ECO-INDUSTRIAL PARK FRAMEWORK

Fostering the adoption of “second life” battery storage systems to increase Competitiveness, Circularity and Resilience of Economic Zones

WORLD BANK GROUP
Finance, Competitiveness & Innovation

Agenda

- Market Opportunity
- Material recovery business model
- Remanufacturing and Reuse business model
- The Eco-Industrial Park framework as a potential market driver for battery storage systems (tear 2)

Market Opportunities

Trends and forecasts on EV markets are generating concerns about:

- Availability of critical raw materials
- Management of end-of-service batteries

140 million: The number of electric vehicles predicted to be on the road worldwide by 2030

11 million: Metric tons of Li-ion batteries expected to reach the end of their service lives between now and 2030

30–40%:The percentage of a Li-ion battery's weight that comes from valuable cathode material

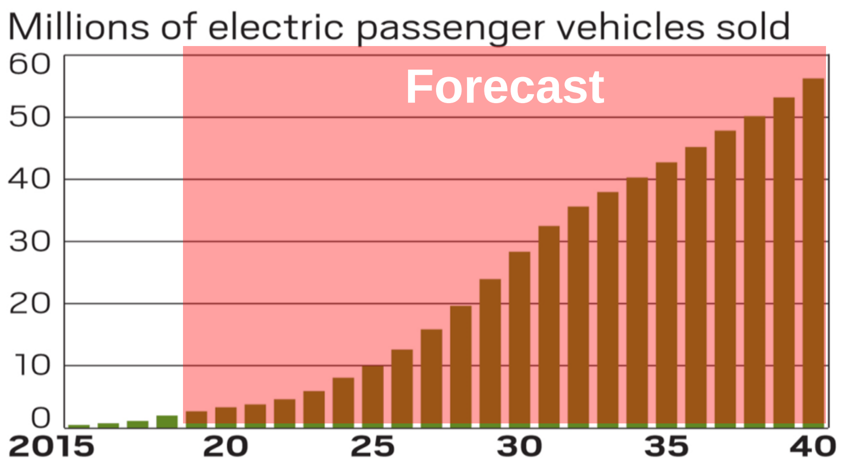
<5%: The percentage of Li-ion batteries that are recycled currently

~100%: The percentage of the lead in common lead-acid car batteries that gets recycled into new batteries

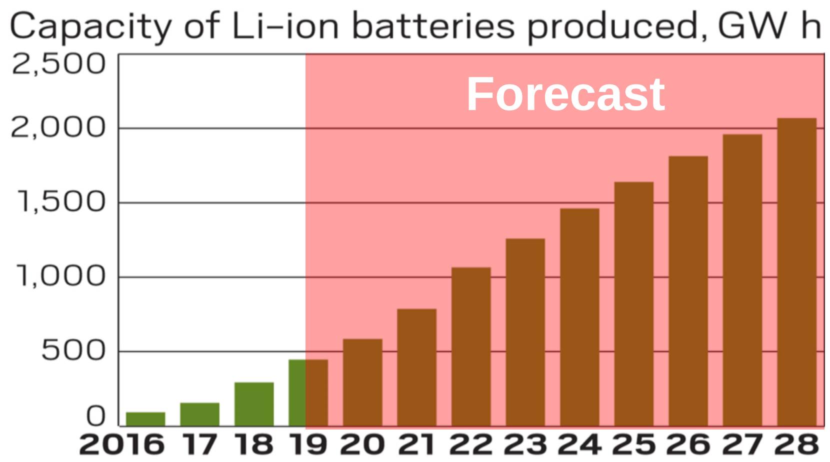
~$70 billion: The value of the Li-ion battery market projected for 2022

Sources: International Energy Agency, US Department of Energy

Current market prices for cobalt and nickel stand at roughly $27,500 per metric ton and $12,600 per metric ton, respectively. In 2018, cobalt's price exceeded $90,000 per metric ton.

