MARKET INTELLIGENCE REPORT

COBRA

KEY TECHNICAL, POLICY AND MARKET DEVELOPMENTS INFLUENCING THE ELECTRIC VEHICLE BATTERY LANDSCAPE

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SECOND LIFE APPLICATIONS

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INTRODUCTION

The trend of ever-decreasing Li-ion battery prices has recently reversed with the pandemic, war in Ukraine and related events strongly destabilising supply chains. For the first time in the 21st century, batteries became more expensive, reaching **$151/kWh** for new packs globally in 2022, a 7% rise from the last year in real terms **[1]**. This outcome may open new opportunities for 2nd life solutions faster than anticipated. Therefore, it becomes urgent and economically justified to solve the remaining technical, market and policy bottlenecks hampering the uptake of repurposed batteries.

This Market Intelligence Report aims to explain the repurposing process, present the variety of 2nd life applications, and outline the key energy storage market numbers. Moreover, our contributors help to reveal important considerations when designing storage systems from used batteries and pinpoint challenges that may lead to interesting opportunities for research and industry.

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OVERVIEW

REMAINING USEFUL LIFE OF EV BATTERIES

EV batteries typically endure a demanding lifetime inside the vehicle, which is partly dependent on a proper Battery Management System (BMS), charging, and driving behaviour. **In theory,** EV batteries will be **removed from the car at 70-80% State of Health**, which is typically used as a threshold for the minimum operating quality of EV batteries **[2]**. **In practice**, the most common scenario of batteries reaching their end of first life is **when they are no longer economical to repair** (figure 1), and the authorised treatment facility (ATF) sends it to the recycler **[3]**.

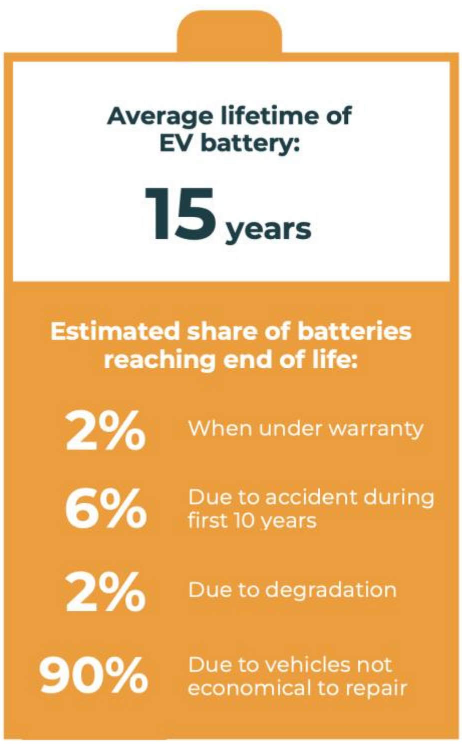

Figure 1. Return battery flows **[4]**

However, recycling is not the only option since some batteries may still have a residual value (figure 2), and the ATF may decide to sell the battery. These batteries can be bought by repurposers and used for less demanding – stationary - applications. Some examples include commercial buildings, EV chargers, construction sites, and backup power (telecom and servers) **[5]**, **[6]**.

This residual value could become a significant source of energy storage in the coming years. It is expected that around **80GWh of grid-scale energy storage** will be installed in Europe by 2031 **[8]**. At the same time, in 2030 alone, **25 GWh worth of end-of-life (EoL) EV** batteries are expected to be available for collection in Europe **[7]**. On the long term, second-life EV batteries could contribute even more to this market. In 2030, it is expected that around **500 GWh of new EV batteries will be deployed**, which will reach their EoL 10-15 years later **[9]**.

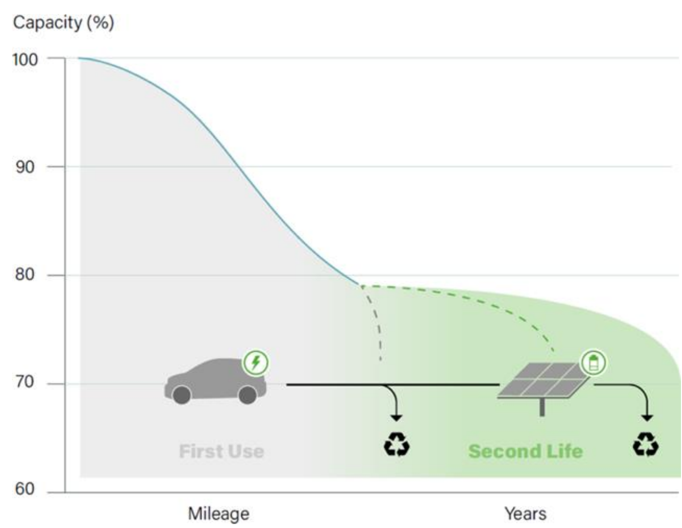

Figure 2. The residual value of EV batteries **[10]**

REPURPOSING PROCESS

Before a second life can be given to EoL EV batteries, they will need to find the right treatment facility for recycling or repurposing. Collection and transportation of used EV batteries to the right place for the right treatment after their first life is called ‘Reverse Logistics’. This process includes several activities, such as the analysis of historical battery pack data and the disassembly of packs into modules. **Figure 3 shows an exemplary procedure for the treatment of batteries after their first life**, adapted from our previous market intelligence report **[11]** and other literature **[12]**. The focus of this report mainly lies on 2nd life applications of EV batteries, otherwise called repurposing. This is a complex process which generally goes through the following four phases: **design, evaluation, re-assembly, and installation of the BMS**. Depending on the business model of the repurposer and the expected 2nd life application, processes can be performed on pack, module, or cell level.

