battery resale structure, which guarantees safety and performance, were set in place. This speaks for the need for proper testing services, which are reliable and affordable. The municipality could thus promote these, either subsidizing these tests to make them more economical, or by enforcing these tests. Enforcement would need careful measures to not prevent recycling, and subsidies need to be calculated carefully, and could be targeted at the battery testers or final consumers by subsidizing refurbished batteries, which is currently not being done.

Another issue surrounding the battery end-of-life management is the misidentification of spent batteries; oftentimes, a battery's decrease in performance is not due to the chemical degradation of the battery cell but to various other electronic components on the e-bike battery. Despite this, replacements for these components are not made available by the manufacturer, and so these batteries are sent to recycling despite having a significant remaining useful life. Companies such as upVolt GmbH, based in Basel, and swissbattery.com, based in Prilly, offer upcycling, refurbishement and repair services for these batteries. However, the process can be tedious, time-intensive and expensive, so municipal subsidies could also target these solutions, to increase attractiveness of these services. Furthermore, they operate at a client-level, and so their integration into the municipal battery life cycle could be hugely beneficial for the reuse of batteries, acting as a filter before spent batteries are sent to Batrec.

There thus exists many creative ways to prolong the use phase of batteries, be it through resell, repair or reuse. These actions can all take place at the municipal level, and can benefit from proper policies, to increase attractiveness and traction.

3. Implementing a Battery Passport to Improve Tracking and End-of-Life Management

To further support the circular management of electric bike batteries at the municipal level, we propose the implementation of a battery passport system linked to a QR code labelled onto each battery. This digital record would store key information including for instance the battery's chemical composition, crucial for facilitating efficient recycling especially as electric vehicle battery chemistries evolve rapidly with innovation. It would also allow users and retailers to register repairs or replacements throughout the battery's life, creating full traceability. Additionally, performance data, mainly remaining capacity, could be periodically entered thanks to portable testing kits like those developed by Circu Li-ion. These offer safe and simple battery diagnosis tools, and are an economic option to be purchased by individual users or made available for free in retail or repair shops. Finally, the same digital interface could help identify nearby certified collection points for end-of-life handling, ensuring batteries are returned to appropriate recycling channels.

This system offers multiple benefits. By making the battery's life cycle transparent and user-updatable, it empowers both consumers and vendors to make better decisions about reuse, resale, or replacement. For recyclers, access to information on the battery's internal chemistry significantly improves material recovery efficiency and reduces safety risks. Regularly updated performance data also opens the door to secondary markets for used batteries with sufficient residual capacity, especially if the next user is going to make a more occasional use of the electric bike. In the long run, this approach would mainly improve battery reliability tracking and reduce environmental harm by minimizing improperly discarded batteries that could be repurposed or reused.

Similar concepts have already been successfully explored in the electric vehicle industry. For example, companies like DENSO and Volvo Cars have partnered with digital traceability platforms to develop battery passports that register material origins, usage, and performance throughout the battery's life. The Global Battery Alliance is also pushing for standardized digital battery passports across Europe by 2027.[5]

In a nutshell, to implement this at a municipal level authorities could introduce policies requiring vendors and retailers to label each sold battery with a QR code linked to the digital passport system, while the database and interface would be centrally managed by the municipality.

4. Raising Public Awareness to Increase Return Rates

To ensure that electric bike batteries are effectively reintegrated into the circular economy, increasing public awareness and participation in return schemes is essential. However, it is estimated that less than 20% of e-bike batteries are returned—far below the 80% target.[6] Many users remain unaware of proper disposal channels or the consequences of holding on to used batteries, ranging from fire hazards to the unnecessary loss of critical materials. A coordinated awareness campaign by the City of Lausanne could significantly improve collection rates by focusing on concrete, relatable messaging and easy-to-access return options. Leveraging regional media outlets such as RTS and Le Matin Dimanche, and broadcasting informative content via social media platforms managed by the municipality, would be key to targeting different demographics. A successful campaign might include short videos showing what happens to a returned battery at Batrec, highlighting the environmental benefits and showing how much critical material is saved. Additionally, campaigns could publicize local drop-off points on Ville de Lausanne website and InoBat or partner with e-bike vendors to attach QR codes on receipts linking to proper return procedures and nearby collection sites.