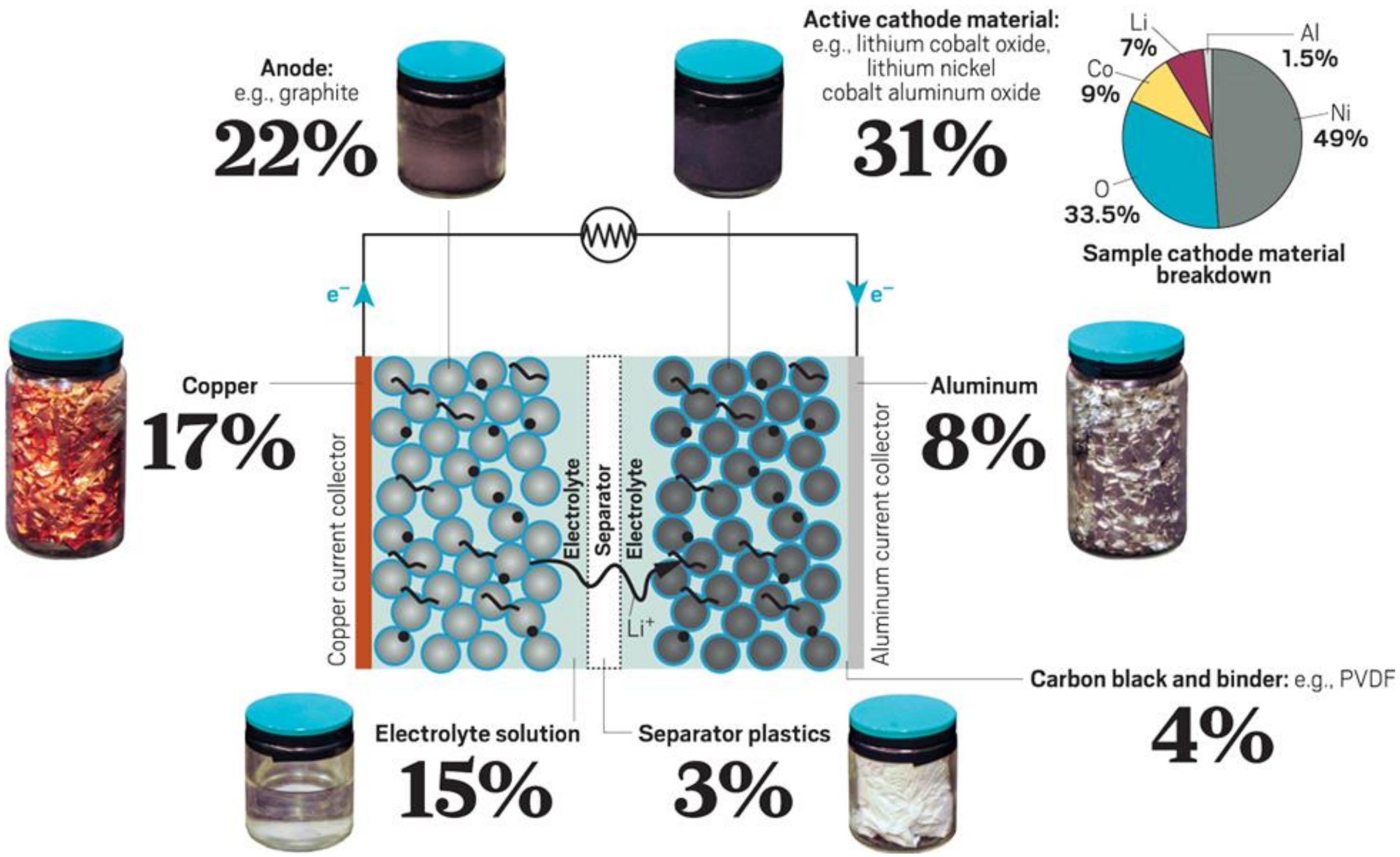


Bloomberg New Energy Finance, Electric Vehicle Outlook 2019. Note: Vehicle sales include all-electric vehicles and plug-in hybrid vehicles. Data up through 2018 are actual; data from 2019 onward are forecast.



Benchmark Mineral Intelligence, Megafactory Assessment, December 2019

End of Life: Material Recovery Business Model - What can we recover?