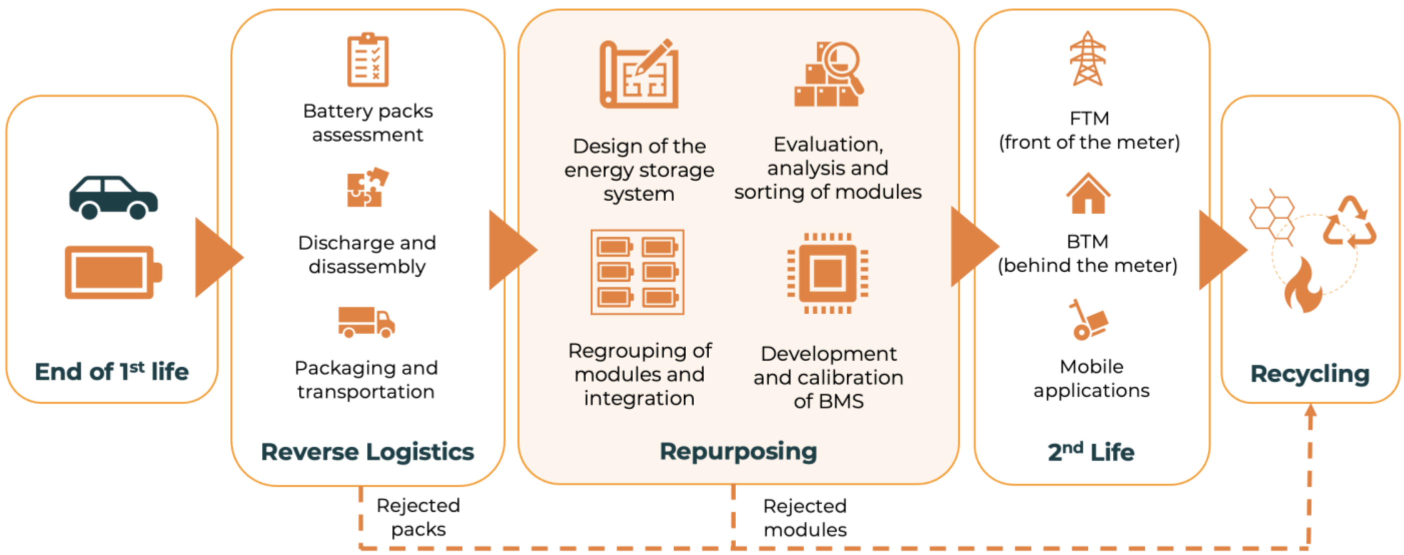

Figure 3. Repurposing process and 2nd life of batteries

DESIGN

The first considerations when designing repurposed battery systems are the **required dimensions, energy density and power of the end application**. For example, grid storage applications will require more energy density and power than a home battery. Here, it is an **advantage to ensure a consolidated flow** of incoming battery packs or modules. A stable and significant flow of battery modules enables a more standardised design, which in turn creates potential cost reductions, an important aspect for selling repurposed battery systems. Furthermore, a standardised flow will also help to use more 2nd life components such as cables, casings, and bolts in the design of repurposed battery systems.

MECHANICAL, ELECTROCHEMICAL AND SAFETY PERFORMANCE EVALUATION

Battery packs, modules and/or cells are monitored **during their lifetime** and their **data is logged in the BMS**. Voltage and current are typically measured at the cell level, whereas other measurements (such as temperature and gas) are done at a component or pack level. Still, **many repurposers must gather their own battery testing data** which is a resource-intensive process. Access to logged BMS information could provide repurposers with a wealth of useful information, but most OEMs do not provide this data [13].

As delineated in one of our previous reports [14] there are several ways to estimate a battery's State of Health, which are aimed at determining the battery's direct properties (e.g. State of Charge, internal resistance), ageing mechanisms, and the Remaining Useful Life (RUL). The **RUL is crucial** to determine the next application that the battery might fulfil in its second life.

RE-ASSEMBLY & BMS

Based on results of the evaluation phase, battery modules are grouped to have approximately the same SoH, optimising the battery's performance. This also allows using a passive balancing which is a less expensive form of managing battery usage compared to active balancing. Still, sorting used modules and subsequent battery management in repurposed batteries remains a challenge. Battery health differs greatly according to factors like the operational climate, driving style and charging behaviour during the first EV battery life. 2nd life cells also have a **higher probability of safety failures** (e.g., gas generation, lithium-plating, dendrite formation), which must be mitigated [12].

