TREASoURcE

# D4.3 Macro-economic assessment of a second life battery market

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# Acronyms and abbreviations

| Acronym | Full name |
|---|---|
| **BESS** | Battery energy storage system |
| **BOS** | Balance of system |
| **EOL** | End of life |
| **EV** | Electric vehicles |
| **GDP** | Gross domestic product |
| **GHG** | Greenhouse gas emissions |
| **IFE** | Institute for Energy Technology |
| **IO** | Input-output |
| **MFA** | Material flow analysis |
| **NVE** | Norwegian Water Resources and Energy Directorate |
| **SUT** | Supply-and-use table |

## Executive Summary

This report is part of WP4 “KVC-DEMOs: Batteries reuse & recycling value chain”, which evaluates possibilities and the potential for use of second-life electrical vehicle (EV) batteries as storage systems. More specifically, it summarizes work performed under task 4.3 “Macro-economic assessment of value chains for battery second life”. We examine how second-life batteries can support the demand for BESS and assess impacts of a growing reuse industry on value added, employment, and greenhouse gas emissions across value chains in Norway. This concerns effects generated both directly, through battery reuse, and indirectly, in other industries.

We employ a scenario-based macro-economic, input-output modelling framework, which focuses on structural changes in terms of economic, social, and environmental dimensions in all sectors of the economy. We use a dynamic simulation model developed by SINTEF and calibrated to Statistics Norway’s supply-and-use tables that present monetary flows among economic sectors in detail. To capture environmental and social outcomes, the tables were extended with satellite accounts for emissions and employment data. We carry out “what-if” scenario analyses comparing baseline and counterfactual scenarios over a projection period from 2023 to 2040. For this, we first describe pathways for future availability of used EV batteries and demand for battery-electrical storage in buildings. Then, we develop scenarios for repurposing the used EV batteries into second-life applications, with different assumptions on repurposing and acceptance rates.

We find that second-life EV battery use generates measurable, though modest, economic and employment contributions. The most notable effects arise in battery repurposing, which emerges as a distinct activity alongside existing collection and recycling. While the aggregate macro-economic impact is small relative to the size of the Norwegian economy, these activities create incremental value and new jobs, particularly for workers with vocational and technical skills. Environmental impacts are similarly limited. Additional processing of second-life batteries results in small increases in GHG emissions due to increased economic activities in other industries, but these are negligible in the context of Norway’s total emissions. In this sense, repurposing contributes to circular economy objectives without adding significant environmental burdens.

The findings imply that: (1) Second-life industries could support Norway’s circular economy and resource efficiency goals by extending the useful lifetime of EV batteries and reducing reliance on imported storage technologies. However, this depends also on acceptance among households and businesses and on the development of effective collection, screening, and repurposing infrastructures. (2) Vocational education and training pathways should be strengthened to ensure availability of the skills required. (3) As recycling

demand is postponed rather than reduced, planning for sufficient long-term recycling capacity remains essential to avoid bottlenecks in the future.

Our results suggest that second-life EV batteries can contribute tangibly to Norway’s economy, labour market, and circular-economy objectives. They complement broader energy-transition strategies by adding resilience and supporting development of specialized industries with clear economic and social value. At the same time, the findings should be interpreted with caution. Key assumptions, such as cost structures, repurposing rates, operational lifetimes of second-life batteries, and levels of household or market acceptance, remain uncertain and could shift the scale of outcomes. Cross-border effects should also be explored more, as Norway’s second-life industry will ultimately be embedded in European and global value chains.

# 1. Introduction

Battery technologies, especially lithium-ion batteries, are a central piece of the strategies for a European transition towards a low-carbon economy. The growth of passenger electric vehicles (EVs) has been substantial in the last decade, from nearly 10 000 EVs on the road in 2010, to 210 000 in 2015, to around 8.7 million by the end of 2024, after a significant increase in EV sales from 2020 on (IEA, 2025). This rapid growth is leading to a rise in the volume of batteries in use and creating an urgent need to manage growing amounts of EV batteries reaching the waste streams. Although much of the discussion on managing retired batteries is focused on recycling (Zhou et al., 2024), extending the lifetime of EV batteries through reuse is a key strategy to reduce the demand for new batteries and the raw materials needed to produce them.

Second-life use of batteries refers to the repurposing of EV batteries after they are removed from use, either because they can no longer meet the performance requirements for mobility applications or because the vehicle is retired due to fault in other components. Once the batteries reach the end of life (EOL) from their first use in EVs, their residual capacity usually varies between 70% and 80% of initial capacity and can still be used in other applications. Instead of being recycled immediately, these batteries are reused in less demanding applications such as stationary battery energy storage systems (BESS), backup power systems, peak shaving, or grid balancing (Bobba et al., 2018). This approach extends the battery's useful lifetime, while reducing the demand for first-life (new) batteries for BESS applications and the impacts associated with raw material production and manufacturing of new batteries. Extending the lifetime of EV batteries will also delay the arrival of these batteries at recycling industries, allowing the development of large-scale reverse logistics for EOL batteries and the growth of recycling capacity in Europe, increasing the chances that batteries are recycled with optimal material recovery in the region.

In this report, we focus on the effects of a second-life market in Norway. We examine how second-life batteries can supply the demand for BESS under two scenarios for battery demand and assess the effects of a growing reuse industry on value added, employment, and greenhouse gas (GHG) emissions across value chains in Norway. The findings of our analysis provide insights that can guide policy, industry development, and investment in the emerging circular battery economy. Although we focus on Norway, the methodology developed here can be adapted to the context of other countries.

This report is structured as follows. Section 2 presents the methods, describing the macro-economic modelling framework, the battery demand pathways used, and the assumptions for value chain modelling. Section 3 provides the results of the modelling and a discussion of these results in the context of the Norwegian economy, as well as an overview of cross-border impacts not captured in the model and other methodological limitations. Finally, section 4 presents our conclusions.

# 2. Methods

## 2.1. Modelling framework: SUMS-Norway

The analysis in this report employs a scenario-based macro-economic, input-output (IO) modelling framework to assess the economy-wide sustainability impacts of deploying second-life EV batteries specifically for stationary BESS in Norway. Rather than focusing on the behavior of individual firms, the analysis evaluates structural changes in terms of economic, social, and environmental dimensions in all sectors of the economy. Specifically, it examines changes in industry-level value added (which contributes to the gross domestic product, GDP), greenhouse gas (GHG) emissions, and employment disaggregated by education and skill level. These indicators were selected to capture the direct, indirect, and induced effects on the Norwegian economy of second-life battery deployment for BESS.

The analysis is conducted using SUMS-Norway[1], a dynamic, demand-driven IO simulation model developed by SINTEF. The model is calibrated to Statistics Norway's 2022 supply-and-use tables (SUT) (SSB, 2025a), which provide a detailed representation of monetary flows among economic sectors in basic prices. To capture environmental and social outcomes, the SUT framework is extended with satellite accounts for emissions (SSB, 2025c) and employment data (SSB, 2025b, 2025d) covering all sectors.

Projections are carried out over the period 2023-2040, that incorporate both exogenous drivers, such as population growth, and endogenous adjustments, including changes in inter-industry demand, import shares, and components of final demand such as household and government consumption, as well as investments. These relationships are modelled using standard input-output accounting identities and econometric methods, following a Leontief demand structure and drawing on macro-economic theory (Wiebe et al., 2023).

The modelling process is structured as a "what-if" scenario analysis, based on the comparison of a baseline and a counterfactual scenario. The baseline projection reflects the expected evolution of the Norwegian economy under current conditions (business-as-usual), serving as a reference trajectory for all key indicators. The alternative scenario is constructed by introducing shocks to selected model parameters, thereby representing the effects of potential policy interventions or technological developments, such as the deployment of second-life batteries for BESS. The model simulates economic, environmental, and social outcomes under both scenarios. Comparison of the resulting indicator trajectories provides a systematic assessment of the impacts and trade-offs associated with implementing these scenarios. The

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[1] A full description of the SUMS-Norway model is available in Simas & Arega (2025), with more details on the structure, equations and underlying assumptions.

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model traces these changes among all sectors of the economy, which allows an assessment of the sustainability implications associated with second-life battery deployment in Norway.

## 2.2. Socio-technical pathways and scenarios

Our scenario development consists of two steps. First, we describe two pathways for the future availability of used EV batteries and the demand for BESS in buildings, which provides the supply and demand. Second, based on these estimates, we develop scenarios for repurposing EOL EV batteries into second life applications. The following subsections describe these steps in detail.

### 2.2.1. Pathways for used EV battery availability for second life and demand for battery systems in buildings

To estimate the availability of used EV batteries and the demand for BESS in buildings, we draw on historical data on EVs on the road and future projections of EV and BESS demand. Data on battery demand and EOL EV batteries until 2040 are taken from Simas et al. (2025), which provides estimates of battery demand by various transport modes and buildings in Norway until 2050.[2]

Battery demand is derived from the IFE-TIMES-Norway model, a long-term optimization model of the Norwegian energy system, developed jointly by the Norwegian Water Resources and Energy Directorate (NVE) and the Institute for Energy Technology (IFE) in 2017 (Haaskjold et al., 2024). TIMES is a bottom-up framework that provides techno-economic analysis of various resources, energy carriers, energy demand and conversion technologies, and minimizes the total discounted cost of the modelled energy system to meet the demand for energy services over the analysis period. IFE-TIMES-Norway is a technology-based model of the Norwegian energy system, divided into five electricity spot pricing regions within Norway. Battery-electric storage in IFE-TIMES-Norway is represented across all sectors, including storage integrated in various transport modes, residential and commercial buildings, light industry, agriculture, and utility-scale grid applications.

To capture uncertainties in future demand, we analysed two socio-technical pathways, SOC and TECH, that vary in technological progress, economic conditions, and societal shifts (Aamodt et al., 2023):

- Social Change Pathway (SOC): Assumes significant socio-institutional and architectural changes, but less technological progress compared to TECH. SOC relies heavily on social innovation, smart solutions and circular economy, with a lower energy demand. Transport needs decline due to increased digitalization, optimization, and a shift towards public transport, car sharing, biking and walking, leading to fewer privately-owned vehicles.

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[2] Although D1.2 presents a material flow analysis (MFA) for EV batteries in Norway until 2050, the model used there does not include the demand for BESS in buildings. Therefore, we chose to use the MFA for batteries in Norway from Simas et al. (2025) instead to provide a common framework for the demand and EOL availability of EV and BESS batteries.

- Technological Change Pathway (TECH): Assumes high advancements in technology, but lower commitment from society compared to SOC. The national economy continues to grow, driven by new industries and a rise in transportation activity. Technological advances enable broader adoption of new clean technologies such as hydrogen and ammonia, a significant reduction in battery costs, and higher investment rates in end-use technologies, including passenger EVs and BESS in buildings, than in the SOC scenario.

