LESSONS LEARNT FROM THE ECO-DESIGN PROCESS FOR AN ELBOW CONNECTOR FOR MEDIUM VOLTAGE NETWORKS

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ABSTRACT

In order to avoid sub-optimization of the environmental performance of a product during design, eco-design is a holistic approach that considers the potential environmental impacts of a product life cycle during design, in order to decrease them. This approach has been followed in the redesign of the 200LR, an elbow connector for medium voltage network, using quantitative life cycle assessment as the main tool for ecodesign.
Important improvements in term of environmental impacts were achieved thanks to a more compact design that fulfills all technical requirements.

INTRODUCTION

With a surge of environmental concerns on product impact, companies are challenged by customers, governments and civil societies to integrate and manage their negative externalities towards ecosystems. One of the solutions that can be implemented to tackle this challenge is ecodesign, which is "the integration of environmental aspects into product design with the aim of improving the environmental performance of the product throughout its whole life cycle"[1]. This methodology was developed to avoid the selection of an idea that seems good for the environment at first sight but, considering a broader context, has a significantly worst impact on the environment than alternative solutions. Such misguided solution can be products that have reduced their environmental impact during manufacturing at the expense of their capacity to be recycled or that have substituted a substance that contributes to global warming with one that is toxic. This is why the latest version of the ISO 14001 is now requesting that the scope of the environmental management system be based on a "life cycle perspective" [2].
The tool of choice for implementing this solution is life cycle assessment-LCA [3]. It can be used to discriminate between two technologies [4], to communicate or to drive a design project.
This paper presents its application to an ecodesign project for a medium voltage cable accessory. The first paragraph presents how it is used for setting up targets for ecodesign at the beginning of the project, the second paragraph focuses on its application to the selection of design solutions and the last paragraph on how it can provide accurate figures for a communication plan. The last paragraph also addresses some of the short-coming of the process.

PROJECT SET-UP

Euromold is the unit of Nexans dedicated to the production and design of pre-moulded accessories for medium and high voltage cables. In 2014, an ambitious project started in order to redesign one of their top runner products: the interface A elbow connector 158LR.

Product overview and project targets

The 158LR is a separable elbow connector designed to connect polymeric insulated cable to equipment (transformers, switchgear, motors...).

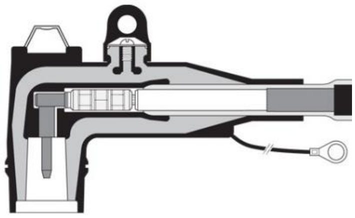

Figure 1. 158LR Elbow connector

In order to reply to customer requests for environmental declaration, the unit was trained on the development of Product Environmental Profiles - PEP [5]. This is a communication format that requires the product designer to perform a life cycle assessment. Familiar with the method, the team decided to use the redesign project as a test run for applying LCA to ecodesign.
So, on top of the targets of providing customers with an improved product and boosting manufacturability, the design team also had to fulfil ecodesign targets: the new version of the product had to have a smaller environmental impact than the 158LR.
To refine design targets and to drive the redesign process, a quantitative life cycle assessment of the product currently manufactured was done.

LCA of the 158LR

The product function is to connect medium voltage cables to various equipment for a minimum service life of 40 years in the same use conditions as the cable itself. It can cover a wide range of conductor cross sections and voltage classes. Because of the broad range of application scenarios, two were retained: 16 mm² copper conductor with an average loading of 10 A and 95 mm² aluminium conductor with an average loading of 100 A.
The product life cycle from cradle, raw material extraction, to grave, end-of-life, is considered, including as well: manufacturing, distribution, installation, use. Packaging and installation kit were also considered in the study.

Data collected for the assessment included: bill of materials, energy measurements for manufacturing equipment, production waste, test measure for energy losses in use, environmental study for medium voltage network end-of-life management, …

Since the unit was committed to develop environmental declarations, PEP program rules were applied for the assessment [5]. The software used for the calculation at the time was EIME, with the database CODDE-2013-02. Even though 11 environmental indicators were considered, a focus was made on four key ones: global warming potential (GWP), abiotic depletion potential of mineral resources (ADPe), total primary energy use (TPE) and water consumption (WD).

The results of the life cycle assessment helped to identify two focus points for the designers: the manufacturing phase, and the use-phase, which is significant in the specific scenario with 100 A loading.