APPROACHES AND KEY PERFORMANCE INDICATORS IN REPURPOSING

There are 3 main approaches to repurposing, each having advantages and limitations. When the 2nd life energy storage system is built from entire **battery packs**, there is no need for dismantling and reconfiguration. The pack is used as it is, which reduces the cost but lowers the flexibility of design and does not allow to replace faulty internal components. On the other hand, building 2nd life battery systems from **cells** can help achieve higher reliability and a more tailored design. However, this is often costly due to the manual disassembly still required today and the need to replace the BMS. Using **modules** offers a good balance between these two approaches, that's why we can see a lot of research focusing on fast testing and pack-to-module dismantling methods.

The KPIs for repurposers can be divided into three groups. On the **technical** side, the most important parameters are SoH, energy usage, peak power and expected cycle life. The key **ecological** indicators are the CO2 footprint and raw material usage. Finally, the **economical** KPIs are, above all: profit margin and amortisation. All indicators depend on the selected business model, type of application, market dynamics (price for new batteries, raw materials availability), and new regulations. As part of the greenBattNutzung project our team analyses these parameters, looking for the best 2nd life battery use cases.

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CATEGORIES OF 2ND APPLICATIONS FOR BATTERIES

Repurposing of batteries means that they are given a different purpose, so the batteries change application from electric vehicles to another one. Looking at the market and technical developments, these applications can broadly be divided into three categories: **Front of the Meter** (FTM) stationary storage, **Behind the Meter** (BTM) stationary storage and **mobile energy storage**. Table 1 presents typical functions that the energy storage systems have [15], [16].

Table 1. Categories of 2nd life energy storage applications

Category	Function	Description	2nd life battery considerations
FTM (Front of the meter) 1 MWh – 1 GWh	Frequency control	Support in maintaining the 50 Hz frequency of the electricity grid by absorbing or providing additional power.	The FTM systems can have a large size, thus it is more economical to be built from battery packs and can utilise lower density battery chemistries. The utility-scale systems have to be additionally certified for safety.
	Power reserve	The battery storage can provide power immediately in response to an unexpected generation outage.	
	Wholesale market arbitrage	Utility-scale energy storage allows to trade electricity on spot market, selling & discharging energy when the demand is high, and purchasing & charging during off-peak hours.	
BTM (Behind the meter) 1 kWh – 1 MWh	Microgrids	Autonomous operation of the site in island mode, connecting local production with local consumption.	The size of BMT systems is closest to the EV battery packs thus there is a higher number of components that can be reused, e.g., the BMS. Sustainability is the key value proposition for the clients.
	Peak shaving	Limiting the maximum instantaneous power withdrawn from the grid which reduces the electricity bill.	
	Power quality	Optimizing the power factor of the site by reducing the reactive power flow, especially of industrial devices.	
MOBILE energy storage 1 - 10 kWh	Micromobility	Application in less demanding electric vehicles, e.g., ferries, 3-wheelers, scooters, forklifts.	Due to the space constraint it has to be built from modules or cells, preferably from higher density chemistries. These applications have a lower barrier to entry for start-ups.
	Mobile generators	Small mobile battery packs can provide electricity in remote locations, usually replacing fuel-based generators (e.g., developing countries, outdoor events).	

NEW BATTERY ESS MARKET

Like EV batteries, the stationary storage market has been dominated by Li-ion batteries in the last decade. About 95% of recently deployed and planned grid-scale ESS projects use Li-ion cells. This mainly relates to the drastically reduced price of Li-ion technology in the last decade **[17]**. Notably, the expected increase in renewable energy share will create a demand for long-term storage, for which cheaper, less energy-dense and long-lasting batteries are more cost-efficient.

For these reasons in the medium term, the lithium iron phosphate **(LFP)** chemistry is expected to overtake more energy dense lithium nickel manganese cobalt oxide **(NMC)** batteries (figure 4) **[18]**. In 2022 LFP cells were 20% cheaper than NMC **[1]**. In the long term the demand for alternatives to lithium-based batteries will increase due to environmental concerns **[19]**.

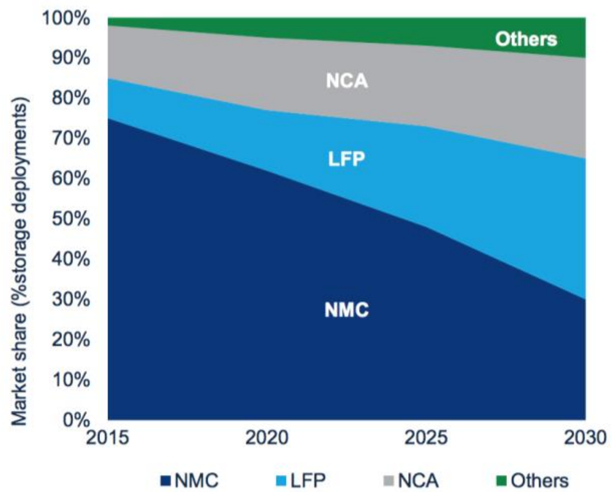

Figure 4. BESS chemistries market share **[18]**

2ND LIFE BATTERY ESS MARKET

The market of 2nd life batteries is currently illiquid, which means that there are still few transactions, with the supply not always finding the demand from repurposers, and vice versa. According to the data reported by Circular Energy Storage in 2021, the prices of traded retired EV batteries ranged between \$59/kWh to \$1183/kWh with the **average at \$220/kWh** **[20]**. With this average price, repurposed batteries can be more competitive than new ones, especially in smaller energy systems.