The IFE-TIMES-Norway model provides information on the total demand for batteries by sectors and regions from 2018 to 2050, reported in 5-years intervals between 2020 and 2050. Batteries are explicitly modelled for transport (passenger vehicles, vans, trucks, maritime transport) and for buildings (residential, commercial, and industry). Based on this total demand, a dynamic material flow analysis (MFA) model was used to assess the flows of batteries from production to end of life, including battery replacement, and scenarios of second-life application in buildings. The MFA provides estimates of annual battery demand by region and use, as well as the annual volumes of batteries reaching EOL and being sent to treatment (recycling or reuse).

The battery volumes used in this study are the annual amounts of EOL batteries from passenger EVs and the annual demand for BESS in buildings, as shown in Figure 1. EOL battery volumes available by 2040 do not change between scenarios, because the model assumes a uniform average lifetime of 17 years for EVs and no battery replacement during EV lifetime, consistent with IFE-TIMES-Norway. This means that batteries available for repurposing in 2040 would have entered the market in 2023. This can lead to an underestimation of EOL batteries available in the earlier years of the time series and an overestimation in the later years. In 2025, retired batteries would amount to 118 MWh, equivalent to nearly 2 000 medium-sized passenger EVs. The number of EVs sold in Norway increased considerably from 2013 (Thorne et al., 2021), which corresponds to a large growth in EOL EV batteries from 2030 on. By 2040, EOL EV batteries surpass 3 000 MWh, equivalent to over 52 000 medium-sized passenger EVs.

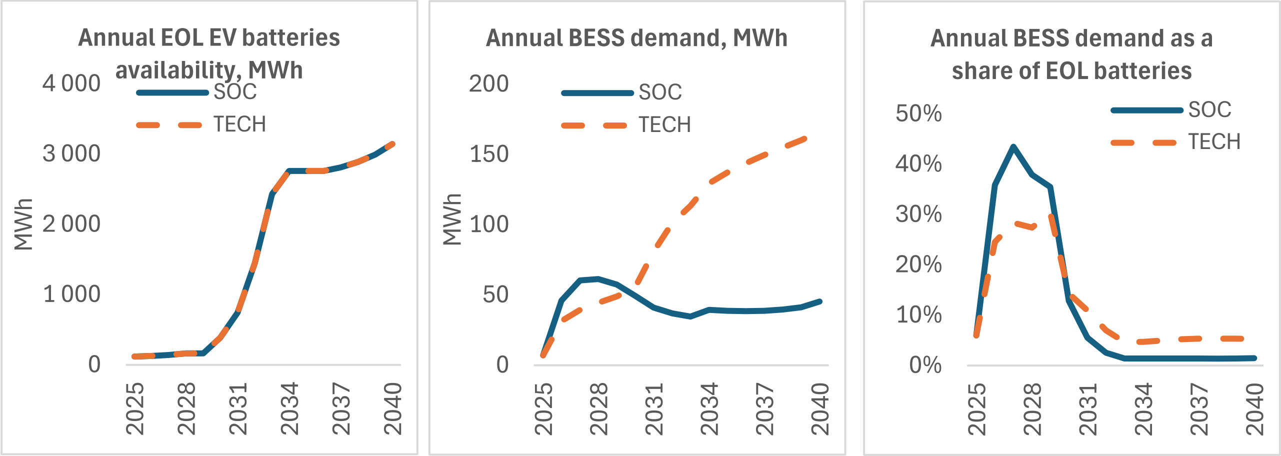

*Figure 1. EOL passenger EV batteries outflow (left) and demand for battery energy storage systems in buildings (middle) between 2025 and 2040 in the SOC and TECH pathways, in MWh. In the left panel, battery demand in buildings as a share of EOL batteries outflow from passenger EVs for each year. Adapted from Simas et al. (2025).*

The demand for BESS in buildings, however, is highly dependent on several assumptions, although it only corresponds to a small share of the total battery demand in Norway, both today and in the next decades. In IFE-TIMES-Norway, battery demand is estimated based on costs and energy use in buildings, but the temporal and spatial resolutions of the model might underestimate this demand. In addition, it does not explicitly model BESS in grid applications, an area that can become important with the growing renewable energy production to satisfy increased energy demand by electrification. As a result, the pathways might underestimate the growth of BESS deployment in buildings. The BESS demand in the model is mostly destined to residential applications, especially in the TECH pathway, due to lower battery costs and higher investments in solar photovoltaic panels. By 2040, annual demand for BESS in buildings reaches 166 MWh in the TECH pathway, compared to only 45 MWh in the SOC pathway, where adoption of batteries in residential buildings remains limited.

### 2.2.2. Scenarios for battery repurposing

Based on the pathways for EOL EV batteries and BESS demand described above, we develop two scenarios to evaluate the impacts of a second-life market on the economy and the environment. The first scenario is a *baseline scenario*, which reflects current practices. It is assumed that retired EV batteries are not repurposed for stationary storage applications. Instead, all batteries used in buildings are assumed to be newly imported, and all EOL EV batteries are either recycled domestically or exported for recycling abroad. This scenario serves as the reference point for assessing the potential impacts of introducing second-life EV battery deployment in alternative scenarios.

The second scenario is a *repurposing scenario*, in which EOL EV batteries are assumed to repurposed for use in BESS, thus substituting for newly imported batteries. This approach does not increase the overall demand for batteries in buildings but changes the source of supply. We assume that only passenger EV batteries are reused. First-life BESS batteries are assumed to have a lifetime of 15 years, while second-life batteries are assumed to last 50% less than a first-life battery, needing replacement after around 7 years (Zhou et al., 2024). Our basic assumption is that EOL EV batteries are retired after the end of their lifetime. However, as some batteries available for repurposing have a much higher state of health due to, for example, the vehicle being retired due to fault of other major components, we might be underestimating the lifetime of repurposed batteries. When second-life batteries reach their EOL, they are sent to recycling.

The two scenarios are illustrated in Figure 2. The stages shown in the green squares occur in years other than when the retired batteries from passenger EVs are sent to either recycling or reuse – which is the annual input to the SUMS-Norway model. These stages in green squares are modified in the dynamic MFA, which provides the annual volumes of recycling and reuse in our model.

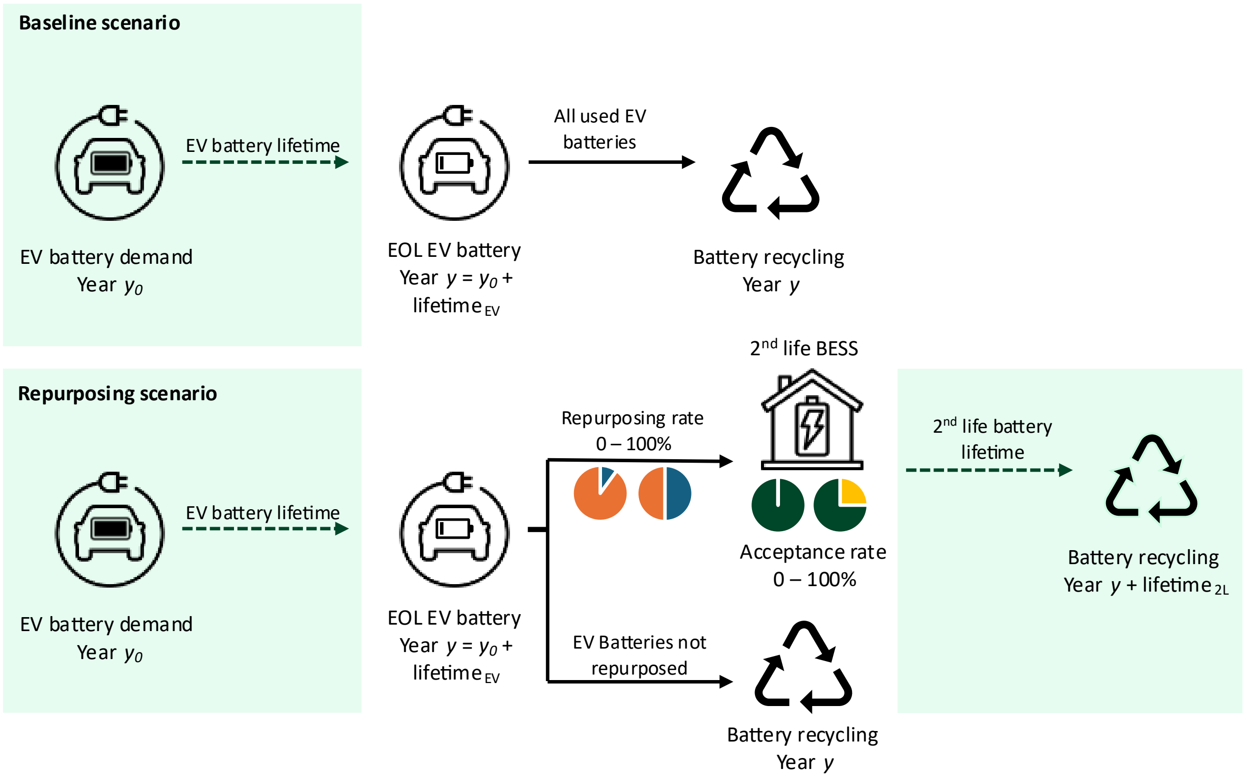

*Figure 2. Overview of material flows over time for baseline scenario (top) and repurposing scenario (bottom). The centre of the figure (white background) represents the flows in year $y$, showing the EOL EV batteries sent to recycling or to repurposing for second-life BESS. Green squares represent flows that happen in years before (left) that affect EOL EV battery availability and after (right) that affect the volume of batteries sent to recycling.*

Additionally, as shown in Figure 2, two inputs determine the quantity of second-life EV batteries. The first one is the repurposing rate. Not all EOL EV batteries are suitable for second-life applications due to degradation, safety concerns, or inconsistent performance. Factors like chemistry type, usage history and remaining capacity often determine whether a battery can be reused or must be recycled. Since battery repurposing is still a nascent industry, there are no good estimates of what share of retired EV batteries could be used for second life. Likewise, if there are more EOL EV batteries available than battery demand, a selection of the best available batteries for repurposing can be made, and EOL batteries with a higher remaining capacity (e.g. retired after a few years of use, before end of lifetime) can be repurposed and reused for a longer period. Therefore, to assess the quantity of first-life batteries replaced with second-life batteries, we evaluate two repurposing rates of 10% (Neef et al., 2021) and 50% (own assumption), which represent the shares of EOL EV batteries that can be repurposed for stationary applications. These different repurposing rates can provide a sensitivity analysis on the availability of EOL batteries suitable for reuse and how this can change the potential of second-life BESS adoption.

The second input is the acceptance rate, which represents the willingness of consumers to use second-life BESS. Our main assumption is that second life could supply up to 100% of the BESS demand in buildings. However, a lower acceptance rate would limit the extent to which first-life batteries can be substituted. To capture this effect, we also look at an acceptance rate of 50%, which provides a sensitivity analysis of the volumes of batteries repurposed and the economic impacts of a lower acceptance rate.