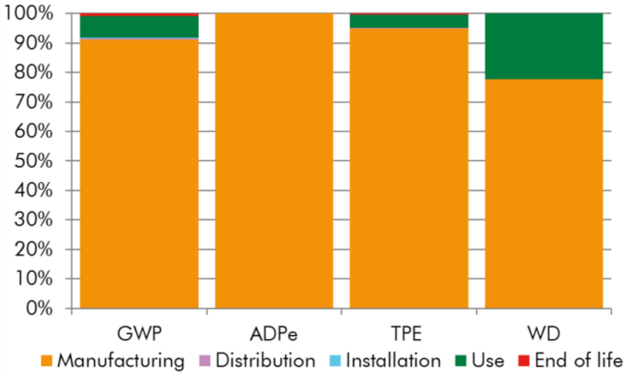

Figure 2. 158LR Life cycle assessment results for 10 A loading.

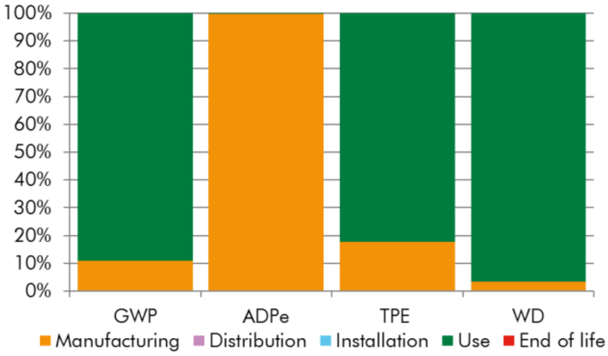

Figure 3. 158LR Life cycle assessment results for 100 A loading.

For the manufacturing phase, the connector body (jacket, insert and insulation) and the cable adaptor are the most significant contributors.

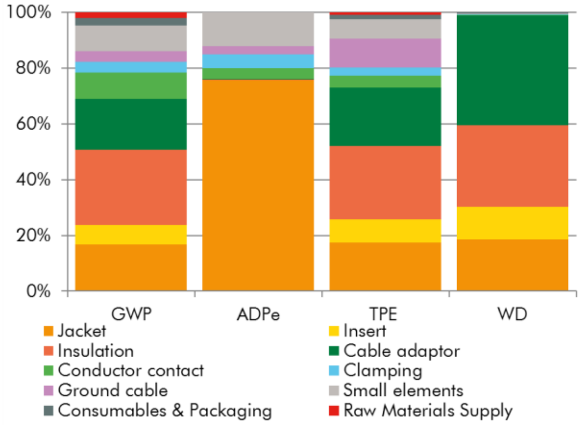

Figure 4. 158LR Manufacturing phase results.

DEVELOPMENT PROCESS OF THE 200LR

Based on the conclusions of the preliminary LCA, several options have been explored by the design team.

Firstly, to tackle losses during use, a design option is to reduce the number of parts and the length of elements that are prone to power losses. Therefore, the conductor contact design for the new 200LR was changed to a more compact shape.

Figure 5. Conductor contact fitted in the 200LR connector.

With the new design, losses in the contact are lowered by 48% compared to the contact in the 158LR.

Secondly, to reduce the impact of manufacturing, especially of the EPDM connector body and of the cable adaptor, several options can be explored: change the type of materials used, reduce product weight, decrease production waste and/or energy consumption of machinery…

For technical products with a long lifetime, developing and qualifying a new material, especially one that can pass the ageing tests, is time and resources consuming. The team decided to focus its effort on developing a more compact product with the same material. On top of the compactness constrain, the product had to be easily processed in order to reduce production losses and energy consumption of the equipment. The team came up with a new design: a smaller connector body with a simplified shape that allows for a highly automated production process. Consequently, the product weight was reduced by 53%.

Ramping up production speed and increasing process reliability, an all-new robotized, closed production cell has been installed. This resulted in the reduction of two-thirds of the energy needed to manufacture the product.

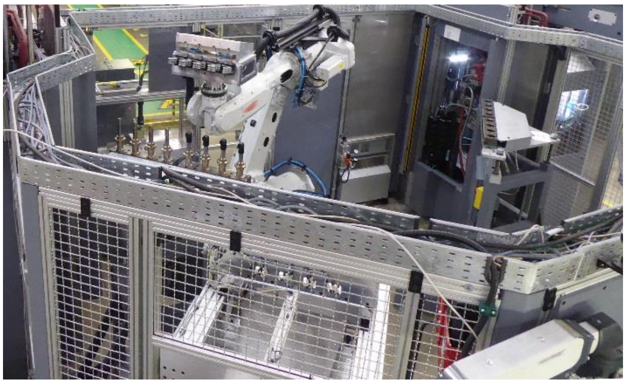

Figure 6. Snapshot of the new robotic line

Figure 7. Dimensions of the 158LR (upper left) and the 200LR (lower right).