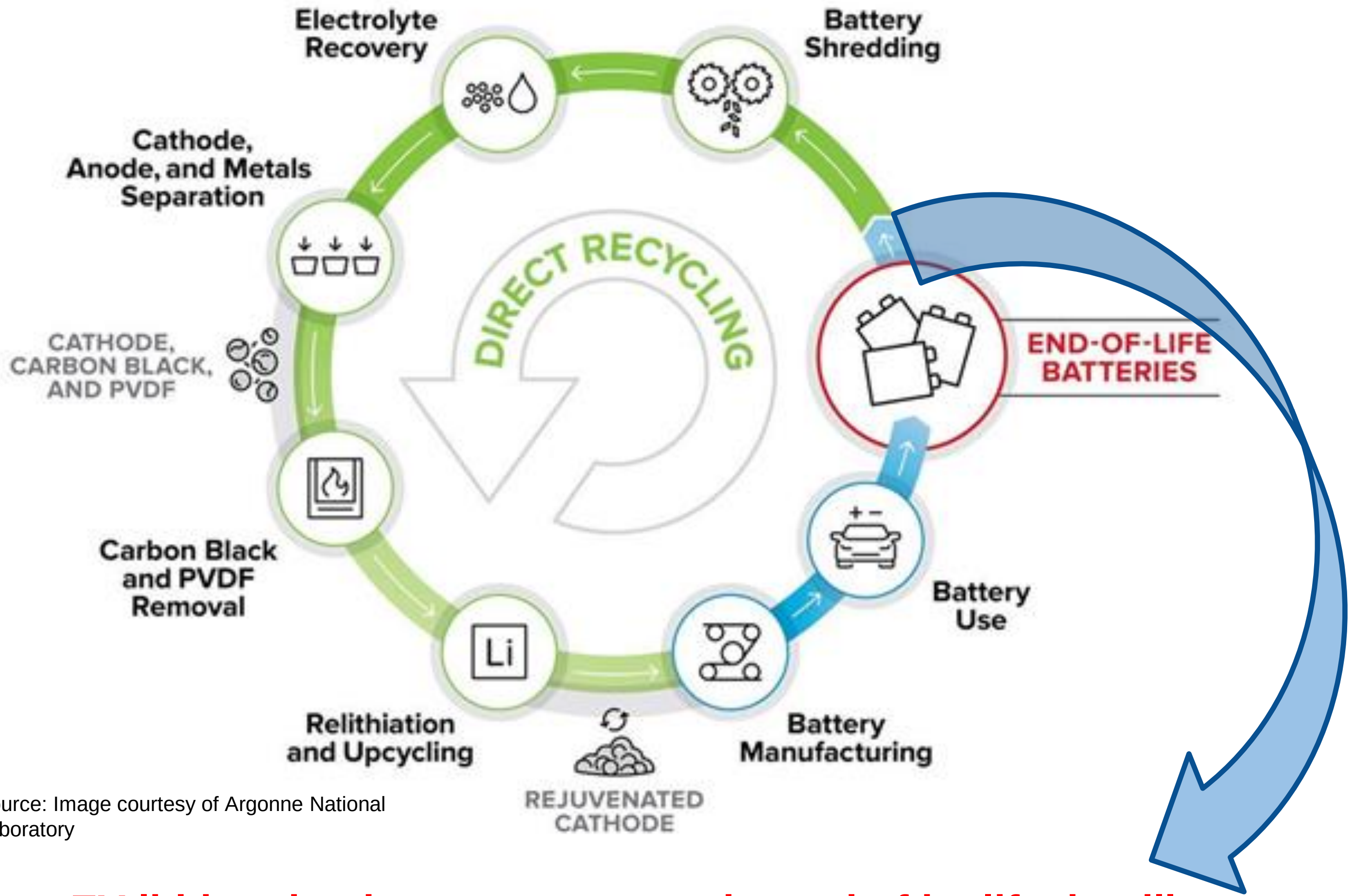
Because the Li-ion battery industry lacks a clear path to large-scale economical recycling, battery researchers and manufacturers have traditionally not focused on improving recyclability.

Instead, they have worked to lower costs and increase battery longevity and charge capacity.

RISKS

- NEW TECHNOLOGIES
- NEW BATTERY DESIGN
- HIGH INVESTMENTS
- LOW AVAILABILITY

End of Life: Material Recovery Business Model – Is It the ultimate solution?



Source: Image courtesy of Argonne National Laboratory

When EV lithium-ion battery comes to the end of its life, it still retains around 80% of its charge. While that's not enough to serve an electric vehicle, it's good enough for a variety of different applications, such as energy storage.

