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Building a Circular Battery Economy:

Insights on progress in Norway

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EXECUTIVE SUMMARY

As global demand for batteries grows, driven by developments in the automotive, maritime, and energy storage sectors, integrating circular economy (CE) principles into the battery value chain is increasingly essential. The approach is key to improving sustainability by extending battery life and reducing battery waste. In Norway, significant stocks of waste electric vehicle (EV) batteries are projected in the near future as a result of its established end market for batteries. This has led to a growing interest in the recycling, repurposing, and reusing of batteries; all of which are argued to contribute to a circular battery economy.

This paper publishes findings from a national survey assessing current CE practices, obstacles, and stakeholder perspectives across Norway's battery value chain. By aligning with national and upcoming EU regulations, the paper outlines strategic recommendations to strengthen the Norway's global market position and sustainability.

BACKGROUND

As the global transition towards cleaner and more sustainable energy sources gains momentum, the demand for lithium-ion batteries has increased rapidly. This has been driven in part by the wider adoption of electric vehicles, totalling 82.4% of Norwegian passenger car sales in 2023 (OFV, 2024). While this transition is essential for reducing our reliance on fossil fuels, it raises significant concerns over the environmental and social impacts of extracting critical materials and disposing of battery waste. These challenges have prompted calls for alternative strategies to reduce emissions and manage resources more sustainably (González and de Haan, 2020).

The Circular Economy (CE) offers a promising framework to address such challenges. At its core, circularity advocates for a restorative and regenerative approach to resource management, which aims to minimise waste and maximise the value of materials by prolonging their usable lifespan (Kirchherr et al., 2023). This represents a departure from the traditional linear model of extraction, production, consumption, and disposal. Instead, it works towards establishing a closed-loop system that prioritises the 6Rs (reuse, recycle, redesign, remanufacture, reduce and recover).

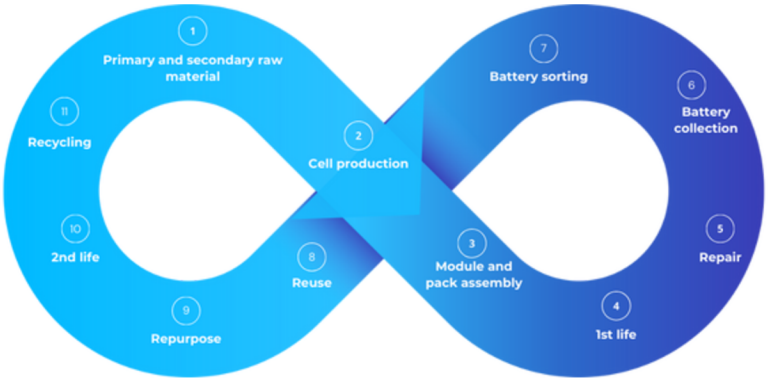


Figure 1: Circular closed-loop system for batteries.

Towards Battery Circularity in Norway:

In the context of the Norwegian battery value chain, the concept of a circular battery economy has emerged as a strategic imperative, especially with substantial amounts of battery waste expected in coming years. This approach seeks to redefine the lifecycle of batteries, extending their utility beyond the initial use. Several waste management options can contribute to circularity by keeping materials in use for as long as possible in this way (Zhu et al., 2021):

(1) Repurposing involves finding new applications for used batteries, such as using electric vehicle batteries for energy storage in renewable energy systems.

(2) Reuse entails utilising batteries again for the same purpose, extending their lifecycle.

(3) Recycling breaks down batteries to recover valuable materials like lithium, cobalt, and nickel, for the manufacture of new batteries.

To gain valuable insights into how to drive circularity within the Norwegian battery sector, we conducted a survey among key industry stakeholders. This survey aimed to identify current attitudes, challenges and effective measures towards fostering a circular battery value chain in Norway.

