4TU.RSC - Team NMi

Final Project Report

Sustainability Assessment of EV Chargers

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Introduction

As Europe accelerates toward carbon-neutral transport, electric vehicle charging infrastructure has become a critical component in ensuring sustainable mobility. While much attention has focused on vehicle emissions and battery regulations, the environmental performance of the charging stations themselves remains an underexplored frontier (De Felice, 2024). The Sustainability Challenge, launched under the 4TU.RSC Honours program in collaboration with NMi Group, seeks to bridge this gap by developing a clear, actionable framework for assessing and comparing the sustainability of EV charging stations.

The Challenge addresses a pressing need among manufacturers, regulators, and end users for transparent sustainability metrics that guide design and procurement decisions (NMi, 2025). Our business case centres on providing a tool that balances scientific rigour with practical usability, empowering stakeholders to evaluate charging solutions across multiple life-cycle dimensions without requiring full in-house LCA expertise.

This report first details our methodological choices, how the team defined the scope, selected key subsystems, and crafted a seven-parameter scorecard based on stakeholder inputs (Methodology). Next, results are presented of our technical analysis and preliminary scoring (Results), followed by a discussion of the implications for industry practices and policy (Discussion and Limitations). The conclusion summarises the findings and leads into concrete recommendations for implementation and further refinement of the sustainability framework (Conclusion & Recommendations).

Methodology

Objective and Research Questions

The initial goal of this project was to conduct a detailed sustainability assessment of a real-world Electric Vehicle Charging Station (EVCS), working in collaboration with NMi and their client ProDrive. The team intended to use internal data, such as bill of materials, manufacturing processes, and energy profiles, to conduct a component-level Life Cycle Assessment (LCA) and translate that into an accessible, visual sustainability profile.

However, due to delays in engagement and confidentiality constraints, we were unable to obtain the necessary product-specific data. This limitation prompted a strategic pivot: rather than assessing a specific product in-depth, we shifted focus toward developing a generalised, questionnaire-based tool that could work with publicly available or self-reported data. The revised goal became to build a flexible, scalable framework that enables manufacturers and stakeholders to quickly evaluate the sustainability of EVCS components without requiring detailed LCA expertise or sensitive internal data.

Project Objective

To design and validate a lightweight, usability-focused sustainability assessment tool for EVCS components that:

- Works with limited or self-reported data
- Covers key environmental and circularity dimensions
- Generates clear visual outputs (e.g. radar charts)
- Enables early-stage product comparison and supports design improvement

Research Questions

1. Which sustainability dimensions are most relevant when evaluating EV charging station components?
2. How can these dimensions be translated into measurable and objective criteria, especially when detailed data is unavailable?
3. What format or tool design ensures usability and comprehension by industry stakeholders?
4. How can the tool provide meaningful feedback while balancing accessibility with technical integrity?

Outcomes of the Engagement and Investigation Phases

The initial scope of the project aimed to conduct a detailed sustainability assessment of an EV charging station component using real product data from ProDrive, facilitated by NMi. We expected access to component-level technical documentation, manufacturing details, and life cycle data to inform a robust LCA-based analysis. However, as the investigation progressed, several constraints, most notably confidentiality limitations and delayed engagement with ProDrive, meant that these inputs were not available. This challenge became a turning point and ultimately reshaped the direction of our project.

Rather than focusing on a deep assessment of a specific product, we pivoted to designing a generalisable framework that could be applied across EVCS products using either public or self-reported data. This decision emerged from both necessity and insight: we recognised that many companies, especially smaller manufacturers, often lack the resources or access to full LCA (NMi, 2025). There was a clear need for a lightweight, easy-to-use tool that could still deliver valuable sustainability insights early in the product development process.

During the engagement phase, discussions with our university coaches and NMi stakeholders helped refine our understanding of what “sustainability” means in this context. We explored a range of existing assessment methods, including LCA, carbon footprinting, and circularity frameworks, using this research to define six core dimensions for our tool: repairability & modularity, durability, circularity, material criticality, carbon impact, and energy efficiency.

Additionally, reviewing the Environmental Product Declaration (EPD) of XCharge’s C7 EV charger allowed us to simulate how sustainability data might be reported and interpreted (EPD-Norge, 2023). This supported the development of our scorecard and validated the kind of information that manufacturers are likely to provide voluntarily. These investigations led to three major outcomes:

1. The conceptual shift is from an in-depth analysis of a single charger to a flexible, multi-use framework for diverse products.
2. The definition of a structured set of sustainability indicators, grounded in both literature and stakeholder needs, and
3. The foundation for a scoring and visualisation tool (radar chart) that allows results to be interpreted quickly and comparatively.

By the end of this phase, our team had established a clear direction and shared vision, aligned with stakeholder feedback and realistic constraints. These outcomes informed the design of the questionnaire and radar chart in the Act phase and ensured that our final tool was both technically informed and practically applicable.

