# LIFE CYCLE ASSESSMENT IMPROVEMENT FOR MEDIUM VOLTAGE CABLE FOR FRENCH MARKET

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***ABSTRACT***

*For several years, GENERAL CABLE France has integrated eco-design in the heart of its activity. The life cycle assessment of the cable is used to identify environmental impact of products. This includes the extraction of raw materials, its end of life in terms of natural resources consumption (materials, energy ...), their production impacts but also wastes generated.*

*With the concern of environment respect and in addition to life cycle assessment of our Medium Voltage products for French market, the autors have chosen to describe the launched approach to minimize the environmental impact of cables.*

*Assessments conducted through EIME software (Environmental Information and Management Explorer) enabled to clearly identify the impacts and to highlight potential improvements of MV products with new raw materials or appropriate design.*

***KEYWORDS***

ECO-DESIGN, LIFE CYCLE ASSESSMENT (LCA), EIME

## INTRODUCTION

Environmental impact is more and more taken into account and the aim of eco-design method is to decrease it. Industries must integrate in enterprise policy which includes design, manufacturing and commercialization, an eco-responsible approach.

Establishing a Life Cycle Assessment (LCA) allows to quantify and after, to compare environmental impacts in order to see new sources of improvement.

The objective of this paper is to introduce the Life Cycle Assessment process, and to highlight potential solutions to improve environmental impact of Medium Voltage cables used for the French Market.

## ECO-DESIGN THEORY

The objective is to introduce during design or re-design step environmental criteria with the same importance than technical and economica criterias. This approach can have different sources:

- Regulation respect (European directives : ROHS, REACH …)
- Standardization (ISO, HQE …)
- Market requirements
- Consumer demand
- Project and corporate culture

According to AFNOR definition, it is « *Sustainable Development* » if « *Ecosystem components and their functions are preserved for present and future generations (2012)* ».

The objective of sustainable development is to define a viable and coherent scheme reconciling the 3 ecological, sociological and economical aspects of human actions as described in Figure 1.


***Figure 1: Sustainable development***

Life cycle assessment, in addition to determine environment impact of existing product, is used as a basis for evaluating environment performances of new solutions.

## LIFE CYCLE ASSESSMENT

The aim is to evaluate product impact on the environment along its whole lifecycle (cradle-to-grave analysis), from raw material extraction to its end of life treatment (Figure 2).

By convention, Installation phase is not taken into account for LCA.

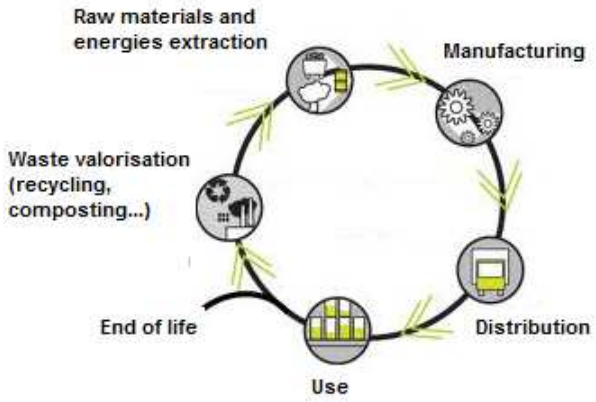


***Figure 2: Steps taken into account for MV LCA***

In the following paragraph, all indicators are defined. Indeed, 2 types of indicators can be considered:

- **Flow indicators**

**Energie Depletion (ED)**

**Water Depletion (WD)**

**Hazardous Waste Production (HWP)**

- **Impact indicators**

**Global Warming Potential (GWP):** The greenhouse effect is a natural phenomenon amplified by human activities and it causes global warming.
*Contributors: $C0_2$, Methane, Nox*

**Ozone Depletion Potential (ODP)**: Result of interaction between chemical component of air and UV radiation.
*Contributors: CFC, agricultural pesticides, $CO_2$…*

**Photochemical Ozone Creation Potential (POCP)**:
Result of chemical reactions between different components creating Ozone at low altitude.
*Contributors: Nox, COVs…*

**Air Acidification (AA)**: Change in an environment's natural chemical balance caused by an increase in the concentration of acidic elements.
*Contributors: Sulphur and nitrogen, ammoniac …*

**Air Toxicity (AT) / Water Toxicity (WT)**: Dangerousness of certain substances in function of a dilution factor to bring them back to a regulatory level.
*Contributors: Heavy metals, dioxins …*