### 2.3. Scenario implementation and the value chains for battery repurposing and recycling

The estimated physical volumes obtained from the steps above are converted into monetary flows to describe the economic value chains for battery repurposing and recycling in order to integrate them into our modelling in SUMS-Norway. In this study, the value chains for battery repurposing and recycling begin with the removal of used batteries from EVs. These EOL EV batteries are collected by companies that work with the reverse logistics of used batteries and forward them to treatment, either to recycling or repurposing. Collection activities include inspection and classification of received batteries, discharging, packaging, labelling and documentation, and transport logistics. In Norway, reverse logistics companies for all types of batteries are Batteriretur, ERP Norway, NORSIRK, and RENAS (Norwegian Environment Agency, 2025).

Recycling in Norway is currently carried out by Hydrovolt, which has a capacity for pre-treatment of 12,000 tons of EV batteries per year (Hydrovolt, 2025). Pre-treatment is a recycling stage that includes sorting batteries according to type and chemistry, discharging, dismantling and removing components like cables and electronics, electrolyte handling, shredding and crushing of battery cells, and sorting of outputs (Fraunhofer ISI, 2024). The main outputs of the pre-treatment recycling are black mass, a mix of valuable metals from battery cathodes and anodes that is used as feedstock for material recovery, and metallic fractions comprising copper, aluminum, and steel. Here, we assume that all black mass and metals from the battery-recycling industry are exported.

Battery repurposing for second life includes discharging, safety checks, testing and diagnostics, grading and sorting, disassembly for removal of damaged units, refurbishment or reconfiguration of modules, integration to new energy systems, and installation in new second-life applications. In this study, the repurposed batteries are used in buildings, substituting imported first-life batteries.

To implement the scenarios in this study, we extend SUMS-Norway to include the value chains for battery repurposing and recycling, consisting of the flow of four products along three industries (see details in section A1.1 in the Annex). The products are: (1) used EV batteries, (2) first-life (new) batteries for buildings, (3) repurposed (second-life) batteries for buildings, and (4) outputs from battery recycling, comprising mostly black mass and metals. The three industries are: (1) collection of used EV batteries, (2) battery repurposing, and (3) battery recycling. In Figure 3, products are shown in blue and industries in green. Black arrows represent flows in Norway, and red arrows indicate imports and exports between Norway and other countries.

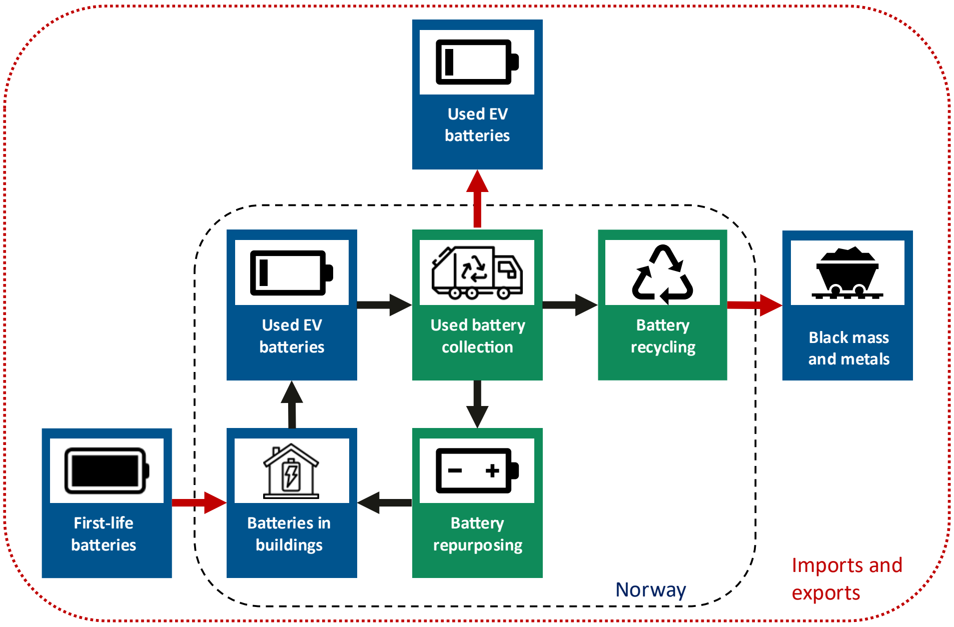

*Figure 3. Value chain for battery repurposing and recycling in Norway. Blue squares represent products, and green squares represent industries. Red arrows represent imports and exports. Flows between battery repurposing and battery recycling industries are not modelled.*

Below, we summarise our assumptions for the added products and industries as well as the main assumptions used for the scenarios.

### 2.3.1. Supply of EOL EV batteries and cost structure for the industry “Collection of used EV batteries”

We assume that all EOL EV batteries are supplied to the economy by the new industry “*Collection of used EV batteries*”[3], and there are no imports of EOL EV batteries. The total supply of EOL EV batteries, which also corresponds to the total output of the “*Collection of used EV batteries*” industry, is calculated as the volume of EOL EV batteries in 2022 multiplied by an assumed price for EOL EV batteries.

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[3] This is a simplification for modelling, since EV batteries are supplied by industries that remove batteries from vehicles, whether they are involved in vehicle maintenance or scrappage. However, we assume that battery collection companies supply the batteries to EOL treatment, either to repurposing industries or to recycling.

EOL EV batteries modelled for 2022 in Simas et al. (2025) amount to 92 MWh, equivalent to around 1,500 EV batteries of medium size. The price of retired EV batteries is assumed to be 50 USD/kWh[4] (537.50 NOK) per kWh[5]. The total economic supply of EOL EV batteries is either sent to repurposing industries, recycling industries, or exported for recycling in other countries, in this priority order.

The total inputs[6] to the "*Collection of used EV batteries*" industry are distributed according to assumptions on annual costs. First, we assume that the share of value added in total output is the same as in the original waste management services industry[7], at 33%. Second, we assume that costs for packaging and transport amount to around 2.10 USD per kg of EOL EV batteries for transport of hazardous waste in medium heavy-duty trucks (Slattery et al., 2021). This corresponds to 22.50 NOK per kg, amounting to 26% of the total costs of the industry. The remaining 41% of annual costs are split between warehousing and transport services, legal and accounting services, architecture and engineering services, and R&D.

### 2.3.2. Supply of new and repurposed batteries for buildings and cost structure for the industry "Battery repurposing"

We assume that first-life (new) batteries are supplied fully by imports, and all repurposed batteries are supplied domestically by the new industry "*Battery repurposing*". The total supply of new batteries corresponds to the demand for new batteries, while the supply of repurposed batteries corresponds to the demand for second life batteries in the repurposing scenarios and to the total output of the "*Battery repurposing*" industry.

The total demand for BESS in buildings in each year is calculated as the demand for new batteries (in kWh) multiplied by the price of new batteries, plus the demand of repurposed batteries (in kWh) multiplied by the price of repurposed batteries. The annual demand for BESS in buildings modelled for 2022 in Simas et al. (2025) amounts to 5.6 MWh. We assume that this is supplied by new batteries at present. The price of repurposed batteries is estimated to be 1,922 NOK per kWh, based on the price for EOL EV batteries and assumptions on the cost structure of repurposed batteries shown in the next paragraph (Neubauer et al., 2015; NREL, 2020, 2024). We assume that new battery packs for BESS, without inverters and any system components, have an average cost of 100 USD per kWh (BloombergNEF, 2022),

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[4] According to Dong et al. (2023), current retired-battery prices vary between 19 and 131 USD per kWh. Prices for retired EV batteries vary according to factors such as age and state of health and are assumed to be around 70-80 USD per kWh currently. This price is expected to drop in the next years. Therefore, we should expect a higher price now and a lower price in 2040. However, we cannot change the structure of the industry throughout the timeseries in the model, thus we assume a constant price for the entire period.

[5] Assuming an exchange rate of 10.75 NOK per USD (average for 2022). This exchange rate does not change over time because SUMS-Norway uses constant prices over time (no inflation).

[6] In the SUT framework, total inputs equal total outputs.

[7] The waste management sector is aggregated in the industry *"Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services"*.

increasing the costs of BESS based on first-life batteries to the equivalent of 2,560 NOK per kWh[8]. Prices for second-life batteries are assumed to range from 30% to 70% of those of new batteries (McKinsey, 2019). Here, the price for second-life battery packs corresponds to half of the costs for new battery packs. However, as most of the cost of a BESS lies in other components, this means that we consider BESS based on repurposed batteries to be at 75% of the price of those based on new batteries.

The structure of the industry "*Battery repurposing*" was based on the Battery Second-Use Repurposing Cost Calculator (NREL, 2020) and on adaptations of the model for Finland (Lieskoski et al., 2024), adjusted to include higher R&D spending and costs for balance of system (BOS) of repurposed batteries, which include, among others, inverters and battery management systems. Major costs for battery repurposing are assumed to be the EOL EV batteries, BOS, and labour, accounting together for over 80% of the costs of second-life BESS. The remaining value added (operating surplus and other net taxes on production) was assumed to be similar of that of the industry "*Manufacture of electric equipment*", relative to the share of labour costs in total output. R&D costs are assumed to account for approximately 6% of the costs of repurposed batteries. The remaining costs cover warranties and insurance, administrative costs and financial services, technical services, rent, electricity, transport, and software and IT services.

We also model capital investments for battery repurposing, based on the Battery Second-Use Repurposing Cost Calculator (NREL, 2020). First, we calculate the annual additional capacity needed to repurpose batteries in the scenarios. We assume that most of the investment happens in 2026, the first year when repurposing begins in our scenarios, with further investments in additional equipment as needed. The calculator estimates the investments required to build a facility with a capacity to repurpose a given volume of batteries (in MWh), for testing and for handling of materials. Equipment for testing includes battery test channels, CAN hardware, and computers, while equipment for material handling includes conveyors, storage racks, forklifts, MD trucks, shipping containers, and work stations. We also assume that equipment costs are twice as expensive in Norway. We do not, however, model investments in buildings, and we include the purchase of EOL EV batteries as operating expenses. The assumptions on installed capacity and investments can be found in section A1.3 in Annex 1.

### 2.3.3. Cost structure for the industry "Battery recycling" and supply of recycled battery materials

We assume that all EOL EV batteries that are not repurposed are sent to recycling. In the short- and medium-term (up to 2040), we assume no expansion of the recycling capacity in Norway, which is capped at 12 000 tons of EOL batteries per year. Any volumes exceeding this capacity are assumed to be exported for recycling in other countries. We further assume that the entire recycling capacity will be used for EV batteries and not occupied by other kinds of batteries (e.g., vans, trucks, two- and three-wheelers,

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[8] The prices per kWh installed vary vastly across installation size (residential, commercial, industrial, grid-scale), year, and location. Our estimates fall in the lower range of reported BESS CAPEX between 200 and 400 €/kWh (Meriläinen et al., 2023).

maritime transport, stationary batteries, electronics). All products from battery recycling (e.g., black mass, copper, aluminium) are assumed to be exported for further refining and processing in other countries.

