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Maximizing the sustainability of day-to-day services for power technology

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SUMMARY

The environmental impact assessment tool described in this paper is an innovative digital solution capable of measuring, evaluating and improving the environmental impact of power system projects and service execution, which contribute mainly to Scope 3 emissions (transport & distributions, machinery & materials, equipment, among others).

The tool is based on equipment Life Cycle Assessments (LCAs) and Environmental Product Declarations (EPDs), complemented by actual shipping data together with all the activities surrounding the project and service execution, such as machinery & tools, operation, teams' travel to site, construction materials, and consumables. Once the environmental impact of all activities has been assessed, the tool can be used to compare scenarios and propose alternatives to mitigate it.

This paper focuses on three main areas:

(1) **Sharing the background information** of the newly developed tool,
(2) **Evaluating real examples** of the environmental impact of project and service activities and the key conclusions of this analysis,
(3) **Presenting the contribution** of this innovative solution to advancing a sustainable energy future for all.

This paper calls for collaboration and innovative spirit between technology providers, system operators, universities, and start-ups. We must act together, given the urgency for a clean energy transition.

KEYWORDS

Carbon footprint, Global warming potential, environmental impact, substation, service, maintenance, project, HV equipment

1 Introduction

Companies worldwide are facing a growing demand to take measures against climate change. Recently, this has even reached the selection process for business and investment partners, as the commitment to reducing greenhouse gas emissions becomes a compelling selection criterion.

Nowadays, several solutions have been commercialized to measure the environmental impact of products during the different phases of their life cycle. However, a solution that focuses on quantifying the environmental impact of a project and service execution was not available. Such activities are very common in the power sector and, consequently, a relevant area to probe.

Given the complexity of these activities in the power sector, Hitachi Energy has developed an environmental impact assessment tool (hereinafter, the Tool) that enables companies to understand, measure, and optimize their environmental impact by assessing service or project execution data in a secure, reliable, and action-oriented manner.

With this innovative solution, the Global Warming Potential (GWP) and other environmental indicators of power grid service and project execution can be quantified, visualized, and analyzed.

This evaluation provides information and facts about the current status and potential quick wins and big-ticket actions that should be prioritized to lower the GWP and other environmental impacts during the execution of these activities.

2 The environmental impact assessment tool

The Tool is a user-friendly digital platform that allows companies to easily understand, quantify, and visualize the environmental impact of their projects and services related to high voltage substations, power quality solutions, and electro mobility charging infrastructure. In this section, we will explain the rationale behind developing this solution.

2.1 Background information

Understanding the environmental impact of products or companies is becoming more and more widespread in the energy industry.

LCAs and EPDs seek to evaluate the environmental impact of a product life cycle, from the extraction of raw materials, through production, distribution, use, and disposal to determine the environmental impact at each stage. Similarly, comprehensive solutions to report companies' environmental impact are available, with a strong focus nowadays on Scope 1[1] and Scope 2[2].

However, the execution of a project to build a new power system (e.g., substation or power quality solution) or the execution of any maintenance activity on that system is often excluded in the above-mentioned reporting alternatives, or accounted for at an insufficient level of detail:

- Product LCAs and EPDs reporting:
    - In these assessments, the installation of a product or group of products (project execution) or the maintenance (service execution) are generally overlooked, or estimated at an insufficient level of detail to provide actionable data.
    - The best-known software tools to measure this impact at the product level applying LCA methodologies cannot be readily applied to the impact of a project or service.
- Enterprise reporting:
    - As this reporting has mainly insights on Scopes 1 and 2, it fails to include neither the service nor the project execution that fall largely under Scope 3[3].
    - Even for those enterprise reports that also attempt to address Scope 3, such information lacks the adequate granularity to evaluate a specific project or service activity.

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[1] Scope 1 covers emissions from sources that an organization owns or controls directly, according to the GHG Protocol.

[2] Scope 2 comprises emissions that a company causes indirectly when the energy it purchases and uses is produced, according to the GHG Protocol.

[3] Scope 3 encompasses emissions that are not produced by the company itself and are not the result of activities from assets owned or controlled by it, but by those it is indirectly responsible for, up and down its value chain, according to the GHG Protocol.