**Water Eutrophication (WE)**: Ecosystem response (algae bloom) to the addition of artificial or natural substances to an aquatic system.
*Contributors: Nitrogen, Phosphorus…*

**Raw Material Depletion (RMD):** Consumption of resources faster than it can be replenished.

## LCA ESTABLISHMENT

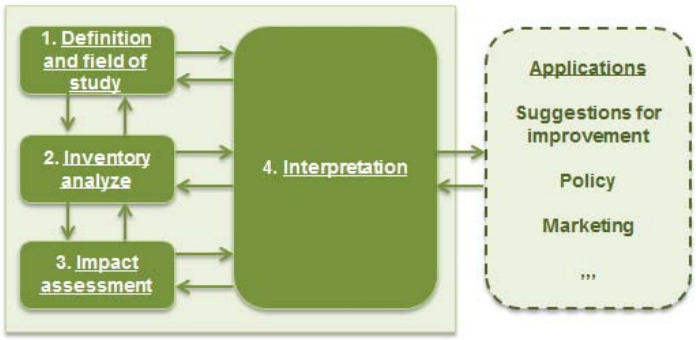


***Figure 3: Four LCA steps according to ISO 14040 and 14044***

For study purpose, it is necessary to define the product, a functional unit (function, technical criterion, operation time) and the system boundaries.

Secondly, the inventory of each step is realized (Figure 4):


***Figure 4: Inventory***

The selected methodology to evaluate impacts leans upon a tool which is the EIME software (Environmental Information and Management Explorer), which is as well supported by many Electric & Electronic Equipment (EEE) suppliers and customers.

It includes databases. They have been input by the experts and cannot be changed by designer. If the target is to upgrade a product, the components of its product should be described as well as the manufacturing process.

Thanks to the database, the software computes preselected environmental impacts.

A comparison between 2 products can be done. In this case, impacts are usually displayed as a "radar" picture. The lower the impact is, the closer to the center is the point on the picture (example described in the Figure 7).

- Example for a **1x150 mm² Aluminum 12/20(24) kV Medium Voltage cable according to NF C 33-226 (Figure 5)**:

***Figure 5: 1x150 mm² Al 12/20(24) kV***

Functional unit: Transport energy for **1 A** on **1km** during **40 years** to a **100% use rate** in conformity with the standard requirements.

The EIME software allows to obtain quantified datas for each step compared to the 11 impact indicators previously defined.

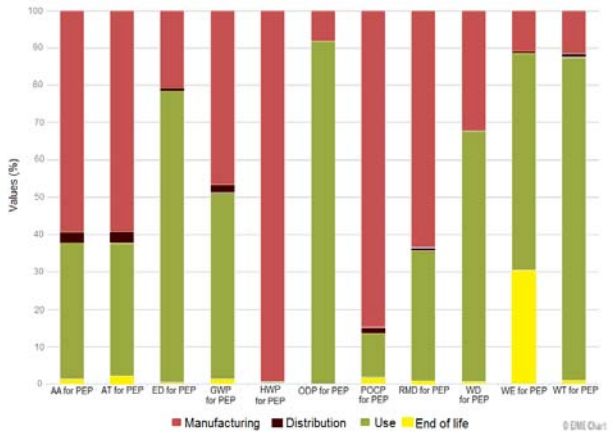


***Figure 6: Phase part for each indicator***

Figure 6 demonstrates the most notable steps in term of environmental impact: **Manufacturing** and **Use** phases.

In Figure 7, a 150 mm² Alu 12/20(24)kV unipolar is compared with a 240 mm² Alu 12/20(24)kV unipolar.

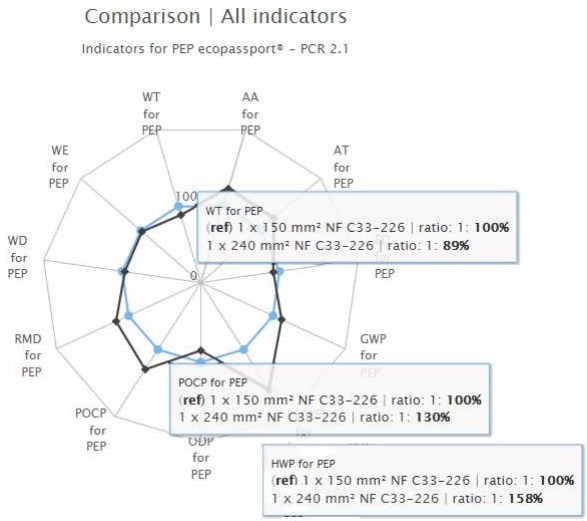


***Figure 7: Example of "radar" picture - Comparison between 2 cables (1x150 mm² Alu 12/20(24)kV and 1x240 mm² Alu 12/20(24)kV)***

6 indicators are higher than reference and 3 are lower. The conductor section has no impact Water Eutrophication (WE) and Water Depletion (WD).