To understand and forecast the composition of retiring EV batteries, the historical chemistries should be tracked. This is best visible at the car dismantlers which report that they currently start receiving and handling batteries from the first EVs introduced in Europe. Among them, early models of Nissan Leaf and Renault Zoe contain **LMO** cells. As presented on figure 5, this chemistry was later replaced with **NMC** and **NCA**, which will be the next most popular battery types available for repurposing.

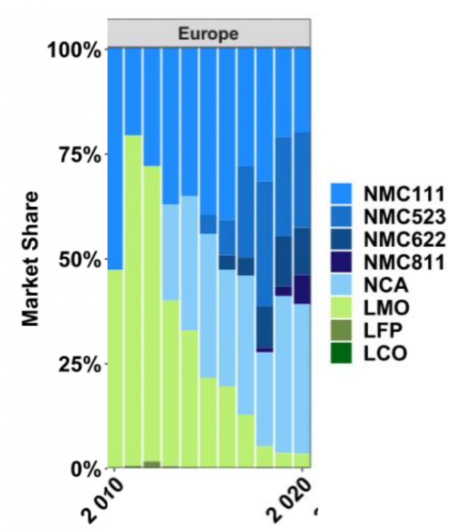

Figure 5. BEV chemistries market share **[21]**

2ND LIFE BATTERY STAKEHOLDERS AND BUSINESS MODELS

BATTERY SUPPLIERS

Only a handful of 2nd life ESS projects actually come from naturally degraded end-of-life batteries. Many projects use modules from the development process instead. Regardless of the origin, there are three main approaches currently observed in the market:

- **Recycling-first**: These automakers are the followers of the regulation, fulfilling the extended producer responsibility (recycling) but not experimenting with the repurposing models.
- **Joint ventures & partnerships**: ESS is often a new branch of business for the automakers and to compensate the lacking know-how and/or industrial capacity they enter partnerships with repurposers, sometimes
- **Vertical integration**: some OEMs try to keep as much value from the batteries as possible, usually founding subsidiaries focused on energy services or aftermarket (e.g., Mercedes-Benz Energy, Volvo Energy).

Very often the OEMs use a mix of these approaches. Although no automaker would officially admit so, many of them believe the repurposing will never make a business case. Still, the market is not liquid, with many pilots and various forms of partnerships being explored **[22]**. Another important share of the 2nd life batteries supply come from dismantlers and insurance companies, which can handle the batteries from damaged cars independently.

REVERSE LOGISTICS PARTNERS

There are various stakeholders which are often not mentioned in the press releases of new deployments but play an important role in the 2nd life business as explained in the Market Intelligence Report on Reverse Logistics **[11]**. In some cases, their activities are performed by the EV OEMs or the repurposers:

- **Logistics and transportation**, e.g., Van Peperzeel, BatteriRetur;
- **Battery testing**, e.g., TÜV SÜD, SGS;
- **Dismantling** (pack to modules), e.g., TES-AMM, Sortbat;
- **Consolidation of supply**, e.g., Cling Systems.

2nd LIFE SYSTEM INTEGRATORS (REPURPOSERS)

The integrators of 2nd life energy storage solutions (repurposers) are the new players in the market. Interestingly, they rarely originate from traditional energy storage business – very often they begin as start-up projects getting their first experiences in design, integration, and deployment of ESS during first pilots. The main challenge for the repurposers is usually to secure a supply of batteries coming from EVs, therefore their key partners are EV OEMs and dismantlers.

END USERS

The end users of 2nd life energy storage vary depending on the application explained in the previous chapter. Most customers investing in repurposed batteries already have experience in 1st life battery energy storage systems. There are two unique selling points of 2nd life projects: lower environmental impact and lower cost compared to the solutions with new batteries. The most common customer types are:

- **Distribution system operators, energy utilities and aggregators** (e.g., RWE, Enel, Engie) – these companies are interested in the ESS for grid services such as backup power supply, and frequency response.
- **Industrial & commercial sector** (e.g., Umicore, Essity, TGN) – these

customers typically have renewable energy systems installed at their premises, such as solar PV, wind turbines and hydropower, and charging stations for EVs and e-bikes.
- **Individual house owners and energy communities** – these users usually have solar PV installed on their roofs and look for an affordable ESS to increase self-consumption of renewable electricity (= lowering their energy bills). In less common off-grid households the ESS is an indispensable component of the microgrid which can replace a diesel generator.

MAXIMISING VALUE FROM EV BATTERIES

Our current value proposition for 2nd-life power systems is based primarily on **sustainability** and them being modular, multi-purpose, portable, and connected. We not only reduce the need to produce new battery cells but also apply eco-design principles to our systems, making them **easy to repair and dismantle**. Our mobile energy storage systems have been designed to cover multiple use-cases, such as replacing fuel-based generators used in off-grid applications, thus reducing CO_2 emissions and local pollution.

One of our biggest challenges was to **certify a second-life battery product** – having this done it is easier to prove the reliability of our solutions to the clients. Now our focus is on the reduction of repurposing costs in order to strengthen our economic advantage against ESS with new battery modules. We are also considering new business models, such as battery-as-a-service.