Based on the aforementioned limitations, the new methodology and tool described in this paper, the Tool, introduces a holistic way of calculating CO_2 equivalent emissions for on-site project and service execution filling a gap in the technology landscape, by bringing together both the results of LCAs (defined in ISO 14040/14044[1, 2]) and EPDs and the carbon reporting and accounting standards described in the Greenhouse Gas Protocol (GHG Protocol[3]), which also justifies the rationale behind focusing on Scope 3 emissions.

The goal is to shift the product-oriented vision of LCAs to a project-based approach that focuses on the activities required to carry out a project. The first stages of LCAs are introduced as an input in the tool (raw materials extraction, processing, and product manufacturing). Furthermore, great attention is placed on all activities performed when executing a project or service (construction materials, consumables, teams' commute to site, and machinery operation), which are typically within a company's Scope 3 emissions according to the GHG Protocol.

2.2 Methodology

This new tool was created with three key requirements in mind:

- Shed light on a phase of products' life cycle often disregarded by existing solutions – Project and service execution,
- Be user-friendly, not requiring environmental professionals to fill in the information, so as to ensure easy reporting by any project or field service technician,
- Address challenges specific to the power sector: equipment, machinery, …

The methodology behind the Tool follows the GHG Protocol, which provides guidance for carbon emissions reporting. Moreover, the methodology described below has been reviewed by an independent accreditation company (DNV)[4] as per ISO/TS 14071:2014 [4].

The most relevant aspect of this methodology is that it has been developed by experts on power system projects and service execution who could translate that process into simple reporting building blocks that represent the core components of any of these activities (see Figure 1). The methodology also aims to translate accessible information into environmental data to facilitate the reporting process.

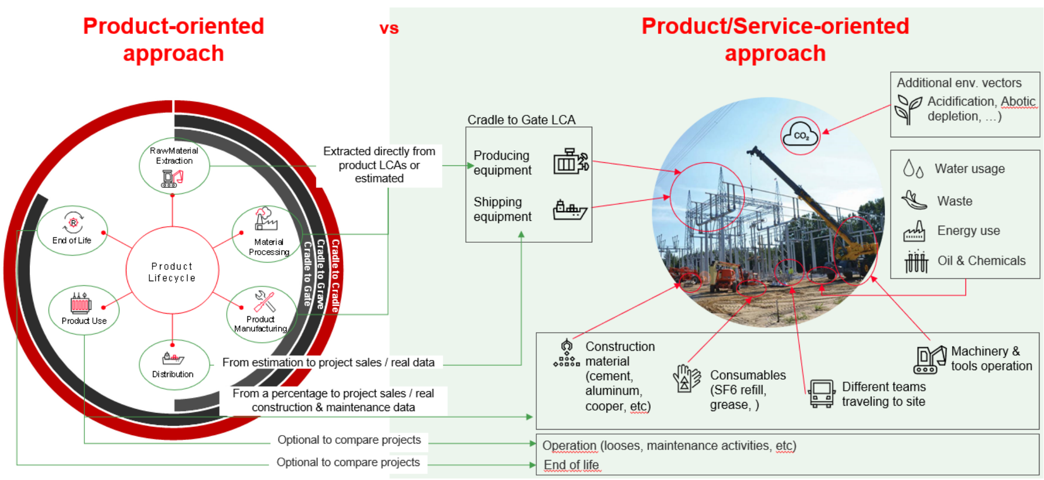

Figure 1:Illustration of interactions between a LCA and the methodology built in the Tool

The following subsections summarize the criteria considered under each of these building blocks.

[4] According to DNV, this LCA Study – Carbon Footprint Methodology & Report and, based on the assessed evidence, nothing has come to their attention showing that the LCA Study – Carbon Footprint has not been done in all material respects, in accordance with the principles of the standard ISO 14044:2006 "Environmental management — Life cycle assessment — Requirements and guidelines".

2.2.1 Equipment & Spare Parts

A strong record and database of LCAs and EPDs for different products (transformers, circuit breakers, …) and systems (substation, STATCOM[5], …) has been built in the past few years and is constantly being updated.[6]

Some of those LCAs and EPDs are conducted by internal consulting resources, using expert software database[5]; others are gleaned from public information, existing LCAs, and EPDs external to the organization.

This database (see Figure 2) includes information regarding raw material extraction, material processing, and product manufacturing. The rest of the information in the LCA or EPD is not deemed the real data of our project or service, but will be included in the other modules of the tool based on the actual project information.