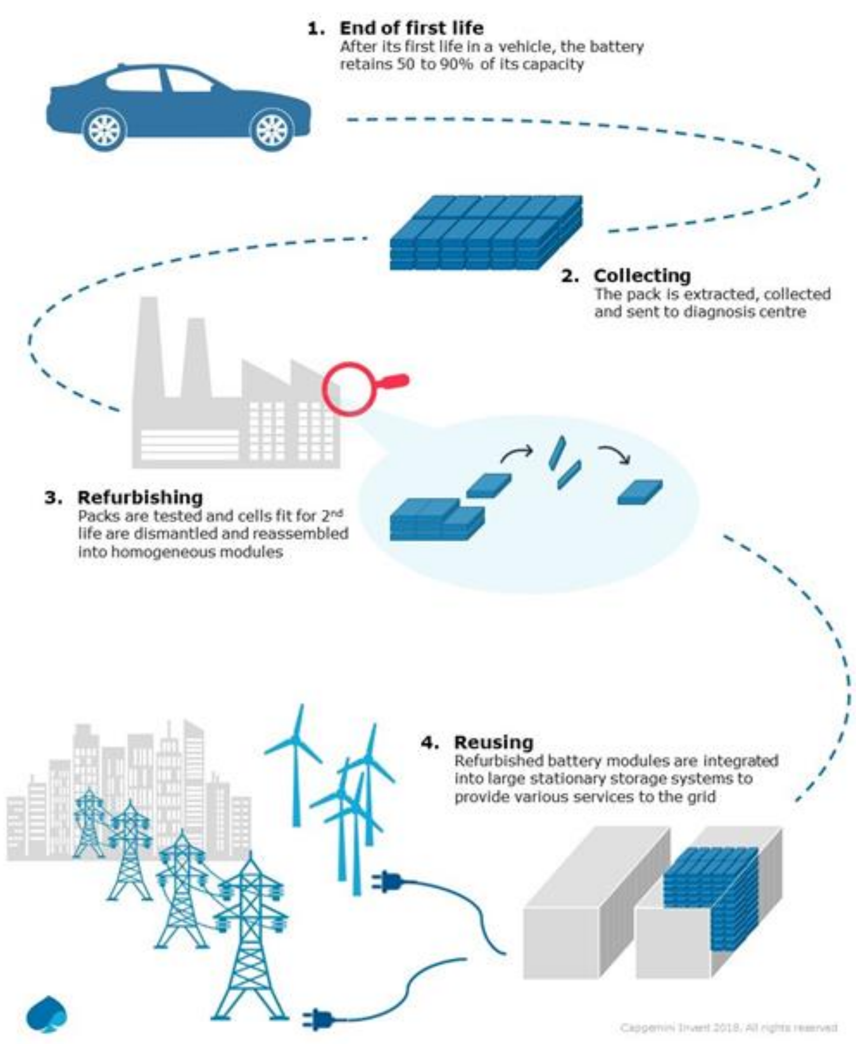
Investment Risks

Technology & Design: efficient and economic material recovery requires new technologies and new battery design

Availability: Significant volumes are expected to be generated in 4 to 8 years since the EV market becomes predominant

Collection: Establishing a network to collect "exhausted" batteries requires involvement of different stakeholders

Remanufacturing (Refurbishing) and Reuse before material recovering



Investment Risks

Availability: Secure partnerships with local stakeholders dealing with the batteries end of life (collectors, recycling companies,…) at the end of car lifetimes.

Collection: Crack the logistics conundrum to centralize the collection and testing of used batteries, reach economies of scale, and reduce transportation & storage costs to a minimum.

Technology: Push the development of energy management systems that can combine 1st and second life batteries, using different brands, chemistries and designs. In this regard the use of artificial intelligence will play an important role.

Lack of data on the performance of different batteries chemistries and designs: assessing the remaining capacity at the cell level remains difficult, as first-generation BMS (Battery Management System) have not been developed for a close monitoring, nor do they provide a full range of technical data history of batteries at different levels.

Market: Potential applications for battery Refurbished Battery Modules (tear 2) compared to utility scale battery systems with new batteries (tear 1).

The EIP Framework – potential application for (tear 2) battery storage system

Market: Potential applications for battery Refurbished Battery Modules (tear 2) compared to utility scale battery systems with new batteries (tear 1).

Battery Storage (tear 2) is a fundamental component of the EIP implementation to increase competitiveness by combining:

Sustainability: *green infrastructures*
Circularity: *integrating recovered products with extended lifecycle*
Resilience: *business continuity & continued service provision*

<u>Main applications for battery storage in EIPs:</u>

Renewables

Telecom Energy Back-up Systems

Tenant Firm Energy Back-up Systems

"EIPs can be defined as managed industrial areas that promote cross-industry and community collaboration for common benefits related to economic, social and environmental performance."

When comparing an **EIP** to a traditional Industrial Park the main differences are in the following **key benefits**:

- Reduced use of raw materials, water, energy and chemicals (toxic)
- Minimized green house gas emissions and release of pollutants
- Reduced waste through resource circularity
- Reduced economic, environmental, social risks

- Improved competitiveness and profitability
- Shared recycling facilities
- Creation of good-quality jobs
- Improved workers health and safety
- Increased quality of life for communities
- Better access to new technologies and finances

Innovative technologies and digitalization to enable resource efficiency, circularity and competitiveness

- **Renewable energy technology/resilient green infrastructures**
  - Ground-mounted / floating solar panels in industrial parks
  - micro-grid, battery storage/ energy storage system and factory EMS
  - Solar water heating/ centralized heating/ cooling technologies
  - Biomass / biogas plants
  - Energy efficient / smart factory/ green buildings, industry zone facilities, warehouses

- **Waste, energy and material recovery**
  - Waste-heat recovery
  - Biological wastewater treatment technologies / reuse of sludge and wastewater generated from CETP to generate energy
  - Industrial symbiosis
  - CO2 recovery and reuse for industrial processes

- **Sharing platforms:** material exchange, energy exchange, knowledge and technologies, offer of underused assets, production sharing, by product offer to third parties outside the park

TAKEAWAYS - Private Sector Engagement

- **Availability and Collection:** in the next five years the availability of used batteries will be still too low to consider significant investments.