COMPARATIVE ASSESSMENT OF THE TWO TECHNOLOGIES

After successful qualification of the first prototypes from Erembodegem's new production lines, the product design was finalized, late 2017. The new product complied with all the design constrains including cost effectiveness, electrical and mechanical testing. To validate whether the new product indeed had a better environmental performance than the previous version of the product, a comparative life cycle assessment was made.

The 158LR's LCA was remodelled to be aligned with the newest development in the LCA field for electrical products and the 200LR was modelled using the same hypotheses. The same software was used for the assessment, EIME, but with a more recent database (Nexans-2017-06).

When compared on a similar basis, the new connector has a reduced environmental impact on all indicators. The overall reduction of impact is around 50% with the exception of abiotic depletion of resources, where the reduction is slightly lower at 44%.

The reduction of impacts is due to the decrease of energy losses (green part in the figure below) but also due to a reduction of the impact of the manufacturing phase.

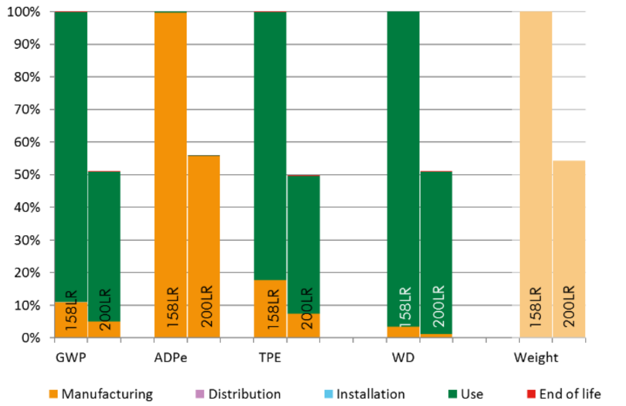

Figure 8. Comparison of the life cycle of the 158LR with the 200LR for the connection of an aluminium cable.

When comparing the contributors to the global warming potential of the manufacturing phase, all individual components found in a 200LR connector kit, show a reduced environmental impact versus the ones used in a 158LR kit.

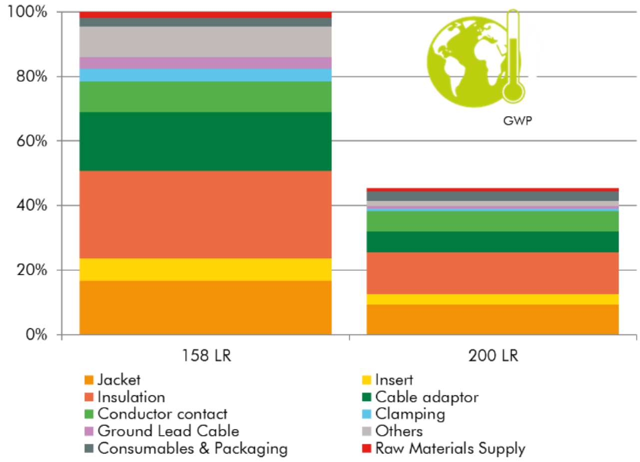

Figure 9. Comparison of the 158LR with the 200LR on the Global warming potential of the manufacturing phase

For abiotic depletion of mineral resources, the most significant reduction of impact comes from the jacket, because of its reduced mass versus the previous design.

It should be noted that the impact of the cable adaptor of the 200LR has increased. Its new design shape and material have more impact on this indicator. Yet, even though an impact transfer is notable at the part level, the impact at the manufacturing phase level is reduced.

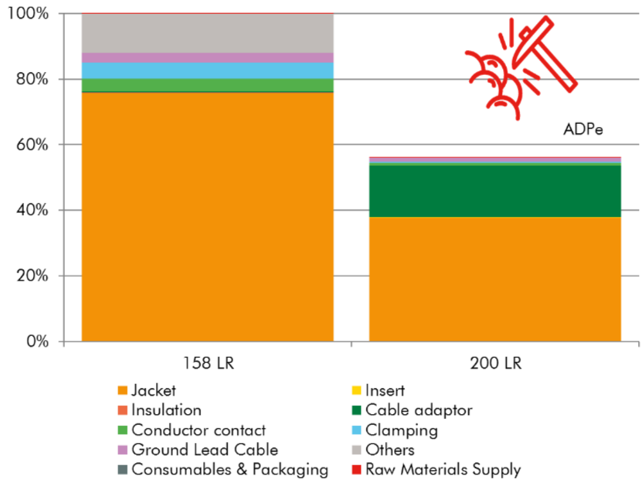

Figure 10. Comparison of the 158LR with the 200LR on the Abiotic depletion potential of the manufacturing phase

All in all, the ecodesign process can be deemed successful: a significant reduction of impact was identified and no notable transfers of impact between life cycle stage or environmental indicators were identified.