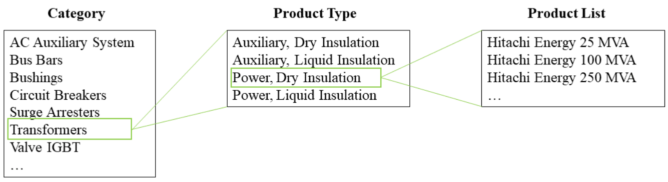

Figure 2: Illustration of options given to a user selecting a product.

Data gaps, equipment, or parts for which there no LCA or EPD is yet available are estimated using algorithms largely based on common scaling techniques which yield an estimation of the environmental impact for products for which an LCA has not been carried out.

The user will select the type of equipment and introduce its weight; the tool then computes this data and translates it into CO_{2eq} emissions and other environmental vectors.

2.2.2 Shipping

For each shipped item, data related to supply chain, mode of transport, and distance is gathered and specified in as much detail as possible to ensure the accuracy of the calculations. If unknown by the user, the tool determines distance based on origin and destination, and emission factors are applied to account for shipping type (truck, rail, sea freight, etc.) and shipment weight (see Figure 3). Multi-modal shipments are also easily introduced by the user base.[7]

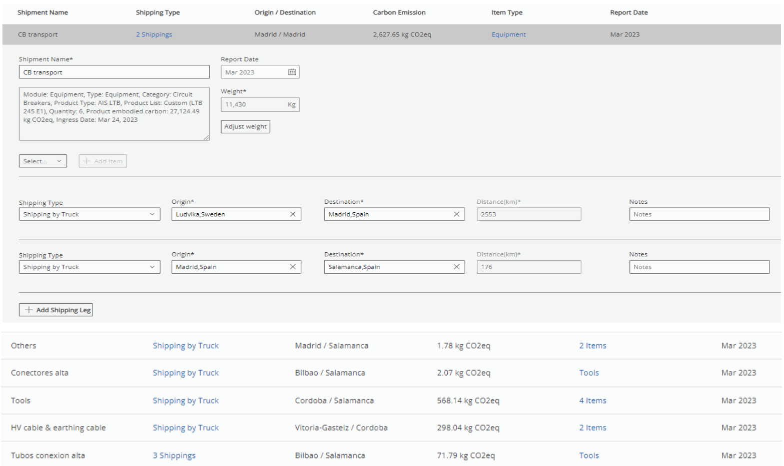

Figure 3: Examples of data introduced by users for the shipping.

[5] STATCOM: STATic synchronous COMpensation

[6] Equipment, spare parts and end of life data sources : based on Hitachi Energy's own LCAs (from Sphera database and Sphera LCA for Experts software) and publicly available LCAs and EPDs for other manufacturers' equipment.

[7] Shipping data sources: Sphera and GHG Protocol

2.2.3 Travel

Employees' travel also comprises a fair share of emissions, especially for service activities that do not depend heavily on equipment or construction material. We distinguish two groups: daily commutes and long-distance flights. The environmental impact is estimated considering the number of passengers/vehicles, number of journeys, transportation mode, and total distances.[8]

2.2.4 Consumables, Construction Materials, and Leakage

Depending on the project, consumables may be necessary. The environmental impact is estimated based on the weight or unit of the selected product, working days, and material production emissions. The impact from civil works is also estimated by the weight of construction materials and their production emissions; for instance, hundreds of tons of concrete and steel reinforcement are used on greenfield projects and must be factored into the total environmental impact.

Leakages might also occur during maintenance, installation, or commissioning due to mishandling and are also accounted for, if needed. SF_6 is an insulating gas used in high voltage equipment for which special care must be taken as its GWP is more than 22800 times greater than that of CO_2 (a leakage of 1 kg of SF_6 has the same GWP as 22800 kg of CO_2).[9]

2.2.5 Tools and Machinery

The use of tools and machinery, such as cranes or forklifts, might be necessary. In those cases, we evaluate the impact of different models of tools and machinery based on their type, the number of hours/days used, type of fuel, quantity, and/or regional electricity mix.