- ***De-risking:*** *planning potential interventions to regulate, incentivize and sustain the trade (import/export), disposal and recovery of EV batteries. Defining a clear roadmap to identify and engage stakeholders at an early stage of the EV market development is a pre-requisite to de-risk private investments.*

- **Technology:** battery to battery business model depends mainly on the adoption of a circular design to allow the recovery of materials in a sustainable and economic way. Refurbishing and reuse have a lower technological complexity, but the lack of a standardization of products affects the overall investment cost.

- ***De-risking:*** *financing thematic R&D challenges and funds (such as EU - Horizon 2020) or facilitating/incentivizing technology transfer to support private sector in investing and partnering with academia/research centers to study and implement new solutions for material recovery and product refurbishing and reuse.*

- **Market:** Refurbished battery systems require to be cost competitive and reliable compared to new ESS. A price driven market can erode margins to make the refurbishing business model less attractive for private investors.

- ***De-risking:*** *Identifying niche markets as entry strategy (Eco-Industrial Parks require the implementation of circular economy business models) and providing state-own additional warranties to mitigate the operation/maintenance cost of the "tier – 2" ESS could foster the establishment of a specialized sector.*

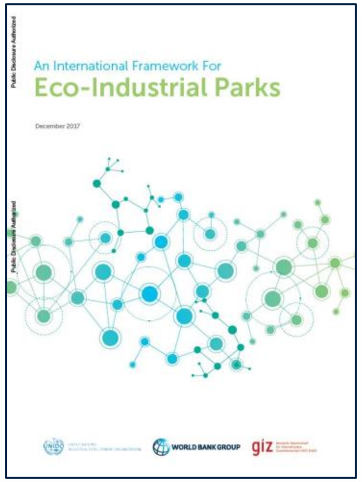
Towards an International Framework for EIPs

1. An International framework for EIPs (2017 v.1; 2021 v.2*)

- Details the pre-requisites and performance requirements to develop EIPs.
- Attempt to create a standardized framework that can be implemented globally (applicable to both developed & developing countries).
- Collaborative initiative of the World Bank Group, United Nations Industrial Development Organization and the German Development Agency (GIZ).

*The new release of the International Framework for EIPS is expected by the end of February 2021

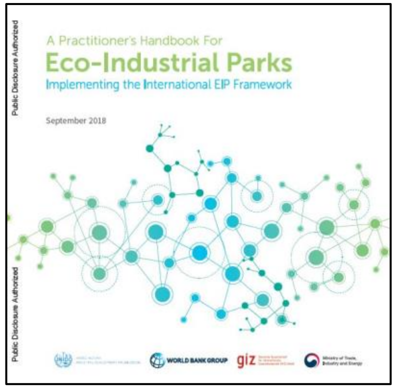
https://openknowledge.worldbank.org/handle/10986/29110



2. Implementing the Framework: A Practitioner's Handbook (2018)

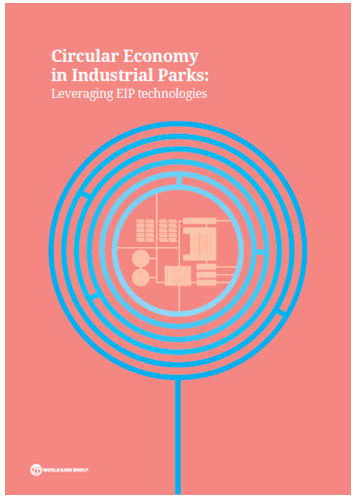
- Provides a step-by-step guide on how to operationalize the framework, including on (1) how to develop a national approach for EIPs and (2) how to implement the approach (3) creating and managing industrial symbiosis networks.
- Collaborative work from World Bank Group (WBG), UNIDO, GIZ, and Ministry of Trade, Industry and Energy of the Republic of Korea (MOTIE).

https://openknowledge.worldbank.org/handle/10986/30458



3. Circular Economy in Industrial Parks: Technologies for competitiveness (to be published – March 2021)

- Detailed assessment of main CE business models and technologies adopted in Eco-Industrial Parks



THANK YOU!

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