We believe the future of the 2nd life battery industry lies in a thorough understanding of the **battery degradation**. Knowing the battery usage profile from the 1st life would allow us to select the optimal 2nd life application. This can be enabled by the implementation of the **battery passport** which would give the repurposers access to more data on the EV batteries.

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Depending on the application, the capacity of batteries can be expressed in various units. **1 Ah** (amper hour) is a charge transferred by a steady current of one ampere flowing for one hour at a given voltage which is commonly known, e.g., smartphone batteries (3.7V) or car starting batteries (12V). **1 Wh** (watt hour) is a unit more commonly used in expressing the capacity of EV batteries or the consumed energy by households. It equals to the work performed in one hour by an appliance running with the power of 1 W. **1 W** (watt) is a unit of power which is a multiplication of current and voltage (1 A x 1 V). This is the most common unit when discussing the grid-scale energy storage systems, where the peak power of the system is more important than its capacity. Table 2 presents a list of selected previous deployments of **2nd life projects**, with the names of involved stakeholders.

*Table 2. Second-life battery use cases and stakeholders involved**

Application	Use case description	Location	Battery provider	ESS integrator	End User
Peak shaving, grid stability services	In September 2022 a 25 MW battery storage facility was commissioned by the JT Energy System joint venture. The system consists of 10,000 modules, largely from used Jungheinrich forklift batteries. → **READ MORE**	Freiberg, Germany	JUNGHEINRICH	JT Energy Systems TRICERA energy	JT Energy Systems
Back-up power supply connected to the local distribution grid	A 4 MW energy storage system from Nissan Leaf batteries (48 used and 30 new packs) was deployed in 2022 and helps secure the continuity of energy supply to 90,000 residents of Melilla, a city in Spain which is isolated from the national grid. → **READ MORE**	Melilla, Spain	NISSAN	LOCCIONI	enel x
PV-powered charging stations for EVs and e-bikes	In April 2021 a partnership led by Battery Loop (subsidiary of Stena Recycling) launched an ESS at the business centre of a health company Essity. The system is based on five Volvo XC40 Recharge batteries that power 78 charging points for BEVs and PHEVs, and 24 for e-bikes. → **READ MORE**	Mölndal, Sweden	VOLVO	BATTERYLOOP	essity
Frequency response services	In November 2021 RWE deployed an ESS consisting of batteries from 60 Audi e-tron development cars. The system will be able to provide temporary storage for about 4.5 MW hours of electricity at the site of the RWE pumped-storage power plant at the Hengsteysee reservoir. → **READ MORE**	Herdecke, Germany	Audi	RWE	RWE
Small EVs, mobile storage	Berlin-based start-up betteries AMPS gives 2nd life to modules from Renault EVs by providing a swappable 48V mobile storage solution. As part of SOLUTIONSplus project, the batteries were used to power small EVs in Vietnam, Nepal and Phillipines. → **READ MORE**	Berlin, Germany	Renault Group	betteries	solutions plus
Reactive power and frequency response services	The British company Connected Energy has completed multiple 2nd life ESS projects. One of them, with a power of 1,2 MW, was deployed at Umicore's industrial plant and provides grid services to ENGIE. → **READ MORE**	Olen, Belgium	Renault Group	CONNECTED ENERGY	umicore ENGIE
Increased self-consumption	As the first C&I system, in November 2021 Evyon delivered a 216-kWh energy storage with used Mercedes-Benz batteries for TGN-Energy – an energy management company. Since then, Evyon has signed several agreements with renewable energy operators. → **READ MORE**	Oslo, Norway	Mercedes-Benz Energy	Evyon	TGN

* This list of use cases is non-exhaustive, and COBRA does not endorse any of the presented companies

CHALLENGES AND SOLUTIONS FOR BATTERY REPURPOSING

To further mainstream battery repurposing, there are still many challenges to be addressed. Here we try to structure the main challenges and their potential solutions:

TECHNICAL

- Current battery pack and module designs are **quite complex and time-consuming to be dismantled**, as they were designed with a focus on maximising density. In the future, a more **flexible design for the dismantling** of various module/pack configurations would make this dismantling process much easier and more efficient.
- Current **BMS and sensors** deployed in commercial batteries have to be **reconfigured** when repurposed while also several sensors will be replaced or added. With current designs but also with current BMS, this is again a very complex and time-consuming process. In the future, BMS and sensors should be developed with second-life flexibility in mind.
- The **cells of EoL batteries are usually not well balanced**, unlike new harmonised cells. This gives an extra complexity when trying to repurpose them and often leads to inferior performance of second-life batteries compared to new ones. An **advanced BMS with active cell balancing** could counter this challenge but this is currently still complex and cost-intensive to develop. Also remanufacturing at the cell level could be a solution to identify and remove weak or damaged cells [23].
- The **characterisation of SoX and RUL is costly, time-consuming, and not harmonised**. Need for further development and research on the technical side to improve these characterisations, but also to harmonise these approaches. At the same time, access to BMS and the data of the battery passport in the future could make this characterisation much easier.