This kind of study can be used in different cases:

- LCA of a product
- Replacement of raw materials or integration of recycled materials
- New supplier
- Design comparison (sections, conductor nature,…)
- End of life recycling
- Etc…

## REDUCTION OF ENVIRONMENTAL IMPACT

In the current study, different formulas and designs of sheath complexes impacts on a LCA have been identified for a Medium Voltage cable according to NF C 33-226 to determine the best design allowing to decrease environmental impact.

Four configurations have been compared to a standard design with PE sheath (described in Figure 5):

| Sheath material | **PE with decreasing of the thickness** | **PE-based blend** | **Recycled PE** | **PVC** |
|---|---|---|---|---|
| Design changes | Thickness | Material and thickness | Material | Material |

Each new configuration is compared with the current

design of MV cable (each impact value at 100% in radar pictures below).

❖ **PVC compound**

Choice of sheath can have an important impact on LCA result:

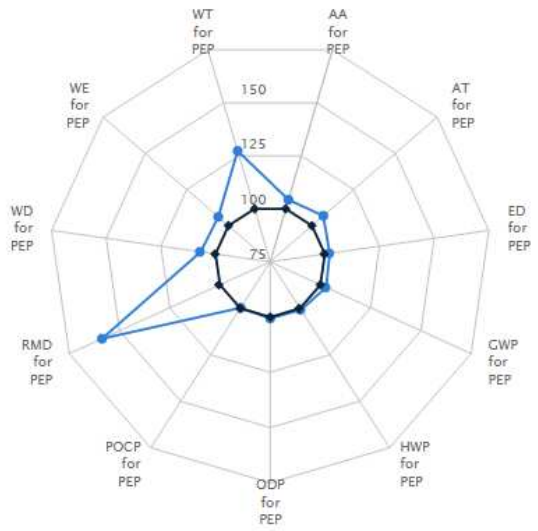


***Figure 8: LCA for PVC compound as sheath***

For this configuration, all indicators (Figure 8) are higher than the reference, in particular, Raw Material Depletion (RMD) and Water Toxicity (WT). From the raw materials extraction to manufacturing step, additives and byproducts are dispersed in water, what explains Water Toxicity (WT) and Water Eutrophication (WE) increasings. PVC resources are lower than PE resources, what explains RMD.

❖ **PE-based blend**

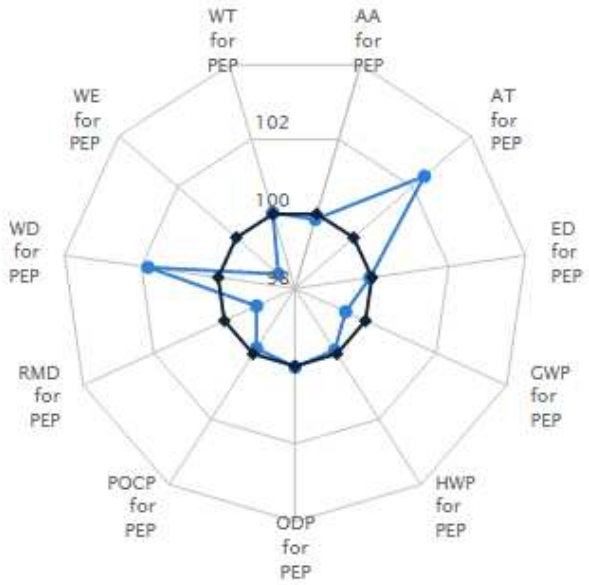


***Figure 9: LCA for a PE-based sheath***

Figure 9 shows increasing of Water Depletion and Air Eutrophication indicators which are due to the process of treatment of additives added in the PE sheath.