2.3 Additional Modules

To optimize the environmental analysis, the Tool also integrated three additional modules that go beyond the GWP of the project or service execution:

2.3.1 Site Usage

Information relative to site activities, such as water use/discharge, energy use (fuel for electricity generation, connection to grid), and waste production can also be collected using the Tool to complement the project or service execution environmental impact information.[10]

2.3.2 Operation

Based on the technical specifications of our products (i.e., losses, oil or gas leakages, …), emissions linked to their use can be determined according to equipment location and the associated grid emission factor. This module makes it possible to compare scenarios beyond the project or service execution. For example, for a "replace *vs* refurbish" project for a transformer, information regarding losses over the life cycle can impact the decision, even if the project execution impact for refurbishment is lower, inasmuch as the refurbished transformer can have higher losses.[10]

2.3.3 End of life

Decommissioning of our equipment or parts of equipment is also not to be ignored. Depending on the end of life solution (reuse, recycling, landfill, …) for each piece of equipment, the corresponding environmental impact is taken from their LCA or EPD.[6]

3 Real Case Analysis

3.1 Case 1: Project Execution

3.1.1 Case Description

The Tool can be used at any stage (from tendering to execution) of a project or service activity, providing accurate, reliable data to enable decision-makers to choose the most sustainable options for their projects. To demonstrate the effectiveness of this tool, a case study of a substation installation and commissioning project in Sines, Portugal, is presented in this section.

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[8] Travelling emission coefficient sources: GHG Protocol.

[9] Construction materials emission coefficient sources: Sphera database and ICE Database. Leakage sources: MIDEL and Sphera database

[10] Fuel, energy mix and operation sources: Sphera database.

The substation will have three bays with voltage levels between 400-150 kV; the GWP of the installation and commissioning using different solutions, such as air-insulated switchgear (AIS), hybrid insulated switchgear (PASS), and gas insulated switchgear (GIS) is compared. This study provides a detailed analysis of GWP associated with each solution and presents recommendations for the most sustainable option.

The findings of this study have important implications for the energy sector and demonstrate the value of using an environmental reporting tool to make informed decisions about sustainability. By presenting these results, we hope to contribute to ongoing efforts to reduce GWP and promote sustainable energy solutions.

3.1.2 Results

Following the methodology in section 2.2, all activities and equipment for each solution were included. The inhouse engineering and consulting teams provided the necessary data with an appropriate level of detail, as represented in Figure 4.

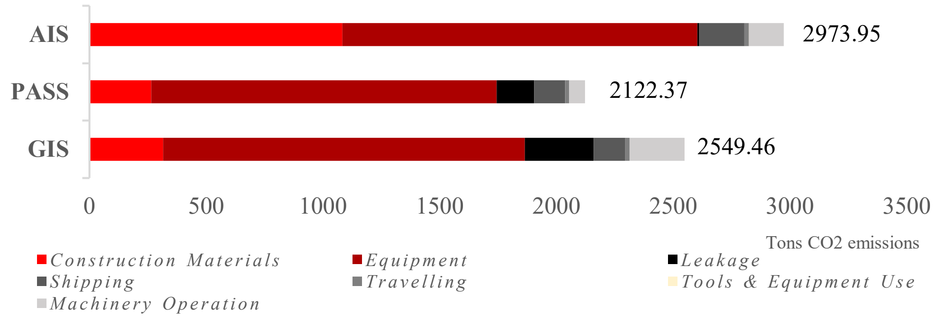

Figure 4: Overview of the case study results.

Based on the analysis, for this specific case, the hybrid solution (PASS) was found to be the most sustainable solution, as it required 10 times less space than the air-insulated switchgear (AIS) solution and used less SF_6 gas than gas insulated switchgear (GIS).

However, it is important to note that the lifetime GWP was not included in the study's scope, which should be contemplated in future studies to have a more holistic understanding of the solution's environmental impacts.

3.1.3 Alternatives/improvements

After conducting a thorough analysis of the GWP of various solutions, alternatives to diminish the GWP of this project can be identified and implemented. The proposed mitigation strategies may involve several options, such as:

- Substituting SF6 gas-dependent equipment with alternative gases like EconiQ gas;
- Implementing specific actions to shorten project execution time;
- Using recycled or green materials during the construction phase (e.g., green steel);
- Optimizing commissioning activities using our digital solutions (e.g., expert remote support),
- For the unavoidable remaining emissions, an optimized carbon removal and/or offsetting strategy can be implemented.

As described above, this reporting methodology can contribute significantly to reducing environmental impact while ensuring a cleaner and greener future for generations to come.

3.2 Case 2: Service Execution

3.2.1 Case Description

This second case seeks to illustrate how this reporting methodology can also be used during execution, highlighting hotspots and identifying areas for improvement.