SURVEY METHODOLOGY

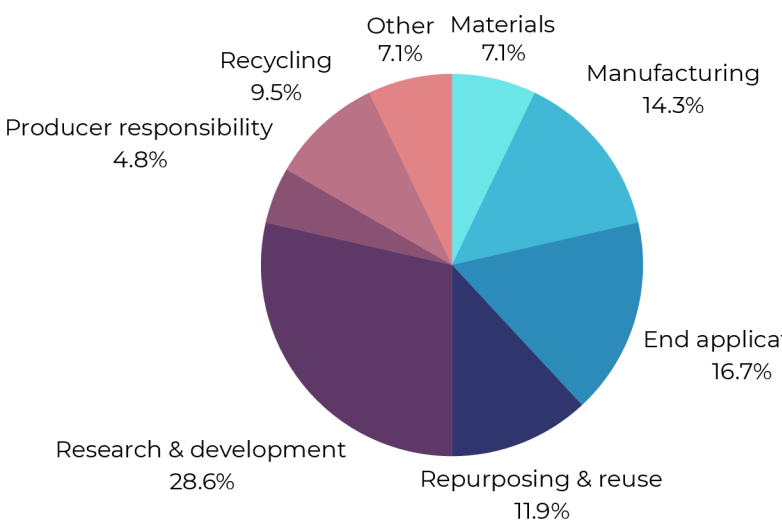
The survey was designed to explore various aspects of circular practices within the battery value chain in Norway. Respondents were selected to represent a broad range of national stakeholders from every sector of the battery value chain. This diverse sampling was intended to capture a wide array of insights and perspectives, which are crucial for a comprehensive analysis of the circular battery economy. Our online survey contained 16 questions and took around 10 minutes to complete. It was distributed using the SurveyXact platform in April-May 2024.

Invitations to anonymously participate were sent via email, ensuring a direct approach to potential respondents, which typically aids in increasing participation rates. While approximately 200 individuals were targeted for the survey, the response rate was lower than anticipated, with a total of 44 stakeholders participating. Nevertheless, the respondents represented a significant cross-section of the Norwegian battery value chain (*Figure 2*).

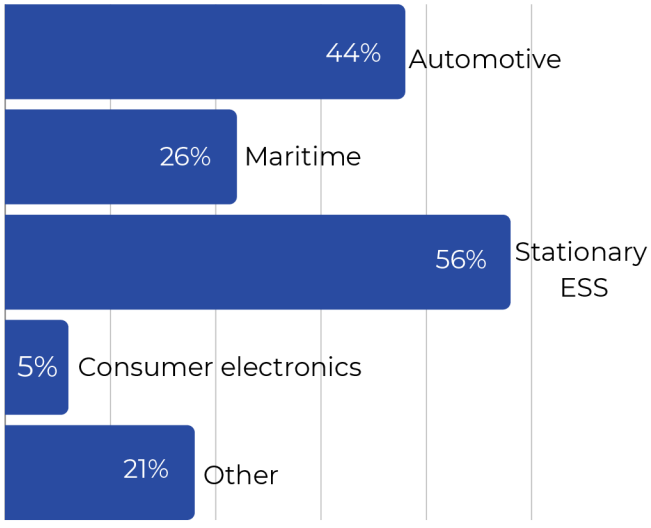
OUR AIMS:

- To gauge stakeholder engagement towards circular economy principles.
- To establish the position of Norwegian battery actors within the current regulatory environment.
- To identify barriers and incentives that could influence the adoption of CE practices across different sectors.

Figure 2: Distribution of respondents by battery value chain segment *(N=44)*.



Respondents, by battery sector (%)



Respondents, by end use for battery (%)