ECONOMICAL

- Currently, the costly and often inefficient and not streamlined repurposing activities do not offer (many) feasible business cases. There is a **need for new business models** (e.g., looking at ownership) that make the economic equation work and make repurposing economically more interesting.
- Linked to the bullet above, the **economic competitiveness of second-life batteries** compared with new batteries is currently lacking [24]. To make this work in the future, streamlined and cost-efficient processes in combination with favourable regulation can boost this competitiveness.
- The current **supply of EoL batteries is not stable** and the volumes are still low. However, within 5-10 years, these volumes are expected to increase exponentially.
- The reliability, predictability and safety of 2nd life products are lower and therefore, it is unclear what type of **warranty** can be offered on those products. Harmonised SoX and RUL approaches should increase reliability and will make it easier to offer a certain warranty. The battery passport will definitely play an important role to make data available in a transparent way.

POLICY & REGULATORY

- The current battery regulation does **not include requirements for 2nd life and the rights or obligations of the repurposing operators**. Therefore, no standards exist on RUL, SoH and safety assessment of the battery. However, the upcoming New Battery Regulation will include measures on this topic (see our MIR on the new battery regulation [24]).

- **End of 1st life batteries is considered waste in current regulation**. Therefore, repurposing is considered a waste treatment operation. On the other hand, the repurposed batteries are considered equally as new batteries so they have to comply with the same requirements as new batteries placed on the market, meaning that they would also need to contain mandatory minimum levels of recycled content by 2027, as mentioned in the new battery regulation.

CHALLENGES FOR BMS DESIGN IN 2ND LIFE SOLUTIONS

When a battery system is repurposed to its 2nd application, the **BMS often has to be reconfigured**. Some changes can be done by a recalibration, e.g., when adding a new sensor or slightly changing the array. More challenges occur if you need to introduce a new communication channel or functionality – this usually requires a major adaptation of the software.

Another important aspect of 2nd life battery operation is balancing of cells. Unlike new batteries where the regular passive balancing is sufficient, used packs can contain cells of different capacities and usage profiles, which requires more complex and **cost intense active balancing**. This could be avoided by accurately selecting 2nd life cells with a similar state of health.

Current developments in connectivity can solve some of these challenges. For example, **wireless access to the BMS** would allow stakeholders to collect battery usage data in real life. This data, combined with advanced degradation models could be utilized to create so-called **digital twins**, helping to estimate the SoH more precisely and optimise batteries for 2nd life applications.

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TECHNICAL DEVELOPMENTS

FAST CAPACITY AND INTERNAL RESISTANCE ESTIMATION METHOD

Researchers from the Public University of Navarre (Spain) presented a new approach to the characterisation of EV batteries, allowing to estimate internal parameters such as capacity and DC resistance. The suggested 2 stages procedure can be applied to cells, modules and packs and, according to the researchers, **shortens the time needed for battery characterisation from one day to 2 minutes**, while reducing the energy needed for cycling from 1.4 kWh to 1 Wh. The method was tested on 506 cells, 203 modules and 3 battery packs from Nissan Leaf vehicles, with mean absolute percentage errors (MAPE) below 2.5% at cell and module level in capacity prediction and lower than 2.4% in resistance estimation.

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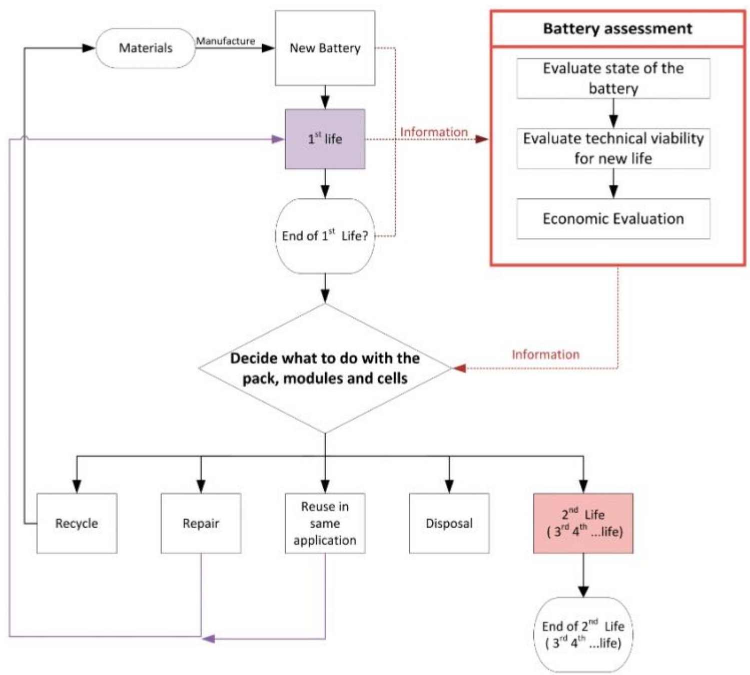
PROCEDURE FOR ASSESSING THE SUITABILITY OF BATTERY SECOND LIFE

One of the bottlenecks in battery repurposing is the lack of a standardised assessment procedure. Researchers from NREL (U.S.), UPC and IREC (Spain) are aiming to address this challenge by proposing a three stages approach, including an evaluation of the state of the battery, an evaluation of the technical viability and an economic evaluation. **Five technical configurations** of 2nd life ESS are presented, with respective trade-offs and implementation strategies. The next step for the researchers will be to consolidate this procedure and apply it to the assessment of second life batteries in relevant EU projects, such as Albatross, COBRA, MARBEL, and HELIOS.



