Battery storage and carbon impact: the carbon cost and carbon benefit

09 June 2026

Do Battery Energy Storage Systems (BESS) avoid more carbon[1] than they create? It's the question at the heart of responsible energy storage, and one Harmony Energy Group (Harmony) takes seriously. Our BESS assets help support and deliver a lower-carbon grid that isn't reliant on fossil fuels or foreign imports, but their carbon footprint has to be weighed honestly against the emissions they displace. This article sets out how we calculate the carbon footprint and avoidance of our BESS assets, and what the numbers tell us about powering a sustainable future.

The Bigger Picture: Why the World Needs BESS

BESS are the backbone of a renewable energy future. They store excess power when it's abundant and release it when it's needed most, smoothing out the natural variability of renewables and ensuring a reliable, clean electricity supply. In practice, this means BESS help address some of the most pressing challenges facing modern electricity systems:

- **Homegrown energy:** BESS store power generated from a nation's own renewable sources, reducing dependence on foreign imports and shielding consumers from volatile global energy prices.
- **Curtailment:** BESS absorb surplus renewable energy that would otherwise be wasted.
- **Peak Demand:** They discharge during high-demand periods, reducing reliance on fossil plants.
- **Grid Stability:** BESS keep the grid stable and resilient by providing balancing services.

BESS are becoming more important as power systems integrate higher shares of renewable energy, increasing the need for flexibility, balancing and storage. At the same time, electricity demand is rising rapidly as homes, vehicles and industries electrify, meaning the grid has to do more than ever before. This is why global efforts to accelerate clean energy deployment are also driving a major push on storage: the International Energy Agency (IEA) says meeting the COP28 goal of tripling renewable capacity by 2030 will require a sixfold increase in global energy storage capacity.

Recent deployment shows strong momentum, with the IEA recently reporting that 108 GW of new battery energy storage capacity was added globally in 2025, around 40% more than in 2024. China, the US and Europe are leading this growth. But if battery storage is to keep pace with the scale of renewable expansion required this decade, progress will need to accelerate further.

Against this backdrop, the key question is not whether BESS matter to the energy transition, but how to assess their impact in full, starting with the carbon footprint of Harmony's activities and BESS assets, and then comparing that with the emissions the assets help avoid.

Harmony Energy Group's 2025 Carbon Footprint

Harmony's 2025 carbon footprint totals 55,570 tCO_2e, providing a clear baseline for understanding where emissions arise across the business.[2] This inventory covers Harmony's full corporate carbon footprint, including emissions from the organisation's corporate offices across the UK and EU, employee travel and

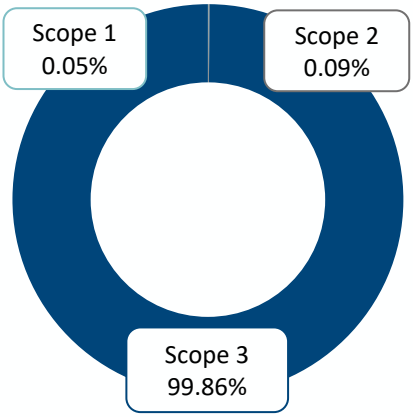
[1] In this article, 'carbon' has been used as shorthand for Greenhouse Gas (GHG) emissions.

[2] Harmony's 2025 GHG emissions inventory has been prepared in alignment with the GHG Protocol using the best available data and estimation methodologies. The results are based on available data, assumptions, and estimation methodologies at the time of reporting and are subject to inherent uncertainties and data limitations. The figures have not been independently verified or externally assured. Continuous improvement will be applied to future years to support the accuracy and consistency of Harmony's reporting.

homeworking, procurement activities and most notably, emissions from Harmony's majority owned BESS assets in construction and operations.

A breakdown by scope shows that almost all emissions sit within Scope 3, with Scope 1 and 2 emissions making up only a negligible proportion of the total footprint:

- Scope 1: 28 tCO_2e (0.05%)
- Scope 2: 49 tCO_2e (0.09%)
- Scope 3: 55,493 tCO_2e (99.86%)