The case study is a replacement of six 245 kV LTB circuit breakers in Salamanca, Spain.

The project is executed in six different interventions that include all the activities carried out for each of them, such as the equipment to be installed and its transport from factory to the site, all construction materials, workers commuting to site during all interventions, leaks during the installation, etc.

3.2.2 Results

The results revealed that the GWP of this project was 164 tons of CO_{2eq}. The tool identified the circuit breakers as the main sources of emissions (Figure 5), accounting for 63% of the total GWP. Additionally, construction materials (18%) and travel (7%) are unusually high for this type of activity that is equipment-intensive. The main reasons behind this result are:

- Construction materials include the manufacturing of steel platforms to access the circuit breakers drives as well as the bus bars and cables for HV connections.
- The planning of the activity with fewer working hours per day and subsequent installation of each breaker, result in more commuting days, both short and long distances.

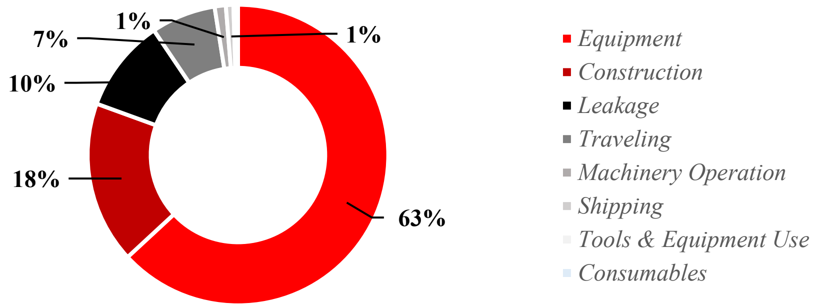

Figure 5: Overview of the second case study results.

3.2.3 Alternatives/improvements

After evaluating the GWP of this activity, the following recommendations were identified:

- For the equipment, no major recommendations can be made considering the customer specification. However, for future works, including this reporting in an early stage (tendering), product alternatives can be evaluated.
- Since travel comprised one of the hotspots, several actions were proposed, such as reducing the total execution days by optimizing the planning and using electric vehicles as means of transport.
- The impact of most of the building blocks (travel, consumables, machinery operation, …) could have been further reduced if the works on the six circuit breakers had been planned to be simultaneous.
- The construction environmental impact could be decreased by using recycled steel or green steel for the circuit breaker drives access platform.
- For the unavoidable remaining emissions, an optimized carbon removal and/or offsetting strategy could be proposed.

The simulation performed, considering implementing these measures demonstrate that, had this analysis been performed during the design phase, the overall impact could have been halved.

3.3 Disclaimer

It is important to highlight that the results presented above are valid for these specific projects with their characteristics and scope and cannot be generalized to others.

The studies provide valuable insights for project decision-makers, helping them make informed decisions based on sustainability and environmental considerations.

4 Value Added

As highlighted throughout this paper, the implementation of this new reporting methodology in our project and service execution brings great value in different aspects:

- Sheds light on an area that is not fully addressed in existing reporting methodologies;

- Drives cultural change in the organization, giving every project and service employee the ability to evaluate the environmental impact of the activity and comprehend what the major contributors to this impact are;
- Enhances understanding of Scope 3 emissions, an existing challenge for many organizations;
- Considers execution alternatives from a different angle. Projects are typically contemplated from a cost, lead time, or reliability perspective; thanks to this new approach, the environmental impact can also be considered as part of the decision-making process
- Implements improvements that result in reducing environmental impact,
- Measures the remaining impact of the project, opening the door to the possibility of compensating or offsetting remaining emissions.

5 Conclusions

Product life cycle assessment is an important way to understand the environmental impact of the equipment we install in our power systems. However, when evaluating the impact based on this approach, we are often disregarding a highly relevant area that, albeit small in the overall lifecycle, is significant when evaluating our daily business project and service execution environmental impact.

Innovative solutions such as the one described in this paper can act as catalysts to improve, not only the equipment losses or manufacturing processes, but also how the equipment is installed and maintained during their life cycle.

Small decisions, such us using more sustainable construction materials, avoiding travel by using digital solutions like sensors or AR remote support, implementing an alternative plan for execution and equipment shipping, … can have a major, positive impact on building a sustainable future for all.

This paper calls for collaboration and an innovative spirit among technology providers, system operators, universities, and start-ups. We must act together given the urgency for a clean energy transition.

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