❖ **Recycled PE**

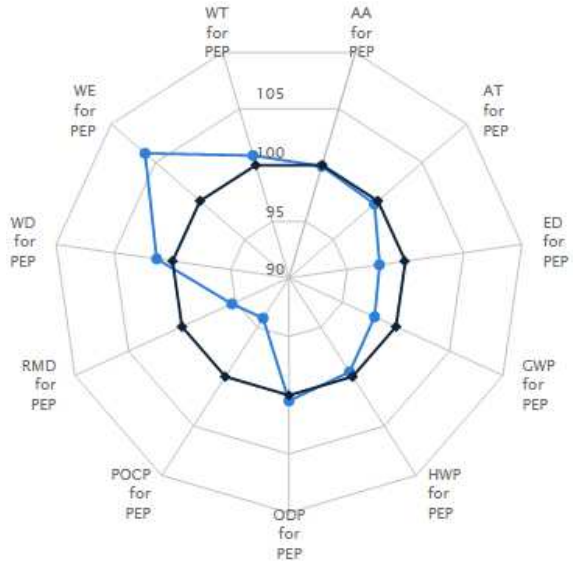


***Figure 10: LCA for recycled PE sheath***

In the Figure 10, using Recycled Polyethylene has a benefit impact for Raw Material Depletion (RMD): no manufacturing of new PE. The retreatment process for recycling consumes less energy than new PE (Photochemical Ozone Creation Potential - POCP).

For PE-based blend and Recycled PE, most impacts have been decreased. These modifications demonstrate a good impact on the environment.

❖ **Sheath thickness decreasing**

Design optimization is the first and the simplest step to Eco-design.

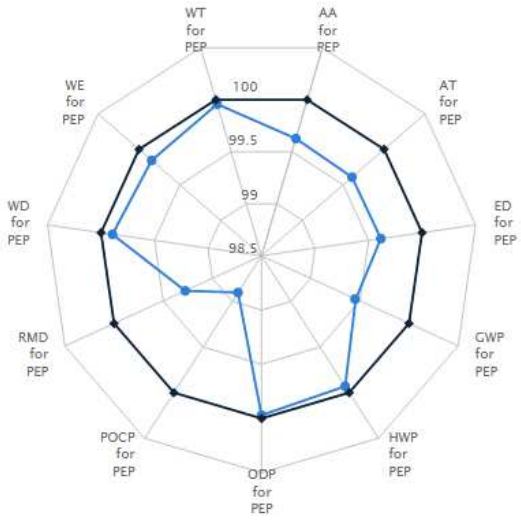


***Figure 11: Sheath thickness reduction***

All indicators have been decreased in Figure 11, leading an improvement of the environmental impact.

Figure 12 summarizes the configurations described above and their indicators:

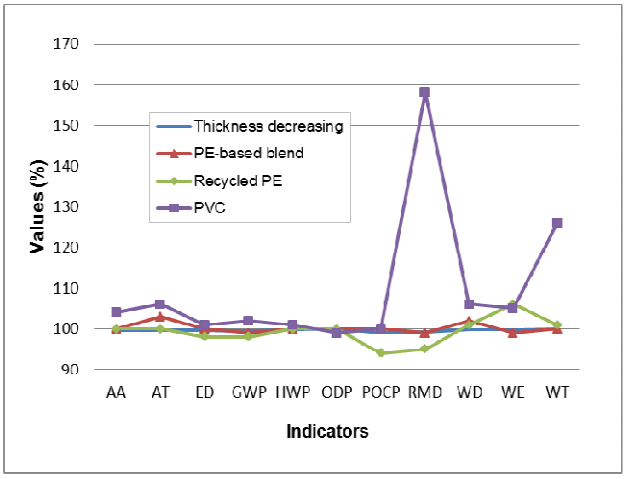


***Figure 12: Comparison between different configurations***

It is difficult to prioritize impacts. It is important to take into account a global decreasing of the environmental impacts. Use **recycled PE** seems to be a good option to decrease environmental impact of MV cable for French Market.

## CONCLUSION

EIME (Environmental Information and Management Explorer) is an appropriate tool to describe the complete life of a MV cable. We identified the most impacting steps, which are still manufacturing and using phases.

Some configurations allow to highlight the notable reductions of environmental impact: Use a recycled PE seems to be a good way. On the contrary, PVC has a bad effect on environmental impact.

However, even if two products/designs can be compared, results must be carefully analyzed before interpretations: Is the same functional unit? Is the same product? Etc…

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