Key Technical Decisions

Following our initial technical briefing with Samridh Sharma (Senior Expert EVCS, NMi), we elected to focus our in-depth analysis on DC chargers. Their higher power ratings, distinct power-conversion architecture, and regulatory gaps in fast-charging infrastructure promised the richest insights into material intensity, energy losses, and end-of-life challenges (Sharma, 2025). However, during the Act phase, stakeholder and mentor feedback indicated that a product-agnostic tool would serve a broader range of manufacturers and end-users. Accordingly, we re-scoped our final deliverable, transforming our radar-chart framework from a DC-specific model into a universal EVCS assessment tool. This decision preserved the deep technical rigour of our DC-charger analysis while ensuring the framework's applicability to both AC and DC charging stations.

Act Phase: Framework Design and Implementation

At the beginning of the project, the team focused on understanding how to evaluate the sustainability of EV charging stations practically and concretely. Initially, the team aimed to collaborate with ProDrive Technologies to access detailed product data and internal environmental insights. However, due to certain circumstances, it was not feasible, and the team had to find other sources. Thus, the publicly available Environmental Product Declaration (EPD) of XCharge, a manufacturer of similar EV chargers, was taken as a reference. This document gave insight into the types of sustainability information typically reported for EV charging systems, such as material composition, energy use, and end-of-life treatment. By reviewing this EPD, the team learned which environmental factors could realistically be assessed based on the kind of information that might be available in real-world situations.

In addition, the team also considered how to approach sustainability assessment in a way that companies could use. Tools like LCA were found to be too detailed, time-consuming, and complex for regular use throughout the process of product development. At the same time, the team was also aware that there was no simple way to report or compare across different components of a product. This led to initial discussions about the need for a clear and structured way to assess sustainability that would work even if only limited information is available. During this phase, radar charts were also explored as a possible visual tool to summarise and compare sustainability performance across different aspects. These early findings and challenges directly shaped the idea of developing a sustainability scorecard in the next phase, where specific indicators and a questionnaire-based scoring method would be introduced.

The Act phase represents the most critical point in the development of our sustainability scorecard framework, where we transition from a conceptual model into a practical and usable tool to evaluate the sustainability performance of EV charging station components. The scorecard was initially envisioned as a high-level matrix with the various components of an EV charging station, such as power conversion unit, enclosures, connectors, thermal management and communication systems, rated against six dimensions of sustainability:

1. <u>Repairability & Modularity</u>: Measures how easily components can be accessed, repaired, replaced, or upgraded with better parts.
2. <u>Durability</u>: Assesses whether components maintain performance over time under environmental stress.
3. <u>Circularity</u>: Considers the use of recycled materials, recycling options, and reuse/refurbishment potential.
4. <u>Material Criticality</u>: Evaluates the use of high-risk or critical materials and the potential for substitution with safer alternatives.
5. <u>Carbon Impact</u>: Evaluates low-carbon manufacturing, transportation emissions, and overall carbon footprint of the component.

6. Efficiency: Measures energy delivery efficiency, idle power consumption, and automatic energy-saving capabilities.

The selected assessment dimensions reflect key themes emphasised in the Ecodesign for Sustainable Products Regulation (ESPR), which proposes eco-design requirements across product life cycles.

While this structured approach successfully identified and prioritised key sustainability metrics in EV charger design, our team encountered a significant challenge regarding the subjectivity inherent in the scoring process. The current framework relies on human assessors to evaluate components using a 1-5 scale for various sustainability metrics, but without clearly defined and standardised criteria for each score value, different assessors often interpret the scales differently. For instance, if a component is being rated for its repairability, one assessor might consider the component “moderately repairable” and assign the score “3” to it, while the other assessor could give the same product design the score “2” or “4”, depending on their subjective judgment, knowledge or expertise in the field, or prior experience with similar products. Such variability in the assessment process highlights a fundamental limitation of the current framework, where the lack of objective scoring benchmarks threatens both the reliability of results and the tool’s overall credibility as a decision-making instrument. To solve this, a mechanism that could translate each abstract sustainability dimension into specific and answerable questions is needed, each with clearly defined and objective scoring criteria. This realisation led to the development and integration of a comprehensive questionnaire-based evaluation system.

The questionnaire was developed as a structured and scalable method to collect consistent and verifiable data about each component. Each question corresponds to one or more sustainability metrics and is formulated to yield a numeric score on a standardised 1–5 scale. Moreover, each score is linked to predefined and concrete descriptions to minimise guesswork. For example, under the “Repairability & Modularity” dimension, the question: “How easily can the component be accessed for repair or replacement?” uses a scoring system where:

1. Score 1 = Permanently fixed; repair not possible
2. Score 2 = Repair is possible only with proprietary tools
3. Score 3 = Difficult to access, but repair is possible with standard tools (e.g., Phillips screwdriver)
4. Score 4 = Component is relatively accessible and repairable with standard tools
5. Score 5 = Designed for quick field repair or part swap (e.g., modular parts)

By specifying criteria for each score, the questionnaire ensures that no matter who is filling it out, whether it is an engineer, sustainability analyst, or other roles, the result is objective and comparable.