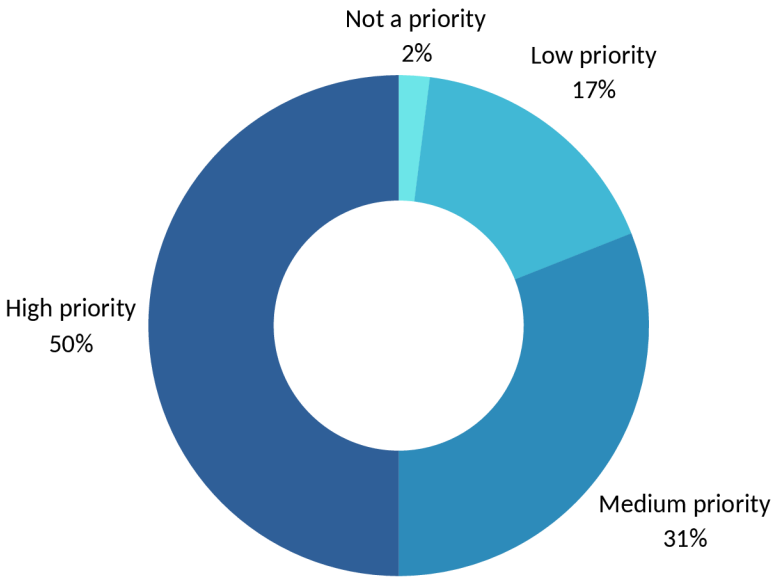
SURVEY RESULTS

In this section, the main findings from the survey are presented. It details how stakeholders across various segments of the battery value chain perceive and engage with CE practices, in addition to highlighting their motivations, barriers, and the impact of existing regulations on their operations.

A. Engagement in battery circularity

Our first set of questions aimed to determine how Norwegian battery stakeholders view circularity, whether they currently employ circular economy practices in their activities and which design features were most critical to facilitate such practices.

Circularity as an organisational priority



Level of priority amongst respondents (%)

On the whole, a significant portion of organisations appear to rank circularity highly in their battery-related activities (*Figure 3*). Half of respondents identified circularity as a "high priority" and 31% as a "medium priority".

However, the 17% of respondents with low priority and the single respondent with no priority at all suggest that there are still barriers and resistance to fully embracing circularity. Understanding the specific reasons behind this lack of prioritisation could help to develop targeted interventions.

Figure 3: How does your organisation prioritise circularity in battery-related prioritise?

Prevalence of recycled, repurposed or reused batteries

Our survey aimed to evaluate the extent to which circular battery waste management practices are being implemented within the Norwegian battery ecosystem. The findings reveal that 65% of respondents are actively engaged in activities involving recycled, repurposed, or reused batteries. However, 26% responded negatively, highlighting the need for better incorporation of circular EOL practices in industrial operations.

Focusing on the specific flows of batteries that undergo recycling, repurposing or reuse, we asked respondents to estimate the amounts of batteries handled by their respective organisations that undergo these EOL processes (*Figure 4*).

While approximately half of respondents were unsure about these quantities, recycling was the most prevalent EOL method from all positive responses. From all positive responses, an average of 44% of batteries handled were sent to recycling. On average for batteries with second life potential, 31% underwent the repurposing process. Meanwhile, 16% were prepared for reuse, as the least common EOL pathway.

Findings suggest recycling is the dominant EOL practice, but there is significant potential to increase battery repurposing and reuse. Improved tracking and reporting could provide clearer insights into battery lifecycles and support the development of a more circular battery economy.