The recycling capacity for EV batteries in Norway only covers pre-treatment. Hence, we adapt the processes in the EverBatt 2023 model (Dai, Spangenberger, et al., 2019) to estimate annual costs for a pre-treatment plant with capacity to disassemble and process the 12 000 tons of used batteries, with a small correction for higher R&D expenditure (assumed at 9%) to reflect the early stages of the battery recycling industries with high investments in innovation. EOL EV batteries themselves are estimated to account for 40% of total costs, followed by labour with 18%. The remaining share of value added (operating surplus and other net taxes on production) is assumed to be similar to that of the industry "*Material recovery*"[9], relative to the share of labour costs in total output, bringing total value added (including labour costs) to 33%. The remaining costs are allocated to legal and accounting services, R&D, electricity, services for maintenance and repair of machinery, transport and warehousing, rent, financial services and insurance, water, waste disposal services, and purchase of chemicals and mineral products. The total output of the recycling industry was estimated to be 1,342 NOK for each kWh of battery recycled, which corresponds to approximately 215 NOK per kg of battery.

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[9] Aggregated into the industry *"Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services"*

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# 3. Results and Discussion

This section presents the scenario results and their implications for the Norwegian economy. Section 3.1 provides an overview of the main drivers for the scenarios, focusing on the demand for primary and second-life batteries and the timing of recycling flows. In section 3.2, we present the results from the macro-economic model for the Norwegian economy, discussing direct impacts and ripple effects on the economy, employment, and GHG emissions. We follow with a discussion on the cross-border effects of the Norwegian second-life market in Europe and beyond in section 3.3. Finally, section 3.4 discusses limitations of our study.

## 3.1. Overview of the pathways for second life and battery recycling markets in Norway

Figure 4 shows the demand for second-life and first-life batteries in the SOC and TECH pathways under various sensitivity assumptions (repurposing rate and acceptance rate).

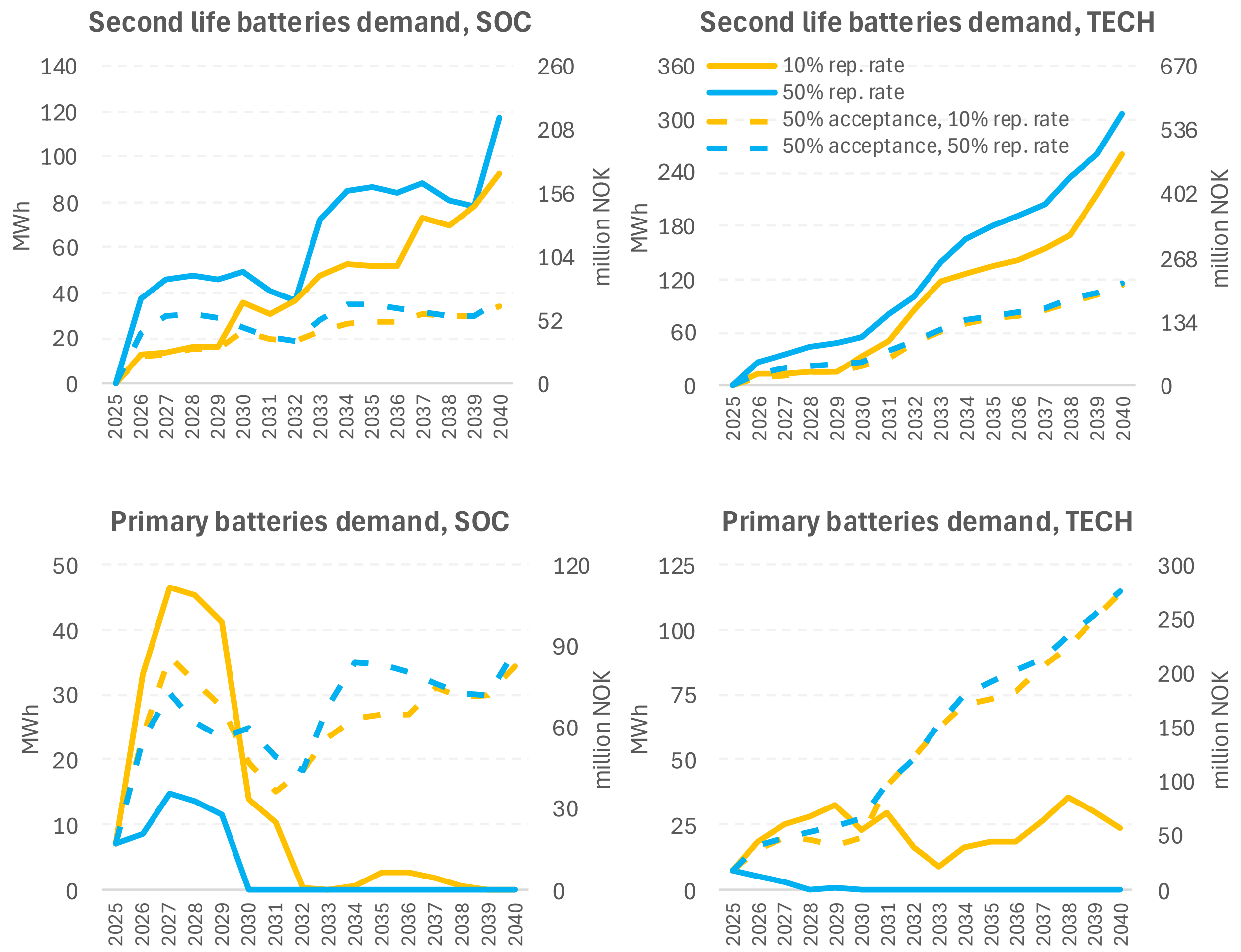

*Figure 4. Annual demand for second-life (top) and first-life (bottom) batteries in the SOC (left) and TECH (right) pathways. Curves show trajectories for repurposing rates of 10% (yellow) and 50% (blue) with 100% acceptance rate in solid line and 50% acceptance rate in dashed line.*

A lower repurposing rate (from blue to yellow, solid lines) leads to a decrease in the cumulative demand for second-life batteries of 32% (SOC) and 25% (TECH) between 2025 and 2040. It can be noted that a 50% repurposing rate leads to potentially meeting the entire BESS capacity demand before 2030 in both SOC and TECH. However, different repurposing rates have nearly no effect when reducing the acceptance rate. A reduced acceptance rate (in dashed lines) could lead to a decrease in the cumulative demand for second life batteries of 46%-56% over the same period.

The second-life use will delay the recycling of repurposed EOL EV batteries by seven years. However, this does not affect the Norwegian recycling industry after 2033, when the number of batteries sent to recycling will exceed maximum capacity for recycling in Norway, as shown in Table 1.[10] Therefore, increased second-life use will affect economic output of the recycling industry only between 2026 and 2032.

*Table 1 Batteries sent to recycling, in MWh, in the TECH pathway, under different repurposing and acceptance rates*

| | Baseline | 10% repurposing rate | 50% repurposing rate | 10% repurposing rate | 50% repurposing rate |
|---|---|---|---|---|---|
| | | 100% acceptance rate | | 50% acceptance rate | |
| **2025** | 118 | 118 | 118 | 118 | 118 |
| **2026** | 129 | 116 | 102 | 116 | 116 |
| **2027** | 139 | 125 | 102 | 125 | 125 |
| **2028** | 162 | 146 | 117 | 146 | 146 |
| **2029** | 162 | 146 | 113 | 146 | 146 |
| **2030** | 386 | 354 | 331 | 359 | 359 |
| **2031** | 741 | 689 | 660 | 698 | 698 |
| **2032** | 1450 | 1365 | 1349 | 1380 | 1380 |
| **2033** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2034** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2035** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2036** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2037** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2038** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2039** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2040** | 1925 | 1925 | 1925 | 1925 | 1925 |

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[10] Table 1 shows batteries being sent to recycling in the TECH pathway. The values do not differ significantly for the SOC pathway, as shown in Table A1 in Annex A1.3.

### 3.2. Direct impacts and spillovers on the Norwegian economy

Here, we show how the socio-technical pathways SOC and TECH may affect the Norwegian economy. For each pathway, we present at a baseline scenario (no repurposing) and two alternatives: (a) a *full acceptance scenario*, with a 50% repurposing rate and full acceptance, which represents the highest adoption of second-life batteries, and (b) a *limited acceptance scenario*, with 50% repurposing but only 50% acceptance, which represents a scenario where second-life use has limited deployment.

#### 3.2.1. Total macro-economic impacts of battery collection, repurposing, and recycling

Figure 5 depicts the total economic impact of battery collection, repurposing, and recycling in the entire Norwegian economy between 2025 and 2040 for the SOC and TECH pathways. It shows the direct value added in the battery industries, plus the indirect spillovers to the rest of the economy due to the demand for goods and services from the rest of the economy. In the baseline scenario, the economy driven by the EOL battery industries (collection and recycling) grows to 4 billion NOK (around 397 million Euro[11]) by 2040. This corresponds to 0.05% of the entire Norwegian economy in 2040.

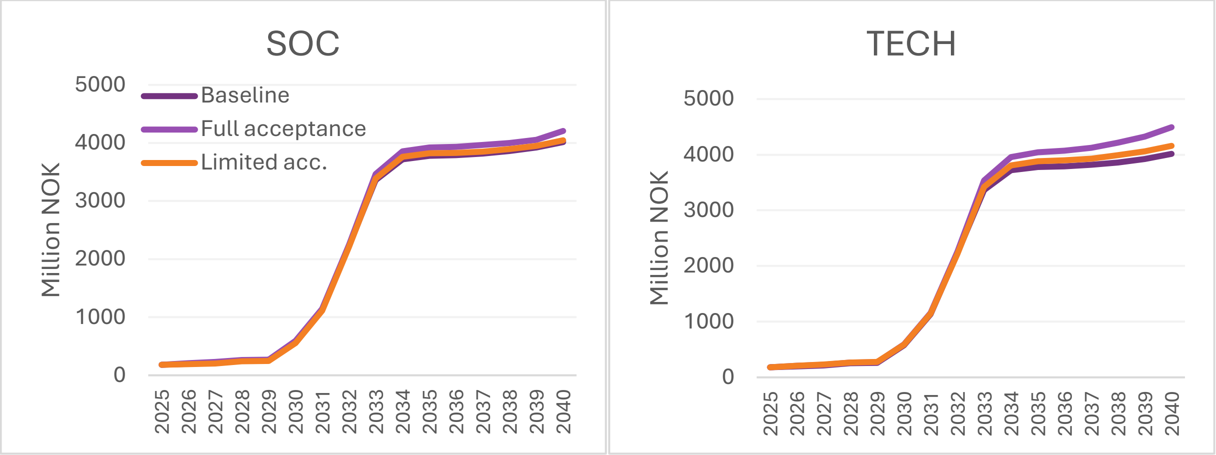

*Figure 5. Total (direct and indirect) value added generated in each scenario (baseline, full acceptance scenario, limited acceptance scenario) for the SOC and TECH socio-economic pathways*

The battery collection, repurposing, and recycling industries together provide around 35% of all value added in the scenarios, as shown in Figure 6. Battery recycling contributes to most of the value added in the battery value chain (19%-21%), followed by EOL battery collection (13%-14%), and by repurposing industries (1%-3% in scenarios with repurposing). The largest contribution to GDP growth in the scenarios comes from the construction and service sectors, amounting to 44%-45% of all value added. This is, partly, because of the demand for services by the battery value chain, but mostly, it is driven by two aspects. First, the Norwegian economy is dominated by services, and the demand for any product by any industry will lead to a demand for services in the economy. Second, the effects on the economy also

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[11] Based on 2022 prices and 2022 average exchange rate of 10.10 NOK per Euro (European Central Bank, 2025)

include induced effects. As the economy grows throughout the time series, driven by the battery industries, the income of households also grows, increasing household demand for products and services in the Norwegian economy.