The questionnaire consists of 29 questions spanning all six sustainability dimensions. Examples of questions include:

1. Availability of repair documentation and spare parts (Repair & Modularity)
2. Use of critical raw materials as defined by the EU (Material Criticality)
3. Environmental durability under heat, moisture, or dust (Durability)
4. Potential for component reuse or refurbishment (Circularity)
5. Use of low-carbon production methods, such as renewable energy sourcing (Carbon Impact)
6. Idle energy consumption and intelligent load management (Efficiency)

The questionnaire is structured into three main sections. It begins with 10 general questions about the firm, the unit of analysis, and any previous LCA work. The second section focuses on the five major components of an EVCS, assessed through 12 core questions. The components covered are: (1) Charging Cable; (2) Power Conversion Unit; (3) Cooling & Thermal Management; (4) Communication & Control Systems; and (5) Enclosure & Safety.

The second section concludes with three further questions on the overall energy efficiency of the EVCS, resulting in 63 individual data points, which later feed into the radar chart.

The final section addresses the firm's sustainability practices. Questions explore the firm's preferences when it comes to important dimensions such as carbon impact and cost, along with how the firm impacts the environment and society, both positively and negatively. The full list of questions can be found in Appendix A.

Once completed by the EVCS manufacturer, the questionnaire results populate a structured Excel document, initiating the analysis phase. The goal of this phase is to convert raw results from the questionnaire into a visual output: the radar chart. The radar chart serves as a visualisation diagnostic tool to identify areas where the product has strong sustainability and areas of weak sustainability.

To support this, the team developed an analysis template which takes the raw results in Excel and automatically converts the numerical score between 1-5 for each component for every question. In total, 63 individual data points across 15 core questions are used to generate the product's sustainability scorecard. With each core question targeting one (sometimes two) sustainability dimensions, the scores for all five components are normalised to obtain the overall score for each question. The score of each question flows into the sustainability scorecard, a set of six tables, one for each dimension.

Each table aggregates the scores of 1-4 core questions regarding the dimension to calculate the total dimension score. For example, the Repairability & Modularity dimension considers scores from three questions: Q11, Q12, and Q13. Once the component-level scores have been normalised to get the question score, these three question scores are plugged into the Repairability & Modularity scorecard table. From there, the average of the three scores is taken to attain a dimension score, which is used in the radar chart. This process is repeated for each of the six sustainability dimensions.

Once the dimension scorecard is completed, the radar chart is automatically created, visualising the product's sustainability profile. The following Results section dives into how to interpret the radar chart with an example.

Summary of Methodology: Timeline and Workflow

The Research Workflow Diagram outlines the key phases of the project, showing the chronological development of the sustainability assessment tool. It begins with initial stakeholder engagement and the identification of a gap in accessible tools for evaluating EV charging stations.

This is followed by the comparative analysis of existing methods such as LCA, carbon footprinting, and circularity assessments. Based on these insights, six core sustainability dimensions were defined, and a questionnaire with standardised scoring was developed to ensure consistency.

The responses feed into a radar chart, designed to visually communicate sustainability performance across components. The process concludes with internal validation using public data and the preparation of demonstration cases to show the tool's value and usability, while also identifying areas for future improvement.

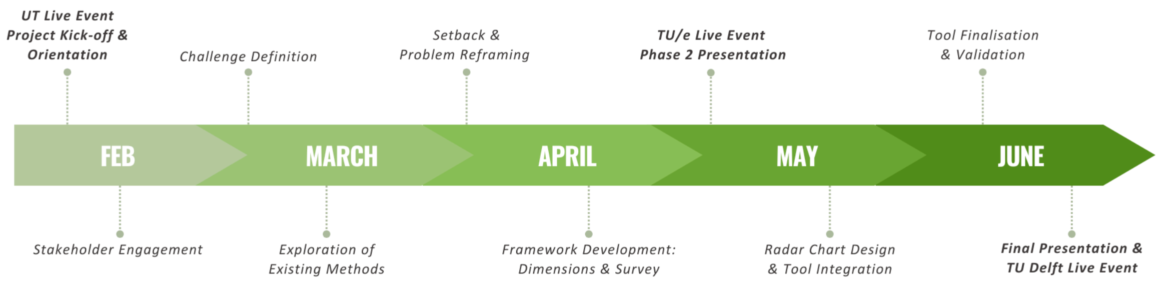

Figure 1: Research Workflow Timeline

Results

The goal of the radar chart is to present the EVCS manufacturer with an intuitive result, visually indicating areas of strength and weakness. Shaped as a hexagon and pentagon, the radar chart plots scores of the six sustainability dimensions and five components used in the EVCS. Each dimension has a minimum score of 1 and a maximum score of 5, with 5 representing optimal sustainability practices.