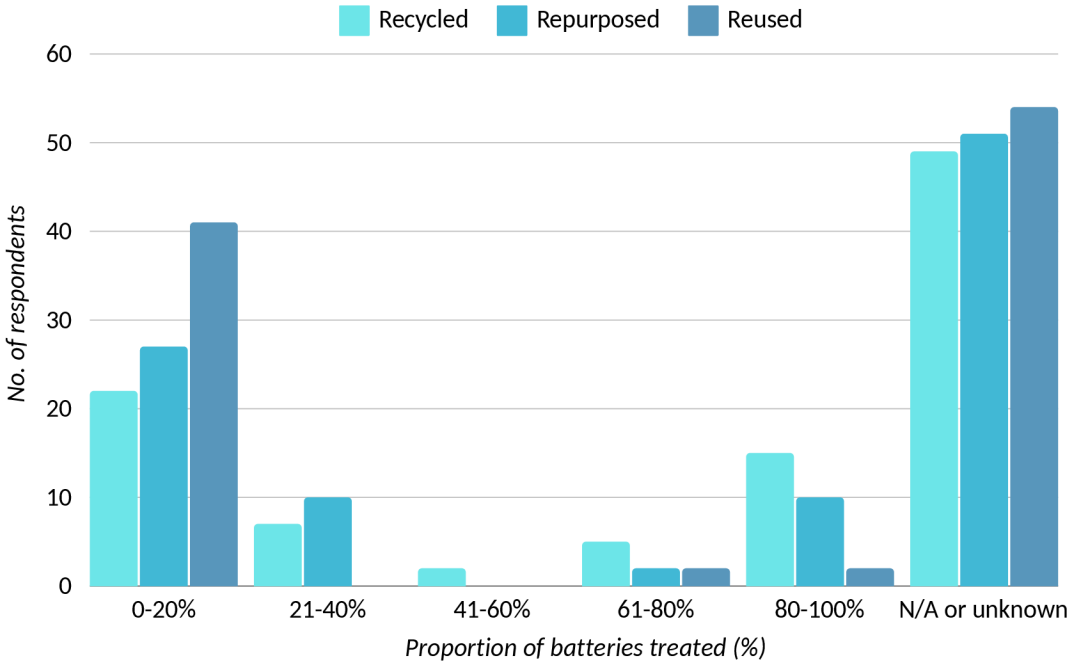


Figure 4: What proportion of batteries handled by your organisation are recycled, repurposed or reused?

Circular design solutions for batteries

The survey responses highlight several critical design features for enhancing battery recyclability and use in a second life (Picatoste et al., 2022). From all options provided, easy disassembly emerges as the most crucial aspect (weighted average score of 3.45). Easy disassembly allows for more efficient separation of battery components, facilitating the recovery of valuable materials and reducing waste. Such a feature not only supports environmental sustainability but also lowers the cost of recycling, making it a priority for both manufacturers and recyclers.

Another important feature is the ability to use recycled materials (weighted average score of 3.16). This underscores the importance of designing batteries that can incorporate recycled components, thereby closing the loop in the manufacturing process and reducing reliance on virgin materials.

Following this, the standardisation of pack architecture is a vital step for eco-design (weighted average score of 3.10). Standardised designs ensure battery packs are uniform in size and structure, simplifying the recycling process and reducing the complexity involved in handling and processing different battery types. Increased efficiency and lower recycling costs are also supported through reuse of battery components, with parts more easily interchanged and repurposed.

Other design features ranked:

"Labelling and marking of parts and materials" (3.09)

"Modular design" (3.01)

"Avoidance of toxic materials" (2.67)

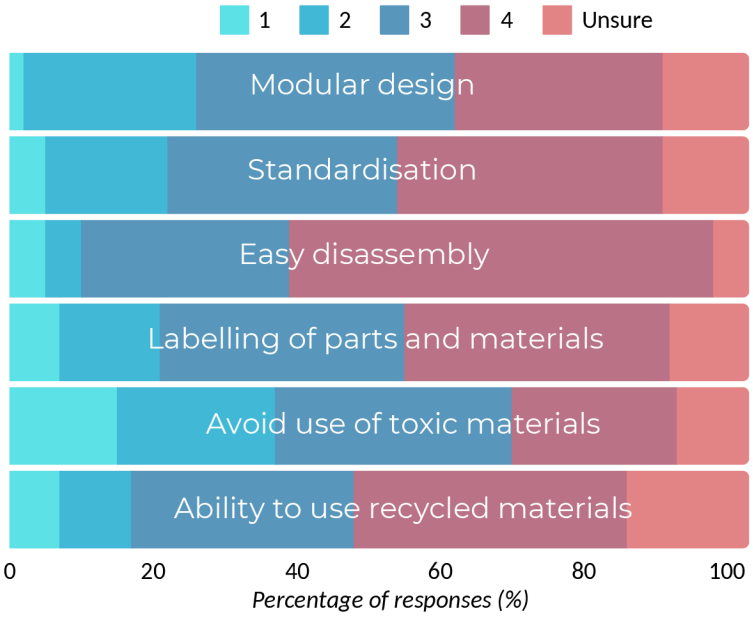


Figure 5: Which design features are most important for battery recyclability and reuse? *(1-4 = least to most important)*

B. Motivations and barriers towards circularity

This section delves into the motivations and barriers influencing Norwegian actors' engagement with circularity. In doing so, the results provide valuable insights into the dynamics shaping the transition towards a circular economy.

Main organisational motivations

To understand more about how stakeholders perceive the shift towards a more circular battery economy, the survey explored the key motivations held by stakeholders engaging with circularity.