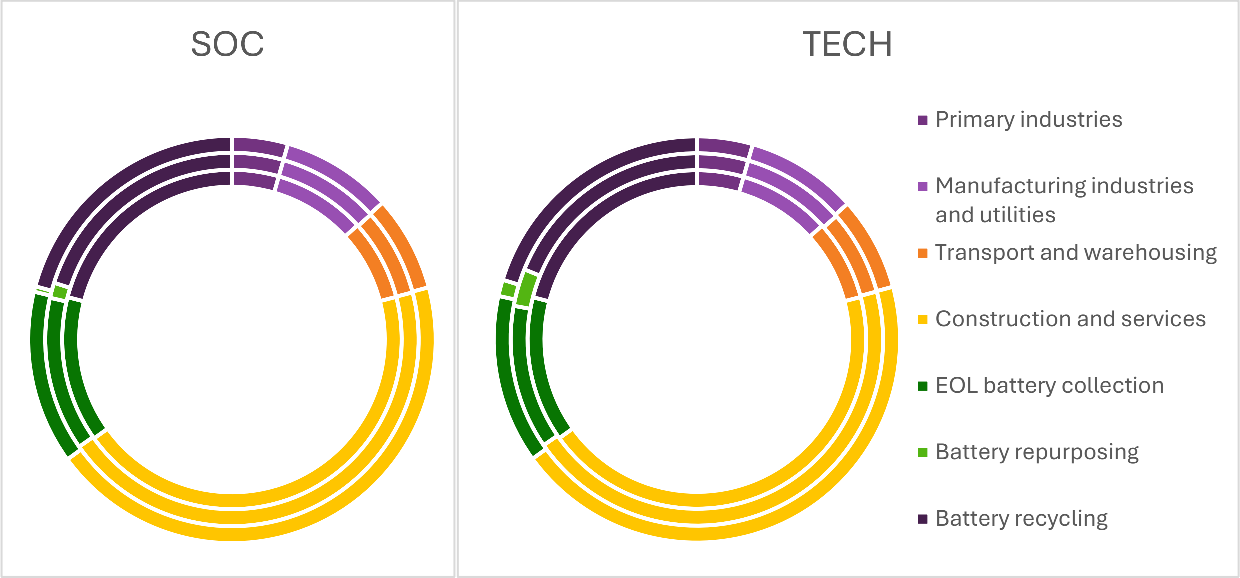

*Figure 6. Distribution of value added per broad industry in the Norwegian economy in the baseline (inner circle), full acceptance (middle circle) and limited acceptance (outer circle) scenarios in the SOC and TECH pathways.*

Scenarios with repurposing lead to higher value added, employment, and GHG emissions in the economy compared to the baseline as shown in Table 2 and Table 3, with low differences in 2030 but higher gains by 2040. In the scenarios with full acceptance, where up to 100% of BESS in buildings can be substituted by second-life batteries, GDP, employment, and GHG emissions are 4%-7% higher by 2040 in the SOC pathway and 10%-17% higher in TECH. Changes in GHG emissions are due to higher economic activity, and not due to direct emissions from repurposing. Limited acceptance scenarios lead to significantly smaller gains. For the SOC pathway, limited acceptance leads to small losses in 2030 (-4% of GDP, 0% of employment, and 3% lower emissions) and very small gains in 2040 (between 0% and 1%). In the TECH pathway, it gives small gains in both 2030 (2% of GDP and GHG emissions and 6% of employment) and 2040 (4% of GDP, 6% of employment and 3% of GHG emissions).

*Table 2. Value added, employment, and GHG emissions in 2030 and 2040 in each scenario for the SOC pathway*

| | 2030 | | | 2040 | | |
|---|---|---|---|---|---|---|
| **SOC Pathway** | **Value added (MNOK)** | **Employment (persons)** | **GHG emissions (ktons $CO_2$-eq)** | **Value added (MNOK)** | **Employment (persons)** | **GHG emissions (ktons $CO_2$-eq)** |
| **Baseline** | 578 | 396 | 3.6 | 4 015 | 2 814 | 27.5 |
| **Full acceptance** | 592 | 435 | 3.7 | 4 207 | 3 010 | 28.7 |
| **Limited acceptance** | 557 | 397 | 3.5 | 4 046 | 2 852 | 27.7 |

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*Table 3. Value added, employment, and GHG emissions in 2030 and 2040 in each scenario for the TECH pathway*

| | 2030 | | | 2040 | | |
|---|---|---|---|---|---|---|
| **TECH Pathway** | **Value added (MNOK)** | **Employment (persons)** | **GHG emissions (ktons $CO_2$-eq)** | **Value added (MNOK)** | **Employment (persons)** | **GHG emissions (ktons $CO_2$-eq)** |
| **Baseline** | 578 | 396 | 3.6 | 4 015 | 2 814 | 27.5 |
| **Full acceptance** | 593 | 439 | 3.7 | 4 494 | 3 306 | 30.4 |
| **Limited acceptance** | 588 | 419 | 3.7 | 4 159 | 2 970 | 28.3 |

### 3.2.2. Impact of repurposing scenarios compared to a baseline without repurposing

Below, we focus on the changes that scenarios with repurposing of EOL EV batteries bring to the economy, compared to the baseline where no repurposing takes place. Figure 7 illustrates the changes in value added, employment, and GHG emissions under the full-acceptance scenarios compared to the baseline scenarios. Under these scenarios, repurposing second-life batteries generates positive macroeconomic outcomes from 2026 onwards.

In the SOC pathway, by 2040, value added increases by 192 million NOK, and employment rises by almost 200 jobs relative to the baseline. GHG emission impacts are marginal, with an additional 1,200 tons of $CO_2$-eq by 2040[12]. In the TECH pathway, impacts are relatively larger due to the larger uptake of BESS in buildings. Value added reaches 478 MNOK by 2040, and employment gains rise to nearly 500 jobs. Emission effects remain minor, adding less than 3,000 tons of $CO_2$-eq in 2040. These results indicate that full acceptance of second-life deployment leads to modest but positive economic and employment effects, without substantially increasing environmental burdens.

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[12] The total GHG emissions of the Norwegian economy in 2022 were 63.7 million tons $CO_2$-eq.

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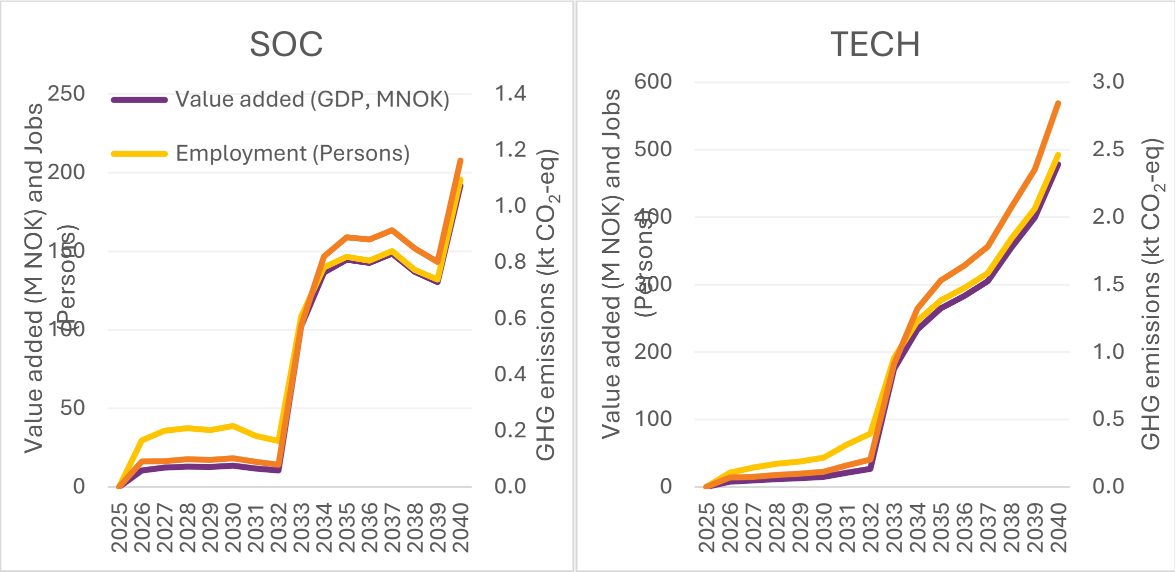

*Figure 7. Changes in value added, employment, and GHG emissions under full acceptance in the SOC and TECH pathways compared to baseline.*

Figure 8 compares the limited-acceptance scenarios (50% repurposing rate, 50% acceptance) with the baseline scenarios. Here, the lower value creation in the repurposing industry does not compensate for the decrease in recycling activities, leading to negative outcomes until 2033, when recycling capacity is reached. After 2033, even lower levels of repurposed batteries lead to a positive value to the economy: as the recycling industry in Norway is unable to recycle batteries domestically, the excess batteries are exported for recycling elsewhere, with no direct impacts on the Norwegian economy. For the SOC pathway, value added is 22 million NOK lower than baseline in 2032 and only 31 million NOK higher than baseline in 2040. Employment gains are also small, with only 38 additional jobs in 2040. For the TECH pathway, most years show a positive impact compared to baseline, except for 2032, when GDP is expected to be 14 million NOK below baseline. By 2040, the limited-acceptance scenario leads to gains of 143 million NOK in GDP and 156 jobs. In both cases, increased GHG emissions are very low and driven by increased economic activity in the rest of the economy.