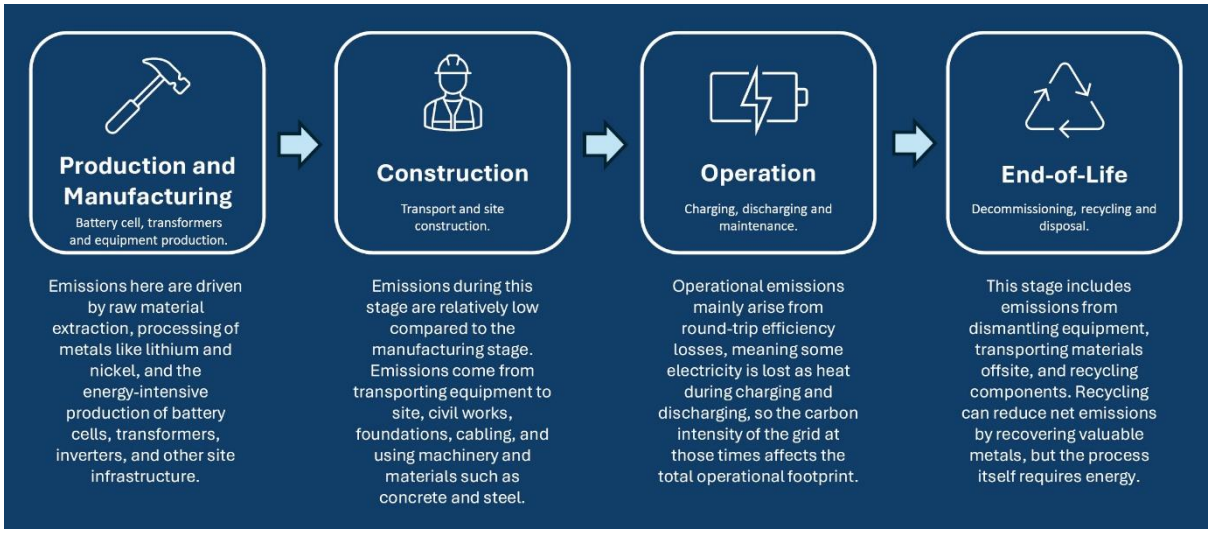


- Scope 1 covers all direct greenhouse gas emissions that a company creates from sources it owns or controls. Harmony's 2025 Scope 1 emissions are from refrigerants at Harmony's offices.
- Scope 2 includes indirect emissions from the generation of purchased energy. Harmony's 2025 Scope 2 emissions are from electricity and district heating and cooling consumed at Harmony's offices, and emissions from on-site electricity use and on-site losses at our operational BESS site.
- Scope 3 includes all other indirect emissions that occur upstream and downstream a company's value chain. Harmony's 2025 Scope 3 emissions are from the purchased goods and services and capital goods – emissions from the BESS equipment (battery megapacks, transformers and other equipment) construction materials, equipment and activities, and other company-related purchased goods and services. Other Scope 3 emissions are from Harmony's business travel, employee commuting and homeworking, waste from offices and energy losses and use from the operational BESS site.

Within Scope 3, the dominant contributor is capital goods, particularly linked to the procurement of BESS assets and equipment, reflecting the company's focus on procurement and construction activities during 2025. These emissions dwarf operational emissions, underscoring that in 2025, the carbon impact of Harmony's activities is primarily embedded upstream in its infrastructure rather than in day-to-day operations. The distribution is significant because it informs how Harmony approaches decarbonisation. Although the majority of our emissions are concentrated in the supply chain, we recognise the importance of decarbonising our own operations, for instance, at our offices and business travel. In future, if more of Harmony's projects become operational, carbon emissions associated with the operational phase are expected to form a greater proportion of Harmony's overall carbon footprint.

The Carbon Footprint Versus Carbon Avoidance of BESS Assets

Understanding the detailed product carbon footprint of BESS assets enables a more complete evaluation of both the embedded and operational cost and the long-term carbon avoidance benefits delivered by these assets. So, where exactly do these emissions come from?



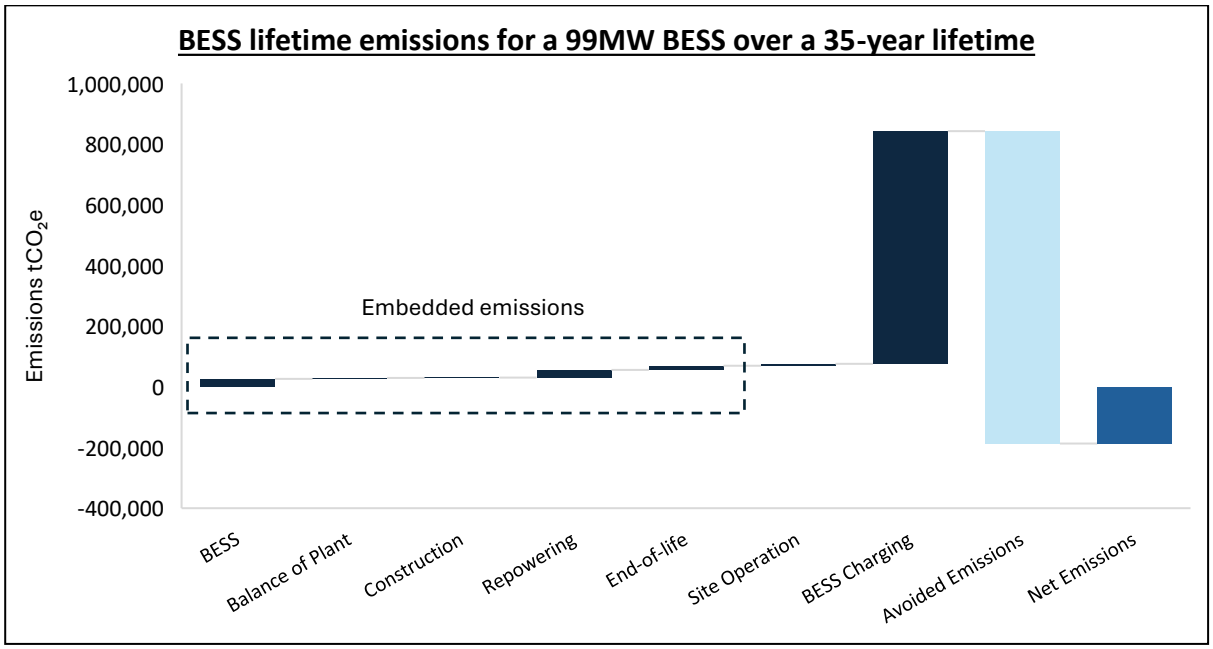
To understand the product carbon footprint and avoided emissions of our BESS assets over their lifetime, Harmony recently commissioned Anthesis, a third-party sustainability advisor, to conduct an independent technical assessment and understand the avoided emissions of one of Harmony's managed 99MW UK BESS assets over a typical 35-year[3] lifetime.