Results indicate that 63% of stakeholders are most driven by the desire to reduce their ecological footprint, minimise resource depletion, and mitigate pollution associated with battery production and disposal. This suggests a growing awareness and commitment to addressing environmental challenges within the battery industry.

A significant 51% of stakeholders highlighted cost reduction as a key driver, thus highlighting the economic incentives driving engagement with circular battery solutions. In this way, adopting circular practices can offer battery actors with opportunities for improved resource utilisation, streamlined processes, and reduced operational expenses.

Innovation, highlighted by 44% of stakeholders, is seen as crucial for developing more sustainable battery technologies and EOL processing, which support the transition to a circular economy. This can position actors as technological leaders. The high number of survey participants working in R&D may contribute to the emphasis on innovation.

Other drivers indicated:

"Market demand" (30%)

"Profitability" (30%)

"Regulatory pressure" (16%)

"Pressure from consumers" (14%)

"Pressure from investors" (2%)

"Pressure from industry partners" (12%)

"International competition" (9%)

Key organisational challenges

In the path towards a more circular Norwegian battery value chain, stakeholders are confronted with multiple barriers that demand careful navigation and strategic intervention.

Nearly half (49%) of respondents identified the lack of standardisation as the main deterrent to pursuing circularity. The range of battery designs and chemistries exacerbate the complexity of EOL processing, making tailored approaches for efficient recycling and material recovery necessary. By deploying national regulations and frameworks from standards bodies such as IEC and ISO, the adoption of standardised components can be accelerated.

Similarly, technological barriers were cited as a challenge by 47% of survey respondents. Whether related to recycling processes, material recovery, or product design, technological hurdles may impede progress towards achieving circularity goals. Addressing these barriers likely requires investment in research, development, and innovation to overcome technical limitations and enhance the efficiency of circular practices.

The high costs associated with circular battery solutions also remain a concern for 40% of stakeholders. Improving the economic viability of such solutions could involve exploring cost-saving measures, incentivising circular practices, or improving economies of scale through collaboration and strategic partnerships.

Other barriers indicated:

"Limited expertise" (28%)

"Limited waste collection infrastructure" (28%)

"Lack of policy support" (28%)

"Consumer awareness" (14%)

"Safety concerns" (28%)

"Limited market development" (23%)

"Lack of opportunities for commercialisation" (16%)

C. Regulatory impacts on the battery value chain

Battery actors must navigate complex and multi-scalar political environments. By examining the key policy and regulatory measures affecting the Norwegian battery value chain, the results offer critical insights into the regulatory dynamics influencing battery actors.

Key policies and regulations identified by respondents:

International:

European Battery Regulation
European Sustainability Reporting Standards
IEC Standards

National:

The Waste Regulations – Discarded batteries
The Pollution Act
The Transparency Act
NEK-486:20211 – Safety requirements for secondary batteries and battery installations
NEK-400 – Electrical low-voltage installations
NEK-410 – Installations and equipment on board ships

EU battery regulation

Several of the above frameworks explicitly aim at encouraging a more circular and sustainable sector, including the EU Battery Regulation. However, respondents were unsure about the effectiveness of this particular regulation in most areas (40-43%) as illustrated in *Figure 6*.

Stakeholders feel the regulation best addresses traceability across the supply chain (49%). This transparency is crucial for identifying if batteries have been produced sustainably, offers insights into their use phase and accounts for flows sent to different EOL pathways. Labelling also had high ratings for effectiveness, with around half of respondents believing it was effective in addressing labelling for recycling (57%) and labelling for safety (47%). This was considerably lower in labelling for reuse and repurposing (18%), which reflects the high rates of uncertainty over how batteries in second life applications are addressed. Meanwhile, many believed the regulation did not adequately address access to materials (31%).