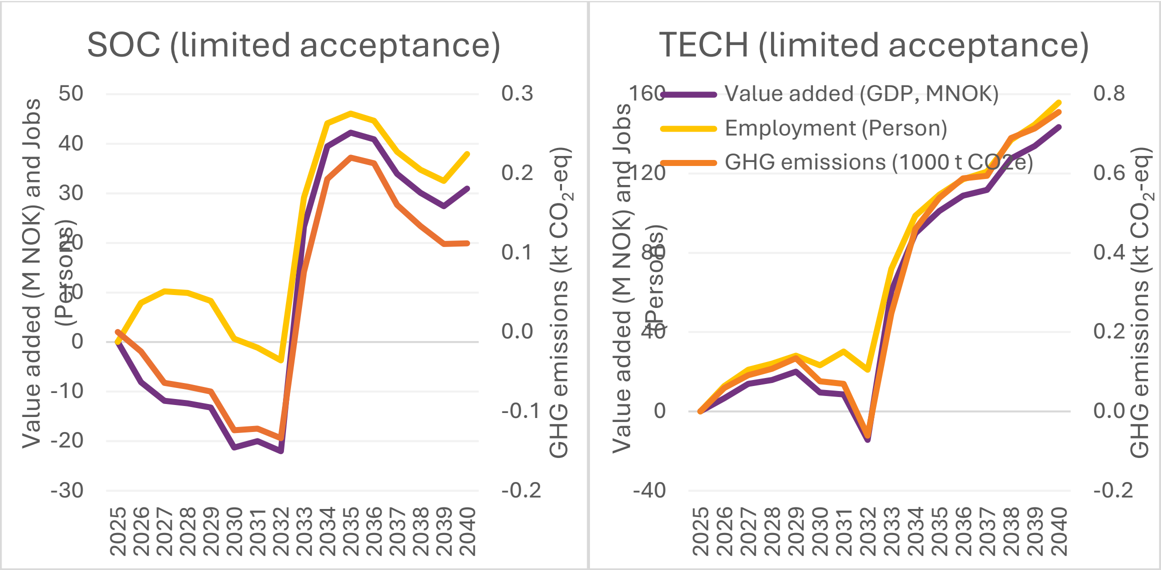

*Figure 8. Changes in value added, employment, and GHG emissions under limited acceptance in the SOC and TECH pathways compared to baseline.*

The comparison between the repurposing scenarios and baseline highlights the importance of the size of the second-life batteries market to determine whether macro-economic impacts of repurposing and postponing recycling will be positive. With full acceptance, second-life batteries substitute new imports, strengthening domestic repurposing and recycling industries, which boosts value added and employment. However, under limited acceptance, the demand for repurposed batteries is lower, constraining the domestic economic benefits. The sensitivity of economic results to acceptance rates suggests that market uptake is as critical as technical suitability in determining the broader sustainability impacts of second-life batteries in Norway.

### 3.2.3. Economic and employment impacts on different industries

Figure 9 and Figure 10 show the breakdown of value added and employment by industries in 2040 for the full-acceptance scenario compared to the baseline.[13] Around 45% of increased value added and 35% of employment arise in service sectors. Manufacturing industries and utilities account for around 15% of gains in value added and 10% in employment. The new industries (battery collection and battery repurposing) account for 38% of gains in value added and 54% in employment. The additional value added and employment for EOL EV battery collection between the repurposing scenarios and the baseline is due to the collection of second-life batteries at their EOL. Repurposing industries account for one third of the value-added gains in 2040 (56 million NOK in SOC and 145 million NOK in TECH) and around half of the employment gains (88 jobs in SOC and 230 jobs in TECH).

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[13] The pattern is similar in the limited-acceptance scenarios.

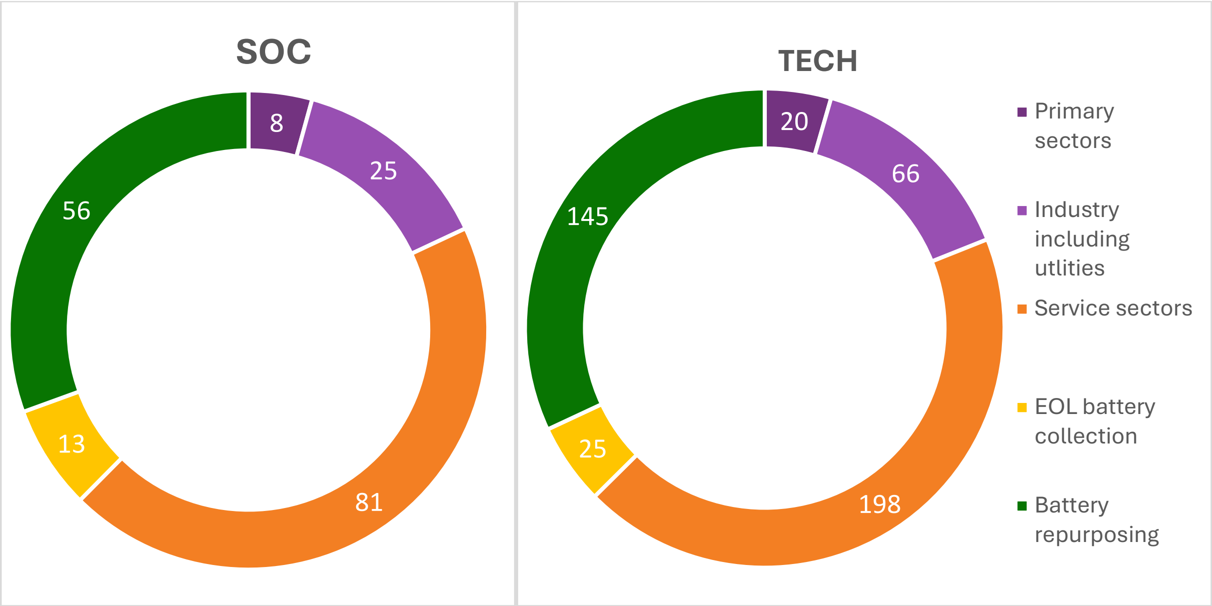

*Figure 9. Changes in value added (million NOK) in full-acceptance scenarios compared to baseline by broad industries in year 2040*

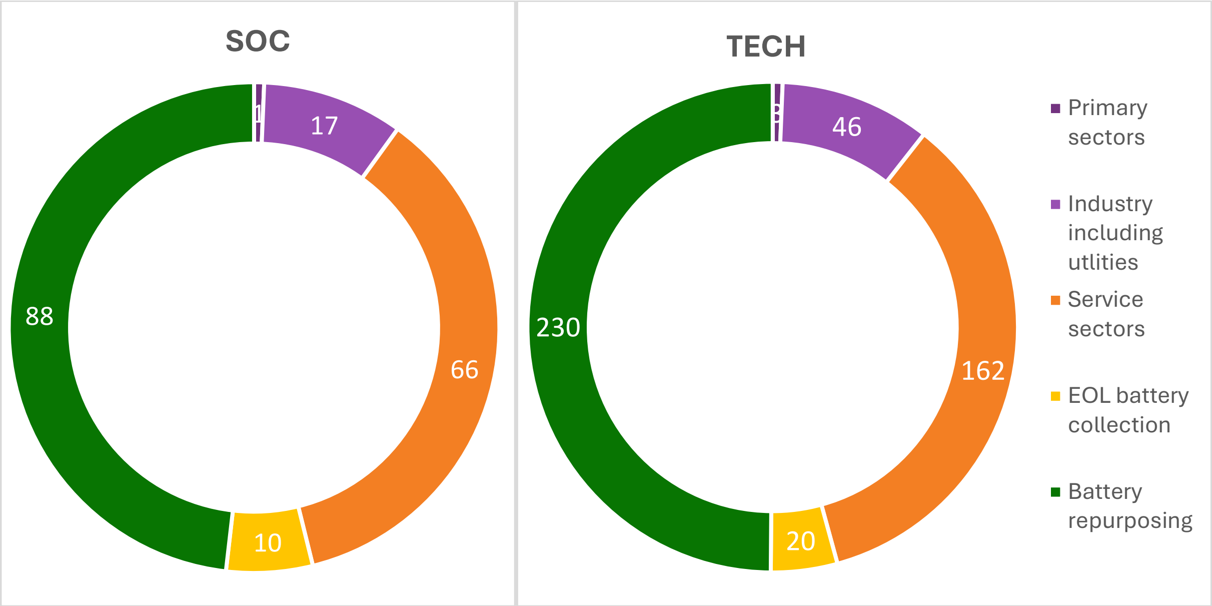

*Figure 10. Changes in employment (persons) in full-acceptance scenarios compared to baseline by broad industries in year 2040*

These results indicate that repurposing industries emerge as new industries in Norway capable of contributing to both GDP and employment by 2040. While indirect and induced spillovers in services and industry remain important, most new value creation and job opportunities within the battery chain come from repurposing. In 2040, there is no change in economic activities of recycling industries in our scenarios. These results underline that the development of a second-life battery market not only generates indirect economic activity but also supports the growth of industries with their own measurable value creation and employment potential.

### 3.2.4. Employment creation, by education and expertise

Employment implications are further illustrated in Figure 11, which highlights shifts in education and expertise requirements by 2040. Although the number of additional jobs is modest in absolute terms, second-life battery deployment affects employment unevenly across education and skill groups. The largest gains are among upper secondary and trade school graduates. Employment also rises for workers with short university education and for those with only compulsory schooling, while the impact for higher university degrees remains limited.

When examined by expertise, the strongest increases occur in crafts, technical, and natural sciences, underscoring the skill intensity of repurposing activities. Moderate growth is observed in general subjects and administration, whereas employment in traditional services and primary sectors remains unchanged. Overall, the results indicate that second-life battery deployment primarily reinforces demand for vocational and technical skills, while generating only marginal effects in other parts of the labour market.

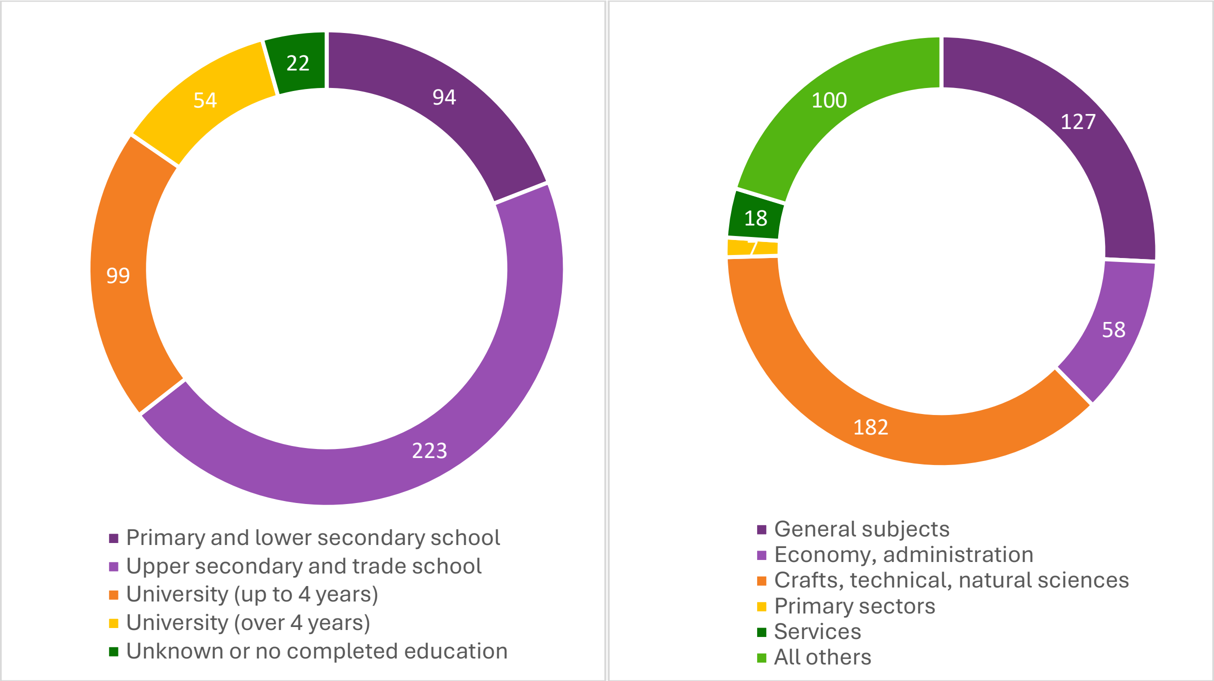

*Figure 11. Changes in employment (persons) by education and expertise background in full-acceptance scenario compared to the baseline in 2040, in the TECH pathway*

### 3.3. Cross-border impacts not captured in the model

Since our analysis only looks at the Norwegian economy, it does not capture impacts that happen in other countries. This means that Norwegian strategies might have positive impacts in Norway but affect other countries negatively. Here, we discuss some of the impacts that are not included in our analysis, both downstream and upstream.