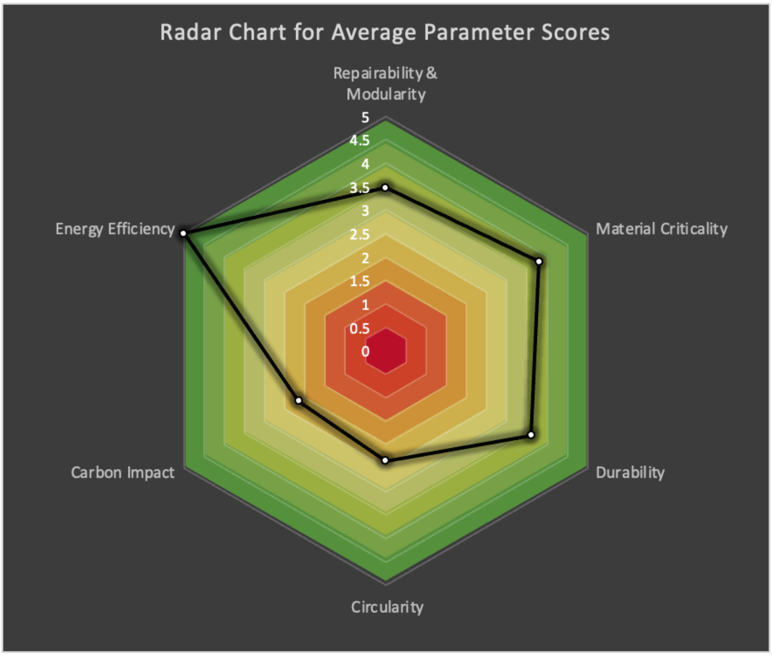

Figure 2: Radar Chart for XCharge's C7 Fast Charger

Using the data gathered for XCharge's C7 Fast Charger, the tool was put to the test. The survey was completed according to the data, and [Figure 2](#) shows the resulting radar chart. At first glance, a significant spike towards the energy efficiency parameter can be seen, indicating the charger is extremely efficient with a score of 5. For XCharge's engineers and management, the takeaway is that efficiency is currently sufficient. Moving clockwise, the C7 Fast Charger scores between a 3.5-4 for three dimensions: Repairability and Modularity, Material Criticality, and Durability. This middle-high score implies a neutral impact on sustainability, but room for improvement remains to become more sustainable.

Moving clockwise again, the C7 Fast Charger scores lower on the Circularity and Carbon Impact metrics. A score of 2.5 for Circularity reveals poor sustainability practices in terms of the reusability of materials, both materials incorporated into the product and the recycling of materials after the product's life. This is a dimension which XCharge's engineers and management should further investigate to improve the sustainability of their charger. Ways to improve this, for example, would be using less virgin materials in the product and replacing them with more recycled materials in the product. The Carbon Impact of the C7 Fast Charger is even less sustainable, scoring just above a 2. In large part, this low score is due to the 15,000km distance from XCharge's manufacturing facility in China to their primary market in Europe. Since carbon impact is a critical dimension for sustainability, XCharge could explore manufacturing closer to Europe or serving a market closer to China if they wish to keep their manufacturing facility there.

In addition to the radar chart for the overall EVCS, Figure R2 breaks the complete system down into scores at the component level. For this analysis, components are analysed on five sustainability dimensions, excluding the sixth, energy efficiency, as that pertains to the comprehensive system. This radar chart gives more pointed feedback to the manufacturer for each component's sustainability, which is useful when taking action to improve. For example, XCharge may take a look at their charging cable and communication/control systems, as those score poorly on carbon impact, circularity, material criticality, and durability. It should be acknowledged that these components do use more rare-earth minerals, which contribute to these low scores. On the other hand, XCharge can see that their enclosure/safety component's high score in material criticality translates to no dependence on materials such as rare Earth minerals. This component is also durable, but the low score in the repair & modularity dimension should prompt the manufacturers to take a closer look at how to improve their repair accessibility and modularity.

Further, Figure 4 shows the average sustainability score for each component, working together with Figure 3 to give pointed feedback on which components the manufacturer should focus on. The radar chart displays middle-of-the-road scores for the components, again with the aforementioned charging cable and communication/control system scoring the lowest.