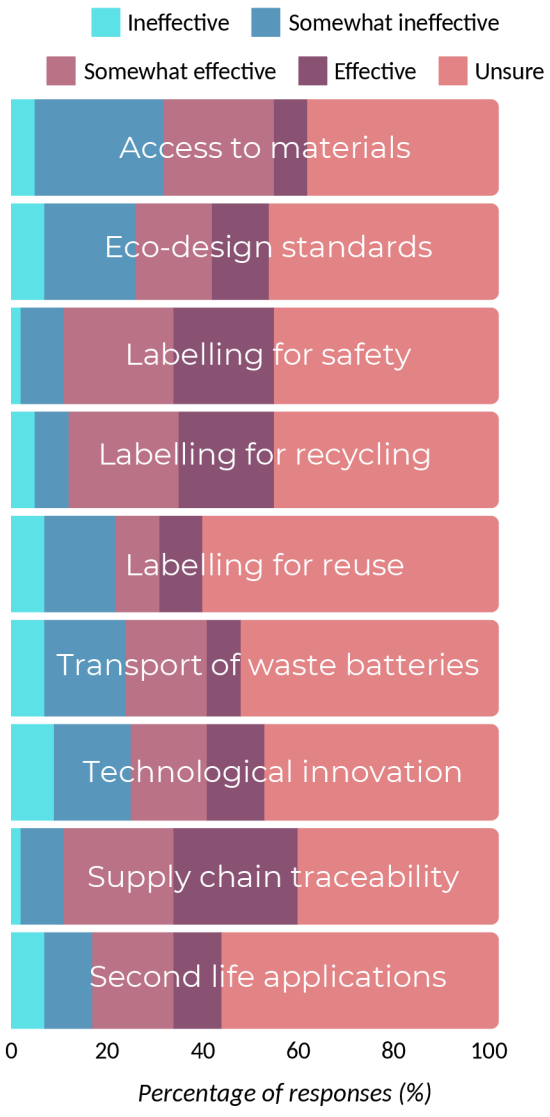


Figure 6: How well are the following areas addressed by the EU Battery Regulation?

These findings suggest that the EU Battery Regulation may be more effective at addressing the labelling and traceability of batteries, but there is still uncertainty over how it supports material security and alternative EOL approaches beyond recycling, including reuse and repurposing. As the regulation is still new, further data will be needed to assess its long-term effectiveness.

Digital battery passports

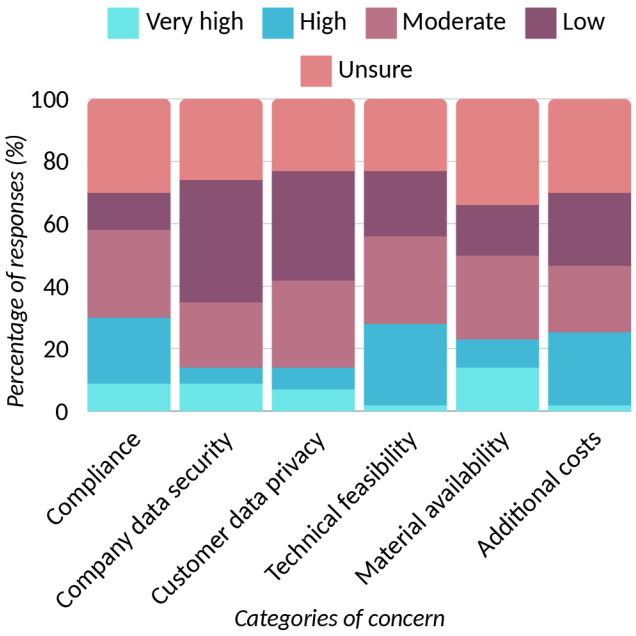
As part of the wider EU Battery Regulation, digital battery passports (DBPs) will be enforced for all batteries entering the European market from February 2027 onwards. This framework will track specific types of batteries across their entire lifecycle, including for those used in EVs, light means of transport and industrial batteries over 2 kWh. In total, the new passports will include 90 data points and are poised to revolutionise information sharing amongst battery actors (Berger et al., 2023). However, there remain significant challenges and uncertainty relating to their implementation (*Figure 7*).

The main concern held by stakeholders regarding DBPs include compliance and enforcement challenges, reflecting the difficulties in ensuring adherence to regulations and the effective implementation of monitoring and enforcement mechanisms. This suggests that clearer, more comprehensive guidelines are needed to facilitate DBP implementation and make different value chain actors aware of their responsibilities.

Figure 7: What level of concern do you have regarding implementation of DBPs?