Downstream impacts not captured refer to impacts beyond Norwegian borders of the use of EOL EV batteries for second life in Norway, in addition to further downstream value chains of the exports of EOL EV batteries for recycling and the export of black mass for material recovery. The comparison between direct impacts and indirect spillovers of repurposing and recycling industries only applies to pre-treatment of EOL EV batteries and not to the material recovery from black mass. That is because there are no commercial-scale plants for refining black mass in Norway. The black mass is exported from Norway to Europe or Asia for material recovery. Similarly, excess EOL EV batteries (above 12,000 tons sent to recycling) have no downstream effect in Norway because they are exported as is, to be recycled elsewhere. Therefore, positive impacts of repurposing in Norway can lead to negative economic outcomes elsewhere due to reduced battery-recycling activities in the short term. Repurposing batteries in Norway (and elsewhere) means that recycling of these materials will be delayed for some years. This is not a bad thing, as circular strategies aim to increase the lifetime of use and service of products and materials that are already in the economy, improving resource efficiency according to the waste hierarchy in the Waste Framework Directive (European Commission, 2008). However, current policies such as the EU Battery Regulation (European Parliament, 2024a) and the Critical Raw Material Act (European Parliament, 2024b) prioritize recycling and material recovery to ensure resilient access to battery materials for European industries. The current policy environment around critical raw materials might reduce the incentives for lifetime extension of batteries and repurposing of EOL EV batteries for second life (Zhou et al., 2024). Furthermore, this delay may give time for the battery recycling industries, especially in Europe, to further develop, such that potentially more batteries can be recycled in Europe instead of being exported.

Upstream impacts are those that occur in the production of batteries and the inputs needed for repurposing and recycling. Many of these happen in other countries. First, direct and indirect effects on the economy of repurposing compared to recycling batteries only cover the industries in Norway, and a share of the real economic, social and environmental impacts associated with imported inputs does not show up in the results of our study. Similarly, a decrease in imported first-life BESS batteries does not affect the scenarios in Norway, as the impacts associated with their production occur in other countries. Increasing the lifetime of batteries by repurposing them for second life will also decrease the impacts of BESS in buildings, since production of new batteries has large environmental and societal impacts (Dai et al., 2019; Rajaeifar et al., 2022; Simas et al., 2025). Neither these are covered in our analysis.

### 3.4. Limitations and uncertainties

Certain limitations and uncertainties should be acknowledged when interpreting the results in this report. First, the labour coefficients used in the IO framework are derived from broad industry classifications. Since new activities such as battery repurposing and collection are not separately identified in official data, employment estimates rely on proxies like “manufacture of electrical equipment”. This creates uncertainty in both magnitude and distribution of labour effects, particularly as around half of the employment gains in our results are linked to repurposing. The estimates by education and expertise also depend on sectoral averages, which may not accurately reflect the requirements of emerging industries.

Second, available sources for data on the cost structure for repurposing are conflicting and incomplete, lacking key components such as BOS costs. In this study, estimates were assembled from a combination of data sources, but as the repurposing sector is still small and evolving, real-world cost structures may differ considerably once the industry scales. Relatedly, the assumed price of EOL EV batteries (50 USD/kWh) is an important parameter. While plausible, this value may be lower than current prices and higher than what could prevail in 2040. Similarly, the price and the cost structure of first-life and second-life BESS (including battery packs, inverters and other components) are dependent on the scale of the system (e.g. residential, commercial, or industrial scale) and will likely change over time. Our assumptions were built using different sources from different locations and years and might not fully reflect current prices in Norway. As prices cannot be endogenously adjusted in the model over the studied time series, the cost structure of repurposing and recycling industries (e.g. with lower cost EOL EV batteries by 2040) may shift in ways not captured by our analysis.

Third, our amin assumptions for the MFA modelling are that all EOL EV batteries are collected after the end of their first life, and the lifetime of repurposed batteries are half of the lifetime of first-life batteries. However, there are retired batteries sent for repurposing which have a higher capacity and shorter first-life use than assumed here. Those are batteries taken out of vehicles that have been retired due to fault on other major components before the end of their lifetime. Thus, these retired batteries are in condition to be reused for much longer than the estimated 7 years lifetime of repurposed batteries, up to comparable lifetimes to first-life batteries. In addition, LFP batteries, which are gaining more space in both stationary systems and EVs, can have even longer lifetimes. Therefore, lifetime of repurposed batteries can be underestimated in this study.

Fourth, there are no reliable sources for data on employment in battery recycling, especially for pre-treatment facilities, which are highly automated (as in the case of Hydrovolt). Current employment figures are available, but it remains unclear how these will evolve once plants operate at full capacity. In addition, the model assumes no expansion of domestic recycling capacity by 2040. While several start-ups exist in Norway, it is unlikely that they will reach full commercial scale in the near future, but this still introduces uncertainty. Moreover, our analysis assumes that the entire recycling capacity is allocated to EV batteries. In practice, recycling also involves maritime batteries, stationary BESS, two- and three-wheelers (including e-bikes), and production scrap from facilities such as the Morrow battery-cell factory.

Finally, changes in EOL EV collection arise because repurposed batteries are processed twice, once after first life and then again after second life. There would be increased activity from EOL battery collection since second-life batteries typically require replacement earlier than first-life BESS, increasing the activity for collection from residential and commercial BESS. However, the model does not account for EOL collection of other battery types, such as first-life BESS, since we assumed that EOL EV batteries would be the main feedstock for recycling plants. Therefore, we may overestimate the gains in the EOL collection industry in the repurposing scenarios.

Overall, these uncertainties highlight that, while our modelling provides valuable insights into the potential economic, social, and environmental effects of second-life deployment of EV batteries, the quantitative estimates of the direct impacts in the collection, recycling and repurposing industries should be interpreted with caution, especially regarding effects on employment in those industries. Improved data on costs, labour inputs, and recycling dynamics will be essential as the industry matures.

# 4. Conclusion

This report examined the economic, social, and environmental implications of deploying second-life EV batteries for BESS in Norway. Using a scenario-based input-output modelling framework, the analysis compared a baseline trajectory, where all building-integrated storage relies on new, imported batteries and EOL EV batteries are recycled or exported, with alternative scenarios where EOL batteries are repurposed for stationary use. The model simulations provide quantitative insights into the potential scale and distribution of impacts across industries, labour markets, and emissions.

The results show that second-life deployment generates measurable, though modest, contributions to GDP and employment by 2040. The most notable effects arise in battery repurposing, which emerges as a distinct activity alongside existing collection and recycling. While the aggregate macro-economic impact is small relative to the size of the Norwegian economy, these activities create incremental value and new jobs, particularly for workers with vocational and technical skills. There is a small decrease in recycling activities in the repurposing scenarios until 2033, when the maximum capacity of the Norwegian battery-recycling industry is reached. In scenarios with more repurposing, the overall economic impact is positive, driven by repurposing activities and the indirect effects of these activities on the economy. After that, recycling activities are unaffected, and economic activity in Norway is positive in any repurposing scenario as repurposing displaces exported batteries instead of batteries recycled in Norway. The environmental impacts are similarly limited. Additional processing of second-life batteries, compared to a scenario where only first-life batteries are used, results in small increases in GHG emissions in the Norwegian economy, but these are negligible in the context of Norway's total emissions. In this sense, repurposing contributes to circular-economy objectives without adding significant environmental burdens.

The findings have several implications. First, second-life industries could support Norway's broader goals of circular economy and resource efficiency by extending the useful lifetime of EV batteries and reducing reliance on imported storage technologies. However, this potential depends not only on the technical suitability of retired batteries but also on acceptance among households and businesses as well as on the development of effective collection, screening, and repurposing infrastructures. Second, the labour market effects suggest a need to strengthen vocational education and training pathways to ensure availability of the skills required for these activities. Third, because recycling demand is postponed rather than reduced, planning for sufficient long-term recycling capacity remains essential to avoid bottlenecks in the future.

Overall, the results suggest that second-life EV batteries can make tangible contributions to Norway's economy, labour market, and circular-economy objectives. Their significance lies both in the large indirect effects on the economy and in the creation of new repurposing and collection activities, the extension of battery lifetimes, and the diversification of industrial and employment opportunities. In this way, second-life deployment complements broader energy-transition strategies by adding resilience and supporting the development of specialized industries with clear economic and social value.

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At the same time, the results should be interpreted with caution. Key assumptions, such as repurposing rates, operational lifetimes of second-life batteries, and levels of household or market acceptance, remain uncertain and could shift the scale of outcomes. Further work is needed to refine these parameters and also to examine cross-border effects more closely, as Norway's second-life industry will ultimately be embedded in European and global value chains.

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# ANNEX 1 – Supplementary method description and assumptions

## A1.1. Structure of input to SUMS-Norway

In SUMS-Norway, the economic inputs of all products in the economy to all industries are described in a table format. The structure of this table for the base year of the model is illustrated in Figure A1.

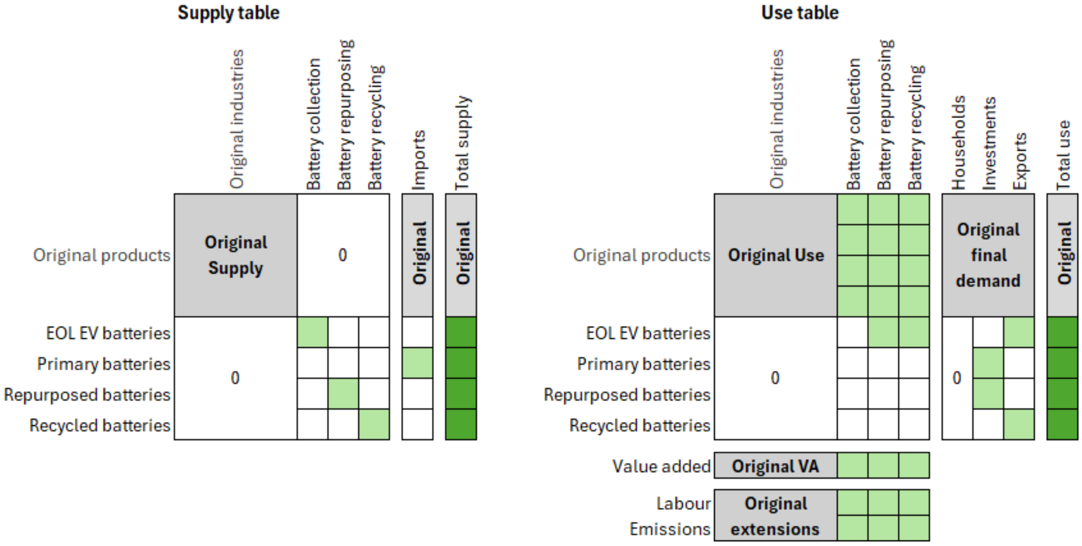

*Figure A1. Simplified illustration of the supply (left) and use (right) tables in the base year (2022) in SUMS-Norway, showing original products and industries from the published Norwegian National Accounts and new products and industries in this study. Grey squares correspond to original data from the Norwegian SUT, green squares correspond to our assumptions for economic supply and use of new industries, and white squares correspond to empty cells, where all values are set to zero.*

The *supply* table, illustrated on the left, shows the supply of products to the economy by each industry and by imports. Total supply of each product corresponds to the sum of domestic supply from Norwegian industries, plus those supplied by imports. The *use* table, illustrated on the right, shows the use of each product (produced domestically and imported) by the Norwegian industries. In addition, it shows the value added created in each industry as well as employment and GHG emissions in each industry. The *use* table also shows how much final demand (households, governments, investments) consumes of each product and all exports of each product. Total use of each product corresponds to use by all domestic industries plus consumption by final demand and exports. The total output of industries corresponds to their total use of products plus value added in that industry.