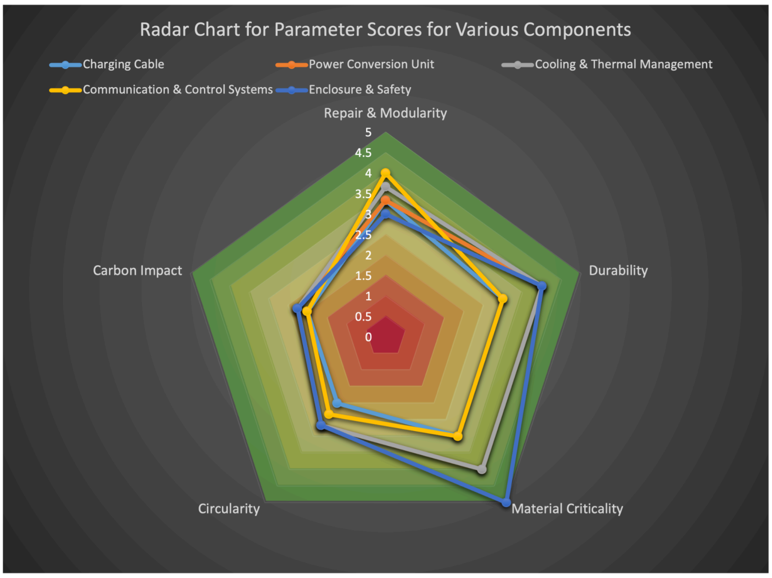

Figure 3: Parameter Scores by Component

Based on all three radar charts, XCharge's conclusion should be that while they offer a very efficient product, their carbon impact remains very high, and the product's end of life should be given more consideration to improve its circularity. Furthermore, the charging cable and communication/control system are main components contributing to the low scores in these categories, indicating the company should take a deeper look to see what improvements can be made to make their product more sustainable.

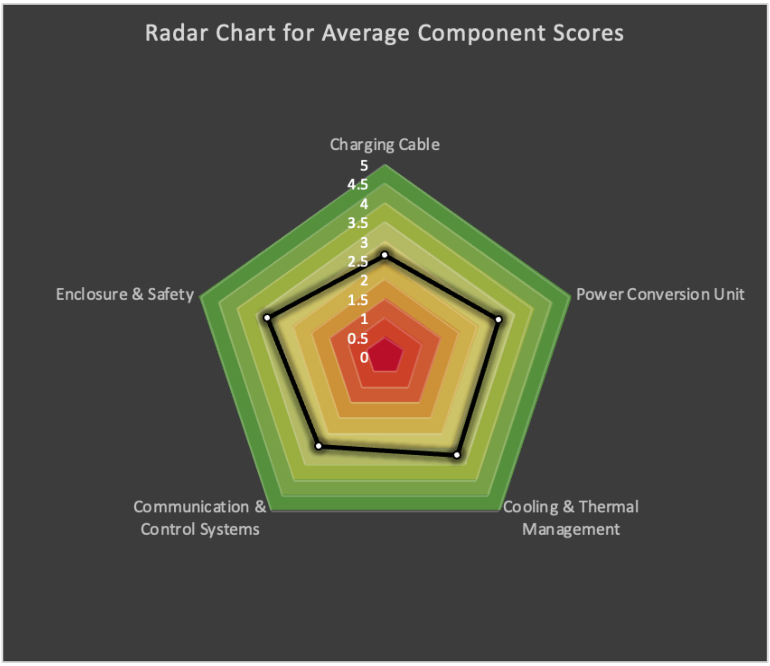

Figure 4: Component Breakdown Radar Chart of XCharge's C7 Fast Charger

Demonstration and Evaluation of the Framework

To evaluate and communicate the usability of our sustainability assessment framework, a live demonstration is planned for the final presentation. The purpose of this demonstration is twofold: first, to allow the audience to engage directly with the tool and experience its value in a realistic context; and second, to reflect on potential areas for refinement based on observed interactions and feedback.

The demonstration will feature a simplified yet fully functional version of the questionnaire-based tool. Participants will be guided through the assessment process for three selected EV chargers, each representing distinct sustainability profiles. These example cases (see Appendix B) have been prepared to highlight how the tool captures differences in design, material use, and life cycle considerations. Attendees will simulate the role of manufacturers or procurement decision-makers and input data to generate radar charts in real-time.

This hands-on format aims to validate both the logic and usability of the framework. While the radar chart visualisation is intended to support intuitive interpretation, the demonstration will allow us to assess whether the framework succeeds in delivering actionable insights to non-expert users. Observing audience engagement will also help us identify possible areas for improvement, such as question clarity, visual presentation, and user navigation.

Ultimately, the demonstration serves as a proof-of-concept for how the tool can be applied in early-stage product design and procurement processes. While it comes at the end of the course, the feedback and reflections gathered from this live test will be instrumental in shaping potential future iterations of the framework.

Framework Process Overview

The framework workflow diagram (Figure 5) illustrates the step-by-step process used to assess the sustainability performance of EV charging station components. It begins with user input, where manufacturers complete a structured 29-question survey aligned with six key sustainability dimensions. These responses are then processed using a predefined scoring system, where each answer is assigned a value from 1 to 5 based on clear criteria. The results are automatically aggregated by component and dimension using an Excel-based backend. This processed data is visualised through a radar chart, providing an intuitive overview of strengths and weaknesses across dimensions such as durability, carbon impact, and circularity. The final step involves interpreting this visual output to inform design decisions, identify areas for improvement, and enable transparent comparisons between products.