Another high concern for battery stakeholders is material availability. Although DBPs help measure the flow of recycled materials, there may not be enough recycled materials to meet regulatory timelines. Further investment and research in EOL technologies may help to boost recycling capacity.

The technical feasibility of DBPs is also questioned, particularly due to the complexity of collecting necessary datasets and the lack of standardised data formats, which impedes efficient data exchange. Industry consortia and standards bodies must develop standards to address this issue. Additionally, DBPs introduce extra costs across the battery value chain, though the Battery Passport Consortium (2024) estimates potential cost reductions of 2-10% in procurement and 10-20% in recycling due to testing avoidance. In contrast, data privacy concerns are minimal, reflecting confidence in data management systems and successful precedents from other digital passport schemes.



Positioning within the global battery market

Regarding Norway's position in the global battery value chain, the survey results provide a nuanced picture. According to the data, 34% of respondents believe that Norway's position is relatively strong within the current regulatory environment, while 22% believe it is weakened to some degree. Notably, a significant portion (44%) are unsure or believe the impact is neither strengthened nor weakened. This uncertainty is further reflected in opinions about current policies and regulations towards a more circular battery economy.

On the international level, 42% of respondents somewhat agree that policies and regulations effectively support a circular battery economy, while 23% strongly disagree and 21% strongly agree. These mixed levels of support highlight the complexities and varying perspectives on how regulatory environments influence Norway's standing in the global battery market.

At the national level, 42% of respondents somewhat agree that Norwegian policies and regulations effectively support a circular battery economy, with 30% somewhat disagreeing and 14% strongly agreeing. This suggests that while there is general support for Norwegian state-led efforts, there is also room for improvement in the eyes of some stakeholders.

In line with this, there is significant support for the Norwegian state to take a more active role in the battery industry. Over half (53%) of respondents strongly agree that the Norwegian state should invest more financial resources into the battery industry, while 26% somewhat agree. Additionally, 70% of respondents somewhat agree that the Norwegian state should provide more funding opportunities for battery-focused R&D.

The demand for increased resources also translates to circular EOL options, with support for further investment in both battery recycling (67%) and second life applications (47%) underscoring the importance of a comprehensive strategy to build a circular battery ecosystem within Norway. By addressing these resource needs, Norway may be able to further enhance its position in the global battery value chain and solidify its reputation as a leader in sustainable battery practices.

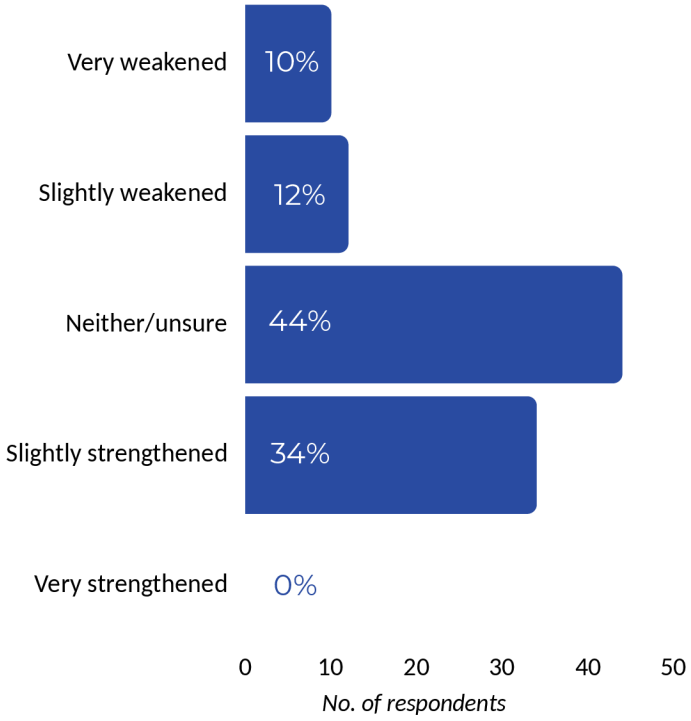


Figure 8: How is Norway's position in the global battery value chain affected by current regulations?

D. Incentives towards closing the loop

To support a more circular battery value chain, various incentives can be employed to promote more sustainable practices within the industry. The survey results highlight favoured measures to drive circularity nationally.