Other European cities have demonstrated the effectiveness of such initiatives. For instance, Amsterdam's "Urban Mining" campaign combined educational pop-ups, school workshops, and mobile collection points, promoted through local influencers and public institutions, leading to a 34% increase in small battery return rates within one year.[7] In Oslo, the city's transport authority, Ruter, launched a three-year pilot program that integrates battery return points within the public transit network, partners with e-bike retailers, and uses digital platforms to inform and engage users—successfully embedding battery returns into daily mobility routines and boosting return rates.[8,9]

Lausanne could pursue a similar approach by leveraging its existing mobility programs. For example, the city's participation in the Pro Velo's cycling campaigns such as Bike to Work offers a promising channel for promoting battery recycling. Incorporating return information and incentives directly into the app would help reach a broader audience and facilitate convenient disposal options for cyclists. Lausanne can adapt these strategies by localizing messaging around regional sustainability goals and emphasizing the economic value of recovered materials in the fight against critical raw material dependency. Additionally, gamifying returns—for instance, awarding digital badges for recyclers—could help normalize battery hand-ins as a community-wide habit and support broader circular economy targets.

[5] Global Battery Alliance (2023). *Battery Passport Initiative.* Accessed May 2025. URL: https://www.globalbattery.org/battery-passport/

[6] Swiss Federal Assembly (2020). *Postulat Reynard: Pour une stratégie de recyclage des batteries de vélos électriques.* Accessed May 2025. URL: https://ws-old.parlament.ch/affairs/20204689

[7] International Council on Clean Transportation (2023). *Recycling Electric Vehicle Batteries: Global Approaches to Collection, Logistics, and Traceability.* Tech. rep. Accessed May 2025. The ICCT. URL: https://theicct.org/wp-content/uploads/2023/02/recycling-electric-vehicle-batteries-feb-23.pdf

[8] *Regulation (EU) 2023/1542 on Batteries and Waste Batteries* (2023). Accessed May 2025. URL: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1542

[9] Global Battery Alliance (2023). *Battery Passport Initiative.* Accessed May 2025. URL: https://www.globalbattery.org/battery-passport/

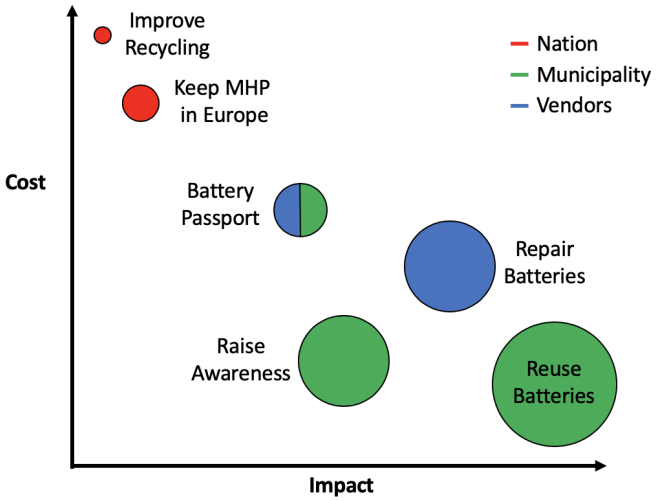

Figure 2. Visualisation of the proposed actions ordered by their cost and impact. The circle size emphasises the priority of the measure, while the colour indicates who has to act.

Conclusion

With e-bike usage on the rise and a growing volume of batteries nearing end-of-life, Lausanne must act now to ensure a sustainable management system is in place. As summarised in Figure 2, there are multiple ways forward. To extend the life cycle of lithium-ion batteries and reduce environmental impact, the city can support second-hand battery use, promote repair and refurbishment services, and introduce a digital battery passport system to improve traceability and reuse. Additionally, a targeted awareness campaign can raise return rates toward the 80% national goal by making proper disposal accessible and incentivized. Together, these measures not only reduce the city's environmental footprint and critical material dependency but also offer socio-economic benefits through new local services and jobs. By piloting these circular economy strategies, Lausanne can evaluate scalable policies potentially transferable to other forms of electric mobility, including electric vehicles and scooters—setting a precedent for urban sustainability across Switzerland and beyond.

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