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BENEFIT ASSESSMENT OF 2ND LIFE BATTERIES IN BTM APPLICATIONS

While 2nd life batteries have been used in all types of energy storage applications, some of them offer a better fit than others. Researchers from the University of Michigan and the University of Singapore looked into this issue and found out that the highest cost benefit can be achieved when the retired EV battery packs are used for **behind-the-meter applications** such as distributed power systems (e.g., residential microgrids), mainly because the refurbishment costs can be minimised.

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MARKET DEVELOPMENTS

MERCEDES-BENZ ENERGY OPENS UP TO 2ND LIFE

Earlier this year one of the largest automakers entered multiple partnerships with 2nd life storage providers around the globe: Evyon (NO), Battery Loop (SE), and Moment Energy (CA). Mercedes-Benz Energy (MBE) in the next years will supply almost 100 MWh of their retired batteries for energy storage projects such as the **3 MW/2MWh ESS** installed at a site in Sweden which will help manage the electricity network and ease grid congestion. The deals can signal a new trend in the repurposing industry: the OEMs may start expanding their repurposing partner's network geographically to optimise the battery handling in local circular loops.

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VOLVO INVESTS IN THE UK-BASED 2nd LIFE BUSINESS

Volvo Energy, a subsidiary of AB Volvo is taking the next step in partnerships with repurposers. The company is investing approx. **SEK 50M for 10% shares** in the UK-based second-life battery energy storage specialist Connected Energy. Volvo Energy is joining other four investors in this round, including Caterpillar Venture Capital Inc., the Hinduja Group, Mercuria and OurCrowd. While this move makes Connected Energy the biggest player in the repurposing industry, close ties with one OEM may limit the capacity to collaborate with other automakers.

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MAN WILL TEST THEIR TRUCK BATTERY PACKS IN STATIONARY STORAGE

Not only the passenger car OEMs are exploring the 2nd life applications. MAN, a leading German manufacturer of trucks and buses, announced a collaboration with the University of Kassel and several undisclosed partners to test whether used truck batteries are suitable for stationary storage systems. For this purpose, around **120 truck battery packs** with an energy content of 18.6 kWh per pack are being handed over to a storage system manufacturer. The battery packs originate from the first field trial with electric trucks from MAN, which began in Austria in 2018 and lasted three years. In addition, it is considered to run a pilot project for a 2nd life storage system based on MAN batteries from the first fully electric Lion's City E series city bus.

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POLICY DEVELOPMENTS

BAN ON REUSE OF BATTERIES IN NEW YORK CITY?

A sharp increase in battery fires from electric micromobility has pushed the city legislators to propose a bill that would hit the slowly growing repurposing industry in the U.S. The bill would **prohibit the sale of second-use lithium-ion batteries** that have been assembled or reconditioned using cells removed from used batteries. A person who violated the proposed local law would be subject to a civil penalty ranging from $200 for a first violation to $1,000 for each subsequent violation within two years. It would also prohibit the assembly of such batteries. The proposal outraged supporters of right-to-repair and circular economy principles.

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THE DEVIL'S IN THE DETAIL – DELEGATED ACTS IN BATTERY REGULATION

EU member states voice their concerns regarding the use of delegated acts in the legislation. Euractiv explains the controversy about this approach: member states and the European Parliament can only vote to reject the proposal tabled by the EC but cannot amend it in the same way they do with ordinary legislation. If they fail to reach a majority against, the rules are adopted automatically after a two-month period, which can be extended once. In its current form, the Battery Regulation foresees as many as **32 delegated and implementing acts** to set technical standards related to battery production and recycling. Some experts argue though that this is the only way to ensure the main regulation can be agreed upon by policymakers on time

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U.S. GOVERNMENT FUNDS 10 RECYCLING & REUSE PROJECTS

As a part of the Bipartisan Infrastructure Law, the U.S. Department of Energy (DOE), announced nearly **$74 million in funding for 10 projects** to advance technologies and processes for electric vehicle (EV) battery recycling and reuse. One project led by RePurpose Energy aims to demonstrate a technology that would allow estimating the SoH of used batteries in less than 2 minutes. Among funded projects there are also pilots of 2^{nd} life ESS, e.g., a consortium led by Smartville will deploy a 3 MWh system, operated with a privately-owned Independent Power Producer (IPP).

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The COBRA project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement 875568.

REFERENCES

[1] "Lithium-ion Battery Pack Prices Rise for First Time to an Average of $151/kWh | BloombergNEF." https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/ (accessed Dec. 07, 2022).

[2] H. Rallo, G. Benveniste, I. Gestoso, and B. Amante, "Economic analysis of the disassembling activities to the reuse of electric vehicles Li-ion batteries," *Resour Conserv Recycl*, vol. 159, p. 104785, Aug. 2020, doi: 10.1016/J.RESCONREC.2020.104785.