Looking forwards to the future

The path towards achieving circularity requires a multi-pronged approach with various measures. Tax credits and subsidies were most favoured, with 60% of respondents supporting them. These financial incentives enhance market acceptance by making circular solutions more economically viable for SMEs and other battery actors.

From a regulatory perspective, mandatory recycling (47%) and reuse targets (37%) were considered top priorities for integrating circularity into the battery sector. National legislation can complement the targets set out under the EU Battery Regulation.

R&D grants are also highly valued (42%), which reflects the importance of innovation in developing new technologies and processes for battery circularity. Existing mechanisms such as the Research Council of Norway, ENOVA, and Innovation Norway can continue to provide targeted support in this area.

42% of respondents highlighted the importance of extended producer responsibility, a key part of the EU Battery Regulation, which ensures that producers are accountable for the end-of-life management of their products and recognises second-life actors as responsible parties following the sale of batteries.

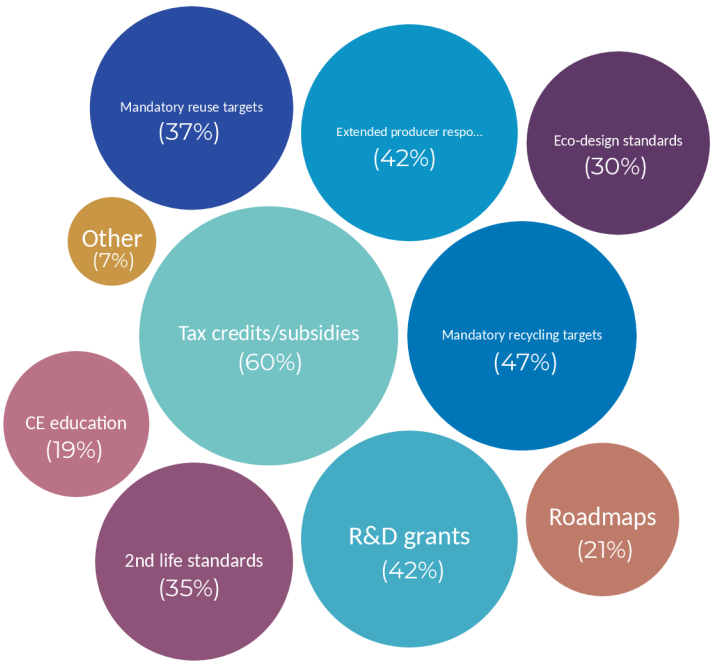


Figure 9: What are the most important incentives for a more circular battery value chain? (select 3)

(30%)

CONCLUSION

The survey findings provide valuable insights into the state of the circular battery economy in Norway. The results highlight that while there is strong engagement and progress across various sectors, significant challenges and barriers remain to achieving a truly circular system.

The high levels of stakeholder awareness and ongoing initiatives demonstrate Norway's commitment to integrating circular economy principles into the battery value chain. The repurposing and reuse of EV batteries emerge as promising avenues, with respondents indicating these will be critical focus areas going forward. Recycling capabilities also appear to be advancing, though issues around scalability and the development of waste infrastructure persist. Furthermore, several barriers impede the further widespread adoption of circular practices. These include a lack of standardisation, technological limitations, and regulatory gaps. Addressing these barriers through coordinated multi-stakeholder efforts will be essential to unlocking the full potential of battery circularity in Norway.

By aligning with upcoming EU legislation and drawing on national innovation capabilities, Norway has an opportunity to position itself as a global leader in sustainable battery management. Continued investment, policy support, and collaboration across the value chain will be crucial to turning the country's circular battery aspirations into reality. A holistic approach can Norway build a truly resilient and environmentally-responsible battery economy for the future.

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FURTHER INFORMATION

This paper is part of a three year RFF-funded research project with the ELAG Consortium (Exploiting the potential of spent electric vehicle batteries, Electric Agder). It includes collaborative efforts to determine how used EV batteries can be automatically processed for use in second life storage applications, along with partners BTG, Hydro, Elkem, Greenwaves, Greenstat, Batteriretur, Pixii and UiA.

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