COMMUNICATION CAMPAIGN

Based on the success of the redesign process, it was decided to promote the environmental performance of the product. Nowadays, a lot of environmental claims are hardly traceable, making it difficult for customers to know whether or not the product is actually better for the environment than an alternative one. To avoid this form of "green washing", ISO 14021 lays down the basis for transparent, traceable, verifiable and relevant self-declared environmental claims [6]. Even though the standard does not make it compulsory to use LCA, it advises to use a life cycle perspective when communicating on environmental issues. It also asks that the calculations, measurements… that are used to sustain the claims are accessible to the public upon request.
To be aligned with the recommendations of the standards and Nexans own internal policy on green claims, it was decided to submit the results of the comparative LCA to an external critical review. This process involved an external expert of LCA for electric and electronic products that reviewed that Nexans' assumptions and hypothesis for assessment were not set-up to artificially inflate environmental performance. Based on the feedback from the expert, the LCA study was modified with no major consequences on the final results: the 200LR can be labelled as ecodesigned because:

- Environmental aspects throughout the product life cycle were integrated in the product design process [1], and;
- Substantial reductions of environmental impacts were achieved through this process when compared with the product that was redesigned.

As such, "ecodesign" was proven to be a valid key talking point in the commercialisation campaign of the 200LR. The final LCA report after critical review is also accessible on the product promotional website.

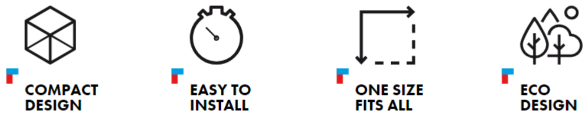

Figure 11. The 4 keys communication message for the 200LR campaign.

In order to promote the ecodesign product to more than just Nexans clients, the 200LR was entered in the "Belgian Environmental Energy Award (EEAward)"-competition. It won the prize in the category Sustainable Energy.

LIMITATIONS

In most of the LCA performed for communication or for ecodesign purposes, the analysis is limited by several constraints.
The first one in this study is that the accessory was studied in isolation from the rest of the medium voltage network. This is due to the fact that Nexans does not have the complete vision that utilities have of their own network. This means that impact transfers, from the connector to another element of the distribution grid could not be identified by this study. Even though this is very unlikely, the change of the connector design might have unexpected consequences, positive or negative, on other elements of the grid. For example, its new shape might ease the installation process, consequently decreasing the number of accessories that are damaged during this step.
This also means that some aspects of the product life cycle were not considered, like the impact of de-installing the connector at the end-of-life, in order to recycle it.
Another limitation is that specific data from Nexans material suppliers were not available. This means that materials environmental impacts are coming from generic database. At best, these data come from industry average through trade association, like Plasticseurope. This limitation is usual for life cycle assessment of electric products, where material suppliers are not pro-actively sharing environmental information.
Additionally, in term of ecodesign strategies, it has been identified that implementing solutions that needs extra qualifications is difficult. For example, changing the type of materials used means that its processability needs to be assessed on top of the usual qualification tests that a new product design need to go through. The change in connector and bail design is also a reason why the development process spanned over a period of 4 years because electrical and mechanical ageing test were required.

CONCLUSIONS AND PERSPECTIVE

Adding the environmental constrain to an already highly

constrained process such as design is challenging. But when using the right tool, like quantitative life cycle assessment, it can be achieved. The redesign of the 158LR connector into the 200LR exemplifies how this can be done by electrical product manufacturers.
Thanks to a complete redesign of the product shape and of the production equipment, the design team of Nexans Euromold successfully developed its first end-to-end ecodesign solution.
It remains to be seen whether this ecological (and thus commercial) advantage of the new 200LR will influence the sales of the product over other competitors' products or over the previous version of the product.
Now that the team did a test-run of ecodesign and in order to comply with the newest version of the ISO 14001:2015, every major re-design project has to integrate ecodesign. The process is based on three major tasks: perform a preliminary life cycle assessment of the current product, use the results of the assessment to set targets for the project and compare the products at the end of the project to define the communication strategy.

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