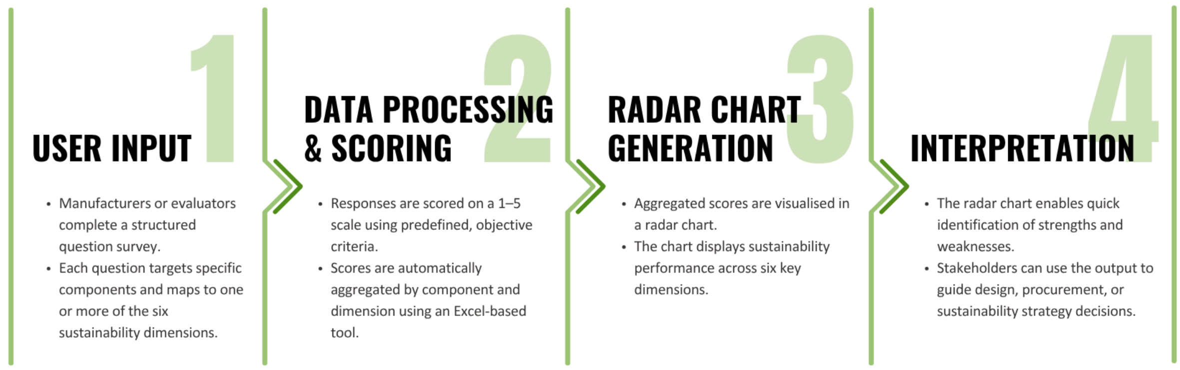

Figure 5: Framework Workflow Diagram

Discussion and Limitations

One of the main limitations of the project was the timing of access to industry-specific data. Although we had continuous engagement with our main stakeholder, NMi, the intended connection with ProDrive, a potential data source and benchmark for the framework, occurred too late in the process. Earlier access to ProDrive's data could have significantly facilitated our research, supported more informed decisions, and potentially shaped the framework around a real-world product case. Instead, we used the publicly available Environmental Product Declaration (EPD) of the XCharge C7 Smart DC Charger as a reference point to proceed with the development independently.

Time constraints posed another significant challenge. Balancing research, stakeholder communication, and tool development within the given timeframe meant that some steps were rushed. With more time, the framework could have undergone deeper research, broader validation, and more user-friendly refinements.

Additionally, the purpose of the framework shifted during the project. Initially, we aimed to create a tool that would translate detailed LCA data into an intuitive radar chart for non-experts. However, following conversations with NMi, the framework evolved into a self-report-based preliminary assessment tool. While this made the tool more accessible and faster to apply, it came at the cost of quantitative precision and depth typically associated with full LCAs.

The framework also simplifies core LCA concepts. Emission factors, which vary depending on location, technology, and process, are generalised in our model. Furthermore, the reliance on self-reported data introduces the potential for bias, vague responses, and inconsistencies, especially in the absence of formal documentation or third-party verification.

It is also acknowledged that the use phase of the product is only indirectly captured. While energy efficiency metrics address part of this, broader impacts like grid carbon intensity or regional operational contexts are not included. Similarly, the framework does not disaggregate the charger into detailed subcomponents, which may mask important sustainability differences between parts such as housing, cabling, or electronics.

Another assumption in our design is that radar charts are more intuitive for quick interpretation and comparison than technical LCA reports. While this assumption is based on our own experience, it may not hold for all stakeholders and could affect the effectiveness of the communication.

Lastly, the framework allows for relative comparison between similar products but does not determine whether a product is "sustainable" in absolute terms. This reflects the broader challenge in sustainability assessment: the absence of universally accepted thresholds or definitions that separate sustainable from unsustainable designs.

Conclusion

The project set out to address a growing need for transparent and accessible sustainability assessment tools in the EV charging industry. In response, a structured, questionnaire-based framework and radar chart visualisation were developed to evaluate the environmental performance of EV charging station components across six core sustainability dimensions. Our approach bridges the gap between detailed LCA and the practical needs of manufacturers, regulators, and procurers by offering a high-level diagnostic tool that can be used without specialised LCA expertise.

Through testing with publicly available data from XCharge, the framework proved capable of identifying key strengths and weaknesses as areas for improvement. The tool's greatest value lies in enabling relative comparisons and facilitating better design and procurement decisions early in product development cycles. The demonstration during the final presentation further reinforced its potential usability by showing how different inputs yield actionable insights, highlighting the framework's strategic role in early-stage sustainability evaluation.

Importantly, the project answered its central research question: How can a technically sound and stakeholder-friendly sustainability assessment framework for EV charging stations be developed? It also addressed the underlying sub-questions by: (1) investigating and comparing existing methods such as LCA, carbon footprinting, and circularity assessments; (2) identifying key sustainability parameters relevant to EV charging station components; and (3) translating those into a practical, scalable evaluation tool based on structured questionnaires and clear scoring logic.

However, the project also revealed several limitations, including time constraints and the reliance on simplified and self-reported inputs. While the framework enhances accessibility and early-stage decision-making, it sacrifices analytical depth, precision, and full LCA rigour. The late engagement from ProDrive and limited data availability further emphasised the need for tools that can operate even when comprehensive data is not accessible.