In Figure A1, the original data from the 2022 Norwegian SUT is shown in grey, while our assumptions for the supply of new products and the use of products by new industries are shown in green. White squares indicate cells with a value of zero, where no economic transactions occur between these products and industries. We also include new value added, labour, and GHG emissions for the new industries.

## A1.2. Industries and products in SUMS-Norway

| Industries | |
|---|---|
| Crop and animal production, hunting and related service activities | Postal and courier activities |
| Forestry and logging | Accommodation and food service activities |
| Fishing and aquaculture | Publishing activities |
| Mining and quarrying | Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities |
| Manufacture of food products, beverages and tobacco products | Telecommunications |
| Manufacture of textiles, wearing apparel and leather products | Computer programming, consultancy and related activities; information service activities |
| Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials | Financial service activities, except insurance and pension funding |
| Manufacture of paper and paper products | Insurance, reinsurance and pension funding, except compulsory social security |
| Printing and reproduction of recorded media | Activities auxiliary to financial services and insurance activities |
| Manufacture of coke and refined petroleum products | Real estate activities (excluding imputed rents) |
| Manufacture of chemicals and chemical products | Imputed rents of owner-occupied dwellings |
| Manufacture of basic pharmaceutical products and pharmaceutical preparations | Legal and accounting activities; activities of head offices; management consultancy activities |
| Manufacture of rubber and plastic products | Architectural and engineering activities; technical testing and analysis |
| Manufacture of other non-metallic mineral products | Scientific research and development |
| Manufacture of basic metals | Advertising and market research |
| Manufacture of fabricated metal products, except machinery and equipment | Other professional, scientific and technical activities; veterinary activities |
| Manufacture of computer, electronic and optical products | Rental and leasing activities |
| Manufacture of electrical equipment | Employment activities |
| Manufacture of machinery and equipment n.e.c. | Travel agency, tour operator reservation service and related activities |
| Manufacture of motor vehicles, trailers and semi-trailers | Security and investigation activities; services to buildings and landscape activities; office administrative, office support and other business support activities |
| Manufacture of other transport equipment | Public administration and defence; compulsory social security |
| Manufacture of furniture; other manufacturing | Education |
| Repair and installation of machinery and equipment | Human health activities |
| Electricity, gas, steam and air conditioning supply | Social work activities |
| Water collection, treatment and supply | Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities |
| Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services | Sports activities and amusement and recreation activities |
| Construction | Activities of membership organisations |
| Wholesale and retail trade and repair of motor vehicles and motorcycles | Repair of computers and personal and household goods |
| Wholesale trade, except of motor vehicles and motorcycles | Other personal service activities |
| Retail trade, except of motor vehicles and motorcycles | Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use |
| Land transport and transport via pipelines | Activities of extra-territorial organisations and bodies |
| Water transport | **EOL battery collection** |
| Air transport | **Battery repurposing** |
| Warehousing and support activities for transportation | **Battery recycling** |

| Products | |
|---|---|
| Products of agriculture, hunting and related services | Accommodation and food services |
| Products of forestry, logging and related services | Publishing services |
| Fish and other fishing products; aquaculture products; support services to fishing | Motion picture, video and television programme production services, sound recording and music publishing; programming and broadcasting services |
| Mining and quarrying | Telecommunications services |
| Food products, beverages and tobacco products | Computer programming, consultancy and related services; information services |
| Textiles, wearing apparel and leather products | Financial services, except insurance and pension funding |
| Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials | Insurance, reinsurance and pension funding services, except compulsory social security |
| Paper and paper products | Services auxiliary to financial services and insurance services |
| Printing and recording services | Real estate services (excluding imputed rents) |
| Coke and refined petroleum products | Imputed rents of owner-occupied dwellings |
| Chemicals and chemical products | Legal and accounting services; services of head offices; management consulting services |
| Basic pharmaceutical products and pharmaceutical preparations | Architectural and engineering services; technical testing and analysis services |
| Rubber and plastics products | Scientific research and development services |
| Other non-metallic mineral products | Advertising and market research services |
| Basic metals | Other professional, scientific and technical services; veterinary services |
| Fabricated metal products, except machinery and equipment | Rental and leasing services |
| Computer, electronic and optical products | Employment services |
| Electrical equipment | Travel agency, tour operator and other reservation services and related services |
| Machinery and equipment n.e.c. | Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services |
| Motor vehicles, trailers and semi-trailers | Public administration and defence services; compulsory social security services |
| Other transport equipment | Education services |
| Furniture; other manufactured goods | Human health services |
| Repair and installation services of machinery and equipment | Social work services |
| Electricity, gas, steam and air-conditioning | Creative, arts and entertainment services; library, archive, museum and other cultural services; gambling and betting services |
| Natural water; water treatment and supply services | Sporting services and amusement and recreation services |
| Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services | Services furnished by membership organisations |
| Constructions and construction works | Repair services of computers and personal and household goods |
| Wholesale and retail trade and repair services of motor vehicles and motorcycles | Other personal services |
| Wholesale trade services, except of motor vehicles and motorcycles | Services of households as employers; undifferentiated goods and services produced by households for own use |
| Retail trade services, except of motor vehicles and motorcycles | Services provided by extraterritorial organisations and bodies |
| Land transport services and transport services via pipelines | **EOL EV batteries** |
| Water transport services | **First-life batteries** |
| Air transport services | **Recycled batteries** |
| Warehousing and support services for transportation | **Repurposed batteries** |
| Postal and courier services | |

## A1.3. Repurposing capacity and investments in the SOC and TECH pathways

### SOC Pathway

*Table A1. Annual repurposing capacity and total repurposing installed capacity in the SOC pathway*

| | Annual repurposing capacity (MWh) | Total installed capacity |
|---|---|---|
| **2025** | 0.00 | 0.00 |
| **2026** | 37.4 | 37.4 |
| **2027** | 45.7 | 45.7 |
| **2028** | 47.8 | 47.8 |
| **2029** | 45.9 | 47.8 |
| **2030** | 49.6 | 49.6 |
| **2031** | 41.1 | 49.6 |
| **2032** | 37.0 | 49.6 |
| **2033** | 72.1 | 72.1 |
| **2034** | 85.2 | 85.2 |
| **2035** | 86.5 | 86.5 |
| **2036** | 84.4 | 86.5 |
| **2037** | 88.5 | 88.5 |
| **2038** | 80.9 | 88.5 |
| **2039** | 78.3 | 88.5 |
| **2040** | 117.4 | 117.4 |

*Table A2. Total capital investments, in Norwegian kroner (NOK), for equipment and components for one repurposing industry reaching the total installed capacity in the SOC pathway, adapted from (NREL, 2020)*

| Equipment | Total investment 2025-2040 (NOK) |
|---|---|
| **Battery Test Channels** | 1 720 000 |
| **MD Truck** | 3 031 500 |
| **Shipping Containers** | 2 805 750 |
| **Conveyors** | 80 625 |
| **Storage Racks** | 8 600 |
| **Computers** | 64 500 |
| **Forklift** | 150 500 |
| **Work Stations** | 96 750 |
| **CAN hardware** | 13 760 |

## TECH Pathway

*Table A3. Annual repurposing capacity and total repurposing installed capacity in the TECH pathway*

| | Annual repurposing capacity (MWh) | Total installed capacity |
|---|---|---|
| **2025** | 0.00 | 0.00 |
| **2026** | 26.3 | 26.3 |
| **2027** | 36.5 | 36.5 |
| **2028** | 44.4 | 44.4 |
| **2029** | 48.5 | 48.5 |
| **2030** | 55.4 | 55.4 |
| **2031** | 81.0 | 81.0 |
| **2032** | 101.2 | 101.2 |
| **2033** | 139.9 | 139.9 |
| **2034** | 165.9 | 165.9 |
| **2035** | 181.5 | 181.5 |
| **2036** | 192.3 | 192.3 |
| **2037** | 205.1 | 205.1 |
| **2038** | 236.1 | 236.1 |
| **2039** | 261.3 | 261.3 |
| **2040** | 306.5 | 306.5 |

*Table A4. Total capital investments, in Norwegian kroner (NOK), for equipment and components for one repurposing industry reaching the total installed capacity in the TECH pathway, adapted from (NREL, 2020)*

| Equipment | Total investment 2025-2040 (NOK) |
|---|---|
| **Battery Test Channels** | 4 730 000 |
| **MD Truck** | 3 031 500 |
| **Shipping Containers** | 2 805 750 |
| **Conveyors** | 193 500 |
| **Storage Racks** | 21 500 |
| **Computers** | 193 500 |
| **Forklift** | 150 500 |
| **Work Stations** | 258 000 |
| **CAN hardware** | 37 840 |

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# ANNEX 2 – Supplementary results

*Table A5. Batteries sent to recycling, in MWh, in the SOC pathway, under different repurposing and acceptance rates*

| | Baseline | 10% repurposing rate | 50% repurposing rate | 10% repurposing rate | 50% repurposing rate |
|---|---|---|---|---|---|
| | | 100% acceptance rate | | 50% acceptance rate | |
| **2025** | 118 | 118 | 118 | 118 | 118 |
| **2026** | 129 | 116 | 91 | 96 | 116 |
| **2027** | 139 | 125 | 93 | 96 | 125 |
| **2028** | 162 | 146 | 114 | 119 | 146 |
| **2029** | 162 | 146 | 116 | 121 | 146 |
| **2030** | 386 | 351 | 337 | 344 | 356 |
| **2031** | 741 | 710 | 699 | 705 | 715 |
| **2032** | 1450 | 1414 | 1413 | 1416 | 1423 |
| **2033** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2034** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2035** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2036** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2037** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2038** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2039** | 1925 | 1925 | 1925 | 1925 | 1925 |
| **2040** | 1925 | 1925 | 1925 | 1925 | 1925 |