[3] "— Circular Energy Storage." https://circularenergystorage.com/articles/2021/1/15/prices-for-used-batteries-are-higher-than-for-new-batteries-this-is-why (accessed Dec. 07, 2022).

[4] "A Second Life For EV Batteries - YouTube." https://www.youtube.com/watch?v=yrkOWipbpQA (accessed May 04, 2022).

[5] "Solutions." https://www.evyon.com/solutions/ (accessed Dec. 02, 2022).

[6] "Octave | Second-life Battery Energy Storage Systems." https://www.octave.energy/ (accessed Dec. 02, 2022).

[7] "Is there life after death for Europe's lithium-ion batteries? - Bax & Company." https://baxcompany.com/insights/is-there-life-after-death-for-europes-lithium-ion-batteries/ (accessed Jul. 27, 2022).

[8] "Europe's grid-scale energy storage capacity will expand 20-fold by 2031 | Wood Mackenzie." https://www.woodmac.com/news/opinion/europes-grid-scale-energy-storage-capacity-will-expand-20-fold-by-2031/ (accessed Dec. 02, 2022).

[9] "New data on the lifecycle of lithium-ion batteries | LinkedIn." https://www.linkedin.com/pulse/new-data-lifecycle-lithium-ion-batteries-hans-eric-melin/ (accessed Dec. 02, 2022).

[10] J. Falk, · Antonio Nedjalkov, M. Angelmahr, and W. Schade, "Applying Lithium-Ion Second Life Batteries for Off-Grid Solar Powered System—A Socio-Economic Case Study for Rural Development," *Zeitschrift für Energiewirtschaft 2020 44:1*, vol. 44, no. 1, pp. 47–60, Mar. 2020, doi: 10.1007/S12398-020-00273-X.

[11] L. Marthaler, P. Grudzien, M. Buysse, M. Ierides, and A. Mccready, "MARKET INTELLIGENCE REPORT REVERSE LOGISTICS," 2022.

[12] J. Zhu *et al.*, "End-of-life or second-life options for retired electric vehicle batteries," *Cell Rep Phys Sci*, vol. 2, no. 8, p. 100537, Aug. 2021, doi: 10.1016/J.XCRP.2021.100537.

[13] W. Meijeer and G. Rinaldi, "Energy Storage - Trends and challenges in a rocketing market: A market analysis report by the STEPS project," 2021.

[14] H. B. Management Curated Lukas Marthaler Piotr Grudzien Maarten Buysse Marcos Ierides and A. Mccready, "MARKET INTELLIGENCE REPORT," 2022, Accessed: Dec. 05, 2022. [Online]. Available: www.baxcompany.com

[15] M. Dubarry *et al.*, "Procedure for Assessing the Suitability of Battery Second Life Applications after EV First Life," 2022, doi: 10.3390/batteries8090122.

[16] T. Bowen and C. Gokhale-Welch, "Behind-The-Meter Battery Energy Storage: Frequently Asked Questions What Is Behind-The-Meter Battery Energy Storage?", Accessed: Dec. 02, 2022. [Online]. Available: www.greeningthegrid.org

[17] "Outlook to 2030: the rise of energy storage | Northvolt." https://northvolt.com/articles/energy-storage-outlook2030/ (accessed Dec. 02, 2022).

[18] "WoodMac: A New Battery Chemistry Will Lead the Stationary Energy Storage Market by 2030 | Greentech Media." https://www.greentechmedia.com/articles/read/lfp-will-overtake-nmc-for-stationary-storage (accessed Dec. 02, 2022).

[19] A. Holland, S. T. Analyst, and X. He, "Advanced Li-ion , Next Generation and Beyond Lithium Batteries 2022-2032 : Technologies , Players , Trends , Markets Copyright , Use and Disclaimer," 2022, Accessed: Dec. 02, 2022. [Online]. Available: https://www.idtechex.com/en/research-report/advanced-li-ion-and-beyond-lithium-batteries-2022-2032-technologies-players-trends-markets/852

[20] "— Circular Energy Storage." https://circularenergystorage.com/articles/2021/1/15/prices-for-used-batteries-are-higher-than-for-new-batteries-this-is-why (accessed Dec. 02, 2022).

[21] J. Dunn, M. Slattery, A. Kendall, H. Ambrose, and S. Shen, "Circularity of Lithium-Ion Battery Materials in Electric Vehicles," *Environ Sci Technol*, vol. 55, no. 8, pp. 5189–5198, Apr. 2021, doi: 10.1021/ACS.EST.0C07030/SUPPL_FILE/ES0C07030_SI_002.XLSX.

[22] "Nissan, Renault, Mercedes lead second life EV battery supply." https://www.energy-storage.news/nissan-renault-and-mercedes-lead-second-life-bess-battery-supply-but-market-still-highly-illiquid/ (accessed Dec. 02, 2022).

[23] "Second-life batteries | Circusol." https://www.circusol.eu/en/topics/second-life-batteries (accessed Dec. 02, 2022).

[24] L. MARTHALER, P. GRUDZIEN, M. BUYSSE, M. IERIDES, and A. MCCREADY, "MARKET INTELLIGENCE REPORT: New Battery Regulation," Jul. 2022.

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