Despite these challenges, the tool presents a strong foundation for further development. It demonstrates that meaningful sustainability assessment can be made both comprehensible and usable, even in complex technical systems. Future work can build on this by refining score definitions, increasing component-level granularity, integrating third-party validation, and aligning the tool more closely with emerging policies such as the Digital Product Passport and Ecodesign regulations.

In sum, the framework shows that simplified sustainability assessments, when thoughtfully designed, can empower more responsible design and procurement decisions. It offers a promising pathway toward embedding sustainability as a practical consideration in everyday industrial practice.

Recommendations and Future Directions

To enhance the practical value and applicability of the framework, several improvements are recommended.

One area for development is the expansion of the charger database to include a wider variety of products and manufacturers. This would support benchmarking, allowing comparative insights, and help validate the tool across different charger types and market segments. With more diverse input data, patterns in sustainability performance could emerge that are not visible when relying on a single reference product.

Another promising direction involves exploring the framework's potential as a foundation for sustainability certification or labelling. Although it currently serves as a rapid assessment tool, aligning it with formal certification schemes or recognised industry standards could boost its credibility and adoption. This would involve refining score thresholds, integrating third-party verification, and ensuring compatibility with relevant policy frameworks such as the Ecodesign Directive or the CSRD.

The questionnaire already collects data on Digital Product Passports (DPP), but this feature is not yet linked to scoring. Integrating DPP information more systematically would enhance the framework's interoperability with broader digital infrastructure and improve traceability across the product lifecycle.

Opportunities also exist to better leverage LCA data. Where available, verified LCA results could be used to inform or cross-validate parameters like carbon impact, bridging the gap between simplified, survey-based methods and rigorous environmental assessments without sacrificing usability.

To ensure transparency and adaptability, the framework would benefit from publishing clear weighting guidelines for radar chart parameters. This would help users understand how final scores are derived and make it easier to tailor the tool for different stakeholder needs or product categories. Introducing adjustable weights could also enable broader application across varying contexts.

Lastly, while the framework currently focuses on product-level attributes, future iterations could extend toward evaluating organisational strategy and sustainability readiness. For example, Quickscan v2.0 from NMi includes dimensions such as Strategy, Planning, Manufacturing, Transport, Use, and End-of-Life. Incorporating a similar strategic layer, either through added survey modules or integration with existing tools, could help assess not only the product's sustainability but also the alignment of the producing organisation's practices and priorities.

Appendices

Appendix A: Sustainability Questionnaire Table of Questions

	Parameter 1	Parameter 2	Question	Output	Input to Radar Chart?
1	General		Manufacturer Name	Open response	As background info
2	General		Product Name	Open response	As background info
3	General		Charger Type	AC/DC	As background info
4	General		Power rating at full load	Number	As background info
5	General		Has your company already conducted an LCA for this product?	Completed <-> Not completed or NA	No
6	General		If you have conducted an LCA, what was the functional unit of the analysis?	Open response	No
7	General		If you have conducted an LCA, was the assessment...	Open response	No
8	General		What were the results of the LCA? Which phases had the largest carbon footprint? How did these results impact your next steps?	Open response	No
9	General		What is the current status of this product's Digital Product Passport (DPP)?	Completed <-> Not completed or NA	No
10	General		Does your company conduct Value Chain Due Diligence and/or engage in Sustainability Reporting aligned with the European Sustainability Reporting Directive (ESRD) or similar?	Yes/no	No
11	Repair & Modularity		How easily can the component be accessed for repair or replacement?	Score 1-5	Yes
12	Repair & Modularity		Are replacement parts or repair documentation readily available?	Score 1-5	Yes
13	Repair & Modularity		Can components be upgraded to counterparts with superior performance?	Score 1-5	Yes
14	Durability		Does the component retain performance under long-term	Score 1-5	Yes

			environmental stress (e.g., heat, moisture, dust) without degradation?		
15	Material Criticality		Are any materials used in this component considered critical or at high supply risk according to the EU Critical Raw Materials List (or similar)?	Score 1-5	Yes
16	Material Criticality		To what extent can the materials used in this component be substituted with more abundant or lower-risk alternatives without significant loss of function?	Score 1-5	Yes
17	Circularity	Carbon Impact	To what extent does this component use recycled or bio-based materials instead of virgin/raw material?	Score 1-5	Yes
18	Circularity		Are closed-loop recycling or recovery systems available for the critical materials used in this component?	Score 1-5	Yes
19	Circularity	Carbon Impact	Can this component be reused or refurbished after its initial use?	Score 1-5	Yes
20	Carbon Impact		Is the component produced using low-carbon manufacturing methods (e.g., efficient processes, renewable energy use)?	Score 1-5	Yes
21	Carbon Impact		What is the typical distance from manufacturing site to point of distribution?	Score 1-5	Yes
22	Circularity		Do you offer a take-back or end-of-life return program for your chargers?	Score 1-5	Yes
23	Efficiency		Roughly what percentage of input power is delivered to the vehicle at full load?	Score 1-5	Yes
24	Efficiency		When idle, how much power does the charger draw as a % of its rated power?	Score 1-5	Yes
25	Efficiency		Does the charger automatically reduce its energy load when lightly loaded or not in use?	Score 1-5	Yes
26	General		For the following sustainability parameters, please rank them from highest (1) to lowest importance (8) for the company.	Ranked list	Potentially (if we use this ranking to weight parameters)
27	General		Does your company have a dedicated sustainability department? If so, what	Open response	No