The real payback of BESS assets comes through the energy they store and discharge into the electricity system. BESS avoid emissions by charging when grid electricity tends to be lower carbon and discharging when demand would otherwise typically be met by higher-carbon generation sources. When a BESS charges during periods of abundant, low-carbon power, typically during high wind and solar output, it stores electricity that would otherwise be curtailed or undervalued. Later, during peak demand, the battery often displaces higher-carbon generation such as gas peaking plants.

Through calculating the product carbon footprint and avoided emissions of a 99MW BESS, the results show that:

A 99MW BESS asset in the UK has estimated net emissions of approximately -186,690 tCO2e and can expect a 4 year payback period

when forecasting the avoided emissions using historic avoided emissions data. These results are sensitive to the forecast grid emissions intensity and avoided emissions methodology.[4]



The BESS asset carbon payback time of approximately four years demonstrates a short carbon payback period and provides clear evidence that the assets deliver net climate benefit over their operational life.

Across the portfolio of BESS assets that Harmony manages on behalf of third parties, the company is also calculating annual avoided emissions using actual measurements of the net energy position, grid

[3] The BESS 35-year lifetime is aligned to the Aurora forecasted curves for a BESS asset from 2026 until 2060, therefore a 35-year lifetime.

[4] Sensitivity analysis indicate that the payback period varies between 2-9 years. These variations are a result of the projected grid emissions factor and avoided emissions scenario model selected. Anthesis supported Harmony with a screening-level carbon footprint and avoided emissions calculation based on available data provided by Harmony and agreed assumptions. The analysis should not be interpreted as, third-party assurance, verification or certification.

emissions intensity and electricity prices at 30 minute intervals inline with industry best practice[5]. For the 10 UK BESS assets Harmony managed in 2025, the renewable energy stored and exported was **129,106 MWh** and carbon avoided was **36,831 tCO2e**.

Lowering the Carbon Impact of BESS

As the battery storage sector grows rapidly, improving the net carbon impact of BESS will depend on a combination of industry-wide innovation and practical steps companies can take within their operational influence. Industry levers to reduce the carbon footprint of BESS span across the lifecycle of the assets:

- **Circular design principles:** Embedding circularity into the design of batteries, making them easier to recycle and recover valuable materials.
- **Chemistry shifts:** Transitioning to lower carbon BESS technologies such as sodium-ion batteries.
- **Second-life batteries:** Repurposing batteries for stationary storage.
- **Low-carbon materials:** Using recycled metals and sustainable supply chains.
- **Cleaner manufacturing electricity:** Sourcing renewable power for battery production.
- **Sustainable construction:** Reducing the carbon impact and improving the environmental management on construction projects.
- **Higher energy density and longer life:** Enabling more energy per unit material, and longer operational lifespans.
- **Smarter dispatch algorithms:** Optimising when and how batteries charge/discharge to maximise carbon benefit.

While many of the biggest carbon impact reductions of battery storage will depend on wider changes across material extraction and processing, manufacturing, power systems and recycling infrastructure, Harmony is working to reduce its operational emissions, working with suppliers and industry peers to identify opportunities for lower-carbon materials, cleaner manufacturing processes, responsible recovery, reuse or recycling of battery assets at end-of-life and advocating for more transparent supply chains.

The Verdict

A battery energy storage system does have a carbon footprint, but the data shows they avoid significantly more than they emit. Harmony's 99MW asset reaches carbon payback within approximately four years, and continues delivering meaningful emissions savings long after. So does a BESS avoid more carbon than it creates? The answer, clearly, is yes. And at grid scale, that makes BESS one of the most powerful tools available for supporting a clean, reliable, and resilient energy system.

[5] Harmony uses a BESS carbon avoidance methodology developed and endorsed by the Electricity Storage Network (ESN) in 2025. The methodology utilises system price data to calculate the marginal emissions factor for each 30-minute settlement period. This marginal emissions factor is then applied to operational site data to calculate the resulting carbon emissions avoided. This methodology is preferred as it is robust, conservative, however still has limitations. Harmony will continue to work with the industry to strengthen the accuracy of the methodology.