		are the main roles and responsibilities?		
28	General	How does your company impact the environment and society, both positively and negatively?	Open response	No
29	General	Is there anything important that we missed in this survey?	Open response	TBD

Appendix B: Demonstration Cases

CHARGER A

URBANLITE 22

UrbanLite 22 is a compact AC charger built for urban settings like office parking areas. It has moderate repairability and uses standard components with some minor critical materials. It's assembled in Europe, but key electronics are imported from Asia.

Repairable with standard tools, but not easily accessible

Minor degradation over typical lifespan

Minor use of critical materials

Reuse possible with moderate effort

Smart. Sustainable. Efficient.

- Power Rating of 22 kW
- Only 5% Idle Power Draw

Figure 6: Demonstration Case: Charger A

Clean Green:

RURALMAX 150

Charger B

A powerful DC charger designed for highway corridors. Manufacturing is primarily done in East Asia, with full systems shipped to Europe.

- Power Rating: 150 kW
- Idle Power Draw: 4–5%
- Performs well under environmental stress

High Performance
High Footprint

- Low circularity
- Critical material dependent

CALL FOR REPAIRS

RECYCLE ONLY

Figure 7: Demonstration Case: Charger B

Figure 8: Demonstration Case: Charger C

Appendix C: Group Reflection

This group reflection focuses exclusively on our experiences during **Phase 3: the Act phase** of the project. It does not cover contributions made in earlier phases, which were documented in previous deliverables. During this phase, our team worked collaboratively to implement the planned actions, finalise our outputs, and ensure alignment with the project's objectives. The reflection below is based on individual member inputs recorded in the group task table, where each participant outlined their specific roles and contributions.

Group Member	**Role**	**Contribution**
Akhilesh	Technical Point of Contact	● Engaged directly with mentors and external stakeholders to gather actionable feedback ● Conducted focused research to support framework adjustments requested in the Act phase ● Drafted and iterated the initial survey questions that form the basis of our radar chart ● Defined and standardised each survey parameter to ensure clarity and consistency
Isabelle	Business Application of Framework	● Proposed a structured questionnaire system using 1-5 rating scale ● Developed the survey questions along with the scoring criteria ● Incorporated feedback to align the questionnaire with the ESPR ● Collaborated on refining the usability and functionality of the framework for business
Sawan	Business Application of Framework	● Investigated various methods of visualising data ● Developed survey questions for material criticality and carbon impact ● Designed and structured the sustainability scorecard for each component and for the overall system ● Developed and applied a correct weighting system following assessment rules ● Built multiple radar charts to visualise sustainability assessment scores over different parameters and components
Nazli	Usability of the Framework & Visual Communication	● Collaborating on refining the usability and functionality of the framework for businesses ● Refined the carbon footprint parameter: reviewed literature, adjusted question phrasing, and defined clear scoring criteria ● Revised the wording, structure, and logic of survey questions for clarity and non-expert usability

		Contributed to the overall structure of the questionnaire, including feedback on flow and logical grouping of dimensions ● Refined the radar chart design, including layout, labelling, and colour coding for better interpretability Designed the interactive demonstration setup for the final presentation to simulate real-world tool usage with visual representations of three EV chargers ● Contributed to the preparation of the final report, reviewing visuals, usability explanations, and integration of survey results
Ryan	Survey, Analysis, and Radar Chart; Stakeholder Point of Contact	● Collaborated with Isabelle to develop the survey questions along with the scoring criteria ● Designed and developed the EVCS Sustainability Questionnaire in Microsoft Forms ● Incorporated feedback to align the questionnaire with the ESPR ● Developed the Excel sheet to gather insights from the questionnaire results and automatically generate the Radar Charts ● Designed interactive activity during final presentation ● Took notes for each meeting ● Proactively communicate with coaches and external stakeholders

We maintained open communication, sharing progress, insights, and challenges regularly. This allowed us to work iteratively and adjust our approach as new information or feedback became available. While some tasks were primarily led by one or two individuals, the majority of our tasks were collaborative, ensuring that all perspectives were considered and that work was balanced across the team. Overall, our collaboration has been marked by flexibility and adaptability. We supported one another's contributions while working towards the project's main goals. Despite some setbacks in our motivation at times, we worked well together as a team, and this collective effort helped reignite our drive and kept us moving forward.

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